Third generation extruded snacks with ancient grains

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ABSTRACT

Third generation (3G) is a term that refers to the levels of processing used to produce a finished product. A 3G snack product starts with a starch based recipe that is extrusion cooked, formed into a dense shaped pellet and then dried. At this point, it is referred to as semi or half product because it needs to be further puffed to develop its texture and flavour. The objective of this project was to develop an unflavoured cereal-based 3G snack formulation with ancient grains. The snack must be unique in shape and suitable for hot air-puffing.

Two 3G wholegrain base formulations were developed. One formulation was made from coarse rice flour, wholemeal wheat flour, potato starch, ancient grain blend (one third amaranth, one third quinoa and one third millet), wheat fibre 600 and salt. The second formulation was maize based by replacing coarse rice flour with maize polenta. These two base formulations contained ancient grains and nutrients that provide health benefits and were suitable for air-puffing. A lab-scale model Clextral BC21 twin screw co-rotating extruder was used for this study. Pasting properties of samples were evaluated using the Rapid Visco Analyser. It was found that ingredient selection and extrusion processing affected extruded pellets' paste viscosities, the die swell and product expansion.

Pasting properties of raw ingredient blend were affected by amylose and lipid content, and particle size of the cereal flour. The more even the raw material particle size was, the more even was the hydration of the material in the extruder. The results showed that inclusion of dietary fibre (wheat fibre 600, Beneo GR or Hi-Maize™ 1043) in the 3G formulations decreased raw ingredients' and extruded pellets' paste viscosities, which resulted in reduced pellet expansion. It was found that wheat fibre 600 at 4 % was the best fibre choice to produce a 3G snack, because it accelerated extruded pellet drying, helped in 'pellet checking' control and producing more uniform cell sized expanded products. Hi-Maize™ ingredients were found to lead to the deterioration of viscosity and snack pellet expansion, and therefore not recommended to be used for 3G snack base formulation.

Increasing the water injection rate to the extruder (from 1.0 to 1.7 L/h) decreased the extruder apparent torque, thrust pressure, die pressure and SME. The degree of starch degradation was also reduced, but the product expansion was increased. Pellet expansion was found closely correlated to the pasting properties of the raw ingredient blend. Pellet expansion increased with the increase of peak viscosity (PV) and final viscosity (FV) of the raw ingredient blend.

A suitable laboratory drying method was developed for 3G snacks. It was found that drying and holding at 1 h ± 5 min intervals including a pre-drying step had minimal pellets defects. Humidity control (60 %) was required throughout this drying process. After puffing, the product sectional expansion index (SEI) increased with the increase in salt concentration from 0.5 % to 1.0 % and increase in moisture content from 9.5 % to 12.1 %. The extruded pellets moisture was found to have the most significant effect on

the finished product expansion, and maximum expansion due to puffing was found at 10.6 % pellet moisture.

A shear-compression analysis of the 3G product prototypes and competitor products showed that most of low moisture commercial snack products available in the market have low bulk density and were brittle. The products produced from the proposed 3G formulations were much harder than the commercial products.

Qualitative consumer focus group studies were conducted to gain insights into consumers' attitudes towards extruded snacks, desirable texture and product claims to be included in the product. The results showed that five themes typically associated with snack consumption (nostalgia, special social occasions, distraction, convenient treat and hunger). Taste and price were the most important to the participants, and the health benefits were only an extra bonus. Participants were not tempted by an ancient grain claim. Product prototypes did not receive very positive feedback due to the taste and the product size. Product texture was found acceptable by most participants.

This study produced initial formulations for a 3G snack, provided a good starting point for understanding of the 3G extruded snack process and provided valuable information for further development work. Further work is required to scale up the recipe, to increase the snack size, to further improve of the 3G snack flavour without significantly increasing the salt content and to carry out a consumer acceptance study on the scaled up 3G snack products.

ACKNOWLEDGEMENTS

Firstly, I thank the Sanitarium Health and Wellbeing Company for sponsoring this project. 3G snacks have good market and potential for development. It is my privilege to have been exposed to the development of such products. This project has been a great learning experience, I hope that the outcome from this project will provide some useful information for a further product development.

There have been many people who have contributed significantly to the completion and achievement in this project; I would like to take this opportunity to thank them.

First and foremost, I would like to thank my supervisors, Allan Hardacre and Associate Professor Marie Wong, for all the time, support and encouragement they have provided. Their academic guidance has been of great assistance.

I would like to thank my parents and everyone at Sanitarium research and development team for their support, assistance and inspiration.

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Ancient grains generally refer to a group of cereal grains or pseudo-cereals that are largely unchanged over the last several hundred years. The most common ancient grains are native to South America including amaranth, quinoa, barley, chia, buckwheat, kamut®, sorghum, millet, spelt and teff.

Beneo GR is a water soluble dietary fibre consisting mainly of chicory inulin, GR stands for granulated powder (details can be found in Appendix A 1.4).

Beneo Hi is a 3G base formulation made from coarse rice flour, wholemeal wheat flour (31 %), potato starch, ancient grain blend, white sugar, nut brown flour and salt. Beneo GR (4 %) was added to the 3G base formulation and extruded using a Clextral BC21 twin screw co-rotating extruder (Firminy Cedex, France) at screw speed 251 rpm, water rate 1.7 kg/h and feed rate dial 60.

Beneo Lo is a 3G base formulation made from coarse rice flour, wholemeal wheat flour (31 %), potato starch, ancient grain blend, white sugar, nut brown flour and salt. Beneo GR (2 %) was added to the 3G base formulation and extruded using a Clextral BC21 twin screw co-rotating extruder (Firminy Cedex, France) at screw speed 251 rpm, water rate 1.7 kg/h and feed rate dial 60.

Breakdown (BD) is the peak viscosity minus the viscosity after the holding period at 95 ºC in a RVA analysis.

Carbohydrate by difference is calculated by subtracting from 100, the average quantity expressed as a percentage of water, protein, fat, dietary fibre, ash, alcohol, and any other unavailable carbohydrate (FSANZ Standard 1.2.8).

Cold Peak (CP) is the maximum cold water viscosity observed at 25 ºC in a RVA analysis.

CW is a 3G base formulation made from maize polenta, wholemeal wheat flour (31 %), potato starch, ancient grain blend, white sugar, nut brown flour and salt (0.5 %). Wheat fibre 600 (4 %) was added to the 3G base formulation.

CW Water Hi is the 3G base formulation 'CW' extruded using a Clextral BC21 twin screw co-rotating extruder (Firminy Cedex, France) at screw speed 251 rpm, water rate 1.7 kg/h and feed rate dial 88.

CW Water Lo is the 3G base formulation 'CW' extruded using a Clextral BC21 twin screw co-rotating extruder (Firminy Cedex, France) at screw speed 251 rpm, water addition rate 1.0 kg/h and feed rate dial 70.

CW Salt Hi is a 3G base formulation made from maize polenta, wholemeal wheat flour (30 %), potato starch, ancient grain blend and salt (1 %). Wheat fibre 600 (4 %) was added to the 3G base formulation.

Die conductance measures the magnitude of the resistance to flow. The die conductance (k) is a function of die geometry and material of construction.

Die swell is the overall expansion of a pellet. It was calculated by dividing the dimension of the pellet by dimension of the die opening.

Flavex is a vegetable protein extract produced by the acid hydrolysis of vegetable proteins. It has an intense savoury flavour and has been used as a flavour enhancer (details can be found in section A 1.5 of Appendix 1).

Hi-Maize^{TM} 1043 is a natural, unmodified, high amylose resistant starch made from maize (details can be found in Appendix A 1.4).

Hi-Maize Hi is a 3G base formulation made from coarse rice flour, wholemeal wheat flour (31 %), potato starch, ancient grain blend, white sugar, nut brown flour and salt. Hi-Maize^{TM} 1043 (7 %) was added to the 3G base formulation and extruded using a Clextral BC21 twin screw co-rotating extruder (Firminy Cedex, France) at screw speed 251 rpm, water rate 1.7 kg/h and feed rate dial 60.

Hi-Maize Lo is a 3G base formulation made from coarse rice flour, wholemeal wheat flour (31 %), potato starch, ancient grain blend, white sugar, nut brown flour and salt. Hi-Maize^{TM} 1043 (3.5 %) was added to the 3G base formulation and extruded using a Clextral BC21 twin screw co-rotating extruder (Firminy Cedex, France) at screw speed 251 rpm, water rate 1.7 kg/h and feed rate dial 60.

Nut brown flour is a light to medium brown finely grounded wholegrain meal with negligible diastatic activity. It is produced by milling crystal malted barley. It has pleasant roasted aroma and slightly bitter sweet in taste (details can be found in section A1.5 of Appendix 1).

Pasting temp is the temperature in a RVA analysis where viscosity first increases by at least 25 cP over a 20 s period. It provides an indication of the minimum temperature required to cook a given sample.

Peak viscosity (PV) is the maximum paste viscosity achieved during the heating cycle of a RVA analysis;

Peak time (PT) is time when maximum paste viscosity achieved in a RVA analysis;

Pellet checking is the hairline crack on or under the surface of the pellets. The formation of checking is pellet cannot deform enough to relax stresses causing by pellet drying before entering the glassy state. Pellet shrinks on losing moisture and the dry outside region will try to contract onto the wet core. Hence the outside of the pellet will be under tension and the core under compression. Checking can occur either during the drying cycle or as long as several weeks after the product has been packaged.

RW is a 3G base formulation made from coarse rice flour, wholemeal wheat flour (31 %), potato starch, ancient grain blend, white sugar, nut brown flour and salt (0.5 %). Wheat fibre 600 (4 %) was added to the 3G base formulation.

RW Water Hi (WF Hi) is the 3G base formulation 'RW' extruded using a Clextral BC21 twin screw co-rotating extruder (Firminy Cedex, France) at screw speed 251 rpm, water rate 1.7 kg/h and feed rate dial 60.

RW Water Lo is the 3G base formulation 'RW' extruded using a Clextral BC21 twin screw co-rotating extruder (Firminy Cedex, France) at screw speed 251 rpm, water addition rate 1.0 kg/h and feed rate dial 60.

RW Salt Hi is a 3G base formulation made from coarse rice flour, wholemeal wheat flour (30 %), potato starch, ancient grain blend and salt (1 %). Wheat fibre 600 (4 %) was added to the 3G base formulation.

RWC is a 3G base formulation made from coarse rice flour, potato starch, wholemeal wheat flour (21 %), Hi-Maize wholegrain flour (10 %), ancient grain blend, white sugar, nut brown flour and salt (0.5 %). Wheat fibre 600 (4 %) was added to the 3G base formulation.

RWC Water Hi is the 3G base formulation 'RWC' extruded using a Clextral BC21 twin screw co-rotating extruder (Firminy Cedex, France) at screw speed 251 rpm, water rate 1.7 kg/h and feed rate dial 85.

RWC Water Lo is the 3G base formulation 'RWC' extruded using a Clextral BC21 twin screw co-rotating extruder (Firminy Cedex, France) at screw speed 251 rpm, water addition rate 1.0 kg/h and feed rate dial 70.

RWC Salt Hi is a 3G base formulation made from coarse rice flour, wholemeal wheat flour (20 %), potato starch, Hi-Maize wholegrain flour (10 %), ancient grain blend and salt (1 %). Wheat fibre 600 (4 %) was added to the 3G base formulation.

Salt Hi is a 3G base formulation made from maize polenta, wholemeal wheat flour (30 %), potato starch, ancient grain blend and salt (1.0 %). Wheat fibre 600 (4 %) was added to the 3G base formulation and extruded using a Clextral BC21 twin screw co-rotating extruder (Firminy Cedex, France) at extruder screw speed 251 rpm, water rate 1.0 kg/h and the feed rate dial 75.

Salt Hi&Flavex is a 3G base formulation made from maize polenta, wholemeal wheat flour (30 %), potato starch, ancient grain blend, salt (1.0 %) and Flavex (0.3 %). Wheat fibre 600 (4 %) was added to the 3G base formulation and extruded using a Clextral BC21 twin screw co-rotating extruder (Firminy Cedex, France) at extruder screw speed 251 rpm, water rate 1.0 kg/h and the feed rate dial 80.

Salt Lo is a 3G base formulation made from maize polenta, wholemeal wheat flour (30 %), potato starch, ancient grain blend and salt (0.5 %). Wheat fibre 600 (4 %) was added to the 3G base formulation and extruded using a Clextral BC21 twin screw co-rotating extruder (Firminy Cedex, France) at extruder screw speed 251 rpm, water rate 1.0 kg/h and the feed rate dial 75.

Salt Lo&Flavex is a 3G base formulation made from maize polenta, wholemeal wheat flour (30 %), potato starch, ancient grain blend, salt (0.5 %) and Flavex (0.3 %). Wheat fibre 600 (4 %) was added to the 3G base formulation and extruded using a Clextral BC21 twin screw co-rotating extruder (Firminy Cedex, France) at extruder screw speed 251 rpm, water rate 1.0 kg/h and the feed rate dial 75.

Setback (SB) is difference between the final viscosity and the viscosity reached after the first holding period in a RVA analysis.

Starch dextrinisation is a process known as a certain degree of fragmentation during extrusion cooking, a decrease in high molecular weight material and a corresponding increase in lower molecular weight polysaccharide.

WF Hi (RW Water Hi) is a 3G base formulation made from coarse rice flour, wholemeal wheat flour (31 %), potato starch, ancient grain blend, white sugar, nut brown flour and salt. Wheat fibre 600 (4 %) was added to the 3G base formulation and extruded using a Clextral BC21 twin screw co-rotating extruder (Firminy Cedex, France) at screw speed 251 rpm, water rate 1.7 kg/h and feed rate dial 60.

WF Lo is a 3G base formulation made from coarse rice flour, wholemeal wheat flour (31 %), potato starch, ancient grain blend, white sugar, nut brown flour and salt. Wheat fibre 600 (2 %) was added to the 3G base formulation and extruded using a Clextral BC21 twin screw co-rotating extruder (Firminy Cedex, France) at screw speed 251 rpm, water rate 1.7 kg/h and feed rate dial 60.

Wheat Fibre 600 is a creamy white, microfine water insoluble dietary fibre produced by a special process from the structure building components of the wheat plant according to the supplier specification (details can be found in Appendix A 1.4).

1. INTRODUCTION

Extruded snacks are the largest segment of the processed snack category representing 53.2 % of its total value (Singh, 2009a). The leading players in the New Zealand processed snacks market are Pepsico and Griffins, Pepsico owns the highest New Zealand market share with 21.1 % through its Bluebird brand (Singh, 2009a).

The value of the extruded snacks market in New Zealand was estimated to be 28.9 million US dollars (NZD$39.6 million) in 2010 for a volume of 2.7 thousand tonnes; Datamonitor forecasted that the market value would increase to 35.9 million US dollars (NZD$49.2 million) and the market volume would be over 3 million kg by 2014 (Datamonitor, 2010; Singh, 2009a). New Zealand's domestic market is extremely small when it compared with the global extruded snack market as shown in Table 1.1. However, when considering the opportunities across the Tasman Sea in Australia, the market size is nearly 6 times larger than that of New Zealand. In addition, a joint New Zealand and Australia Food Standard was established in December 1995, which allows food products made in New Zealand can easily be sold in Australia. Furthermore, the extruded snack market in New Zealand is growing much faster than that of Australia and the overall growth rate is even faster than the global market (Table 1.1).

Table 1.1: Extruded snacks market value by country for 2010-2014 in millions of US dollars (Datamonitor, 2010)

Country	2010	2011	2012	2013	2014	Overall Growth	CAGR* (2010-2014)
Australia	172	179	186	194	201	16.8 %	4.0 %
New Zealand	29	31	32	34	36	24.2 %	5.6 %
Global	21605	22645	23760	24956	26239	21.5 %	5.0 %

*CAGR the compound annual growth rate, which is calculated by taking the nth root of the total percentage growth rate, where n is the number of years in the period being considered.

Snacks are the traditional convenience and fun foods that are consumed throughout the world. Although most snacks are not primarily consumed for their nutrients, there is an increasing trend of incorporating nutrients into snack foods as part of the healthy eating strategies (Datamonitor, 2012). Globally, the snack food market is saturated and more than 10,000 SKUs (stock keeping units) are launched every year (Datamonitor, 2011). As a result, competition is fierce and the need to differentiate has never been greater. A point of difference may be the inclusion of ancient grains to snack foods. Consumer demand is growing for snacks made with whole and ancient grains (Blackwell, 2013; Schafer, 2012). Fibre fortification would add a 'healthy' image to the product (FDA, 1997; Giacosa & Rondanelli, 2010). There is clearly potentials for adding a 'health message' to the product and the current market leaders have done very little to explore this opportunity.

Manufacturers generally use "first generation", "second generation" and "third generation" to describe the snacks available in the market (Hertzel & Plattner, 2005; Riaz, 2006). Their features have been summarised in Table 1.2.

Table 1.2: Characteristics of different snack generations (Choi, Phillips, & Resurreccion, 2007; Hertzel & Plattner, 2005; Huber, 2001; Riaz, 2006; Sunderland, 1996)

Generation	*Raw Material*	*Advantage*	*Disadvantage*	*Example*
First	All natural products	Least amount of processing is involved	Very little freedom in changing the product shape and texture	Nuts, potato chips and popcorn
Second	Cereal-based materials	Products are cooked, shaped and expanded all in one process with an extruder.	Can be expensive for transportation due to low bulk density of the product.	Corn tortilla chips and majority of the expanded snacks (i.e. Twisties)
Third	Cereal-based starchy materials	Extrusion cooked and formed dense pellets, which can be transported easily and stored. Can handle more completed shape and produce 3D snack.	The pellets need to be further expanded in hot oil, hot air or microwave to develop the product texture and flavour	SKOF Tripots and Munchos

Extrusion offers many basic design advantages (Hertzel & Plattner, 2005; Riaz, 2006). Once a basic formulation is established, a wide range of products can be produced by changing minor components, shapes, colour and flavours. A typical local example is the Bluebird corn snack range, the same corn base formulation is used to produce Twisties, Rashuns, Burger Rings and Cheezels. Thus, production efficiency may be increased.

If 3G snack technologies can be used to demonstrate the manufacture of nutritious snacks with health benefits and with unique shapes, this point of difference could be used to build a competitive advantage while adding to the product variety as well as providing efficiencies during manufacture. However, published studies on the development and manufacture of 3G snacks are limited and the technology is not very well understood by Sanitarium Health & Wellbeing Company. Research is required to understand and develop fundamental knowledge of the process, as well as the raw material in relation to processing and expansion characteristics of the finished products.

1.1. OBJECTIVES

The aim of this study is to develop an unflavoured cereal-based formulation for a 3G savoury snack. The snack must be unique in shape and suitable for hot air-puffing, contain a minimum of two ancient grains, a minimum of 2 % of fibre on a dry weight basis per serve and contain 25 % of wholegrain on a dry weight basis per 100 gram after savoury coating.

The study was designed to investigate the effect of ingredients and process conditions on a novel 3G snack; to identify key process parameters which influence the snack quality and to evaluate the acceptability of the novel snack base.

1.2. CONSTRAINTS

The project constraints were:

(a) Pilot plant extruder was only available for five trials budgeted for this project.
(b) Only one environmental chamber and one air-oven were available in the pilot plant shared by all research students;
(c) Raw material cost must be kept low to maintain profitability;

2. LITERATURE REVIEW

Extrusion processing converts raw materials into viscoelastic melts before it is forced to flow through a restricted aperture die plate to form the desired shape and pellet structure. The processing conditions and visco-elastic properties of the melt as it exits the die plate depends upon the raw material composition, the degree of starch gelatinization during extrusion, and the temperature and shear stress which are generated (Arhaliass, Bouvier, & Legrand, 2003; Ilo, Tomschik, Berghofer, & Mundigler, 1996; Ramirez Ortiz, San Martin-Martinez, & Martinez Padilla, 2008; Sacchetti, Pinnavaia, Guidolin, & Rosa, 2004; Wang, Bouvier, & Gelus, 1990; Wang, Casulli, & Bouvier, 1993). The melt properties subsequently determine the expansion structure and quality of the finished product (Arhaliass et al., 2003; Boischot, Moraru, & Kokini, 2003; Chen & Yeh, 2000; Fan, Mitchell, & Blanshard, 1994). The melt properties are commonly quantified by their rheological behaviour on-line or off-line, degree of starch gelatinisation and the glass transition temperature of the snack pellets (Bhattacharya & Padmanabhan, 1992; Brent, Mulvaney, Cohen, & Bartsch, 1997; Brent Jr, Mulvaney, Cohen, & Bartsch, 1997; Chanvrier, Valle, & Lourdin, 2006; Chen & Yeh, 2001; Davidson, 1992; De Graaf, Karman, & Janssen, 2003; Della Valle, Colonna, Patria, & Vergnes, 1996; Della Valle, Vergnes, Colonna, & Patria, 1997; Lai & Kokini, 1992; Li, Campanella, & Hardacre, 2004; Ramirez Ortiz et al., 2008; Van Laarhoven & Staal, 1991; Xie, Yu, Su, Liu, Wang, Liu & Chen, 2009). The best approach to achieve the research objectives is to systematically examine the five key areas of 3G snack processing: raw materials, extrusion processing, melt rheology, drying and expansion.

2.1. INGREDIENT SELECTION AND THEIR FUNCTIONALITIES

In general, the functionalities of ingredients in food systems can be used to build the physical structure of the food or to add nutritional value to the food, and most ingredients also contribute to sensory properties of the food. The addition of certain additives such as lecithin a stabiliser/emulsifier may have special technical purposes, such as improving the texture. During manufacturing of 3G snacks, the ingredients are subjected to a number of unit operations in the extruder, i.e. mass transfer, shear mixing and heating, to transform them into melts, which are then shaped to new functional forms (Huber, 2001). These ingredients will interact with one another to affect the transformations taking place. Therefore, it is important to understand the role of each ingredient in the formulation, as well as the effect of ingredient variation on the extruder performance and final product characteristics (Guy, 2001).

Ingredient selection for 3G snacks should be based primarily on the nutritional requirements of the finished products as well as meeting the textural, appearance and flavour needs of the product (Guy, 2001; Janssen, 1989). The Guy Classification System divides ingredients for extrusion cooking into seven different groups based on their functional role: structure-forming materials, dispersed-phased filling agents, soluble solids, lubricants, nucleating, colouring and flavouring substances (Guy, 2001). The major expense of producing 3G snacks is the cost of the Ingredients and this component plays a very important role for raw material selection as defined in the research constrains.

Recently, there is increasing of international attention towards wholegrain consumption, as a large number of studies demonstrate that including wholegrains in everyday diet leads to better health, vitality and reduced risk of coronary heart disease and some cancers (Flight & Clifton, 2006; McKeown, Meigs, Liu, Wilson, & Jacques, 2002; Seal, 2006; Slavin, 2004; Williams, 2003). According to Food Standard Australia New Zealand (FSANZ), wholegrain can be the constituents – endosperm, germ and bran of a processed grain, present in such proportions that represent the typical ratio of those fractions occurring in the whole cereal (FSANZ, 2004). The cheaper wholegrain sources in the commercial market are wheat and corn, of which wheat is the most commonly used.

Hertzel and Plattner (2005) suggest that a typical 3G snack recipe should be comprised primarily of carbohydrates, with smaller amount of proteins, lipids and other ingredients such as seasonings and processing aids. Common carbohydrate sources used in 3G snacks are starch, sugar and dietary fibre. They provide product texture, mouth feel, appearance and flavour; they also have a major influence on the expansion and bulk density of expanded 3G snacks (Hertzel & Plattner, 2005). The following sections will review some of the major raw materials based on their functionalities.

2.1.1. Starch

Starch is one of the most abundant carbohydrates in nature and occurs naturally as discrete granules produced for energy storage by many food plants (Fennema, 1996). According to the Guy Classification System for the ingredients, starch is the most important structure-forming material in which the other materials are held to form the product texture (Guy, 2001). It has been recommended that a typical 3G snack recipe should contain more than 60 % starch to maximize expansion of the snack pellet during hot oil or hot air puffing (Hertzel & Plattner, 2005; Riaz, 2006; Sunderland, 1996). It is well established that starches undergo dextrinisation, a process known as a certain degree of fragmentation during extrusion cooking, a decrease in high molecular weight material and a corresponding increase in lower molecular weight polysaccharide (Riaz, 2000; Singh, Gamlath, & Wakeling, 2007).

2.1.1.1. Starch Chemistry and Starch Gelatinisation

Starch is made of linear amylose and branched amylopectin composed of linear polymers of glucose sub-units and has the general chemical formula of $(C_6H_{10}O_5)_n$ with n the number of glucose monomers (Fennema, 1996). The structures of amylose and amylopectin are shown in Figure 2.1 a and b.

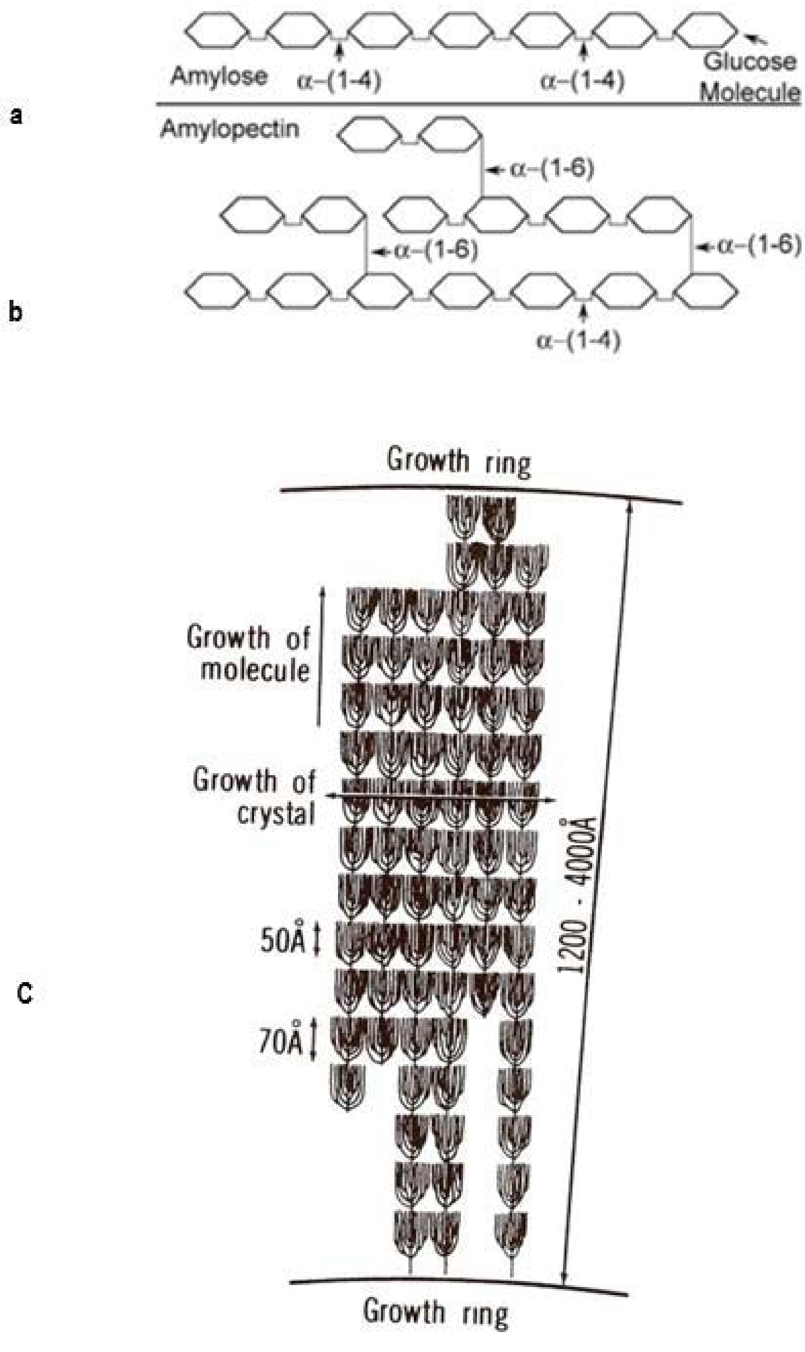


Figure 2.1: Structure of amylose (a), amylopectin (b) and amylopectin structure showing the clusters of chains (c), which form crystallites in the starch granule (Huang & Rooney, 2001; Thomas & Atwell, 1999)

Amylose is a polysaccharide of α-D-glucopyranosyl units linked by α(1→4) bonds. It has an average molecular weight of about 10^6 g/mol and typically constitutes 25 % of starch; whereas, amylopectin has 4 – 5 % α(1→6) linked branched points and may contain up to 2×10^6 glucose units with molecular weight of around 10^8 g/mol (Fennema, 1996). It typically constitutes 75 % of the starch present in most plant tissues. There are high amylopectin (waxy) and high amylose varieties (Dendy & Dobraszczyk, 2001). The most common waxy and high amylose varieties used are from corn. Amylopectin is responsible for the crystallite/micelles structure (organised areas as shown in Figure 2.1 c) of the starch granules and amylose is found in the amorphous regions of the starch granules (Huang & Rooney, 2001; Tester & Morrison, 1990a, 1990b; Thomas & Atwell, 1999). The interior of the starch granule is composed of alternating crystalline and amorphous regions (Abd El-Khalek & Janssens, 2010).

Gelatinisation is an important starch property, which can be defined as the heat and water required to cause the disruption of molecular order within starch granule (Fennema, 1996). Total gelatinisation usually occurs over a temperature range (Fennema, 1996). It has been shown that under no or low shear conditions, full gelatinization of starch requires a suspension of no more than 30 % starch in 70 % water (Wang, Chiang, Yeh, Zhao, & Kim, 1989). Gelatinisation can include irreversible granule swelling, loss of crystallinity, leaching of amylose and eventual total disruption of granules especially with the application of shear forces (Dendy & Dobraszczyk, 2001; Fennema, 1996; Huang & Rooney, 2001).

The viscometric behaviour of a suspension of starch granules in water as temperature increases is shown in Figure 2.2. Starches are not soluble when heated in the presence of excess cold water (Fennema, 1996). The viscosity of the starch slurry is very low before the temperature reaches the onset for gelatinisation (Li, 1998). At this point, the swelling of the starch granules is still reversible. When the temperature rises above the pasting temperature, the starch granules begin to swell, and the viscosity increases on shearing. The pasting temperature is the temperature at the onset of the rise in viscosity. The pasting temperature provides an indication of the minimum temperature required to cook a given sample. The viscosity of the paste increases largely as a result of the leaching of amylose from the amorphous region of the starch granules and flow resistance of the hydrated granules (Anonymous, 1997).

The peak viscosity occurs at the equilibrium point between swelling and polymer leaching; it indicates the water-binding capacity of the starch granules and is often correlated with final product quality (Anonymous, 1997). It had been reported to provide an indication of the viscous load likely to be encountered by a mixing cooker (Anonymous, 1997). Further heating leads to starch granules break down and disruption of the crystalline regions in the starch granules. When the number of granules destroyed exceeds the number of granules swelling, the viscosity of the paste decreases. The breakdown viscosity indicates the ability of a sample to withstand heating and shear stress (Anonymous, 1997).

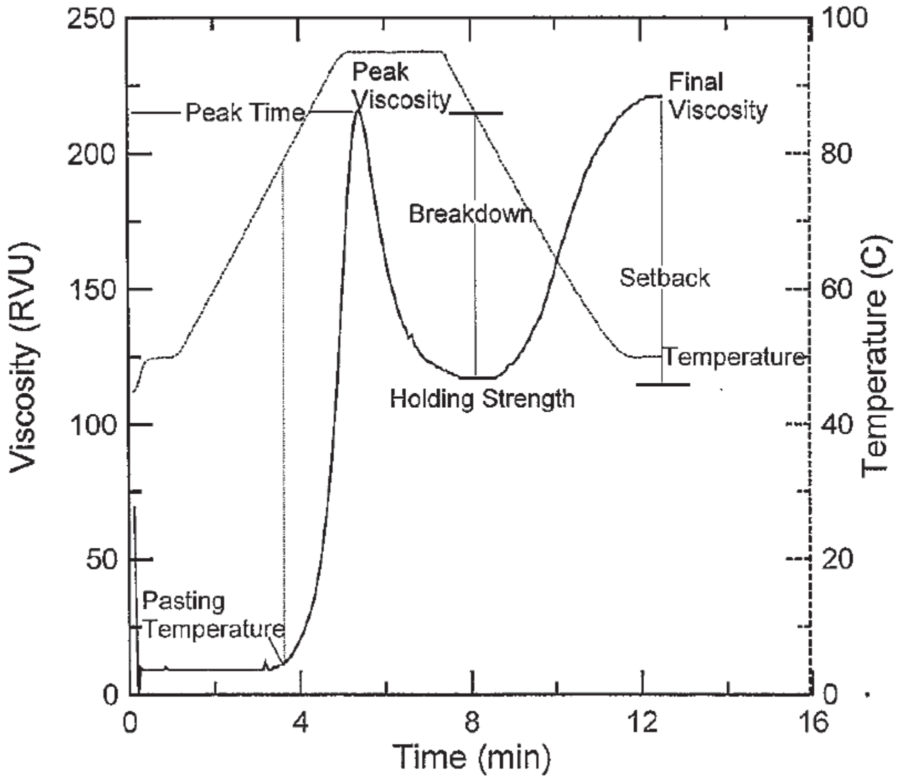


Figure 2.2: Typical rapid visco-analyser (RVA) pasting curve representation of starch gelatinisation in the presence of sufficient or excess water (Anonymous, 1997)

Retrogradation occurs when starch is cooked in water beyond its gelatinisation temperature and is then cooled to reach a final viscosity (Fennema, 1996). The starch starts aggregating and reorganising. Viscosity gradually increases again when the solution is cooled to form a gel. The strength of the gel is determined by the type and concentration of starch in the product. However, starch gels are unstable. When a starch gel is left to stand for some time, alignment of the molecules increases and water may be expelled from the gel matrix (Fennema, 1996). Final viscosity in the RVA is the most commonly used parameter to define a particular sample's quality, as it indicates the ability of the material to form a viscous paste after cooking and cooling (Anonymous, 1997). The setback of the sample is commonly measured as the difference between final viscosity and holding strength. It has been correlated with texture of various products (Anonymous, 1997).

The applications of different starch viscosity assessment methods are summarised in Figure 2.3. Rapid viscosity analysis measures the degree of starch transformation (paste viscosity) subject to high temperature at a controlled shear rate, the viscosity changes produced by heating and cooling of starches in water (Anonymous, 1997). The quality of extruded food products mainly relates to starch transformation, it may be used to assess raw material characteristics and to provide a 'fingerprint' for more consistent product/process control (Forte & Young, 2003).

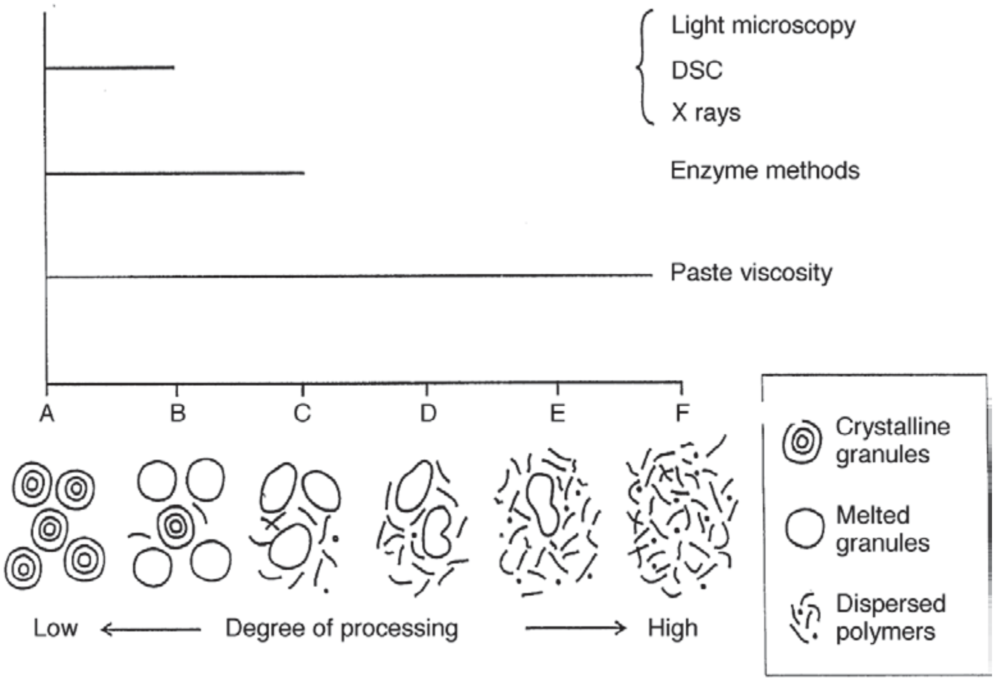


Figure 2.3: Physical forms of starch and methods of assessment (Guy, 2001)

The factors affecting RVA profiles are the physico-chemical characteristics of starch, such as the source of starch granule, particle size distribution and amylose/amylopectin ratio (Abd El-Khalek & Janssens, 2010; Chiotelli & Le Meste, 2002; Fennema, 1996; Hoseney, 1994; Lindeboom, Chang, & Tyler, 2004; Singh, Kaur, Sandhu, Kaur, & Nishinari, 2006). A brief functional comparison of amylose and amylopectin are summarised by Ingredion (Table 2.1).

Table 2.1: Functional comparison of amylose and amylopectin in extrusion application (Le, 2010)

Amylose	Amylopectin
Delayed Gelation	Shear Sensitive (break down more rapidly)
Low Water Holding	High Water holding
Retrogrades quickly	Retrogrades slowly
Firm Gelling	Softer Gelling

Starch with high amylose content are more resistant to gelatinisation during processing (Abd El-Khalek & Janssens, 2010; Lai & Kokini, 1990). Research found that starch that is high in amylose swells more slowly than the starch rich in amylopectin and swelling is a property of amylopectin (Abd El-Khalek & Janssens, 2010; Tester & Morrison, 1990a, 1990b). The swelling and gelatinisation of a starch granule are largely influenced by the nature of amylopectin crystallites. The amylose content acts both as a diluent and as an inhibitor of swelling, especially when it forms insoluble complexes during swelling and gelatinises with the presence of some lipids (Bultosa & Taylor, 2003; Tester & Morrison, 1990a, 1990b).

Starch gelatinisation is also heavily influenced by energy input (Forte & Young, 2003). High-shear and high-pressure extrusion changes the crystalline structure of the starch and gelatinisation will not occur in the way described above (Thomas, Huijnen, Vliet, Zuilichem, & Poel, 1999). Starch gelatinisation under extrusion conditions requires less water, the starch granules swell and the crystalline region melts and becomes an amorphous plastic at the same time (Forte & Young, 2003). Starch granules are then ruptured by the mechanical shear and thermal energies during extrusion, and change to more water soluble forms at 51 to 78 º C (Hertzel & Plattner, 2005; Xue, Yu, Xie, Chen, & Li, 2008). Ruptured starch granules are aligned and dextrinised to form an entangled polymer network (Forte & Young, 2003). As the hot melt cools, it passes through the glass transition and set to a hard glassy state (Forte & Young, 2003; Xue et al., 2008).

2.1.1.2. Sources of starches and their characteristics

Commercial starches are obtained from cereal grain seeds (corn, wheat and rice), and from tubers and roots (potato, sweet potato, tapioca or cassava) (Fennema, 1996). The starch granule size and gelatinisation temperature range of common starches are summarised in Table 2.2.

Large starch granules are generally less dense and easier to gelatinise than small granules (Fennema, 1996). This is because gelatinisation is an endothermic transition, and large starch granules have a slightly higher gelatinisation enthalpy than that of small granules (Chiotelli & Le Meste, 2002; Myllärinen, Autio, Schulman, & Poutanen, 1998).

Common tuber sources are potato and tapioca. Tuber starches have amylose chains that are five times longer than the average chain length found in cereal grains. These longer chains associate with their neighbouring chains and exhibit film-forming properties. Their intermolecular bonding is weak and the highly swollen granules break easily with only moderate shear (Fennema, 1996). Tuber starches expand easily and much more than the cereal source starches. This is particularly true for potato starch due to the presence of the phosphate ester group on amylopectin molecules (Fennema, 1996). A slight negative charge from the phosphate ester group contributes to several key properties of potato starch (Fennema, 1996). A formulation containing native potato starch has characteristics of low gelatinisation temperatures, high viscosity during gelatinisation, high water absorption and low rate of retrogradation (Hertzel & Plattner, 2005; Sunderland, 1996).

Table 2.2: Starch granule size and gelatinisation temperature for a range of starches from common cereal grain, ancient grains and tuber

Category	Starch Source	Starch Granule Size[1]	Pasting Temperature Range (˚C)	Reference
Common Cereal Starches	Wheat	Bimodal (> 25 μm and 5 – 10 μm)	51.5 - 64.0	(Hoseney, 1994; Hsieh, Grenus, Hu, & Huff, 1993; Lindeboom et al., 2004; Tan, Torley, & Halley, 2008; Zhou, Robards, Helliwell, & Blanchard, 2002)
	Corn	Medium (10 – 25 μm)	57.6 - 72.0	
	Rice	Small (2 – 10 μm)	68.0 - 86.0	
Common Ancient Grain Starches	Amaranth	Very small (< 5 μm)	66.1 - 87.2	(Belton & Taylor, 2002; Fujita, Sugimoto, Yamashita, & Fuwa, 1996; Ie et al., 2012; Lindeboom et al., 2004; Qian & Kuhn, 1999)
	Quinoa	Very small (< 5 μm)	59.5 - 71.5	
	Millet	Small (5 – 10 μm)	66.2 - 91	
	Sorghum	Medium (10 – 25 μm)	67.4 - 91.3	
	Spelt	Bimodal (10 – 25 μm and 5 – 10 μm)	56.7 - 68.8	
Common Tuber Starches	Potato	Large (> 25 μm)	50 - 60	(Dendy & Dobraszczyk, 2001; Forte & Young, 2003)
	Tapioca	Medium (10 – 25 μm)	67 - 78	

Most common ancient grains have a lower percentage of amylose compared to common cereal grains as shown in Table 2.3. However, the starch granule sizes are generally small, which makes ancient grain starches slightly harder to gelatinise than those of the most common cereal grains.

Table 2.3: Amylose content of some ancient grains

Starch Source	***Percentage of Amylose Starch (%)***	***Reference***
Amaranth	7.8 ± 0.11	(Qian & Kuhn, 1999)
Quinoa	12.2 ± 0.28	(Qian & Kuhn, 1999)
Teff	24.9~ 31.7	(Bultosa et al., 2002)
Millet	21.3	(Gaffa, Yoshimoto, Hanashiro, Honda, Kawasaki, & Takeda, 2004)
Sorghum	20.1~20.4	(Gaffa et al., 2004)

2.1.2. Fibre

Food Standards Australia New Zealand (FSANZ) defines Dietary Fibre in Standard 1.2.8 of the ANZ Food Standards Code as follows:

> "Dietary fibre means that fraction of the edible part of plants or their extracts, or synthetic analogues that are resistant to the digestion and absorption in the small intestine, usually with complete or partial fermentation in the large intestine."

2.1.2.1. Sources of Dietary Fibre and Their Functionality

Dietary fibres can be categorised into water soluble and water insoluble fibres (Raninen, Lappi, Mykkänen, & Poutanen, 2011). Water insoluble fibres include cellulose, hemicellulose, lignin and majority of the resistant starches; water soluble fibres include polydextrose, resistant oligosaccharides (inulin, fructo-oligosaccharide (FOS), galacto-oligosaccharides (GOS)), pectins, hydrocolloids (beta-glucan, mucilages and gums) and a few resistant starches. It is well established that the consumption of adequate amount of dietary fibre can promote good digestive health (FDA, 1997; Giacosa & Rondanelli, 2010).

Insoluble fibres are typically linked to laxative properties. Soluble fibres, such as beta-glucan and psyllium (66 % soluble fibre) have earned a healthy reputation for their ability to lower blood lipid levels (Abumweis, Jew, & Ames, 2010; FDA, 1997; Giacosa & Rondanelli, 2010). A recently study shows that the addition of soluble fibre dextrins to food reduce short term energy intake, and may have implications in helping consumers control their appetite and energy intake (Monsivais, Carter, Christiansen, Perrigue, & Drewnowski, 2010). Resistant dextrins have also been shown to reduce the glycaemic and insulin responses (Kendall, Esfahani, Hoffman, Evans, Sanders, Josse, Vidgen, & Potter, 2008; Kishimoto, Oga, Tagami, Okuma, & Gordon, 2007). One of the most studied and commonly used soluble fibres is inulin. Other than being a prebiotic fibre, a study found that regular consumption of inulin could increase calcium absorption (Abrams, Hawthorone, Aliu, Hicks, Chen, & Griffin, 2007).

Resistant starch (RS) refers to the portion of starch and starch products that cannot be broken down by the digestive enzymes to D-glucose (resist digestion) in the small intestine (Fuentes-Zaragoza, Riquelme-Navarrete, Sánchez-Zapata, & Pérez-Álvarez, 2010). Starch becomes resistant to digestion due to several reasons. It may be physically inaccessible, retrograded or chemically modified (Sharma & Yadav, 2008).

Resistant starches have been categorized into four types, which are mostly defined according to their physical and chemical characteristics (Fuentes-Zaragoza et al., 2010; Nugent, 2005; Sharma & Yadav, 2008):

RS1 represents the starch granules that are physically inaccessible or digestible, as these are found enclosed in the intact cell walls, such as that found in seeds or legumes and unprocessed whole grains. RS1 is heat stable in most normal cooking operations;

RS2 represents raw, un-gelatinised native starch, such as uncooked potato, green banana flour and high amylose corn;

RS3 represents retrograded starch that is formed when starch-containing foods are cooked and cooled such as in bread, cornflakes and cooked-and-chilled potatoes or retrograded high amylose corn;

RS4 is chemically modified form that cannot be broken down due to cross bonding with chemical reagents. This type of resistant starches can have a wide variety of structures and cannot be found in nature.

Resistant starch is considered as a type of dietary fibre (Fuentes-Zaragoza et al., 2010; Nugent, 2005; Sharma & Yadav, 2008). In comparison with traditional fibres, such as bran, resistant starch possesses the advantage of affecting the sensory properties of the final products less and gives better product texture, which is very positive for consumer acceptability (Charalampopoulos, Wang, Pandiella, & Webb, 2002). RS2 also found to provide many technological properties, such as increased expansion and enhanced product crispiness (Brennan, 2008; Fuentes-Zaragoza et al., 2010).

Fibre is used as a dispersed-phase filling material (bulking agent) to provide nutritional attributes and as a nucleating substance to modify the texture of the 3G snacks (Frame, 1994; Pai, Blake, Hamaker, & Campanella, 2009; Van der Sman & Broeze, 2013). The presence of the dispersed-phase materials, especially insoluble fibres, affects the physical properties of the extrudate in two ways (Huber, 2001). Firstly, their physical presence in the cell walls of extrusion expanded foam will reduce the potential for product expansion by disrupting the cell walls when their structures penetrate the walls of the starch film (Huber, 2001). Secondly, they decrease the elasticity of the continuous phase had hence affect the final swelling of an extruded product exiting the final die (Huber, 2001).

Dietary fibre can also impact some functional properties to foods, such as increasing water and oil holding capacity, or gel formation. Product textural properties may also be modified (Elleuch, Bedigian, Roiseux, Besbes, Blecker, & Attia, 2011). Fibres have been used to fine-tune the puffing characteristics of the pellet to manipulate bite, texture and mouth feel (Hertzel & Plattner, 2005). Studies on direct expanded rice/corn extrudates suggested that at lower additions (<12 %), the extruded product expansion increased; at higher levels, the expansion decreased (Grenus, Hsieh, & Huff, 1993; Onwulata, Konstance, Smith, & Holsinger, 2001). However, Hertzel & Plattner

(2005) suggested that the amount of fibre usage should be limited in the 3G snack formulation and it is recommended to add 1 – 5 %.

It was noted that after direct extrusion with high amylose corn, a decrease was observed in the content of total dietary fibre and of the insoluble fraction, with simultaneous increase in the content of the soluble fraction by 40 %, compared to the expected values resulting from the raw material composition (Gibbs, 2003; Zarzycki & Rzedzicki, 2009).

2.1.2.2. Dietary Fibre Fortification Guideline and Methods for Testing

The recommended average dietary fibre intake for Australia and New Zealand male is 30 g per day and female is 25 g per day as published by Australian National Health and Medical Research Council (NHMRC) and New Zealand Ministry of Health (MOH) in 2006. The Australia New Zealand Food Standard Code Standard 1.2.7 Nutrition, Health and related claims requires that the food must contain at least two grams of fibre per serve before making any dietary fibre content claims.

Figure 2.4 shows that a variety of analytical methods used to quantify and characterise different fibre components. The Association of Official Analytical Chemists AOAC Official Method 985.29 or 991.43 for analysing total dietary fibre, does not cover specific types of fibres such as polydextrose, non-digestible oligosaccharides and some of the resistant starches (McCleary, 2008).

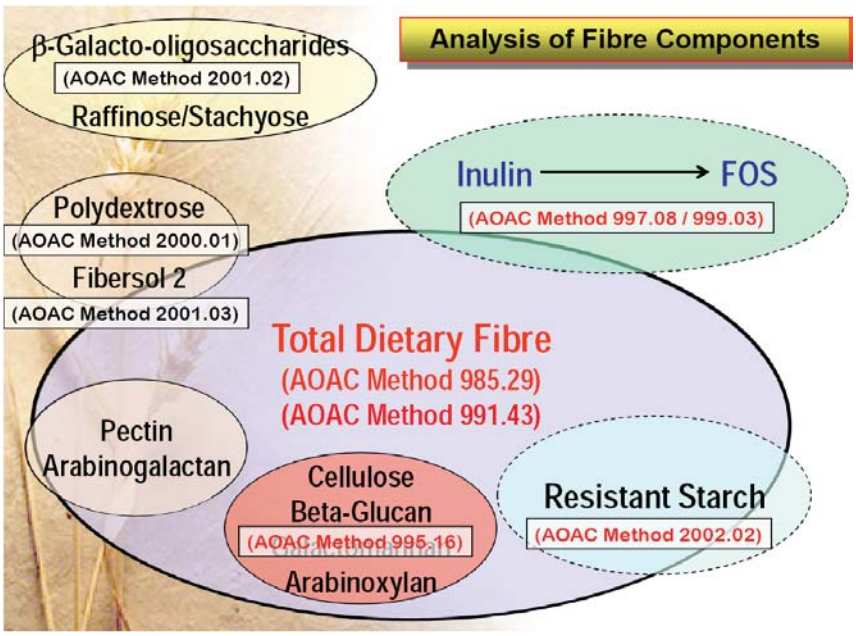


Figure 2.4: Analysis of fibre components (McCleary, 2008)

2.1.3. Protein

Proteins are made up from 20 amino acids and the general chemical structure can be written as $RCH(NH_2)COOH$ (Fennema, 1996). Amino acids are covalently bonded and the sequential position of the chemically distinct side chains determine the chemical properties of the protein (Fennema, 1996).

Native proteins can be either globular or fibrous and in native state are retained in the granule (Forte & Young, 2003). Globular proteins will be hydrated with addition of water and heat (Forte & Young, 2003). With shear, heat (60 ºC to 70 ºC) and pressure from extrusion, proteins become denatured and change from soluble to insoluble forms (Forte & Young, 2003). Denaturation is the transformation of well-defined, folded structure of protein, to an unfolded state under non-physiological conditions (Fennema, 1996). Amino groups of the destroyed proteins begin to align themselves with the direction of extruder follow and begin to texturize (form cross-links) (Forte & Young, 2003).

Protein nutritional quality is determined by the proportions of essential amino acids (Fennema, 1996; Shewry, 2007). Essential amino acid refers to an amino acid that is required to meet physiological needs of human beings and must be supplied in the diet (Fennema, 1996). Vegetable protein sources, such as cereals and legumes are usually lacking in one or more of the essential amino acids. However, of all the proteins sources, cereal proteins are the cheapest and most important for 3G snacks (Guy, 2001). The amino acid compositions of a range of major cereals, ancient grains and human growth requirements suggested by the United Nations Food and Agriculture Organisation (FAO) are summarised in Table 2.5.

Table 2.5 shows that lysine is deficient in all major cereals. The amounts of lysine in oats and rice are much higher than that in wheat and maize. The nutritional quality of a protein that is deficient in an essential amino acid can be improved by mixing it with another protein that is rich in the deficient essential amino acid. This is how ancient grains, such as amaranth and quinoa came into the picture. Table 2.5 shows that the proteins from amaranth and quinoa are richer in lysine. Proteins from white millets and sorghum contain significant amounts of essential amino acids particularly the leucine. If these ancient grains are to be mixed with other major cereal proteins, the final product will provide a more complete and balanced essential amino acids.

Table 2.4: Comparison the contents of essential amino acid profile of major cereals and ancient grains with FAO requirements for human (Ahamed, Singhal, Kulkarni, & Pal, 1998; Amadou, Gounga, & Guo-Wei, 2013; FAO/WHO/UNU, 2002; Kulp & Ponte, 2000; Mosse, Huet, & Baudet, 1988; Písaříková, Kráčmar, & Herzig, 2005; Shewry, 2007)

Essential Amino Acids	Wheat Flour (g/100g protein)	Rice Milled (g/100g protein)	Maize Flour (g/100g protein)	Oat Groat (g/100g protein)	Barley Grain (g/100g protein)	Amaranth (g/100g protein)	Quinoa (g/100g protein)	White Millet (g/100g protein)	Sorghum (g/100g protein)	FAO Recommendations (g/100g protein)	
										Children (age 3-10)	Adults
His	2.2	2.4	2.7	2.2	2.3	1.9	-	2.1	2.3	1.6	1.5
Ile	3.6	3.8	3.6	3.9	3.7	3.6	3.8-4.2	4.1	4.1	3.1	3.0
Leu	6.7	8.2	12.5	7.4	7.0	6.4	-	12.2	14.2	6.1	5.9
Lys	2.2	3.7	2.7	4.2	3.5	7.5	5.4-6.3	1.5	2.1	4.8	4.5
Met	1.3	2.1	1.9	2.5	1.7	2.1	0.3-2.6	2.2	1.0	2.4	1.6
Cys	2.5	1.6	1.6	1.6	2.3	3.3	0.6-1.4	1.7	NA		0.6
Phe	4.8	4.8	5.0	5.3	5.2	6.0	6.2-8.9	5.5	5.1	4.1	3.8
Tyr	1.5	2.5	3.8	3.1	2.9			4.0	NA		
Thr	2.6	3.4	3.7	3.3	3.6	4.7	3.6-4.4	3.0	3.3	2.5	2.3
Trp	1.1	1.3	0.6	ND	1.9	-	0.8-1.1	0.8	1.0	0.66	0.6
Val	4.1	5.8	4.8	5.3	4.9	4.9	4.7-4.8	5.4	5.4	4.0	3.9

Product expansion can be influenced to a greater extent by the presence of protein. Studies found that the addition of proteins, depends on their type and concentration, can increase or reduce finished product expansion (Allen, Carpenter, & Walsh, 2007; Onwulata, Konstance, Smith, & Holsinger, 1998). Addition of protein at lower levels, similar to the functions of fibre, may also act as a dispersed-phase filling materials (bulking agent) to provide nutritional attributes and to modify the texture of the expanded products by reducing shrinkage of the starch, subsequently helped in increasing expansion ratio (Alavi, Gogoi, Khan, Bowman, & Rizvi, 1999). When the protein was added at higher levels, it enhanced the protein-protein interactions, the protein fractions reinforce the product cell wall and increase breaking strength, hence reduced the product expansion (Singh, Nielsen, Chambers, Martinez-Serna, & Villota, 1991).

2.1.4. Sugar and salt

Sugar usually refers to sucrose, which primarily comes from sugar cane and sugar beets (Fennema, 1996). Salt is composed primarily sodium chloride. It is generally a fine white crystalline solid and is normally obtained from sea water or rock deposits (Fennema, 1996). Both sugar and salt are highly soluble in water. During manufacturing of snacks, sugar and salt are often added to enhance flavours, they are also very useful in stabilisation and water activity control.

The effect of sugar and salt is dependent on concentration and their chemical interaction with starch and protein polymers (Guy, 2001). The level of addition of salt is limited by the product taste and that of sugar is limited by the capability of maintaining a stable process (Hsieh et al., 1993). It was recommended that salt is usually extruded at 1 % or less and sugars are extruded at 5 % or less (Hsieh et al., 1993). However, Hertzel & Plattner (2005) suggested that the addition of sugar to a 3G snack recipe is normally limited to 1 to 2 % for slight colour and flavour enhancement; usage levels more than 7 % for providing sweetness can inhibit expansion.

Sugars react with amino acids in Maillard browning reactions (Fennema, 1996). These reactions play an important role in colour control in 3G snack processing. Sugar also helps in the finished product texture development through plasticisation of the extrudate structure (Barrett, Kaletunç, Rosenburg, & Breslauer, 1995). At very high concentration (>10 %), sugars tend to bind water needed for starch gelatinisation, the time and temperature required to gelatinise starch during extrusion is increased (Barrett et al., 1995). The addition of sucrose alters the extrudate properties due to interactions between sucrose and cereal flour components at certain extrusion conditions as shown in Figure 2.5 (Barrett et al., 1995).

Other studies on twin-screw extrusion with rice flour or corn flour show similar results. As the concentration of sugar increases, specific mechanical energy (SME), die pressure and melt temperature were reduced, resulting in a decrease of expansion and an increase in product density (Barrett et al., 1995; Jin, Hsieh, & Huff, 1994).

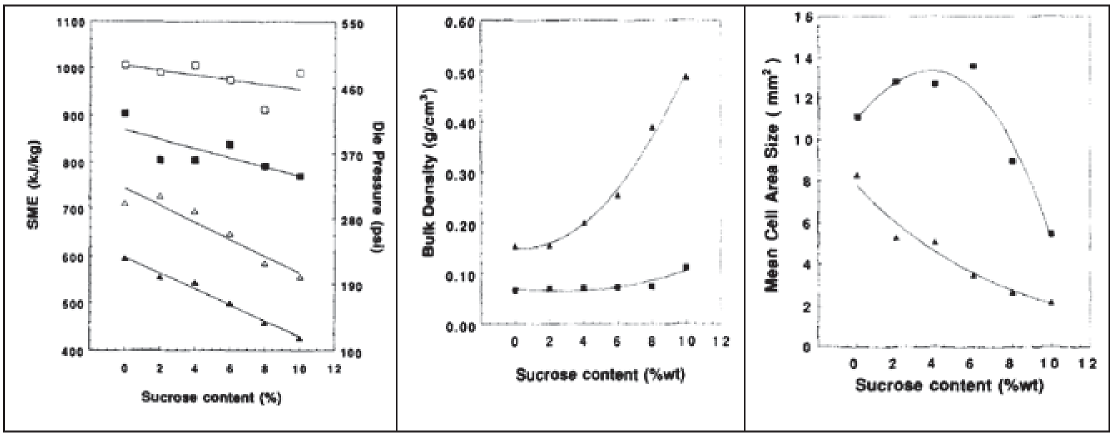


Figure 2.5: Effect of sucrose content on SME(∆ □), die pressure (▲■), corn extrudate bulk density and mean cell area (■ 15 %, ▲ 20 % extrusion moisture) (Barrett et al., 1995)

Salt alters extrudate properties and affects extruded product expansion in an opposite way to sugar (Chinnaswamy, 1993; Hsieh et al., 1993; Jin et al., 1994; Norton, Greenwood, Noble, & Cox, 2011). Addition of salts significantly increased peak, breakdown, and final viscosities, and pasting temperature of rice starch and xanthan gum blends (Samutsri & Suphantharika, 2012). A significant increase of extrudate specific volume was observed when the salt content was increased from 0 to 3 % (Hsieh et al., 1993). Jin et al. (1994) also found that enhanced lightness of the corn extrudates with addition of salt from 0 to 2 %. Chinnaswamy (1993) studied the effects of sodium chloride, sodium bicarbonate, and urea on the corn extrudate expansion. One gram of each of sodium chloride, sodium bicarbonate and urea were mixed with 100 g of various corn starches before extrusion cooking. The expansion ratio in relation to amylose contents of starches is presented in Figure 2.6.

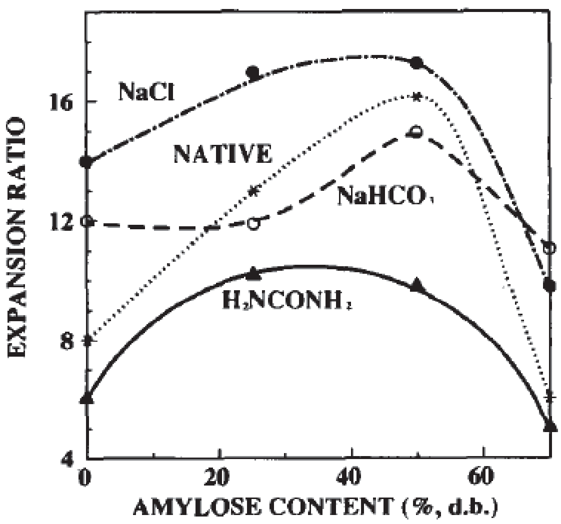


Figure 2.6: Effect chemical additives on the expansion radio of native corn starches with different amylose contents (Chinnaswamy, 1993)

It was clear from Figure 2.6 that with added sodium chloride higher expansion ratios were achieved compared to addition of the other chemicals. The study showed that sodium chloride increased the expansion ratio by 0.5 to 5.5 depending on the type of corn starch (Chinnaswamy, 1993). Norton et. al. (2011) studied the effect of salt on hot air expansion of potato starch pellets. They also found that the addition of sodium chloride or potassium chloride improved pellet expansion. The authors explained the increase in expansion was due to an interaction of the cation with starch. Sodium chloride reduced the glass transition temperature of gelatinised starch, and therefore, ease the pores to expand. Salt was also found to be useful in assisting equilibration of moisture in snack pellets (Hertzel & Plattner, 2005).

2.1.5. Lipids

Lipids are made up of fatty acids attached to glycerol esters (Fennema, 1996). Lipids may be used as lubricants at a level up to 2 % in the extrusion formulation (Frame, 1994) Lipids undergo complex chemical changes and react with other food constituents during the extrusion process (Fennema, 1996). These materials lubricate the particles in the dough, the surfaces of the screws and barrels, and reduce particle to screw frictional forces (Huber, 2001). Addition of lipid reduces degradation of the starch polymer and prevents water from being absorbed by starch (Moraru & Kokini, 2003). At lower levels, lipids improve energy efficiency of extrusion with little or no impact on product expansion. At higher levels, the expansion of the extrudates was compromised to a greater extent due to a reduction in the pressure drop at the die, for example, a 2 % increase in melt fat content leads to a 51 % decrease in die pressure, if all other process parameters are constant. High lipid content also leads to collapse of the excessively softened matrix. (Forte & Young, 2003; Moraru & Kokini, 2003).

2.2. EXTRUSION PROCESSING FOR 3G SNACKS

Extrusion is a continuous process that forces raw material through a restricted opening by using pressure to form a desired product shape and format (Singh, 2009b). It operates in dynamic steady state equilibrium, where the input variables and the outputs are balanced (Guy, 2001). It may include a series of unit operations: conveying, mixing, kneading, shearing, heating, cooling, shaping, forming, partial drying or puffing (Ainsworth, 2012; Singh, 2009b). A major difference between extrusion and other forms of food processing is that gelatinisation occurs at low moisture levels (12 – 22 %) (Riaz, 2000).

Third generation (3G) snacks or half products are extrusion cooked, and formed at low pressure to prevent expansion, and then dried to a final moisture content of about 8 – 12 % to form a glassy dense pellet that is suitable for transporting and storage (Hertzel & Plattner, 2005; Riaz, 2006). Later, the half product is heated rapidly in hot oil or air to achieve expansion. The extrusion system could be composed of a cooking extruder (single or twin) followed by a single screw forming extruder or an intermeshing co-rotating twin screw extruder configured for both cooking and forming (Huber, 2001).

2.2.1. Extruder terminology

The follow defines some commonly used terms in the extrusion process (Bouvier, 2001; Riaz, 2000). Some terminology is illustrated in Figure 2.7:

Flight (Figure 2.7)**:** the helical conveying surface of the screw that pushes the product forward.
Pitch (Figure 2.7)**:** the angle of the flight, relative to the axis of the root.
Root (Figure 2.7)**:** the solid or shaft part of the screw, around which the flight is wound.
Worm: a hollow-core, segmented screw element that slips over the shaft in modular screw;
Shearlock/Steamlock: a ring-like device that locks together individual worm sections on a modular screw. The function of shearlocks is to hold up the flow of the product and to lock steam in certain extruder heads.
Barrel (Figure 2.7): a pipe-like retainer in which the extruder screw turns.
L/D (Length–to–Diameter) **ratio**: distance from the internal rear edge to the discharge end of the barrel, divided by the diameter of the bore; The extruder is characterised primarily by its L/D ratio In the direct expanded extrusion-cooking process, the L/D ratio ranges between 9 and 15; while in the pellet-to-flaking extrusion-cooking process, it ranges between 20 and 30 to allow cooling and prevent expansion of the pellet.
Die plate: final assembly for shaping the product as it leaves the extruder.
Pellet: discrete particle which is shaped and cut by an extruder, regardless of shape.

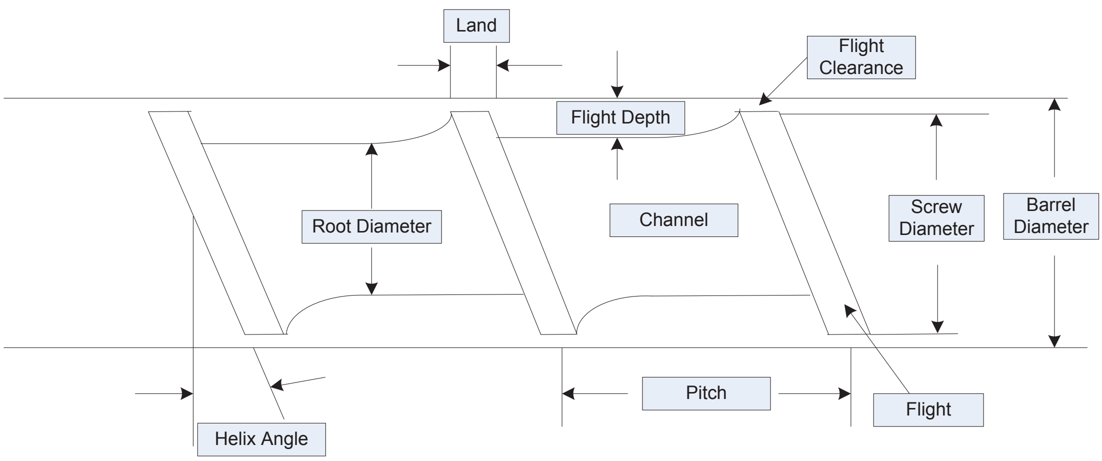


Figure 2.7: Section of an extruder screw (Forte & Young, 2003)

Special mechanical energy (**SME**) consumption is another important extruder terminology to understand, as it provides a good characterisation of the extrusion process (Godavarti & Karwe, 1997). SME is defined as the amount of mechanical energy used during processing per unit mass of the material. SME can be calculated using the Equation 2.1 (Frame, 1994):

$$SME\ (\mathrm{kWh/h}) = \frac{\mathrm{P\ (kW)}}{\mathrm{Q\ (kg/h)}} \qquad \text{(Eq. 2.1)}$$

Where *P*= Mechanical energy from the extruder motor (kW)

Q = throughput (kg/h)

2.2.2. Extruder components, types of extruders and their applications

A typical extruder consists of a feed hopper, an extruder barrel with helical screws inside, a die at the end of the barrel and cutting knife/knives (Figure 2.8). The feed hopper is designed to hold raw materials and continuously feed this material into the extruder barrel. A pre-conditioner may be used to obtain a higher moisture feed and longer retention time. The barrel of extruder is made up of screws, heads, and shearlocks (Riaz 2000). The extruder barrel generally can be categorised into three sections based on the movement and transformation of material. The zones are feeding, kneading and cooking zones (Riaz 2000).

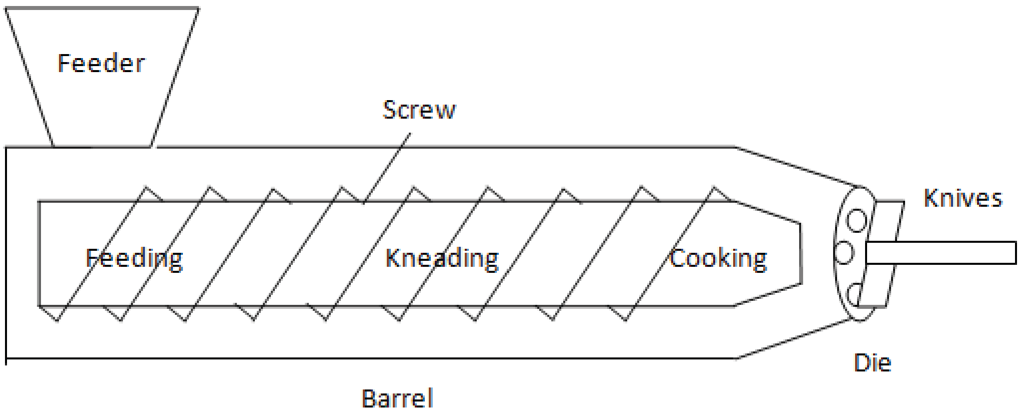


Figure 2.8: Schematic diagram of extruder basic components (Guy, 2001)

An extruder may be classified according to the number of screws in the barrel – single-screw and twin-screw extruders. The single-screw extruders are often short barrel and they are operated at high shear (Ainsworth, 2012). The single-screw barrel is mainly used for directly expanded products (Riaz, 2000). The ingredients used are usually low in moisture to ensure a good expansion (Burtea, 2001). Currently, single-screw extruder is dominantly used in the pet and fish food production, which account for the largest annual tonnage of extruded cooked product in the world (Riaz, 2000). Single-screw extruders also have widely been used in textured vegetable protein, breakfast and snack production (Huber, 2001; Riaz, 2000).

Twin-screw extruders generally have a greater operation range, are more process stable and give an uniform product (Riaz, 2000). It may be considered as a positive displacement device, as the channel of one screw is blocked by the flight of the other screw resulting in C-shaped chambers and materials are transferred from the chambers toward the die with the rotation of the screws (Frame, 1994). The movement of the material is dependent upon the screw geometry and independent of the operating conditions. Therefore, they not only can do everything that a single-screw extruder can, but also can handle high fat, high moisture raw materials (Moscicki, 2011). The major drawbacks for this type of extruders are higher capital investment, higher maintenance cost and operation cost than that of single-screw extruders (Huber, 2001; Riaz, 2000). Twin screw extruder can be further classified as counter- or co-rotating, and intermeshing or non-intermeshing. The co-rotating intermeshing twin-screw extruder is the most widely used twin-screw extruder for producing a range of food products (Riaz, 2000). Twin-screw extruders have been widely used in confectionary, particularly in 3G snack manufacture. The different types of twin-screw extruder characteristic and their main applications are illustrated in Figure 2.9.

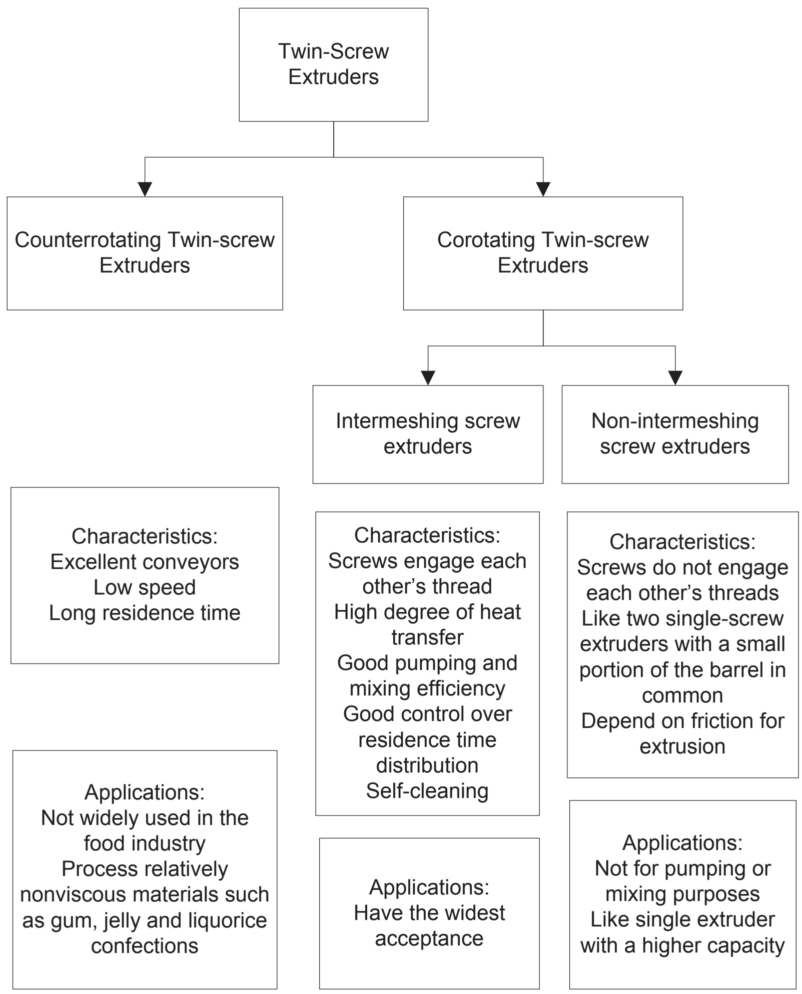


Figure 2.9: The classifications, characteristics and applications of twin-screw extruders (Riaz, 2000)

2.2.3. Pellet manufacturing process

There are three ways to manufacture the snack pellet (Guy, 2001; Van Laarhoven & Staal, 1991). The first and simplest method is to use pre-gelatinised materials mixed with water to develop a dough, which is then shaped into pieces and dried to a glassy state to form the half-product. Many of these products were based on potato derivatives. The second process method is a two-stage extrusion process. In the first extruder the conditions are set to melt the crystalline structures in the starch granules with minimum shear. The temperature may be raised to 100°C to 120°C, or even higher with barrel heating to reduce the fluid viscosity and minimise the SME input. The hot melt fluid will expand at the die, flash-off some water and cool rapidly to 80-90°C. It then enters the feed port of the forming extruder and is compressed back into a dense fluid. The third possible process method is to use a single-stage extruder with a long barrel, typically 25-30 L/D, with a cooking zone for the melting process followed by a cooling section downstream. Intermeshing co-rotating extruders are particularly suited to applications (Hertzel & Plattner, 2005). The starch must be melted in the first section and then the whole fluid cooled to less than 100°C before it is extruded. While both two-stage and one-stage systems have been used, Hertzel & Plattner (2005) recommended the latter for process and product flexibility and control. Figure 2.10 shows an example of process flow chart for manufacturing 3G snack by using a twin screw extruder in a single-stage extrusion process.

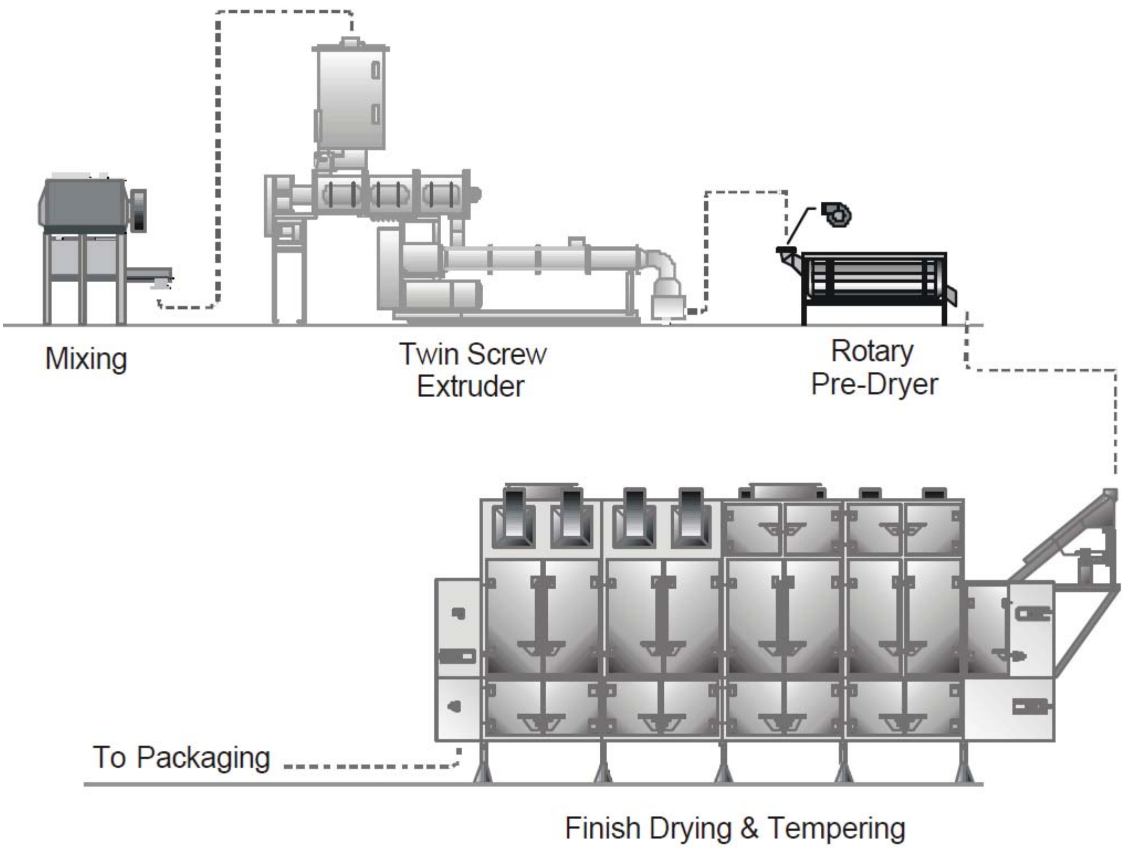


Figure 2.10: Example of 3G process flow chart (Hertzel & Plattner, 2005)

This process shown in Figure 2.10 requires relatively low shear extrusion cooking. The desired temperature can be reached through internal heating and barrel heating. It is important that pellets are free from any air cells. These would give distortion in the snack during expansion by forming large cavities (Huber, 2001). However, Guy (2001) believes a two-stage extrusion process is better for producing 3G pellets, as it is easier to control the cooking and cooling processes separately when they are not linked together, and greater throughput on the unit can be achieved.

2.2.4. The importance of extrusion configuration

The extruder and die configurations are independent variables, which can directly be controlled by an extruder operator and have a great impact on the final product characteristics (Riaz, 2000). Choosing a proper extruder configuration can improve the chances of having a successful operation (Frame, 1994; Riaz, 2000).

The selection of a proper extruder configuration includes considering screw profile, die and knife configurations (Riaz, 2000). The extruder screw configuration and die designs are the most important. Details of die design will be discussed in section 2.3.3. The design of screw profile consists of pitch length, flight depth, root diameter, number of flights and shear lock design (Frame, 1994; Riaz, 2000).

The screw profile affects the degree of compression and shear force within the extruder. The higher shear enhances internal mixing, mechanical energy dissipation and therefore increases the temperature in the barrel, ultimately increasing the degree of cooking and influencing the physical properties of the extruded products (Brennan, 2008; Gibbs, 2003).

In general, there are two types of screws, forward and reverse screws. The configuration of these screws alters the pressure profile within the barrel (Ainsworth, 2012). The forward-conveying screws push the material toward the die, increasing the pressure in the barrel; whereas reverse-conveying screws reduce the pressure by delaying the passage of material through the extruder, increasing the barrel fill prior to the die, allowing additional processing and increase heat transfer efficiency through the barrel wall (Ainsworth, 2012).

The geometry of the screws contributes to the product flow rate and pressure increase within the barrel (Riaz, 2000). For instance, the amount of shear increases with shallow flights (Gibbs, 2003). The screws may have various pitches to increase residence time within the extruder without changing the free volume of the screw (Huber, 1990). Where kneading and cooking are required, the screws may have one or multiple flights, and some screws may be cut flights or have interrupted flights in order to add turbulence, increase backflow, or increase mechanical energy dissipation into the extrudate (Huber, 1990). Therefore, reduce conveying efficiency and add residence time to the extrudate.

The flight and pitch of the screws generally are increased at the feeding zone of the extruder for efficient conveying of the raw materials, they are decreased along the length of the shaft to increase the compression on the raw materials and therefore generate heat and pressure for cooking (Riaz, 2000). As the material moves towards the die, there is usually an increase in pressure and temperature. The configuration of the final screw needs to provide an uniform pressure distribution around the screw periphery, and prevent any pulsations which may be present in the final section of the extruder (Huber, 1990). For 3G snack pellet processing, the final screw is normally a forward conveying screw with slightly increased flight and pitch to reduce the pressure increase (Forte & Young, 2003).

2.2.5. Key extrusion process variables

Control of the extrusion process variables is crucial to the success of manufacturing any final product (Ding, Ainsworth, Plunkett, Tucker, & Marson, 2006; Gutkoski & El-Dash, 1999; Ilo et al., 1996; Moraru & Kokini, 2003; Raphaelides, Arsenoudi, Exarhopoulos, & Xu, 2010; Ryu & Ng, 2001). There are independent variables and dependent variables. Independent variables can be controlled directly, while dependent variables are simply a result of what is controlled (Riaz, 2000). A summary of the independent variables and dependent process variables are shown in Table 2.5.

Table 2.5: Classification of extrusion processing variables (Chessari & Sellahewa, 2001; Moraru & Kokini, 2003; Riaz, 2000)

Independent Variables	*Dependent Variables*
L/D Ratio	Residence Time
Feed Rate	Moisture in the Extruder
Water/steam Injected to the process	Preconditioner Temperature
Preconditioner Shaft Speed	Barrel and Die Temperature
Screw Speed	Die Pressure
Extruder Barrel Heating	Torque and SME
	Degree of Barrel Fill

Screw speed was found positively correlated to extrudate expansion due to the increase in shear (Lai & Kokini, 1992). Moisture is strongly correlated to product melting temperature (Guy, 2001). As moisture is increased within limits, the mechanical energy required for processing decreases (Frame, 1994). Even a small fluctuation in water rate could have a significant impact on product quality (Chessari & Sellahewa, 2001). For example, water injection rate (0.41-0.86 kg/h) and barrel temperature were found significantly affected the cross-sectional expansion index and finished product breaking strength in bending (Ryu & Ng, 2001). The research showed that the cross-sectional expansion index (SEI) of wheat flour and cornmeal directly expanded extrudates was increased and the breaking strength in bending dropped with a decrease in water injection rate and/or an increase in barrel temperature.

Moraru & Kokini (2003) suggested that the SME input is a good quantitative descriptor in extrusion process, as it allows the direct comparison of different combinations of extrusion conditions such as screw speed, barrel temperature, feeding rate and torque. SME determines the extend of molecular breakdown and interactions, such as starch conversion that take place (Godavarti & Karwe, 1997; Moraru & Kokini, 2003). SME increases with increasing viscosity, increasing screw speed and decreasing mass flow rate (Godavarti & Karwe, 1997)

Barrel and die temperature determine the amount of heat transfer in the extruder, it impacts on the degree of starch gelatinisation, physical, chemical, nutritional and microbiological changes in the extrudates (Brennan, Derbyshire, Tiwari, & Brennan, 2013; Ryu & Ng, 2001). High die pressure results in the increased product expansion exiting die. Feed rate and screw speed determine the resident time and degree of fill within the extruder (Guy, 2001). Consistence feed rate is crucial to ensure a stable and uniform product (Guy, 2001). One of the most common causes of non-uniform product is instability in the extruder. This is caused by the emptying of the barrel. This happens when the screw speed is too high relative to the feed rate. Therefore, it is important to control the feed rate and screw speed so that the barrel is not empty or flooded (Chessari & Sellahewa, 2001).

2.3. ROLE OF RHEOLOGY IN EXTRUSION

Rheology is the science of studying the viscous behaviour of fluid materials. Viscosity is defined as the internal friction of a liquid or is a measure of a given fluids tendency to resist flow (Dikeman & Fahey Jr, 2006; Forte & Young, 2003). The rheological properties of the extrusion melt are determined by the raw material properties and extrusion process variables (Van Laarhoven & Staal, 1991). The viscous behaviour of the melt inside the extruder has a direct influence on the finished product quality (Moraru & Kokini, 2003). It also has a direct influence upon the design of a process since pressure drop during transport is directly dependent upon the viscosity of the material, the screw energy consumption, screw design and flow dynamics (Forte & Young, 2003). Therefore, understanding the behaviour of the melt is very important to control the extrusion process (Forte & Young, 2003; Moraru & Kokini, 2003).

2.3.1. State diagram of extrusion process

For a typical extrusion process, there are generally two main energy inputs to the system: the energy transferred from the rotation of the screws and the energy transferred from the heaters through the barrel walls (Ainsworth, 2012). Figure 2.11 demonstrates the relationship between the total energy input (yielding a given product temperature in the extruder barrel) and the product moisture of a typical extrusion process (Strahm, 1998). The raw materials start from a point below the glass transition (T_g) curve. Preconditioning increases the raw materials moisture. Moistened materials are further heated and moistened in the extruder barrel. The materials are then melted in the cooking zone under relatively high temperature and high pressure. The product is in a rubbery state while in an extruder. The difference between the 3G extrusion and direct expansion is that 3G extruded product will stay in a rubbery state when it exits the extruder before cooling and drying. It will go harden when the temperature of the extruded product is cooled/dried below T_g, whereas, the directly expanded product will become semisolid/solid at the die due to the sudden reduction in pressure which causes moisture to flash off rapidly and puffing the product occurs (Ainsworth, 2012; Riaz, 2000).

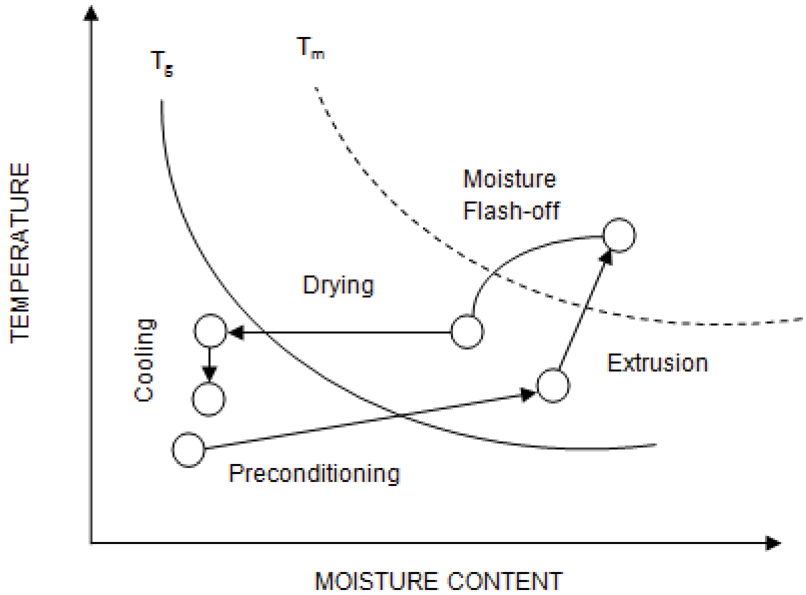


Figure 2.11: Glass and melt transition curves for extruded products (Strahm, 1998)

2.3.2. Rheology properties of extrudates

The thermo-mechanical behaviour of the food melt has been well studied and understood (Davidson, 1992). Most food extrudates are pseudo-plastic (Singh, 2009b). A number of mathematical equations of models have been described in the literature to estimate viscosity of non-Newtonian fluids with empirical data (Chanvrier et al., 2006; Dikeman & Fahey Jr, 2006). The power law model is the most commonly used to express the rheological behaviour of the food extrusion melt at the die and apparent viscosity, at a given shear rate, is the most common term in the literature to describe melt rheological properties (Arhaliass et al., 2003; Arhaliass, Legrand, Vauchel, Fodil-Pacha, Lamer, & Bouvier, 2009; Della Valle et al., 1996; Dikeman & Fahey Jr, 2006; Fan et al., 1994; Guha & Ali, 2006; Li et al., 2004; Moscicki, 2011; Wang et al., 1990). The apparent viscosity as defined by the power law is shown in Equation 2.2.

$$\mu_{apparent} = K\gamma^{n-1} \qquad \text{(Eq. 2.2)}$$

Where K is the consistency coefficient, γ is the shear rate and n is the flow behaviour index. The consistency coefficient is calculated from empirical data as if the fluid being measured exhibited Newtonian flow and obeyed Newton's Law (Dikeman & Fahey Jr, 2006; Singh, 2009b). The flow behaviour index is normally between 0.3 and 0.5 for most extrusion melts (Forte & Young, 2003).

Apparent viscosity is function of shear rate, temperature, moisture level as well as the extent of reactions that occur during the extrusion process (Davidson, 1992). In order to account for the significant influence of food extrudates' moisture content and temperature on the flow characteristics, Equation 2.3 has been proposed based on Arrhenius equation (Singh, 2009b):

$$\mu_{apparent} = k_0 e^{(\frac{A}{T})} e^{(BM)} \gamma^{n-1} \qquad \text{(Eq. 2.3)}$$

Where k_0 is consistency coefficient of extrudate at given temperature (in Kelvin), A is the activation energy constant, T is the temperature (in Kelvin) of extrudates, B is exponential constant and M is dry basis moisture content (Singh, 2009b).

From Equation 2.3, it can easily be deduced that a 5 % increase in melt moisture content leads to a 50 % decrease in apparent viscosity, if all other process parameters and raw materials remain unchanged; and similarly, a 10 ºC decrease in melt temperature leads to a 20 % increase in melt apparent viscosity (Forte & Young, 2003).

2.3.3. Die design and its impact on melt rheology

The die is assembled at the end of the extrusion barrel, which is used to control the amount of pressure within the barrel as well as to shape the finished product (Arhaliass et al., 2009). Die design is very important for an extruder, it can affect material dwell time, increase the shear or temperature of the product, and more importantly has a direct impact on the extruded product density and structure (Forte & Young, 2003). A good die design will permit uniform extrusion and drying, the final product will then exhibit adequate product strength with minimal damage and deliver the customer expectations in terms of texture (Kill & Turnbull, 2001).

The pressure drop (ΔP) across a die can be stated as a function of net output, apparent viscosity and die conductance (Frame, 1994). Melt viscosity is inversely proportional to the volumetric flow rate; the higher the viscosity, the lower the flow rate, if everything else remains constant (Equation 2.4). Pressure drop is the driving force for melt to flow. As the melt viscosity is directly proportional to the pressure drop, then the higher the pressure drop, the higher the melt viscosity (Equation 2.4). The magnitude of the resistance to flow is measured by the die conductance. The smaller the k is, the lower the flow rate at a given pressure drop and viscosity (Equation 2.4).

$$Q_{net} = k \frac{\Delta P}{\mu_{apparent}}$$ (Eq. 2.4)

Q_{net} = Volumetric flow rate ($m^3 s^{-1}$)
k = die conductance (m^3)
ΔP = Pressure drop along the land (Pa)
$\mu_{apparent}$ = Apparent viscosity (Pa·S)

The basic die terminology is shown in Figure 2.12. The die conductance is determined by die geometry. For rectangular opening, die conductance can be calculated using the Equation 2.5 (Forte & Young, 2003):

$$k = \frac{WH^3 / L}{12 + 16.6(H/W)^{1.5}} \approx \frac{WH^3}{12L} \text{ (when W > 6 H)}$$ (Eq. 2.5)

Where W is the width of the die opening (mm);
H is height of the die opening (mm);
L is the length of the die land (mm)

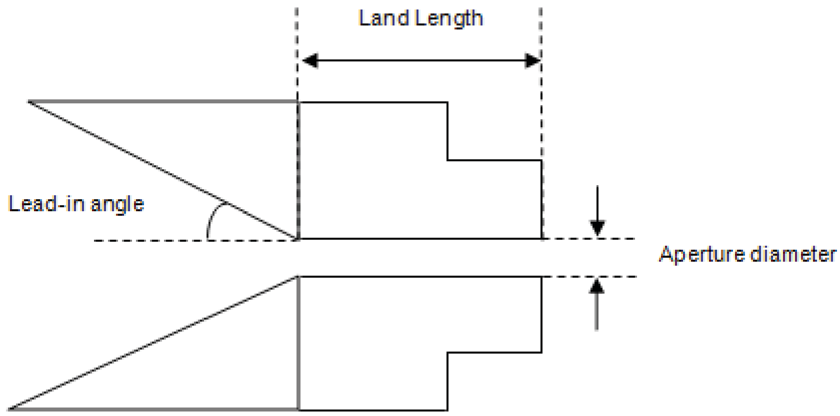


Figure 2.12: Basic die terminology (Forte & Young, 2003)

For a slit die, where W>>H, the shear stress (τ_w) and shear rate (γ_w) at the die wall may be written as Equation 2.6 and 2.7 respectively (Forte & Young, 2003; Singh, 2009b; Son, 2007):

$$\tau_w = \frac{H\Delta P}{2L}$$ (Eq. 2.6)

$$\gamma_w = \left(\frac{2n+1}{3n}\right)\left(\frac{6Q}{WH^2}\right)$$ (Eq. 2.7)

Since $\tau_w = K\gamma_w^{\,n}$, The relation between pressure drop (ΔP) and volumetric flow rate (Q) can be deduced from Equation 2.8 (Son, 2007)

$$\frac{H\Delta P}{2L} = K\left(\frac{2n+1}{3n}\right)^n \left(\frac{6Q}{WH^2}\right)^n \qquad \text{(Eq. 2.8)}$$

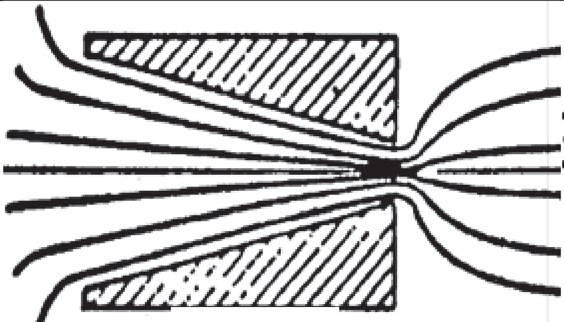
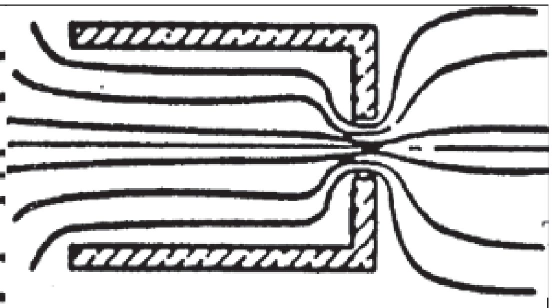
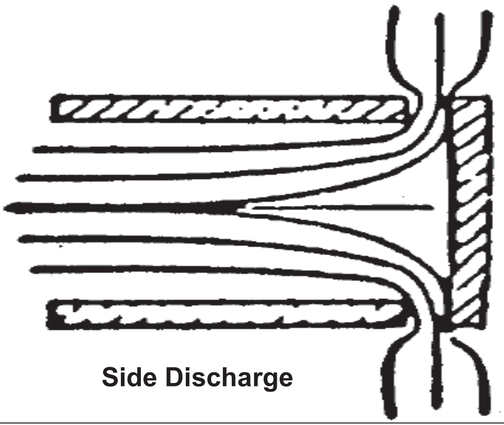
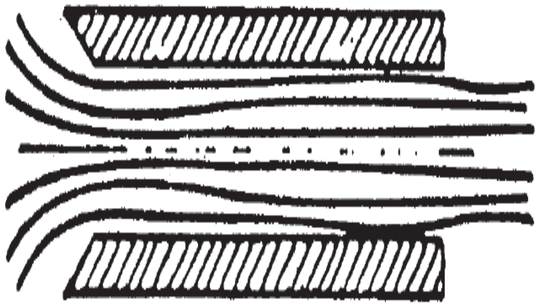
From Equations 2.2, 2.7 and 2.8, the relation between apparent viscosity, pressure drop and die land can be express below:

$$\mu_{apparent} \propto \frac{\Delta PWH^3}{QL} \qquad \text{(Eq. 2.9)}$$

Melt viscosity is inversely proportional to land length, the longer the land length, the lower the melt viscosity. Melt viscosity is also closely related to the die geometry, especially to the die opening, it is proportional to H^3 , if the pressure drop and flow rate remain constant.

The velocity profile outside the die is dominated by the elastic behaviour of the melt. Types of the final die design and their functionalities are summarised in Table 2.6 (Forte & Young, 2003). As can be seen from Table 2.6, the shape of the inlet is critical to the laminar flow, uniformity, finished product structure and level of expansion. The land length plays a crucial role in pressure development behind the die, which is an important control for producing 3G snack. A study on melt expansion with corn grits on a twin-screw extruder illustrated that product expansion was strongly dependent on the geometrical characteristics of the die (Arhaliass et al., 2003)

Table 2.6: Types of die design and their impact on extruded product (Forte & Young, 2003)

 Tapered	 Abrupt Cross-section
Smoother surface; less expansion; squarer ends	Surface irregularities; finer cell structure; rounder ends
 Side Discharge	 Long Cooled
Increased Lamination	Reduced Expansion; Increased Fibrous Structures

2.3.4. Effect of raw materials and extrusion parameters on melt rheology

Starch content and degree of starch gelatinisation have direct impact on melt rheology as previously described in section 2.1.1. An increase in the degree of starch gelatinisation results in a more viscous melt. The amylose/amylopectin ratio was also found significantly correlated with melt rheology and extruded pellet expansion. A number of researchers reported high amylose starches exhibit higher viscosity than high amylopectin starches (Della Valle et al., 1996; Lai & Kokini, 1990; Xie et al., 2009). This may have been caused by longer α-D-glucopyranosyl chains which induce more entanglements than shorter chains (Della Valle et al., 1996).

While starch is the major component and has the most influence on the melt viscosity, minor components such as proteins, fibres, sugars, salt and lipids also play important roles. Both protein and fibre are dispersed-phase filling materials, but their impacts on melt viscosity are not exactly the same. Literature shows that addition of protein during extrusion reduced the melt viscosity as denatured protein acted as a diluent (Balasubramanian, Borah, Singh, & Patil, 2012; Cho & Rizvi, 2009). The physicochemical characteristics of the fibre have a huge impact on the melt viscosity. For large fibre particles, such as wheat bran 0.8 – 2 mm, these particles bind little water, and therefore, has little effect on the melt rheology at low concentration of 1 – 2 %, but when added at higher concentrations (8 – 9 %), it can reduce the melt rheology and potential for starch expansion as much as 50 % by disrupting the wall of film (Huber, 2001). On the other hand, highly refined fibre with very fine particle size, such as Vitacel® wheat fibre 600 (JRS, Germany) (average fibre length 80μm, average fibre thickness 20 μm), has very high water binding capacity (4.2 – 5.5 g water per gram of dry solid of wheat fibre 600) (A 1.4 in Appendix 1). Therefore, it can significantly increase the melt viscosity at higher dosage in the formulation. Sugars, salt and water function as plasticiser and lipids function as lubricants (Frame, 1994). Excess of these materials decrease the dissipation of the mechanical energy and decreases the heat input, decreasing glass transition temperature (Tg) and mechanical resistance, and therefore, lowers the melt viscosity (Huber, 2001; Moraru & Kokini, 2003).

The power law model (Equation 2.2) and the Arrhenius equation (Equation 2.3) can be used to describe the relationships among extrusion operating parameters and melt viscosity. Two factors influence the apparent viscosity of the melt in the extrusion cooking: the thermal and the mechanical effects (Wang et al., 1990). Thermal effects include barrel and die temperatures. For uncooked raw materials, an increase in the temperatures would increase starch gelatinisation. As the material is cooked, the effect of temperature on apparent viscosity has been discussed in Section 2.3.2, it is expected that increasing temperature would decrease melt viscosity (Ding et al., 2006; Lai & Kokini, 1992). Mechanical effects include extrusion pressure, shear, screw speed and SME. The effect of pressure drop on apparent viscosity has been discussed in Section 2.3.3. Apparent viscosity decreases logarithmically as the apparent wall shear rate increases at constant SME (Wang et al., 1990). High screw speed decreases melt viscosity. This is because increase in the screw speed was found to reduce the torque and die pressure, while SME was found to linearly increase with screw speed (Bhattacharya, 1997; Lai & Kokini, 1992; Moraru & Kokini, 2003). The amount of SME input determines the extent of macromolecular transformations and interactions take place, Hence, starch gelatinisation has impact on the rheological properties of the melt, increased SME leads to lower viscosity (Bhattacharya, 1997; Lai & Kokini, 1992; Moraru & Kokini, 2003; Wang et al., 1990).

2.3.5. Rheological measurement

It is difficult to characterise the rheological behaviour of food materials because the melt is typically non-Newtonian. Rheological properties of the melts vary largely with the raw material composition and the operating conditions of the extrusion process (Frame, 1994; Lai & Kokini, 1992; Li et al., 2004; Van Laarhoven & Staal, 1991). Rheological models can serve as a fundamental basis for choosing appropriate operating conditions in the design of extrusion processes. They can be used to predict viscosity changes during extrusion processes. Despite the fact that a number of empirical models were developed, the use of such information is limited, because of the assumptions used in the description of the phenomenon. Moreover, small variations in processing conditions affect several process variables, which cause difficulties in estimating the changes in the melt viscosity (Ding et al., 2006).

The melt rheology in extrusion can be measured in-line or off-line. In-line viscosity measurement provides the most accurate and real time information of the melt rheology. A capillary die viscometer, tube viscometer or a slit die viscometer are the most commonly employed viscometers for the in-line measurement of the melt viscosity (Lai & Kokini, 1992; Martin, Averous, & Della Valle, 2003; Wang et al., 1990). The viscometers were attached to the extruder die. Off-line viscosity measurement is an indirect way of measuring melt viscosity. The degree of starch gelatinisation, extrudate viscograph, and glass transition temperature of the extrudates are often used to characterise to the melt viscosity. The advantage of doing off-line viscosity measurement is the absence of any influence on the production process. The most commonly employed instruments are RVA, DSC, Barbender and DMTA (Balasubramanian et al., 2012; Champion, Le Meste, & Simatos, 2000; Guha, Ali, & Bhattacharya, 1998; Limpisut & Jindal, 2002; Marti, Caramanico, Bottega, & Pagani, 2013; Sandoval, Nuñez, Müller, Valle, & Lourdin, 2009).

2.4. DRYING AND EXPANSION

After extrusion cooking and forming, shaped pellets are dried under a humidity and temperature controlled conditions (Hertzel & Plattner, 2005; Kill & Turnbull, 2001). The dried pellets are either packaged and sold directly as a half-product, or are stored and later puffed by hot air, fried or microwaved at 160-190°C for 10-20 seconds (Hertzel & Plattner, 2005). Frying is the most common way chosen for snack pellet puffing. However, with the increasing health awareness, more research and development work has been drawn to hot air and microwave puffing (Aguilar-Palazuelos, Zazueta-Morales, & MartÃ-nez-Bustos, 2006; Boischot et al., 2003; Ernoult, Moraru, & Kokini, 2002; Guraya & Toledo, 1994; Norton et al., 2011).

2.4.1. Drying of 3G snack pellets

Drying is a critical unit operation for producing 3G snacks. Drying the product to a water activity (Aw) below 0.6 will ensure a good pellet shelf life (Fennema, 1996; Geankoplis, 2003; Jay, Loessner, & Golden, 2005). However, excess drying is not good either, since moisture content provides the driving force for expansion which will then determine the finished product texture (Hertzel & Plattner, 2005; Moraru & Kokini, 2003; Norton et al., 2011). It was recommended that moist pellets from the extruder must be dried from 28 – 32 % to approximately 9 – 12 % moisture to ensure microbiological and biochemical stability as well as allowing for maximum expansion (Hertzel & Plattner, 2005; Kulp & Ponte, 2000).

It has been reported the way moisture is removed from pellets must be carefully controlled to ensure even drying (Hertzel & Plattner, 2005). It is important for retaining the product shape and integrity. If the pellets are dried too rapidly, these pellets can easily case-harden (Kill & Turnbull, 2001). Case-hardening occurs when the outer surface forms a barrier that is impermeable to moisture transfer from the product centre, thereby introduces moisture gradients, which can cause the product to deform and crack (also known as check) (Hertzel & Plattner, 2005). Checking can occur either during the drying cycle or as long as several weeks after the product has been packaged (Kill & Turnbull, 2001).

The formation of checking was explained in detail by Kill & Turnbull (2001). Pellet shrinks on losing moisture and the dry outside region will try to contract onto the wet core. Hence the outside of the pellet will be under tension and the core under compression. The pellet can deform to relax these stresses before entering the glassy state. If the stresses are retained after entering the glass state and exceed the strength of the pellet at any point, checking will occur. This can be avoided by artificially reducing the drying rate through injection of steam into the dryer (Hertzel & Plattner, 2005). The steam raises the humidity in the dryer, and helps keep the product surface moisture while the moisture slowly diffuses from the interior of the pellet (Kill & Turnbull, 2001).

Lastly, the time required for the drying is of economic importance. Drying can be divided into three regimes, heating up, constant rate and falling rate (Geankoplis, 2003). The pellet heating up period is small. The drying time for slab geometry can be estimated using Equations 2.10 and 2.11 (Geankoplis, 2003):

$$t_d = \frac{s\rho_s(X_1 - X_c)}{R_c} + \frac{s\rho_s(X_c - X^*)}{R_c}\ln\left(\frac{X_c - X^*}{X_2 - X^*}\right) \text{ (Capillary)} \qquad \text{(Eq. 2.10)}$$

$$t_d = \frac{s\rho_s(X_1 - X_c)}{R_c} + \frac{4s^2}{\pi^2 D_v}\ln\left[\frac{8\left(X_c - X^*\right)}{\pi^2\left(X_2 - X^*\right)}\right] \text{ (Diffusion)} \qquad \text{(Eq. 2.11)}$$

Where t_d = drying time (seconds),

s = ½ thickness of the slab when drying occurs from the top and bottom parallel faces (m),

R_c= rate of evaporation (kg/m^{2}s)

ρ_s = Dry material density (kg/m^3),

X_1 = initial free moisture content (kg/kg),

X_c = moisture content of the pellets (kg/kg),

X^* = equilibrium moisture content of the pellets in the drying air (kg/kg),

X_2 = final free moisture content (kg/kg),

D_v = the liquid diffusion coefficient in m^2/s.

Among which, the rate of evaporation can be deduced from drying temperatures and relative humidity (Geankoplis, 2003):

$$R_c = \frac{h_c(\theta_{air} - \theta_{surface})}{h_{fg}} \qquad \text{(Eq. 2.12)}$$

Where θ_{air} = temperature of the drying air (˚C)

$\theta_{surface}$ = temperature of the product surface (˚C)

h_c = convective heat transfer coefficient from the air to the product surface (W/m^{2}K)

h_{fg} = latent heat of evaporation evaluated at the product surface temperature (kJ/kg)

From Equation 2.12, it is easy to deduce that an increase in drying temperature, the rate of evaporation will also increase. Subsequently, the drying time will be reduced (Equation 2.10 and 2.11). The drying temperature also has significantly impact on the water diffusion rate from core to surface. The effect is illustrated in Equation 2.13 (Geankoplis, 2003):

$$\frac{D_{v1}}{D_{v2}} = \left(\frac{T_1}{T_2}\right)^{1.5} \qquad \text{(Eq. 2.13)}$$

Where T is the temperature in Kevin.

2.4.2. Factors affect pellet drying

There are a number of factors have impact on pellet drying efficiency and evenness. They can be categorised into product factors and process factors. These factors are summarised and illustrated in Figure 2.13.

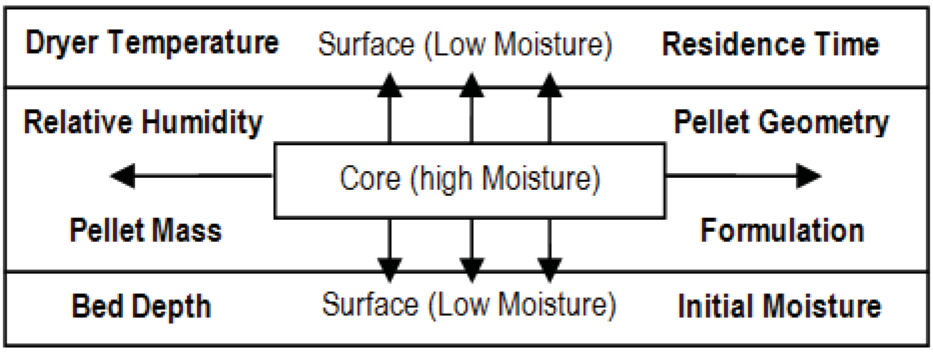


Figure 2.13: Factors affect half pellet drying

The most important process parameters are drying temperature, bed depth, relative humidity, pellet mass, product flow rate depending on if it is a batch or continuous process, and residence time (Hertzel & Plattner, 2005; Moscicki, 2011; Wang, Xiao, Wang, Zhang, Ding, Liu & Yang, 2012). High humidity drying is an effective way to reduce the chances of surface checking on the dried pellets. However, it will decrease the drying rate and therefore a longer drying time is required. This can be resolved by increasing the temperature, which will also increase the diffusion rate (Equations 2.10, 2.11, 2.12 and 2.13). Other dryer process parameters include air velocity and air flow direction (Wang et al., 2012). In a study of drying behaviour of extruded pellets in a fixed bed found that drying with alternating air flow direction improved the moisture uniformity of extruded pellets (Wang et al., 2012). Hertzel and Plattner (2005) recommended the pellets to be initially dried at a minimal bed depth to help promote uniform drying and reduce product sticking; the bed depth can be gradually increased as the pellets pass through the dryer.

Product factors are product formulation, pellet geometry and initial moisture (Hertzel & Plattner, 2005; Kill & Turnbull, 2001). Product formulation determines the product bulk density and strength of the pellet, the stresses the pellet can take during drying (Kill & Turnbull, 2001). Product geometry can affect drying in two ways. Firstly, the pellet thickness affects the drying time and tempering time to allow the product to equilibrate (Equations 2.10 and 2.11). The thinner the pallet wall, the shorter the time will be required. Secondly, product shape is one of the main determinants for product bulk density. It also determines to what degree the product can withstand stresses. A product shape with tight radii and re-entrant corners can easily concentrate five- to ten-fold stresses locally, so the product cracks (Kill & Turnbull, 2001). Products with widely differing wall thicknesses are particularly prone to cracking as such walls will shrink at different rates (Kill & Turnbull, 2001).

2.4.3. Expansion of dried pellets

Expansion of pellets results in a product with a cellular foam structure. It has been proposed that expansion of the starch pellet is driven by the vaporisation of water within a starch matrix and the high temperatures soften the walls of the pores (Konishi, Iyota, Yoshida, Moritani, Inoue, Nishimura, & Nomura, 2004).

The expansion phenomenon consists of nucleation, growth phase followed by a coalescence phase (Arhaliass et al., 2009; Moraru & Kokini, 2003). Nucleation is the cell initiation; it depends to a large extent on raw materials and process parameters (Forte & Young, 2003). As the product pressure begins to drop and also due to the degree of the superheating, the dispersed water will begin to boil in regions adjacent to nucleation sites (Forte & Young, 2003). The growth of the cells within a product structure is the result of a dynamic equilibrium between the internal steam pressure (the driving force) and the surface tension, and product rheology (the retarding forces) (Forte & Young, 2003; Moraru & Kokini, 2003). Last is the coalescence. In this phase, the cells interact by joining or coalescing into larger cells (Forte & Young, 2003).

State diagrams of the extrudate expansion are often used to define the different physical and chemical states of a food system as a function of moisture content and temperature (Moraru & Kokini, 2003). The diagram of indirect-expanded product is shown in Figure 2.14. According to this diagram, upon heating of the pellets, moisture generates superheated steam for expansion. As the cereal matrix undergoes a phase transition, moisture is lost as the product expands. Upon cessation of microwave heating, the matrix cools down and reverts to the glass state and forms the final structure.

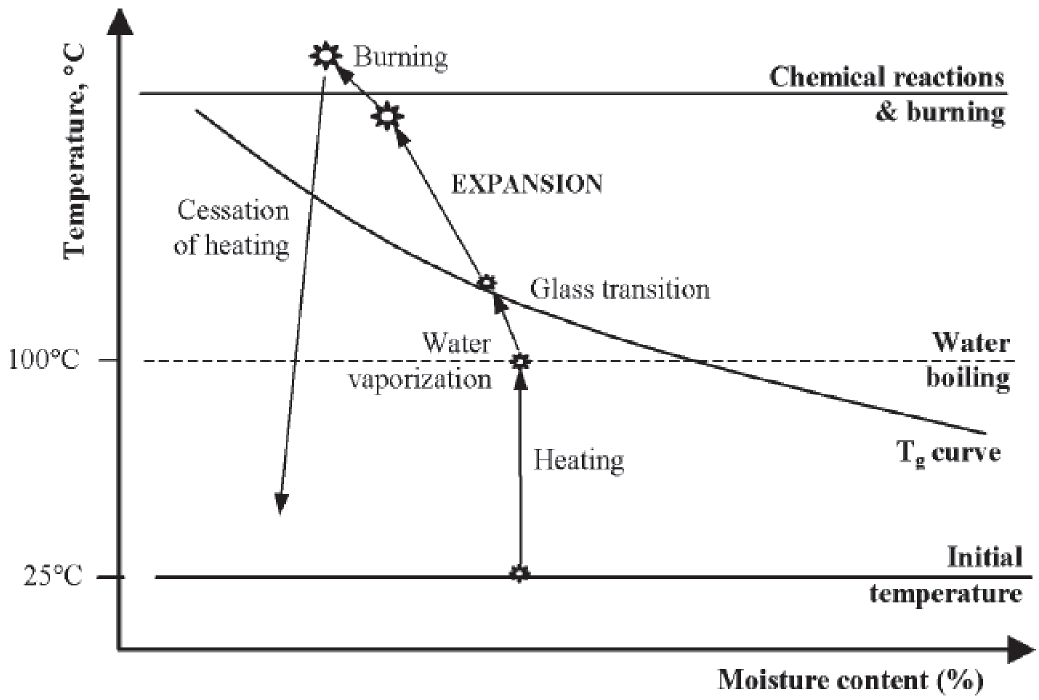


Figure 2.14: Glass and melt transition curves for an indirect-expanded product with microwave (Boischot et al., 2003)

2.4.4. Factors affect pellet expansion

The largest influence on expansion is exerted by moisture content and temperature history (de Mesa, Alavi, Singh, Shi, Dogan & Sang, 2009). Research has found a parabolic relationship between expansion and moisture content of the pellets (Konishi et al., 2004; Norton et al., 2011). They postulated that below the critical moisture, there was insufficient water to build up sufficient internal pressure to fully expand the matrix. Above critical moisture, water acted as a plasticizer, and the amount of pressure achieved in the cells was reduced.

Previous researches showed that product expansion and the number of cells per unit area were affected by small cells already present in the glassy structures (Cisneros & Kokini, 2002) and the degree of starch gelatinisation (Kraus, Enke, Gaukel, & Schuchmann, 2014; Lee, Lim, Lim, & Lim, 2000; Van der Sman & Broeze, 2013).

The effects of the degree of gelatinization (DG) on the expansion and the number of cells was reviewed by Van der Sman & Broeze (2013) and presented in Figure 2.15. It illustrates that the product density and the number density of cells as a function of degree of starch gelatinisation. The figure shows that when DG < 0.6, lowering the DG will increase the number of nucleation sites and reduce the expansion, maximum expansion was research at DG = 0.6, and the product bulk density and the number density of cells remained constant at DG >0.6. However, a study on extruded corn starch pellets indicated a nonlinear correlation between degree of gelatinisation and the expansion volume, and optimum level of starch gelatinisation for maximum expansion is around 50 % (Lee et al., 2000).

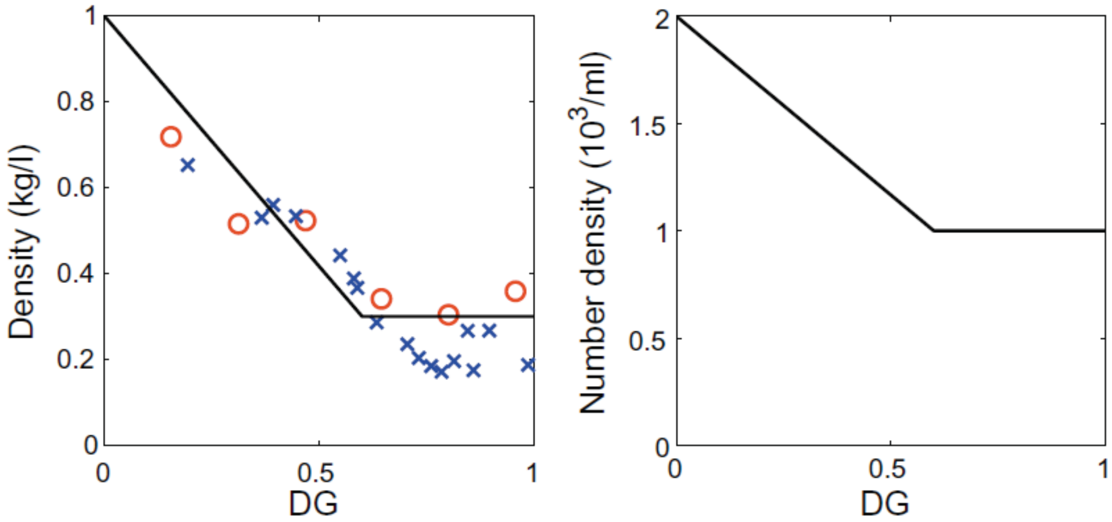


Figure 2.15: Mass density and number density of cells of expanded starchy snacks as function of the degree of gelatinisation (DG) (Van der Sman & Broeze, 2013)

Many studies have investigated the roles of raw materials and extrusion processing variables on the expansion volume of the product (Aguilar-Palazuelos et al., 2006; Arhaliass et al., 2009; Chinnaswamy, 1993; Hertzel & Plattner, 2005; Moraru & Kokini, 2003; Norton et al., 2011).

The expansion ratio of snack pellets decreased as the amylose content increased (Chen & Yeh, 2001; Della Valle et al., 1997; Huang & Rooney, 2001). High-amylose blends gives crisper and firmer texture, whereas, higher amylopectin content provided a light and soft texture (Rooney, 2009).

They illustrated that cereal matrix rheological properties depend on the extrusion variables and raw material chemical composition; and the melt rheological properties determine the product expansion. For instance, extruded food matrix should reach certain viscosity to control the shrinkage of an extrudate after it has reached its maximum expansion and prevent rupture of the gas cells. On the other hand, if the extrudate is too viscous, there will be rapid shrinkage and loss of apparent expansion in extrudates. The factors that have a significant influence on extrusion expansion are summarised by Moraru & Kokini (2003) in Figure 2.16.

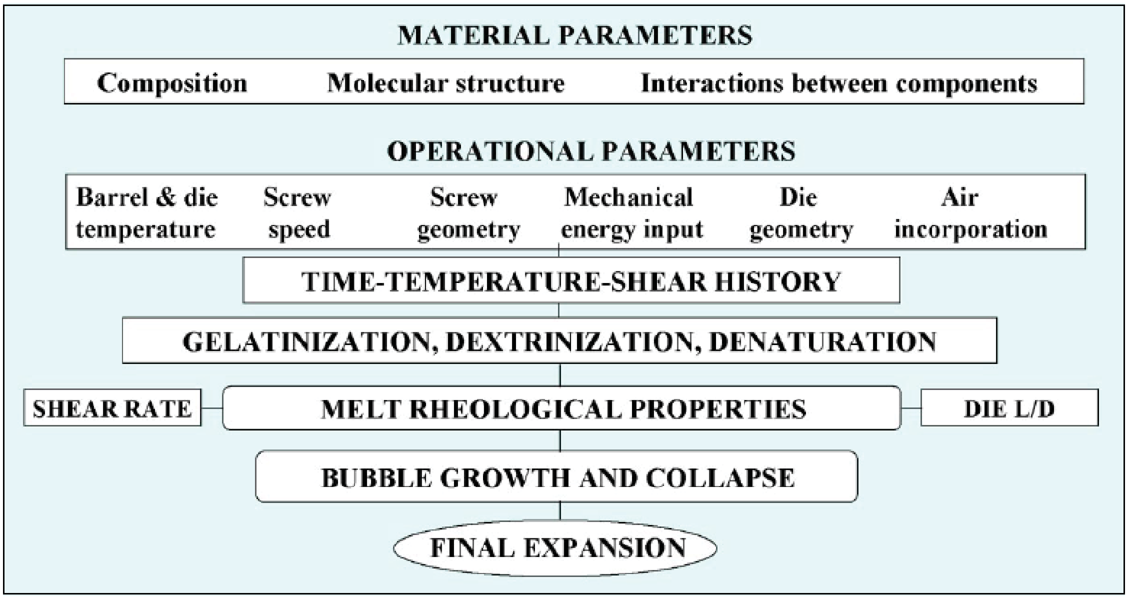


Figure 2.16: Factors that influence extrudate expansion (Moraru & Kokini, 2003)

2.5. CONCLUSIONS AND RECOMMENDATIONS

Third generation (3G) snack production involves raw material selection, extrusion, drying and expansion. This chapter has reviewed some criteria for selection of the suitable raw materials, extrusion configuration and die design to meet the project requirements. It has also reviewed the effect of extrusion variables on melt rheological properties, which subsequently determine product final expansion.

The key factors that need to consider for the raw material selections are source of starch and its characteristics, raw material starch content and particle size distribution. Inclusion of tuber starches, especially potato starch, should help with the product expansion. Fibre usage should be limited to 5 % or less and sugar usage should be limited to 2 % or less in a 3G snack formulation, as it may impact on the 3G snack expansion.

The key factors that need to consider for the extrusion are extruder screw speed, water injection rate and raw material feed rate to the extruder. It was recommended that freshly extruded moist pellets must be dried from 28 – 32 % to approximately 9 – 12 % moisture to ensure microbiological and biochemical stability as well as allowing for maximum expansion. The way moisture is removed from pellets must be carefully controlled to retain the pellet shape and integrity.

The data presented in this chapter provides a good guideline and understanding of the process. Despite the fact that extensive work has been carried out on extrusion, extrudate expansion and suggestions were given, the process itself has proven to be a very intricate field involving a lot of variables both in ingredient selection and operational setup. Even though each variable has its own way in influencing the quality and characteristics of the extruded product, their interaction and the detailed mechanism is very complex. It was found each extrusion system has its own unique features and characteristic, only practise extensively on a specific extrusion system along with relevant theories can consistently produce a good extruded product. Therefore, further experimental and simulation work is required to achieve the project goals and validate some of the findings reviewed.

3. MATERIAL AND METHODS

3.1. INGREDIENT SELECTION

The 3G snack pellets were made using a base recipe incorporating coarse cereal flours (rice or maize), wholemeal wheat flour, potato starch and ancient grain flour blend. The sources of the raw materials are detailed in Table 3.1.

Table 3.1: Main raw material sources, price and their functionality

Ingredients	Main functions in the product	Supplier	Price obtained in 2012 (NZD/kg)	Batch Information
Coarse Rice Flour	Base ingredient for structure, help with conveying at feeder	Davis Food Ingredients	1.80	Best Before 28/12/2012
Maize Polenta	Base ingredient for structure; help with conveying at feeder	Corson New Zealand	1.36	Best Before July 2012
Potato Starch (Elian 100)	Base ingredient for structure and help with expansion	National Starch Pty Ltd (New Zealand)	3.35	Best Before November 2015
Wholemeal Wheat Flour	Base ingredient for structure and wholegrain claim	Goodman Fielder	1.10	Best Before 09/04/2012
Ancient Grain Flour Blend	Base ingredient for structure and ancient grain claim	Scalzo Food Industries	6.72	Best Before 23/04/2012
Hi-Maize^{TM} Wholegrain Flour	Base ingredient for structure and wholegrain claim	National Starch Pty Ltd (New Zealand)	3.30	Date of Manufacturing 15/04/2011 (9 month shelf life)
Wheat Fibre 600 (JRS)	Insoluble fibre	IMCD New Zealand Limited	4.40	Expiry Date January 2014
Hi-Maize^{TM} 1043	Resistant starch	National Starch Pty Ltd (New Zealand)	4.95	Expiry Date May 2012
Beneo GR	Soluble fibre	Invita NZ Limited	5.75	Expiry Date May 2014
Nut Brown Flour	Flavour	Brenntag New Zealand Ltd	3.38	Best Before July 2011
Flavex (Vegetable protein extract)	Flavour enhancer	J.C.Sherratt &Co. Ltd	9.50	Date of Manufacture June 2011

Three types of fibre were studied; insoluble fibre (wheat fibre 600), soluble fibre (Beneo GR) and resistant starch (Hi-Maize^{TM} 1043). All ingredients were sealed and stored in a cool, clean and dry designated area away from light sources at ambient temperature.

The ingredients were selected based on the extrusion needs, ingredient local availability and cost. Ancient grain blend (one third amaranth, one third quinoa and one third millet) was the most expensive base ingredient for structure. Thereby, its level of usage was kept minimal in the formulation for the characteristic ingredient claim.

3.2. EXTRUDER CONFIGURATION

A lab-scale extruder, model Clextral BC21 twin screw co-rotating extruder (Firminy Cedex, France), was used for the experiments (Figure 3.1). The lab-scale extruder was a co-rotating model with barrel diameter horizontal 46 mm, vertical 25 mm, and 700 mm long with screw diameter of 24.7 mm, which was evenly divided into seven 100mm long temperature controlled zones.

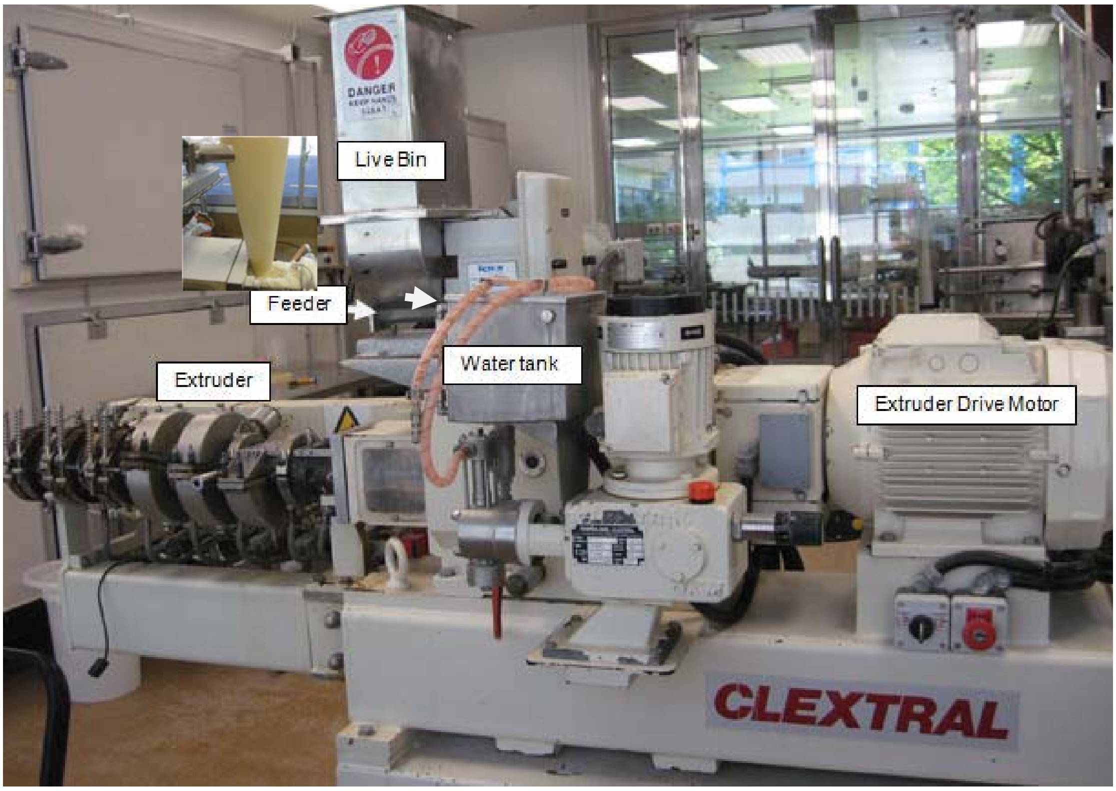


Figure 3.1: Picture of a Clextral twin-Screw extruder BC21

Preliminary trials were carried out using all forward screw configurations, which were typically used for producing directly expanded snacks. Initial results showed that the pressure and shear generated by the extruder were not enough to gelatinise all the starch and the product showed little or no expansion. Consequently, a more aggressive screw configuration was used with three reverse cut flight screws in order to increase the mixing and shearing in the centre of the barrel during extrusion (Table 3.2 and Figure 3.2).

Table 3.2: Clextral BC21 twin screw extruder screw configuration

	Length of Screw (mm)	Screw Pitch* (mm)	Land (mm)	Forward/Reverse
Zone 1	50	22	3	Forward
	50	22	3	Forward
Zone 2	50	15	2	Forward
	50	15	2	Forward
Zone 3	50	11.5	1	Forward
	50	11.5	1	Forward
Zone 4	50	11.5	1	Forward
	50	11.5	1	Forward
Zone 5	25	8 (Cut Flight)	0.5	Reverse
	50	15	2	Forward
	25	8 (Cut Flight)	0.5	Reverse
Zone 6	50	8	0.5	Forward
	25	8 (Cut Flight)	0.5	Reverse
	25	8	0.5	Forward
Zone 7	50	8	0.5	Forward
	50	8	0.5	Forward

*Note all screws are double pitch

Figure 3.2: Picture of Clextral BC21 twin screw extruder screw configuration

3.3. EXTRUDER DIE DESIGN

Preliminary trials were carried out using a die with 15.0mm × 1.6 mm slit die as shown in Figure 3.3. The upper opening was blocked to generate more back pressure and shear during extrusion. The degree of starch cooking also known as starch dextrinisation was investigated by determining the apparent paste viscosity of the milled and sieved pellets using a Rapid Visco-analyser (RVA Super 4, Newport Scientific, Warriwold, Australia) (Section 3.8.2) (Carvalho & Mitchell, 2000). High peak viscosities were observed from the pellets' time-temperature pasting curves, which suggested that the extrusion cooking were not sufficient. Figure 3.4 shows an example of such a pasting curve.

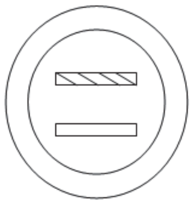


Figure 3.3: Rectangular opening die for 3G snack preliminary trial work

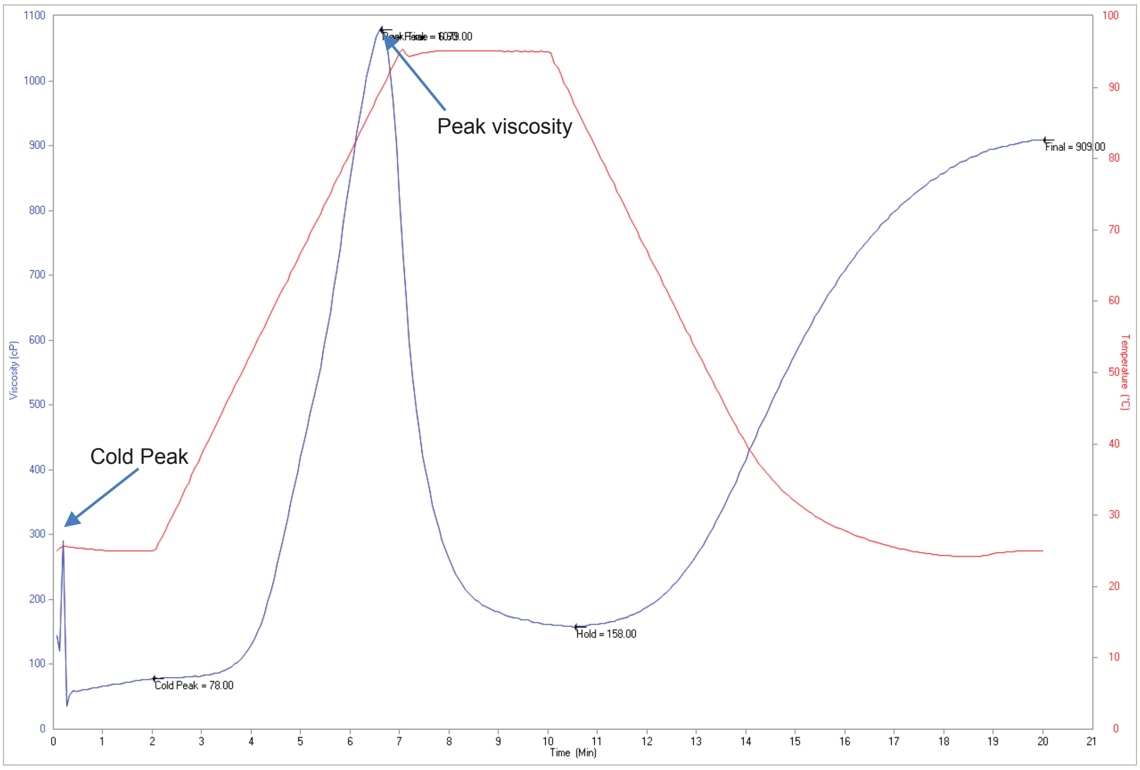


Figure 3.4: Pasting curve of pellets made with maize polenta and potato starch

There are three ways to increase the cooking in the extruder. Firstly, the temperatures in the cooking zones can be increased. Secondly, extruder back pressure was reduced by reducing the die opening area. Thirdly, the extruder configuration could be changed to increase the product residence time in the extruder (Section 3.2 captured this change).

The existing slit die opening of 1.6 mm in height was also not ideal to obtain good heat transfer during pellet drying and puffing. Most commercial snack pellets were found to be 0.7-1.0 mm in thickness. The importance of pellet geometry on drying was reviewed in Section 2.4.2. Therefore, a special wave shaped die was designed for subsequent study with a reduced opening area of 0.8 mm in height (Figure 3.5). The tapered section length and die land length were the same as the slit die shown in Figure 3.3. As the result of the reduction of the die opening, the die conductance was also significantly reduced as shown in Table 3.3. The die was manufactured by Courtney Engineering Ltd, Panmure, Auckland.

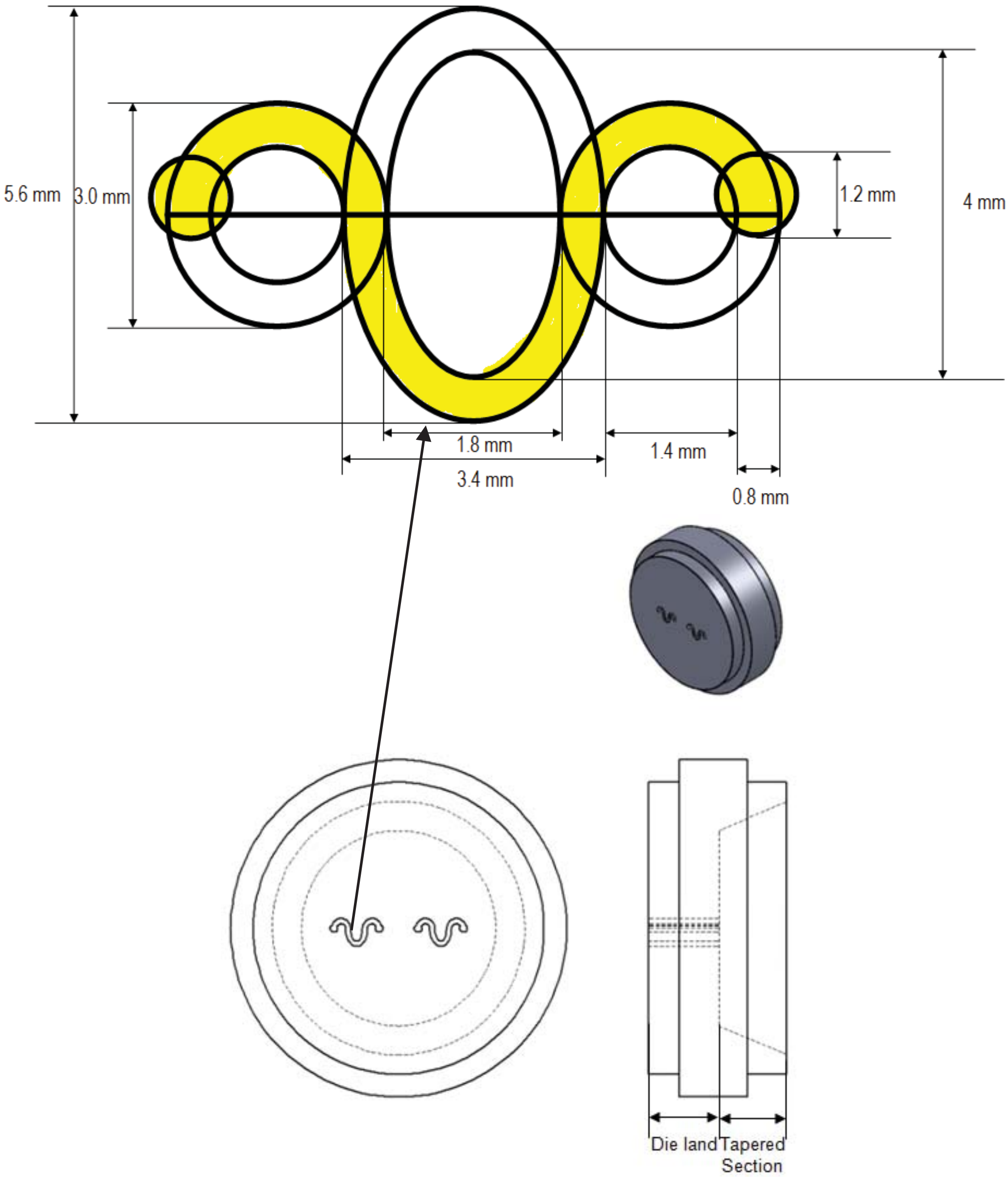


Figure 3.5: Wave shaped 3G snack die design and opening dimensions

Table 3.3: The comparison of die design between rectangular opening die and wave shaped die

	Rectangular Opening Die	*Wave Shaped Die*
Length of Tapered Section (mm)	13.00	13.00
Length of Die Land (mm)	10.30	10.30
Die conductance*	0.50	0.10

*Note: Calculated from Equation 2.5 (Section 2.3.3), details refer to Appendix 2.

3.4. EXTRUDER CUTTER DESIGN

Preliminary trials were carried out on manual cutting of the extruded pellets. It was very labour intensive and the inconsistent size of the pellets made subsequent quality analysis difficult. A special cutter was designed and manufactured by Massey University engineering workshop at Palmerston North for this study (Figure 3.6). The cutter was attached at the end of the cooling conveyor with a pneumatic system to control the cutting frequency. Thus, the size of the pellet could be controlled and pellets of consistent size could be produced.

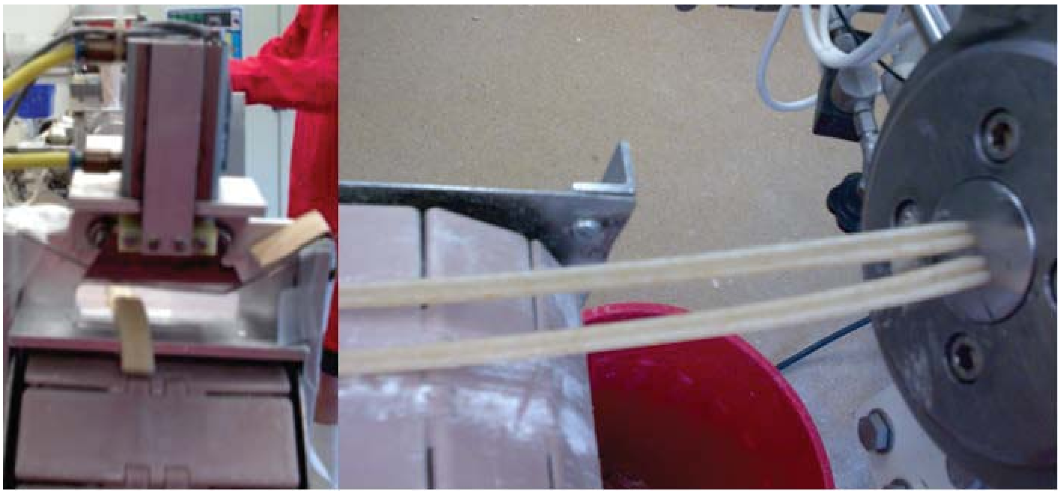


Figure 3.6: Picture of cooling conveyor and cutter for 3G snack process

3.5. EXPERIMENT DESIGN

3.5.1. Effect of inclusion of different types of fibres into 3G extruded snacks

The base recipe from which the 3G snack products were made is shown in Table 3.4. Preliminary trials were conducted with three levels of potato starch 0 %, 30 % and 50 % (w/w). According to raw material specifications (Appendix 1), both wheat fibre 600 and Beneo GR were to deliver over 89 % w/w of the dietary fibre, whereas, Hi-Maize™ 1043 only delivered approximately 52 % w/w dietary fibre.

Table 3.4: Formulations to determine the effect of soluble fibre, insoluble fibre and resistant starch on 3G snacks

	Percentage of each base ingredient w/w										
ID	*Coarse Rice Flour*	*Potato Starch*	*WM Wheat Flour* [1]	*Ancient Grain Blend*	*White Sugar*	*Nut Brown Flour*	*Salt*	*Coarse Rice flour*	*Wheat Fibre 600*	*Beneo GR*	*Hi-Maize 1043*
Control	26.0	27.5	31.0	5.0	2.0	1.0	0.5	7.0	0	0	0
WF Lo	26.0	27.5	31.0	5.0	2.0	1.0	0.5	5.0	2.0	0	0
WF Hi	26.0	27.5	31.0	5.0	2.0	1.0	0.5	3.0	4.0	0	0
Beneo Lo	26.0	27.5	31.0	5.0	2.0	1.0	0.5	5.0	0	2.0	0
Beneo Hi	26.0	27.5	31.0	5.0	2.0	1.0	0.5	3.0	0	4.0	0
Hi-Maize Lo	26.0	27.5	31.0	5.0	2.0	1.0	0.5	3.5	0	0	3.5
Hi-Maize Hi	26.0	27.5	31.0	5.0	2.0	1.0	0.5	0	0	0	7.0

[1] Wholemeal Wheat Flour

Batch size for each formulation was 2 kg. The same extrusion process set up was used for all 7 treatments: extruder screw speed 251 rpm, water rate 1.7 kg/h and feed rate dial 60, which was equivalent to 4.0 –5.3 kg/h, depending on the product formulation. The temperature settings in each zone, 1 to 7, for the extruder were 45, 45, 100, 150, 150, 150 and 65 ºC, respectively. The reason to have the low temperature setting in the last zone was to cool the extruded melt and avoid expansion.

After extrusion, pellets were dried to 10 – 12 % moisture and stored in an insulated polystyrene box at 30 ± 5°C for 48 hours to allow the moisture in the pellets to equilibrate before puffing in a popcorn machine (Crazy™ Popper, Breville Australia). Ten grams of pellets were used for air expansion. Microstructure analysis was carried out to determine the cell structure of the 3G snack.

3.5.2. Effect of water on 3G extruded snacks

This work was conducted based on the outcome trials outlined in Section 3.5.1. Two levels of water addition (1.7 kg/h and 1.0 kg/h) were studied on the wheat fibre 600 enriched base formulations (RW, CW, RWC as shown in Table 3.5). The same formulations and extrusion setup were used for both water treatments. Batch size for each formulation and the extrusion process parameters were the same as the previous series of experiments (Section 3.5.1). The effects of water on finished product expansion were assessed. SMEs for both process conditions were calculated according to Equation 2.1 (Section 2.2.1).

Table 3.5: Formulations to determine the effect of water addition rate on 3G snacks

ID	*Percentage of each base ingredient w/w*									
	Coarse Rice Flour	*Maize Polenta*	*Hi-Maize WG* [1]	*Potato Starch*	*WM Wheat Flour* [2]	*Ancient Grain Blend*	*White Sugar*	*Nut Brown Flour*	*Salt*	*Wheat Fibre 600*
RW	29.0	-	0	27.5	31.0	5.0	2.0	1.0	0.5	4.0
CW	0	29.0	0	27.5	31.0	5.0	2.0	1.0	0.5	4.0
RWC	29.0	-	10.0	27.5	21.0	5.0	2.0	1.0	0.5	4.0

[1] Hi-Maize™ Wholegrain Flour
[2] Wholemeal Wheat Flour

3.5.3. Effect of salt and flavour enhancer on 3G extruded snacks

The objectives of this set of experiments were to investigate the effects of salt on the extrusion system variables and product properties. A maize polenta, potato starch and wholemeal wheat flour based formulation (reformulated 'CW') was used for this study as shown in Table 3.6. Flavex Powder Standard is a vegetable protein extract produced by the acid hydrolysis of vegetable proteins. It has an intense savoury flavour and has been used as a flavour enhancer.

The same extruder setup was used for all 4 treatments in Table 3.6. The batch size for each formulation was 2 kg. The extruder screw speed was kept constant at 251 rpm, water was added at 1.0 kg/h and the feed rate dial was adjusted between 75 (4.35 ± 0.10 kg/h) and 80 (5.3 ± 0.10 kg/h) to keep the extruder energy consumption constant at 1.11 kW to 1.12kW. The temperature settings for the extruder in each zone, 1 to 7, were 45, 45, 100, 150, 150, 150 and 65 ºC, respectively. SMEs were calculated according to Equation 2.1.

Table 3.6: Formulations used to determine the effect of salt and Flavex (vegetable protein extract) on reformulated 'CW' snacks

ID	*Percentage of each base ingredient w/w*							
	Maize Polenta	*Potato Starch*	*WM Wheat Flour* [1]	*Ancient Grain Blend*	*Salt*	*Flavex Powder*	*Maize Polenta*	*Wheat Fibre 600*
Salt Lo	32.2	27.5	30.0	5.0	0.5	0	0.8	4.0
Salt Hi	32.2	27.5	30.0	5.0	1.0	0	0.3	4.0
Salt Lo&Flavex	32.2	27.5	30.0	5.0	0.5	0.3	0.5	4.0
Salt Hi&Flavex	32.2	27.5	30.0	5.0	1.0	0.3	0	4.0

[1] Wholemeal Wheat Flour

3.5.4. Texture analysis of reformulated 3G extruded snacks

The objectives of this set of experiments were to investigate the texture difference between the research prototypes (Table 3.7) and commercial products. Three base formulations (RW Salt Hi, CW Salt Hi and RWC Salt Hi) were modified according to the outcome of the flavour enhancer study. The three base formulations used different structure building ingredients, which were shown on the formulation IDs. The recipes are detailed in Table 3.7.

Table 3.7: The shear-compression analysis on three 3G snack base formulations

ID	*Percentage of each base ingredient w/w*							
	Coarse Rice Flour	*Maize Polenta*	*Hi-Maize WG* [1]	*Potato Starch*	*WM Wheat Flour* [2]	*Ancient Grain Blend*	*Salt*	*Wheat Fibre 600*
RW Salt Hi	32.5	-	0	27.5	30.0	5.0	1.0	4.0
CW Salt Hi	0	32.5	0	27.5	30.0	5.0	1.0	4.0
RWC Salt Hi	32.5	-	10.0	27.5	20.0	5.0	1.0	4.0

[1] Hi-Maize^{TM} Wholegrain Flour

[2] Wholemeal Wheat Flour

The same extruder setup was used for all three treatments. The batch size for each formulation was kept at 2 kg. The extruder screw speed was kept constant at 248 rpm, water was added at 1.0 kg/h. The temperature settings for the extruder in each zone, 1 to 7, were 45, 45, 100, 150, 150, 150 and 65 ºC, respectively. SMEs were calculated according to Equation 2.1.

3.6. PHYSICO-CHEMICAL PROPERTIES OF PELLETS AND PUFFED SNACKS

3.6.1. Moisture

The moisture content of the product was determine by placing a defined amount of samples into an air oven at 108 ± 5°C according to the AACC method 44-15A (Anonymous, 2000). The loss in weight was measured before and after drying.

For samples containing less than 10 % moisture, a one-stage drying procedure was used. Approximately 4 grams of testing sample was ground into powder and placed into a pre-weighed aluminium dish with the lid was placed underneath. The dish and sample was weighed to four decimal places. The ground sample was dried for 3 hours with the lid removed. Before removing from the oven, a matching lid was placed onto each dish while it was still in the oven; then the dishes were removed from the oven and transferred rapidly to a desiccator, cooled for a minimum of 30 minutes at room temperature. Once cooled, the samples and dish were weighed again to four decimal places.

For samples containing more than 10 % moisture, a two-stage drying procedure was used. Approximately 10 grams of testing sample was used. Firstly, the pre-weighed unground sample in the pre-weighed dish was dried for 90 minutes at 108 ± 5 ºC, then cooled for 90 minutes in a desiccator. The sample was then weighed prior to being ground to a powder and then re-weighted again to four decimal places. The ground sample was dried for a further 2 hours at 108 ± 5 ºC, followed by cooling in a desiccator for a minimum 30 minutes at room temperature. Once cooled, the samples and dish were weighed again to four decimal places. All measurements were carried out in duplicates.

One-stage Moisture Procedure Calculation of Moisture Content:

$$Moisture\ (\%) = \frac{(W2 - W3)\ x\ 100}{(W2 - W1)} \qquad \text{(Eq. 3.1)}$$

Where W_1 = weight in grams of moisture dish with lid

W_2 = weight in grams of moisture dish, lid and sample (before drying)

W_3 = weigh in grams of moisture dish, lid and sample (after drying)

Two-stage Moisture Procedure Calculation of Total Moisture Content:

$$Total\ Moisture\ (\%) = M1 + \frac{(100-M1)M2}{100} \qquad \text{(Eq. 3.2)}$$

Where M_1 = percentage moisture loss at first stage

M_2 = percentage moisture loss at second stage

3.6.2. Water activity

The water activity of samples was measured to monitor pellet dryness using an Aqualab, CX2 water activity meter (Decagon Devices, Pullman, WA). The whole pellets were placed in the sample cup to cover the bottom of the cup, and water activity was determined by following the instructions for the meter. For puffed extrudates, the sample was ground and placed into the sample cup to half its depth. The sample was covered with nylon mesh to prevent loss of powder from the sample. The sample cup was placed in the sample drawer of the water activity meter and water activity values were read off the screen. The temperature was set at ambient room temperature 22 ± 1°C. The measurement was carried out in duplicate.

3.6.3. Die swell analysis

The reason for die swell was summarised by Moraru & Kokini (2003). When the starchy polymer melt emerges from the extruder die and starts cooling down, the elastic forces to the rheology of the melt increases significantly, which causes the die swelling. Die swell controls the overall expansion of the extrudate. The die swell was calculated by dividing the dimension of the extrudate by the dimension of the die opening.

Due to the irregularity of the pellet shape, measurement of the extrudate dimension was not simple. The width and thickness of 10 pieces of pellets taken at random for each treatment were measured using a Mitutoyo calliper (Japan) and the average calculated. The die swell of each individual pellet was calculated by multiplying its die swell width and die swell thickness.

3.6.4. Section expansion indices

Expansion of extrudates was evaluated as sectional (radical) expansion (SEI), the width and thickness of 10 pieces of extrudate taken at random were measured with a Mitutoyo calliper (Japan) and the average calculated. The sectional expansion index was calculated using the equation proposed by (Alvarez-Martinez, Kondury, & Harper, 1988):

$$SEI = \frac{S_e}{S_d} = \frac{W_e h_e}{W_d h_d} \qquad \text{(Eq. 3.3)}$$

Where S_e and S_d are the cross-sectional areas of the extrudate and the die; W_e and h_e are the width and thickness of the extrudate and W_d and h_d are the width and thickness of the die, respectively.

3.6.5. Bulk density

The bulk density (BD) was determined in expanded pellets. An empty container was weighed before and after filling with water right to the brim, at ambient room temperature 22 ± 1°C. The weight of water was converted to the volume of the container dividing by the water density. The same container was washed, dried and filled with extrudates to the brim and tapped three times before being levelled off with a ruler. The weight of the extrudates with the container was recorded and the procedure was repeated for the replicated measurements. Measurements for each sample were carried out in triplicate and the bulk density of the extrudates was calculated using the equation 3.4 (Kusumaningram, 2008):

$$Bulk\ Density\ (\frac{g}{L}) = \frac{Extrudate\ Weight\ (g)}{Container\ Volume\ (L)} \qquad \text{(Eq. 3.4)}$$

3.6.6. Product particle density

The poppy seeds displacement method was used to determine the particle density of the extrudate. Firstly, the density of water was determined by filling a metal jug with water to determine the volume and weight. The container was then washed, dried and filled with poppy seeds to the brim, tapped ten times, levelled off with a ruler and the weight was recorded. The density of the poppy seeds was determined by dividing the weight of the seeds by the volume of container.

Poppy seeds were then used to fill the bottom of the same jug before a layer of extrudate samples were laid on top of the grains. Poppy seeds were laid on top of the extrudates and the layering technique was repeated until the container was entirely filled and all extrudates, completely surrounded with poppy seeds. The filled container was settled by tapping ten times and levelled off with a ruler. The mixture of seeds and extrudates were sieved, separated and the individual components were weighed. Measurements were carried out in triplicate and the particle density of extrudate was then calculated using equations 3.5 and 3.6 (Kusumaningram, 2008):

$$Displaced\ poppy\ seed\ volume\ (L) = \frac{Displaced\ poppy\ seed\ weight\ (g)}{Poppy\ seed\ density\ (\mathrm{g/L})} \qquad \text{(Eq. 3.5)}$$

$$Particle\ density\ (\mathrm{g/L}) = \frac{Extrudate\ weight\ (g)}{Displaced\ poppy\ seed\ volume\ (L)} \qquad \text{(Eq. 3.6)}$$

3.6.7. Microstructure analysis on expanded products

Product bulk density and particle density measurements were the most suitable measurements, if the product size was uniform and expansion was even. They were less applicable when there was a large amount of checked or uneven shaped pellets. It made bulk density measurements inaccurate and meaningless. However, it was necessary to estimate puffed product measurements to guide further product improvement work. Hence, expanded product microstructure analysis was used as an alternative way to carry out the assessment.

The microstructure was evaluated on an expanded product which was further equilibrated at 30 ºC and 80 ± 5 % humidity for 24 h. Samples were sliced to expose an interior cross-section and coloured with a marker. Cross-sections were viewed under a dissection microscope (Leica EZ4D, Switzerland), the images were magnified eight times and captured with the attached camera. The image was analysed with microsystems LAS EZ V1.80 for Windows 2003-2009 (Switzerland). For irregular cells, diameters of the cavities were measured at their maximum lengths. All the cell length measurements were divided into three groups: cell length >3000 µm, cell length <500 µm and those in between. SolidWorks 2012 (France) was used for area calculation. Three randomly chosen uniform and evenly expanded samples from each treatment were evaluated. Structural attributes measured were cell size, number of cells per unit area and cell size distribution, which have been reported to be highly correlated with product texture (Guraya & Toledo, 1996).

3.7. TEXTURE MEASUREMENT OF EXTRUDED PRODUCTS

A compression test determines the compressive strength of expanded products under crushing loads. The aim of the texture determination was to determine the hardness of samples compared to commercial extruded products. Before the measurement was carried out, the probe was calibrated using % strain measurement to acknowledge the texture analyser test surface. A compression test was performed on all extrudates samples using an Instron 4502 Texture analyser version 1.34 (1995) (Canners Machinery Ltd. Simcoe, Ontario Canada) (Figure 3.7)

A kramer cell (64 mm length × 68 mm width × 65 mm depth) three-blade probe (Figure 3.6) was used, with test speed of 0.1 mm/s. Standard bulk volume of 250 cm^3 of sample was used each test, and compression was carried out with a 1000 N load limit and extension limit of 50 mm. Hardness was determined as the peak force obtained in newton. Measurements were carried out in triplicate.

Figure 3.7: Picture of Kramer cell setup for Instron texture analyser

3.8. DETERMINATION OF PASTING PROPERTIES

The pasting properties of both the raw ingredients and the extruded pellets were determined using a Rapid Visco-analyser (RVA Super 4, Newport Scientific, Warriwold, Australia).

3.8.1. Pasting properties of raw ingredients

An ingredient or ingredient mixture sample of 3.5 g (14 % moisture basis) was weighed into an aluminium canister in which 25 mL deionized water had already been filled. Sample was stirred with the paddle for 10 s to disperse it and to prevent formation of lumps. The RVA^{TM} general pasting method standard 1 profile was chosen for determination of the pasting properties of individual raw materials. The process started at 50 °C with spindle speed at 960 rpm. The speed of the spindle was reduced to 160 rpm after 10 seconds and the temperature was kept for 1 min, then ramped up linearly to 95 °C in 3 min and 42 s, holding at 95 °C for 2 min and 30 s, then cooling the system to 50 °C in 3 min and 48 s, holding at 50 °C and ending the process after 2 min. The total test time was 13 min, and readings are carried out every 4 s. Full details of the procedure used are given by RVA-Super4 Manual (Anonymous, 1997).

3.8.2. Pasting properties of extruded pellets

A laboratory cyclone sample mill (Udy Corporation, Model 3010-019, Fort Collins, USA) with a 280 µm screen was used. A milled and sieved sample of 4.0 g (14 % moisture basis) was weighed into an aluminium canister in which 25 mL deionized water had already been filled. The sample was stirred with the paddle for 10 s to disperse it and to prevent formation of lumps. Then the standard RVA™ extrusion method non-alcohol added profile was chosen for determination of the pasting properties of extruded pellets by activating the program. The whole process started at 25 °C with spindle speed at 960 rpm. The speed of the spindle was reduced to 160 rpm after 10 seconds and the temperature was kept for 2 min, then ramped linearly to 95 °C in 5 min, holding at 95 °C for 3 min, then cooling the system to 25 °C in 5 min, holding at 25 °C and ending the process after 20 min. Readings are carried out every 4 s. Full details of the procedure used are given by RVA-Super4 Manual (Anonymous, 1997).

3.8.3. Analysis of pasting properties

For pasting properties of the raw materials, results obtained were pasting temperature, peak viscosity (PV), peak time (PT), final viscosity (FV), breakdown (BV) and setback (SB). Pasting Temp is the temperature where viscosity first increases by at least 25 cP over a 20 s period; PV is the maximum paste viscosity achieved during the heating cycle; PT is time when maximum paste viscosity achieved; BD is the peak viscosity minus the viscosity after the holding period at 95 ºC; FV is the final viscosity; SB is the difference between the final viscosity and the viscosity reached after the first holding period.

For extruded pellet samples, results obtained were cold peak (CP), peak viscosity (PV), final viscosity (FV), breakdown (BV) and setback (SB). CP is the maximum cold water viscosity observed at 25 ºC.

Duplicate measurements were conducted to obtain the reported value (mean ± SD). The computer software Thermocline for Windows (Newport Scientific, Warriwood, Australia) was used to analyse the pasting profile. The data obtained was transferred to Microsoft Excel for further analysis and graph drawing. Full details of the procedure used are given by RVA-Super4 Manual (Anonymous, 1997). Data were subjected to statistical analysis using Minitab Release 16 Statistical Software (Minitab Inc., State College, Pennsylvania, US). Results were analysed using a one-way analysis of variance (ANOVA), Tukey's HSD significance test. Significance was defined as $p<0.05$.

3.9. PRODUCT NUTRITIONAL ANALYSIS

3.9.1. Protein determination using the Kjeldahl method

The protein content of the product was measured based on AOAC 991.20. Approximately 1.5 gram sample was accurately weighed into a digestion tube. Two Kjeldahl tablets (each containing 3.5 g K_2SO_4 and 0.0035 g Se) and 15 mL concentrated sulphuric acid were added. The tube was heated in a digestion block to 420 ºC until the solution became clear and then removed from the heat block. After cooling for 10 minutes, approximately 100 mL cold distilled water was added, before it was placed in a distillation unit. A conical flask containing 25 mL of 4 % boric acid solution (containing indicator) was placed under the condenser outlet. Thirty millilitres of 40 % NaOH was dispensed into the digestion tube and distilled for 4 minutes. The resulting ammonium borate solution was titrated against 0.1 M hydrochloric acid to a mauve/grey end point. The protein content was calculated below:

$$Nitrogen\ (\%) = \frac{A \times B \times 14 \times 100}{1000 \times C} \quad \text{(Eq. 3.7)}$$

Where A = mLs of HCL used

B = Exact molarity of HCL (0.1 M)

C = weigh in grams of sample taken

% Crude protein = % Nitrogen × 5.83 (converting factor) (Eq. 3.8)

3.9.2. Total fat determination using the Mojonnier method

The total fat content of the product was measured based on AACC Method 30-10. Approximately 4 g of ground puffed extrudate sample was accurately weighed into a 50 mL beaker. Three millilitres of ethanol was added to moisten the sample and prevent any lumps occurring on addition of acid. The sample was then hydrolysed with 10 mL of HCL. The beaker was placed on a boiling water bath and the sample was stirred at frequent intervals for 40 min. Then the sample was taken out from the water bath and allowed to cool for half an hour. After cooling, 10 mL of ethanol was added and mixed with the sample. Then, the mixture was transferred to a Mojonnier fat extraction tube.

The beaker was rinsed with 25 mL of diethyl ether into the extraction tube, and then a stopper was placed on the tube and rocked gently for about 1 minute. The stopper was removed and 25 mL of petroleum ether was added. The stopper was put back on the tube and rocked gently for 30 s. After that, the Mojonnier tubes were placed into a centrifuge for 2 min at 600 rpm. The upper organic solvent layer was carefully decanted into a pre-weighed conical flask. Once all the possible solvent was decanted without disturbing the lower phase, five mL of ethanol was added to the Mojonnier tube and mixed. This helped preventing emulsions forming. The stopper was removed to release the gas after mixing. The extraction procedure was repeated with 15 mL of diethyl ether and 15 mL of petroleum ether. The second extract was added into the same flake. During the extraction steps, fat was dissolved in methylated spirits and removed from the sample through two extraction cycles with ether. The conical flask was placed on the boiling water bath until the solvents were evaporated completely. The conical flask was dried in 108 ± 5 ºC air oven for 90 minutes, then cooled and re-weighed. The fat content was calculated below:

$$Fat\ in\ food\ (\%) = \frac{(w2 - w1) \times 100}{w3} \qquad \text{(Eq. 3.9)}$$

Where w_1 = weight in grams of empty flask
w_2 = weight in grams of flask and fat
w_3 = weight in grams of sample taken

3.9.3. Total fibre determination

The total dietary fibre contents of the products were measured based on AOAC 991.43. It was determined using the Total Dietary Fibre Assay Kit from Megazyme International (Wicklow, Ireland). Sample tests were carried out by Nutrition Laboratory, Institute of Food, Nutrition and Human Health, Massey University Palmerston North.

3.10. STATISTICAL ANALYSIS

Unless otherwise stated, the data reported are means of triplicate observations and mean ± standard deviation (SD) was presented. Data were subjected to statistical analysis using Minitab Release 16 Statistical Software (Minitab Inc., State College, Pennsylvania, US). Results were analysed using a one-way analysis of variance (ANOVA), Tukey's HSD significance test and Pearson's correlation analysis. Significance was defined as $p<0.05$.

4. INGREDIENT SELECTION FOR 3G EXTRUDED SNACKS

4.1. INTRODUCTION

Ingredient selection is one of the most crucial steps for producing 3G extruded snacks successfully. Its importance has been reviewed in Section 2.1. Selection was carried out based on physico-chemical properties of ingredients, their pasting properties, and the performance of a cereal-potato starch mixture during and after 3G snack extrusion.

Ingredient physico-chemical properties have direct impact on the finished product quality. The effect of different ingredients' particle size and chemical composition on microstructure, pasting and textural properties of extruded products has been reported (Arhaliass et al., 2009; Carvalho, Takeiti, Onwulata, & Pordesimo, 2010; Singh, Kaur, McCarthy, Moughan, & Singh, 2009). For instance, Arhaliass et al., (2009) found that more expansion was obtained with maize flour than wheat flour during extrusion, which was caused by differences in their composition; starch content in maize flour is higher than in wheat flour and protein content in wheat flour is higher than maize flour. In the work of Carvalho et al. (2010) corn meal expansion was found to decrease as the particle size decreased. Increasing the particle size decreased the SME input, and subsequently reduced starch conversion.

Rapid visco analysis was used to study the pasting properties of individual ingredients, which is an important functional property of starches. The pasting profile is usually studied by observing changes in the viscosity of a starch system through heating and cooling at controlled temperatures (Anonymous, 1997). From the pasting curve, the effect of granule size and chemical composition of the ingredient on the pasting properties was observed. Singh et al. (2009) reported the RVA pasting characteristics of the potato flours were significantly affected by their starch content. The quantity of potato starch to be added into the base formulation and its impact on enhancing 3G snack pellet expansion were studied. This study provided information on the physical characteristics and rheological behaviours of key ingredients, which were used to guide the 3G snack formulation for achieving desirable characteristics of a 3G snack.

4.2. MATERIALS AND METHODS

4.2.1. Materials

All major 3G extruded snack structure building ingredients were studied. Raw materials, coarse rice flour, maize polenta, wholemeal wheat flour, Hi-Maize^{TM} wholegrain flour, ancient grain flour blend and potato starch, used in this series of experiments are detailed in Section 3.1. Ancient grain flour blend was made of one third amaranth, one third quinoa and one third millet.

4.2.2. Physico-chemical analysis

Supplier product specifications were obtained and used to summarise typical macronutrient composition of individual raw materials (Appendix 1). Particle size distribution of raw materials were obtained by sieving a 200 gram flour sample through a 710µm, a 500µm and a 280µm perforated laboratory test sieves with square holes (Endecotts Ltd., London, England) using a sieve shaker (Endecotts Ltd., Model minor 3278-13, London, England). Sample retained on each sieve was weighted and the percentage retained was calculated as shown in Equation 4.1.

$$\text{Retained on sieve (\%)} = \frac{\text{weight of sample retained on sieve} \times 100}{\text{Total weight of sample}} \qquad \text{(Eq 4.1)}$$

Four representative samples were measured and results were presented as mean ± standard deviation.

Starch content of the ingredient was estimated and calculated by subtracting total sugar from ‘carbohydrate by difference’ (Brand & Maggiore, 1994; Jacob, 2015). Food Standards Australia New Zealand (FSANZ) states that ‘carbohydrate by difference’ is calculated by subtracting from 100, the average quantity expressed as a percentage of water, protein, fat, dietary fibre, ash, alcohol, and any other unavailable carbohydrate (Standard 1.2.8). Total sugar and ‘carbohydrate by difference’ of each ingredient tested is available on the raw material specification (Appendix 1). The typical chemical composition of ancient grain flour blend was calculated by average nutrient values of amaranth, quinoa and millet.

4.2.3. Pasting properties by RVA

The pasting properties of the individual raw materials were determined according to Section 3.8.1. For cereal flours, they were measured both in their original format (how it was supplied) and ground format. For ground cereal samples, a laboratory cyclone sample mill (Udy Corporation, Model 3010-019, Fort Collins, USA) with a 280 µm screen was used. Samples that passed through the sieve were used for RVA. Pasting properties were analysed according to Section 3.8.3 and the RVA pasting properties of ingredients before and after grinding were compared.

4.2.4. Preliminary assessments of extruded cereal-potato starch mixtures

Potato starch was mixed with either coarse rice flour or maize polenta at 0, 30 % and 50 % (w/w) for extrusion. Extruder configuration used in this series of experiments is detailed in Section 3.2. A 15.00mm × 1.60 mm rectangular opening die was used (Figure 3.3). The temperature settings in each 100 mm long temperature controlled zones (Table 3.2) were 40, 40, 100, 150, 150, 65, 60 ºC, respectively. Two kilograms of cereal-potato starch mixture equating to one batch, was run through the extruder. The mixture's free flow ability was assessed visually by observing the feeding of the cereal-potato starch mixture from living bin to feeder and from feeder to the extruder (Figure 3.1). A large variation on the extruder processing dependent variables such as apparent torque and thrust pressure (Table 2.5) also indicates inconsistent feed rate when other extruder processing parameters remain constant as reviewed in Section 2.2.5. After exiting the die, wet extrudates (Figure 4.1) were sliced manually into approximately 1 mm thickness pellets prior to drying. Pellets were dried to 10 – 12 % w/w moisture and stored at ambient temperature for a minimum of 12 hours before puffing in a popcorn machine (Crazy™ Popper, Breville Australia). Expansion of extrudates were evaluated as sectional expansion index (SEI). The method was detailed in Section 3.6.4 with some modifications. The sectional expansion index was calculated by Equation 4.2.

$$SEI = \frac{S_e}{S_p} = \frac{W_e h_e}{W_p h_p} \qquad \text{(Eq 4.2)}$$

Where S_e and S_p are the cross-sectional areas of the expanded product and the pellet; W_e and h_e are the width and thickness of the expanded product and W_p and h_p are the width and thickness of the pellet, respectively. Ten representative samples were measured and results were presented as mean ± standard deviation.

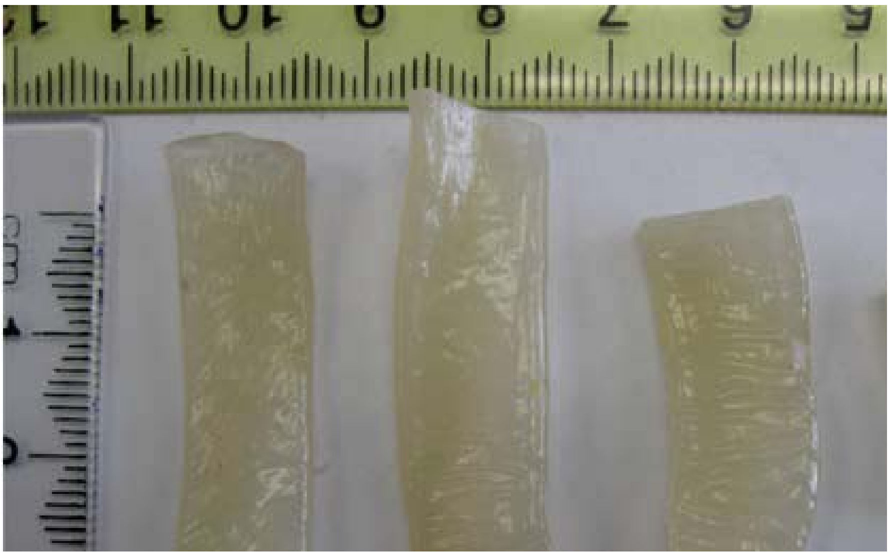


Figure 4.1: Wet extrudate of coarse rice flour (70 %) and potato starch (30 %)

4.3. RESULTS AND DISCUSSION

4.3.1. Physico-chemical properties of individual ingredients

The particle sizes of unground major raw materials were determined as described in Section 4.2.2 and the results are summarised in Table 4.1. Potato starch was found to be a very fine powder and all samples passed through the 280 μm sieve. Maize polenta had the highest portion of particles above 500 μm (81.91 %) and the lowest portion of particles below 280 μm (2.12 %), followed by ancient grain flour blend. The typical particle size of maize polenta was found to be largest of all the samples tested. Ancient grain flour blend showed the greatest particle size variation. Even though the portion of particles smaller than 280 μm was the majority in the blend, the portion of particles greater than 500 μm and the portion of particles between 280 μm and 500 μm were both over 25 %. Wholemeal wheat flour was found to have the finest particle size in cereal ingredients with approximately 77 % of the particles less than 280 μm. The portion of wholemeal wheat flour particles greater than 500 μm were found to be mostly bran with very little endosperm as shown in Figure 4.2. This was different from the particle size variation observed for the ancient grain flour blend, the portion of ancient grain particles greater than 500 μm (31.7 %) were found to be mostly endosperm. Hi-Maize™ wholegrain flour and coarse rice flour had similar particle size distributions. Both of which had less than 5 % of the flour particles more than 500 μm and approximately 50 % of the flour particles less than 280 μm. Hi-Maize™ wholegrain flour was found to have more particles less than 280 μm than that of coarse rice flour.

Table 4.1: Typical particle size of ingredients

	Retained on 710 μm (%)	**Retained on 500 μm (%)**	**Retained on 280 μm (%)**	**<280 μm (%)**
Ancient Grain Flour Blend	5.00± 0.07	26.66 ± 2.13	25.17 ± 0.59	46.11 ± 4.04
Coarse Rice Flour	1.02 ± 0.06	3.72 ± 0.48	50.27 ± 1.49	44.99 ± 1.76
Maize Polenta	22.52 ± 0.80	59.39 ± 1.33	15.97 ± 0.66	2.12 ± 0.46
Wholemeal Wheat Flour	13.35 ± 0.91	6.82 ± 1.52	2.26 ± 0.56	77.57 ± 2.40
Hi-Maize Wholegrain Flour	0.01 ± 0.15	1.17 ± 0.28	30.85 ± 1.94	67.97 ± 1.30
Potato Starch (Elian™ 100)	0	0	0	100

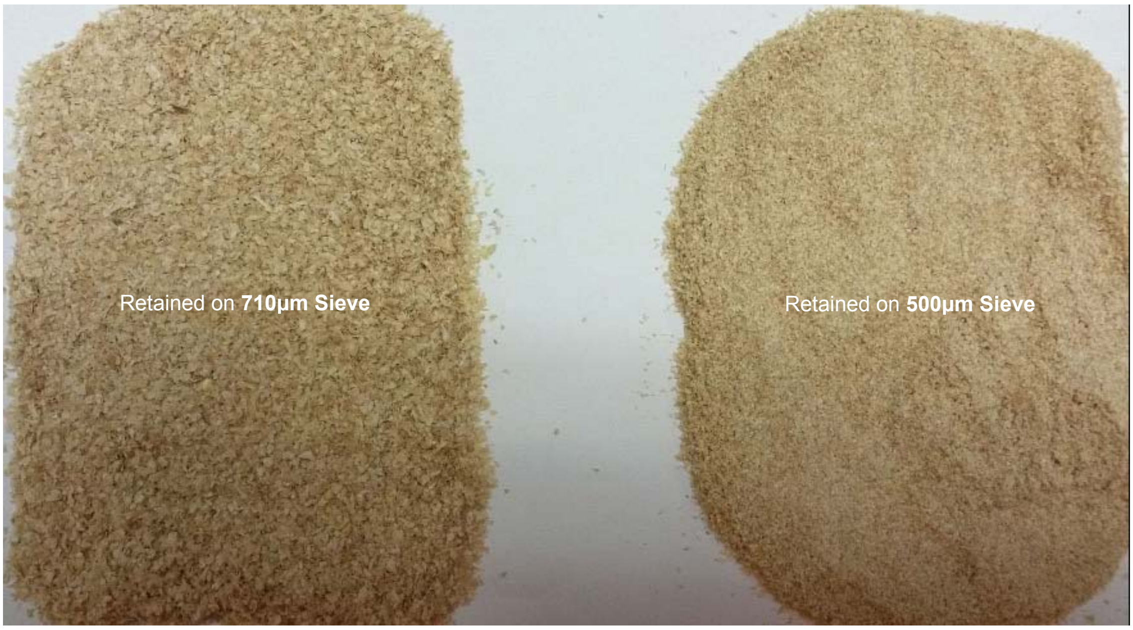


Figure 4.2: Wholemeal wheat flour retained on 710 µm and 500 µm sieves

The proximate composition and moisture contents of the ingredients are summarised in Table 4.2. All raw material moisture contents were similar with most ranging between 10 % to 13 % w/w. Ancient grain flour blend has the lowest moisture content, and potato starch has the highest moisture content. Hi-Maize^{TM} wholegrain flour is significantly lower in carbohydrate and higher in dietary fibre than all other raw materials. Hi-Maize^{TM} wholegrain flour also has the lowest starch content (≤ 47.0 % w/w) and the highest fat content. The protein content of Hi-Maize^{TM} wholegrain flour is also relatively high compared to all the other materials but is not the highest. Ancient grains flour blend has the highest protein content and its fat content is similar to Hi-Maize^{TM} wholegrain flour. The carbohydrate content and starch content of ancient grains and wholemeal wheat flour are similar at approximately 60 % w/w.

Among all cereal ingredients, coarse rice flour has the highest carbohydrate content and starch content, followed by maize polenta. Their typical protein contents are identical at 7.5 % w/w and both are low in dietary fibre. Potato starch contains the highest carbohydrate and starch. The protein content and fibre content of potato starch are less than 0.1 % w/w. A typical 3G snack recipe requires more than 60 % starch to maximize expansion of the snack pellet during hot oil or hot air puffing (Hertzel & Plattner, 2005; Riaz, 2006; Sunderland, 1996). Coarse rice flour, maize polenta and potato starch contain more than 70 % of starch. Thus, they can be used as the main structural building ingredients for the 3G snack recipe.

Table 4.2: Typical proximate composition of ingredients

Raw Material	*Carbohydrate[1] (g/100g)*	*Sugar[1] (g/100g)*	*Protein[1] (g/100g)*	*Fat[1] (g/100g)*	*Dietary Fibre[1] (g/100g)*	*Starch[2] (g/100g)*	*Moisture[3] (%)*
Ancient Grain Flour Blend[4]	60.3	0.5	13.1	5.8	8.1	59.8	10.1
Wholemeal Wheat Flour	60.9	1.0	11.0	2.0	11.8	59.9	12.7
Maize Polenta	76.0	≤ 4.0	7.5	2.0	≤ 3.0	72.0	11.8
Coarse Rice Flour	78.5	1.0	7.5	0.7	0.5	77.5	12.5
Hi-Maize™ Wholegrain Flour	47.0	NA[5]	9.5	5.0	25.0	≤ 47.0	11.2
Potato Starch (Elian™ 100)	80.0	0	<0.1	0.05	0	80.0	13.2

[1] Information provided in raw material specifications from supplier

[2] Calculated by subtracting sugar from carbohydrate

[3] Moisture content determined as described in Section 3.6.1

[4] Calculated by average nutrient values of amaranth, quinoa and millet.

[5] Information is not available on the raw material specification

4.3.2. Pasting properties of individual ingredients

The RVA pasting properties of all the major 3G snack ingredients, namely ancient grain flour blend, coarse rice flour, maize polenta, wholemeal wheat flour, Hi-Maize^{TM} wholegrain flour and potato starch, are summarised in Table 4.3. The results presented were taken from the pasting curve generated as shown in Figure 2.2.

Table 4.3: Pasting properties of ingredients (mean values ± standard deviation for n=2)

	Pasting Temp (˚C)	PV (cP)	PT (seconds)	BD (cP)	FV (cP)	SB (cP)
Ancient Grain Flour Blend	83.3 ± 3.4^{a}	1268.5 ± 290.6^{c}	434.0 ± 2.8^{a}	-	2667.0 ± 586.9^{cd}	-
Coarse Rice Flour	81.2 ± 0.5^{a}	3350.0 ± 21.2^{b}	378.0 ± 14.1^{b}	41.0 ± 25.5^{b}	6527.0 ± 106.1^{a}	3218.0 ± 59.4^{a}
Maize Polenta	85.3 ± 0.6^{a}	1090.5 ± 38.9^{c}	432.0 ± 0.0^{a}	-	3200.5 ± 167.6^{bc}	-
Wholemeal Wheat Flour	68.9 ± 0.6^{b}	1442.5 ± 79.9^{c}	320.0 ± 0.00^{c}	773.0 ± 38.2^{b}	1575.5 ± 29.0^{d}	906.0 ± 70.7^{b}
Hi-Maize Wholegrain Flour	-	37.5 ± 0.7^{d}	408.0 ± 0.0^{ab}	5.5 ± 0.7^{b}	39.5 ± 0.7^{e}	7.5 ± 0.7^{b}
Potato Starch	70.3 ± 0.0^{b}	5703.0 ± 349.3^{a}	210.0 ± 25.5^{d}	3120.5 ± 953.9^{a}	3964.5 ± 386.8^{b}	1382.0 ± 916.4^{ab}

Value in a column with superscripts in common did not differ significantly ($p < 0.05$). Analysis details refer to Appendix A 3.1.

Pasting Temp, the temperature where viscosity first increases by at least 25 cP over a 20 s period; PV, maximum paste viscosity achieved during the heating cycle; PT, time when maximum paste viscosity achieved; BD, peak viscosity minus the viscosity after the holding period at 95 °C; FV, final viscosity; SB, difference between the final viscosity and the viscosity reached after the first holding period.

As shown in Table 4.3, all cereal flours exhibited significantly lower peak and breakdown viscosities and had much longer peak time than shown for potato starch. This could be because of the large starch granule size of potato starch and the presence of a phosphate ester group on amylopectin molecules of the starch (Fennema, 1996; Singh et al., 2009; Zaidul, Norulaini, Omar, Yamauchi, & Noda, 2007). Large starch granules are generally less dense and easier to gelatinise than small granules as reviewed in Section 2.1.1.2. This is because gelatinisation is an endothermic transition, and large starch granules have a higher gelatinisation enthalpy than that of small granules (Chiotelli & Le Meste, 2002; Myllärinen et al., 1998).

Among the cereal flours, coarse rice flour had the highest peak, final and setback viscosities; whereas, Hi-Maize^{TM} wholegrain flour exhibited the lowest peak, final and setback viscosities. High peak viscosity was associated with small particle, low lipid content and high starch content flour (Chiang & Yeh, 2002). No breakdown and setback viscosities were observed for ancient grain flour blend and maize polenta. The peak and final viscosities of the ancient grain flour blend and potato starch had very large standard deviations. Repeated tests were carried out, but was not able to produce a repeatable curve. No pasting temperature was recorded for Hi-Maize^{TM} wholegrain flour, because the largest increase of viscosity was 13.5 ± 2.1 cP over a 20s period.

Representative pasting curves for ancient grain flour blend, coarse rice flour, maize polenta, wholemeal wheat flour and potato starch are shown in Figure 4.3. Figure 4.3 shows that the potato starch pasting curve was jagged. This may be due to the high viscosity of potato starch. It was suggested that the concentration of the potato starch should be reduced for the test, as viscous pastes are prone to form an air cell behind the paddle blade, resulting in a non-repeatable and jagged curve (Anonymous, 1997). Observation on the pasting properties of potato starch was in agreement with studies of Zaidul et al. (2007), in which they found that potato starch exhibited the highest peak and breakdown viscosities among all the commercial starches. They reported the potato starch had a pasting temperature of 69.1 ºC. This is similar to the potato starch pasting temperature results (70.3 ºC) in this study.

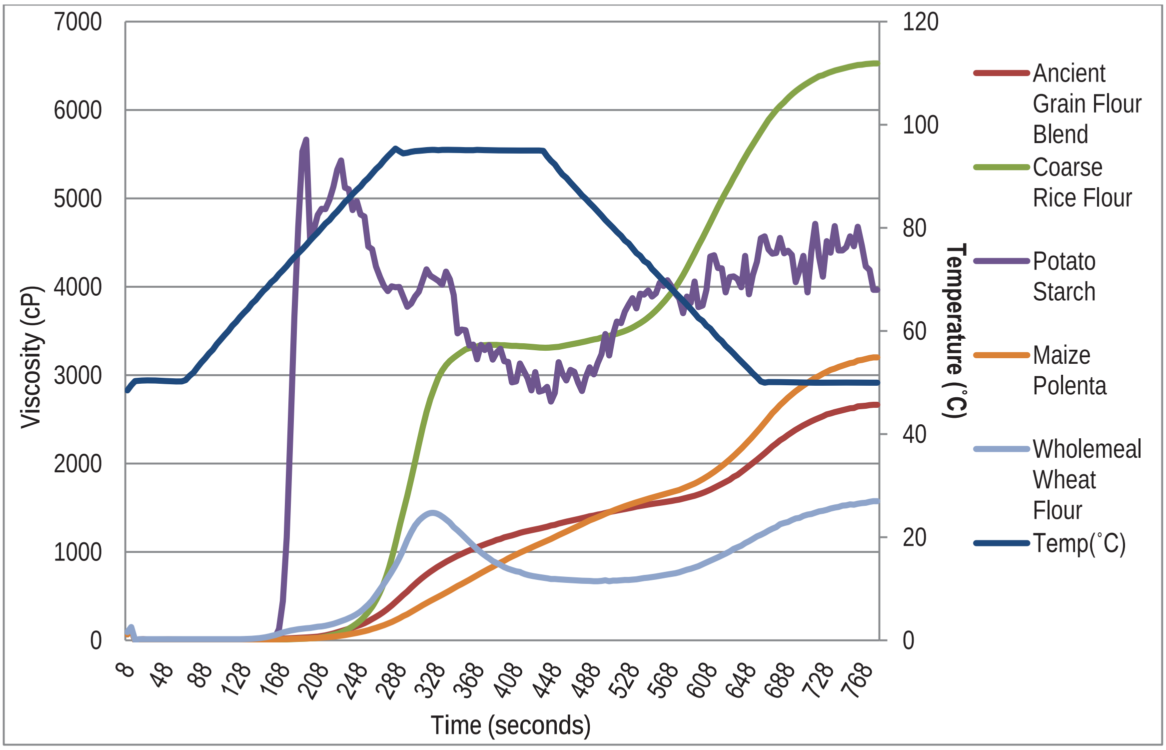


Figure 4.3: Representative pasting curves of ingredients by rapid visco-analyser

The pasting curve obtained for the ancient grain flour blend and that of maize polenta were quite similar. Maize polenta had a slightly higher final viscosity than that of the ancient grain blend flour. The coarse rice flour pasting curve showed a plateau after reaching peak viscosity, and the viscosity continued to rise upon cooling until the final viscosity was achieved at the end of the test. Similar results for rice flour were reported by Zhou et al. (2002). They explained a high setback value was attributed to leached amylose from rice starch. These molecules interacted with other components in rice, which inhibited softening (Zhou et al., 2002). The lower breakdown value obtained implied higher hot paste stability (resistance to shear thinning during cooking) (Qian & Kuhn, 1999). This is good for extrudates to retain their shape after puffing.

Wholemeal wheat flour produced a typical pasting curve that comprised of peak, break down, final and setback viscosities. It had a significantly lower pasting temperature and peak time than other cereal flours. This was assumed to be due to the small particle size of the wholemeal wheat flour.

The cereal ingredients were then ground to ensure they passed through a 280 µm screen. The ground cereals were then tested on the RVA as described in Section 3.8.1. Viscosity data are summarised in Table 4.4.

Table 4.4: Pasting properties of ground cereal ingredients (mean values ± standard deviation for n=2)

	Pasting Temp (˚C)	**PV (cP)**	**PT (seconds)**	**BD (cP)**	**FV (cP)**	**SB (cP)**
Ancient Grain Flour Blend	71.0 ± 0.1^{c}	1299.5 ± 3.5^{c}	374.0 ± 36.8^{ab}	383.0 ± 427.1^{bc}	1632.5 ± 27.6^{c}	716.0 ± 458.2^{cd}
Coarse Rice Flour	79.1 ± 0.0^{a}	4351.0 ± 244.7^{a}	356.0 ± 5.7^{bc}	1127.5 ± 33.2^{ab}	6477.5 ± 126.6^{a}	3254.0 ± 151.3^{a}
Maize Polenta	73.9 ± 0.5^{b}	2892.0 ± 219.2^{b}	302.0 ± 2.8^{c}	1309.5 ± 128.0^{a}	3885.0 ± 118.8^{b}	2302.5 ± 27.6^{b}
Wholemeal Wheat Flour	70.6 ± 0.5^{c}	1302.5 ± 7.8^{c}	344.0 ± 5.7^{bc}	701.5 ± 23.3^{abc}	1540.0 ± 32.5^{c}	939.0 ± 17.0^{c}
Hi-Maize Wholegrain Flour	-	61.0 ± 2.8^{d}	444.0 ± 11.3^{a}	9.0 ± 1.4^{c}	68.0 ± 2.8^{d}	16.0 ± 1.4^{d}

Value in a column with superscripts in common did not differ significantly ($p < 0.05$). Analysis details refer to Appendix A 3.2.

Pasting Temp, the temperature where viscosity first increases by at least 25 cP over a 20 s period; PV, maximum paste viscosity achieved during the heating cycle; PT, time when maximum paste viscosity achieved; BD, peak viscosity minus the viscosity after the holding period at 95 °C; FV, final viscosity; SB, difference between the final viscosity and the viscosity reached after the first holding period.

The breakdown and setback viscosities of the ancient grain flour blend had very large standard deviations. This was assumed to be due to the composition variation of the grain mixture. Ground coarse rice flour still exhibited the highest peak, final and setback viscosities among ground cereal flours, followed by ground maize polenta. The peak viscosity of potato starch (Table 4.3) was still much higher than all the other ground cereal ingredients. Ground Hi-Maize™ wholegrain flour still exhibited the lowest peak, final and setback viscosities. No pasting temperature was recorded for

Hi-Maize^{TM} wholegrain flour, because the largest increase of viscosity was 23.5 ± 2.1 cPs over 20s period. It also showed the lowest breakdown viscosity, and the longest peak time.

Representative pasting curves of ancient grain flour blend, coarse rice flour, maize polenta and wholemeal wheat flour after grinding are shown in Figure 4.4. After grinding, other than the Hi-Maize^{TM} wholegrain flour, all other cereal flours showed more of a typical RVA pasting curve; all had pasting temperatures and peak, breakdown, final and setback viscosities. The pasting curve of ancient grain flour blend and that of wholemeal wheat flour were similar. This was due to the similarity of their physical-chemical properties. They both had significantly lower pasting temperatures; also had lower peak, final and setback viscosities than those of coarse rice flour and maize polenta, but ancient grain flour blend was found to be more resistant to breakdown. This may have been because the ancient grain flour blend only contained approximately half the amount of amylose compared to that of wholemeal wheat flour (Section 2.1.1.2). The fat content of ancient grain flour blend was nearly three times higher than that of wholemeal wheat flour (Table 4.2). Amylose-lipid complexes are easily formed to inhibit viscosity change (Singh et al., 2009). The low peak viscosity, high paste stability of ancient grain flour blend would make it suitable for high temperature high shear food extrusion process (Qian & Kuhn, 1999).

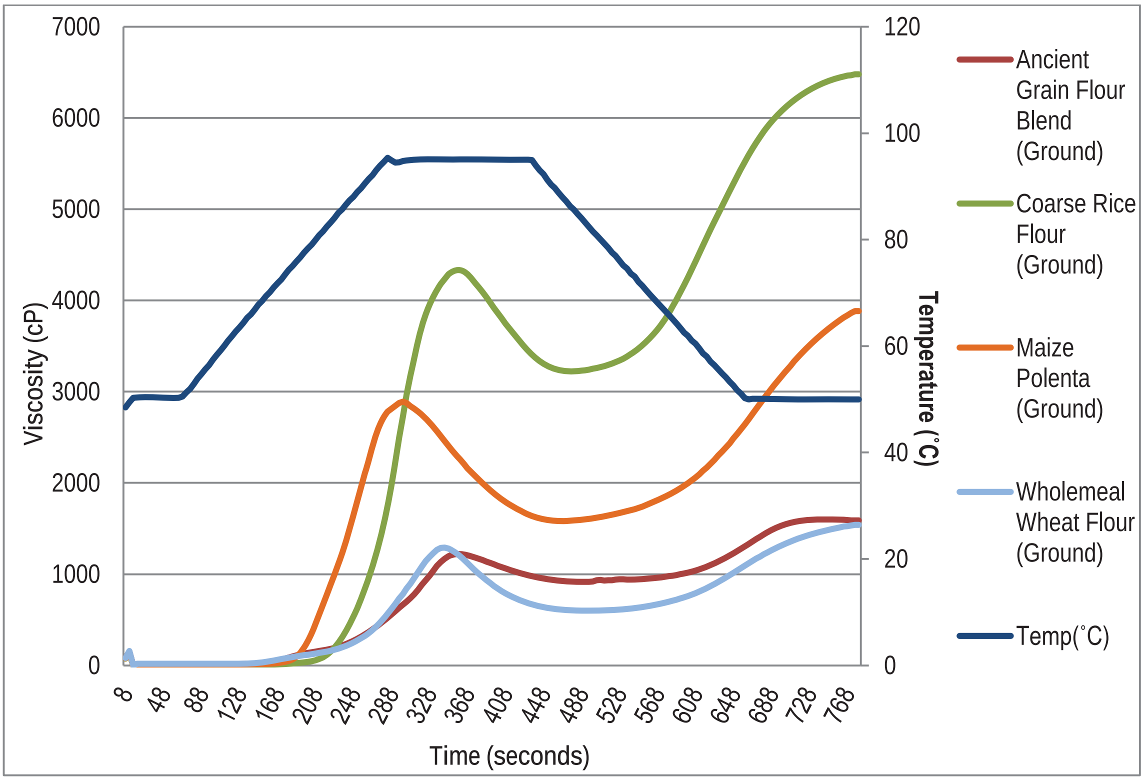


Figure 4.4: Representative pasting curves of ground cereal materials by rapid visco-analyser

The RVA pasting properties of the main ingredients before and after grinding were compared. Particle size of the ingredients was found to have an effect on the starch pasting profile (Table

4.3 and 4.4). This observation was supported by similar observations by (Marshall, 1992) and (Hoseney, 1994). The viscosity profiles after grinding, for all cereal flours except for wholemeal wheat flour, began to paste at a lower temperature. At the same ingredient particle size (< 280 µm), rice flour had significantly higher pasting temperature than that of maize flour, ancient grain flour blend and wholemeal wheat flour. The pasting temperatures of coarse rice flour, 73-86 ºC, are in agreement with Zhou et al., (2002). The pasting temperature provides an indication of the minimum temperature required to cook a given sample.

The pasting curves of coarse rice flour, maize polenta, ancient grain flour blend and Hi-Maize™ wholegrain flour after grinding also had higher peak, breakdown and setback viscosities than the original flours in corresponding to unground raw materials. The grinding of the rice flour had little effect on the final viscosity and cooling period of the pasting curve. Unground maize polenta had no breakdown and setback viscosities (Figure 4.2), the viscosity increased over the testing period. When the maize polenta was ground to less than 280 µm particle size, a significantly lower pasting temperature (unground maize polenta 85.3 ± 0.6 ˚C, ground maize polenta 73.9 ± 0.5 ˚C, $p<0.05$) and a significantly higher peak viscosity was observed (unground maize polenta 1090.5 ± 38.9 cP, ground maize polenta 2892.0 ± 219.2 cP, $p<0.05$) (Table 4.3 and 4.4). Ground ancient grain flour blend had increasing viscosities over the testing period. Smaller particle size resulted in a slight reduction in pasting temperature. The peak time was a little shorter for the ground sample and the peak viscosity increased slightly. The variability of viscosities and non-repeatable pasting curves may be due to the variable particle size distribution of the different flours (Table 4.1) and the composition variation of the grain mixture.

The pasting properties for wholemeal wheat flour largely remained unchanged before and after grinding (Table 4.3 and 4.4). This was because of the narrow particle size distribution of the wholemeal wheat flour and the majority of the particles (73 %) were less than 280 µm, which is the same as the mill sieve of 280 µm. Particles greater than 500 µm (25.3 %) were mostly coarse wheat bran (Figure 4.2), which does not participate in the starch gelatinisation. Hence, similar pasting curves were obtained before and after grinding the wholemeal wheat flour.

Hi-Maize™ wholegrain flour illustrated unique pasting curves. Figure 4.5 shows the pasting curves of Hi-Maize™ wholegrain flour before and after grinding, and after reheating. The reheating curve was generated by re-starting the RVA™ general pasting programme immediately after completing the initial RVA cycle without adding more Hi-Maize™ wholegrain flour and deionized water and the same RVA temperature profile was used. Figure 4.5 shows that for Hi-Maize™ wholegrain flour the PV, BD, FV and SB were all very low after gelatinisation. The increased in cold peak viscosity (212.0 cP) and flat reheated curve shows the degree of cook also increases for the Hi-Maize™ wholegrain flour (Singh et al., 2009). No cold peak viscosity change was observed for Hi-Maize™ wholegrain flour before (136.5 cP) and after grinding (138.0 cP). The Hi-Maize™ wholegrain flour is high in lipid content (5.9 %) and low in starch (≤ 47.0 %) (Table 4.2). In addition, the starch is high in amylose content. Amylose and natural lipids can cause substantial suppression of swelling of starches under conditions when amylose-lipid complexes can be formed (Anonymous, 1997; Tester & Morrison, 1990a). In addition, the tightness of Hi-Maize™ starch structure leads to lower rate of water penetration and reduced swelling of starch granules (Qian & Kuhn, 1999). This observation agreed with that of Zaidul et al. (2007), who studied the pasting properties of cassava, sorghum and *Curuma zedoaria* and, found that higher amylose starches had low viscosities and exhibited very small differences between the peak and final viscosities. This observation can be explained by Fennema (1996), who reported that under ordinary cooking conditions, where the slurry is heated to 95 - 100 °C, high amylose corn starch does not impact on viscosity and, pasting does not occur until the temperature reaches 160 - 170 °C.

For Hi-Maize™ wholegrain flour, as the sample cooled down at approximately 610 seconds, an increase in viscosity was observed (Figure 4.5). This was assumed to be due to retrogradation of amylose (Fennema, 1996). The amylose content was also highly correlated to the final and setback viscosities (Singh et al., 2006). Similar to other cereal pasting curves, after grinding, the Hi-Maize™ wholegrain flour had higher peak, breakdown and setback viscosities than the original flours.

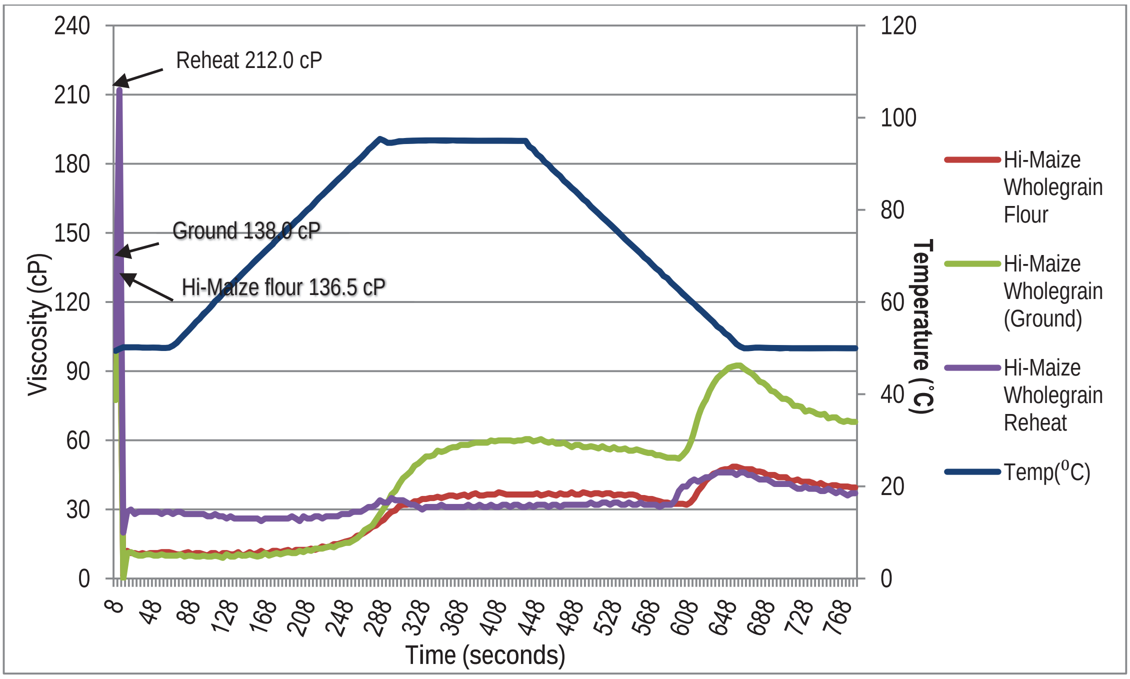


Figure 4.5: Representative pasting profiles of original, ground and reheated Hi-Maize™ wholegrain flour

4.3.3. Preliminary assessments of extruded cereal-potato starch mixtures

To understand the limit and impact of potato starch to be added to the base 3G snack formulations, coarse rice flour-potato starch mixture and maize polenta-potato starch mixture were studied. The cereal flour were replaced with potato starch at 0, 30 % and 50 %, followed by extrusion. The preliminary snack formulations and extruder processing parameters used are summarised in Table 4.5 and 4.6, respectively.

Table 4.5: Preliminary 3G snack formulation

ID	Coarse Rice Flour	Corn Polenta	Potato Starch
Coarse rice flour	100.0	0	0
Coarse rice flour-potato starch 70:30	70.0	0	30.0
Coarse rice flour-potato starch 50:50	50.0	0	50.0
Maize polenta	0	100.0	0
Maize polenta-potato starch 70:30	0	70.0	30.0
Maize polenta-potato starch 50:50	0	50.0	50.0

Replacing less than 30 % of cereal flour with potato starch did not affect the flow of the ingredients in the extruder (Table 4.6). The coarse rice flour and potato starch 50/50 mixture experienced inconsistent feed twice during a 15 minute run, and the problem was worse for maize polenta and potato starch 50/50 mixture, significant feeder and auger bridges were observed during the run. The bridging points are shown in Figure 4.6. Modification for feeder chute was required for further work. Another issue identified with maize polenta and potato starch mixtures was that some of the maize particles were still visible in the extruded pellets. This would give uneven expansion of the pellets. It was recommended to reduce the water addition rate or decrease the screw speed in order to increase the time to allow for ingredient melting in the extruder.

The rice flour - potato starch pellets and their expanded product properties were compared. The results are shown in Table 4.7. Results show that potato starch resulted in significant improvement on the product texture (softer on bite) and increased puffing. However, adding more potato starch (50 %) did not enhance puffing, but caused complications on feeding, the increased amount of potato starch caused bridging in the feeder. Therefore, it was recommended to use 70 % cereal flour and 30 % potato starch as the base 3G snack formulation for further work.

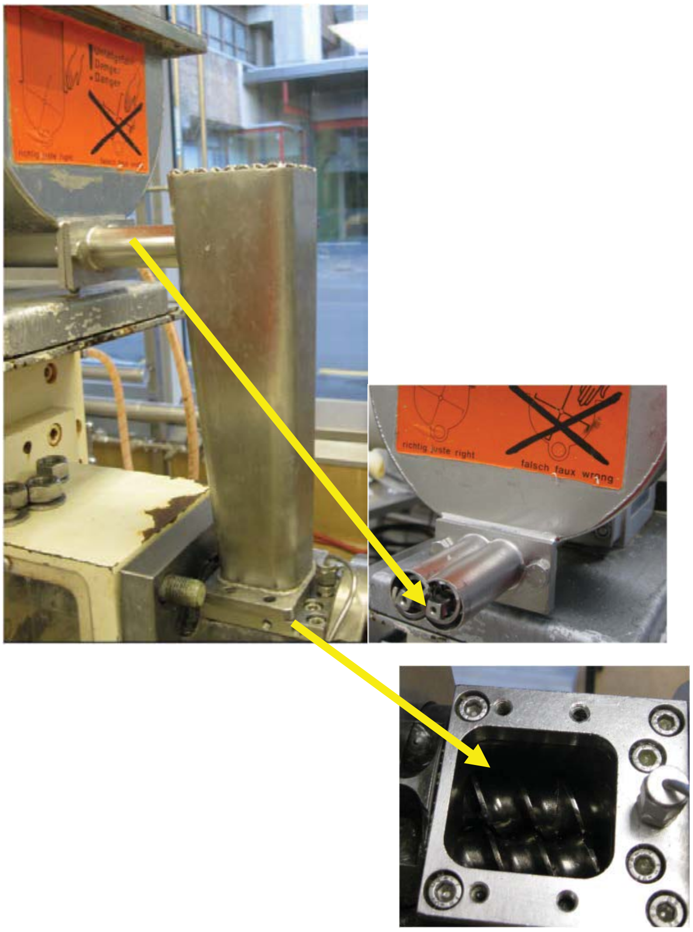


Figure 4.6: Extruder feeder settings and potential bridging points

Table 4.6: Extruder processing parameters for cereal-potato starch mixtures

	Apparent Torque (Nm)	*Screw Speed (rpm)*	*Feed Rate (dial)*	*Water Rate (kg/h)*	*Thrust Pressure (Bar)*	*Power (kW)*	*SME (kWh/kg)*	*Die Pressure (bar)*
Coarse rice flour	4.1	452	63	1.8	29.0	1.8	0.20±0.01	69.0
Coarse rice flour-potato starch 70:30	5.4	452	60	1.8	14.0	2.0	0.26±0.01	51.0
Coarse rice flour-potato starch 50:50	3.4	452	61	1.8	5.0	1.2	0.18±0.01	46.0
Maize polenta	3.4	451	46	1.6	9.0	1.3	0.21±0.01	52.0
Maize polenta-potato starch 70:30	3.8	452	53	1.6	10.0	1.6	0.19±0.01	57.0
Maize polenta-potato starch 50:50	Feeder and auger were bridged badly resulted in large variations on extruder apparent torque, thrust pressure and die pressure. Product came out very wet and corn particles were still visible.							

Table 4.7: Comparison of rice pellets made with 0 %, 30 % and 50 % potato starch

	100 % Coarse Rice Flour	***70 % Coarse Rice Flour & 30 % Potato Starch***	***50 % Coarse Rice flour & 50 % Potato Starch***
Pellet Thickness (mm)	0.90 ± 0.11	0.86±0.11	0.93 ± 0.09
SEI (Eq 4.2)	4.36 ± 0.26	6.29±0.50	5.92 ± 0.30
Pictures			

The base formulation was improved by incorporating wholegrain and ancient grain as shown in Table 4.8. Sanitarium Health & Wellbeing Company required a product containing minimum of 25 % wholegrain in the finished product to be able to make a wholegrain claim. Ancient grain flour blend was the most expensive cereal ingredients at more than three times the price of normal cereal flours. Therefore, it was kept as minimal as possible (5 %), but still met the required ingredient claim.

Table 4.8: Third generation (3G) snack base formulation with wholegrain wheat and ancient grains

Ingredient	***Percentage (%)***
Coarse Rice Flour	40
Wholemeal Wheat Flour	25
Ancient Grain Blend	5
Potato Starch	30

The 3G snack base formulation in Table 4.8 ran through the extruder with the processing parameters shown in Table 4.9. No feeding issues were experienced. However, it was found that ancient grain flour particles were still visible in the final pellets. It was suggested that the degree of cooking in the extruder should be increased. Due to the incomplete starch gelatinisation, extruded pellets were not puffed for further analysis.

Table 4.9: Extruder processing parameters for improved 3G snack base formulation

Apparent Torque (Nm)	**Screw Speed (rpm)**	**Feed Rate (dial)**	**Water Rate (kg/h)**	**Thrust Pressure (Bar)**	**Power (kW)**	**SME (kWh/kg)**	**Die Pressure (bar)**
5.2	352	79	1.8	16	1.5	0.19±0.00	57

4.4. CONCLUSIONS AND RECOMMENDATIONS

It is clear from the current results that pasting properties were affected by amylose and lipid content, and particle size of the cereal flour. The pasting curve results indicated that cereal flours, whole grain meal and potato starch have a wide range of pasting properties, and pasting curve providing information about the viscosity of the cereal flour. The peak viscosity provides an indication of the viscous load likely to be encountered during extrusion. The higher the peak viscosity, the more energy consumption is likely to occur during extrusion.

Based on the outcome of the physico-chemical analysis and pasting properties of ingredients, both coarse rice flour and maize polenta can be used as the major structure-building ingredient for the 3G snack. The portion of wholemeal wheat flour and ancient grain flour will be added to ensure a wholegrain claim can be made. Hi-Maize^{TM} wholegrain flour was not suitable to be used as the structure-building ingredient for 3G snack. Potato starch is to be used to manipulate the pasting properties of the ingredient mixture for the final product. However, potato starch should not be used at more than 30 % to ensure free flow of ingredients to the extruder and to achieve good puffing.

The improved multigrain 3G snack formulation: coarse rice flour 40 %, wholemeal wheat flour 25 %, ancient grain flour blend 5 %, and potato starch 30 %, was found to run well during extrusion. However, the degree of cooking in extruder needs to be increased to minimise visible cereal particles in the pellets and to ensure adequate pellet puffing subsequently.

5. EFFECT OF FIBRE ON 3G EXTRUDED SNACKS

5.1. INTRODUCTION

A base 3G snack formulation was established through ingredient selection in Chapter 4. Sanitarium Health & Wellbeing Food Company desired a more advanced pellet shape with a fibre claim for the 3G snack development work, which would be a challenge for the formulation and process. A special wave shaped die was designed (Figure 3.4). Regarding the fibre fortification, three types of dietary fibre were studied.

The three types of dietary fibres were wheat fibre 600, Beneo GR and Hi-Maize^{TM} 1043. Wheat Fibre 600 is a creamy white, microfine, water insoluble dietary fibre produced by a special process from the structure building components of the wheat plant according to the supplier specification (Appendix A 1.4). Beneo GR is a water soluble dietary fibre consisting mainly of chicory inulin, GR stands for granulated powder (Appendix A 1.4). Hi-Maize^{TM} 1043 is a natural, unmodified, high amylose resistant starch made from maize (Appendix A 1.4).

Previous research revealed that the effect of fibre on extrudate expansion was concentration dependent (Grenus et al., 1993; Onwulata et al., 2001) and Hertzel & Plattner (2005) suggested that the amount of fibre usage in the 3G snack should be less than 5 %. However, there has been limited research aimed at 3G snacks with different types of fibre, especially the effect of fibres and process variables on physical and textural properties of pellets and puffed products.

To understand the aforementioned relationships, this study investigated the effect of three types of fibre on the physico-chemical and RVA pasting properties of a rice, wheat and potato starch based 3G snack under controlled extrusion, drying and subsequent puffing conditions. The water activity of the pellets during the drying process was measured, because it provided a good indication of the pellet shelf life as described in Section 2.4.1. Pasting parameters generated from the RVA of raw and extruded formulations were important, because they provided information on the effect of the different types and levels of fibre on pasting properties of ingredient mixture. It was assumed to provide a relative measure of the degree of starch gelatinisation and disintegration during extrusion, which could influence the finished product expansion and texture (Section 2.4.4). Physico-chemical properties of the puffed product provided direct evidence of the effect of fibre on the pellet expansion. The results of this study will determine the most suitable fibre and its concentration for a 3G snack.

5.2. MATERIALS AND METHODS

The ingredients, formulation and extruder parameters used in this series of experiments are detailed in Section 3.1 and Section 3.5.1, respectively. A 2×3 full factorial design was used. The experimental factors were: three types of fibre, two levels of the each fibre, plus a control without any fibre inclusion. The formulations tested are shown in Table 3.4 in Chapter 3. For each fibre inclusion, they were designated as either 'Lo' low concentration or 'Hi' high concentration.

A process was developed to produce air-puffed 3G snacks in lab. The process flow chart is shown in Figure 5.1. Extruded pellets were dried in the air oven at 55 ± 5˚C for 2 hours with relative humidity controlled at approximately 60 %. The pellets were then sealed in polypropylene plastic containers, held in a polystyrene box with saturated sodium chloride solutions (RH 75 %) (Wexler & Hasegawa, 1954) and stored in a warm room (30 ± 5˚C) for 2 hours to help keep the product surface moisture high and hence accelerate water diffusion rate from pellet core to surface (Eq 2.13). The pellets were then placed back in the air oven at 55 ± 5˚C to dry for a further 2 to 2.5 hours. The pellets were then held in sealed polypropylene plastic containers in the polystyrene box with saturated sodium chloride solutions (RH 75 %) (Wexler & Hasegawa, 1954) at 30 ± 5˚C overnight. The dried pellet moisture content was measured hourly and calculated according to Section 3.6.1. Pellet water activity was measured hourly according to Section 3.6.2. Pellet average moisture loss rate was calculated by Equation 5.1.

$$\text{Average moisture loss rate} = \frac{(\text{Exit extruder moisture} - \text{End of drying moisture})}{\text{Total drying time}} \quad \text{(Eq. 5.1)}$$

If the moisture content was more than 10 % w/w, the pellets were further dried to approximately 9.5 % in the same air oven and with the same oven settings. Dried pellets were kept in the sealed plastic polypropylene containers for a minimum of 48 hours before puffing. Ten grams of snack pellets were placed into a popcorn machine (Crazy™ Popper, Breville Australia). Pellets were puffed for 50 ± 2 seconds and then poured into a bowl to cool down.

A series of assessments were conducted to determine the characteristics and quality of the pellets and puffed products. Firstly, visual assessment was carried out to determine the quality of extruded pellets after drying and 48 hours of storage. Ten grams of random sampled pellets from each treatment were used for pellet checking assessment. Pellet checking was for visible cracks on or under the surface of the pellets. The assessment was carried out in triplicate for each treatment. The mean number of checked pellets ± standard deviation (SD) values are presented. Secondly, the pasting properties of the extruded pellets were studied to determine the influence of the added fibres. Experimental details are presented in Section 3.8. Last but not least, structural assessment was carried out on the puffed products. Structural attributes measured were according to Section 3.6.7 microstructure analysis. The experiments were completed in triplicate.

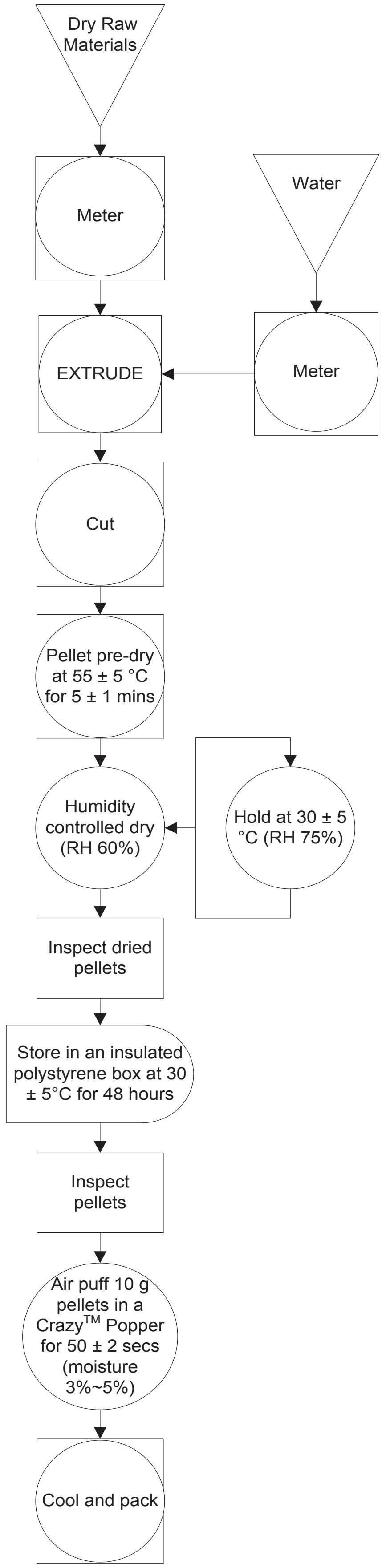


Figure 5.1: Lab-made air-puffed 3G snack process flow chart

5.3. RESULTS AND DISCUSSION

5.3.1. Chemical Characteristics of fibre enriched 3G formulation

Starch content of the different ingredients was estimated and calculated by subtracting total sugar from carbohydrate as described in Section 4.2.2. Given the fact that the actual seasoning coating ratio for the final product was unknown, this formulation was designed in a way to meet project nutrient and texture (relate to formulation starch content) requirements assuming the seasoning coating would contribute approximately 20 – 25 % of the nutrients. Hence, the 3G base formulations contained 36 % w/w wholegrain, 5 % w/w ancient grain blend, approximately 6.8 % w/w fibre at lower fibre addition and 8.8 % w/w fibre at high fibre addition (Table 5.1). The starch contents of all the formulations were more than 65 %.

Table 5.1: Wholegrain, theoretical starch and fibre contents of 3G formulations

ID	*Starch Content (%)*	*Wholegrain (%)*	*Fibre Content (%)*
Control	69.9	36	4.8
WF Lo	68.3	36	6.8
WF Hi	66.8	36	8.8
Beneo Lo	68.3	36	6.7
Beneo Hi	66.8	36	8.6
Hi-Maize Lo	68.3	36	6.8
Hi-Maize Hi	66.8	36	8.8

Note: starch and fibre content calculation details refer to Appendix A 4.1.

5.3.2. Extrusion process and pellet moisture change after extrusion and drying

Table 5.2 shows that even though the extruder configuration and independent processing parameters were set the same in all treatments (Section 3.5.1), the resulting dependent process parameters, such as torque, SME, die and thrust pressures were quite variable. There was little variation between treatments containing wheat fibre 600 and Beneo GR. However, it was observed that treatments containing Hi-Maize^{TM} 1043 were difficult to feed into the extruder. The extruder apparent torque, thrust and die pressures in treatments containing Hi-Maize^{TM} 1043 were all much lower than that of other treatments. The SME for Hi-Maize Hi was lower than that of all other treatments.

Table 5.2: Resulting dependent extruder processing parameters

	Apparent Torque (Nm)	*Thrust Pressure (Bar)*	*Temperature at die (˚C)*	*Die pressure (Bar)*	*Power (kW)*	*SME (kWh/kg)*
Control	4.6	42	45.8	74	0.98	0.133 ± 0.002
WF Lo	4.3	40	46.7	77	0.98	0.135 ± 0.001
WF Hi	4.7	38	48.6	75	0.98	0.129 ± 0.003
Beneo Lo	4.6	40	49.9	78	0.98	0.124 ± 0.005
Beneo Hi	4.4	40	50.8	78	0.96	0.120 ± 0.003
Hi-Maize Lo	3.9	30	50.4	68	0.87	0.127 ± 0.011
Hi-Maize Hi	3.2	24	48.6	62	0.73	0.112 ± 0.004

The moisture contents of all raw and extruder exit samples are shown in Table 5.3. The blends of raw material prior to the extruder had similar moisture contents, except the recipes with Hi-Maize^{TM} had slightly higher raw material moisture contents. The amount of added water (1.7 kg/h) was the same for all treatments during the extrusion process. However, the increase in moisture content after extrusion varied among the treatments with the control and low level wheat fibre samples showing the greatest increase in moisture. The total drying time required to achieve approximately 9.5 % moisture was less for treatments containing Hi-Maize^{TM} 1043 (Table 5.3) and longer for all other formulations except for WF Hi. The average moisture loss rates were also much higher for the treatments containing Hi-Maize^{TM} 1043 or WF Hi (>4.0 %/h) versus 3.3 to 3.6 %/h for other formulations.

As mentioned above the drying time for either Hi-Maize Hi or WF Hi was much less than the other formulations. This could be because Beneo GR bound more water within its fibres. Beneo GR's solubility in water is 120 g/L at 25 °C to 350 g/L at 90 °C (Appendix A 1.4). Wheat Fibre 600 is water insoluble; its water binding capacity is 4.2 – 5.5 g H_2O per gram of dry solid (Appendix A 1.4). Both Beneo GR and wheat fibre 600 could compete with starches in the formulation for water. Amylose has a low water binding (Le, 2010). Hi-Maize^{TM} 1043 did not bind much of the added water; the unbound water could easily be evaporated during drying.

Table 5.3: Summary of pellet moisture content and loss from all treatments and after drying (mean values ± standard deviation for n=2)

	Raw Material Moisture (%)	*Extruder Exit Moisture (%)*	*Moisture Increase (%)*	*End of drying Moisture (%)*	*Total Moisture Loss (%)*	*Total Drying time[1] (h)*	*Average Moisture Loss Rate[2] (% / h)*
Control	14.01 ± 0.14	29.04 ± 0.01	15.03	9.73 ± 0.04	19.31	5.33	3.62
WF Lo	13.80 ± 0.08	28.92 ± 0.00	15.12	9.48 ± 0.02	19.44	5.33	3.65
WF Hi	13.87 ± 0.06	27.63 ± 0.00	13.76	9.57 ± 0.12	18.06	4.00	4.52
Beneo Lo	13.97 ± 0.08	28.11 ± 0.00	14.14	9.53 ± 0.06	18.58	5.47	3.40
Beneo Hi	13.90 ± 0.09	27.01 ± 0.00	13.11	9.50 ± 0.02	17.51	5.33	3.29
Hi-Maize Lo	14.24 ± 0.12	28.02 ± 0.00	13.78	9.56 ± 0.10	18.46	4.58	4.03
Hi-Maize Hi	14.26 ± 0.08	29.18 ± 0.00	14.92	9.56 ± 0.07	19.62	4.25	4.62

[1] Total drying time includes drying at 55°C, excludes conditioning at 30 °C.

[2] Equation 5.1

The extruded pellets moisture loss during the drying process is shown in Figure 5.2. The results shown in Figure 5.2 show that the drying patterns for all treatments were the same. There was an initial rapid drying rate which corresponded to a constant rate period followed by a slower falling rate period in the second hour of drying. The moisture loss was considerably slower after 3 hours of drying in the falling rate period (excluding 2 hours of conditioning).

The changes in water activity (Aw) of the extruded pellets during the drying process are presented in Figure 5.3. The study found that after 3 hours of drying, the water activities of all treatments fell below 0.6, a critical Aw to control for pellet shelf stability (Fennema, 1996; Geankoplis, 2003; Jay, et al., 2005).

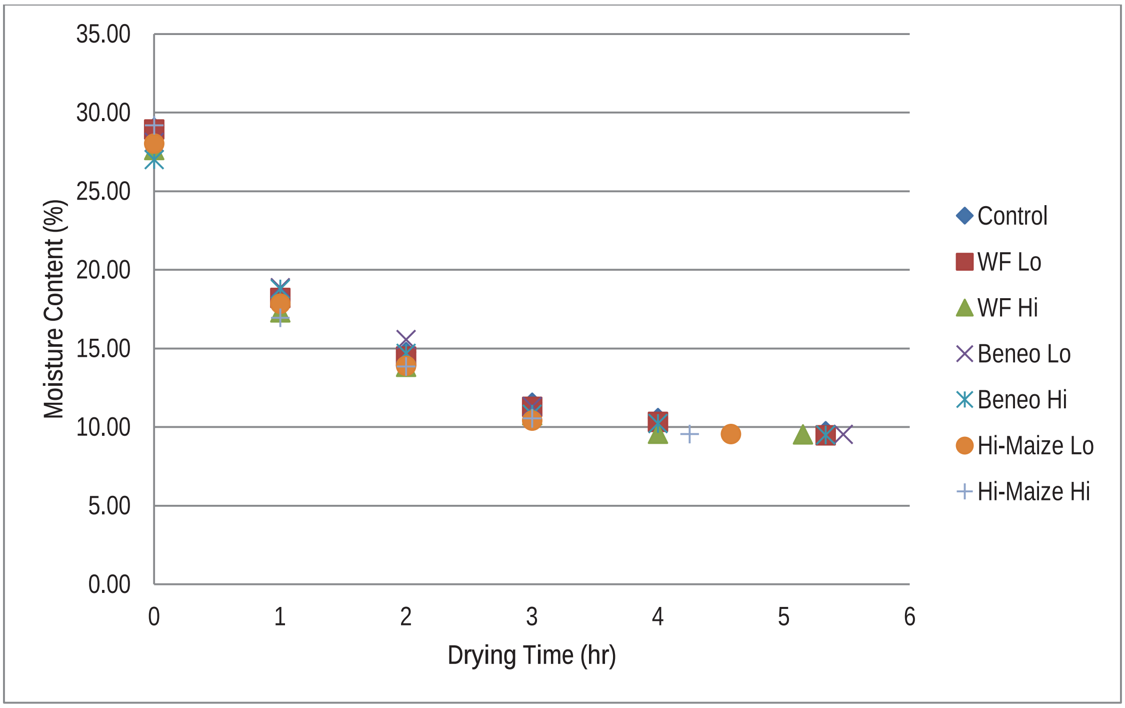


Figure 5.2: Moisture contents of snack pellets during drying (exclude conditioning periods)

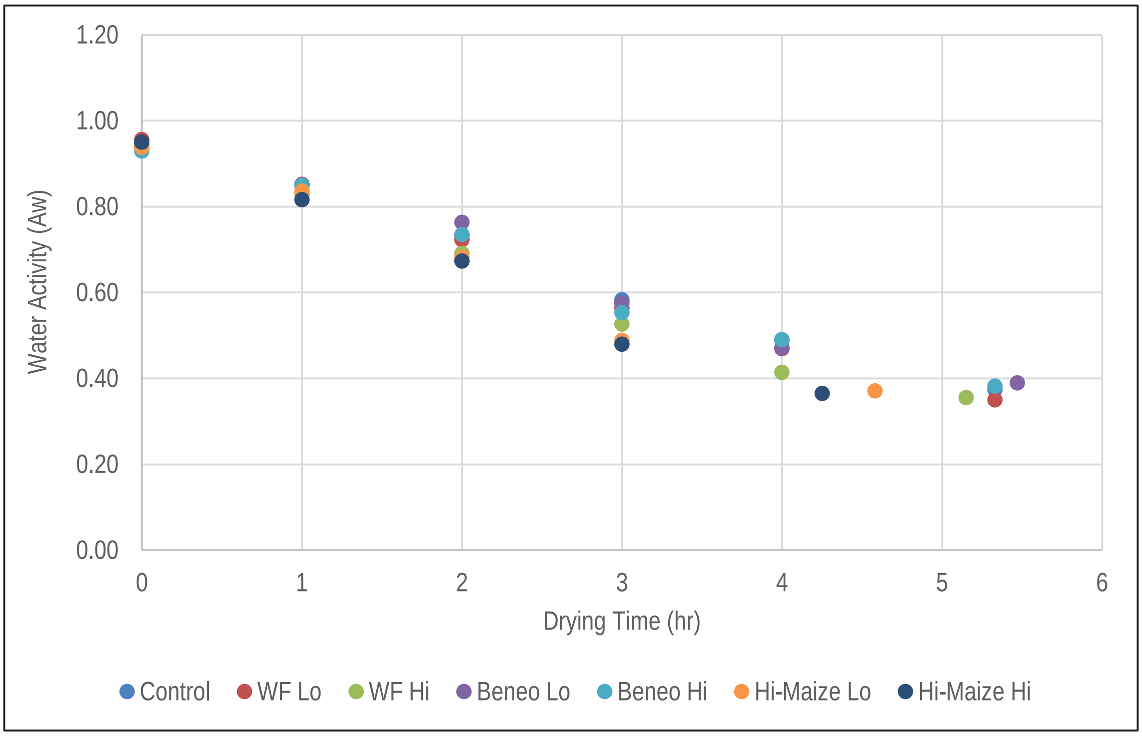


Figure 5.3: Water activity (Aw) of snack pellets during drying (exclude conditioning periods)

5.3.3. Pasting properties of fibre enriched raw ingredients and extruded 3G snack pellets

The pasting properties of fibre enriched formulations are presented in Table 5.4. The absence of any significant differences in pasting temperature and peak time for all the formulations suggested that the fibre inclusion did not have a significant effect on those pasting properties of the raw ingredient blend. The peak, breakdown, final and setback viscosities of the raw ingredients blends were affected by the fibre inclusion. Significant differences were observed. The inclusion of fibre into the base recipe resulted in a decrease in peak and final viscosities of the raw paste. The results were similar to the findings for fibre enriched directly expanded breakfast cereal (Brennan, 2008).

The SME results in Table 5.2 confirmed the observation. It decreased as the level of fibre increased. This may be attributed to the starch content and amylose content of the blend (Table 5.1). Zaidual et al. (2007) reported that peak viscosities increased significantly with an increase in the starch content in the mixture. The effect of fibre on the breakdown and setback viscosities showed similar patterns to the peak and final viscosities for all the samples. Formulations containing Beneo GR and Hi-Maize^{TM} had lower peak, breakdown, final and setback viscosities.

Table 5.4: Pasting properties of fibre enriched formulations of raw ingredient blends (mean values ± standard deviation for n=2)

	Pasting Temp (˚C)	PV (cP)	PT (seconds)	BD (cP)	FV (cP)	SB (cP)
Control	73.1 ± 0.5	2129.5 ± 109.6^{a}	324.0 ± 11.3	651.5 ± 47.4^{a}	2189.0 ± 89.1^{a}	711.0 ± 26.9^{a}
WF Lo	73.1 ± 0.6	1916.5 ± 82.7^{ab}	324.0 ± 5.7	592.5 ± 3.5^{ab}	2009.5 ± 85.6^{ab}	685.5 ± 0.7^{ab}
WF Hi	73.6 ± 0.1	1805.5 ± 77.1^{ab}	338.0 ± 2.8	548.0 ± 65.1^{ab}	1923.5 ± 38.9^{ab}	666.0 ± 26.9^{abc}
Beneo Lo	74.0 ± 0.6	1674.5 ± 342.9^{ab}	334.0 ± 19.8	477.5 ± 92.6^{ab}	1811.0 ± 329.5^{ab}	614.0 ± 79.2^{abc}
Beneo Hi	73.5 ± 0.0	1410.0 ± 45.3^{b}	326.0 ± 8.5	428.0 ± 15.6^{b}	1530.0 ± 59.4^{b}	548.0 ± 29.7^{bc}
Hi-Maize Lo	73.1 ± 0.6	1370.5 ± 30.4^{b}	324.0 ± 5.7	425.5 ± 7.8^{b}	1484.5 ± 20.5^{b}	539.5 ± 2.1^{c}
Hi-Maize Hi	73.5 ± 0.1	1539.5 ± 12.0^{b}	332.0 ± 5.7	476.0 ± 9.9^{ab}	1640.0 ± 18.4^{b}	576.5 ± 16.3^{abc}

Value in a column with superscripts in common did not differ significantly ($p < 0.05$). Analysis details refer to Appendix A 4.2.

Pasting Temp, the temperature where viscosity first increases by at least 25 cP over a 20 s period; PV, maximum paste viscosity achieved during the heating cycle; PT, time when maximum paste viscosity achieved; BD, peak viscosity minus the viscosity after the holding period at 95 °C; FV, final viscosity; SB, difference between the final viscosity and the viscosity reached after the first holding period.

The pasting properties of the extruded pellets after drying to approximately 9.5 % moisture and grinding to a powder are presented in Table 5.5. The results clearly show that after extrusion the pasting properties of the different formulations changed. The control sample exhibited the typical pasting behaviour of typical rice and wheat based 3G snack formulation. Fibre addition significantly modified the viscosities measured.

Table 5.5: Pasting properties of extruded fibre enriched pellets after extrusion and drying (mean values ± standard deviation for n=2)

	CP (cP)	PV (cP)	BD (cP)	FV (cP)	SB (cP)
Control	1707.5 ± 181.7	-	-	608.0 ± 14.1^{a}	417.5 ± 6.4^{a}
WF Lo	1420.0 ± 80.6	-	-	497.0 ± 18.4^{bc}	348.0 ± 9.9^{bc}
WF Hi	1325.5 ± 19.1	-	-	386.5 ± 5.0^{d}	266.0 ± 4.3^{d}
Beneo Lo	1073.5 ± 105.4	-	-	501.0 ± 11.3^{bc}	359.0 ± 5.7^{bc}
Beneo Hi	916.5 ± 174.7	-	-	444.5 ± 26.2^{cd}	311.5 ± 9.2^{cd}
Hi-Maize Lo	848.0 ± 776.4	1697.5 ± 415.1	1556.0 ± 408.7	525.5 ± 20.5^{b}	384.0 ± 26.9^{ab}
Hi-Maize Hi	349.0 ± 386.1	1943.5 ± 491.4	1808.0 ± 490.7	464.0 ± 22.6^{bc}	328.5 ± 21.9^{bc}

Value in a column with superscripts in common did not differ significantly ($p < 0.05$). Analysis details refer to Appendix A 4.3.

CP, maximum cold water viscosity observed at 25 ºC; PV, maximum paste viscosity achieved during the heating cycle; BD, peak viscosity minus the viscosity after the holding period at 95 ºC; FV, final viscosity; SB, difference between the final viscosity and the viscosity reached after the first holding period.

Generally, the cold viscosity of extrudates increase through starch pre-gelatinisation, and then eventually decreased through dextrinisation and granule rupture, as the degree of cook increases (Ozcan & Jackson, 2005; Singh et al., 2009; Yağci & Göğüş, 2012). High values of cold viscosity indicates greater starch breakdown and no peak viscosity at 95 ºC indicates full starch gelatinisation or dextrinisation (Carvalho & Mitchell, 2000).

Table 5.5 shows that after extrusion, high values of cold peak (CP) viscosities, and no peak or breakdown viscosities were observed for all treatments except for the treatments containing Hi-Maize^{TM} 1043 (Hi-Maize Lo and Hi-Maize Hi). The results indicated that the formulations of raw material mixtures containing Hi-Maize^{TM} 1043 were not gelatinised or dextrinised to the same extent as in the other formulations. Lower cold peak (CP) viscosity values were observed for these extruded pellets. In addition, large standard deviations of the cold peak and peak viscosities were observed for samples containing Hi-Maize^{TM} 1043. This was due to the inconsistency of the extrusion feed as described earlier (Section 5.3.1). This caused thrust pressure changes in the extruder (Table 5.2), which could have led to incomplete gelatinisation of the raw material mixtures.

The pasting properties of extruded pellets showed that cold peak viscosity (CP) decreased with increasing concentration of fibre inclusion. Samples with Beneo GR inclusion had lower cold peak viscosities (CP) than those with wheat fibre inclusion. As expected, it was found that the extruded samples had significantly lower final and setback viscosities compared to raw ingredients prior to extrusion. This has been previously reported for extruded starch pastes with lower retrogradation values than non-extruded starch (Yağci & Göğüș, 2012). The extruded WF Hi samples had the lowest final and setback viscosities among all the samples, followed by extruded Beneo Hi. This indicated that the formulation containing 4 % wheat fibre was more resistant to the heat and mechanical shearing applied in the extruder than the control (Anonymous, 1997).

5.3.4. Visual pellet checking assessment

All extruded fibre enriched pellets and the control pellets were oven dried for 3 hours, and inspected the day after drying or after 48 hours of storage. Three hour drying samples were used for checking assessment and subsequent microstructure analysis, because there were less hairline cracks (checking) on the pellets due to less moisture gradient within these pellets. The method used for assessing 'pellet checking' was detailed in Section 5.2.

The results from 'pellet checking' assessment and the puffed products' moistures contents are shown in Table 5.6. A 3G 'checked' snack pellets is shown in Figure 5.4 (Hi-Maize Hi). The percentage of checked pellets in the WF Hi was low at 1.33 % ± 1.16 %. The control, Beneo Lo, Hi-Maize Lo and Hi-Maize Hi all had more than 50 % of the pellets 'checked'. The higher the concentration of the wheat fibre 600 and Beneo GR in the formulation, the lower the percentage of 'checked' pellets after drying. The sample containing Hi-Maize^{TM} 1043 had the highest percentage of 'checked' pellets among all treatments. A possible reason why the Beneo GR and wheat fibre 600 containing formulations resulted in less pellet 'checking' could be because both fibres provided mechanical strength and they both have high water binding capacity (Appendix A 1.4). These fibres bound water upon mixing and were evenly distributed in the pellets during extrusion. Wheat fibre and water formed loose binding and, therefore, water was redistributed faster to prevent moisture gradients within the pellet; whereas, Beneo GR was more strongly bound to water and, therefore, water was redistributed at a slower rate before a moisture gradient formed in the pellets. Hi-Maize^{TM} 1043 had low water binding capacity and water was not able to penetrate through (Qian & Kuhn, 1999). This may have intensified the moisture gradients in the pellets.

Table 5.6: Pellet visual assessment for checking and puffed sample moistures (mean values ± standard deviation for 10 gram samples)

	Pellet Moisture Content (%)	*Puffed Product Moisture Content (%)*	*Percentage of 'checked' pellets (%)*
Control	11.54 ± 0.13	5.13 ± 0.04	69.16 ± 10.03
WF Lo	11.28 ± 0.12	5.07 ± 0.05	41.67 ± 7.45
WF Hi	10.76 ± 0.08	4.93 ± 0.01	1.33 ± 1.16
Beneo Lo	11.30 ± 0.17	5.09 ± 0.04	83.80 ± 4.22
Beneo Hi	10.83 ± 0.12	5.25 ± 0.04	20.20 ± 12.13
Hi-Maize Lo	10.40 ± 0.02	4.91 ± 0.04	79.51 ± 3.23
Hi-Maize Hi	10.56 ± 0.01	4.84 ± 0.03	85.01 ± 2.77

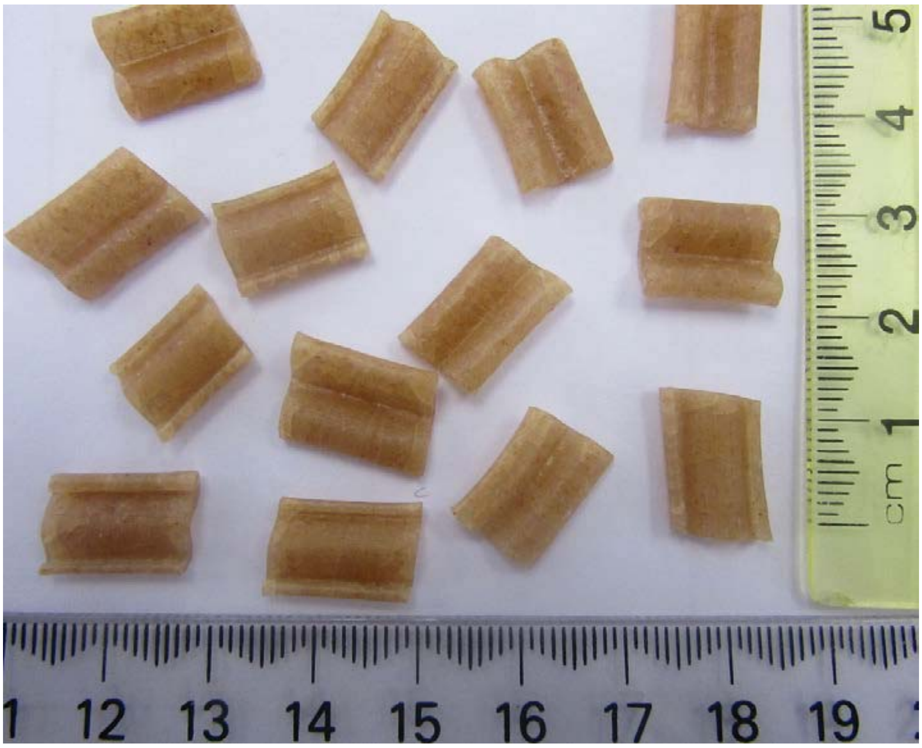


Figure 5.4: Example of checked snack pellets before puffing – formulation 'Hi-Maize Hi'

5.3.5. Puffed product microstructure analysis

In the puffed products the structural attributes measured were cell size, number of cells per mm^2 of cross-sectional area and cell size distribution. The results are shown in Tables 5.7 and Figures 5.5 and 5.6.

Table 5.7 shows that the average cell lengths within the puffed 3G snacks from seven treatments. The average cell lengths in the Control, Beneo Lo and WF Lo were all above 2500 μm and were not significantly different. The average cell length of Beneo Hi and WF Hi were 1815.9 ± 20.3 μm and 1503.9 ± 24.9 μm, respectively. Both of which were significantly smaller than that of the Control, Beneo Lo and WF Lo. The samples containing Hi-Maize^{TM} 1043 had the lowest average cell lengths among all treatments. There was a trend, the average cell length of the puffed 3G snack decreased when wheat fibre 600 and Beneo GR were increased up to 4 %. The average cell lengths of puffed products were less than half of the Control average cell length after adding 3.5 % of Hi-Maize^{TM} 1043. Doubling the Hi-Maize^{TM} 1043 content did not lead to smaller cell lengths. The cross-section images of the extruded pellets after expansion were presented in Table 5.8.

Table 5.7: The effect of different types and levels of fibre addition on average cell size for rice and wheat based 3G snack (mean values ± standard deviation for n=3)

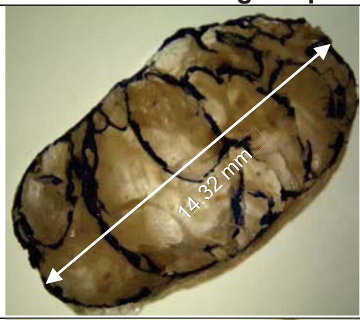
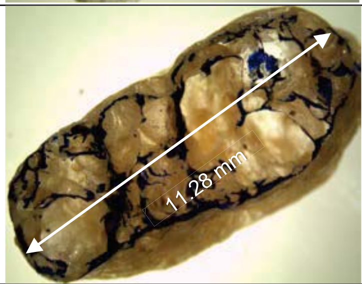
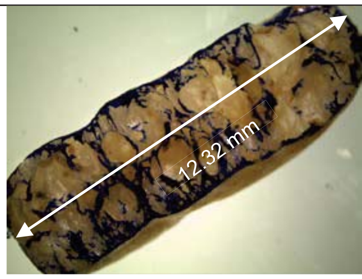
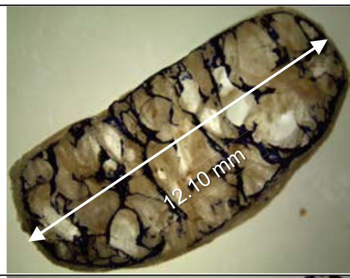
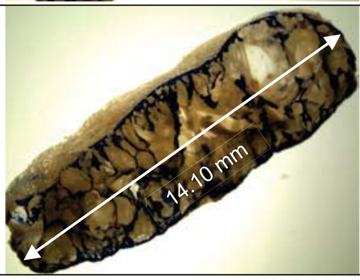
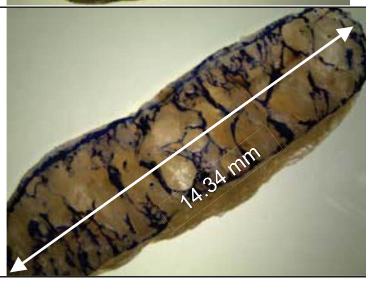
Product	*Average Cell Length (μm)*	*Grouping**
Control	2578.0 ± 224.7	A
Beneo Lo	2813.8 ± 457.6	A
Beneo Hi	1815.9 ± 20.3	B
WF Lo	2639.4 ± 374.2	A
WF Hi	1503.9 ± 24.9	BC
Hi-Maize Lo	1069.8 ± 108.0	C
Hi-Maize Hi	1190.9 ± 166.3	BC

*Grouping information using Tukey Method, different letters in a column are significantly different at $p < 0.05$. Analysis details refer to Appendix A 4.4.

Figure 5.5 shows the number of cells per mm^2 of cross-sectional area for each 3G snack formulations. The puffed snack products with the largest average cell length had the least number of cells per mm^2 and vice versa. The addition of fibres increased the cell density, but the cells did not expand so the cell lengths were less, this was especially seen in the Hi-Maize formulations.

The samples containing Hi-Maize^{TM} 1043 nearly doubled the number of cells per mm^2 of cross-sectional area than that of other treatments. Van der Sman and Broeze (2013) provided an explanation of this phenomenon, when they reviewed the structure formation of indirectly expanded, potato-based products. Their hypothesis was that ungelatinized starch granules were the nucleation sites for vapour cells. This indicated that the Hi-Maize^{TM} 1043 samples were not fully gelatinised as shown in Table 5.5. Thus, it resulted in a significantly greater number of cells per mm^2 of cross-sectional area.

Table 5.8: Cross-section Images of extruded pellets containing different fibres after expansion (8 × magnification)

	Cross-section Image of puffed pellets	
Control		
WF Lo (left) WF Hi (right)		
Beneo Lo (left) Beneo Hi (right)		
Hi-Maize Lo (left) Hi-Maize Hi (right)		

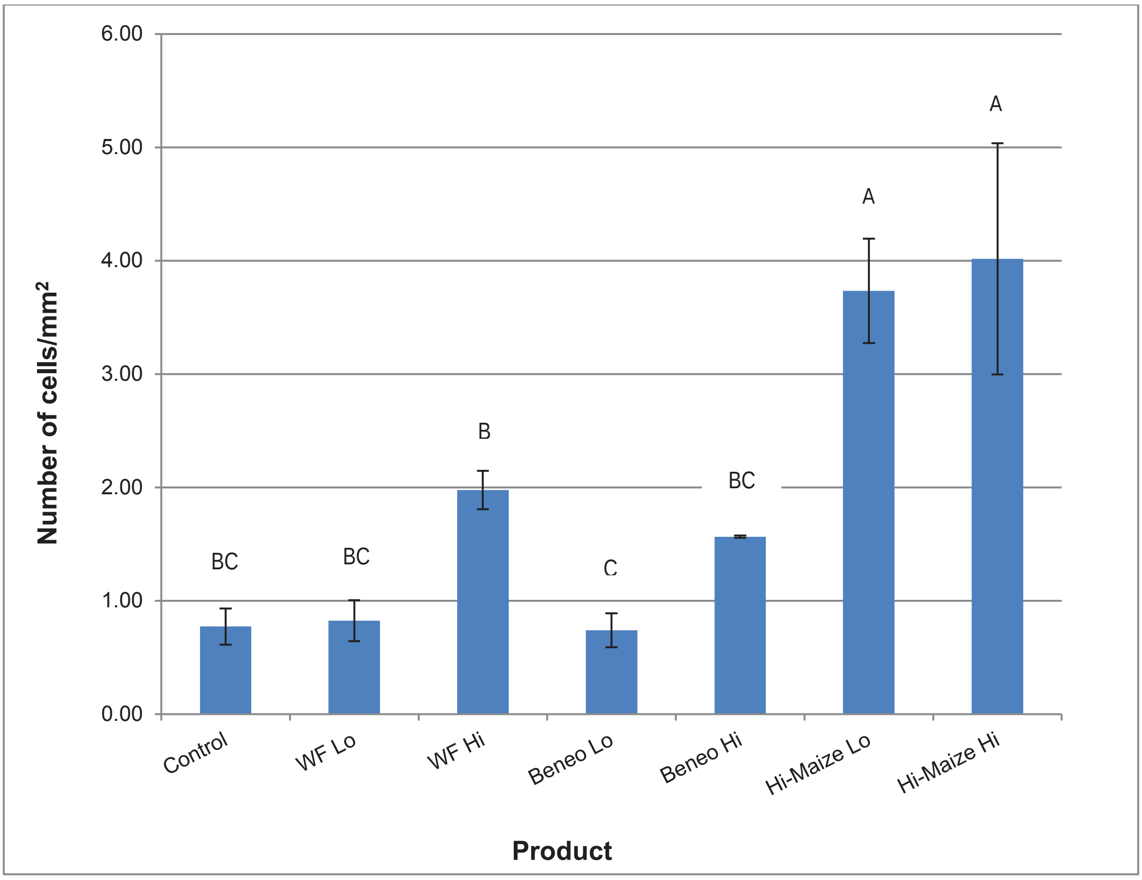


Figure 5.5: The effect of different types and levels of fibre addition on number of cells per mm^2 of cross-sectional area for rice and wheat based 3G snack (mean values ± standard deviation for n=3)

Note: Grouping information using Tukey Method, different letters above a column are significantly different at $p < 0.05$. Analysis details refer to Appendix A 4.5.

The cell size distribution varied considerably depending on the formulation as shown in Figure 5.6. Figure 5.6 shows the percentage of cells that were > 3000 µm, the percentage of cells that were < 500 µm and those in between. The Control, WF Lo and Beneo Lo all had very high percentages of cells > 3000 µm and a very low percentage of small cells < 500 µm. In contrast, the samples containing Hi-Maize^{TM} 1043 had significantly high percentages of small cells and low percentage of large cells. WF Hi and Beneo Hi samples had more balanced numbers of extremely small and large cells, 10 – 20 % of each.

The trend observed was that as the cell size decreased, more cells were found per mm^2. Konishi et al. (2004) proposed that expansion of the starch pellet is driven by the vaporisation of the water within a starch matrix. If a larger number of cells were nucleated by the fibres or Hi-Maize, less water can diffuse into every single cell, possibly resulting in lower water vapour pressure, hence less expansion on each cell (Kraus et al., 2014). This finding is contradicted to the results presented in Brennan (2008), who found Hi-Maize^{TM} increased the expansion ratio of a directly expanded cereal product.

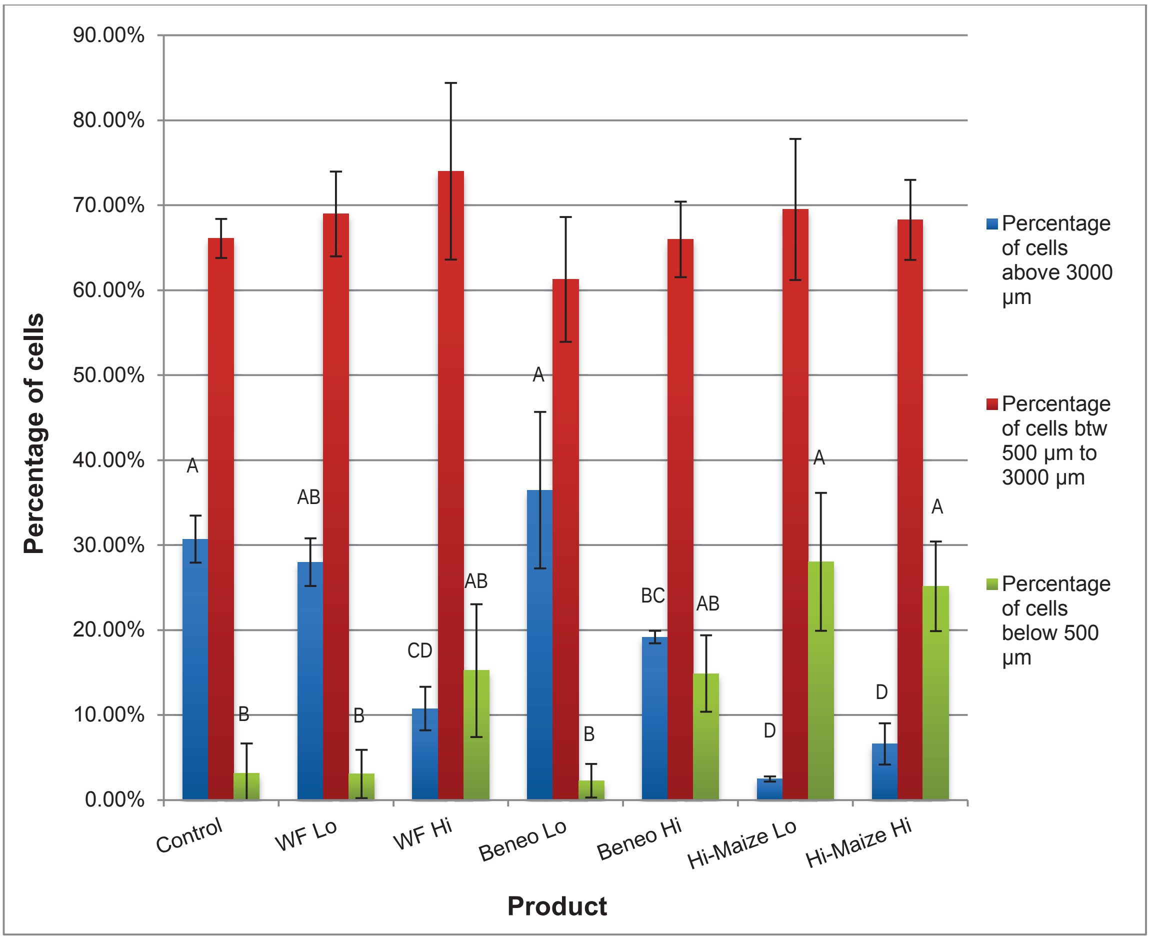


Figure 5.6: The effect of different types and levels of fibre addition on cell size distribution for rice and wheat based 3G snacks (mean values ± standard deviation for n=3)

Note: Grouping information using Tukey Method, different letters above a column are significantly different at $p < 0.05$. Analysis details refer to Appendix A 4.6.

Hi-Maize^{TM} 1043 is not recommended to be used as the fibre inclusion for the base of 3G snack, because it caused some feeding issues, which led to incomplete gelatinisation of the starches during the extrusion process. Reducing the concentration of Hi-Maize^{TM} 1043 for inclusion in the formulation may help to resolve the ingredient flow ability issue during extrusion, but it will not be possible to meet the fibre claim requirement. The recipes containing Hi-Maize^{TM} 1043 had the highest percentage of checked pellets, which means it will be the most process demanding recipe for the control of drying. The excessively large amount of small cells (less than 500µm) (>25 %) found during microstructure analysis indicated that the puffed product would likely to have a hard texture.

5.4. CONCLUSIONS AND RECOMMENDATIONS

The results show that fibres can be utilised in the extrusion process to produce 3G snacks. Three hours of oven drying at 55 ± 5 ºC with two hours tempering at 30 ± 5 ˚C (RH 75 %) in between will reduce the water activity (Aw) to below 0.6, to deliver a shelf stable pellets. As the fibre concentration was increased in the formulations, the cold peak (CP), final (FV), and setback (SB) viscosities of the extruded pellets decreased; which produced puffed final products with smaller and more uniform cell size compared to the Control. Hi-Maize^{TM} 1043 is not recommended as a suitable fibre source for a 3G snack formulation, because it caused issues with feeding, ingredient mixture gelatinisation, extruded pellet checking and gave a hard texture in the puffed product. Further study is required to confirm the findings.

The formulation with 4 % wheat fibre 600 (WF) was considered the best for 3G snack to proceed with. This conclusion was made based on the following reasons. Firstly, it did not create any feeding issues during the extrusion process and the process parameters were comparable to other treatments. Secondly, it had one of the highest pellet moisture loss rates during drying. Therefore, it will take less time to dry. Thirdly, pellets containing 4 % wheat fibre were more ‘check’ resistant. Therefore, it will provide more tolerance on the controlling of pellet drying to allow for successful manufacture of the 3G product. It also showed the highest paste stability and the cell size of its puffed product was the most evenly distributed than any other treatments. To sum up, wheat fibre clearly affected extruded pellet quality, pasting property, cell nucleation and pellet expansion.

6. BASE FORMULATION AND PROCESS IMPROVEMENTS ON 3G SNACK

6.1. INTRODUCTION

A base 3G snack formulation with increased dietary fibre content was established in Chapter 5. Published literature has shown that starch type has a significant effect on the expansion of extruded products (Chinnaswamy, 1993; Hertzel & Plattner, 2005). Maize polenta exhibits good expansion and has been found to be suitable to be used as a structure building ingredient in 3G snacks (Chapter 4). Further study should be carried out on the 3G snack formulation made with maize polenta. Although previous results showed that Hi-Maize™ 1043 was not suitable to be used as a suitable fibre source for the 3G snack, the use of Hi-Maize™ as a wholegrain source has not been studied. Further improvements were required on the 3G snack formulation established in Chapter 5 and to explore a variety of wholegrain options with rice or maize based 3G formulations. In addition, various issues were exposed during the development work including inconsistent feed to the extruder, incomplete gelatinisation of extruded pellets and pellet checking after drying.

The process improvements were aimed at improving the starch gelatinisation in the pellets, and to reduce the likelihood of 'checking' occurring after drying. One key process factor to improve pellet gelatinisation or dextrinisation was to control the amount of water added during extrusion. The water rate to extruder was controlled at 1.7 kg/h in Chapter 5. Chessari & Sellahewa (2001) reported that even a small fluctuation in water rate could have a significant impact on product quality. Earlier research shows that reduced water rate to extrusion would increase the melt viscosity and ultimately affect pellet expansion (Huber, 2001; Moraru & Kokini, 2003). Thus, it was decided to explore the potential of using the water rate to extruder to improve the expansion of 3G snack. The key to controlling the drying process successfully is to avoid case-hardening and to prevent the formation of a moisture gradient within the pellets (Hertzel & Plattner, 2005; Kill & Turnbull, 2001). Previous study established that addition of wheat fibre 600 (WF) at 4 % to 3G snack formulation could reduce pellet checking (Chapter 5). However, even a small amount of faulty pellets cannot be tolerated to a commercially produced product. Therefore, the drying method needed to be improved to eliminate the occurrence of pellet checking.

The objectives for this section of the work were to determine the effect of varying the water addition on a rice or maize based 3G formulation using wheat or/and Hi-Maize™ flour as the wholegrain sources and to develop a new drying method to eliminate pellet checking.

6.2. MATERIALS AND METHODS

The ingredients used in this series of experiments were the same as those detailed in Section 3.1. The 3G formulations and experiment design were detailed in Section 3.5.2. Third generation snacks were produced according to Figure 5.1.

6.2.1. Effect of water on extrusion process and 3G snack base formulations

Three formulations (RW, CW and RWC) containing wholegrain ingredients were tested with different rates of water addition using a 2 × 3 full factorial design. The factors tested were water addition rate (2 levels) and three formulations. The same three formulations and extrusion setup were used for both water treatments (Section 3.5.2). The formulations tested are shown in Table 3.5. For each formulation they were designated as either 'Water Lo' – low water addition rate (1.0 kg/h) or 'Water Hi' – high water addition rate (1.7 kg/h). Extrusion process parameters were unchanged for "RW Water Hi' as presented in Table 5.2 (WF Hi) in Chapter 5. Feed rates of the other two 'Water Hi' formulations were adjusted to deliver approximately the same SME as 'RW Water Hi'. The same feed rate of 'RW Water Hi' was used for the 'RW Water Lo'. The feed rates of the other two 'Water Lo' formulations were adjusted to deliver approximately the same SME as obtained for "RW Water Lo'.

The raw ingredient mixture for all 6 treatments, and their respective 3G pellets and expanded products were studied for their pasting properties, finished product microstructure and expansion analysis. The pasting properties of both raw and extruded recipes were compared. For experimental details refer to Section 3.8. Pellets from all formulations were dried to approximately 9.5 –10.0 % w/w moisture content and equilibrated for a minimum of 24 hours before puffing. Die swell analysis was carried out on extruded pellets according to Section 3.6.3. Puffed product SEI was carried out according to Section 3.6.4. Microstructural assessment was also carried out on puffed product. Structural attributes measured were according to Section 3.6.7 and analysis details refer to Section 3.10.

6.2.2. Drying process improvement

Preliminary trials tested Method 1 and 2 drying protocols (Figure 6.1). Severe pellet checking (>70 % checked pellets) was observed for all tested formulations. The drying method was improved and the Method 3 drying procedure (Figure 6.1) used in Chapter 5 had shown some considerable improvements in some of the 3G snack formulations, especially the formulation with 4% wheat fibre 600 (percentage of checked pellets 1.33 ± 1.16, Table 5.6).

Further improvements were made to Method 3. Method 4 was developed as shown in Figure 6.1. Dried pellets were assessed visually for checking immediately after drying and after 48 hours of storage.

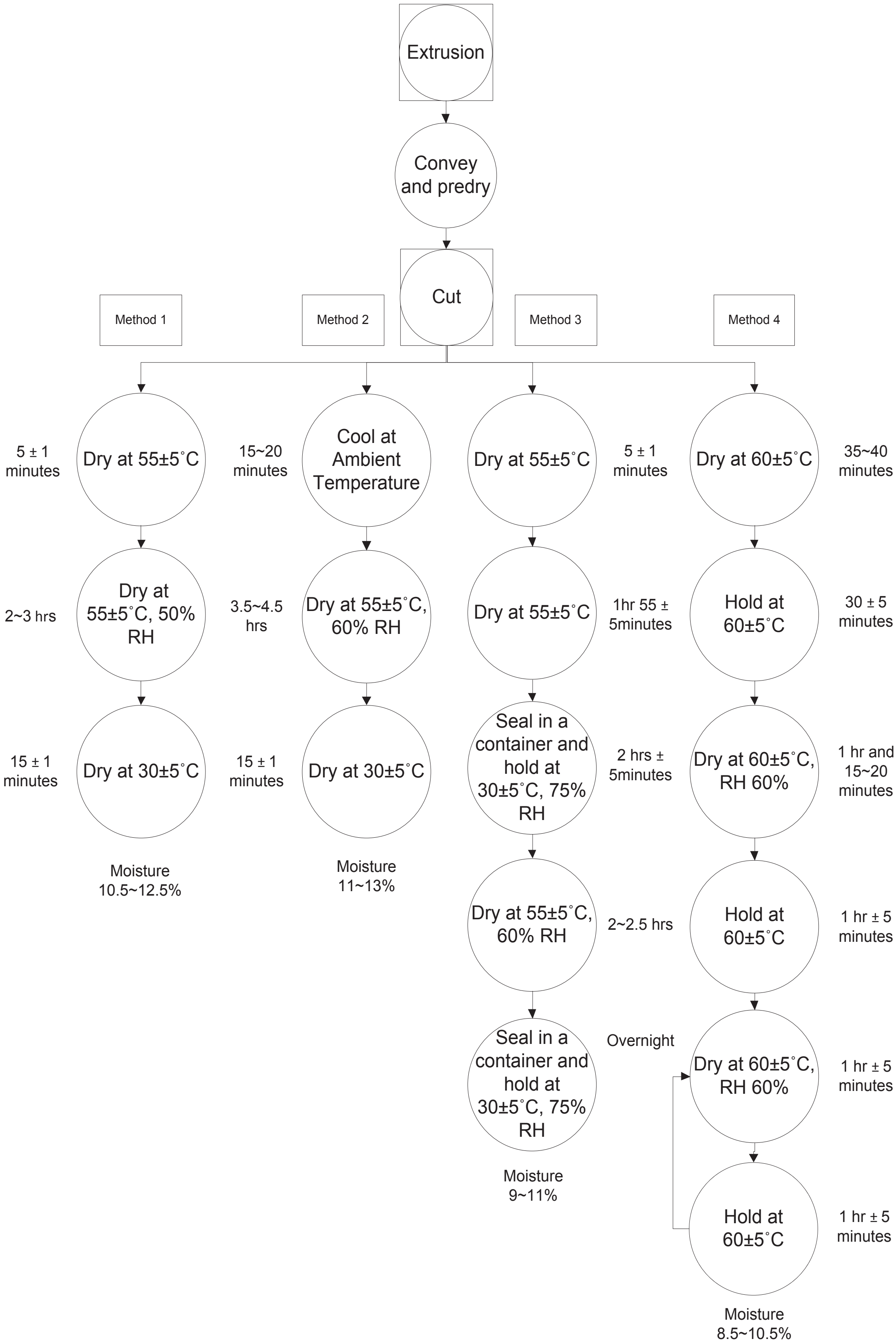


Figure 6.1: Temperature-time profiles of four pellet drying methods

6.3. RESULTS AND DISCUSSION

6.3.1. Effect of water on extrusion process

Table 6.1 shows the effect of water addition rate on the extrusion conditions for the wheat fibre enriched 3G snack base formulation. Differences were observed between the two water addition rates. When the ingredient mixture, extruder screw speed and feed rate were kept constant, the reduced water feed rate results in an increased extruder apparent torque, thrust pressure and die pressure. As a result of reducing the water addition rate (1.0 kg/h), the SME was twice that when the water addition rate was increased to 1.7 kg/h. Recipes with low water input had SMEs of 0.237 - 0.249 kWh/kg (Table 6.1). Recipes with 1.7 kg/h water addition rate had SMEs of 0.124 - 0.129 kWh/kg.

Table 6.1: The effect of water on 3G snack extrusion process

Recipe	*Apparent Torque (Nm)*	*Screw (rpm)*	*Feed Rate (dial)*	*Water Rate (kg/h)*	*Thrust Pressure (Bar)*	*Die pressure (Bar)*	*Power (kW)*	*SME (kWh/kg)*
RW Water Lo	7.2	251	60	1.0	69	108	1.46	0.237 ± 0.005
RW Water Hi	4.7	251	60	1.7	38	75	0.98	0.129 ± 0.003
CW Water Lo	6.5	251	70	1.0	63	103	1.31	0.239 ± 0.000
CW Water Hi	4.4	251	88	1.7	39	77	0.94	0.124 ± 0.012
RWC Water Lo	6.0	251	70	1.0	47	90	1.20	0.249 ± 0.003
RWC Water Hi	4.4	251	85	1.7	35	74	0.92	0.124 ± 0.005

These results were expected, as water functions as a plasticiser (Frame, 1994). Excess water decreases the dissipation of the mechanical energy, decreases the heat input and, decreases mechanical resistance; subsequently lowering the melt viscosity (Huber, 2001; Moraru & Kokini, 2003). This will then lead to a lower SME.

6.3.2. Comparison of pasting properties of raw ingredients and extruded pellets for the three base snack formulations

Pasting properties of raw ingredients blend from three base snack formulations (RW, CW and RWC) were summarised in Table 6.2. Little difference was observed between pasting properties of 'RW' and 'CW'. The 'RWC' recipe showed the lowest peak (PV), breakdown (BD), final (FV) and setback (SB) viscosities. It also had the longest peak time. This was due to the Hi-Maize^{TM} wholegrain flour content of the formulation as discussed in Section 4.3.2.

Table 6.2: Pasting properties of raw ingredients from three base snack formulation (mean values ± standard deviation for n=2)

Recipe	Pasting Temp (˚C)	PV (cP)	PT (seconds)	BD (cP)	FV (cP)	SB (cP)
RW	73.6 ± 0.1	1805.5 ± 77.1	338.0 ± 2.8^{a}	548.0 ± 65.1^{ab}	1923.5 ± 38.9	666.0 ± 26.9
CW	73.1 ± 0.7	1805.0 ± 155.6	308.0 ± 11.3^{b}	686.5 ± 71.4^{a}	1769.0 ± 142.8	650.5 ± 84.1
RWC	73.5 ± 0.0	1549.5 ± 24.0	350.0 ± 2.8^{a}	373.0 ± 9.9^{b}	1681.5 ± 26.2	505.5 ± 12.0

Value in a column with superscripts in common did not differ significantly ($p < 0.05$). Analysis details refer to Appendix A 5.1.

Pasting Temp, the temperature where viscosity first increases by at least 25cP over a 20s period; PV, maximum paste viscosity achieved during the heating cycle; PT, time when maximum paste viscosity achieved; BD, peak viscosity minus the viscosity after the holding period at 95°C; FV, final viscosity; SB, difference between the final viscosity and the viscosity reached after the first holding period.

RVA results of the extruded pellets from three base snack formulations, 'RW', 'CW', and 'RWC', are summarised in Table 6.3. High values of cold viscosity indicates greater starch breakdown and no peak viscosity at 95 ºC indicates full starch gelatinisation or dextrinisation (Carvalho & Mitchell, 2000).

Table 6.3: The effect of water addition rate and formulation on pellet pasting properties (mean values ± standard deviation for n=2)

Product	CP (cP)	PV (cP)	BD (cP)	FV (cP)	SB (cP)
RW Water Lo	1069.0 ± 18.4^{b}	-	-	297.5 ± 10.6^{d}	222.5 ± 9.2^{d}
RW Water Hi	1325.5 ± 19.1^{a}	-	-	386.5 ± 5.0^{c}	266.0 ± 4.3^{c}
CW Water Lo	674.5 ± 48.8^{d}	-	-	225.0 ± 8.5^{e}	157.5 ± 7.8^{e}
CW Water Hi	916.5 ± 2.1^{c}	1176.5 ± 3.5	1055.0 ± 1.4	380.0 ± 1.4^{c}	258.5 ± 0.7^{c}
RWC Water Lo	945.0 ± 28.3^{c}	-	-	425.0 ± 2.8^{b}	339.0 ± 1.4^{b}
RWC Water Hi	500.0 ± 35.4^{e}	1151.5 ± 68.6	1024.5 ± 67.2	556.5 ± 7.8^{a}	429.5 ± 9.2^{a}

Value in a column with superscripts in common did not differ significantly ($p < 0.05$). Analysis details refer to Appendix A 5.2.

CP, maximum cold water viscosity observed at 25 °C; PV, maximum paste viscosity achieved during the heating cycle; BD, peak viscosity minus the viscosity after the holding period at 95 °C; FV, final viscosity; SB, difference between the final viscosity and the viscosity reached after the first holding period.

The results indicated that when the ingredient blend, extruder screw speed and SME were kept constant, the extrusion water addition rate had a significant impact on the starch gelatinisation or dextrinisation of the wheat fibre 600 enriched 3G snack formulation. The lack of peak (PV) and breakdown (BD) viscosities indicated that starches in all the formulations with low water addition rate ('Lo', 1.0 kg/h) were fully gelatinised or dextrinised. In contrast, other than 'RW Water Hi', both peak (PV) and breakdown (BD) viscosities were observed for treatment of 'CW Water Hi' and 'RWC Water Hi', which indicates that they were not gelatinised or dextrinised to the same extent as in the other formulations. The cold peak viscosity (CP) of 'CW Water Hi' was significantly higher than the 'RWC Water Hi', and the final (FV) and setback (SB) viscosities of 'CW Water Hi' were significantly lower.

Starch present in the formulations to make pellets produced using 'Hi' and 'Lo' water addition rates for the 'RW' formulation were fully gelatinised. When pasting properties of both treatments were compared, it showed that the cold peak viscosity (CP) of the extruded pellets was significantly lower when less water was added. The same pattern was also observed for the final (FV) and setback (SB) viscosities. This was assumed to be due to the significant increase of SME when water was decreased in the formulation. Ozcan & Jackson (2005) reported that increasing the severity of an extrusion treatment, that is, increasing the SME can result in a decrease in initial cold viscosity.

When the pasting properties of all three low water treatment ('Lo') formulations were compared, the 'CW Water Lo' formulation had significantly lower peak (PV), final (FV) and setback (SB) viscosities. This was probably caused by the particle size of the maize polenta as discussed in Chapter 4. A large particle size of the polenta in the formulation during extrusion may hinder the melting process. Hence, the low cold peak viscosity (CP) of the extruded pellets. The 'RW Water Lo' formulation had the highest cold peak viscosity (CP). This is due to the high starch content of the rice flour (Table 4.2) as discussed in the Chapter 4 ingredient selection. Of all the cereal structure building ingredients, rice flour had the highest peak (PV), final (FV) and setback (SB) viscosities. 'RWC' had the highest final and setback viscosities. This was probably because of the higher amylose content of the formulation from Hi-Maize™ wholegrain flour, which would make the pellets more susceptible to retrogradation.

6.3.3. Puffed product microstructure analysis

Structural attributes measured were cell length, number of cells per mm^2 of cross-sectional area and cell size distribution. The results are shown in Table 6.4, Figure 6.2 and Figure 6.3. The average cell lengths of 'RW Water Hi' and 'CW Water Hi' were significantly higher than those of 'Lo' water formulations. This was because water changed the rheological properties of the extrudates and expansion of the starch pellet was driven by the vaporisation of water (Konishi et al., 2004; Moraru & Kokini, 2003).

The formulations containing Hi-Maize™ wholegrain flour had the lowest average cell length. This finding agreed with results found in Chapter 5, where the recipe with Hi-Maize™ 1043 had the lowest average cell length. Although not significant, 'RWC Water Lo' had longer average cell length than that of 'RWC Water Hi'. This could be because the starch in the 'RWC Water Hi' formulation was not fully gelatinised. Previous researchers showed that product expansion was affected by the degree of starch gelatinisation (Kraus et al., 2014; Lee et al., 2000; Van der Sman & Broeze, 2013). A nonlinear correlation was found between the degree of gelatinisation and the expansion volume, and optimum level of starch gelatinisation for maximum expansion was around 50 % (Lee et al., 2000).

Table 6.4: The effect of water addition and formulation on average cell length (mean values ± standard deviation for n=3)

Product	*Average Cell Length (μm)*	*Grouping**
RW Water Lo	1001.5 ± 37.1	B
RW Water Hi	1053.9 ± 24.9	A
CW Water Lo	965.3 ± 40.2	BC
CW Water Hi	1366.4 ± 103.4	A
RWC Water Lo	794.5 ± 87.7	CD
RWC Water Hi	630.1 ± 102.6	D

* Value in a column with superscripts in common did not differ significantly ($p < 0.05$). Analysis details refer to Appendix A 5.3.

Figure 6.2 shows the number of cell per mm^2 for the six 3G snack formulations. 'Lo' water formulations generally had more cells per mm^2 except the 'RWC Water Hi', which was found to produce the most cells per mm^2 (13.3 ± 3.7 cells per mm^2).

There was little difference in the number of cell per mm^2 observed between samples of 'RW' and 'CW'. The samples containing Hi-Maize™ wholegrain flour ('RWC' Lo and Hi) had significantly higher number of cell per mm^2 than the other formulations. Unusual observation was found on 'RWC Water Hi'. This was probably due to the incomplete gelatinisation of the starch pellets.

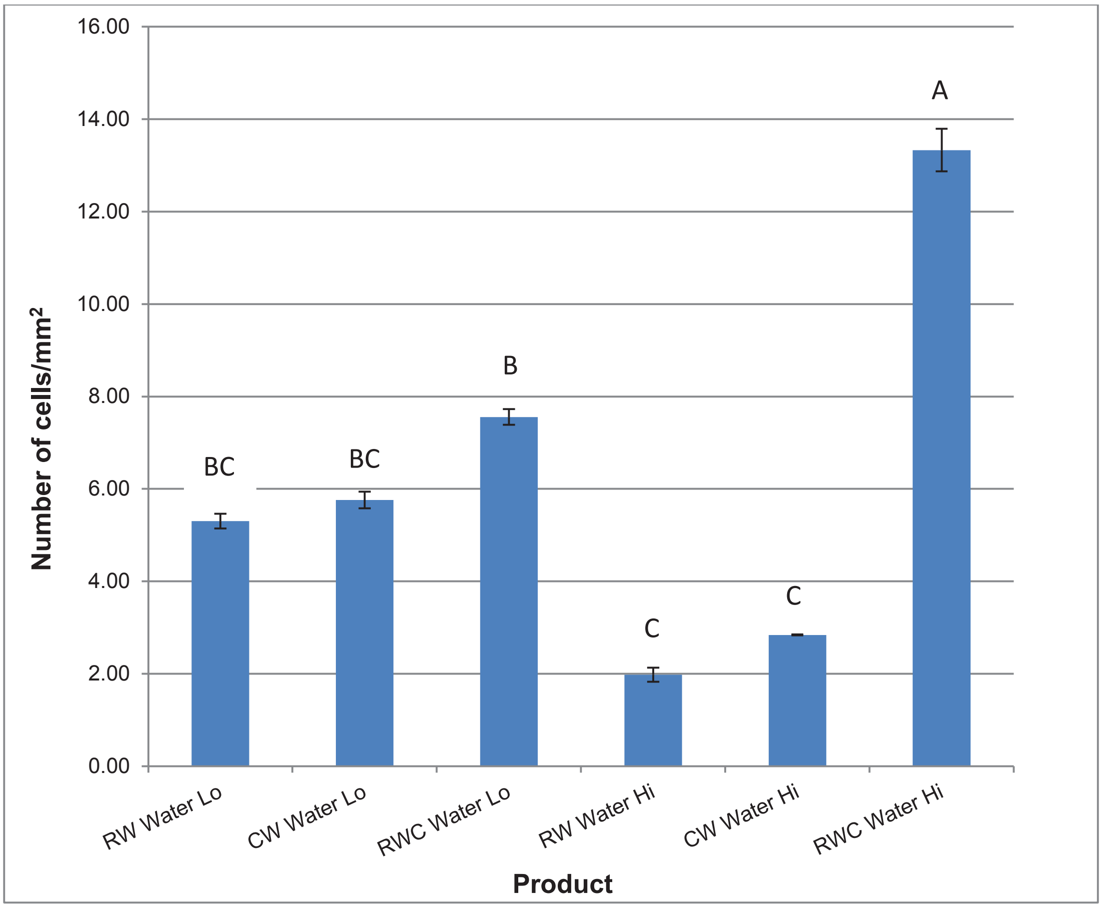


Figure 6.2: The effect of water addition on the number of cells per mm^2 for 3G snack pellets (mean values ± standard deviation for n=3)

Note: Grouping information using Tukey Method, different letters in a column are significantly different at $p < 0.05$. Analysis details refer to Appendix A 5.4.

The cell size distribution followed the same trend of number of cells per unit area. Samples from low water treatments (Lo) all had very low percentage of extremely large cells (>3000µm) and very high percentage of extremely small cells (<500µm). In contrast, the samples from high water treatments had more balanced number of extremely small and large cells except for 'RWC Water Hi'. The results were illustrated in Figure 6.3.

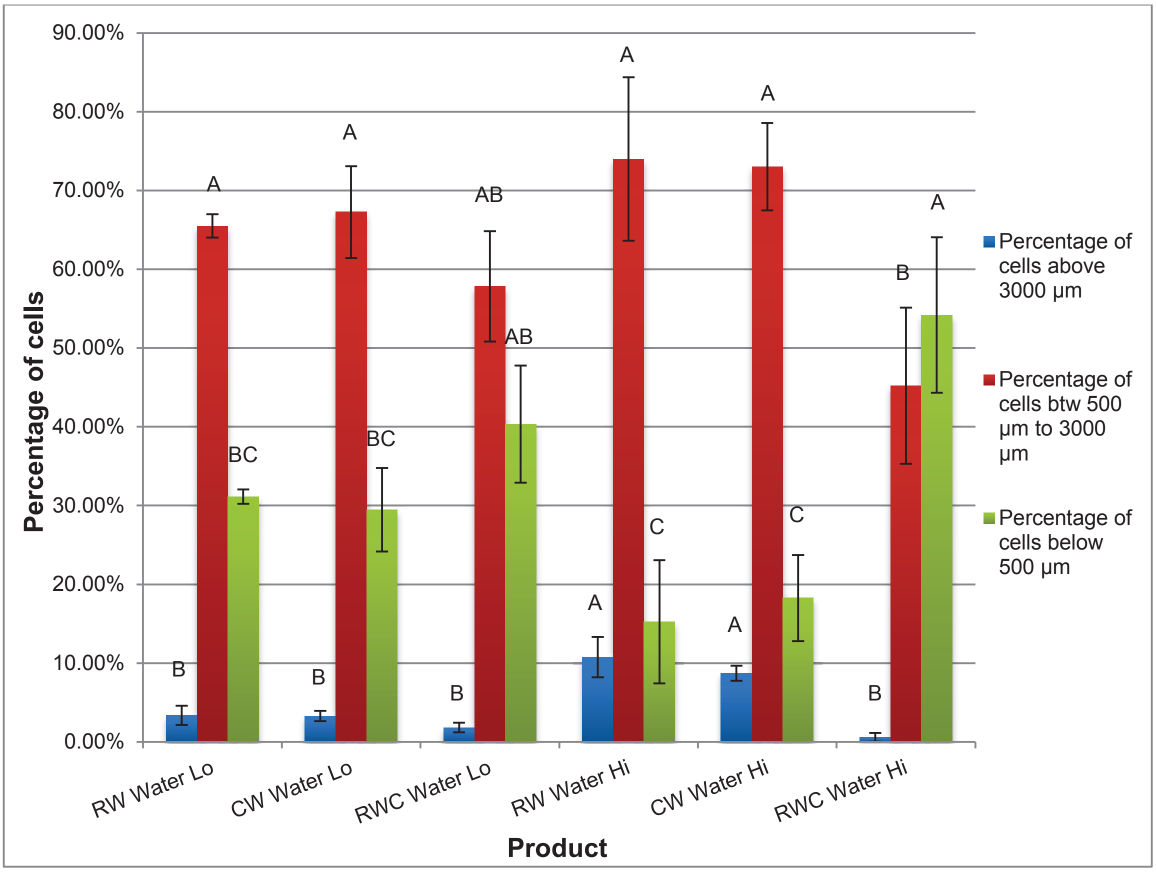


Figure 6.3: The effect of water addition and formulation on the cell size distribution (mean values ± standard deviation for n=3)

Note: Grouping information using Tukey Method, different letters in a column are significantly different at $p < 0.05$. Analysis details refer to Appendix A 5.5.

6.3.4. Die Swell and Product Expansion Analysis

Table 6.5 and Table 6.6 summarise the results from die swell and expansion analysis of the 3G snack formulation extruded with two levels of water addition. The results show that there was more die swell and finished product expansion in the 'Hi' water addition formulations than with 'Lo' water addition. The Pearson correlation (Table 6.7) shows that the die swell width was not significantly attributed to the product SEI, but the die swell thickness was. The higher the die swells thickness, the more expansion was observed.

The die swells of 'RW' and 'CW' formulations were not statistically different at the same water addition level. 'RWC Water Hi' showed similar level of die swell as the 'RW Water Hi' and 'CW Water Hi'. However, the 'RWC Water Hi' had significantly lower SEI than the 'RW Water Hi' and 'CW Water Hi' after expansion. For the low water addition treatments, 'RWC Water Lo' demonstrated the lowest die swell and SEI after expansion. Even though the die swell of 'RW Water Lo' and 'CW Water Lo' were similar, the SEI of 'RW Water Lo' was significantly higher than that of "CW Water Lo'.

Table 6.5: Width and thickness expansion analysis of 3G formulation extruded with two water levels (mean values ± standard deviation for n=10)

ID	Die Swell Width	Width Expansion	Die Swell Thickness	Thickness Expansion
RW Water Lo	0.99 ± 0.02^{b}	2.00 ± 0.06^{a}	1.39 ± 0.05^{c}	6.14 ± 0.66^{bc}
RW Water Hi	0.95 ± 0.04^{b}	1.94 ± 0.08^{ab}	1.69 ± 0.07^{a}	6.91 ± 0.52^{a}
CW Water Lo	0.98 ± 0.04^{b}	1.87 ± 0.08^{bc}	1.31 ± 0.06^{c}	5.61 ± 0.52^{cd}
CW Water Hi	1.05 ± 0.03^{a}	1.96 ± 0.11^{ab}	1.53 ± 0.12^{b}	6.31 ± 0.71^{ab}
RWC Water Lo	0.96 ± 0.03^{b}	1.83 ± 0.04^{c}	1.08 ± 0.05^{d}	4.19 ± 0.23^{e}
RWC Water Hi	1.08 ± 0.03^{a}	2.00 ± 0.07^{a}	1.52 ± 0.07^{b}	4.96 ± 0.33^{d}

Note: Value in a column with superscripts in common did not differ significantly ($p < 0.05$). Analysis details refer to Appendix A 5.6.

Table 6.6: Die swell and SEI of 3G formulations extruded with two water levels of water addition (mean values ± standard deviation for n=10)

ID	Die Swell	SEI
RW Water Lo	1.37 ± 0.06^{b}	12.29 ± 1.65^{a}
RW Water Hi	1.60 ± 0.11^{a}	13.41 ± 1.23^{a}
CW Water Lo	1.29 ± 0.07^{b}	10.50 ± 1.25^{b}
CW Water Hi	1.60 ± 0.14^{a}	12.39 ± 1.47^{a}
RWC Water Lo	1.04 ± 0.06^{c}	7.66 ± 0.55^{c}
RWC Water Hi	1.63 ± 0.09^{a}	9.93 ± 0.88^{b}

Note: Different letters in a column are significantly different at $p < 0.05$. Analysis details refer to Appendix A 5.6.

Table 6.7: The correlation of width and thickness die swell and expansion to product SEI

	Die Swell Width	*Die Swell Thickness*	*Width Expansion*	*Thickness Expansion*
Pearson Correlation	0.025	0.660	0.586	0.972
P-Value	0.848	<0.005	<0.005	<0.005

Analysis details refer to Appendix A 5.7.

The exact degree of starch gelatinisation in the formulations was unknown. Forte & Young (2003) and Moraru & Kokini (2003) explained that a low degree of starch gelatinisation can be related to a low viscoelasticity of melted ingredient mixture and therefore results in low expansion. With a high degree of starch gelatinisation, the viscoelasticity of the melted ingredient mixture is high, which prevents collapse of the cells at the outer surface. Hence, a higher product expansion (SEI) obtained. In this case, the product SEI results clearly showed that the expansions of the extruded pellets were significantly compromised by the inclusion of Hi-Maize™ wholegrain flour (Table 6.6).

6.3.5. Pellet drying improvement

Four different temperature-time drying procedures were trialled and the procedures were summarised in Figure 6.1 (Method 1 to 4). There were clearly improvements from Method 1 to Method 3 to avoid surface over drying, but Method 3 still exhibited checked pellets after two days storage. Pellet thickness was reduced by changing the die design (Figure 3.5). The thickness of opening was kept minimal at 0.8mm to enhance moisture migration and heat transfer. However, the wave shaped die design made the control of drying extremely challenging, as the tight radii can easily concentrate five to ten-fold stresses locally, so the pellet checked easily (Kill & Turnbull, 2001).

Method 1 was a conventional drying procedure, which divided the batch drying into three fundamental stages: pre-drying, humid air drying, and final tempering. The reason for having the pre-drying step was to aid in the separation of the freshly extruded high moisture pellets. As the extrudates left the die, they were soft and warm, and had a tendency to stick together. Even though a lab conveyor was used, it had little effect in cooling and drying to remove the excess surface moisture (Figure 3.5). Therefore, the pre-drying step was required to remove some water from the pellets, so they could be easily handled. Drying with humid air was required to avoid the pellet surface from drying too quickly and case-hardening (Kill & Turnbull, 2001). The last step was to temper the dried pellets at 30 ± 5°C. Method 1 was found to result in checked pellets a few hours after completion the drying, hence it required further modification.

A couple of changes were made to Method 2. Instead of the pre-drying step, ambient air drying was used. The relative humidity was increased for the second stage of drying to minimise any formation of a moisture gradient. However, the results showed that no improvements were made with the changes, but the overall drying time was increased by 25 % for all the formulations (1 h – 1 h 25 minutes).

The rate of moisture loss during drying using Method 1 and 2 was found to be similar to that shown in Figure 5.1. It shows that the pellet moisture went through a fast falling rate at the first couple of hours of drying (minimum distances between a fitted linear line and the first three moisture data points). According to Geankoplis (2003), these pellets were drying at a constant rate. When drying the pellet in the constant rate period, mass transfer of water is fast enough to keep the surface fully wet. Hence, a dynamic equilibrium is achieved where the rate of heat transfer to the evaporating surface is balanced by the rate of heat removal from the surface by the evaporation of water. The hypothesis was that if moisture could be removed through two hours constant drying period without humidity drying, the overall drying time required could be significantly shortened. Hence, the change made to the first drying period in the Method 3 and Method 4.

Method 3 was changed to dry the pellets at 55 ± 5 °C for 2 hours, followed by a 2 hours tempering time in a sealed container and hold at 30 ± 5 °C with 75 % relative humidity. Then the process was repeated again. As a tempering step was included between drying periods, Method 3 had a longer overall drying time than Method 1 and 2. This process modification was adopted based on solutions to similar pellet checking problems were encountered in the pasta drying process (Hummel, 1966; Kill & Turnbull, 2001; Krueger, Matsuo, & Dick, 1996). The purpose of including the tempering period was to allow some time for water to move from the centre of the pellet to the surface. During this time, pellets were sealed in a plastic container and kept at 30 ± 5 °C to avoid further moisture loss, so the formation of a moisture gradient in the pellets could be minimised. All the aforementioned researchers recommended an increase in the oven relative humidity during the falling period of drying to avoid the pellet surface from over drying. However, this solution was impractical, as there was only one oven available at the time for this experiment. Extrusion was a continuous process and all formulations were extruded within a day. It was not easy to change the temperature and humidity profile during drying, when each formulation was placed into the oven at a different time.

This method showed some improvements. Although the majority of the pellets were still checked, most of the checking appeared after two days storage. Hummel (1966) explained the phenomenon was due to the moisture gradient formed and maintained during drying. The pellets left the oven with no stresses but a built-in moisture gradient. When the pellets cooled down and harden, the water gradient between the surface and the interior slowly disintegrated. As water diffused from the interior to the exterior, the interior continued to contract, eventually no more water was available for evaporation from the surface. During storage, the difference in water content will lead to plastic deformation to release the stress. When the stress was more than the strength of the pellets, the checking occurred (Kill & Turnbull, 2001). This was the reason that when the pellets left the oven with the required water content, they looked good and strong. But, in a day or two, they started to check and checking began to spread all over the pellet.

Method 4 was developed to address the issue of the moisture gradient in the pellets during drying and shorten the total drying time. Firstly, the drying temperature was increased to 60 ± 5 °C. Secondly, the drying time for the pre-drying step was increased to 35 – 40 minutes without relative humidity control, the subsequent drying time was reduced to 1 hour and the relative humidity was maintained at 60 % RH in the drying period. Thirdly, a tempering period between drying was introduced to hold the pellets in the oven at 60 ± 5 °C for 1 hour (Figure 6.1).

Method 4 resolved the moisture gradient problem previously encountered by increasing the temperature for tempering. The increase in drying temperature resulted in an increase in drying and diffusion rate. The initial holding temperature for pellet tempering was 30 ± 5 °C. By doubling the holding temperature to 60 ± 5 °C, the diffusion coefficient would have been 15 % greater than the original diffusion coefficient according to Equation 2.13 (analysis details refer to Appendix A 5.8), implying a faster diffusion rate. Therefore, the chance of moisture gradient formation had been remarkably reduced.

6.4. CONCLUSIONS AND RECOMMENDATIONS

Three 3G snack base formulations were successfully developed for focus group study. They were 'RW Water Lo', 'CW Water Lo', and 'RWC Water Lo'. This study provided a framework for better understanding the effects of water in extrusion and quality of the three base formulations for 3G snacks.

Two water addition levels, 1.7 kg/h and 1.0 kg/h, for 3G snack pellet extrusion were studied. Water acts as a plasticizer in the extrusion process. With reduced water rate to extruder, the extrusion condition changed considerably. The extruders apparent torque was increased; thrust and die pressures were increased, and the SME nearly doubled. As a result of the reduced water addition to extruder, the degree of starch gelatinisation and the degree of starch degradation increased. The pellets extruded also exhibited less die swell and average cell lengths were significantly smaller. There were more cells per mm^2 but most of the cells were smaller than 500 μm.

Adding Hi-Maize™ wholegrain flour (10 %) altered the pasting properties of 3G base formulation. More energy was required to fully gelatinise this 3G formulation. The expansion of products was significantly reduced and the microstructure analysis showed that more small cells (< 500 μm) were formed.

It was found that a pasta drying process was the most suitable process for drying the half pellets after extrusion. A laboratory drying method was modified according to the process. The tempering temperature changed from 30 °C to 60 °C which increased the water diffusion rate to allow for more even drying. This change was proven successful in reducing the formation of 'checking' in pellets.

7. FOCUS GROUP STUDY ON EXTRUDED SNACKS

7.1. INTRODUCTION

Engaging consumers early in the product development process is very important, as they can compare the product prototypes with the competitive products and identify advantages and disadvantages in the new product concept, and therefore, provide guidance for product improvement and optimization (Earle & Earle, 1999). A high level of acceptance of the target consumers is an essential prerequisite for a successful product.

There are two types of consumer research: qualitative and quantitative. Quantitative research involves collecting feedback from a large number of consumers. Qualitative consumer research is useful for defining critical attributes and for gaining a deeper insight into consumer reactions to product concepts, their attitudes, opinions, feeling and behaviour for food choices from a relatively small group of consumers (Kemp, Hollowood, & Hort, 2009; Rabiee, 2004; Resurreccion, 1998). There are various qualitative research methods including one-to-one in-depth interviews, group interviews and, most commonly, focus groups (Kemp et al., 2009).

There are several advantages for using focus groups to obtain consumer information not easily obtained with quantitative research. Focus group studies have a number of applications including idea generation and early assessment of a product concept or prototype. They can also be used to build up a concept or improve a product prototype. Qualitative focus groups involve fewer participants compared to quantitative methods (Resurreccion, 1998). Although fewer participants does not mean less effort in recruiting participants, as rich data can only be generated if the members of the group feel comfortable with each other and engage in discussion (Krueger & Casey, 2000). The uniqueness of a focus group is its ability to generate data based on the synergy of the group interaction (Rabiee, 2004). Therefore, it is very important to invest time and effort in selecting members of the group and the right environment for this exercise. Another advantage for focus group study is that it can generate a large amount of data in a relatively short time at lower cost.

Kemp et.al (2009) recommended eight to twelve participants to be recruited per group. However, (Krueger & Casey, 2000) suggested between six and eight participants to be the optimum number for a focus group. Eight is the common number proposed by both researchers. Since focus group information is qualitative and involves fewer consumers compare to the quantitative method, statistical analysis is not always appropriate (Kemp et al., 2009; Resurreccion, 1998). Rabiee (2004) provided practical guidance for analysis of focus group data including words, context, internal consistency, frequency, intensity and comments, specificity of response, extensiveness and big picture.

The objectives of this study were to gain insights into consumers' attitudes towards extruded snacks, to find out what they wanted for extruded snacks, to obtain their perception of key competitors' products and to evaluate product prototypes. The findings may also be used to maximise the desired product attributes and minimise or eliminate the unwanted characteristics for further product development work.

7.2. EXTRUDED SNACK FOCUS GROUP PROCEDURE

This focus group study was evaluated and judged to be low risk to human participants. Consequently, a 'Low Risk Notification' (Appendix A 6.1) was issued and recorded on the Low Risk Database which was reported in the Massey University Human Ethics Committee Annual Report prior to the recruitment of the focus groups.

7.2.1. Recruitment Procedure

The primary target market was consumers who regularly consume extruded products. A gift bag to the value of $20 was used as an incentive, in appreciation of a participants' time and effort to take part in the focus group. Human ethics approval was obtained and three snack focus groups were conducted for the study. Each focus group session had seven to eight participants. Due to time and budget restrictions, recruitment of the focus groups was conducted through the use of three methods:

1. Recommendation: potential participants were introduced by friends, family contact and work colleagues (emailed, telephoned or word of mouth);
2. Advertisement: potential participants were recruited through advertisements in local supermarkets and shopping malls (posted flyer Appendix A 6.2);
3. Direct recruitment: potential participants were recruited through student group email list at Massey University Albany campus.

A flyer was posted or emailed which contained a brief explanation of the study, approximate session time, main issues to be discussed and key screening criteria. Screening criteria were setup as shown in Appendix A 6.3. Those who consume one or more pre-listed snack products at least fortnightly and were able to attend were sent more information (time, venue and location) via e-mails.

7.2.2. Administrative and participants details

Among the three focus groups, two were conducted between 6 pm and 7 pm on 8th and 15th of November 2011 at Favona kindergarten, Auckland and one was conducted between 1:30pm and 2:30pm on 18th of November 2011 at Massey University Albany campus, Auckland. The chairs and a table were set up in a circle to encourage open discussion. The participants' demographic information is summarised in Table 7.1.

Table 7.1: Demographic characteristics of participants (n= 22)		
Variables		Number of responding
Gender	Male	9
	Female	13
Age	16 to 24	6
	25 to 34	6
	35 to 44	5
	45 and over	5
Race	Caucasian	11
	Maori	2
	Asian	4
	Pacific Islanders	5
Marital status	Single	10
	Married	8
	Others	2
Employment	Employed full-time	13
	Employed part-time	2
	Homemaker	1
	Student	6

Of the 22 snack group participants, six (27.3 %) participants were aged between 16 and 24; six (27.3 %) were aged between 25 and 34; five (22.7 %) participants were aged between 35 and 44 and five (22.7 %) were over 45. Nine (40.9 %) participants were male whilst thirteen (59.1 %) were female. In terms of ethnical groups, half of the participants were European New Zealander;

seven (31.8 %) were New Zealand Maori or Pacific Islanders; four (18.2 %) were New Zealand Asian. The majority (59.1 %) were employed full-time and 6 (27.3 %) were students.

In order to make a homogenous group to gather representative diversity views, each focus group contained four to five females and three male participants, who were in different age groups and belonged to different ethnic groups.

7.2.3. Focus Groups

7.2.3.1. 3G snack product prototype coating

Unseasoned puffed 3G snacks were not suitable to be used for sensory evaluation against commercial extruded snacks, because participants' scores were likely to be biased driven by the product taste. Hence, commercial seasoning products were sourced and the 3G snack product prototypes were coated for the focus group study.

One seasoning product was supplied by Givaudan and two seasoning products were supplied by IFF as shown in Table 7.2. The product specifications are in Appendix 1. Despite the large macronutrients differences for the different seasoning products, the same dosage rate (5 % w/w) was applied to all products.

Table 7.2: Seasoning product sources and their price

Ingredients	***Supplier***	***Price obtained in 2014 (NZD/kg)***
QF13045 Tomato Salsa	Givaudan	15.56
SC273864 Cheese	International Flavours & Fragrances (NZ) Ltd.	11.79
SC236534 Sour Cream & Chives	International Flavours & Fragrances (NZ) Ltd.	13.60

Ten grams of snack pellets were placed into a popcorn machine (Crazy^{TM} Popper, Breville Australia). Pellets were puffed for 50 ± 2 seconds and then poured into a bowl to cool down to 50 ± 5 °C. Coating of snacks with seasonings was carried out in 40 g batches, which was carried out with a resealable clear plastic bags (230 mm x 305 mm). Two grams of sunflower oil (5 % w/w) (Essente^{TM}, Marsanta Foods) and two grams of seasoning (5 % w/w) were first added into the bag. Thirty-six grams of the puffed warm snack base (55 ± 5 °C) were then added into the bag. The bag was immediately sealed and shaken by hand. The coating process was stopped when the surfaces of snacks were entirely coated with seasoning and the seasoning was evenly distributed.

Each sample including the commercial products was coded with a three-digit number. Multiple samples were presented to the panellists with the sample presentation order randomised to reduce the order effect (Kemp, et al., 2009).

7.2.3.2. Focus Group Procedure

Each group discussion lasted around one hour and was audio-taped. A guide was prepared to moderate each group discussion as shown in Appendix A 6.4. The exact wording of the questions outlined in the guide was not prescriptive. The author posed questions conversationally to allow the discussion to flow more fluidly. Each focus group session was divided into four phases as illustrated in the guide. The group began with the introduction phase. The moderator (author) described a brief background of the project and purpose of the discussion. The main purpose of this was to ensure participants understood the main focus of the study, confidentiality, recording of answers and that there were no right or wrong answers.

Next was to get the participants familiar with each other, so that the group felt comfortable with each other and engaged in the follow up discussion. The discussion would be general issues, such as introduction of participants themselves, snack preference and consumption habits. The discussion would then pertain to individual factors such as social association with snacks, key purchase criteria, liking and perceptions of health benefits. Questions also focused on characteristics of extruded snacks that differentiate them from other snack foods. To maximise the data obtained from each participant, after an open discussion, all participants were asked to note down the key purchase criteria (Appendix A 6.5) and explain their choices as well as scored a product claim sheet to the level of attractiveness (Appendix A 6.6). The objectives of this part of the discussion was to gain an insight into attitude and motivation toward extruded snack foods, social associations with the snack food and key purchase criteria. Subsequently, participants were asked to score the importance of a range of attributes, most of which were generated from the key purchase criteria discussion.

Participants were then asked to taste a range of commercial extruded snacks including a product prototype as shown in Table 7.3 and to rate their acceptance of each product on 9-point hedonic scales (Appendix A 6.7). The reason for this arrangement was to avoid biased opinions on the product prototypes due to the presentation order. Small samples of each product were presented in plastic cups with a randomly generated three digital code during the focus group study. This was to ensure participants were not biased towards the samples due to the codes. Participants were also asked to pick their favourite product/products and to nominate one or two products they disliked the most. Nutrition information panel summary for all tasted products was provided to assist their choices (Appendix A 6.8). The main purpose of competitor analysis was to gain insight into what message, and product characteristics attract consumers, and what product characteristics the consumers disliked.

Lastly, three product prototypes were presented and participants were asked to score the product appearance, texture, shape and size on a 9-point hedonic scale (Appendix A 6.9). The product prototype identities are shown in Table 7.4. The main objective of this part of study was to evaluate the product prototypes and gather feedback for product improvement. At the end of the discussion, the moderator (author) reviewed concepts and issues, asked for clarification and suggestions. Finally, the moderator (author) expressed the appreciation to all the attendees for their participation and contribution as well as closing the discussion.

Table 7.3: Competitor analysis products

Product Code	***Brand***	***Product Name***	***Flavour***
252	ETA	Good Bites	Cheddar Cheese
328	Bluebird	Biguns	Cheese
387	Bluebird	Burger Rings	Burger
409	Pams	Aliens	Cheese
564	Bluebird	Twisties	Cheese
736	Research Prototype	'CW Water Lo'[1]	Group 1 & 2:Tomato & Salsa Group 3: Cheese
791	Bluebird	Grainwaves	Sour cream & chives
940	Healtheries	Rice Wheels	Burger
973	ETA	SKOF Tripods	Chicken

Table 7.4: Focus groups 3G snack product prototypes

Product Code	***Identification***	***Flavour***
694	'RW Water Lo'[1]	Group 1 &2:Tomato & Salsa Group 3: Cheese
119 (736)	'CW Water Lo'[1]	Group 1 &2:Tomato & Salsa Group 3: Cheese
515	'RWC Water Lo'[1]	Group 1 &2:Tomato & Salsa Group 3: Cheese

[1] 'Lo' stands for low water addition rate (1.0 kg/h)

7.2.4. Modification of discussion guide and data analysis

The questions used in the first focus group discussion were found to elicit the desired information and were not modified prior to use with the remaining groups. The product claim questionnaire was slightly modified after the first focus group discussion with ancient grain claim added to the list. The sessions were audiotaped and the audiotapes were transcribed verbatim as shown in Appendix A 6.10. Qualitative data analysis procedures as suggested by Rabiee (2004) were used. Representative quotes from the participants were identified. Rating scale data were summarised by calculating means, standard deviation and frequencies using Minitab 16 statistical software package (Minitab Inc., State College, Pennsylvania, US).

7.3. RESULTS AND DISCUSSION

7.3.1. Social association with snack food

The results from three focus groups indicated that there are five themes typically associated with snack consumption. They are nostalgia, special social occasions, distraction, convenient treat and hunger. Examples of relevant quotes for each theme are shown in Table 7.5. These themes can be divided into two categories, emotional association and functional association. Emotional snacking including nostalgia and special social occasions was typically associated with gratification and indulgence; whereas, functional consumption including distraction and hunger. Convenient treat fits into both categories. According to research carried out by Datamonitor (2011), when consumers want to treat themselves, sensory pleasure and affordability are two key requirements from treating.

Table 7.5: Typical themes associated with snack consumption

Themes	Representative quotes for each theme
Nostalgia associated with childhood memories	*"I always had wine gum lollies, ever since I was young, very young, I used to go buy my own, cause it was only two cents back in the day. I never stopped eating wine gums to this day. Of all the snacks I've eaten. That is my favourite and I eat them daily."* (Group 1 Participant 1) *"I think my favourite snack was Twisties. I started from my childhood, like you'll have it in your lunch. It has been ongoing."* (Group 1 Participant 2)
Special social occasions i.e. events or parties, associated with good time	*"I think it's the social time what you have it for. Like more recently, we've got the whole package for Hallowing for the kid's thing. You just eat them all."* (Group 3 Participant 4) *"Going back it would only be on special occasions, parties. Yeah, sort like good time, yum."* (Group 1 Participant 3) *"All of my friends would like watch a movie together. They'll go get some snacks. They'll get some that everyone would like kind of thing."* (Group 1 Participant 5)
Distraction a. habitual snacking, absent-minded behaviour among leisure activities b. Stress relief	*"I just like to grab a lot in front of the TV, on a couch of the …snacking away. That's kind of thing I think of. Yeah, when I'm being lazy and that's the thing to think about, more like casual, yeah, without even think about it really when you're watching TV."* (Group 1 Participant 5) *"Sitting down and watch a cheap B great movie, really old Peggy's 70th movie."* (Group 2 Participant 1) *"I probably think about the snacks while watching a movie or something on TV, or maybe something between meals. Just something to do until dinner is ready."* (Group 1 Participant 7) *"You know food disappears while you are studying. If you have it in the cupboard, it goes."* (Group 3 Participant 4)
Convenient treat A prerequisite for extruded snacks.	*"If I need 5 minutes always from my kids, that's how I get the quiet out."* (Group 2 Participant 5) *"For me, it's a convenient treat. Basically that's what it is. If it's there and I can have it quickly, open the bag, yeah, and I'm happy."* (Group 1 Participant 6)
Hunger Snack between meals	*"When I'm peckish, but not hungry enough for big meal"* (Group 3 Participant 1)

7.3.2. Advantages of extruded snacks over biscuits or crackers

Consumers were asked why they would choose extruded snacks over biscuit and crackers. It was found that participants could not differentiate between chips and extruded snacks. The main reason for the participants to choose an extruded snack or chips over other types of snacks was the taste. They indicated that extruded snacks or chips were savoury and often quite flavoursome, which made them addictive for consumers. Other reasons for preferring extruded snacks/chips were convenience, more attractive appearance, light, crispy texture and a suitable bite size. The representative quotes of for each attributes were shown in Table 7.6.

Table 7.6: Key reasons for choosing extruded snacks

Reasons for choosing extruded snacks	Representative quotes for each reason
More flavoursome and being savoury	*"Normally, crackers are plain. Extruded snacks are flavoured."* (Group 1 Participant 1) *"Extruded snacks are savoury. I think you can eat more savoury than you can for sweet."* (Group 1 Participant 3)
Tasty and addictive	*"My baby is just 3 year old. I always buy the small packet for him. Once he opens one, he will finish it and ask for another one"* (Group 3 Participant 6) *"Most of the snacks are very salty, very artificially enhanced sort of flavours, and unfortunately I think I agree we getting a little bit addicted to it."* (Group 3 Participant 1)
Convenient to eat (no preparation required)	*"The thing with biscuits, you have to make a cup of tea, or something. For chips, you just rip the bag and there you go."* (Group 1 Participant 6)
Wholesome light texture; not feel stuffed afterwards.	*"Look a pack of chips, it's light, it doesn't weight very much like a pack of biscuits, and senses healthier."* (Group 1 Participant 7)
More attractive appearance	*"I think I pick up a food colour 550. It gives the product bright orange colour".* (Group 3 Participant 4)
Suitable bite size; so that when bite into extruded snacks, they just crumble in mouth.	*"The snack I can fill in my mouth"* (Group 2 Participant 1)

7.3.3. Key purchase criteria for extruded snacks

The majority of the participants indicated that they make their own purchase decisions when it comes to snack food. They were asked to write down all the key purchase criteria for extruded snack. The results were summarised and presented in Figure 7.1.

Taste/flavour was the most important purchase criterion. It was well emphasized by all the participants across all three focus groups. Participants needed a variety of flavours to choose from for themselves and for their families. This findings were consistent with results from international research indicating purchases of snack products emphasize taste well over and above anything else (Datamonitor, 2012).

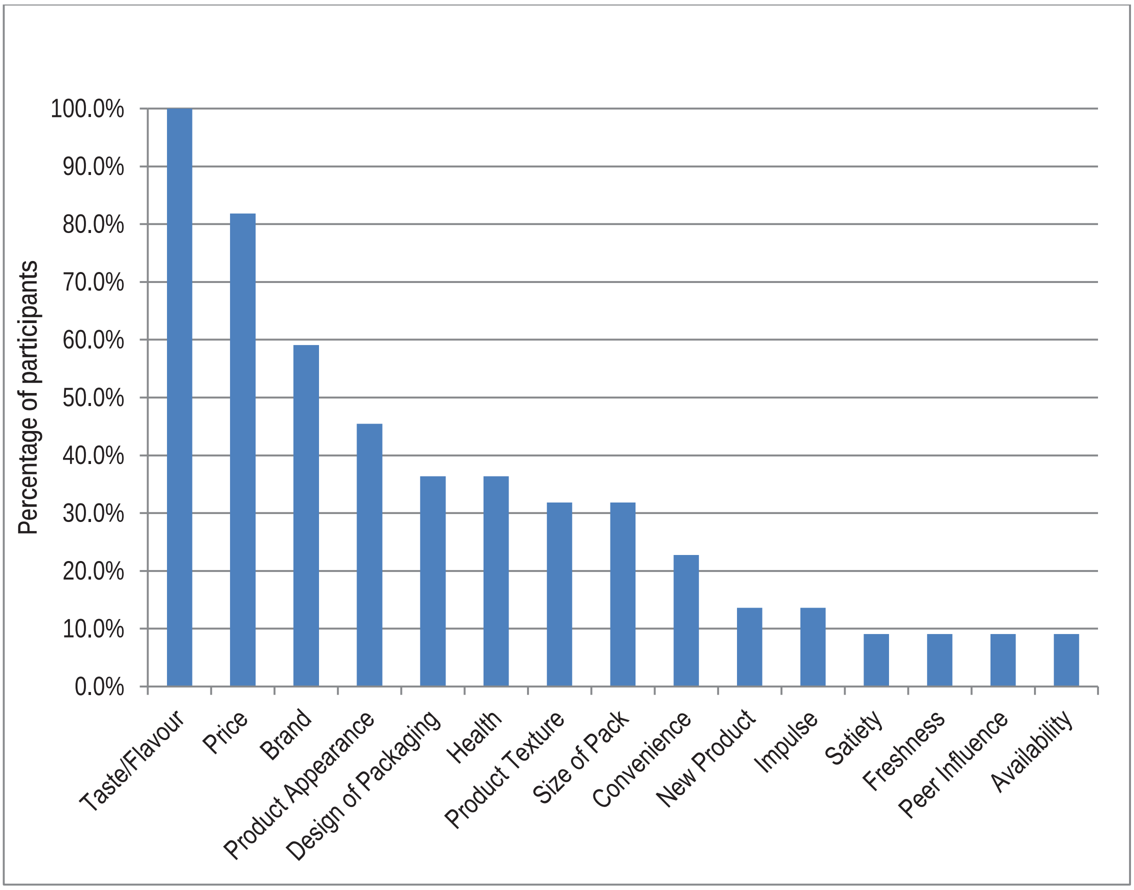


Figure 7.1: Key purchase criteria for extruded snacks

The participants' definition of a good flavour was when the smell and taste of a product matched their expectations and the flavour strength was about just right. The representative quotes are shown below:

> *"It tastes like what they say."* (Group 2 Participant 7)

> *"Flavour strength, I'm not sure if he's already said that. If it's really strong, I'd be less likely to have it or I gonna buy small packet of it or something, I could never get a big pack."* (Group 1 Participant 5)

Price was the second most important purchase criterion for the extruded snack category with more than 80 % of the participants stating it influenced their purchase decision. Price was found to be correlated with 'size of pack' during focus group discussion. At the same price, the bigger the pack size, participants will be more likely to buy the product, 31.8 % of the participants stated the 'size of pack' was one of the key purchase criteria for extruded snacks. Lower prices were especially appealing to participants with a big families and were not very health conscious; they looked for larger sharing pack formats in order to get better value for money (Group 1 Participant 6).

Product familiarity was another key purchase criterion. The familiarity came in two ways. One way was the brand history and trust. Nearly 60 % of the participants indicated brand was an important purchase criterion. A good brand needs a long time to win public praise and trust. People have consumed the same brands since they were children. Marketing through various media was the other way to engage consumers. Good brands are normally heavily promoted to raise public attention. Participants believed branded snacks had better taste and quality, rather than risking their money on something new, they brought branded snacks they knew, as they were guaranteed good treats (Group 1 Participant 1 and Participant 7, Group 2 Participant 1, Group 3 Participant 1).

Product appearance (45.5 %) and design of packaging (36.4 %) appeared to strongly affect selection of the extruded snacks. According to focus group discussion, product appearance consisted of colour, size and degree of expansion ('puffiness'). Without tasting the product, appearance could give participants a first impression of the products taste and texture. Colour was associated with the products taste, whereas, size and 'puffiness' of the product were associated with the product texture. The representative quotes were shown below:

> *"If they have a picture in the front (of the packaging) and it looks good… that makes you wanna eat it."* (Group 1 Participant 6)

> *"(Colour) make them (snacks) look tasty"* (Group 3 Participant 3)

> *"I like the big ones… the little ones look too hard."* (Group 3 Participant 4 and 5)

In terms of packaging design, participants indicated that they looked for features that stood out from the range available, such as bright, colourful and shiny packaging (Group 1 Participant 7, Group 3 Participant 3). Participants admitted that they would pay attention to special event promotion of snack foods using special packaging. It captured the popularity of the event as well as the interest of the brand fans. For example, a trusted snack brand creates a limited edition for a special event (Group 3 Participant 4).

As can be seen from Figure 7.1, health was more important than product texture for extruded snacks. However, many participants claimed that they were not snacking for healthiness but as treats and they were not willing to forego taste and flavour for health benefits (Group 1 Participant 5 and 7, Group 3 Participant 2, 4 and 6). Thus, unlike other purchase criterion, health cannot be the sole purchase driver, but an added benefit.

Important features health conscious participants looked for prior to purchase were firstly, the product packaging design. A natural image with stand-out features is something they are looking for (Group 1 Participant 3 and 5). Secondly, the health information on the pack (i.e. wholegrain components), compare nutritional values focusing on fat, sodium, and fibre etc., and looked at whether it contained any artificial ingredients or preservatives (Group 1 Participant 4, Group 3 Participant 5). Next was the portion size, some of the health conscious participants reported that they would sometimes only buy, pre-portioned snacks to keep their snack consumption under control (Group 1 Participant 3). Pre-portioned snacks are a growing trend in Australia. Nearly half of Australians (46 %) reported that they try to eat and drink smaller portions either “most of the time” or “all the time” in 2010 (Datamonitor, 2012), this was a 17 % increase on the number reported the previous year (Datamonitor, 2012).

Around one-third of the participants chose product texture as an important purchase criterion for extruded snacks. Participants were looking for crunchy or crispy products. The wholesome light and crispy texture of the extruded snacks is one of key attractive characteristics over biscuits and crackers (Group 1 Participant 7, Group 2 Participant 1 and 7, Group 3 Participant 1).

Only about 23 % of the participants mentioned convenience to be the key purchase criterion for extruded products. It does not mean it is less important. The same as for product texture, most participants thought it was a given characteristic for extruded snacks. This was shown during the discussion of advantages of extruded snacks over biscuits and crackers. Greasiness on hand was a concern for some of the participants. When they consumed snacks on the go, greasy and coloured ones were less preferred, as they require time and extra preparation for cleaning (Group 1 Participant 3 and 7). However, for some participants, greasiness was not a concern and the coloured snacks were preferred, as it added visual interests (Group 3 Participant 3, 4 and 8)

Both new products and peer influence are important means to increase market share. A number of participants (13.8 %), especially female participants, reported that they were quite open to new products/flavours and willing to give them a try. A new product for them was an experiment and was a break from their normal routines, but after the initial excitement, the product had to have something more than ‘new’ to make the participants stay. The representative quotes were shown below:

> *“If it’s a new brand, I will try it. If I don’t like it, I will pass on to the kids.”* (Group 2 Participant 5)

> *“I look the different flavours that could be novel kind of flavour.”* (Group 3 Participant 3)

> *“I thought something we had seen before. These Pams one came out a couple of months ago, everyone just went crazy for them, because it was new and they tasted it. They were different from Twisties but it was like Twisties. ‘Twist’ I think that was called, so that was something we went for, but we have gone off them and just gone back to our really salted ones we like until we found something else.”* (Group 1 Participant 6)

A recent consumer insight research on mealtime and snacking trends in Australia discussed this phenomenon: “snacks are an ideal gateway for consumers to test new flavours; they are less of a commitment than a main meal and thus more conductive to experimentation.” (Datamonitor, 2012). The new products could be promoted further to more conservative consumers through peer influence (Group 1 Participant 5).

Impulse purchase, 13.8 % participants indicated as their key purchase criterion, was found associated with two other purchase criteria —satiety and product availability during the focus group discussion. The representative quotes were shown below:

> *“I tend to decide whether I’m hungry for it at that moment. Do I want to eat that at that moment, otherwise, I can walk pass it. If my stomach says I really need it, I’ll go and buy it.”* (Group 2 Participant 3)

> *“The fact that see it on the shelf, because sometimes it does remind me”* (Group 1 Participant 7)

Although there were only a small number of participants, who pointed out that product freshness was their main purchase criterion for extruded snacks; it had direct associations with product taste and texture. Participants indicated that freshness was detected by the product aroma, initial taste and texture when they opened the packet (Group 1 Participant 2, Group 2 Participant 1 and 7).

These key purchase criteria can be summarised into rational and emotional criteria as shown in Table 7.7. According to the global research carried out by Datamonitor (2011), emotional consumption are non-conscious responses including treating, indulgence and impulse. The arrows in the Table mean that some of criteria can influence the others. Based on the responses from the focus groups, extruded snacks are more often consumed due to emotional criteria than for rational criteria.

Table 7.7: Key purchase criteria presented by categories and inter-connections between criteria

Rational criteria	**Emotional criteria**
Price	Product Appearance
Value for money Health Portion control	Design of Packaging
Size of Pack	Impulse (satiety and availability)
Quality (flavour, product texture and freshness)	Brand
Convenience	
	New Product
	Peer Influence

7.3.4. Participants' perception towards ingredient list, nutritional information (NIP) and product claims for extruded snacks

The initial hypothesis was that prototypes using the ancient grains would create products with a clear point of differentiation. These products might have appealed to participants who wanted snacks above and beyond the ordinary. The fibre fortification and wholegrain claim would further enhance the product health image. However, the focus group study showed that participants' perceptions towards product claims were mostly negative. General attitudes were 'not care', 'not believe' or 'not understand'. However, there were a few participants who claimed that they read the nutritional information and ingredient list also admitted paying attention to certain product claims. The representative quotes for each attitude are shown in Table 7.8. Discussion details can be found at 'the impact of NIP and product claims' sessions for all 3 focus group transcripts in Appendix A 6.10 and the analysis results are shown in Appendix A 6.11.

More than 40 % of the participants were seeking snacks for indulgence only and claimed they simply ate what they wanted. Many participants, who were not very health conscious, were found to be young to middle-aged males. For those participants who normally just followed their routine brands would also less likely to pay attention to the ingredient list and NIP. In comparison, many female participants were concerned about their calories and fat intakes. However, rather than focusing on the health benefits, they were keen to have a snack with balanced taste and health. Most participants, who were aged 50 or over, showed much stronger concerns about the healthiness of the snacks. They were concerned about preservatives and artificial ingredients, i.e. MSG, artificial colours and flavours, and wanted to avoid them (Group 1 Participant 3 and 4, Group 2 Participant 1). Similar results were found in a global consumer research, which reported that a significant proportion of younger consumers did not worry about the food they ate. This was especially true for men. The worry grew among women in their mid-30s and more gradually among men in their mid-40s (Datamonitor, 2011).

Table 7.8: Participants' attitude towards product claims

Attitudes	Representative quotes
Not Care	*"After I've eaten it, I'll check it out (laughing)."* (Group 3 Participant 4) *"I just eat them, I don't wanna know"* (Group 1 Participant 1)
Not Believe	*"You have to believe the claims though. Something is reliable."* (Group 1 Participant 7) *"I don't believe a lot of the words. It only means it taste worst or not true anyway. You read the label, just got the same stuff in it."* (Group 2 Participant 1)
Not Understand	*"When you say a source of wholegrain, does that mean whether it's corn or wheat or whatever?"* (Group 1 Participant 3) *"What does MSG means?"* (Group 1 Participant 2)
Attention to Specific Claims	*"I'd like to compare how much sodium it's in them, any preservatives or MSG or whatever."* (Group 1 Participant 4) *"I'm constantly trying to find the low fat chips that are good for you, but I haven't found it yet."* (Group 1 Participant 3)

Previous studies showed an association exists between feelings of guilt and the amount of food eaten (Rozin, Kabnick, Pete, Fischler, & Shields, 2003). For those who would pay attention to the nutritional information and ingredient list claimed that they were more likely to look at this when they first tried it (Group 1 Participant 5). Comparing two products was the most common means for the health conscious participants to use the nutritional information, as they usually did not know the meanings of the numbers by themselves (Group 1 Participant 7). Moreover, the participants indicated that they would normally use the product they were familiar with as the standard (Group 3 Participant 6). Regarding nutritional information for extruded snack, participants were mostly interested in knowing the fat and salt contents (Group 1 Participant 3 and 4, Group 2 Participant 1).

Four participants had problems to understand 'MSG" or 'Wholegrain'. The level of understanding of these terms were better than the 'ancient grain' claim, the feedback from virtually all participants was that they all had a very poor understanding of ancient grains, either by definition or benefits. Some participants concerned about the price of the product with ancient grains. They were not willing to pay extra for their health benefit unless they knew more details of the active ingredients. The poor understanding of ancient grains has also reflected on the data published in Mintel GNPD

(2013) (analysis details refer to Appendix A 6.12.1). There were only three products launched in Australia and New Zealand with ancient grain or grains between 2008 and 2012 (Figure 7.2).

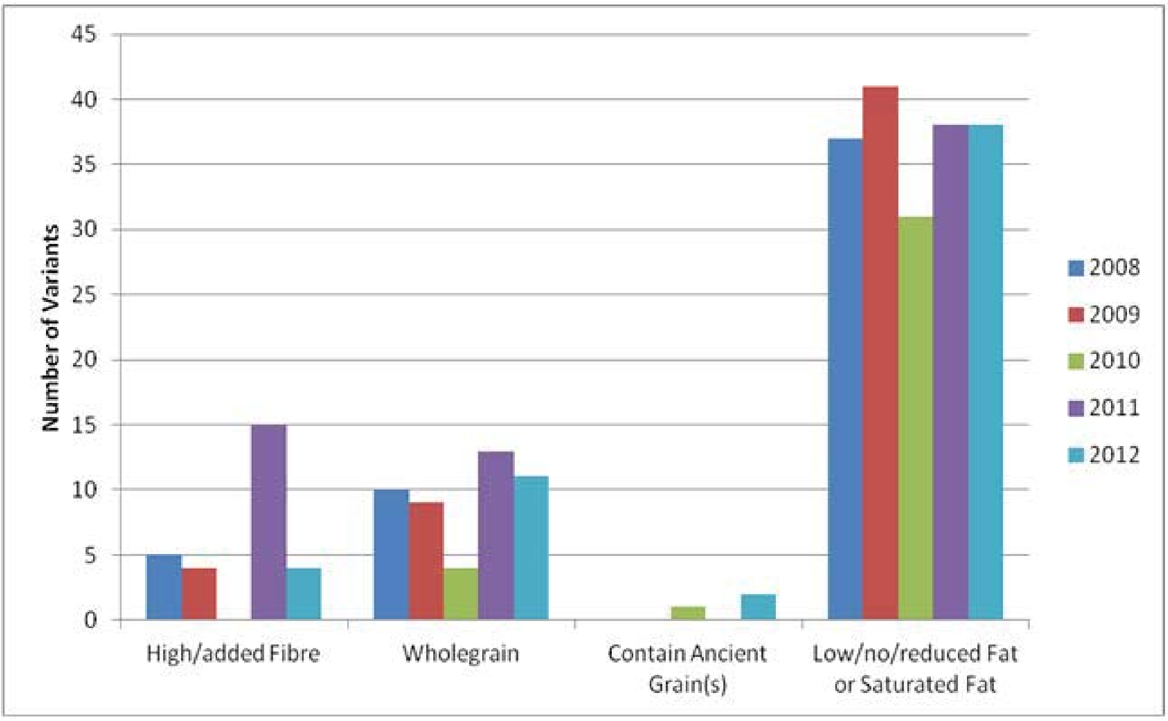


Figure 7.2: Number of snack variants published on mintel GNPD for Austarlia and New Zealand between 2008 and 2012 segregated by claims (Mintel, 2013)

Globally, the numbers of new launches with ancient grain(s) doubled in 2012 (Figure 7.3) (analysis details refer to Appendix A 6.12.2). Although there was definitely an increasing popularity toward ancient grains, it was still a relatively small share of the market compared to other product claims. The number of variants launched in Australia and New Zealand carrying a fat related claim were more than 10 times of the ones containing ancient grain(s) (Figure 7.2). A similar result can also be seen globally (Figure 7.3). Different from the ancient grain claim, the global trend for wholegrain claim was increasing every year, but the growth was relatively constant in the Australia and New Zealand market. With the increasing international attention towards wholegrain consumption and health benefits associated, the local market trend may pick up in the future.

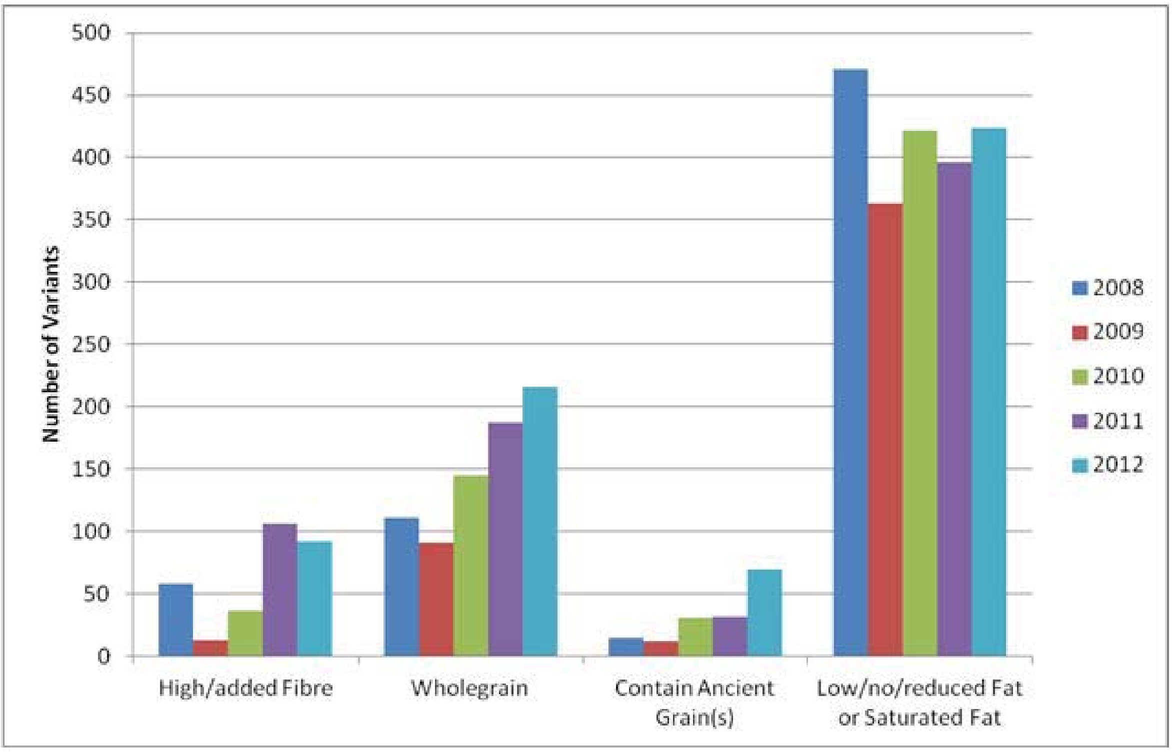


Figure 7.3: Number of snack variants published on Mintel GNPD gobally between 2008 and 2012 segregated by claims (Mintel, 2013)

Descriptive analysis on the product claim questionnaires shows that 'low in sugar', 'high in fibre' and fat related claims were quite attractive to participants with mean score of 7 (moderately attractive) out of 9 or above (Appendix A 6.11.1). There were definitely more fibre related claims than the ancient grain(s) claims. The 'high in fibre' claim was perceived to be positive by all age group participants with 15 participants (65 %) scoring this 7 (moderately attractive) or above out of 9 for the claim attractiveness. According to Mintel GNPD, the number of new snack products with high/added fibre increased significantly in 2011 and were greater in number than the ones launched with a wholegrain claim (Figure 7.2).

Among the fat related claims, 'low in saturated fat' was of the highest acceptance with mean score of 7.3±1.3. 'Baked not fried' may be a better option than 'less fat' claim, although the mean score for the 'less fat' claim was slightly higher. Firstly, the histograms of 'less fat' and 'baked not fried' in Appendix 3 shows that the scores distribution were slightly more skewed to the right (more attractive) for the 'baked not fried' claim than the 'less fat' claim. Secondly, according to the focus group, making claims like less fat and salt would not have any positive impact on the consumers purchase decision, as they often associate blandness or a significant taste compromise with a healthier product.

There was some division of opinion among participants about a 'gluten free' claim. Participants who were 45 or older were more likely to be attracted by this claim than participants who were younger than 45 as illustrated in Appendix A 6.11.2.

The focus group findings on extruded snacks were slightly different from the overall snack trends in New Zealand. A recent Australia and New Zealand snack insight report (Mintel, 2012) claimed that top five claims were 'no additive/preservatives', 'low/no/reduced allergen', 'low/no/reduced fat', 'gluten-free' and 'eco-friendly package'. 'No additives/ preservatives' is the top claim for snacks in Australia and New Zealand and this is growing over time. Low/no/reduced fat is the second most important claim for snacks in Australasia (Mintel, 2012).

7.3.5. Participants' perception of key competitors and their products

7.3.5.1. Attributes importance and Preferred extruded snacks

Participants were presented with nine products for tasting. Prior to the tasting, they were asked to score the importance of a range of attributes on a 9-point hedonic scale, most of which were generated in the previous part of discussion (Appendix A 6.7). The results are shown in Table 7.9. The results were mostly in-line with the key purchase criteria findings, except the post-purchase attributes were scored much higher than the health and convenience attributes, which illustrates the apparent conflict in consumers' minds: they wanted to snack healthily but when they saw the products, their emotions took charge; product appearance, flavour and texture became the more important attributes for choosing their preferred snacks with flavour remained the most important one.

Table 7.9: The importance of product attributes

	Product Attributes	Importance
Pre-purchase Attributes	Flavour Variety	6.8±2.0
	Price	7.3±1.7
Post-purchase Attributes	Product Appearance	7.5±1.6
	Product Size	6.3±1.6
	Crispness/Crunchiness	7.5±2.0
	Flavour	7.9±1.8
	Flavour Strength	7.5±1.5
Other Attributes (convenience/health)	Greasiness on hands	5.8±2.6
	Nutrition	5.4±2.1
	Product Claim	5.6±2.2

7.3.5.2. Features of preferred extruded snacks

Among the nine products tested (eight commercial products and flavoured 'CW Water Lo'), Bluebird Bigun was the clear winner with almost half of the participants picked it as their favourite or one of their favourites snacks. The second most popular product was the Grainwaves with just over one third of the participants picked it as their favourite or one of their favourites. In comparison, the two products participants disliked the most were the research prototype and ETA Good Bites. Both of the products had 10 votes out of 23 participants. Table 7.10 summarises all participants' average scores against each important post-purchase product attributes.

Table 7.10: Important post-purchase product attributes comparison

Post-purchase Product Attributes	Favourite Sample(s)		Disliked Sample(s)	
	Bigun	GrainWaves	'CW Water Lo'	Good Bites
Product Appearance	7.6±1.9	6.6±2.4	4.9±2.5	4.9±2.6
Product Size	7.4±2.2	7.1±2.3	3.5±2.4	5.9±2.3
Crispness/Crunchiness	7.6±1.6	7.8±1.7	6.0±2.3	4.3±2.3
Flavour	7.4±2.0	6.9±2.1	4.7±2.7	4.5±2.5
Flavour Strength	6.7±2.0	7.0±1.9	4.7±2.8	3.9±2.4

As discussed earlier, the product appearance was directly associated with the product taste and texture. Bluebird Bigun's scored the highest for the product appearance and size. The score for product texture was also highly preferable. GrainWaves got the highest score for the product texture. The product size and flavour strength were also scored highly. The key reason that the flavoured 'CW Water Lo' sample got rejected was because of the size of the sample. The flavour delivery was also weak. However, the texture was acceptable. 'Good Bites' has the lowest score for flavour strength and texture. The representative quotes for participants' choices were summarised in Table 7.11.

Participants reported that a good extruded snack should have a good product appearance, crispy/crunchy texture and is made by a reputable manufacturer with a flavour they liked and sold at a price, which was considered to be value for money.

Table 7. 11: Reasons for participants' like/dislike choices

Attitudes	Representative quotes
Appearance	*"Look a bit dense. Not fluffy enough."* (Group 1 Participant 7) *"I find them actually quite ugly"* (Group 3 Participant 2)
Size	*"I like the size of it straight away draws your attention to these things. It is bigger than any others"* (Group 2 Participant 7) *"I like 328 (Bigun) the most, cause it has nice appearance, good size."* (Group 3 Participant 3) *"You have to put five in your mouth to get the same results as you would with one, maybe it's the math thing. Thinking I'm eat five compare to one."* (Group 1 Participant 2)
Flavour Strength	*"My favourite was 791. I really liked the flavour and it was crunchy. The flavour wasn't very strong. I don't really like strong ones."* (Group 1 Participant 5) *"I thought this flavour is too strong for me."* (Group 1 Participant 3) *"252's (Good Bites) taste is bland. The flavour disappeared very quickly. A little hidden taste, all of the sudden, it's gone. Not fresh."* (Group 2 Participant 7)
Texture	*"My favourite was 791. That was because it was really crunchy."* (Group 1 Participant 6) *Texture was pretty horrible, like it's got moisture in the pack and it stuck to your teeth."* (Group 1 Participant 5)

7.3.6. Product Concepts

Participants were asked about the acceptability of three new product prototypes. They indicated that all three prototypes were very similar in terms of appearance, size and texture as illustrated in Table 7.12. The sample made with corn and wheat was slightly preferred in terms of texture than the other two prototypes, but the prototype acceptability scores did not agree with their preference choices. Respondents were disappointed in the flavour intensity of the sample they were given, as there was not a consistently strong flavour throughout. Some participants commented the samples were not fresh due to the sudden loss of flavour after the first couple of bites.

Although product size was not an important product feature raised in the previous discussion phases (Section 7.3.3), it became the biggest concern for the research prototypes in this phase. Participants found the products were very inconvenient to eat as they were small. In addition, children may choke on the small sized product, and therefore it was considered to be not suitable for children. Moreover, the small size resulted in the product being dense, thus the pack looked smaller for the same weight. When the product is displayed in the supermarkets and consumers are charged similar prices as other snack products, consumers may feel it is not good value.

Table 7.12: Acceptability of 3G snack research product prototypes

Identification	*Appearance*	*Size*	*Crispness/Crunchiness*
'RW Water Lo'[1]	4.0 ± 2.2	3.1± 2.0	6.7 ± 1.8
'CW Water Lo'[1]	4.1 ± 2.2	3.3 ± 2.0	6.6 ± 2.1
'RWC Water Lo'[1]	4.4 ± 2.4	3.4 ±2.1	6.4 ± 1.8

[1] 'Water Lo' means low water addition rate (1.0 kg/h)

Participants were divided regarding the ideal texture for the extruded snacks. Some participants advocated for the current product texture (Group 1 Participant 3, 6 and 7, Group 2 Participant 1), while a few participants suggested the texture was a little hard and need to be slightly softened (Group 3 participant 4 and 8), but this could be because of the small product size.

Participants suggested the ideal product size should be about three times larger than the current research prototype product size or similar to the size of Grainwaves and a couple of participants suggested a different product shape may be more attractive (Group 1 Participant 7, Group 3 Participant 1 and 3). Participants also recommended that the new product could be made into a stick form and go with dips to improve the product flavour (Group 2 Participant 5). Product size was determined by the opening of the extruder die, a new die design would be required to make the change. For a commercial product, scaled up, the size of the product would also be scaled up proportionally. Hence, no further size improvements were planned at this stage of the development work.

Most participants disregarded the proposed health benefits of the product offered: 75 % less fat than potato chips; baked not fried; no MSG; a source of wholegrain and high in fibre. Male participants were more likely to disregard worries about health when snacking; they reiterated that they would not buy snacks for the health reasons. Participants showed high expectations in terms of balancing taste and health. They admitted the claims were attractive, but they were not prepared to compromise taste for it.

7.4. CONCLUSIONS AND RECOMMENDATIONS

Five themes typically associated with snack consumption were nostalgia, special social occasions, distraction, convenient treat and hunger. The uniqueness of the extruded snacks was their various appearances, light and crispy texture, convenient bite size and being savoury. The top three key purchase criteria for extruded snack category were taste, price and brand. Product appearance, the fourth most important purchase criteria, had shown strong influence on selection of the extruded snacks at the post-purchase stage.

Indulgence snacking was still prevalent and participants generally did not pay much attention to product ingredient list, nutrition information and claims, but health had become a very important purchase criterion (Figure 7.1). The importance of healthiness of foods was increasing for the participants who were aged 50 or over. The finding agreed with some international research indicating health was at the top of their mind for many snack consumers. Health fortified snacks would help to offset guilt. However, they were only prepared to compromise on taste for healthiness to a certain extent and this depended on how health conscious they were.

The 3G snack research prototypes (‘RW Water Lo’, ‘CW Water Lo’ and ‘RWC Water Lo’) did not receive very positive feedback. The issues were mainly associated with the size and flavour delivery. Product texture was found acceptable by most participants. Fat related claims were still the most popular ones. The low fat 3G snack prototype will help to raise the products health claims. On the other hand, the poor understanding of ancient grains and wholegrain may have also have contributed to the product concept failure.

The results of the current study provided some guidance for product improvement. Key findings of this research indicated that education about ancient grain and wholegrains was required, and that participant’s preferences for a larger bite size, tasty and visually appealing products need to be addressed to increase the acceptability of the research prototypes. The base formulation improvement is necessary to obtain more consistent and a prolonged savoury flavour and a slight more expansion may also help the product to be perceived better than it was as it was found to be too dense. The key challenge here is to provide a health fortified snack without compromising on taste.

8. TASTE AND TEXTURE IMPROVEMENT ON 3G SNACK BASE FORMULATION

8.1. INTRODUCTION

From the focus group study, presented in Chapter 7, the texture of the 3G snack formulations was found to be 'like slightly' but the size and flavour of the 3G snacks scored below 'neither like or dislike' to 'dislike moderately'. Minor changes were made to the base formulation with the seasoning to see if this would improve the flavour.

Flavex Powder Standard, a dry free flowing powder produced by the acid hydrolysis of vegetable proteins (HVP), was recommended. HVP is commonly used to enhance seasoning taste due to the presence of free amino acids, smaller peptides, salt, and various volatile compounds (Aaslyng et al., 1998). The free amino acids especially glutamic acid is important as a flavour enhancer because of its umami taste, also known as the fifth taste (Aaslyng et al., 1998). Flavex Powder Standard contains 30.2 grams of protein and 20.1 grams of sodium per 100 gram of the product (Appendix A 1.5). Another simple ingredient to enhance the sensory properties of extruded savoury snack is salt (Pitts, Favaro, Austin, & Day, 2014). It does not only help with the flavour perception, but also can have profound effects on starch-based food extrusion cooking and product expansion (Chinnaswamy, 1993; Hsieh et al., 1993; Jin et al., 1994; Norton et al., 2011). If the pellet expansion could be increased, it may result in a more acceptable product texture. In contrast, adding sugar resulted in a decrease of product expansion and an increase in product density (Barrett et al., 1995; Jin et al., 1994). If the sugar was removed from the 3G snack base formulation, it may also result in a more expanded snack product.

Hertzel and Plattner (2005) reported that 3G snacks should be dried to 9 to 14 percent moisture prior to storage. However, the optimal moisture for expansion for the base 3G snack was still unknown. Hence the objectives of this study were to determine the relationship between the expansion and the pellet moisture content and to examine the effects of salt and Flavex on extrusion and product expansion. The outcome of the study was used to improve existing 3G base formulations used for focus group study.

The correlations between sensory and instrumental measurements of texture were well established (Bourne, 2002). The instrumental measurements of product texture have been used to predict consumer response, as the degree of liking and the overall acceptance of a new product (Szczesniak, 1987). If an appropriate instrumental method was used to assess the texture of commercial and research products, it would be very helpful in understanding the texture difference between the target texture desired and the actual texture of the products, therefore, providing a guideline for improvement and optimisation. The texture strengths of the reformulated 3G formulations were measured to compare to that of commercial products. Protein, total fat and dietary fibre analysis were also carried out on the final 3G snack base formulations to confirm if research objectives were met.

8.2. MATERIALS AND METHODS

The ingredients used in this series of experiments are detailed in Section 3.1. The formulations (Table 3.6) and extrusion parameters are detailed in Section 3.5.3. A 2×2 factorial design was used. Experimental factors were two types of savoury flavour enhancer (salt and Flavex), each of the flavour enhancers was dosed at two levels for the reformulated 'CW' 3G snack formulation. For each formulation they were designated as either 'Lo' low salt (0.5 % w/w) or 'Hi' high salt (1.0 % w/w). Flavex was either not added or added in the formulations at supplier recommended dosage of 0.3 % w/w. 'Salt Lo' is the control formulation and most similar to the 'CW Water Lo' formulation used in Chapter 7. Both sugar and nut brown flour (roasted barley malt flour) were removed from the base formulation in order to improve product expansion and savoury flavour.

The raw ingredient blend for all formulations, and their respective 3G pellets were studied for their pasting properties and analysed for their finished expansion. The pasting properties of both raw and extruded recipes were compared. For experimental details refer to Section 3.8 and analysis details refer to Section 3.10. Third generation snacks were produced according to Figure 5.1. Pellets from all formulations were dried according to Method 4 shown in Figure 6.1. Pellets were collected after 2 hour 15 minutes, 3 hour 15 minutes and 4 hour 15 minutes drying time (this excluded pre-drying and holding time). Dried pellets were kept in an insulated storage box at 30 ± 5 °C for a minimum of 24 hours before puffing. Die swell analysis was carried out on extruded pellets according to Section 3.6.3. Puffed product SEI was carried out according to Section 3.6.4. The pellet die swells and SEIs were compared to the original ('CW Water Lo' from focus group study) at approximately 9.6 ± 0.3 % moisture. Data analysed using the General Linear Model procedure in Minitab Release 16 Statistical Software (Minitab Inc., State College, Pennsylvania, US). The main effects of moisture, salt, Flavex and the interaction between moisture and salt, moisture and Flavex, salt and Flavex were assessed by Analysis of Variance (ANOVA). Tukey comparisons of means were carried out. Significance was defined as $P < 0.05$ at 95 % confidence.

Puffed samples from the four treatments (Table 3.6) were coated with SC273864 Cheese flavour (IFF, Table 7.2). A similar coating method was used as detailed in Section 7.2.3.1 with some modifications. For every 40 g batch, two grams of sunflower oil (5 % w/w) (Essente™, Marsanta Foods) and 2.4 grams of seasoning (6 % w/w) were first added into a resealable clear plastic bag (230 mm x 305 mm). Thirty-five point six grams of the puffed warm snack base (55 ± 5 °C) was then added into the bag. The bag was immediately sealed and shaken by hand. The coating process was stopped when the surfaces of snacks were entirely coated seasoning and the seasoning was evenly distributed. More seasoning (1 % more) was used to improve product taste. Three-digit coded samples were provided to a panel of three 4th year food technology students at Massey University Palmerston North for blind tasting. Assessments were focused on texture and flavour. Comments were collected and collated.

'RW, 'CW' and 'RWC' base formulations from Chapter 6 were modified according to the outcome of the flavour enhancer study. The texture and bulk density assessments of the three reformulated research prototypes outlined in Table 3.7 ('RW Salt Hi', 'CW Salt Hi', 'RWC Salt Hi') were determined. Texture can be related to the deformation and disintegration of the food when a compression, shear or extrusion force is applied (Bourne, 2002; Paula & Conti-Silva, 2014). Hardness and crunchiness were the most used terms to describe the texture of the 3G snacks during the focus group study. Hence, they were the targeted descriptors for this study.

It was difficult to accurately measure the mechanical force applied on individual pieces due to the shape and size of the product. Kramer shear cells can be used to measures product textures in bulk, this technique is more suitable for irregularly shaped and small sized products (Figure 3.7). The test was also restricted by the maximum compression load required to carry out the test. Using an Instron 4502 texture analyser with a maximum of 1000 N compression was found most appropriate for this study. The results were used to compare the texture and bulk density of the seven commercial samples previously used for focus group study (Chapter 7). The compressive strength of research prototypes and commercial samples under crushing loads were measured as described in Section 3.7 and bulk density analyses were carried out as described in Section 3.6.5. Pearson correlations of bulk density and maximum compression force were carried out and data analysis details are described in Section 3.10. The crude protein, total fat and dietary fibre on the base of final 3G expanded products was carried out as described in Section 3.9.

8.3. RESULTS AND DISCUSSION

8.3.1. Effect of salt and Flavex on extrusion process

Table 8.1 shows the effect of salt and Flavex on the extrusion conditions of the reformulated 'CW' 3G snack formulation. No major variation in extrusion conditions were observed between the different recipes. However, it was noted that 'Salt Hi&Flavex' recipe, in which the feed rate was increased by 0.95 kg/h to obtain the similar die pressure, apparent torque and thrust pressure as the 'Salt Lo'. 'Salt Hi' had slightly lower thrust pressure and die pressure at the same feed rate and apparent torque as the 'Salt Lo', There was little difference in extrusion conditions observed between 'Salt Lo' and 'Salt Lo&Flavex'. 'Salt Hi&Flavex' had the lowest SME despite of its higher feed rate. When the treatments had similar power inputs, the lower SMEs, mean the throughputs were slightly higher (Eq. 2.1).

Table 8.1: Extrusion condition of reformulated 'CW' 3G formulation extruded with salt and Flavex (mean values ± standard deviation for n=2)

Recipe	*Apparent Torque (Nm)*	*Feed Rate (kg/h)*	*Thrust Pressure (Bar)*	*Die pressure (Bar)*	*Power (kW)*	*SME (kWh/kg)*
Salt Lo	5.0	4.35 ± 0.10	61	100	1.11	0.202 ± 0.001
Salt Hi	5.0	4.35 ± 0.10	59	96	1.12	0.189 ± 0.003
Salt Lo&Flavex	4.8	4.35 ± 0.10	63	102	1.07	0.195 ± 0.002
Salt Hi&Flavex	5.1	5.30 ± 0.10	61	99	1.12	0.183 ± 0.003

Salt contains 39.1 grams of sodium per 100 grams (Appendix 1) and Flavex Powder contains 20.1 grams of sodium per 100 grams (Appendix 1). 'Salt Hi&Flavex' treatment had more than twice the sodium content than that of Salt Lo (Table 8.2). It is believed that the presence of sodium chloride in the extrusion alters the melt viscosity of the starchy based materials (Chinnaswamy, 1993). Hence, adding more sodium chloride lowered the extruder thrust pressure, die pressure and SME. This reduction in SME is limited as to the level of salt addition is limited by the product taste (Hsieh et al., 1993). Hsieh et al. (1990) reported that high salt (up to 3 %) in the feed decreased the die pressure, torque and SME (Hsieh, Peng, & Huff, 1990).

Table 8.2: Added sodium content for the reformulate 'CW' 3G formulation extruded with salt and Flavex

Recipe	*Added Sodium (mg)*
Salt Lo	218.3
Salt Hi	436.3
Salt Lo&Flavex	285.6
Salt Hi&Flavex	503.5

8.3.2. Effect of salt and Flavex on pasting properties of reformulated 'CW' 3G snack formulation

In order to further understand the effect of salt and Flavex on the behaviour of the feed material and the melt rheology of the reformulated 'CW' 3G snack formulations before and after extrusion, the dry blends of all four formulations (Table 3.7) were tested for their pasting properties. The results for the raw blend and extruded pellets are summarised in Table 8.3 and Table 8.4 respectively.

Salt and Flavex did not appear to significantly influence the pasting properties of the raw materials (Appendix A 7.1). However, it was noted that 'Salt Lo' treatment had the lowest peak and final viscosities. The pasting properties of 'Salt Hi' and 'Salt Hi & Flavex' were very similar. A trend was observed that increasing the concentration of sodium chloride, the raw ingredient blend peak (PV) and final viscosity (FV) increased. Similar results have been described by Samutsri &

Suphantharika (2012) who showed that addition of salts significantly increased peak, final viscosities, and pasting temperature of rice starch.

Table 8.3: Pasting properties of reformulated 'CW' raw ingredients with salt and Flavex (mean values ± standard deviation for n=2)

Treatment	*Pasting Temp (˚C)*	*PV (cP)*	*PT (seconds)*	*BD (cP)*	*FV (cP)*	*SB (cP)*
Salt Lo	73.1 ± 0.7	1840.0 ± 49.5	298.0 ± 25.5	612.0 ± 14.1	1870.5 ± 62.9	642.5 ± 0.7
Salt Hi	74.0 ± 0.6	1928.5 ± 14.8	320.0 ± 5.7	605.0 ± 5.7	1984.0 ± 32.5	660.5 ± 12.0
Salt Lo &Flavex	73.5 ± 0.0	1889.0 ± 26.9	320.0 ± 0.0	627.5 ± 48.8	1954.0 ± 9.9	692.5 ± 31.8
Salt Hi &Flavex	73.5 ± 0.0	1910.5 ± 38.9	322.0 ± 8.5	595.0 ± 5.7	1985.0 ± 32.5	669.5 ± 0.7

Pasting Temp, the temperature where viscosity first increases by at least 25 cP over a 20 s period; PV, maximum paste viscosity achieved during the heating cycle; PT, time when maximum paste viscosity achieved; BD, peak viscosity minus the viscosity after the holding period at 95 °C; FV, final viscosity; SB, difference between the final viscosity and the viscosity reached after the first holding period.

Results presented in Table 8.4 show that the pellets with Flavex had much lower cold peak viscosities (CP) compare to those without Flavex. 'Salt Hi&Flavex' had significantly lower cold peak viscosities (CP) compared to all other recipes. The results were likely because the 'Salt Hi&Flavex' had the highest concentration of sodium chloride among all treatments. No significant differences were observed for pellet final (FV) and setback (SB) viscosities.

Table 8.4: The effect of salt and Flavex on 'CW' snack pellet pasting properties (mean values ± standard deviation for n=2)

Treatment	*CP (cP)*	*FV (cP)*	*SB (cP)*
Salt Lo	1081.0 ± 9.9^{a}	263.5 ± 2.1	187.5 ± 0.7
Salt Hi	1094.0 ± 17.0^{a}	259.5 ± 2.1	183.5 ± 2.1
Salt Lo&Flavex	963.5 ± 50.2^{ab}	253.0 ± 2.8	175.0 ± 1.4
Salt Hi&Flavex	884.5 ± 36.1^{b}	246.5 ± 16.3	167.5 ± 12.0

Value in a column with superscripts in common did not differ significantly ($p < 0.05$). Analysis details refer to Appendix A 7.2.

CP, maximum cold water viscosity observed at 25 °C; FV, final viscosity; SB, difference between the final viscosity and the viscosity reached after the first holding period.

8.3.3. Effect of salt, Flavex and moisture on reformulated 'CW' snack pellet die swell and expansion

The effect of salt and Flavex on extruded pellets die swell were analysed and the results are summarised in Table 8.5. Sodium chloride had a significant impact on pellet die swell width, but not on the die swell thickness. Although not statistically significant, a trend was observed that increasing the concentration of sodium chloride and the addition of Flavex resulted in the increased die swelling of pellets.

Table 8.5: Effect of salt and Flavex on the reformulated 'CW' snack pellet die swell (mean values ± standard deviation for n=10)

Treatment	Die Swell Width*	Die Swell Thickness	Die Swell
Salt Lo	1.02 ± 0.02 ^{b}	1.79 ± 0.06	1.83 ± 0.08
Salt Hi	1.05 ± 0.03 ^{ab}	1.82 ± 0.12	1.90 ± 0.16
Salt Lo&Flavex	1.05 ± 0.02 ^{ab}	1.87 ± 0.13	1.97 ± 0.17
Salt Hi&Flavex	1.06 ± 0.02 ^{a}	1.87 ± 0.12	1.98 ± 0.15

Value in a column with superscripts in common did not differ significantly ($p < 0.05$). Analysis details refer to Appendix A 7.3.

No checked pellets were observed in any of the treatments at different moistures, which confirmed that the previous developed drying method was the best to reduce checking. Salt may also have helped in achieving this outcome, as research has been reported to show that salt assists equilibration of moisture in snack pellets (Hertzel & Plattner, 2005)

The sectional expansion index (SEI) of the extrudates containing various amounts of moisture, salt and Flavex are shown in Figure 8.1. The main effects plot for SEI are presented in Figure 8.2. The statistical analysis (Appendix A. 7.4.1) showed that SEI of the extrudates were significantly affected by changes in the levels of moisture ($p < 0.001$) or salt ($p < 0.001$) or Flavex ($p < 0.001$). Figure 8.1 and Figure 8.2 clearly show that product containing Flavex had greater sectional expansion and SEI increased with the increase of moisture. SEIs from products containing Flavex were less sensitive to the pellet moisture change. The effects of increasing Flavex from 0 % to 0.3 % were significantly greater than increasing the salt content from 0.5 % to 1.0 %.

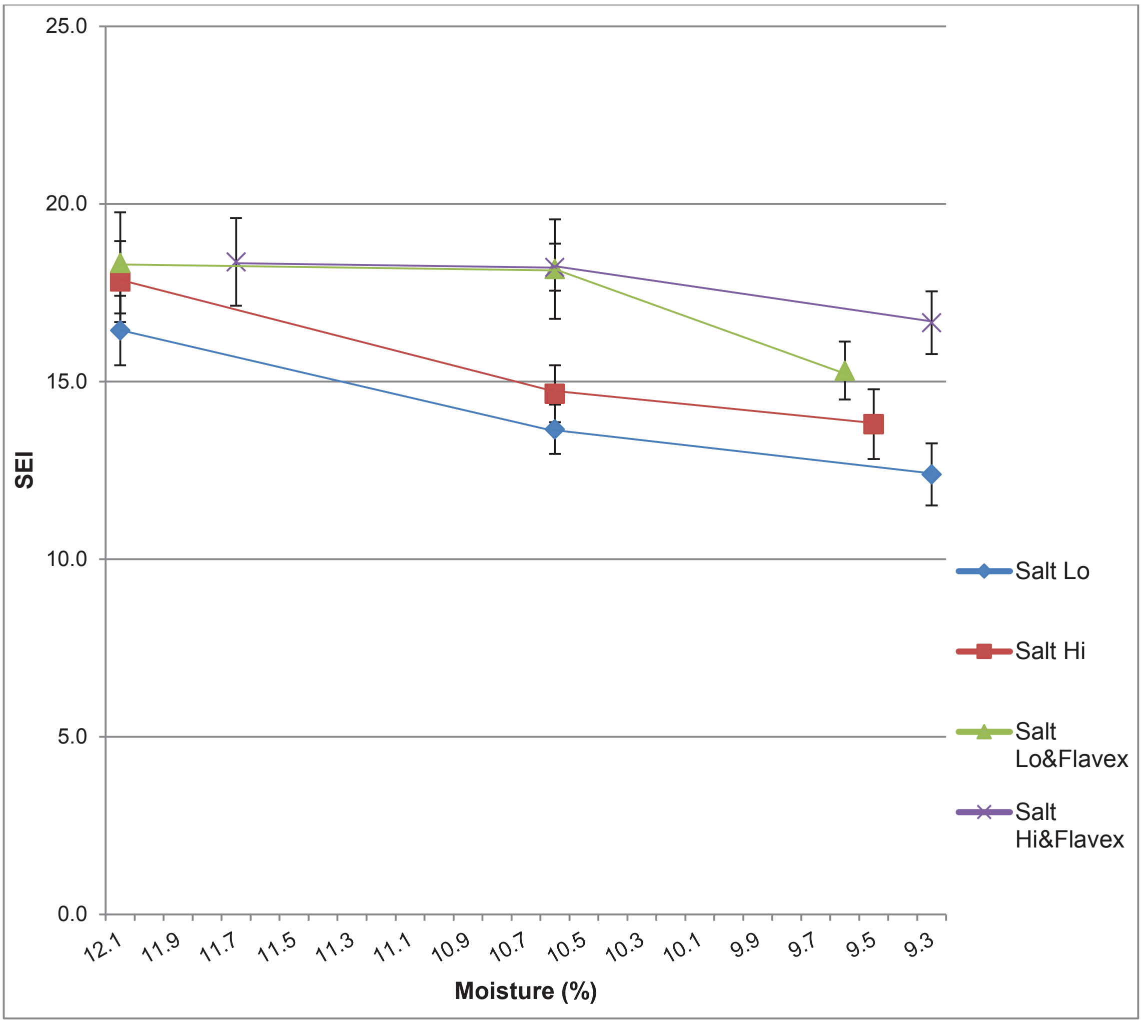


Figure 8.1: Reformulated 'CW' product SEI at different levels of salt, Flavex and moisture content (mean values ± standard deviation for n=10)

The same results (increased expansion with addition of salt) were also observed by Norton et al. (2011) when studying the effect of salt concentrations on hot air expanded potato starch pellets. They explained that the glass transition temperature of the starch pellet decreased with the increase in sodium chloride addition. Hence, the better expansion obtained. Flavex had a significant influence on the product SEI was probably due to the synergy effects of sodium chloride and protein (Moraru & Kokini, 2003). Literature showed product expansion depends on protein concentration. At lower concentrations of proteins, its addition helped to reduce shrinkage of the starch, subsequently helping to increase the expansion ratio (Alavi et al., 1999; Moraru & Kokini, 2003).

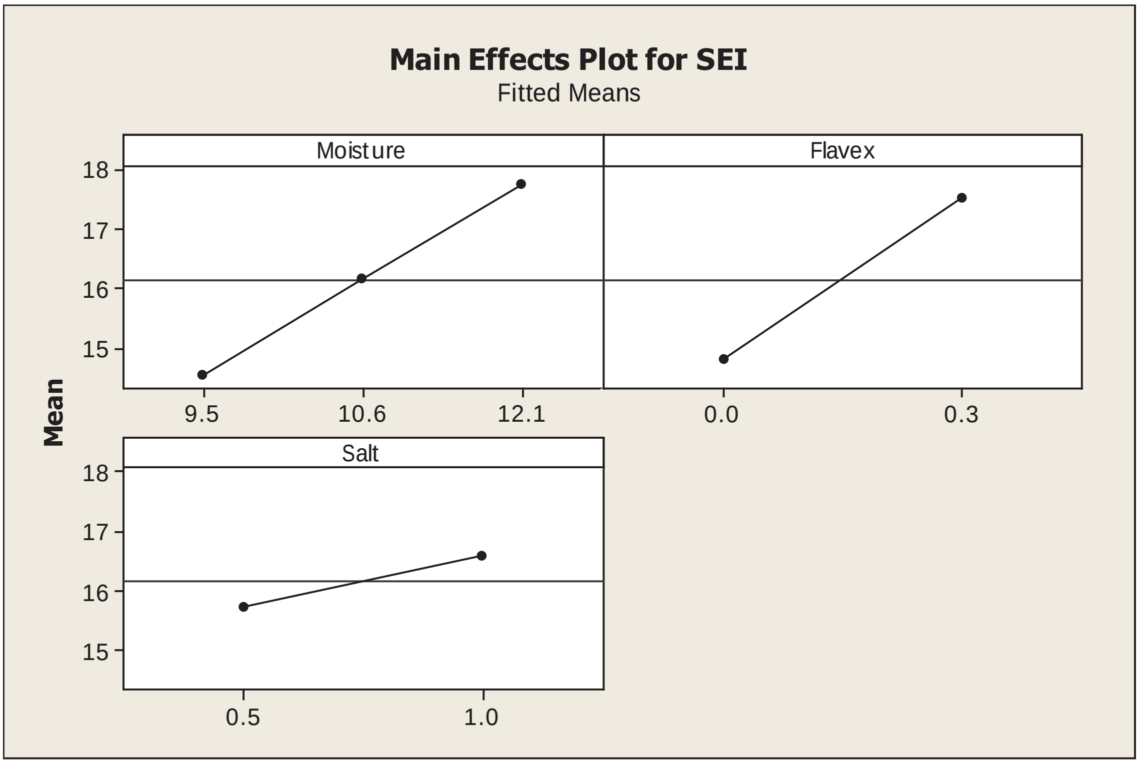


Figure 8.2: The effect of pellet moisture, salt and Flavex on the reformulated 'CW' product SEI (graph a: pellet moisture contents (x-axis), product SEI (y-axis); graph b: formulation 'CW' Flavex contents (x-axis), product SEI (y-axis); graph c: formulation 'CW' salt contents (x-axis), product SEI (y-axis))

The effects of salt, Flavex and moisture on the reformulated 'CW' products' particle densities are shown in Figure 8.3. The main effects plot for the expanded products' particle densities is presented in Figure 8.4. The results from statistical analysis (Appendix A 7.4.2) show that the particle densities of the pellets were significantly affected by changes in moisture content ($p < 0.001$) or salt ($p < 0.05$) or Flavex concentration ($p < 0.001$).

Figure 8.3 shows there was little difference in particle density at a pellet moisture content of 12.1 %. Differences in the particle densities of the different products were more noticeable at lower moisture contents. Products containing Flavex had slightly lower particle densities. The lowest particle density products were collected at a pellet moisture content of 10.6 %. Konishi et al. (2004) and Norton et al. (2011) reported that below critical moisture, there was insufficient water to build up sufficient internal pressure to fully expand the matrix at the puffing step; above critical moisture, water acted as a plasticizer and changed the melt viscosity, and the amount of pressure achieved in each cell was reduced. Hence, the reduced product expansion.

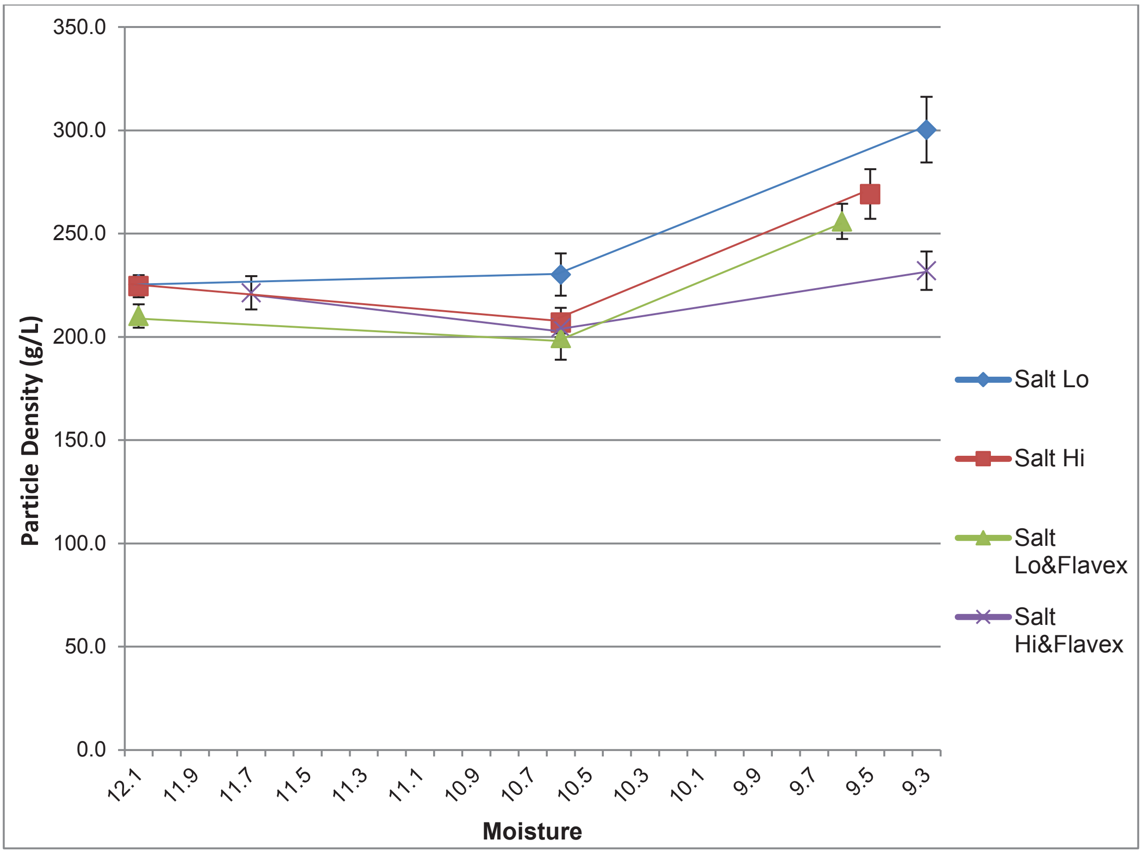


Figure 8.3: Reformulated 'CW' product' particle density at different levels of salt, Flavex and moisture (mean values ± standard deviation for n=3)

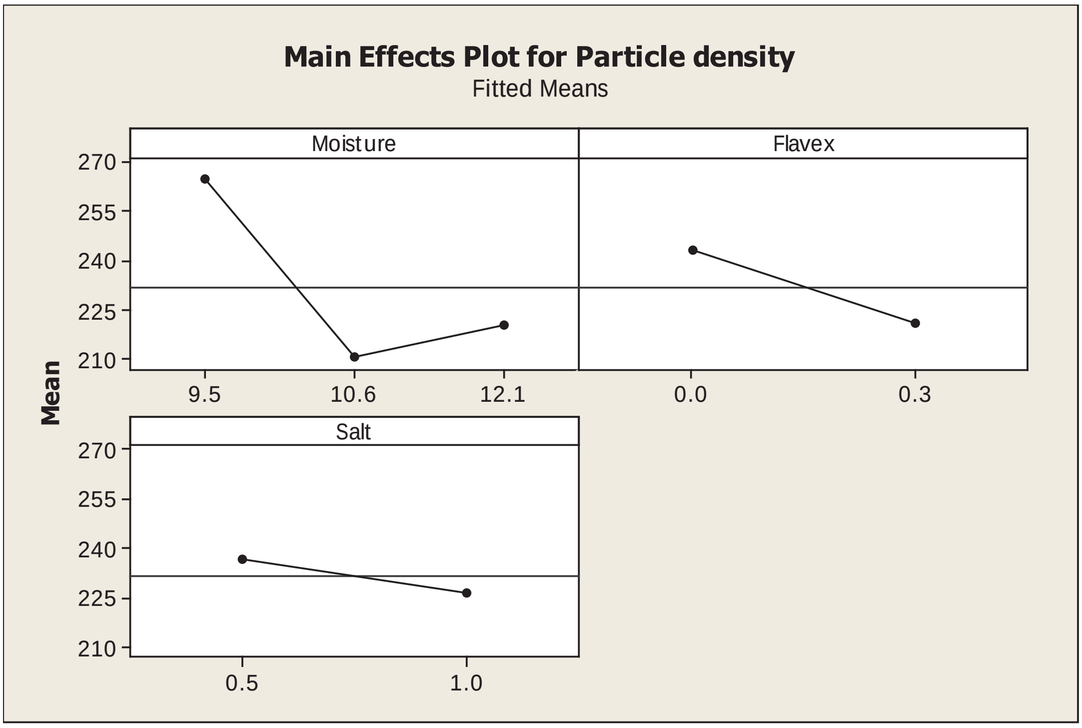


Figure 8.4: The effect pellet moisture, salt and Flavex on expanded reformulated 'CW' product' particle density (graph a: pellet moisture contents (x-axis), particle density (y-axis); graph b: formulation 'CW' Flavex contents (x-axis), particle density (y-axis); graph c: formulation 'CW' salt contents (x-axis), particle density (y-axis))

Figure 8.4 shows that increasing the salt content from 0.5 to 1.0 % and the addition of Flavex (at 0.3 %) led to a reduction in the puffed products' particle densities. A decrease in particle density at a pellet moisture of 10.6% was probably linked to the increased extrudate SEI. An inverse relationship was observed between the particle density and sectional expansion index of the expanded reformulated 'CW' snack. Again, the effects of increasing Flavex from 0 % to 0.3 % were significantly greater on the puffed products' particle densities than increasing the salt content from 0.5 % to 1.0 %.

8.3.4. Evaluation on the improvements of extruded reformulated 'CW' snack product

Despite the higher moisture of the 'CW Water Lo' pellets, Table 8.6 shows that 'Salt Lo' had significantly higher pellet die swell and SEI of the finished product. Product expansion improvement confirmed that the formulation changes were positive, i.e. removal of sugar and nut brown flour (roasted barley malt flour) from the base formulation. Previous researchers have shown that sugar played a key role in reducing the pellet die swell and product SEI by altering the melt properties of the extrudates (Barrett et al., 1995; Carvalho & Mitchell, 2000; Fan, Mitchell, & Blanshard, 1996; Hsieh et al., 1993; Hsieh et al., 1990; Jin et al., 1994; Pitts et al., 2014)

Table 8.6: Comparison of pellet die swell and SEI on original and reformulated 'CW' 3G formulation (mean values ± standard deviation for n=10)

	Moisture	Die Swell	SEI
CW Water Lo (focus group)	9.95 ± 0.03	1.29 ± 0.07^{b}	10.50 ± 1.25^{b}
Salt Lo	9.29 ± 0.05	1.83 ± 0.08^{a}	12.39 ± 0.87^{a}

Value in a column without superscripts in common differ significantly ($p < 0.05$). Analysis details refer to Appendix A 7.5

An informal sensory evaluation with a panel of three 4th year food technology students from Massey University Palmerston North was carried out on the reformulated 'CW' 3G snacks. The comments from the informal qualitative sensory assessment is summarised in Table 8.7.

Table 8.7: Qualitative sensory assessment on the reformulated cheese flavoured 'CW'

Treatment	*Comments*
Salt Lo	Quite hard crunchy, flavour does not linger
Salt Hi	Hard base but more acceptable. Flavour lingers longer. Taste like cheese and chicken
Salt Lo&Flavex	Not quite get the flavour, very short note. Base is a little hard. Stick to teeth
Salt Hi&Flavex	Base is hard (ok), flavour lingering. But feel false, not so much cheesy.

Salt Lo was found to have the hardest base. No differences in texture were detected among ‘Salt Hi’, ‘Salt Lo&Flavex’ and ‘Salt Hi&Flavex’. It was clear that the addition of 1 % sodium chloride to the base formulation resulted in a more acceptable product in terms of flavour/taste. The cheese flavour added to the pellets was found to last longer. The samples with Flavex were found to be preferred less than the samples without Flavex.

Further increasing the salt content was not considered to be acceptable as consumers are looking to reduce salt in their food (Brown, Tzoulaki, Candeias, & Elliott, 2009). The effect of Flavex on the flavour of base formulation was unclear. The best formulation was the ‘Salt Hi’, as it clearly had improved texture and flavour compare to the original formulation (‘CW Water Lo’ from focus group study).

8.3.5. Physico-chemical properties of reformulated 3G snack base formulations

The formulation improvement learnings from reformulated ‘CW’ 3G snack formulation work were applied on the RW and RWC formulations (Table 3.7). Sugar and nut brown flour (roasted barley malt flour) were removed from the base formulation and salt content was increased to 1 %. The extrusion settings and processing parameters are summarised in Table 8.8 and the extruder screw speed was kept at 248 rpm for all the three recipes. The pellets were dried to close to optimise expansion moisture of 10.5 %. The physico-chemical properties of the reformulated 3G base formulations were studied to verify previous findings.

Table 8.8: Extrusion condition of ‘RW Salt Hi’ ‘CW Salt Hi’ and ‘RWC Salt Hi’ (mean values ± standard deviation for n=2)

Recipes	*Apparent Torque (Nm)*	*Feed Rate (kg/h)*	*Water (kg/h)*	*Thrust Pressure (Bar)*	*Die pressure (Bar)*	*Power (kW)*	*SME (kWh/kg)*
RW Salt Hi	5.2	4.16 ± 0.15	1.0	54	92	1.12	0.175 ± 0.002
CW Salt Hi	5.2	4.16 ± 0.15	1.0	63	101	1.05	0.168 ± 0.004
RWC Salt Hi	5.2	3.87± 0.05	1.0	63	99	1.10	0.196 ± 0.005

8.3.5.1. Pellet moisture loss and changes in water activity (Aw) during drying

The extruded pellet moisture loss and Aw changes on the reformulated 3G base formulations were studied. The results are summarised in Table 8.9 and Table 8.10. The overall drying and holding time in the oven were according to Method 4 shown in Figure 6.1, but the total drying time (excluding holding time) was shortened; total average drying time was 2 h 30 minutes versus 3 h 30minutes on average previously. The pellets were found to lose water at a faster rate. No checked pellets were found for all the pellets of reformulated 3G formulations. The Aw was below 0.5 (Table 8.10) at end of drying. It confirmed that the drying pellets to 10 to 10.5 % would deliver shelf stable products.

Table 8.9: Pellet moisture loss of reformulated 'RW', 'CW' and 'RWC' 3G snack base formulations on drying (mean values ± standard deviation for n=2)

Formulations	*Raw Material Moisture (%)*	*Exit Extruder Moisture (%)*	*Exit Conveyor (%)*	*35 min Drying (%)*	*1 h 10 min Drying (%)*	*1 h 10 min Drying (%)*	*End of Drying (%)*
RW Salt Hi	13.05 ± 0.14	31.33 ± 0.30	31.00 ± 0.39	19.42 ± 0.09	14.18 ± 0.00	12.30 ± 0.06	10.32 ± 0.01
CW Salt Hi	13.28 ± 0.08	29.28 ± 0.05	27.69 ± 0.14	19.46 ± 0.14	14.90 ± 0.03	12.94 ± 0.12	10.37 ± 0.07
RWC Salt Hi	12.99 ± 0.06	28.29 ± 0.06	27.76 ± 0.74	18.15 ± 0.29	13.89 ± 0.11	11.72 ± 0.02	10.10 ± 0.01

Table 8.10: Summary of pellet Aw change of reformulated 'RW', 'CW' and 'RWC' 3G snack base formulations on drying

Formulations	*Exit-extruder*	*Ex-Conveyor*	*35 Min*	*1h 10min*	*1h 45 min*	*End of Drying*
RW Salt Hi	0.9704	0.9736	0.8671	0.7299	0.6182	0.4439
CW Salt Hi	0.9590	0.9473	0.8696	0.7601	0.6644	0.4622
RWC Salt Hi	0.9543	0.9507	0.8539	0.7185	0.5813	0.4944

8.3.5.2. Pasting properties of raw ingredient blend and extruded pellets

RVA results of the raw ingredient blend and extruded pellets from three reformulated base snack formulations were summarised in Table 8.11 and Table 8.12, respectively. Table 8.11 shows that little difference observed between the raw ingredient blend of 'RW Salt Hi' and 'CW Salt Hi'. The raw ingredient blend of 'RWC Salt Hi' had much lower peak (PV), breakdown (BD), final (FV) and setback (SB) viscosities. Table 8.12 shows the extruded pellets from 'RWC Salt Hi' had a very low cold peak viscosity (CP) and a high peak viscosity (PV) at 95 ºC. It indicated that the starch in the pellets was not fully gelatinised or dextrinised (Carvalho & Mitchell, 2000). This was because the addition of wholegrain Hi-Maize™ flour at 10 %. This result has confirmed that Hi-Maize™ can significantly alter the pasting properties of a starch blend.

Table 8.11: Pasting properties of raw ingredients blend from high salt 3G formulations (mean values ± standard deviation for n=2)

Formulation	*Pasting Temp (˚C)*	*PV (cP)*	*PT (seconds)*	*BD (cP)*	*FV (cP)*	*SB (cP)*
RW Salt Hi	73.5 ± 0.1	2067.0 ± 8.5	326.0 ± 8.5	641.0 ± 16.3	2106.5 ± 10.6	681.0 ± 18.4
CW Salt Hi	74.0 ± 0.6	1925.5 ± 31.8	316.0 ± 5.7	620.5 ± 23.3	1973.5 ± 7.8	668.5 ± 0.7
RWC Salt Hi	73.8 ± 0.6	1568.0 ± 9.9	340.0 ± 5.7	390.0 ± 2.8	1680.0 ± 2.8	502.0 ± 9.9

Pasting Temp, the temperature where viscosity first increases by at least 25 cP over a 20 s period; PV, maximum paste viscosity achieved during the heating cycle; PT, time when maximum paste viscosity achieved; BD, peak viscosity minus the viscosity after the holding period at 95 °C; FV, final viscosity; SB, difference between the final viscosity and the viscosity reached after the first holding period.

Table 8.12 Pasting properties of extruded pellets from high salt 3G formulations (mean values ± standard deviation for n=2)

Product	*CP (cP)*	*PV (cP)*	*BD (cP)*	*FV (cP)*	*SB (cP)*
RW Salt Hi	1132.5 ± 46.0	-	-	287.5 ± 3.5	209.5 ± 5.0
CW Salt Hi	1173.0 ± 15.6	-	-	273.0 ± 7.1	187.5 ± 9.2
RWC Salt Hi	395.5 ± 54.4	930.0 ± 33.9	827.0 ± 29.7	456.0 ± 17.0	353.0 ± 12.7

CP, maximum cold water viscosity observed at 25 °C; PV, maximum paste viscosity achieved during the heating cycle; BD, peak viscosity minus the viscosity after the holding period at 95 °C; FV, final viscosity; SB, difference between the final viscosity and the viscosity reached after the first holding period.

8.3.5.3. Die Swell and Product Sectional Expansion Analysis

Table 8.13 and Table 8.14 summarises the results from die swell and expansion analysis of the three reformulated high salt 3G snack formulations. The results were compared to die swells and SEIs of 'RW Water Lo', 'CW Water Lo' and 'RWC Water Lo' from Tables 6.6 and 6.7.

The die swells and SEIs of formulation 'RW Salt Hi' and 'CW Salt Hi' were similar. Formulation 'RWC Salt Hi' was found to have less die swell and SEI than these two formulations. This observation is in agreement with earlier findings (Table 6.6 and 6.7), the addition of wholegrain Hi-Maize™ flour at 10 % compromised the pellet expansion to a great extent. The SEIs of the 'RW Salt Hi' (14.95 ± 0.80), 'CW Salt Hi' (14.22 ± 0.57), 'RWC Salt Hi' (9.83 ± 1.12) were all much higher than the SEIs of the pellets from 'RW Water Lo' (12.29 ± 1.65), 'CW Water Lo' (10.50 ± 1.25), and 'RWC Water Lo' (7.66 ± 0.55) (Section 6.3.4). It confirms the formulation changes, remove sugar and nut brown flour (roasted barley malt flour) from the base formulation and increase salt content to 1 %, improved pellet expansion.

Table 8.13: Width and thickness expansion analysis of high salt 3G formulation (mean values ± standard deviation for n=10)

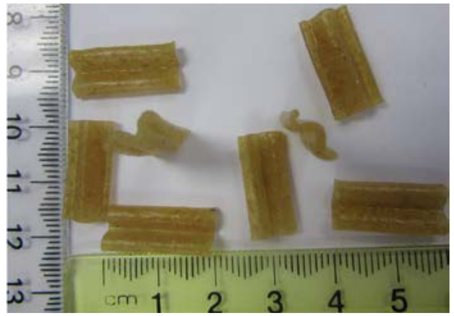
	Die Swell Width	Width Expansion	Die Swell Thickness	Thickness Expansion
RW Salt Hi	0.99 ± 0.02	2.19 ± 0.06	1.49 ± 0.11	6.84 ± 0.23
CW Salt Hi	1.02 ± 0.04	2.13 ± 0.08	1.58 ± 0.16	6.67 ± 0.25
RWC Salt Hi	1.02 ± 0.04	2.10 ± 0.06	1.37 ± 0.10	4.67 ± 0.44

Table 8.14: Die swell and SEI of reformulated high salt 3G formulation (mean values ± standard deviation for n=10)

	Die Swell	SEI
RW Salt Hi	1.48 ± 0.10	14.95 ± 0.80
CW Salt Hi	1.61 ± 0.19	14.22 ± 0.57
RWC Salt Hi	1.41 ± 0.14	9.83 ± 1.12

The physical measurements of the pellets from the 'RW Salt Hi' and 'CW Salt Hi' and 'RWC Salt Hi' base 3G formulations are summarised in Table 8.15. Pellets from the 'CW Salt Hi' formulation had the highest bulk density and pellets from the formulation of 'RWC Salt Hi' had the lowest bulk density. The changes in pellet bulk density were affected by the pellet weight and dimension differences.

Table 8.15: Physical specifications of high salt 3G pellets (mean values ± standard deviation for n=10)

Sample ID	*Pellet Width (mm)*	*Pellet Length (mm)*	*Pellet Thickness (mm)*	*Ten Pellets Weight (g)*	*Pellet Bulk Density (g/L)*	*Product Picture*
RW Salt Hi	7.95 ± 0.16	18.11 ± 0.61	1.19 ± 0.09	3.37 ± 0.10	526.27 ± 1.07	
CW Salt Hi	8.15 ± 0.36	18.43 ± 0.76	1.26 ± 0.13	3.53 ± 0.07	544.30 ± 0.82	
RWC Salt Hi	8.18 ± 0.28	17.56 ± 0.56	1.10 ± 0.08	3.24 ± 0.13	501.0 ± 2.05	

8.3.5.4. Shear-compression analysis of reformulated 3G product prototypes and competitor products

Seven commercial snacks used in the focus group study and three reformulated expanded 3G base products were tested for the peak forces. The texture of commercial snacks would be used as benchmarks for crunch as they were already well accepted by the consumers. The texture analysis results were summarised in Table 8.16. All research prototypes required much higher maximum compressive load force, which indicated the product texture of the reformulated 3G snack prototypes was much harder than the commercial products. No significant texture difference were observed between the three reformulated 3G research prototypes.

Table 8.16: Max compressive load force (N) analysis (mean values ± standard deviation for n=3)

	SAMPLE ID	*Brand and Country*	*Max Compressive Load Force (N)*	*Bulk Density (g/L)*
Commercial Products	Burger Ring	Bluebird, New Zealand	78.9 ± 4.7^{d}	76.7 ± 0.5^{e}
	Cheezel	Bluebird, New Zealand	91.0 ± 3.0^{d}	101.2 ± 1.8^{cd}
	Good Bites	ETA, New Zealand	135.7 ± 2.7^{d}	44.3 ± 0.1^{f}
	Grainwaves	Bluebird, New Zealand	310.3 ± 55.7^{c}	152.9 ± 0.2^{a}
	Rice Wheels	Healtheries, New Zealand	457.2 ± 40.5^{b}	106.3 ± 0.3^{c}
	SKOF Tripots	ETA, New Zealand	114.1 ± 4.3^{d}	95.6 ± 2.8^{d}
	Twisties	Bluebird, New Zealand	161.5 ± 12.3^{d}	97.2 ± 0.2^{d}
Research Prototypes	RW Salt Hi	-	499.6 ± 74.1^{ab}	143.5 ± 4.1^{b}
	CW Salt Hi	-	586.4 ± 19.0^{a}	140.2 ± 3.5^{b}
	RWC Salt Hi	-	543.3 ± 25.9^{ab}	152.1 ± 4.8^{a}

Value in a column with superscripts in common did not differ significantly ($p < 0.05$). Analysis details refer to Appendix A 7.6.

The 'RW Salt Hi' air-puffed products required the lowest maximum compressive load force of the three reformulated base formulations and the results were very close to that of 'Rice Wheels™

(Healtheries, New Zealand). A significant positive correlation of 0.749 was found between product bulk density and maximum load force ($p < 0.005$). This implies that if the sizes of the 3G snacks could be increased to reduce the bulk density, this could also lead to a reduction in the maximum force required to compress the pellets making them less hard.

8.3.5.5. Macronutrients analysis of 3G base formulations

The three reformulated 3G base snack pellets were expanded to approximately 3.5 – 4.0 % moisture and then analysed for crude protein, total fat and total dietary fibre. The theoretical and analytical results for the reformulated 3G base formulations were summarised in Table 8.17.

The theoretical calculation of the protein results were well matched with the analytical results (< 5 % error). However, the theoretical results over estimated the total dietary fibre by 8 – 13 % compared to the actual analytical results. Total fat was underestimated by the theoretical calculation by 25 – 38 %.

Brennan (2008) also found less dietary fibre in their samples than estimated. Hi-Maize™ sample has been found to be susceptible to degradation; the fibre reduction can be as much as 50 % (Brennan, 2008). Wheat fibre is the primary source of the dietary fibre, it was a very fine powder (90 % is less than 70 μm) which could have attributed to its loss as it was difficult to incorporate when fed into the feeder. The variation in the fat content could be due to the natural variation in the raw ingredients.

Table 8.17: Theoretical and analytical protein, total fat and total dietary fibre of high salt 3G base formulations (mean values ± standard deviation for n=3)

	Theoretical			Actual Analysis		
	Protein (%)	**Total Fat (%)**	**Total Dietary Fibre (%)**	**Protein (%)**	**Total Fat (%)**	**Total Dietary Fibre* (%)**
RW Salt Hi	7.03	1.25	8.4	7.54 ± 0.05	1.73 ± 0.03	7.7
CW Salt Hi	7.02	1.70	9.1	7.23 ± 0.01	2.13 ± 0.03	8.0
RWC Salt Hi	6.86	1.57	10.0	7.11 ± 0.02	2.08 ± 0.00	8.7

*Commerical lab tested results

Table 8.18 shows that despite the fat and dietary fibre discrepancies, the analytical test result confirmed the fibre contents of the 3G base snacks were much higher than the Grainwaves and Rice Wheels. Protein contents were also similar with all the commercial products tested.

Table 8.18: Protein, fat and dietary fibre contents of commercial savoury snacks (data collected from product nutrition information panel)

Commercial Products	*Brand and Country*	*Protein (%)*	*Total Fat (%)*	*Total Dietary Fibre (%)*
Burger Rings	Bluebird, New Zealand	6.1	32.1	NA*
Cheezels	Bluebird, New Zealand	5.2	32.7	NA*
Good Bites Cheddar	ETA, New Zealand	7.8	8.3	NA*
Grainwaves	Bluebird, New Zealand	7.1	22.8	5.8
Rice Wheels	Healtheries, New Zealand	8.7	8.5	1.0
SKOF Tripots	ETA, New Zealand	4.3	40.7	NA*
Twisties	Bluebird, New Zealand	6.4	25.0	NA*

*information is not available on the product packaging

8.4. CONCLUSIONS AND RECOMMENDATIONS

The moisture content of the pellet and the salt and Flavex concentration, all significantly affected the expansion of the 3G pellets. Increase in salt concentration from 0.5 to 1.0 % and increase in moisture content from 9.5 to 12.1 % resulted in increased product SEI. Addition of 0.3 % Flavex also increase product SEI. The products' particle density was inversely correlated to the product SEI. An informal qualitative sensory evaluation on the reformulated 'CW' snacks indicated that salt at 1 % improved the flavour and base texture. But addition of Flavex did not.

Pellet expansion was improved from the focus group prototypes by removing sugar and nut brown flour (roasted barley malt flour) from the base formulation and increasing the salt content to 1 %. The instrumental texture measurements on the 'RW Salt Hi', 'CW Salt Hi' and 'RWC Salt Hi' 3G snack products showed that the reformulated 3G snacks still had much harder textures than all commercial products tested. However, it is recommended to overcome the difference by increasing the size of the product when scaled up. The reformulated 'RW' 3G base required the least force to compress indicating the softest texture of the reformulated 3G formulations. The results obtained confirmed that all the research objectives had been met of unique in shape and suitable for hot air-puffing, contain a minimum of two ancient grains, a minimum of 2 % of fibre on a dry weight basis per serve and contain 25 % of wholegrain on a dry weight basis per 100 gram after savoury coating.

9. GENERAL DISCUSSION

The base flavour and texture of pellets made from “RW Salt Hi’, ‘CW Salt Hi’ and ‘RWC Salt Hi’ (Table 3.7) were improved through successive improvement steps. This chapter discusses the effect of ingredients and effect of die design on the extruder operation, pasting properties and physico-chemical properties of the formulated 3G snacks.

9.1. Effects of ingredients on 3G snack

The quality of the extruded pellet was found to be greatly affected by the raw materials used. Ingredients were selected primarily based on the finished product nutrition requirements, i.e. wholegrain, ancient grain and fibre contents (Chapter 4). The ingredients were then screened based on the extrusion requirements to produce the base product of the right texture and taste, i.e. starch, fibre and wholegrain contents (Chapter 5). Ingredient availability in New Zealand and cost of production were also very important factors considered (Section 3.1).

Starch was the most important structure-forming material for the 3G extruded snacks. Cereal flours and tuber starches provide the most abundant sources of starches. The selection criteria for cereal grains was mainly based on their starch content and nutritional properties. Hence, coarse rice flour and maize polenta were selected as the main base ingredients. Wholemeal wheat flour was used for the pellet wholegrain content requirement. Potato starch can be used to manipulate pasting properties of the ingredient mixture for specific end-use and it was found to enhance 3G snack pellet hot air expansion. However, it should not be used at more than 30 % addition to ensure free flow of ingredients to the extruder and it does not add any nutritional value to the product (Chapter 4). Amaranth and quinoa, are perhaps the best known and the most popular ancient grains. They have higher protein contents than most cereals and a much better balance of amino acids (Section 2.1.3).

Cereal flour particle size was found to have a large impact on pasting properties of the ingredient blend (Section 4.3.2). Large grain particles resulted in insufficient water penetration; subsequently resulting in incomplete cooking of starches during the extrusion process. Smaller finer particles hydrated faster. However, too fine or small grain particles could cause a number of feeding problems, such as raw material bridging when feed into the extruder barrel, dust and a change in apparent viscosity in the extruder barrel. The more even the overall particle size was, the more even the hydration of the raw material in the extruder was observed. Reduce the particle size of the main structure building cereal flour resulted in reduced pasting temperature and PT, and increase PV and BD. The effect of different ingredients on pasting properties of RW or CW, including original and reformulated 3G formulations, are summarised in Table 9.1.

Table 9.1: Effect of ingredients on pasting properties and expansion of 3G snack formulation (usage change from low to high limit)

Factor	Usage (%) Low-high limit	Before Extrusion (Raw ingredient or ingredients blend)						After Extrusion (Pellets)			Pellet Expansion
		Pasting Temp (˚C)	PV (cP)	PT (seconds)	BD (cP)	FV (cP)	SB (cP)	CP (cP)	FV (cP)	SB (cP)	
Potato Starch	0 – 30.0	↓	↑	↓	↑	–	–				↑
Hi-Maize™ Wholegrain Flour	0 – 10.0	–	↓	↑	↓	↓	↓	↓	↓	↓	↓
Wheat Fibre 600	0 – 4.0	–	↓	–	↓	↓	↓	↓	↓	↓	↓
Beneo GR	0 – 4.0	–	↓	–	↓	↓	↓	↓	↓	↓	↓
Hi-Maize™ 1043	0 – 7.0	–	↓	–	↓	↓	↓	↓	↓	↓	↓
Salt	0.5 – 1.0	–	↑	↑	–	↑	↑	–	–	–	↑
Flavex	0 – 0.3	–	↑	↑	–	↑	↑	–	–	–	↑
Sugar	0 – 2.0	–	↓	↑	↓	↓	↓	↓	–	–	↓

The sign '–' means no significant change was observed

Pasting Temp, the temperature where viscosity first increases by at least 25 cP over a 20 s period; CP, maximum cold water viscosity observed at 25 ºC; PV, maximum paste viscosity achieved during the heating cycle; PT, time when maximum paste viscosity achieved; BD, peak viscosity minus the viscosity after the holding period at 95 °C; FV, final viscosity; SB, difference between the final viscosity and the viscosity reached after the first holding period.

It is clear from Table 9.1 that the pellet expansion after puffing was closely correlated to the pasting properties of the raw ingredient blend. Pellet expansion increased with the increase of peak viscosity (PV) and final viscosity (FV) of the raw ingredient blend. The results from this study suggest that the coarse rice flour was the best structure-building ingredient for 3G snacks due to its high starch content and good pasting properties (high peak and final viscosities). Maize polenta was also a good structure-building ingredient for 3G snack, but its particle size needs to be reduced for easier melting during extrusion and to obtain better pasting properties (Section 4.3.2 in Chapter 4).

Dietary fibre can be added to the extrusion process to enhance the nutritional value of the 3G snacks. As the dietary fibre concentration was increased in the formulations, all the pasting viscosities of the raw ingredient blends (PV, BD, FV and SB) and extruded pellets (CP, FV and SB) decreased and ultimately resulted in reduced pellet expansion (Chapter 5). The effects of different types of dietary fibre on 3G pellet drying, checking and expansion are summarised in Table 9.2.

Both Wheat Fibre 600 (at 4 %) and Hi-Maize^{TM} 1043 (at 3.5 % and 7 %) accelerated extruded pellet drying. The pellet checking decreased as the Wheat Fibre 600 and Beneo GR increased to 4 % in the 3G snack formulation. In contrast, Hi-Maize^{TM} 1043 increased the pellet checking as its concentration was increased in the formulation. Although the pellet expansion decreased slightly, Wheat Fibre 600 and Beneo GR at 4 % helped in producing more uniform cell sizes in the expanded product compared to the Control. For all the above reasons, Wheat Fibre 600 at 4 % was considered to be the best choice to produce 3G snack.

The results from this study showed that formulations with Hi-Maize^{TM} wholegrain corn (10 %) or Hi-Maize^{TM} 1043 (3.5 % and 7.0 %) were more resistant to gelatinisation during processing than the formulations without (Section 5.3.3 and Section 6.3.2). Inclusion of Hi-Maize^{TM} wholegrain corn or Hi-Maize^{TM} 1043 significantly altered the pasting properties of the 3G base formulation (Table 9.1), where peak (PV) and final (FV) viscosities of the raw ingredient blend and cold peak viscosity (CP) of pellet were greatly decreased. The pellet expansion was reduced significantly with excessive small cells (less than 500 μm). This finding was in agreement with the literature, which suggested that the temperature required for gelatinisation was higher than 160 - 170 °C for high amylose maize (Fennema, 1996; Swanston et al., 2001). Amylose is an important parameter controlling the viscoelastic properties of the product. A number of researchers reported high amylose starches exhibited higher viscosity than high amylopectin starches (Della Valle et al., 1996; Lai & Kokini, 1990; Xie et al., 2009). This may have been caused by longer α-D-glucopyranosyl chains which induce more entanglements than shorter chains (Della Valle et al., 1996). The linear amylose polymer aligns during shear, and thus are difficult to pull apart during expansion (Moraru & Kokini, 2003; Xie et al., 2009). Formulations high in amylose content lead to hard, less expanded extrudates (Chen & Yeh, 2001). Based on the study outcome, both Hi-Maize^{TM} wholegrain corn and Hi-Maize^{TM} 1043 are not recommended to be used for the 3G snack base formulation.

Table 9.2: Effect of different types of fibre on 3G pellet drying, checking and expansion (usage change from low to high limit)

Factor	***Usage (%)*** ***Low-high limit***	***Extruded Pellets***		***Pellet Expansion***		
		Pellet Drying Rate	*Pellet Checking*	*Average Cell Size*	*No. of cells per unit area*	*Cell size distribution*
Wheat Fibre 600	0 – 4.0	− at 2 %	− at 2 %	− at 2 %	− at 2 %	− at 2 %
		↑ at 4 %	↓ at 4 %	↓ at 4 %	↑ at 4 %	At 4%: more balanced numbers of extremely small (less than 500 μm) and large cells (more than 3000 μm), higher percentage of extremely small cells than large cells
Beneo GR	0 – 4.0	↓ at 2 %	↑ at 2 %	− at 2 %	− at 2 %	− at 2 %
		↓ at 4 %	↓ at 4 %	↓ at 4 %	↑ at 4 %	At 4%: most balanced numbers of extremely small (less than 500 μm) and large cells (more than 3000 μm), higher percentage of extremely large cells than small cells
Hi-Maize^{TM} 1043	0 – 7.0	↑ at 3.5 %	↑ at 3.5 %	↓ at 3.5 %	↑ at 3.5 %	Extremely small cells (less than 500 μm) far out numbers the extremely large cells (more than 3000 μm)
		↑ at 7.0 %	↑ at 7.0 %	↓ at 7.0 %	↑ at 7.0 %	

The sign '−' means no significant change was observed

The addition of sodium chloride (salt) and Flavex flavouring significantly increased peak and final viscosities of the raw ingredient blend. As a result, a significant increase in pellet sectional expansion (SEI) was observed when the salt content was increased from 0.5 % to 1.0 % and when the Flavex was added into the formulation at 0.3 %. In contrast, inclusion of 2 % sugar in the 3G snack formulation reduced pellet expansion. The higher the sodium chloride (salt) content, the higher pellet expansion ratios after puffing were achieved. The observation was in agreement with a number of researchers, where they found the expansions of rice, corn or potato extrudates increased with addition of salt up to 3 % (Chinnaswamy, 1993; Hsieh et al., 1993; Jin et al., 1994; Norton et. al., 2011; Samutsri & Suphantharika, 2012). Salt also played an important role in enhancing the savoury flavour profile of the seasoned 3G snack, but the addition of Flavex did not (Table 8.7, Chapter 8). Further optimisation of the 3G snack flavour without significantly increasing the salt content could be possible, for example, yeast extracts are commonly used in the snack industry as a natural savoury flavour enhancer with strong umami sensation. However, the snack flavour optimisation is beyond the scope of this study.

The raw material costs for the 3G snack base formulations are summarised in Table 9.3. The ingredient cost of the 'CW Salt Hi' was the lowest; and the ingredient cost of the 'RWC Salt Hi' was the highest. The ingredient cost of the 'RWC Salt Hi' was 9.4 % higher than the 'RW Salt Hi' and 16.3 % higher than the 'CW Salt Hi'.

Table 9.3: Raw material cost for 3G extruded snack base formulations

Ingredient	***Price obtained in 2012 (NZD/kg)***	***RW Salt Hi (%)***	***CW Salt Hi (%)***	***RWC Salt Hi (%)***
Coarse Rice Flour	1.80	32.5	0	32.5
Corn Polenta	1.36	0	32.5	0
Wholegrain Hi-Maize™ Flour	3.30	0	0	10
Potato Starch	3.35	27.5	27.5	27.5
Wholemeal Wheat Flour	1.10	30.0	30.0	20.0
Ancient Grain Blend	6.72	5.0	5.0	5.0
Wheat Fibre 600	4.40	4.0	4.0	4.0
Salt	0.43	1.0	1.0	1.0
TOTAL COST (NZD per kg)		**2.35**	**2.21**	**2.57**

Based on the raw material cost and pasting properties of Hi-Maize™ wholegrain corn, the 'RWC Salt Hi' is not recommended for further 3G snack formulation study. There are two optimised 3G wholegrain basic formulations (Table 9.4) that are suitable for further development work. Ancient grain blend (one third amaranth, one third quinoa and one third millet) was the most expensive ingredient (Table 3.1, Chapter 3). Thereby, its level of usage was kept at 5 % in the formulation for the characteristic ingredient claim.

Table 9.4: Third generation extruded snack base recipe with ancient grains

Recipe	*Coarse Rice Flour (%)*	*Corn Polenta (%)*	*Potato Starch (%)*	*Wholemeal Wheat Flour (%)*	*Ancient Grain Blend (%)*	*Salt (%)*	*Wheat Fibre 600 (%)*	*TOTAL (%)*
RW Salt Hi	32.5	0	27.5	30.0	5.0	1.0	4.0	100.0
CW Salt Hi	0	32.5	27.5	30.0	5.0	1.0	4.0	100.0

9.2. Effect of die design, extruder configuration and process on 3G snack

A suitable extruder screw configuration was found for Clextral BC21 twin screw extruder with 3 cut flight reversing screws (Table 3.2) and a die with two wave shaped openings was designed with die conductance of 0.10 (Figure 3.5). Three reverse cut flight screws were found necessary to increase the mixing and shearing in the centre of the barrel during extrusion. It was important not to place the reverse cut flight screws at the end of the extrusion zone to avoid large pressure drops at the die, which will lead to direct expansion at the die exit (second generation snack as characterised in Table 1.2). To produce a 3G snack pellet with a single-stage long barrel extruder, it was recommended to use the last one or two zones of the extruder as the cooling section (Forte & Young, 2003; Hertzel & Plattner, 2005). The extruder thrust pressure and die pressure were largely increased by reducing the die conductance from 0.5 to 0.1. However, the reduced die conductance also lead to a reduced volumetric flow rate. The result can be explained by Equation 2.4.

It was concluded that the optimized extrusion conditions for production of half pellets on a Clextral BC21 twin screw extruder was screw speed of 250 ± 2 rpm, water rate of 1.0 L/h, and varying feed rate to maintain a torque value between 5 – 5.5 Nm and die pressure between 95 – 105 bar (Chapter 8). The effects of water injection rate and salt on the expansion dependent variables and pellet expansion were determined. The results are summarised in Table 9.5.

The extruder energy consumption (power) increased by reducing the water injection rate (Table 6.1), and therefore resulted in completed starch gelatinisation and dextrinisation (Table 6.3). Several researchers have reported that an increase of water content resulted in a lower degree of starch gelatinisation for different products during extrusion (Huber, 2001; Moraru & Kokini, 2003). Both extruder water injection rate and salt significantly affected the extruded pellets' cold peak viscosities (CP) ($P < 0.05$), pellet die swell width ($P < 0.05$) and expansion (SEI or product bulk density) ($P < 0.05$).

Table 9.5: Effect of water and salt on the extrusion process and pellet expansion (usage change from low to high limit)

Factor	Usage Low-high limit	Extrusion Dependent Variables				Pellet Expansion	
		Apparent Torque (Nm)	*Thrust Pressure (Bar)*	*Die Pressure (Bar)*	*SME (kWh/kg)*	*Die Swell*	*SEI*
Water	1.0 ~ 1.7 kg/h	↓	↓	↓	↓	↑	↑
Salt	0.5 ~ 1.0 %	–	↓	↓	↓	↑	↑

Drying was found to be the most challenging process in the manufacture of the snack pellets. It was more than just simple dehydration. Four drying methods were trialled. It was found that drying and holding at 1 h ± 5 min intervals resulted minimal half pellets defects (Chapter 6). Prior to oven drying, pre-drying was required with a fan blowing a current of air on to the freshly extruded pellets. The pre-drier served two distinct purposes, firstly, it could extract a certain amount of water from the pellets and prevent the pellets sticking together. The second and very important purpose of a pre-drier was that it served as a pellet quality inspection point as the pellets left the extruder. Throughout this drying process the humidity must be carefully controlled at 60 % RH to promote uniform drying. Insulated tempering periods between the drying periods played a key role in preventing moisture loss on the pellet surface and increased the rate of water migration within the pellets. The drying process was found to be identical to pasta drying (Kill & Turnbull, 2001). The pasta drying technology should be suitable for producing 3G snack pellets. The moisture content of the dried pellet significantly affected the expansion of the 3G pellets (Chapter 8). Half pellets dried between 9.5 % and 12.1 % were trialled and it was found that this moisture range was suitable for air-puffing. The optimum pellet expansion was obtained at pellet moisture content of 10.6 %.

The shape of the pellets is one of the main quality attributes perceived by consumers. As can be seen in Figure 9.1, pellet shape distortion was observed during the experiments. These non-uniformities resulted in non-uniform pellet expansion, bending or twisting of the finished product. Figure 9.2 and 9.3 explained the reason why this had occurred. For laminar flow extrusion melt, the velocity profile inside of the die is parabolic (Singh, 2009b). The melt velocity profile was controlled by heat transfer and pressure variation (Figure 9.2) and the pressure variation can be attributed to the action of the pressure pulsation which occurs as the screw rotates (Figure 9.3) (Forte & Young, 2003). Forte & Young (2003) suggested that the correct design of an extrusion die requires not only the die conductance and product shape, but also the location of the die opening in relation to the screw. Further study will be required to correctly position the die opening and eliminate the deformed pellets.

Figure 9.1: Deformed pellets

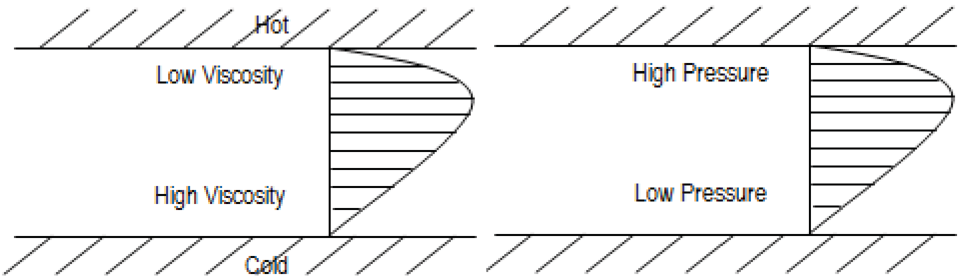


Figure 9.2: Velocity distribution affected by heat transfer and pressure variation inside of the die (Forte & Young, 2003)

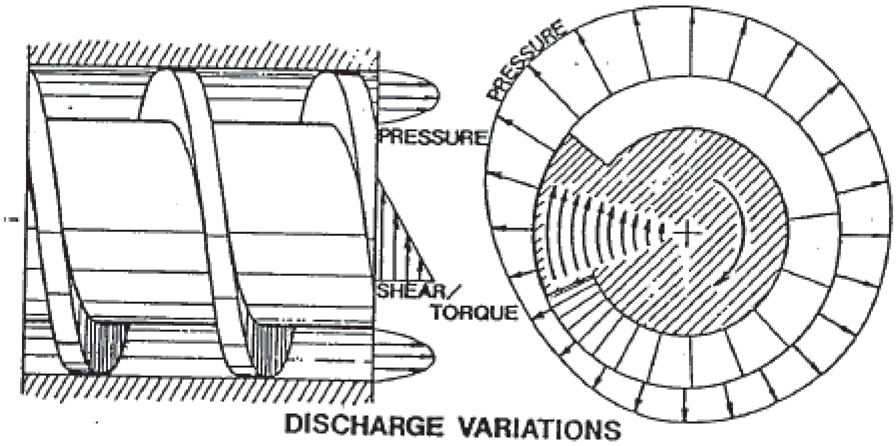


Figure 9.3: A schematic diagram of pressure variation at extruder opening (Forte & Young, 2003)

Most of low moisture commercial snack products available in the market were found to have low bulk density and were brittle (Section 8.3.5.4). The focus group study (Chapter 7) found that extruded snacks are consumed to meet emotional needs rather than other needs. There were five themes typically associated with snack consumption. They are nostalgia, special social occasions, distraction, convenient treat and hunger. The taste and price of the low moisture high starch snack foods were found to be most important to the participants, and the health benefits were only an extra bonus. Even though the numbers of new launches with ancient grain(s) are on the rise both in Australasia and globally, participants were not tempted by an ancient grain claim. Mostly because they had trouble understanding the benefits. The 3G snack product prototypes did not receive very positive feedback due to the taste and the product size. The 3G snack product texture was found acceptable by most participants. The size of the 3G snack would need to be increased at the scale up. Product taste was improved by increasing the salt content to 1 %. However, a formal sensory study will be required to confirm the findings.

10. OVERALL CONCLUSIONS AND RECOMMENDATIONS

10.1. Conclusions

Two 3G wholegrain base formulations were successfully developed. One formulation was made from coarse rice flour, wholemeal wheat flour, potato starch, ancient grain blend (one third amaranth, one third quinoa and one third millet), wheat fibre 600 and salt. The second formulation was maize based by replacing coarse rice flour with maize polenta. A special wave shaped die was designed to meet the project's unique shape requirement and both base formulations met the project nutritional requirements. The estimated cost of the coarse rice flour based and maize polenta based 3G formulation were \$ 2.35 per kg and \$ 2.21 per kg, respectively.

The quality of the extruded pellet was greatly affected by the raw material. Pellet expansion was closely correlated to the pasting properties of the raw ingredient blend. Pellet expansion increased with the increase of peak viscosity (PV) and final viscosity (FV) of the raw ingredient blend. Hi-Maize^{TM} ingredients were found to lead to the deterioration of viscosity and snack pellet expansion, exhibited superior firmness after puffing compared to standard, and therefore not recommended to be used for 3G snack base formulation. The pellet expansion improved by removing sugar from the base formulation and increasing the salt content to 1 %. Inclusion of fibres in the 3G formulations decreased raw ingredients' and extruded pellets' paste viscosities, which resulted in reduced pellet expansion. Wheat fibre 600 at 4 % was considered to be the best fibre choice to produce a 3G snack, because it accelerated extruded pellet drying, helped in decreasing the 'pellet checking' and producing more uniform cell sized expanded products.

From this study, it was concluded that the optimized extrusion conditions for production of extruded pellets on a Clextral BC21 twin screw extruder was screw speed of 250 ± 2 rpm, water rate of 1.0 L/h, and varying feed rate to maintain a torque value between 5 – 5.5 Nm and die pressure between 95 – 105 bar. Water injection rate to extruder significantly affected the extruded pellets' cold peak viscosities (CP), pellet die swell and expansion. A pasta drying procedure was found to be the most suitable method for drying the 3G snack after extrusion. The optimum pellet expansion due to puffing was obtained at pellet moisture of 10.6 %.

10.2. Recommendations

It is recommended:

1) to reduce particle size of maize polenta for 3G snack formulation;
2) to triple the current pellet size;
3) to correctly position the die opening and eliminate the deformed pellets;
4) to scale up the pilot plant trial work to gather further information;
5) to further improve of the 3G snack flavour without significantly increasing the salt content by using yeast extracts,
6) to carry out a consumer acceptance study on the scaled up 3G snack products.

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APPENDICES

Appendix 1: Raw material specifications

A 1.1 Raw material specifications for 3G snack base structure

Product Information Form   Page 1   Print date:9/8/2013

FOOD INDUSTRY - PRODUCT INFORMATION FORM

VERSION 5.0 - released 07 December 2011

insert your logo here ...

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WARRANTY: This document is intended as a guide only: legal requirements are contained in the Food Standards Code and relevant food legislation and other applicable laws. The information in this document should not be relied upon as legal advice or used as a substitute for legal advice. You should exercise your own skill, care and judgement before relying on this information in any important matter.

1 CONTACT DETAILS & DECLARATION

SUPPLIER'S PRODUCT NAME	ELIANE 100	SPECIFY COUNTRY IMPORTED INTO	
SUPPLIER'S PRODUCT CODE	660200 / 04400L00	SPECIFY COUNTRY EXPORTED FROM	
BARCODE - UNIT GTIN	Not applicable	SPECIFY IMPORT TARIFF CODE	

1.1 SUPPLIER INFORMATION

	COMPANY NAME	Ingredion ANZ Pty Ltd		
	BUSINESS NUMBER (ABN)	71 129 702 576		
	TRADING NAME	Ingredion ANZ Pty Ltd		
BUSINESS ADDRESS	NUMBER / STREET / SUBURB	170 Epping Rd	Lane Cove	
	STATE / COUNTRY / POST CODE	NSW	Australia	2770
POSTAL ADDRESS	POST ADDRESS / SUBURB	Locked Bag 61, PO		
	CITY / COUNTRY / POST CODE	Lane Cove	Australia	1595
KEY CONTACT FOR QUERIES	NAME	Laura Khoury		
	POSITION TITLE	Technical Service Manager		
	EMAIL ADDRESS	laura.khoury@ingredion.com		
	PHONE	02 99111242	FAX	20 94187830
	DATE FORM COMPLETED	01-August-2013	ISSUE DATE	01-August-2013
	DOCUMENT NO:	AFGC-031	ISSUE NUMBER	6

1.2 MANUFACTURING INFORMATION

Provide details where the manufacturer or site location differ to above:

	COMPANY NAME	AVEBE Kartoffelstarkefabrik		
SITE: #1	NUMBER / STREET / SUBURB			
	STATE / COUNTRY / POST CODE	Dallmin	Germany	
	COMPANY NAME			
SITE: #2	NUMBER / STREET / SUBURB			
	STATE / COUNTRY / POST CODE			
	COMPANY NAME			
SITE: #3	NUMBER / STREET / SUBURB			
	STATE / COUNTRY / POST CODE			

If more than three manufacturing sites, provide additional site information in Section 8.2

1.3 CONTACT DETAILS FOR TECHNICAL & ALLERGEN INFORMATION

Please specify the contact details if further information related to technical or allergen information is needed:

NAME	Laura Khoury		
JOB TITLE	Technical Service Manager		
EMAIL	laura.khoury@ingredion.com		
TELEPHONE - WORK	02 99111242	TELEPHONE - MOBILE	

1.4 SUPPLIER DECLARATION AND WARRANTY

The Supplier -

1) certifies that this product complies with the Australia New Zealand Food Standards Code; and, in addition to the information provided specifically in this form, and without limitation to compliance with any other part of the Code, that the product complies with:

- (a) Standard 1.3.4 - Identity and Purity
- (b) Standard 1.4.1 - Contaminants & Natural Toxicants
- (c) Standard 1.4.2 - Maximum Residue Limits in Food (In Australia), or
- (d) Maximum Residue Limits of Agricultural Compounds, Mandatory Food Standard 1999 (and subsequent amendments) issued under sections 11C and 11Z of the Food Act 1981 in New Zealand
- (e) Standard 1.4.3 - Articles & Materials in Contact with Food
- (f) Standard 1.4.4 - Prohibited & Restricted Plants & Fungi

where applicable, and that where such certification relies on third party audits, analysis, industry codes, or equivalence of international standards to demonstrate compliance, that certificates are current and available;

2) acknowledges that the Customer, and Supply Chain Customers of the Customer, will rely on the accuracy of the Product Information for food quality, safety and labelling purposes;

3) certifies that the accuracy of the Product Information is limited to the following degree: –

- (a) that the Product Information in relation to ingredients obtained from a third party relies in good faith on Product Information provided by that third party;
- (b) that the information is, to the best of the supplier's knowledge (having undertaken all reasonable verification procedures), true and accurate in relation to all other substances and processes;

4) agrees that all Product it supplies to the Customer will conform with the Product Information unless otherwise agreed to in writing and in advance by the Customer;

5) will immediately inform the Customer (and confirm in writing as soon as possible) if the supplier becomes aware of any error or omission in the Product Information;

6) will inform the Customer in writing and in advance of any change to the Product Information provided herein (including any changes that result from new or modified processes) if and when the supplier becomes aware of such changes; and

7) acknowledges that the Customer may provide the Product Information to –

- (a) regulatory agencies in relation to any matter raised by such agencies;
- (b) courts and other legal tribunals for the purposes of any proceedings; and
- (c) to its related businesses and partners who are involved in the acquisition, use, sale or compliance of the Product, under this same restriction as to disclosure.

but will otherwise NOT disclose the Product Information.

8) acknowledges that, subject to the prior written agreement of the supplier and any restrictions nominated by the supplier in regard to disclosure of confidential information, the Customer may provide the Product Information to its own customers subject to those customers ensuring the information is not further disclosed.

COMPANY NAME Signed for and on behalf of	Ingredion ANZ Pty Ltd
NAME (Please print)	Laura Khoury
JOB TITLE (Please print)	Technical Service Manager
AUTHORISED SIGNATURE	L. Khoury
DATE OF AUTHORISATION	01-August-2013

1.5 CUSTOMER DETAILS (WHERE KNOWN)

COMPANY NAME			
NUMBER / STREET / SUBURB			
CITY / COUNTRY / POST CODE			
CUSTOMER CONTACT NAME			
CUSTOMER'S PRODUCT NAME			
CUSTOMER'S PRODUCT CODE			

Customer Internal Use Only			
Internal Product Code/Description			
Version No.			
Reason for Update			
Received and Reviewed By			
Approved [Yes / No]	_	**Date:**	
Signature:	**Insert signature here**		

1.6 DEFINITIONS / REFERENCES

References to the "Code" or specific "Standards" throughout this document refer to the standards outlined in the Australia New Zealand Food Standards Code. The Australia New Zealand Food Standards Code can be viewed at: http://www.foodstandards.gov.au/foodstandardscode/

The AFGC provides some industry guides, specifically on how to apply date marking, and the AFGC Allergen Management and Labelling Guide which are available from the AFGC website: http://www.afgc.org.au/

Additional related documents on allergen management and VITAL (Voluntary Incidental Trace Allergen Labelling) documents can be viewed at: http://www.allergenbureau.net/vital/

1.7 CHECKLIST AND ATTACHMENTS

- X **Page 2 has been signed and dated (Section 1.4)**
- X Current Certificates attached - if applicable (Section 3.2.3 and Section 5.2)
- Supplier C of C, or C of A for analysis - if applicable (Section 7)
- X Other associated documents attached as requested by the customer (e.g. MSDS, HACCP certification, product specification, and related documents)

1.8 Status of completion for each section:

COMPLETED	Section 1 - Contact details and declaration
COMPLETED	Section 2 - Product Information & Ingredients
COMPLETED	Section 3 - Compositional information
COMPLETED	Section 4 - Foods requiring pre-market clearance
PARTIAL	Section 5 - Nutrients & consumer information claims
COMPLETED	Section 6 - Product shelf life, storage & packaging
COMPLETED	Section 7 - Chemical, microbial, organoleptic & physical specifications
COMPLETED	Section 8 - Additional comments

Check Box if help is needed identify mandatory sections of form which have NOT been completed: X

2 PRODUCT INFORMATION & INGREDIENTS

2.1 PRODUCT DESCRIPTION (Physical and technological description)

Food starch derived from potato

2.2 LEGAL DESCRIPTION / SUGGESTED LABELLING DESCRIPTION

Suggested labelling on Customer Packaging : Starch

2.3 PRODUCT APPLICATION AND INTENDED USE

2.3.1 Specify the intended use of the product

Food supplied as an ingredient for use in further manufacturing or processing

2.3.2 Specify which best describes the product

Solid, semi-solid or powder substance, intended for use in further preparation

2.4 COUNTRY OF ORIGIN

2.4.1 Specify the most appropriate overarching country of origin declaration which applies to this product :

Declaration:	Country:
Made in	Germany

2.4.2 Indicate if the local content of ingredients/components originating from Germany on average exceeds 95% **Yes** Yes/No

2.4.3 Are the primary components, from which this product is made or derived, sourced from more than one country? **No** Yes/No

2.4.4 Indicate if the following apply in determining country of origin declaration in 2.4.1:

The IMPORTED COMPONENTS have undergone substantial transformation	No	Yes/No
The PRODUCT has undergone substantial transformation	No	Yes/No
50% or more of total product costs are incurred in the country stated	Yes	Yes/No
Essential characteristic of the product is the result of local processing conditions	Yes	Yes/No

2.5 COMPONENT TYPE

Specify the type of the components present in product (Tick ONLY ONE check box below)

- [X] product is **a single component** substance
- [ ] product contains ingredients, which may include **compound** substances
- [ ] product consists of various ingredients which are **NOT compound** substances

2.6 INGREDIENT DECLARATION

Specify all ingredients including food additives in descending order, including percentage labelling of characterising components or ingredients. Compound substances must specify all ingredients and additives present and the characterising ingredient or component. Food additives must specify a functional class name and the food additive name or code number [e.g. antioxidants (304, 306), or food acid (citric)]

How many components are in this product? 1

COMPONENT NAME	PERCENT OF TOTAL %
Potato starch	100%

2.6 INGREDIENT DECLARATION INCLUDING PERCENTAGE LABELLING (continued)

COMPONENT NAME	PERCENT OF TOTAL %

2.7 PROCESSING AIDS

Specify all processing aids used in the manufacture of this product not otherwise declared in the ingredient list.

NAME OF PROCESSING AID	FSC ADDITIVE NUMBER OR EC *(as applicable)*	PERMITTED USE AND CLASS NAME

3 COMPOSITIONAL INFORMATION

3.1 MANDATORY ADVISORY OR WARNING STATEMENTS & DECLARATIONS

(" Yes" response triggers a mandatory advisory or warning statement. Refer Standard 1.2.3 of the Code)

FOOD / COMPONENT	PRESENT YES / NO
Bee pollen presented as a food or ingredient	No
Propolis presented as a food or ingredient	No
Unpasteurised milk and unpasteurised liquid milk products	No
Aspartame or aspartame-acesulphame salt (or phenylalanine)	No
Unpasteurised egg products	No
Quinine	No
Kola beverages containing added caffeine	No
Guarana or extracts of guarana	No
Phytosterol esters	No
Tall oil phytosterols.	No
Cereal-based beverages, where these foods contain no more than 2.5% m/m fat and less than 3% m/m protein, or less than 3% m/m protein only.	No
Evaporated and dried products made from cereals, where these foods contain no more than 2.5% m/m fat and less than 3% m/m protein, or less than 3% m/m protein only, as reconstituted according to directions for direct consumption.	No
Milk, and beverages made from soy or cereals, where these foods contain no more than 2.5% m/m fat.	No
Evaporated milks, dried milks and equivalent products made from soy or cereals, where these foods contain no more than 2.5% m/m fat as reconstituted according to directions for direct consumption.	No
Royal jelly presented as a food or ingredient	No
Polyols, Isomalts, Polydextrose (Lactitol, Maltitol, Maltitol syrup, Mannitol, Xylitol, Erythritol, Isomalt, Polydextrose, Sorbitol)	No

3.2 ALLERGEN MANAGEMENT & CONTROL

		Yes/No
3.2.1	Does the facility have a Food Safety Program?	Yes
3.2.2	Does the facility have a documented allergen management plan?	Yes
	IF YES, does this include the management of cross contact allergens?	Yes
3.2.3	Has the Food Safety Program been independently audited and certified?	Yes

If Yes provide name of Certifying Body: Refer to certificate attached

Date of most recent audit / inspection: Refer to certificate attache — Provide copy of certificate

3.2.4 Indicate if any of the following is applied in order to manage allergens and minimise allergen cross contact within the manufacturing facility: *(Select all appropriate checkboxes)*

	validated cleaning procedures		production scheduling
	control of personnel movement in factory	X	staff training
X	documented procedures and controls		isolated storage of allergens
	raw material sourcing & tracing		dedicated equipment
X	other: HACCP Program, Site Allergen Policy		

3.3 INGREDIENTS TO BE DECLARED AS ALLERGENS OR SULPHITE

Please insert **YES** or **NO** to indicate if the product contains, or was manufactured using, any ingredient, additive or processing aid which has been derived from the following food sources. Highly processed derivatives must always be declared. Carefully assess compound ingredients for hidden allergens. [** Lupin included as a possible future addition to the Food Standards Code.]

Yes/No	
No	**Cereals containing gluten** & their products [*wheat, rye, barley, oats, spelt*]
No	**Crustacea** & crustacea products
No	**Egg** & egg products
No	**Fish** & fish products (including mollusc with or without shells and fish oils)
No	**Lupin** & lupin products [** not a mandatory labelling allergen at this time]
No	**Milk** & milk products
No	**Peanut** & peanut products
No	**Sesame seed** & sesame seed products
No	**Soybean** & soybean products
No	**Tree nuts** & tree nut products
	Reserved for future allergen - left blank intentionally

Yes	**Sulphites,** present **in** ingredients, additives or processing aids

Specify the amount of sulphite:

naturally occurring in ingredients	0.0	mg/kg
residual from processing aid, or carry-over in ingredient	<10	mg/kg
added as an ingredient	0	mg/kg
Total Sulphite	less than 10	mg/kg

Specify type of added sulphite/s and additive number/s:

3.3.1 Complete all coloured rows corresponding with "YES" declaration provided above.

ALLERGENIC SUBSTANCE	SOURCE NAME The allergenic food from which ingredient is derived (e.g. wheat)	DERIVATIVE NAME Ingredient, additive or processing aid (e.g. maltodextrin)	PROPORTION (%)		PROCESS Allergenic protein is removed?
			Derivative in product	Protein in derivative	
Cereals containing gluten and their products [wheat, rye, barley, oats, spelt & derived product e.g. wheat maltodextrin]					
Crustacea & crustacea products					
Egg & egg products					
Fish & fish products (including mollusc extract and fish oils)					
Lupin & lupin products					
Milk & milk products					
Peanut & peanut products (including peanut oil)					
Sesame Seed & sesame seed products (including sesame oils)					
Soybean & soybean products (including soybean oils)					
Tree nuts & tree nut products					
Reserved for future allergen					

3.4 ALLERGEN CROSS CONTACT

Yes/No

3.4.1 Except for any allergens listed in Section 3.3, does your company have on site and handle ANY OTHER allergenic substances listed below? **No**

IF NO, specify "No" to indicate allergens are NOT IN THE SAME FACILITY then go to Section 3.4

***Refer to VITAL procedure and decision tree.* http://www.allergenbureau.net/vital/

3.4.2 All columns must be completed WHERE HIGHLIGHTED

ALLERGENIC SUBSTANCE	PRESENT IN SAME FACILITY Yes/No	PRESENT ON SAME LINE Yes/No	SOURCE FOOD The allergenic food from which ingredient is derived (e.g. wheat)	DERIVATIVE NAME Ingredient, additive or processing aid (e.g. maltodextrin)	TOTAL PROTEIN** protein level by VITAL, or specify "particulate" mg/kg
Cereals containing gluten & their products	No	No			
Crustacea & crustacea products	No	No			
Egg & egg products	No	No			
Fish & fish products (inc mollusc & oils)	No	No			
Lupin & lupin products	No	No			
Milk & milk products	No	No			
Peanuts & peanut products (inc peanut oil)	No	No			
Sesame Seed & sesame products	No	No			
Soybeans & soybean products (inc soybean oil)	No	No			
Tree nuts & tree nut products	No	No			
Reserved for future allergen					

3.5 INTERNATIONAL ALLERGEN, LABELLING & INFORMATION REQUIREMENTS

FOOD / COMPONENT		PRESENT (Yes/No)	NAME OF FOOD (e.g. apple)	DERIVATIVE NAME (e.g. cider vinegar)
Gelatine	beef - collagen	**No**		
	other source	**No**		
Seafood products	Algae/carrageenan	**No**		
	Shellfish (Mollusc)	**No**		
Fungi	Matsutake mushroom	**No**		
	Other mushroom	**No**		
Fruits	Avocado	**No**		
	Banana	**No**		
	Pome fruit - apples, pears	**No**		
	Stone fruit - cherry, peach, plum, apricot.	**No**		
	Berry Fruits - blueberry, kiwifruit, strawberry	**No**		
	Citrus Fruits - grapefruit, lemon, lime, orange	**No**		
Grains, Seeds, Nuts & Spices	Buckwheat	**No**		
	Coconut, poppy, sunflower, etc	**No**		
	Mustard	**No**		
Vegetables	Tomato	**No**		
	Yam	**No**		
	Allium genus - chive, leek, onion, garlic, spring onion	**No**		
	Legumes - other than peanut soybeans & lupins	**No**		
	Umbelliferae - aniseed, carrot, celery, celeriac, chervil, cumin, dill, coriander, fennel, parsley, parsnip	**No**		
Yeast & Yeast Products *(including yeast extracts)* *Tick box if hydrolysed or autolysed*		**No**		
Herbs *Tick box if herb / herb extract*		**No**		
Spice *(excluding mustard)* *Tick box if spice / spice extract*		**No**		

3.6 ADDITIONAL LABELLING & INFORMATION REQUIREMENTS

FOOD / COMPONENT		PRESENT (Yes/No)	ADDITIONAL INFORMATION TO BE PROVIDED WHERE PROMPTED		
Antioxidants	Butylated hydroxyanisole (BHA)	No	amount added (milligram/kilogram)		
	Butylated hydroxytoluene (BHT)	No	amount added (milligram/kilogram)		
	Other antioxidants	No	Specify type:		
			amount added (milligram/kilogram)		
Added Caffeine *(exclude naturally occurring)*		No	amount added (milligram/kilogram)		
Alcohol (Residual)		No	level % v/v:		
			specific gravity if product is alcohol:		
Added Fats & Oils	Animal	No	Specify types of fats and oils:		
			Has fatty acid composition been altered?		Yes/No
			Specify the process used to alter composition:		
	Vegetable	No	Specify types of fats and oils:		
			If Palm oil is present, is this RSPO certified?		Yes/No
			Has fatty acid composition been altered?		Yes/No
			Specify the process used to alter composition:		
Hydrolysed Vegetable Proteins	Acid Hydrolysed	No	Specify type of vegetable protein:		
			100% hydrolysis		
	Enzyme Hydrolysed	No	Specify type of vegetable protein:		
			100% hydrolysis		
Intense sweetener		No	Name of sweetener	Number	Amount (mg/kg)
Preservatives		No	Name of preservative	Number	Amount (mg/kg)
Flavour enhancers		No	Name of flavour enhancer	Additive number	
Added Colours		No			
Added Flavours		No			
Added Salt		No	amount added (milligram/100g)		
Added Sugar		No	amount added (gram/100g)		
	List specific component:		Provide relevant details necessary for consumer advice:		

ANY OTHER COMPONENT		

3.7 QUARANTINE & IMPORT/EXPORT INFORMATION REQUIREMENTS

FOOD / COMPONENT	PRESENT (Yes/No)	ADDITIONAL INFORMATION TO BE PROVIDED WHERE PROMPTED	
Animal & Animal products (e.g. animal flesh, organs, stock, gelatine, animal fat, tallow, milk, collagen from skin and / or hides etc)	**No**	Specify type of animals	
		Specify type of animal derivatives	
		Specify country/ies of origin	
		Describe any heat processing used in the manufacture of this product (temperature/time):	
Meat & Meat products (e.g. animal flesh, animal organs, meat extracts)	**No**	Specify type of animals *(tick appropriate box)*	
		Specify type of meat derivatives	
		Specify source of meat products (i.e. Country and city):	
		Describe any heat processing used in the manufacture of this product (temperature/time):	
		How do you ensure products are derived from animals free of bovine spongiform encephalopathy (BSE)?	
Bird & Bird products (e.g. meat, fat, eggs, extracts, feathers, feet, etc.)	**No**	Specify type of birds *(tick appropriate box)*	
		Specify type of bird derivatives	
		Specify source of bird products (i.e. Country and city):	
		Describe any heat processing used in the manufacture of this product (temperature/time):	
Fish & Fish products (e.g. smoked salmon, pilchards, shark fin, fish roe, etc)	**No**	Specify type of fish:	
		Specify type of fish derivatives	
		Specify source of fish products (i.e. Country and city):	
		Describe any heat processing used in the manufacture of this product (temperature/time):	
Honey & Honey products	**No**	Specify type of honey or honey derivatives	
		Specify source of honey products (i.e. Country and State):	
		Describe any heat processing used in the manufacture of this product (temperature/time):	

4 FOODS REQUIRING PRE-MARKET CLEARANCE

4.1 NOVEL FOODS (Refer Standard 1.5.1 of the Code)

4.1.1 Is this product (or any of its components) listed as a novel food in the standard? **No** Yes/No

4.2 QUARANTINE TREATMENTS

Specify if this product (or any of its components) has been treated with the following:

TREATMENT METHOD	USED ON ANY COMPONENT	SPECIFY TREATED INGREDIENT
Steam sterilisation	No	
Ionising (gamma) irradiation	No	
Ethylene oxide	No	
Other fumigants or sterilants	No	

4.3 FOOD PRODUCED USING GENE TECHNOLOGY (Standard 1.5.2)

4.3.1 Are there any ingredients (including food additives, processing aids and enzymes) in this product that come from genetically modified (GM) plants or animals, or are the result of synthesis by GM micro-organisms, but with the exemption of use of GM feedstock? **No** Yes/No

IF NO, specify which of the following are applicable:

- [ ] No GM varieties of this food / ingredient available
- [x] Non GM variety is used
- [ ] Identity preservation program in place
- [ ] Analytical testing confirms absence
- [ ] Verifiable documentation of status
- [ ] Other – Specify

Go to Question 4.3.7 and continue

GM CROSS CONTAMINATION IN FOODS AND INGREDIENTS **Yes/No**

4.3.7. Is this a raw/bulk commodity which is transported by freight/tanker AND where the freight/tanker could have previously been used to transport other GM product? **No**

4.3.8. Is this product manufactured or stored at a production site where genetically modified protein or DNA is used for the manufacture of other products? **No**

4.3.9. Is there an identity preservation system separating non GM and GM components to ensure the absence of genetically modified material in this product? **No**

Specify details: Please see attached Non-GM statement

4.3.10. Has Polymerase Chain Reaction (PCR) testing for GM materials been carried out? **No**

4.3.11. Is any GM food or GM ingredient unintentionally present at MORE THAN 10g/kg **No**

EXEMPTION TO LABELLING APPLIES AND GM LABELLING IS NOT REQUIRED

4.3.12. (OPTIONAL) Are any ingredients derived from an animal which has been fed with feedstock containing GM ingredients or ingredients derived from GM micro-organisms?

Specify details:

5 NUTRIENTS & CONSUMER INFORMATION CLAIMS

5.1 NUTRITION INFORMATION

5.1.1 Serve size is not relevant for this product.

5.1.2 For nutrition information below, please specify the **UNITS of measure**: X grams

Complete nutrient table below. Mandatory nutrients highlighted in blue and bolded, others optional.

NUTRIENT	AVG QUANTITY per 100 g
Energy	1350 kJ
Protein, total	Less than 0.1 g
- Gluten	
Fat, total	0.05 g
- saturated	0 g
- transfat	0 g
- polyunsaturated	
- monounsaturated	
Cholesterol	0 mg
Carbohydrate	80 g
- sugars	0 g
Dietary fibre, total	0 g
Sodium	9 mg
Potassium	60 mg

Nutrient information is relevant to product AS SUPPLIED

DO NOT leave bolded NIP fields blank. Use numbers, or text "less than" with value; or "unavailable" or "not detected" for gluten.

Nutrient information table INCOMPLETE

5.1.3 Additional nutrients - vitamins, minerals and other nutritive substances

Specify only one target population for product *(selection ONLY ONE check box)*:

Select ONLY ONE population group: ☐ **Adults** ☐ **Young Children** ☐ **Infants**

VITAMINS specify which vitamin	AVG QUANTITY per 100 g

MINERALS specify which minerals	AVG QUANTITY per 100 g
calcium	30.0 mg
iron	0.1 mg
magnesium	5.0 mg
phosphorus	70.0 mg

NOTE: there is no permission to FORTIFY foods with this substance indicated with **

Insert any other nutrient or biologically active substance

NAME OF SUBSTANCE	AVG QUANTITY per 100 g	%RDI / serve

5.1.4 Please provide the following analytical data:

% Ash	0.00%
% Moisture	</=20g

Estimation content accounted for per 100 g	N/A

5.1.5 Please specify how the carbohydrate value has been determined:

X Difference as defined in Standard 1.2.8 ☐ Available Carbohydrate as defined in Standard 1.2.8 ☐ Other - specify: ☐ Unknown

5.1.6 Please nominate the source used to provide nutrition data in the tables above

Analytical – e.g. Laboratory Tested ☐ Theoretical – e.g. By Calculation. X

Please specify the source of data used for the theoretical calculations (e.g. Nuttab, AusNut, NZ food tables, etc)

5.2 SUITABILITY TO MAKE CERTAIN CLAIMS

Specify if the product is suitable for use in product intended for the following consumer uses.

SPECIFY IF SUITABLE FOR ...	Yes / No	HOW HAS THIS BEEN VALIDATED?	CERTIFICATE AVAILABLE (Yes/No)
Halal	Yes	Certified	Yes
Kosher	Yes	Certified	Yes
Organic	No		
Biodynamic	No		
Ovo-lacto-vegetarian	Yes	Verified by ingredients used	No
Lacto-vegetarian	Yes	Verified by ingredients used	No
Vegan	Yes	Verified by ingredients used	No

A copy of relevant certificates must be provided as attachments to form

PRODUCT SUITABILITY FOR ...	Yes / No	SPECIFY PARTICULAR CLAIMS	HOW IS CLAIM VALIDATED?
"Free" claims	No		
Sustainability claims	No		
Humane treatment	No		
Any other claims			

6 DURABILITY, PACKAGING AND SUPPLY CHAIN

6.1 SHELF LIFE

6.1.1 Please complete the following details:

	PRODUCT AS SUPPLIED unopened pack or bulk container		PRODUCT - ONCE IN USE resealable pack or bulk container	
Specify shelf life	24	Months	24	Months
Temperature control during storage	Is required ?	No	Is required ?	No
			Specify range:	
Temperature control during transport	Is required ?	No		
Specify any OTHER storage requirements:	Stored in a clean, dry area at ambient temperature and away from heavily aromatic material		24 months for resealable pack provided bag is opened under hygienic conditions and resealed tightly. Store in a clean, dry area at ambient temperature and away from heavily aromatic material	

6.1.2 Specify the type of date mark to be used: **Best before**

Refer to AFGC Date Marking Guide

6.2 POTENTIAL HAZARDS

6.2.1 Are there any potential hazards associated with the product ? **No** Yes/No

6.3 TRANSPORT

How is product transported and packaged? Packaged for catering/manufacturing supply

6.4 TRADE MEASUREMENT

6.4.1 Specify which method of trade measurement is used: **Net quantity**

6.4.2 What is the package size	25.0	kg	(specify unit of measure)
6.4.3 Target Fill (if applicable)	25.00	kg	(specify unit of measure)
6.4.4 Drained Weight (if applicable)			(specify unit of measure)

6.4.5 IF AQS is used, what is the statistical variance in the fill measurement?

6.5 TRACEABILITY

Please provide any general comments about the traceability coding used on the product:

Please specify the following where applicable:

TRACKING CODE	UNIT				SHIPPER (if applicable)			
Type of Primary Coding (*Please TICK as appropriate*)	X	Date code		Batch number		Date code		Batch number
	X	Product code	X	Lot number		Product code		Lot number
Method of coding	Printing							
Location of code	Side of bag							
Number of characters in code	8							
Example of coding format	Y WW D LL XX							
Coding translation	Year, Week, Day, Production Line, Number							

6.6 PRODUCT PACKAGING

6.6.1 Are tamper evident controls included in the packaging design? **Yes** Yes/No

6.6.2 Has unit packaging been assessed for migration of substances into food? **Yes** Yes/No

6.6.3 Are engineered nanoparticles present in unit packaging? **No** Yes/No

6.6.4 Are you a signatory to relevant packaging stewardship in Australian or NZ ? **No** Yes/No

6.6.5 Provide a general description of unit packaging:

6.6.6 Complete the following table for questions related to packaging of unit package and/or shipper

PACKAGING		UNIT	SHIPPER
Type	Packaging format	Multi paper bags	
Specify components / material used in packaging	Ceramic	No	
	Glass	No	
	Metal	No	
	Paper / cardboard	Yes	
	Packing materials	No	
	Plastics	No	
	% of total using recycled component		
Seal	What is the seal method?	Ultrasonic sealing	
Dimensions	Height (mm)	72	
	Width (mm)	35	
	Depth (mm)	13	

6.7 PALLET CONFIGURATION

6.7.1 Gross weight of loaded pallet ☐ kg

6.7.2 Stack height of loaded pallet ☐ cm

6.7.3 Specify the type of pallet ☐ Wooden ☐ Plastic ☐ Other

6.7.4 What is the pallet pattern ☐ Column stack ☐ Interlocking

6.7.5 Number of : units per shipper ☐ shippers per pallet ☐

layers per pallet ☐

7 SPECIFICATIONS FOR COMPLIANCE

Test Methods are mandatory and must quote AOAC methods or recognised independent Australian or International standards. Where a supplier's internal test method is quoted a copy must be attached. Also state if Certificate of Analysis (C of A) or Certificate of Conformance (C of C) can be provided.

7.1 ORGANOLEPTIC SPECIFICATIONS

(Examples may include flavour, colour, aroma, texture etc)

TEST / PARAMETER	SPECIFICATION	TEST METHOD	AVAILABILITY C of A	C of C
Color*	White to Off-white	Visual	No	

7.2 PHYSICAL SPECIFICATIONS

(Examples may include particle size, shape, specific gravity, metal detection, foreign matter tolerances, physical defect tolerances etc as appropriate for the product)

TEST / PARAMETER	SPECIFICATION	TEST METHOD	AVAILABILITY C of A	C of C
Arsenic*	≤0.1 mg/kg	Atomic absorbtion method	Yes	
Cadmium*	≤0.1 mg/kg	Atomic absorbtion method	Yes	
Mercury*	≤0.05 mg/kg	Atomic absorbtion method	Yes	
Lead*	≤0.5 mg/kg	Atomic absorbtion method	Yes	
Sulphite (as SO2)*	≤10 mg/kg	ISO 5379	Yes	
Sulphated ash*	≤10 mg/kg	ISO 5809	Yes	

7.3 MICROBIOLOGICAL SPECIFICATIONS

(Examples may include standard plate count, yeasts & moulds, coliforms, salmonella, listeria etc)

TEST / PARAMETER	SPECIFICATION	TEST METHOD	AVAILABILITY C of A	C of C
Total aerobic mesophilic count	≤10000 CFU/g	ISO 4833	Yes	
Yeasts	≤100 CFU/g	ISO 7954	Yes	
Moulds	≤250 CFU/g	ISO 7954	Yes	
Escherichia coli (1g)	Absent	ISO 16649	Yes	
Salmonella (25g)	Absent	ISO 6579	Yes	

7.4 CHEMICAL SPECIFICATIONS

(Examples may include pesticide residue screen, antibiotic residue screen, heavy metal screen, aflatoxins screen, salt, acid, pH, moisture, brix, Aw, Nutrition Information Test, etc)

TEST / PARAMETER	SPECIFICATION	TEST METHOD	AVAILABILITY C of A	AVAILABILITY C of C
Moisture	≤205 mg/g	ISO 1666	Yes	

8 COMMENTS / ADDITIONAL INFORMATION

8.1 Do you have any comments or additional information ? **Yes** Yes/No

Question Number	Line Number	Comments
6.6.6.	799-801	Dimensions are aproximates only
7.1, 7.2	822, 832-837	(*) While this information is typical of this product it should not be considered as a specificaiton.

8.2 ADDITIONAL MANUFACTURING SITE INFORMATION (if required)

When nominating product is supplied from more than one manufacturing site, the details provided must be applicable to product coming from any of the sites. For example, if particular allergens occur at only one site then the information provided in the form should identify that the allergens are present even though batches of product made at other sites may be allergen free.

	COMPANY NAME			
SITE: #4	NUMBER / STREET / SUBURB			
	STATE / COUNTRY / POST CODE			
	COMPANY NAME			
SITE: #5	NUMBER / STREET / SUBURB			
	STATE / COUNTRY / POST CODE			
	COMPANY NAME			
SITE: #6	NUMBER / STREET / SUBURB			
	STATE / COUNTRY / POST CODE			

FOOD INDUSTRY - PRODUCT INFORMATION FORM

VERSION 5.01 - 2011

1 CONTACT DETAILS & DECLARATION

SUPPLIER'S PRODUCT NAME	Maize Polenta	SPECIFY COUNTRY IMPORTED INTO	
SUPPLIER'S PRODUCT CODE	52032003	SPECIFY COUNTRY EXPORTED FROM	
BARCODE - UNIT GTIN	N/A	SPECIFY IMPORT TARIFF CODE	

1.1 SUPPLIER INFORMATION

	COMPANY NAME	Corson Grain Ltd		
	BUSINESS NUMBER (ABN)			
	TRADING NAME	Corson		
BUSINESS ADDRESS	NUMBER / STREET / SUBURB	415	Gladstone Road	Gisborne
	STATE / COUNTRY / POST CODE	East Coast 4010	New Zealand	
POSTAL ADDRESS	POST ADDRESS / SUBURB	P 0 Box 1046		Gisborne
	CITY / COUNTRY / POST CODE	East Coast 4010	New Zealand	
KEY CONTACT FOR QUERIES	NAME	Hamish Cheetham		
	POSITION TITLE	Food Sales Manager		
	EMAIL ADDRESS	hamishc@corson.co.nz		
	PHONE	6468691380	FAX	6468679307
	DATE FORM COMPLETED	06-December-2011	ISSUE DATE	06-December-2011
	DOCUMENT NO:	PIF Maize Polenta	ISSUE NUMBER	3

1.2 MANUFACTURING INFORMATION

Provide details where the manufacturer or site location differ to above:

	COMPANY NAME			
SITE: #1	NUMBER / STREET / SUBURB			
	STATE / COUNTRY / POST CODE			
	COMPANY NAME			
SITE: #2	NUMBER / STREET / SUBURB			
	STATE / COUNTRY / POST CODE			
	COMPANY NAME			
SITE: #3	NUMBER / STREET / SUBURB			
	STATE / COUNTRY / POST CODE			

If more than three manufacturing sites, provide additional site information in Section 8.2

1.3 CONTACT DETAILS FOR TECHNICAL & ALLERGEN INFORMATION

Please specify the contact details if further information related to technical or allergen information is needed:

NAME	Steve Brown		
JOB TITLE	QA / Tech Services Manager		
EMAIL	steveb@corson.co.nz		
TELEPHONE - WORK	6468691391	TELEPHONE - MOBILE	276855781

1.4 SUPPLIER DECLARATION AND WARRANTY

The Supplier -

1) certifies that this product complies with the Australia New Zealand Food Standards Code; and, in addition to the information provided specifically in this form, and without limitation to compliance with any other part of the Code, that the product complies with:

(a) Standard 1.3.4 - Identity and Purity
(b) Standard 1.4.1 - Contaminants & Natural Toxicants
(c) Standard 1.4.2 - Maximum Residue Limits in Food (In Australia), or
(d) Maximum Residue Limits of Agricultural Compounds, Mandatory Food Standard 1999 (and subsequent amendments) issued under sections 11C and 11Z of the Food Act 1981 in New Zealand
(e) Standard 1.4.3 - Articles & Materials in Contact with Food
(f) Standard 1.4.4 - Prohibited & Restricted Plants & Fungi

where applicable, and that where such certification relies on third party audits, analysis, industry codes, or equivalence of international standards to demonstrate compliance, that certificates are current and available;

2) acknowledges that the Customer, and Supply Chain Customers of the Customer, will rely on the accuracy of the Product Information for food quality, safety and labelling purposes;

3) certifies that the accuracy of the Product Information is limited to the following degree: –

(a) that the Product Information in relation to ingredients obtained from a third party relies in good faith on Product Information provided by that third party;
(b) that the information is, to the best of the supplier's knowledge (having undertaken all reasonable verification procedures), true and accurate in relation to all other substances and processes;

4) agrees that all Product it supplies to the Customer will conform with the Product Information unless otherwise agreed to in writing and in advance by the Customer;

5) will immediately inform the Customer (and confirm in writing as soon as possible) if the supplier becomes aware of any error or omission in the Product Information;

6) will inform the Customer in writing and in advance of any change to the Product Information provided herein (including any changes that result from new or modified processes) if and when the supplier becomes aware of such changes; and

7) acknowledges that the Customer may provide the Product Information to –

(a) regulatory agencies in relation to any matter raised by such agencies;
(b) courts and other legal tribunals for the purposes of any proceedings; and
(c) to its related businesses and partners who are involved in the acquisition, use, sale or compliance of the Product, under this same restriction as to disclosure.

but will otherwise NOT disclose the Product Information.

8) acknowledges that, subject to the prior written agreement of the supplier and any restrictions nominated by the supplier in regard to disclosure of confidential information, the Customer may provide the Product Information to its own customers subject to those customers ensuring the information is not further disclosed.

COMPANY NAME Signed for and on behalf of	Corson Grain Ltd (Corson)
NAME (Please print)	Steve Brown
JOB TITLE (Please print)	QA / Tech Services Manager
AUTHORISED SIGNATURE	
DATE OF AUTHORISATION	06-December-2011

1.5 CUSTOMER DETAILS (WHERE KNOWN)

COMPANY NAME			
NUMBER / STREET / SUBURB			
CITY / COUNTRY / POST CODE			
CUSTOMER CONTACT NAME			
CUSTOMER'S PRODUCT NAME			
CUSTOMER'S PRODUCT CODE			

Customer Internal Use Only			
Internal Product Code/Description			
Version No.			
Reason for Update			
Received and Reviewed By			
Approved [Yes / No]		**Date:**	
Signature:	**Insert signature here**		

1.6 DEFINITIONS / REFERENCES

References to the "Code" or specific "Standards" throughout this document refer to the standards outlined in the Australia New Zealand Food Standards Code. The Australia New Zealand Food Standards Code can be viewed at: http://www.foodstandards.gov.au/foodstandardscode/

The AFGC provides some industry guides, specifically on how to apply date marking, and the AFGC Allergen Management and Labelling Guide which are available from the AFGC website: http://www.afgc.org.au/

Additional related documents on allergen management and VITAL (Voluntary Incidental Trace Allergen Labelling) documents can be viewed at: http://www.allergenbureau.net/vital/

1.7 CHECKLIST AND ATTACHMENTS

- X **Page 2 has been signed and dated (Section 1.4)**
- X Current Certificates attached - if applicable (Section 3.2.3 and Section 5.2)
- X Supplier C of C, or C of A for analysis - if applicable (Section 7)
- X Other associated documents attached as requested by the customer (e.g. MSDS, HACCP certification, product specification, and related documents)

1.8 Status of completion for each section:

COMPLETED	Section 1 - Contact details and declaration
COMPLETED	Section 2 - Product Information & Ingredients
COMPLETED	Section 3 - Compositional information
COMPLETED	Section 4 - Foods requiring pre-market clearance
COMPLETED	Section 5 - Nutrients & consumer information claims
COMPLETED	Section 6 - Product shelf life, storage & packaging
COMPLETED	Section 7 - Chemical, microbial, organoleptic & physical specifications
COMPLETED	Section 8 - Additional comments

Check Box if help is needed identify mandatory sections of form which have NOT been completed: X

MANDATORY input boxes which are not complete will now be coloured dark purple.

2 PRODUCT INFORMATION & INGREDIENTS

2.1 PRODUCT DESCRIPTION (Physical and technological description)

A fine granular, yellow, degermed maize grit derived from milling whole maize

2.2 LEGAL DESCRIPTION / SUGGESTED LABELLING DESCRIPTION

Maize Polenta

2.3 PRODUCT APPLICATION AND INTENDED USE

2.3.1 Specify the intended use of the product

Food supplied as an ingredient for use in further manufacturing or processing

2.3.2 Specify which best describes the product

Solid, semi-solid or powder substance, intended for use in further preparation

2.4 COUNTRY OF ORIGIN

2.4.1 Specify the most appropriate overarching country of origin declaration which applies to this product :

Declaration:	Country:
Product of	New Zealand

2.4.2 Indicate if the local content of ingredients/components originating from New Zealand

on average exceeds 95%	Yes	Yes/No
on average exceeds 50%		Yes/No

2.4.3 Are the primary components, from which this product is made or derived, sourced from more than one country? No Yes/No

2.4.4 Indicate if the following apply in determining country of origin declaration in 2.4.1:

The IMPORTED COMPONENTS have undergone substantial transformation	No	Yes/No
The PRODUCT has undergone substantial transformation	No	Yes/No
50% or more of total product costs are incurred in the country stated	Yes	Yes/No
Essential characteristic of the product is the result of local processing conditions	Yes	Yes/No

2.5 COMPONENT TYPE

Specify the type of the components present in product (Tick ONLY ONE check box below)

- [X] product is **a single component** substance
- [ ] product contains ingredients, which may include **compound** substances
- [ ] product consists of various ingredients which are **NOT compound** substances

2.6 INGREDIENT DECLARATION

Specify all ingredients including food additives in descending order, including percentage labelling of characterising components or ingredients. Compound substances must specify all ingredients and additives present and the characterising ingredient or component. Food additives must specify a functional class name and the food additive name or code number [e.g. antioxidants (304, 306), or food acid (citric)]

How many components are in this product? 1

COMPONENT NAME	PERCENT OF TOTAL %
Maize	100.00%

2.6 INGREDIENT DECLARATION INCLUDING PERCENTAGE LABELLING (continued)

COMPONENT NAME	PERCENT OF TOTAL %

2.7 PROCESSING AIDS

Specify all processing aids used in the manufacture of this product not otherwise declared in the ingredient list.

NAME OF PROCESSING AID	FSC ADDITIVE NUMBER OR EC (as applicable)	PERMITTED USE AND CLASS NAME
Minor amount of Potable water added to assist removal of pericarp (transparent kernel husk)		

3 COMPOSITIONAL INFORMATION

3.1 MANDATORY ADVISORY OR WARNING STATEMENTS & DECLARATIONS

(" Yes" response triggers a mandatory advisory or warning statement. Refer Standard 1.2.3 of the Code)

FOOD / COMPONENT	PRESENT YES / NO
Bee pollen presented as a food or ingredient	No
Propolis presented as a food or ingredient	No
Unpasteurised milk and unpasteurised liquid milk products	No
Aspartame or aspartame-acesulphame salt (or phenylalanine)	No
Unpasteurised egg products	No
Quinine	No
Kola beverages containing added caffeine	No
Guarana or extracts of guarana	No
Phytosterol esters	No
Tall oil phytosterols.	No
Cereal-based beverages, where these foods contain no more than 2.5% m/m fat and less than 3% m/m protein, or less than 3% m/m protein only.	No
Evaporated and dried products made from cereals, where these foods contain no more than 2.5% m/m fat and less than 3% m/m protein, or less than 3% m/m protein only, as reconstituted according to directions for direct consumption.	No
Milk, and beverages made from soy or cereals, where these foods contain no more than 2.5% m/m fat.	No
Evaporated milks, dried milks and equivalent products made from soy or cereals, where these foods contain no more than 2.5% m/m fat as reconstituted according to directions for direct consumption.	No
Royal jelly presented as a food or ingredient	No
Polyols, Isomalts, Polydextrose (Lactitol, Maltitol, Maltitol syrup, Mannitol, Xylitol, Erythritol, Isomalt, Polydextrose, Sorbitol)	No

3.2 ALLERGEN MANAGEMENT & CONTROL

		Yes/No
3.2.1	Does the facility have a Food Safety Program?	Yes
3.2.2	Does the facility have a documented allergen management plan?	No
	IF NO, SPECIFY DATE to implement allergen management plan:	Vital Tool has
3.2.3	Has the Food Safety Program been independently audited and certified?	Yes

If Yes provide name of Certifying Body: Assured Food Safety Ltd NZ (Auckland NZ)

Date of most recent audit / inspection: 31 May 2012 — Provide copy of certificate

3.2.4 Indicate if any of the following is applied in order to manage allergens and minimise allergen cross contact within the manufacturing facility: *(Select all appropriate checkboxes)*

X	validated cleaning procedures		production scheduling
X	control of personnel movement in factory	X	staff training
X	documented procedures and controls		isolated storage of allergens
X	raw material sourcing & tracing	X	dedicated equipment
	other		

3.3 INGREDIENTS TO BE DECLARED AS ALLERGENS OR SULPHITE

Please insert **YES** or **NO** to indicate if the product contains, or was manufactured using, any ingredient, additive or processing aid which has been derived from the following food sources. Highly processed derivatives must always be declared. Carefully assess compound ingredients for hidden allergens. [** Lupin included as a possible future addition to the Food Standards Code.]

Yes/No	
No	**Cereals containing gluten** & their products [*wheat, rye, barley, oats, spelt*]
No	**Crustacea** & crustacea products
No	**Egg** & egg products
No	**Fish** & fish products (including mollusc with or without shells and fish oils)
No	**Lupin** & lupin products [** not a mandatory labelling allergen at this time]
No	**Milk** & milk products
No	**Peanut** & peanut products
No	**Sesame seed** & sesame seed products
No	**Soybean** & soybean products
No	**Tree nuts** & tree nut products
	Reserved for future allergen - left blank intentionally

No	**Sulphites,** present **in** ingredients, additives or processing aids

3.3.1 Complete all coloured rows corresponding with "YES" declaration provided above.

ALLERGENIC SUBSTANCE	SOURCE NAME The allergenic food from which ingredient is derived (e.g. wheat)	DERIVATIVE NAME Ingredient, additive or processing aid (e.g. maltodextrin)	PROPORTION (%)		PROCESS Allergenic protein is removed?
			Derivative in product	Protein in derivative	
Cereals containing gluten and their products [wheat, rye, barley, oats, spelt & derived product e.g. wheat maltodextrin]					
Crustacea & crustacea products					
Egg & egg products					
Fish & fish products (Including mollusc extract and fish oils)					
Lupin & lupin products					
Milk & milk products					
Peanut & peanut products (including peanut oil)					
Sesame Seed & sesame seed products (including sesame oils)					
Soybean & soybean products (including soybean oils)					
Tree nuts & tree nut products					
Reserved for future allergen					

3.4 ALLERGEN CROSS CONTACT

Yes/No

3.4.1 Except for any allergens listed in Section 3.3, does your company have on site and handle ANY OTHER allergenic substances listed below? **No**

IF NO, specify "No" to indicate allergens are NOT IN THE SAME FACILITY then go to Section 3.4

Refer to VITAL procedure and decision tree. http://www.allergenbureau.net/vital/

3.4.2 All columns must be completed WHERE HIGHLIGHTED

ALLERGENIC SUBSTANCE	**PRESENT IN SAME FACILITY** Yes/No	**PRESENT ON SAME LINE** Yes/No	**SOURCE FOOD** The allergenic food from which ingredient is derived (e.g. wheat)	**DERIVATIVE NAME** Ingredient, additive or processing aid (e.g. maltodextrin)	**TOTAL PROTEIN** estimated using the VITAL procedure **mg/kg (ppm)**
Cereals containing gluten & their products	No				
Crustacea & crustacea products	No				
Egg & egg products	No				
Fish & fish products (inc mollusc & oils)	No				
Lupin & lupin products	No				
Milk & milk products	No				
Peanuts & peanut products (inc peanut oil)	No				
Sesame Seed & sesame products	No				
Soybeans & soybean products (inc soybean oil)	No				
Tree nuts & tree nut products	No				
Reserved for future allergen					

3.5 INTERNATIONAL ALLERGEN, LABELLING & INFORMATION REQUIREMENTS

FOOD / COMPONENT		PRESENT (Yes/No)	NAME OF FOOD (e.g. apple)	DERIVATIVE NAME (e.g. cider vinegar)
Gelatine	beef - collagen	No		
	other source	No		
Seafood products	Algae/carrageenan	No		
	Shellfish (Mollusc)	No		
Fungi	Matsutake mushroom	No		
	Other mushroom	No		
Fruits	Avocado	No		
	Banana	No		
	Pome fruit - apples, pears	No		
	Stone fruit - cherry, peach, plum, apricot.	No		
	Berry Fruits - blueberry, kiwifruit, strawberry	No		
	Citrus Fruits - grapefruit, lemon, lime, orange	No		
Grains, Seeds, Nuts & Spices	Buckwheat	No		
	Coconut, poppy, sunflower, etc	No		
	Mustard	No		
Vegetables	Tomato	No		
	Yam	No		
	Allium genus - chive, leek, onion, garlic, spring onion	No		
	Legumes - other than peanut soybeans & lupins	No		
	Umbelliferae - aniseed, carrot, celery, celeriac, chervil, cumin, dill, coriander, fennel, parsley, parsnip	No		
Yeast & Yeast Products *(including yeast extracts)* *Tick box if hydrolysed or autolysed*		No		
Herbs *Tick box if herb / herb extract*		No		
Spice *(excluding mustard)* *Tick box if spice / spice extract*		No		

3.6 ADDITIONAL LABELLING & INFORMATION REQUIREMENTS

FOOD / COMPONENT		PRESENT (Yes/No)	ADDITIONAL INFORMATION TO BE PROVIDED WHERE PROMPTED			
Antioxidants	Butylated hydroxyanisole (BHA)	No	amount added (milligram/kilogram)			
	Butylated hydroxytoluene (BHT)	No	amount added (milligram/kilogram)			
	Other antioxidants	No	Specify type:			
			amount added (milligram/kilogram)			
Added Caffeine *(exclude naturally occurring)*		No	amount added (milligram/kilogram)			
Alcohol (Residual)		No	level % v/v:			
			specific gravity if product is alcohol:			
Added Fats & Oils	Animal	No	Specify types of fats and oils:			
			Has fatty acid composition been altered?		Yes/No	
			Specify the process used to alter composition:			
	Vegetable	No	Specify types of fats and oils:			
			If Palm oil is present, is this RSPO certified?		Yes/No	
			Has fatty acid composition been altered?		Yes/No	
			Specify the process used to alter composition:			
Hydrolysed Vegetable Proteins	Acid Hydrolysed	No	Specify type of vegetable protein:			
			100% hydrolysis			
	Enzyme Hydrolysed	No	Specify type of vegetable protein:			
			100% hydrolysis			
Intense sweetener		No	Name of sweetener	Number	Amount (mg/kg)	
Preservatives		No	Name of preservative	Number	Amount (mg/kg)	
Flavour enhancers		No	Name of flavour enhancer	Additive number		
Added Colours		No				
Added Flavours		No				
Added Salt		No	amount added (milligram/100g)			
Added Sugar		No	amount added (gram/100g)			

ANY OTHER COMPONENT	List specific component:		Provide relevant details necessary for consumer advice:

3.7 QUARANTINE & IMPORT/EXPORT INFORMATION REQUIREMENTS

FOOD / COMPONENT	PRESENT (Yes/No)	ADDITIONAL INFORMATION TO BE PROVIDED WHERE PROMPTED	
Animal & Animal products (e.g. animal flesh, organs, stock, gelatine, animal fat, tallow, milk, collagen from skin and / or hides etc)	**No**	Specify type of animals	
		Specify type of animal derivatives	
		Specify country/ies of origin	
		Describe any heat processing used in the manufacture of this product (temperature/time):	
Meat & Meat products (e.g. animal flesh, animal organs, meat extracts)	**No**	Specify type of animals *(tick appropriate box)*	
		Specify type of meat derivatives	
		Specify source of meat products (i.e. Country and city):	
		Describe any heat processing used in the manufacture of this product (temperature/time):	
		How do you ensure products are derived from animals free of bovine spongiform encephalopathy (BSE)?	
Bird & Bird products (e.g. meat, fat, eggs, extracts, feathers, feet, etc.)	**No**	Specify type of birds *(tick appropriate box)*	
		Specify type of bird derivatives	
		Specify source of bird products (i.e. Country and city):	
		Describe any heat processing used in the manufacture of this product (temperature/time):	
Fish & Fish products (e.g. smoked salmon, pilchards, shark fin, fish roe, etc)	**No**	Specify type of fish:	
		Specify type of fish derivatives	
		Specify source of fish products (i.e. Country and city):	
		Describe any heat processing used in the manufacture of this product (temperature/time):	
Honey & Honey products	**No**	Specify type of honey or honey derivatives	
		Specify source of honey products (i.e. Country and State):	
		Describe any heat processing used in the manufacture of this product (temperature/time):	

4 FOODS REQUIRING PRE-MARKET CLEARANCE

4.1 NOVEL FOODS (Refer Standard 1.5.1 of the Code)

4.1.1 Is this product (or any of its components) listed as a novel food in the standard? **No** Yes/No

4.2 QUARANTINE TREATMENTS

Specify if this product (or any of its components) has been treated with the following:

TREATMENT METHOD	USED ON ANY COMPONENT	SPECIFY TREATED INGREDIENT
Steam sterilisation	No	
Ionising (gamma) irradiation	No	
Ethylene oxide	No	
Other fumigants or sterilants	No	

4.3 FOOD PRODUCED USING GENE TECHNOLOGY (Standard 1.5.2)

4.3.1 Are there any ingredients (including food additives, processing aids and enzymes) in this product that come from genetically modified (GM) plants or animals, or are the result of synthesis by GM micro-organisms, but with the exemption of use of GM feedstock? **No** Yes/No

IF NO, specify which of the following are applicable:

- [ ] No GM varieties of this food / ingredient available
- [X] Non GM variety is used
- [X] Identity preservation program in place
- [X] Analytical testing confirms absence
- [ ] Verifiable documentation of status
- [ ] Other – Specify

Go to Question 4.3.7 and continue

GM CROSS CONTAMINATION IN FOODS AND INGREDIENTS **Yes/No**

4.3.7. Is this a raw/bulk commodity which is transported by freight/tanker AND where the freight/tanker could have previously been used to transport other GM product? **No**

4.3.8. Is this product manufactured or stored at a production site where genetically modified protein or DNA is used for the manufacture of other products? **No**

4.3.9. Is there an identity preservation system separating non GM and GM components to ensure the absence of genetically modified material in this product?

Specify details:

4.3.10. Has Polymerase Chain Reaction (PCR) testing for GM materials been carried out? **Yes**

Are results positive and show GM DNA or Novel Protein is detected? **No**

4.3.11. Is any GM food or GM ingredient unintentionally present at MORE THAN 10g/kg **No**

4.3.12. (OPTIONAL) Are any ingredients derived from an animal which has been fed with feedstock containing GM ingredients or ingredients derived from GM micro-organisms?

Specify details:

5 NUTRIENTS & CONSUMER INFORMATION CLAIMS

5.1 NUTRITION INFORMATION

5.1.1 Serve size is not relevant for this product.

5.1.2 For nutrition information below, please specify the **UNITS of measure**: X grams

Complete nutrient table below. Mandatory nutrients highlighted in blue and bolded, others optional.

NUTRIENT	AVG QUANTITY per 100 g
Energy	1400 Kj
Protein, total	7.5 g
- Gluten	Not detected
Fat, total	2 g
- saturated	0.3 g
- transfat	unavailable
- polyunsaturated	unavailable
- monounsaturated	unavailable
Cholesterol	unavailable
Carbohydrate	76 g
- sugars	Less than 4.0 g
Dietary fibre, total	Less than 3.0 g
Sodium	9 mg
Potassium	unavailable

Nutrient information is relevant to product AS SUPPLIED

Please confirm fat subgroup levels are correct

5.1.3 Additional nutrients - vitamins, minerals and other nutritive substances
Specify only one target population for product *(selection ONLY ONE check box)* :

X **Adults** **Young Children** **Infants**

VITAMINS specify which vitamin	AVG QUANTITY per 100 g

MINERALS specify which minerals	AVG QUANTITY per 100 g

NOTE: there is no permission to FORTIFY foods with this substance indicated with **

Insert any other nutrient or biologically active substance

NAME OF SUBSTANCE	AVG QUANTITY per 100 g	%RDI / serve

5.1.4 Please provide the following analytical data:

% Ash	1.50%
% Moisture	13.00%

Estimation content accounted for per 100 g	100.00

5.1.5 Please specify how the carbohydrate value has been determined:

Difference as defined in Standard 1.2.8   Available Carbohydrate as defined in Standard 1.2.8   X Other - specify: Analysed by   Unknown

5.1.6 Please nominate the source used to provide nutrition data in the tables above

Analytical – e.g. Laboratory Tested X Theoretical – e.g. By Calculation.

For laboratory analysis, specify date of analysis: 10-May-2011

5.2 SUITABILITY TO MAKE CERTAIN CLAIMS

Specify if the product is suitable for use in product intended for the following consumer uses.

SPECIFY IF SUITABLE FOR ...	Yes / No	HOW HAS THIS BEEN VALIDATED?	CERTIFICATE AVAILABLE (Yes/No)
Halal	Yes	Not validated - in progress	No
Kosher	No		
Organic	No		
Biodynamic	No		
Ovo-lacto-vegetarian	Yes	Literature search	No
Lacto-vegetarian	Yes	Literature search	No
Vegan	Yes	Literature search	No

PRODUCT SUITABILITY FOR ...	Yes / No	SPECIFY PARTICULAR CLAIMS	HOW IS CLAIM VALIDATED?
"Free" claims	No		
Sustainability claims	No		
Humane treatment	No		
Any other claims	Yes	Gluten Free	Independent analysis

6 DURABILITY, PACKAGING AND SUPPLY CHAIN

6.1 SHELF LIFE

6.1.1 Please complete the following details:

	PRODUCT AS SUPPLIED unopened pack or bulk container		PRODUCT - ONCE IN USE resealable pack or bulk container	
Specify shelf life	6	Months	30	Days
Temperature control during storage	Is required ?	Yes	Is required ?	Yes
	Specify range:	under 25 °C	Specify range:	under 25 °C
Temperature control during transport	Is required ?	No		
Specify any OTHER storage requirements:	Protect from direct sunlight. Protect from rodent, insect, & moth infestation			

6.1.2 Specify the type of date mark to be used: **Best before**

Refer to AFGC Date Marking Guide

6.2 POTENTIAL HAZARDS

6.2.1 Are there any potential hazards associated with the product ? **No** Yes/No

6.3 TRANSPORT

How is product transported and packaged? Packaged for catering/manufacturing supply

6.4 TRADE MEASUREMENT

6.4.1 Specify which method of trade measurement is used: **Net quantity**

6.4.2 What is the package size	25.00	kg	(specify unit of measure)
6.4.3 Target Fill (if applicable)	25.05	kg	(specify unit of measure)
6.4.4 Drained Weight (if applicable)			(specify unit of measure)

6.4.5 IF AQS is used, what is the statistical variance in the fill measurement?

6.5 TRACEABILITY

Please provide any general comments about the traceability coding used on the product:

Julian date code system adopted for traceability and a Best before month is stamped on outer packaging.

Please specify the following where applicable:

TRACKING CODE	UNIT		SHIPPER (if applicable)	
Type of Primary Coding (*Please TICK as appropriate*)	X Date code	X Batch number	Date code	Batch number
	X Product code	Lot number	Product code	Lot number
Method of coding	Stamped (Blue colour ink)			
Location of code	At the base of front panel of bag			
Number of characters in code	4.00			
Example of coding format	1340			
Coding translation	6 day of December 2011			

6.6 PRODUCT PACKAGING

6.6.1 Are tamper evident controls included in the packaging design? **No** Yes/No

6.6.2 Has unit packaging been assessed for migration of substances into food? **Yes** Yes/No

6.6.3 Are engineered nanoparticles present in unit packaging? **No** Yes/No

6.6.4 Are you a signatory to relevant packaging stewardship in Australian or NZ ? **No** Yes/No

6.6.5 Provide a general description of unit packaging:

Multiply papersack that complies with Food Act 1981 section9(4) & FDA Title 21 176.170

6.6.6 Complete the following table for questions related to packaging of unit package and/or shipper

PACKAGING		UNIT	SHIPPER
Type	Packaging format	Multi layer wet strength	Multi layer wet strength
Specify components / material used in packaging	Ceramic	**No**	**No**
	Glass	**No**	**No**
	Metal	**No**	**No**
	Paper / cardboard	**Yes**	**Yes**
	Packing materials	**No**	**No**
	Plastics	**No**	**No**
	% of total using recycled component		
Seal	What is the seal method?	Stitched closed	
Dimensions	Height (mm)	810mm	
	Width (mm)	395mm	
	Depth (mm)	125mm	

6.7 PALLET CONFIGURATION

6.7.1 Gross weight of loaded pallet 1035.0 kg

6.7.2 Stack height of loaded pallet 130.0 cm

6.7.3 Specify the type of pallet [X] Wooden [ ] Plastic [ ] Other

6.7.4 What is the pallet pattern [ ] Column stack [ ] Interlocking

6.7.5 Number of : units per shipper [ ] shippers per pallet 40

layers per pallet 8

7 SPECIFICATIONS FOR COMPLIANCE

Test Methods are mandatory and must quote AOAC methods or recognised independent Australian or International standards. Where a supplier's internal test method is quoted a copy must be attached. Also state if Certificate of Analysis (C of A) or Certificate of Conformance (C of C) can be provided.

7.1 ORGANOLEPTIC SPECIFICATIONS

(Examples may include flavour, colour, aroma, texture etc)

TEST / PARAMETER	SPECIFICATION	TEST METHOD	AVAILABILITY C of A	C of C
Flavour / odour	Free of any musty taste and odours	Supplier devised method (one tablespoon from a composite	Yes	

7.2 PHYSICAL SPECIFICATIONS

(Examples may include particle size, shape, specific gravity, metal detection, foreign matter tolerances, physical defect tolerances etc as appropriate for the product)

TEST / PARAMETER	SPECIFICATION	TEST METHOD	AVAILABILITY C of A	C of C
Particle size (microns)	As per product specification	Endecott sieves standard methods for particle size	Yes	
Test Weight (kg/hl)	As per product specification	As per Seedburo USDA defined test method for determining test	Yes	
Metal detection	1mm Fe; 1mm N/F; 1.5mm S/S	Inspection Ltd method for in line	Yes	
Black Specs	As per product specification	Supplier internal method	Yes	

7.3 MICROBIOLOGICAL SPECIFICATIONS

(Examples may include standard plate count, yeasts & moulds, coliforms, salmonella, listeria etc)

TEST / PARAMETER	SPECIFICATION	TEST METHOD	AVAILABILITY C of A	C of C
APC	Not greater than 100,000/g	APHA 4th Edition 2001 Chp7	No	
Coliforms	Not greater than 10/g	APHA 4th Edition 2001 Chp	No	
Yeasts	Not greater than 2,000/g	APHA 4th Edition 2001 Chp20	No	
Moulds	Not greater than 2,000/g	APHA 4th Edition 2001 Chp20	No	
Bacillus cereus	Not greater than 100/g	APHA 4th Edition 2001 Chp32	No	
Salmonella	Not detected per 25g	APHA ISO 6579	No	
Ecoli	Less than 4/g	APHA 4th Edition 2001 Chp8	No	
Bacillus Rope spore	Less than 3/g	APHA 4th Edit 2001CHp 22.52	No	
Enterobacteriaceae	Less than 100/g	Petrifilm4th Edition Chp8	No	

7.4 CHEMICAL SPECIFICATIONS
(Examples may include pesticide residue screen, antibiotic residue screen, heavy metal screen, aflatoxins screen, salt, acid, pH, moisture, brix, Aw, Nutrition Information Test, etc)

TEST / PARAMETER	SPECIFICATION	TEST METHOD	AVAILABILITY	
			C of A	C of C
% Moisture content	11.0 - 15.0	MF 50 analyser & air oven method	Yes	
% Oil content	0 - 3.0	Foss & Soxtec Avanti	Yes	
Aflatoxin B1,2,G1,2	Less than 5 ppb	Enzyme Immuno assay aflacup	Yes	
Pesticide residue	Max 5 mg/kg pirimiphos-methyl	SGS & Hill Labs AOAC method	No	
Mycotoxin screen	Less than 1.5 mg/kg Niv & Don	Plant & Food Research method	No	
Nutrition profile	As per food standards	SGS & Hill Labs AOAC method	No	
Aw	Typically less than 0.8	AsureQuality Aqualab 4 method	No	

8 COMMENTS / ADDITIONAL INFORMATION

8.1 Do you have any comments or additional information ? **No** Yes/No

Question Number	Line Number	Comments
5.1	650-663	Refer product specification attached for range values w.r.t. % moisture, %oil content, Particle size /granulation

8.2 ADDITIONAL MANUFACTURING SITE INFORMATION (if required)

When nominating product is supplied from more than one manufacturing site, the details provided must be applicable to product coming from any of the sites. For example, if particular allergens occur at only one site then the information provided in the form should identify that the allergens are present even though batches of product made at other sites may be allergen free.

	COMPANY NAME			
SITE: #4	NUMBER / STREET / SUBURB			
	STATE / COUNTRY / POST CODE			
	COMPANY NAME			
SITE: #5	NUMBER / STREET / SUBURB			
	STATE / COUNTRY / POST CODE			
	COMPANY NAME			
SITE: #6	NUMBER / STREET / SUBURB			

STATE / COUNTRY / POST CODE			

FOOD INDUSTRY - PRODUCT INFORMATION FORM

VERSION 4.3 - 17 Dec 2010

1 CONTACT DETAILS & DECLARATION

SUPPLIER'S PRODUCT NAME	RICE FLOUR COARSE	SPECIFY COUNTRY IMPORTED INTO	New Zealand
SUPPLIER'S PRODUCT CODE	RICEFC	SPECIFY COUNTRY EXPORTED FROM	Pakistan
BARCODE - UNIT GTIN	NA	SPECIFY IMPORT TARIFF CODE	1102.90.01.00J

1.1 SUPPLIER INFORMATION

COMPANY NAME	DAVIS TRADING COMPANY Ltd		
ABN	/		
TRADING NAME	DAVIS TRADING COMPANY Ltd		
BUSINESS ADDRESS NUMBER / STREET / SUBURB	91-93	CARBINE ROAD	MT WELLINGTON
TATE / COUNTRY / POST CODE	AUCKLAND	New Zealand	1060
POSTAL ADDRESS POST ADDRESS / SUBURB	PO BOX 132 - 159		SYLVIA PARK
CITY / COUNTRY / POST CODE	AUCKLAND	New Zealand	
KEY CONTACT FOR QUERIES NAME	Samantha Boyde		
POSITION TITLE	Quality Systems Supervisor		
EMAIL ADDRESS	sboyde@davis.co.nz		
PHONE	09 5742250	FAX	09573 0055
DATE FORM COMPLETED	14-July-2011	ISSUE DATE	19-December-2012
DOCUMENT NO:	FTA	ISSUE NUMBER	2

1.2 MANUFACTURER/S INFORMATION

Provide details where the manufacturer or site location differ to above:

	COMPANY NAME	NA		
SITE: #1	NUMBER / STREET / SUBURB	NA	NA	NA
	STATE / COUNTRY / POST CODE	NA	Pakistan	NA
	COMPANY NAME	NA		
SITE: #2	NUMBER / STREET / SUBURB	NA	NA	NA
	STATE / COUNTRY / POST CODE	NA		NA
	COMPANY NAME	NA		
SITE: #3	NUMBER / STREET / SUBURB	NA	NA	NA
	STATE / COUNTRY / POST CODE	NA		NA

If more than three manufacturing sites, provide additional site information in Section 8.3

1.3 CONTACT DETAILS FOR TECHNICAL & ALLERGEN INFORMATION

Please specify the contact details if further information related to technical or allergen information is needed:

NAME	Samantha Boyde		
JOB TITLE	Quality Systems Supervisor		
EMAIL	sboyde@davis.co.nz		
TELEPHONE - WORK	95742250	TELEPHONE - MOBILE	NA

1.4 SUPPLIER DECLARATION AND WARRANTY

The Supplier -

1} certifies that this product complies with the Australia New Zealand Food Standards Code; and, in addition to the information provided specifically in this form, and without limitation to compliance with any other part of the Code, that the product complies with:

(a) Standard 1.3.4 - Identity and Purity
(b) Standard 1.4.1 - Contaminants & Natural Toxicants
(c) Standard 1.4.2 - Maximum Residue Limits in Food (In Australia), or
(d) Maximum Residue Limits of Agricultural Compounds, Mandatory Food Standard 1999 (and subsequent amendments) issued under sections 11C and 11Z of the Food Act 1981 in New Zealand
(e) Standard 1.4.3 - Articles & Materials in Contact with Food
(f) Standard 1.4.4 - Prohibited & Restricted Plants & Fungi

where applicable, and that where such certification relies on third party audits, analysis, industry codes, or equivalence of international standards to demonstrate compliance, that certificates are current and available;

2} acknowledges that the Customer, and Supply Chain Customers of the Customer, will rely on the accuracy of the Product Information for food quality, safety and labelling purposes;

3} certifies that the accuracy of the Product Information is limited to the following degree: –

(a) that the Product Information in relation to ingredients obtained from a third party relies in good faith on Product Information provided by that third party;
(b) that the information is, to the best of the supplier's knowledge (having undertaken all reasonable verification procedures), true and accurate in relation to all other substances and processes;

4} agrees that all Product it supplies to the Customer will conform with the Product Information unless otherwise agreed to in writing and in advance by the Customer;

5} will immediately inform the Customer (and confirm in writing as soon as possible) if the supplier becomes aware of any error or omission in the Product Information;

6} will inform the Customer in writing and in advance of any change to the Product Information provided herein (including any changes that result from new or modified processes) if and when the supplier becomes aware of such changes; and

7} acknowledges that the Customer may provide the Product Information to –

(a) regulatory agencies in relation to any matter raised by such agencies;
(b) courts and other legal tribunals for the purposes of any proceedings; and
(c) to its related businesses and partners who are involved in the acquisition, use, sale or compliance of the Product, under this same restriction as to disclosure.

but will otherwise NOT disclose the Product Information.

8} acknowledges that, subject to the prior written agreement of the supplier and any restrictions nominated by the supplier in regard to disclosure of confidential information, the Customer may provide the Product Information to its own customers subject to those customers ensuring the information is not further disclosed.

COMPANY NAME Signed for and on behalf of	DAVIS TRADING COMPANY LTD
NAME (Please print)	Samantha Boyde
JOB TITLE (Please print)	Quality Systems supervisor
AUTHORISED SIGNATURE	S. Boyde
DATE OF AUTHORISATION	19-December-2012

Click on the field name "2.1 PRODUCT DESCRIPTION" to continue to tab through the document.

1.5 CUSTOMER DETAILS (WHERE KNOWN)

COMPANY NAME	SUPPLIED TO VARIOUS CUSTOMERS		
NUMBER / STREET / SUBURB	NA	NA	NA
CITY / COUNTRY / POST CODE	NA	New Zealand	
CUSTOMER CONTACT NAME	NA		
CUSTOMER'S PRODUCT NAME	NA		
CUSTOMER'S PRODUCT CODE	NA		

Customer Internal Use Only			
Internal Product Code/Description			
Version No.			
Reason for Update			
Received and Reviewed By			
Approved [Yes / No]		**Date:**	
Signature:	**Insert signature here**		

1.6 DEFINITIONS / REFERENCES

References to the "Code" or specific "Standards" throughout this document refer to the standards outlined in the Australia New Zealand Food Standards Code. The Australia New Zealand Food Standards Code can be viewed at: http://www.foodstandards.gov.au/foodstandardscode/

The AFGC provides some industry guides, specifically on how to apply date marking, and the AFGC Allergen Management and Labelling Guide which are available from the AFGC website: http://www.afgc.org.au/

Additional related documents on allergen management and VITAL (Voluntary Incidental Trace Allergen Labelling) documents can be viewed at: http://www.allergenbureau.net/vital/

1.7 CHECKLIST AND ATTACHMENTS

- [X] **Page 2 has been signed and dated (Section 1.4)**
- [ ] Current Certificates attached - if applicable (Section 4.2)
- [ ] Supplier TEST METHODS attached - if applicable (Section 7)
- [ ] Other associated documents attached as requested by the customer (e.g. MSDS, HACCP certification, product specification, and related documents)

1.8 Status of completion for each section:

COMPLETED	Section 1 - Contact details and declaration
COMPLETED	Section 2 - Product Information & Ingredients
COMPLETED	Section 3 - Compositional information
PARTIAL	Section 4 - Nutrients & consumer information claims
COMPLETED	Section 5 - Foods requiring pre-market clearance
PARTIAL	Section 6 - Product shelf life, storage & packaging
COMPLETED	Section 7 - Chemical, microbial, organoleptic & physical specifications
COMPLETED	Section 8 - Additional comments

Check Box if help is needed identify mandatory sections of form which have NOT been completed: [ ]

2 PRODUCT INFORMATION & INGREDIENTS

2.1 PRODUCT DESCRIPTION (Physical and technological description)

Slighly coarse, creamy off white powder produced by milling polished long grain rice. Its high amylose content makes it a good choice for coatings, batters and other applications.

2.2 LEGAL DESCRIPTION / SUGGESTED LABELLING DESCRIPTION

Rice flour

2.3 PRODUCT APPLICATION AND INTENDED USE

2.3.1 Specify the application of the product:

Food supplied as an ingredient for use in further manufacturing or processing

2.3.2 Specify product characterisation or intended use

Solid, semi-solid or powder substance, intended for use in further preparation

2.4 COUNTRY OF ORIGIN

2.4.1 Specify the most appropriate overarching country of origin declaration which applies to this product :

Declaration:	Country:	
Product of	Pakistan	

2.4.2 Indicate if the local content of ingredients/components originating from Pakistan

on average exceeds 95%	Yes	Yes/No
on average exceeds 51%	Yes	Yes/No

2.4.3 Are the primary components, from which this product is made or derived, sourced from more than one country? **No** Yes/No

2.4.4 Indicate if the following apply in determining country of origin declaration in 2.4.1:

The IMPORTED COMPONENTS have undergone substantial transformation	Yes	Yes/No
The PRODUCT has undergone substantial transformation	Yes	Yes/No
50% or more of total product costs are incurred in the country stated	Yes	Yes/No
Essential characteristic of the product is the result of local processing conditions	Yes	Yes/No

2.5 COMPONENT TYPE

Specify the type of the components present in *(select ONLY ONE check box)*

- [X] product is **a single component** substance
- [ ] product contains ingredients, which may include **compound** substances
- [ ] product consists of various ingredients which are **NOT compound** substances

2.6 INGREDIENT DECLARATION

Specify all ingredients including food additives in descending order, including percentage labelling of characterising components or ingredients. Compound substances must specify ingredients and additives present and the characterising component. Food additives must specify function and name or code number, [e.g. antioxidants (304, 306), or food acid (citric)]

How many components are in this product? 1

COMPONENT NAME	PERCENT OF TOTAL %
Rice flour	100.00%

2.6 INGREDIENT DECLARATION INCLUDING PERCENTAGE LABELLING (continued)

COMPONENT NAME	PERCENT OF TOTAL %

2.7 PROCESSING AIDS

Specify all processing aids used in the manufacture of this product not otherwise declared in the ingredient list.

NAME OF PROCESSING AID	FSC ADDITIVE NUMBER OR EC (as applicable)	FSC REFERENCE & FUNCTION
None		

3 COMPOSITIONAL INFORMATION

3.1 MANDATORY ADVISORY OR WARNING STATEMENTS & DECLARATIONS

(" Yes" response triggers a mandatory advisory or warning statement. Refer Standard 1.2.3 of the Code)

FOOD / COMPONENT	PRESENT YES / NO
Bee pollen presented as a food or ingredient	No
Propolis presented as a food or ingredient	No
Unpasteurised milk and unpasteurised liquid milk products	No
Aspartame or aspartame-acesulphame salt (or phenylalanine)	No
Unpasteurised egg products	No
Quinine	No
Kola beverages containing added caffeine	No
Guarana or extracts of guarana	No
Phytosterol esters	No
Tall oil phytosterols.	No
Cereal-based beverages, where these foods contain no more than 2.5% m/m fat and less than 3% m/m protein, or less than 3% m/m protein only.	No
Evaporated and dried products made from cereals, where these foods contain no more than 2.5% m/m fat and less than 3% m/m protein, or less than 3% m/m protein only, as reconstituted according to directions for direct consumption.	No
Milk, and beverages made from soy or cereals, where these foods contain no more than 2.5% m/m fat.	No
Evaporated milks, dried milks and equivalent products made from soy or cereals, where these foods contain no more than 2.5% m/m fat as reconstituted according to directions for direct consumption.	No
Royal jelly presented as a food or ingredient	No
Polyols, Isomalts, Polydextrose (Lactitol, Maltitol, Maltitol syrup, Mannitol, Xylitol, Erythritol, Isomalt, Polydextrose, Sorbitol) **If "yes"** specify type/s and levels:	No

3.2 ALLERGEN MANAGEMENT & CONTROL

3.2.1 Does production facility have a documented cross contact allergen management plan? **Yes** Yes/No

3.2.2 Is Allergen Management incorporated into the company's Food Safety Program? **Yes** Yes/No

3.2.3 Has the Food Safety Program been independently audited and certified? **Yes** Yes/No

If Yes please provide name of Certifying Body: Bureau Veritas

Date of most recent audit / inspection: 27-November-2011 **Provide copy of certificate**

3.2.4 Indicate if any of the following is applied in order to manage allergens and minimise allergen cross contact within the manufacturing facility: *(Select all appropriate checkboxes)*

- [ ] validated cleaning procedures
- [ ] control of personnel movement in factory
- [X] documented procedures and controls
- [ ] raw material sourcing & tracing
- [ ] other
- [ ] production scheduling
- [X] staff training
- [ ] isolated storage of allergens
- [X] dedicated equipment

3.3 MANDATORY DECLARATION OF CERTAIN SUBSTANCES (Refer Standard 1.2.3 of the Code)

Please insert **YES** or **NO** to indicate if the product contains, or was manufactured using, any ingredient, additive or processing aid which has been derived from the following food sources. Highly processed derivatives must always be declared. Carefully assess compound ingredients for hidden allergens. [** Lupin included as a possible future addition to the Food Standards Code.]

Yes/No	
No	**Cereals containing gluten** & their products [*wheat, rye, barley, oats, spelt*]
No	**Crustacea** & crustacea products
No	**Egg** & egg products
No	**Fish** & fish products (including mollusc with or without shells and fish oils)
No	**Lupin** & lupin products [** not a mandatory labelling allergen at this time]
No	**Milk** & milk products
No	**Peanut** & peanut products
No	**Sesame seed** & sesame seed products
No	**Soybean** & soybean products
No	**Tree nuts** & tree nut products
	Reserved for future allergen - left blank intentionally

No	**Sulphites,** present **in** ingredients, additives or processing aids

3.3.1 Complete all coloured rows corresponding with "YES" declaration provided above.

ALLERGENIC SUBSTANCE	SOURCE NAME The allergenic food from which ingredient is derived (e.g. wheat)	DERIVATIVE NAME Ingredient, additive or processing aid (e.g. maltodextrin)	PROPORTION (%)		PROCESS Allergenic protein is removed?
			Allergen in derivative	**Derivative** in product	
Cereals containing gluten and their products [wheat, rye, barley, oats, spelt & derived product e.g. wheat maltodextrin]					
Crustacea & crustacea products					
Egg & egg products					
Fish & fish products (Including mollusc and fish oils)					
Lupin & lupin products					
Milk & milk products					
Peanut & peanut products (including peanut oil)					
Sesame Seed & sesame seed products					
Soybean & soybean products (including soybean oils)					
Tree nuts & tree nut products					
Reserved for future allergen					

3.4 ALLERGEN CROSS CONTACT Yes/No

3.4.1 Except for any allergens listed in Section 3.3, does your company have on site and handle ANY OTHER allergenic substances listed below? **Yes**

IF YES, complete ALL columns with respect to the potential cross contact allergens based on information received through YOUR supply chain AND YOUR manufacturing processes.

Refer to VITAL procedure and decision tree. http://www.allergenbureau.net/vital/

3.4.2 All columns must be completed WHERE HIGHLIGHTED

ALLERGENIC SUBSTANCE	PRESENT IN SAME FACILITY Yes/No	PRESENT ON SAME LINE Yes/No	SOURCE FOOD The allergenic food from which ingredient is derived (e.g. wheat)	DERIVATIVE NAME Ingredient, additive or processing aid (e.g. maltodextrin)	TOTAL PROTEIN (or gluten in cereals) estimated using the **VITAL procedure.** mg/kg (ppm)
Cereals containing gluten & their products	**Yes**	**No**	Packed and sealed wheat, Malt, oats and Gluten products in there finished product packaging are stored seperately in the same Davis Warehouse		Refer comment in Section 8
Crustacea & crustacea products	**No**				
Egg & egg products	**Yes**	**No**	Packed and sealed Eggs and egg products in there finished product packaging are stored seperately in the same Davis Warehouse		Refer comment in Section 8
Fish & fish products (inc mollusc & oils)	**Yes**	**No**	A few cans of Tuna and Anchovys products are stored seperately in the same Davis Warehouse		Refer comment in Section 8
Lupin & lupin products	**No**				
Milk & milk products	**Yes**	**No**	Packed and sealed powdered milk products are stored seperately in the same Davis Warehouse in there finished product format.		Refer comment in Section 8

Peanuts & peanut products (inc peanut oil)	**Yes**	**No**	A few peanuts products in there finished product packaging are stored seperately in the same Davis Warehouse in exclusive locations		Refer comment in Section 8
Sesame Seed & sesame products	**Yes**	**No**	Sesame seeds and there products in there finished product packaging are stored seperately in the same Davis Warehouse in exclusive locations		
Soybeans & soybean products (inc soybean oil)	**Yes**	**No**	Soya and Soya products in there finished product packaging are stored seperately in the same Davis Warehouse.		Refer comment in Section 8
Tree nuts & tree nut products	**Yes**	**No**	Packed and sealed tree nut products in there finished product packaging are stored seperately in the same Davis Warehouse.		Refer comment in Section 8
Reserved for future allergen					

3.4.3 Is crosscontact allergen present in **particulate form** in the facility or on same lines? **No** Yes/No

3.4.5 Have cross contact allergen levels been assessed using the VITAL procedure? **No** Yes/No

IF NO, provide appropriate precautionary statement for this product in the box below:

Refer section 8 for further comments

3.5 INTERNATIONAL ALLERGEN, LABELLING & INFORMATION REQUIREMENTS

FOOD / COMPONENT		PRESENT (Yes/No)	NAME OF FOOD (e.g. apple)	DERIVATIVE NAME (e.g. cider vinegar)
Gelatine	beef - collagen	No		
	other source	No		
Seafood products	Algae/carrageenan	No		
	Mollusc (shelled)	No		
Fungi	Matsutake mushroom	No		
	Other mushroom	No		
Fruits	Avocado	No		
	Banana	No		
	Pome fruit - apples, pears	No		
	Stone fruit - cherry, peach, plum, apricot.	No		
	Berry Fruits - blueberry, kiwifruit, strawberry	No		
	Citrus Fruits - grapefruit, lemon, lime, orange	No		
Grains, Seeds, Nuts & Spices	Buckwheat	No		
	Coconut, poppy, sunflower, etc	No		
	Mustard	No		
Vegetables	Tomato	No		
	Yam	No		
	Allium genus - chive, garlic, leek, onion, garlic, spring onion	No		
	Legumes other than peanut soybeans & lupins	No		
	Umbelliferae - aniseed, carrot, celery, celeriac, chervil, cumin, dill, coriander, fennel, parsley, parsnip	No		
Yeast & Yeast Products (including yeast extracts)		No		
Herbs		No		
Spice (other than mustard)		No		

3.6 ADDITIONAL LABELLING & INFORMATION REQUIREMENTS

FOOD / COMPONENT		PRESENT (Yes/No)	ADDITIONAL INFORMATION TO BE PROVIDED WHERE PROMPTED		
Antioxidants	BHA	No	amount added (mg/kg)		
	BHT	No	amount added (mg/kg)		
	Other Antioxidant	No	Specify type:		
			amount added (mg/kg)		
Added Caffeine (exclude naturally occurring)		No	amount added (mg/kg)		
Alcohol (Residual)		No	level % v/v:		
			specific gravity of product:		
Added Fats & Oils	Animal	No	Specify types of fats and oils:		
			If applicable, specify the process used to alter the fatty acid composition:		
	Vegetable	No	Specify types of fats and oils:		
			If applicable specify the name of any process used to alter the fatty acid composition:		
Hydrolysed Vegetable Proteins	Acid Hydrolysed	No	Specify type of vegetable protein:		
			100% hydrolysis		
	Enzyme Hydrolysed	No	Specify type of vegetable protein:		
			100% hydrolysis		
Intense sweetener		No	Name of sweetener	Number	Amount (mg/kg)
Preservatives		No	Name of preservative	Number	Amount (mg/kg)
Flavour enhancers		No	Name of flavour enhancer	Additive number	
Added Colours		No	Specify type/s	Specify Additive Number/s	
			Natural		
			Artificial		
			Not Defined		
Added Flavours		No	Specify type/s	Natural	Thermal process
				Synthetic	Smoke
			Specify if contains Diacetyl as flavour:		Yes/No
Added Salt		No	amount added (mg/100g)		
Added Sugar		No	amount added (g/100g)		
ANY OTHER COMPONENT	List specific component:		Provide relevant details necessary for consumer advice:		

3.7 ALLERGEN, LABELLING & IMPORT/EXPORT INFORMATION REQUIREMENTS

FOOD / COMPONENT	PRESENT (Yes/No)	ADDITIONAL INFORMATION TO BE PROVIDED WHERE PROMPTED	
Animal & Animal products (e.g. animal flesh, organs, stock, gelatine, animal fat, tallow, milk, collagen from skin and / or hides etc)	**No**	Specify type of animals	
		Specify type of animal derivatives	
		Specify country/ies of origin	
		Describe any heat processing used in the manufacture of this product (temperature/time):	
Meat & Meat products (e.g. animal flesh, animal organs, meat extracts)	**No**	Specify type of animal:	
		Specify type of meat derivatives	
		Specify source of meat products (i.e. Country and city):	
		Describe any heat processing used in the manufacture of this product (temperature/time):	
		How do you ensure products are derived from animals free of bovine spongiform encephalopathy (BSE)?	
Bird & Bird products (e.g. meat, fat, eggs, extracts, feathers, feet, etc.)	**No**	Specify type of bird:	
		Specify type of bird derivatives	
		Specify source of bird products (i.e. Country and city):	
		Describe any heat processing used in the manufacture of this product (temperature/time):	
Fish & Fish products (e.g. smoked salmon, pilchards, shark fin, fish roe, etc)	**No**	Specify type of fish:	
		Specify type of fish derivatives	
		Specify source of fish products (i.e. Country and city):	
		Describe any heat processing used in the manufacture of this product (temperature/time):	
Honey & Honey products	**No**	Specify type of honey or honey derivatives	
		Specify source of honey products (i.e. Country and State):	
		Describe any heat processing used in the manufacture of this product (temperature/time):	

4 NUTRIENTS & CONSUMER INFORMATION CLAIMS

4.1 NUTRITION INFORMATION

4.1.1 Serve size is not relevant for this product.

4.1.2 **Complete nutrient table below.** Mandatory nutrients highlighted in blue and bolded, others optional.

NUTRIENT	AVG QUANTITY per 100 g
Energy	1390 kJ
Protein, total	7.5 g
- Gluten	
Fat, total	0.7 g
- saturated	0.4 g
- transfat	<0.1
- polyunsaturated	
- monounsaturated	
Cholesterol	
Carbohydrate	78.5 g
- sugars	1 g
Dietary fibre, total	0.5 g
Sodium	6 mg
Potassium	100 mg

Nutrient information is relevant to product AS SUPPLIED

#VALUE!

4.1.3 Additional nutrients - vitamins, minerals and other nutritive substances

Specify only one target population for product *(selection ONLY ONE check box)*:

[X] **Adults** [ ] **Young Children** [ ] **Infants**

VITAMINS specify which vitamin	AVG QUANTITY per 100 g

MINERALS specify which minerals	AVG QUANTITY per 100 g

NOTE: there is no permission to FORTIFY foods with this substance indicated with **

Insert any other nutrient or biologically active substance

NAME OF SUBSTANCE	AVG QUANTITY per 100 g	%RDI / serve

4.1.4 Please provide the following analytical data:

% Ash	<1.0
% Moisture	

Estimation content accounted for per 100 g	#VALUE!

4.1.5 Please specify how the carbohydrate value has been determined:

[ ] Difference as defined in Standard 1.2.8 [ ] Available Carbohydrate as defined in Standard 1.2.8 [ ] Other - specify: NA [X] Unknown

4.1.6 Please nominate the data source used in the nutrition tables

Analytical – e.g. Laboratory Tested [ ] Theoretical – e.g. By Calculation [X]

Please specify the source of data used for the theoretical calculations (e.g. Nuttab, AusNut, NZ food tables, etc)

Provided by the supplier

4.2 SUITABILITY TO MAKE CERTAIN CLAIMS

Specify if the product is suitable for use in product intended for the following consumer uses.

SPECIFY IF SUITABLE FOR ...	Yes / No	HOW HAS THIS BEEN VALIDATED?	CERTIFICATE AVAILABLE (Yes/No)
Halal	Yes		No
Kosher	Yes		No
Organic	No		No
Biodynamic	No		No
Ovo-lacto-vegetarian	Yes		No
Lacto-vegetarian	Yes		No
Vegan	Yes		No

PRODUCT SUITABILITY FOR ...	Yes / No	SPECIFY PARTICULAR CLAIMS	HOW IS CLAIM VALIDATED?
"Free" claims	No		
Sustainability claims	No		
Humane treatment	No		
Any other claims	No		

5 FOODS REQUIRING PRE-MARKET CLEARANCE

5.1 NOVEL FOODS (Refer Standard 1.5.1 of the Code)

5.1.1 Is this product (or any of its components) listed as a novel food in the standard? **No** Yes/No

5.2 FOOD IRRADIATION / STERILISATION

Specify if this product (or any of its components) has been treated with the following:

TREATMENT METHOD	USED ON ANY COMPONENT	SPECIFY TREATED INGREDIENT
Steam Sterilisation	No	
Ionising Radiation	No	
Ethylene Oxide	No	
Other fumigants or sterilants	No	

5.3 FOOD PRODUCED USING GENE TECHNOLOGY

5.3.1 Are there any ingredients (including food additives, processing aids and enzymes) in this product which contain or have been derived from genetically modified (GM) material, or have been produced using GM organisms? **No** Yes/No

IF NO, specify which of the following are applicable:

- [ ] No GM varieties of this food / ingredient available
- [X] Non GM variety is used
- [ ] Identity preservation program in place
- [ ] Analytical testing confirms absence
- [ ] Verifiable documentation of status
- [ ] Other – Specify

Go to Question 5.3.6 and continue

5.3.6.	Is this a raw/bulk commodity which is transported by freight/tanker AND where the freight/tanker could have previously been used to transport other GM product?	No Yes/No
5.3.7.	Is this product manufactured or stored at a production site where genetically modified protein or DNA is used for the manufacture of other products?	No Yes/No
5.3.9.	Has Polymerase Chain Reaction (PCR) testing for GM materials been carried out?	No Yes/No
5.3.10.	Is any GM food or GM ingredient unintentionally present at MORE THAN 10mg/kg	No Yes/No
5.3.11.	Does this product contain any ingredient derived from an animal or other organism, which has been fed GM feedstock?	No Yes/No

6 PRODUCT TRANSPORT, SHELF LIFE, MEASUREMENT & PACKAGING

6.1 SHELF LIFE

6.1.1 Please complete the following details:

	PRODUCT AS SUPPLIED unopened pack or bulk container		PRODUCT - ONCE IN USE resealable pack or bulk container	
Specify shelf life	24	**Months**		
Temperature control during storage	Is required ?	**Yes**	Is required ?	
	Specify range:	**20 - 25 ℃**	Specify range:	
Temperature control during transport	Is required ?	**No**		
Specify any OTHER storage requirements:	Cool,dry,clean away from pests			

6.1.2 Specify the type of date mark to be used: **Best before**

Refer to AFGC Date Marking Guide

6.2 POTENTIAL HAZARDS

Are there any potential hazards associated with the product during:

a. handling	No	Yes/No
b. transport	No	Yes/No
c. storage	No	Yes/No
d. disposal	No	Yes/No

6.3 TRANSPORT

How is the product transported and packaged: Packaged for catering/manufacturing supply

6.4 TRADE MEASUREMENT

6.4.1 Specify which method of trade measurement is used: **Net quantity**

6.4.2	What is the package size	25.00	**kg**	(specify unit of measure)
6.4.3	Target Fill (if applicable)			(specify unit of measure)
6.4.4	Drained Weight (if applicable)			(specify unit of measure)

6.4.5 IF AQS is used, what is the statistical variance in the fill measurement?

6.5 TRACEABILITY

Please provide any general comments about the tracking code used on packaging:

Production and best before date

Please specify the following where applicable:

TRACKING CODE	UNIT	SHIPPER (if applicable)
Type of Primary Coding	Batch Number	
Method of coding	Inkjet	
Location of code	Main panel of bag	
Number of characters in code		
Example of coding format	Month YYYY	
Coding translation		

6.6 PRODUCT PACKAGING

6.6.1 Are tamper evident controls included in the packaging design? **Yes** Yes/No

6.6.2 Does Unit packaging meet specifications for migration of substances into food? **Yes** Yes/No

6.6.3 Are engineered nanoparticles present in unit packaging? **No** Yes/No

6.6.4 Is your company a signatory to the Australian Packaging Covenant? **No** Yes/No

6.6.5 Provide a general description of unit packaging:

White poly bag or Kraft paper bag

6.6.6 Complete the following table for questions related to packaging of unit package and/or shipper

PACKAGING		UNIT	SHIPPER
Type	Packaging format	Bag	
Specify components / material used in packaging	Ceramic	No	
	Glass	No	
	Metal	No	
	Paper / cardboard	No	
	Packing materials	No	
	Plastics	Yes	
Recycling	Specify plastic coding symbol number		
	Proportion of total recycled component %		
Seal	What is the seal method?	Sewn	
Dimensions	Height (mm)	480	
	Width (mm)	310	
	Depth (mm)	100	

6.7 PALLET CONFIGURATION

6.7.1 Gross weight of loaded pallet 1000.0 kg

6.7.2 Stack height of loaded pallet cm

6.7.3 Specify the type of pallet [X] Wooden [ ] Plastic [ ] Other

6.7.4 What is the pallet pattern [ ] Column stack [ ] Interlocking

6.7.5 Number of : units per shipper 1 shippers per pallet 40

layers per pallet

7 ORGANOLEPTIC, PHYSICAL , MICROBIAL & CHEMICAL SPECIFICATIONS

Test Methods are mandatory and must quote AOAC methods or recognised independent Australian or International standards. Where a supplier's internal test method is quoted a copy must be attached. Also state if Certificate of Analysis (C of A) or Certificate of Conformance (C of C) can be provided.

7.1 ORGANOLEPTIC SPECIFICATIONS

(Examples may include flavour, colour, aroma, texture etc)

TEST / PARAMETER	SPECIFICATION	TEST METHOD	AVAILABILITY C of A	C of C
Appearance	Typical of rice flour	Visual inspection	No	
Flavour/Odour	Characteristic of rice, Free fro foreign flavours/odours	Organoleptic	No	

7.2 PHYSICAL SPECIFICATIONS

(Examples may include particle size, shape, specific gravity, metal detection, foreign matter tolerances, physical defect tolerances etc as appropriate for the product)

TEST / PARAMETER	SPECIFICATION	TEST METHOD	AVAILABILITY C of A	C of C
Retained on 500Um Screen	5% max	Sieve analysis	Yes	
Retained on 425um screen	10-30%	Sieve analysis	Yes	
Retained on 250um screen	40-60%	Sieve analysis	Yes	
Through 250um screeen	15-35%	Sieve analysis	Yes	
Metal, Glass, Stones	Nil	Metal detection, Inspection	No	
Insects	Nil	Inspection	No	

7.3 MICROBIOLOGICAL SPECIFICATIONS

(Examples may include standard plate count, yeasts & moulds, coliforms, salmonella, listeria etc)

TEST / PARAMETER	SPECIFICATION	TEST METHOD	AVAILABILITY C of A	C of C
Standard Plate count	100,000 per g max	AS 5013.1	Yes	
Coliforms	200 per g max	AS 5013.3	Yes	
Yeast and moulds	1,000 per g max	AS 1766.2.2-1997	Yes	
Bacillus Cereus	100 per g max	AS1766.2.6 - 1991	Yes	
E.coli	10 per g max	AS5013.15	Yes	
Salmonella	Not detected in 25g	AS5013.10	Yes	

7.4 CHEMICAL SPECIFICATIONS

(Examples may include pesticide residue screen, antibiotic residue screen, heavy metal screen, aflatoxins screen, salt, acid, pH, moisture, brix, Aw, Nutrition Information Test, etc)

TEST / PARAMETER	SPECIFICATION	TEST METHOD	AVAILABILITY C of A	AVAILABILITY C of C
Moisture	9-14%	AOAC 934.06	Yes	

8 COMMENTS / ADDITIONAL INFORMATION

8.1 Do you have any comments or additional information ? **Yes** Yes/No

Section Number	Comment Number	Line Number	Comments
3.4	1.0	1	Allergens Cross Contact is answered as such because Davis Warehouse stores some allergen related products. However, all stored prodycts are in there final, sealed packagin configurartion and kept in standard sized warehouse racks. Several allergen groups such as peanuts, sesame seeds and milk have there own exclusive locations. Hence risk of Cross contamination is very low.
8.1	2.0	1	The information is provided in the belief that it is accurate within generally accepted industry standards and is provided for the information of qualified personnel. It does not constitute an offer by the manufacturer/supplier nor does the manufacturer/supplier warrant or guarantee its accuracy or completeness in describing the performance or suitability. This product is an agricultural product, hence it is almost impossible to provide a 100% guarantee of nil tolerance for food allergens and or foreign matter in some product types. Prospective users are encouraged to conduct their own tests and studies to determine the suitability for a particular purpose and specific applications. This specification is based on product at time of packing and there may be some variation at time of delivery

8.2 ADDITIONAL MANUFACTURERING SITE INFORMATION (if required)

COMPANY NAME			
SITE: #4 NUMBER / STREET / SUBURB			
STATE / COUNTRY / POST CODE			
COMPANY NAME			
SITE: #5 NUMBER / STREET / SUBURB			
STATE / COUNTRY / POST CODE			
COMPANY NAME			
SITE: #6 NUMBER / STREET / SUBURB			
STATE / COUNTRY / POST CODE			

A 1.2 Raw material specifications for 3G snack wholegrain claim

National Starch
FOOD INNOVATION

PRODUCT DATA SHEET

CONFIDENTIAL

Hi-maize® Whole Grain Corn Flour

Label Designation	Whole Grain Corn Flour
Source	Corn

Physical and Chemical Characteristics (*):

Color	Light to moderate yellow
Form	Coarse Powder

Physical and Chemical Specifications:

Granulation	
On USSS#35	5% maximum
Through USSS#100	40% maximum
Moisture	14% maximum

Microbiological Specifications:

Total Plate Count	50,000/g maximum
Yeast & Mold	2,500/g maximum
E. coli	Negative
Salmonella	Negative
Aflatoxin – Total	10 ppb maximum
Fumonisin – Total	2000 ppm maximum

Packaging and Storage:

Hi-maize Whole Grain Corn Flour is packaged in double brown paper bag with poly liner with a net weight of 25 kg. We recommend that Hi-maize Whole Grain Corn Flour be stored in a clean, dry area at ambient temperature and away from heavily aromatic material. The best before date for Hi-maize Whole Grain Corn Flour is 9 months from the date of manufacture.

(*) While this information is typical of Hi-Maize Whole Grain Corn Flour it should not be considered a specification.

Revised on 14 June 2011 (AP)
560172 (AP)

Nutritional Data
(Tentative)

Hi-maize Whole Grain Corn Flour

	Per 100g
Energy[1]	1345 kJ (321 kcal)
Moisture*	Approximately 12%
Protein (g)	9.5
Total Fat (g)	5.0
Carbohydrate[2] (g)	47
Total Dietary Fibre (g) AOAC 991.43	25
Ash (g)	1.5
Sodium (mg)	2.7

[1]**Calories:** Calculated was defined by Food Standard Australia and New Zealand, Standard 1.2.8 Nutrition Information Requirements, November 2004. For nutrition calculation outside of Australia and NZ, please follow local country food regulations.

[2]**Carbohydrate**: Carbohydrate level was derived by difference.

***Moisture**: The moisture content of all starches will vary, depending on environmental conditions during storage and manufacture. However, Hi-maize Whole Grain Corn Flour will generally have moisture content of around 12%.

Note: Please note that while the above information is typical of Hi-maize Whole Grain Corn Flour, it should not be considered a specification, since the values may vary slightly between samples. All values are reported on an "as is" basis.

Revised on 30 May 2011 (AUS)

FOOD INDUSTRY - PRODUCT INFORMATION FORM

VERSION 5.0 - released 10 February 2012

WARRANTY: This document is intended as a guide only: legal requirements are contained in the Food Standards Code and relevant food legislation and other applicable laws. The information in this document should not be relied upon as legal advice or used as a substitute for legal advice. You should exercise your own skill, care and judgement before relying on this information in any important matter.

1 CONTACT DETAILS & DECLARATION

SUPPLIER'S PRODUCT NAME	Champion Viva Wholemeal Flour 20Kg	SPECIFY COUNTRY IMPORTED INTO	
SUPPLIER'S PRODUCT CODE	66952	SPECIFY COUNTRY EXPORTED FROM	
BARCODE - UNIT GTIN		SPECIFY IMPORT TARIFF CODE	

1.1 SUPPLIER INFORMATION

	COMPANY NAME	Goodman Fielder NZ Ltd.		
	BUSINESS NUMBER (ABN)			
	TRADING NAME	Champion Baking Ingredients		
BUSINESS ADDRESS	NUMBER / STREET / SUBURB	2/8	Nelson Street	
	STATE / COUNTRY / POST CODE	Auckland	New Zealand	
POSTAL ADDRESS	POST ADDRESS / SUBURB			
	CITY / COUNTRY / POST CODE			
KEY CONTACT FOR QUERIES	NAME	Lindy Malcolm		
	POSITION TITLE	Key Account Manager		
	EMAIL ADDRESS	Lindy.Malcolm@goodmanfielder.co.nz		
	PHONE		FAX	
	DATE FORM COMPLETED	26-July-2012	ISSUE DATE	26-July-2012
	DOCUMENT NO:	PIF-0066952	ISSUE NUMBER	11

1.2 MANUFACTURING INFORMATION

Provide details where the manufacturer or site location differ to above:

	COMPANY NAME	Champion Baking Ingredients		
SITE: #1	NUMBER / STREET / SUBURB		Wharf Road	Mount Maunganui
	STATE / COUNTRY / POST CODE	Tauranga	New Zealand	
	COMPANY NAME			
SITE: #2	NUMBER / STREET / SUBURB			
	STATE / COUNTRY / POST CODE			
	COMPANY NAME			
SITE: #3	NUMBER / STREET / SUBURB			
	STATE / COUNTRY / POST CODE			

If more than three manufacturing sites, provide additional site information in Section 8.2

1.3 CONTACT DETAILS FOR TECHNICAL & ALLERGEN INFORMATION

Please specify the contact details if further information related to technical or allergen information is needed:

NAME	Glen Matthews		
JOB TITLE	National Quality Manager		
EMAIL	Glen.Matthews@goodmanfielder.co.nz		
TELEPHONE - WORK	(07) 572 9939	TELEPHONE - MOBILE	(027) 2009687

1.4 SUPPLIER DECLARATION AND WARRANTY

The Supplier -

1) certifies that this product complies with the Australia New Zealand Food Standards Code; and, in addition to the information provided specifically in this form, and without limitation to compliance with any other part of the Code, that the product complies with:

(a) Standard 1.3.4 - Identity and Purity
(b) Standard 1.4.1 - Contaminants & Natural Toxicants
(c) Standard 1.4.2 - Maximum Residue Limits in Food (In Australia), or
(d) Maximum Residue Limits of Agricultural Compounds, Mandatory Food Standard 1999 (and subsequent amendments) issued under sections 11C and 11Z of the Food Act 1981 in New Zealand
(e) Standard 1.4.3 - Articles & Materials in Contact with Food
(f) Standard 1.4.4 - Prohibited & Restricted Plants & Fungi

where applicable, and that where such certification relies on third party audits, analysis, industry codes, or equivalence of international standards to demonstrate compliance, that certificates are current and available;

2) acknowledges that the Customer, and Supply Chain Customers of the Customer, will rely on the accuracy of the Product Information for food quality, safety and labelling purposes;

3) certifies that the accuracy of the Product Information is limited to the following degree: –

(a) that the Product Information in relation to ingredients obtained from a third party relies in good faith on Product Information provided by that third party;
(b) that the information is, to the best of the supplier's knowledge (having undertaken all reasonable verification procedures), true and accurate in relation to all other substances and processes;

4) agrees that all Product it supplies to the Customer will conform with the Product Information unless otherwise agreed to in writing and in advance by the Customer;

5) will immediately inform the Customer (and confirm in writing as soon as possible) if the supplier becomes aware of any error or omission in the Product Information;

6) will inform the Customer in writing and in advance of any change to the Product Information provided herein (including any changes that result from new or modified processes) if and when the supplier becomes aware of such changes; and

7) acknowledges that the Customer may provide the Product Information to –

(a) regulatory agencies in relation to any matter raised by such agencies;
(b) courts and other legal tribunals for the purposes of any proceedings; and
(c) to its related businesses and partners who are involved in the acquisition, use, sale or compliance of the Product, under this same restriction as to disclosure.

but will otherwise NOT disclose the Product Information.

8) acknowledges that, subject to the prior written agreement of the supplier and any restrictions nominated by the supplier in regard to disclosure of confidential information, the Customer may provide the Product Information to its own customers subject to those customers ensuring the information is not further disclosed.

COMPANY NAME Signed for and on behalf of	Goodman Fielder NZ Ltd.
NAME (Please print)	Ria Susanty
JOB TITLE (Please print)	Quality Facilitator
AUTHORISED SIGNATURE	
DATE OF AUTHORISATION	26-July-2012

1.5 CUSTOMER DETAILS (WHERE KNOWN)

COMPANY NAME			
NUMBER / STREET / SUBURB			
CITY / COUNTRY / POST CODE			
CUSTOMER CONTACT NAME			
CUSTOMER'S PRODUCT NAME			
CUSTOMER'S PRODUCT CODE			

Customer Internal Use Only			
Internal Product Code/Description			
Version No.			
Reason for Update			
Received and Reviewed By			
Approved [Yes / No]	_	**Date:**	
Signature:	**Insert signature here**		

1.6 DEFINITIONS / REFERENCES

References to the "Code" or specific "Standards" throughout this document refer to the standards outlined in the Australia New Zealand Food Standards Code. The Australia New Zealand Food Standards Code can be viewed at http://www.foodstandards.gov.au/foodstandardscode/

The AFGC provides some industry guides, specifically on how to apply date marking, and the AFGC Allergen Management and Labelling Guide which are available from the AFGC website: http://www.afgc.org.au/

Additional related documents on allergen management and VITAL (Voluntary Incidental Trace Allergen Labelling) documents can be viewed at: http://www.allergenbureau.net/vital/

1.7 CHECKLIST AND ATTACHMENTS

- [ ] **Page 2 has been signed and dated (Section 1.4)**
- [ ] Current Certificates attached - if applicable (Section 3.2.3 and Section 5.2)
- [ ] Supplier C of C, or C of A for analysis - if applicable (Section 7)
- [ ] Other associated documents attached as requested by the customer (e.g. MSDS, HACCP certification, product specification, and related documents)

1.8 Status of completion for each section:

PARTIAL	Section 1 - Contact details and declaration
COMPLETED	Section 2 - Product Information & Ingredients
PARTIAL	Section 3 - Compositional information
COMPLETED	Section 4 - Foods requiring pre-market clearance
PARTIAL	Section 5 - Nutrients & consumer information claims
PARTIAL	Section 6 - Product shelf life, storage & packaging
PARTIAL	Section 7 - Chemical, microbial, organoleptic & physical specifications
COMPLETED	Section 8 - Additional comments

Check Box if help is needed identify mandatory sections of form which have NOT been completed: [ ]

2 PRODUCT INFORMATION & INGREDIENTS

2.1 PRODUCT DESCRIPTION (Physical and technological description)

A 100% wholemeal flour milled from sound hard and semi-hard Australian wheat with medium/high protein and good bread baking quality.

2.2 LEGAL DESCRIPTION / SUGGESTED LABELLING DESCRIPTION

Wholemeal wheat flour.

2.3 PRODUCT APPLICATION AND INTENDED USE

2.3.1 Specify the intended use of the product

Food supplied as an ingredient for use in further manufacturing or processing

2.3.2 Specify which best describes the product

Solid, semi-solid or powder substance, intended for use in further preparation

2.4 COUNTRY OF ORIGIN

2.4.1 Specify the most appropriate overarching country of origin declaration which applies to this product :

Declaration:	Country:	
Made in (with imported & local ingredients)	New Zealand	

2.4.2 Indicate if the local content of ingredients/components originating from New Zealand on average exceeds 95% **No** Yes/No

2.4.3 Are the primary components, from which this product is made or derived, sourced from more than one country? **No** Yes/No

2.4.4 Indicate if the following apply in determining country of origin declaration in 2.4.1:

The IMPORTED COMPONENTS have undergone substantial transformation		Yes/No
The PRODUCT has undergone substantial transformation		Yes/No
50% or more of total product costs are incurred in the country stated		Yes/No
Essential characteristic of the product is the result of local processing conditions		Yes/No

2.5 COMPONENT TYPE

Specify the type of the components present in product (Tick ONLY ONE check box below)

- [X] product is **a single component** substance
- [ ] product contains ingredients, which may include **compound** substances
- [ ] product consists of various ingredients which are **NOT compound** substances

2.6 INGREDIENT DECLARATION

Specify all ingredients including food additives in descending order, including percentage labelling of characterising components or ingredients. Compound substances must specify all ingredients and additives present and the characterising ingredient or component. Food additives must specify a functional class name and the food additive name or code number [e.g. antioxidants (304, 306), or food acid (citric)]

How many components are in this product? 1

COMPONENT NAME	PERCENT OF TOTAL %
Wheat	100.00%

2.6 INGREDIENT DECLARATION INCLUDING PERCENTAGE LABELLING (continued)

COMPONENT NAME	PERCENT OF TOTAL %

2.7 PROCESSING AIDS

Specify all processing aids used in the manufacture of this product not otherwise declared in the ingredient list.

NAME OF PROCESSING AID	FSC ADDITIVE NUMBER OR EC *(as applicable)*	PERMITTED USE AND CLASS NAME

3 COMPOSITIONAL INFORMATION

3.1 MANDATORY ADVISORY OR WARNING STATEMENTS & DECLARATIONS

(" Yes" response triggers a mandatory advisory or warning statement. Refer Standard 1.2.3 of the Code)

FOOD / COMPONENT	PRESENT YES / NO
Bee pollen presented as a food or ingredient	No
Propolis presented as a food or ingredient	No
Unpasteurised milk and unpasteurised liquid milk products	No
Aspartame or aspartame-acesulphame salt (or phenylalanine)	No
Unpasteurised egg products	No
Quinine	No
Kola beverages containing added caffeine	No
Guarana or extracts of guarana	No
Phytosterol esters	No
Tall oil phytosterols.	No
Cereal-based beverages, where these foods contain no more than 2.5% m/m fat and less than 3% m/m protein, or less than 3% m/m protein only.	No
Evaporated and dried products made from cereals, where these foods contain no more than 2.5% m/m fat and less than 3% m/m protein, or less than 3% m/m protein only, as reconstituted according to directions for direct consumption.	No
Milk, and beverages made from soy or cereals, where these foods contain no more than 2.5% m/m fat.	No
Evaporated milks, dried milks and equivalent products made from soy or cereals, where these foods contain no more than 2.5% m/m fat as reconstituted according to directions for direct consumption.	No
Royal jelly presented as a food or ingredient	No
Polyols, Isomalts, Polydextrose (Lactitol, Maltitol, Maltitol syrup, Mannitol, Xylitol, Erythritol, Isomalt, Polydextrose, Sorbitol) **If "yes"** specify type/s and levels:	No

3.2 ALLERGEN MANAGEMENT & CONTROL

		Yes/No
3.2.1	Does the facility have a Food Safety Program?	Yes
3.2.2	Does the facility have a documented allergen management plan?	
3.2.3	Has the Food Safety Program been independently audited and certified?	Yes

If Yes provide name of Certifying Body: Asure Quality

Date of most recent audit / inspection: 01-October-2011 — Provide copy of certificate

3.2.4 Indicate if any of the following is applied in order to manage allergens and minimise allergen cross contact within the manufacturing facility: *(Select all appropriate checkboxes)*

- [X] validated cleaning procedures
- [X] control of personnel movement in factory
- [X] documented procedures and controls
- [X] raw material sourcing & tracing
- [ ] other
- [X] production scheduling
- [X] staff training
- [ ] isolated storage of allergens
- [ ] dedicated equipment

3.3 INGREDIENTS TO BE DECLARED AS ALLERGENS OR SULPHITE

Please insert **YES** or **NO** to indicate if the product contains, or was manufactured using, any ingredient, additive or processing aid which has been derived from the following food sources. Highly processed derivatives must always be declared. Carefully assess compound ingredients for hidden allergens. [** Lupin included as a possible future addition to the Food Standards Code.]

Yes/No	
Yes	**Cereals containing gluten** & their products [*wheat, rye, barley, oats, spelt*]
No	**Crustacea** & crustacea products
No	**Egg** & egg products
No	**Fish** & fish products (including mollusc with or without shells and fish oils)
No	**Lupin** & lupin products [** not a mandatory labelling allergen at this time]
No	**Milk** & milk products
No	**Peanut** & peanut products
No	**Sesame seed** & sesame seed products
No	**Soybean** & soybean products
No	**Tree nuts** & tree nut products
	Reserved for future allergen - left blank intentionally

Cereals containing gluten & their products		Yes/No
	Has processing rendered this GLUTEN FREE (no detectable gluten)?	No
	Has processing rendered this FREE OF WHEAT PROTEINS ?	No

No	**Sulphites,** present **in** ingredients, additives or processing aids

3.3.1 Complete all coloured rows corresponding with "YES" declaration provided above.

ALLERGENIC SUBSTANCE	SOURCE NAME The allergenic food from which ingredient is derived (e.g. wheat)	DERIVATIVE NAME Ingredient, additive or processing aid (e.g. maltodextrin)	PROPORTION (%)		PROCESS Allergenic protein is removed?
			Derivativein product	Protein in derivative	
Cereals containing gluten and their products [wheat, rye, barley, oats, spelt & derived product e.g. wheat maltodextrin]	Wheat		100.00%	80.00%	No
Crustacea & crustacea products					
Egg & egg products					
Fish & fish products (including mollusc extract and fish oils)					
Lupin & lupin products					
Milk & milk products					
Peanut & peanut products (including peanut oil)					
Sesame Seed & sesame seed products (including sesame oils)					
Soybean & soybean products (including soybean oils)					
Tree nuts & tree nut products					
Reserved for future allergen					

3.3.3 Based on Section 3.3, SPECIFY allergenic ingredients to be declared:

Contains: Gluten

3.4 ALLERGEN CROSS CONTACT

Yes/No

3.4.1 Except for any allergens listed in Section 3.3, does your company have on site and handle ANY OTHER allergenic substances listed below? **No**

IF NO, specify "No" to indicate allergens are NOT IN THE SAME FACILITY then go to Section 3.4

***Refer to VITAL procedure and decision tree.* http://www.allergenbureau.net/vital/

3.4.2 All columns must be completed WHERE HIGHLIGHTED

ALLERGENIC SUBSTANCE	PRESENT IN SAME FACILITY Yes/No	PRESENT ON SAME LINE Yes/No	SOURCE FOOD The allergenic food from which ingredient is derived (e.g. wheat)	DERIVATIVE NAME Ingredient, additive or processing aid (e.g. maltodextrin)	TOTAL PROTEIN** protein level by VITAL, or specify "particulate" mg/kg
Cereals containing gluten & their products	Yes	Yes	Wheat		
Crustacea & crustacea products	No				
Egg & egg products	No				
Fish & fish products (inc mollusc & oils)	No				
Lupin & lupin products	No				
Milk & milk products	No				
Peanuts & peanut products (inc peanut oil)	No				
Sesame Seed & sesame products	No				
Soybeans & soybean products (inc soybean oil)	No				
Tree nuts & tree nut products	No				
Reserved for future allergen					

IF NO, Provide appropriate precautionary statement for this product in box below:

Only wheat is the raw material used on site.

3.5 INTERNATIONAL ALLERGEN, LABELLING & INFORMATION REQUIREMENTS

FOOD / COMPONENT		PRESENT (Yes/No)	NAME OF FOOD (e.g. apple)	DERIVATIVE NAME (e.g. cider vinegar)
Gelatine	beef - collagen	No		
	other source	No		
Seafood products	Algae/carrageenan	No		
	Shellfish (Mollusc)	No		
Fungi	Matsutake mushroom	No		
	Other mushroom	No		
Fruits	Avocado	No		
	Banana	No		
	Pome fruit - apples, pears	No		
	Stone fruit - cherry, peach, plum, apricot.	No		
	Berry Fruits - blueberry, kiwifruit, strawberry	No		
	Citrus Fruits - grapefruit, lemon, lime, orange	No		
Grains, Seeds, Nuts & Spices	Buckwheat	No		
	Coconut, poppy, sunflower, etc	No		
	Mustard	No		
Vegetables	Tomato	No		
	Yam	No		
	Allium genus - chive, leek, onion, garlic, spring onion	No		
	Legumes - other than peanut soybeans & lupins	No		
	Umbelliferae - aniseed, carrot, celery, celeriac, chervil, cumin, dill, coriander, fennel, parsley, parsnip	No		
Yeast & Yeast Products *(including yeast extracts)* *Tick box if hydrolysed or autolysed*		No		
Herbs *Tick box if herb / herb extract*		No		
Spice *(excluding mustard)* *Tick box if spice / spice extract*		No		

3.6 ADDITIONAL LABELLING & INFORMATION REQUIREMENTS

FOOD / COMPONENT		PRESENT (Yes/No)	ADDITIONAL INFORMATION TO BE PROVIDED WHERE PROMPTED			
Antioxidants	Butylated hydroxyanisole (BHA)	No	amount added (milligram/kilogram)			
	Butylated hydroxytoluene (BHT)	No	amount added (milligram/kilogram)			
	Other antioxidants	No	Specify type:			
			amount added (milligram/kilogram)			
Added Caffeine *(exclude naturally occurring)*		No	amount added (milligram/kilogram)			
Alcohol (Residual)		No	level % v/v:			
			specific gravity if product is alcohol:			
Added Fats & Oils	Animal	No	Specify types of fats and oils:			
			Has fatty acid composition been altered?			Yes/No
			Specify the process used to alter composition:			
	Vegetable	No	Specify types of fats and oils:			
			If Palm oil is present, is this RSPO certified?			Yes/No
			Has fatty acid composition been altered?			Yes/No
			Specify the process used to alter composition:			
Hydrolysed Vegetable Proteins	Acid Hydrolysed	No	Specify type of vegetable protein:			
			100% hydrolysis			
	Enzyme Hydrolysed	No	Specify type of vegetable protein:			
			100% hydrolysis			
Intense sweetener		No	Name of sweetener	Number	Amount (mg/kg)	
Preservatives		No	Name of preservative	Number	Amount (mg/kg)	
Flavour enhancers		No	Name of flavour enhancer	Additive number		
Added Colours		No				
Added Flavours		No		Flavouring		
				Natural Flavouring		
				Flavouring precursors		
				Synthetic flavouring substances		
				Natural flavouring substances		
				Natural flavouring complexes/preparations		
				Thermal process flavourings		
				Smoke flavourings		
				Other flavouring		
Added Salt		No	amount added (milligram/100g)			
Added Sugar		No	amount added (gram/100g)			

ANY OTHER COMPONENT	List specific component:		Provide relevant details necessary for consumer advice:

3.7 QUARANTINE & IMPORT/EXPORT INFORMATION REQUIREMENTS

FOOD / COMPONENT	PRESENT (Yes/No)	ADDITIONAL INFORMATION TO BE PROVIDED WHERE PROMPTED	
Animal & Animal products (e.g. animal flesh, organs, stock, gelatine, animal fat, tallow, milk, collagen from skin and / or hides etc)	**No**	Specify type of animals	
		Specify type of animal derivatives	
		Specify country/ies of origin	
		Describe any heat processing used in the manufacture of this product (temperature/time):	
Meat & Meat products (e.g. animal flesh, animal organs, meat extracts)	**No**	Specify type of animals *(tick appropriate box)*	
		Specify type of meat derivatives	
		Specify source of meat products (i.e. Country and city):	
		Describe any heat processing used in the manufacture of this product (temperature/time):	
		How do you ensure products are derived from animals free of bovine spongiform encephalopathy (BSE)?	
Bird & Bird products (e.g. meat, fat, eggs, extracts, feathers, feet, etc.)	**No**	Specify type of birds *(tick appropriate box)*	
		Specify type of bird derivatives	
		Specify source of bird products (i.e. Country and city):	
		Describe any heat processing used in the manufacture of this product (temperature/time):	
Fish & Fish products (e.g. smoked salmon, pilchards, shark fin, fish roe, etc)	**No**	Specify type of fish:	
		Specify type of fish derivatives	
		Specify source of fish products (i.e. Country and city):	
		Describe any heat processing used in the manufacture of this product (temperature/time):	
Honey & Honey products	**No**	Specify type of honey or honey derivatives	
		Specify source of honey products (i.e. Country and State):	
		Describe any heat processing used in the manufacture of this product (temperature/time):	

4 FOODS REQUIRING PRE-MARKET CLEARANCE

4.1 NOVEL FOODS (Refer Standard 1.5.1 of the Code)

4.1.1 Is this product (or any of its components) listed as a novel food in the standard? **No** Yes/No

4.2 QUARANTINE TREATMENTS

Specify if this product (or any of its components) has been treated with the following:

TREATMENT METHOD	USED ON ANY COMPONENT	SPECIFY TREATED INGREDIENT
Steam sterilisation	No	
Ionising (gamma) irradiation	No	
Ethylene oxide	No	
Other fumigants or sterilants	No	

4.3 FOOD PRODUCED USING GENE TECHNOLOGY (Standard 1.5.2)

4.3.1 Are there any ingredients (including food additives, processing aids and enzymes) in this product that come from genetically modified (GM) plants or animals, or are the result of synthesis by GM micro-organisms, but with the exemption of use of GM feedstock? **No** Yes/No

IF NO, specify which of the following are applicable:

- [X] No GM varieties of this food / ingredient available
- [ ] Non GM variety is used
- [ ] Identity preservation program in place
- [ ] Analytical testing confirms absence
- [ ] Verifiable documentation of status
- [ ] Other – Specify

Go to Question 4.3.7 and continue

GM CROSS CONTAMINATION IN FOODS AND INGREDIENTS **Yes/No**

4.3.7. Is this a raw/bulk commodity which is transported by freight/tanker AND where the freight/tanker could have previously been used to transport other GM product? **No**

4.3.8. Is this product manufactured or stored at a production site where genetically modified protein or DNA is used for the manufacture of other products? **No**

4.3.9. Is there an identity preservation system separating non GM and GM components to ensure the absence of genetically modified material in this product?

Specify details:

4.3.10. Has Polymerase Chain Reaction (PCR) testing for GM materials been carried out? **No**

4.3.11. Is any GM food or GM ingredient unintentionally present at MORE THAN 10g/kg **No**

4.3.12. (OPTIONAL) Are any ingredients derived from an <u>animal</u> which has been fed with feedstock containing GM ingredients or ingredients derived from GM micro-organisms?

Specify details:

5 NUTRIENTS & CONSUMER INFORMATION CLAIMS

5.1 NUTRITION INFORMATION

5.1.1 Serve size is not relevant for this product.

5.1.2 For nutrition information below, please specify the **UNITS of measure**: [X] grams [ ]

Complete nutrient table below. Mandatory nutrients highlighted in blue and bolded, others optional.

NUTRIENT			AVG QUANTITY per 100 g
Energy	0 kJ	0%	1390 kJ
Protein, total	0 g		11 g
- Gluten			
Fat, total	0 g		2 g
- saturated	0 g		0.3 g
- transfat			
- polyunsaturated			
- monounsaturated			
Cholesterol			
Carbohydrate	0 g	0%	60.9 g
- sugars	0 g	0%	1 g
Dietary fibre, total	0 g		11.8 g
Sodium	0 mg	0%	8 mg
Potassium			

Nutrient information is relevant to product AS SUPPLIED

DO NOT leave bolded NIP fields blank. Use numbers, or text "less than" with value; or "unavailable" or "not detected" for gluten.

5.1.3 Additional nutrients - vitamins, minerals and other nutritive substances
Specify only one target population for product *(selection ONLY ONE check box)*:

[X] **Adults** [ ] **Young Children** [ ] **Infants**

VITAMINS specify which vitamin	AVG QUANTITY per 100 g

MINERALS specify which minerals	AVG QUANTITY per 100 g

NOTE: there is no permission to FORTIFY foods with this substance indicated with **

Insert any other nutrient or biologically active substance

NAME OF SUBSTANCE	AVG QUANTITY per 100 g	%RDI / serve

5.1.4 Please provide the following analytical data:

% Ash	
% Moisture	Max 14.9

Estimation content accounted for per 100 g	N/A

5.1.5 Please specify how the carbohydrate value has been determined:

[ ] Difference as defined in Standard 1.2.8 [X] Available Carbohydrate as defined in Standard 1.2.8 [ ] Other - specify: [ ] Unknown

5.1.6 Please nominate the source used to provide nutrition data in the tables above

Analytical – e.g. Laboratory Tested [ ] Theoretical – e.g. By Calculation. [X]

Please specify the source of data used for the theoretical calculations (e.g. Nuttab, AusNut, NZ food tables, etc)

NZ Food Composition Tables

5.2 SUITABILITY TO MAKE CERTAIN CLAIMS

Specify if the product is suitable for use in product intended for the following consumer uses.

SPECIFY IF SUITABLE FOR ...	Yes / No	HOW HAS THIS BEEN VALIDATED?	CERTIFICATE AVAILABLE (Yes/No)
Halal	Yes		No
Kosher	Yes		No
Organic	Yes		No
Biodynamic			
Ovo-lacto-vegetarian			
Lacto-vegetarian			
Vegan			

PRODUCT SUITABILITY FOR ...	Yes / No	SPECIFY PARTICULAR CLAIMS	HOW IS CLAIM VALIDATED?
"Free" claims			
Sustainability claims			
Humane treatment			
Any other claims			

6 DURABILITY, PACKAGING AND SUPPLY CHAIN

6.1 SHELF LIFE

6.1.1 Please complete the following details:

	PRODUCT AS SUPPLIED unopened pack or bulk container		PRODUCT - ONCE IN USE resealable pack or bulk container	
Specify shelf life	6	Months	6	Months
Temperature control during storage	Is required ?	Yes	Is required ?	Yes
	Specify range:	20-25 °C	Specify range:	20-25 °C
Temperature control during transport	Is required ?	Yes		
	Specify range:	20-25 °C		
Specify any OTHER storage requirements:	dark, dry and cool			

6.1.2 Specify the type of date mark to be used: **Best before**

Refer to AFGC Date Marking Guide

6.2 POTENTIAL HAZARDS

6.2.1 Are there any potential hazards associated with the product ? **No** Yes/No

6.3 TRANSPORT

How is product transported and packaged?

6.4 TRADE MEASUREMENT

6.4.1 Specify which method of trade measurement is used: **Net quantity**

6.4.2 What is the package size 20.00 **kg** (specify unit of measure)

6.4.3 Target Fill (if applicable) (specify unit of measure)

6.4.4 Drained Weight (if applicable) (specify unit of measure)

6.4.5 IF AQS is used, what is the statistical variance in the fill measurement?

6.5 TRACEABILITY

Please provide any general comments about the traceability coding used on the product:

Best before date (batch numbers) related to packed on date.

Please specify the following where applicable:

TRACKING CODE	UNIT				SHIPPER (if applicable)			
Type of Primary Coding (*Please TICK as appropriate*)		Date code	X	Batch number		Date code		Batch number
		Product code		Lot number		Product code		Lot number
Method of coding	Ink jet							
Location of code	Side of the packaging							
Number of characters in code	6 digits							
Example of coding format	Best Before:09 01 13							
Coding translation	Packed on:13 07 12							

6.6 PRODUCT PACKAGING

6.6.1 Are tamper evident controls included in the packaging design? Yes/No

6.6.2 Has unit packaging been assessed for migration of substances into food? Yes/No

6.6.3 Are engineered nanoparticles present in unit packaging? Yes/No

6.6.4 Are you a signatory to relevant packaging stewardship in Australian or NZ ? Yes/No

6.6.5 Provide a general description of unit packaging:

20 Kg multiwall paper bags.

6.6.6 Complete the following table for questions related to packaging of unit package and/or shipper

PACKAGING		UNIT	SHIPPER
Type	Packaging format		
Specify components / material used in packaging	Ceramic		
	Glass		
	Metal		
	Paper / cardboard	**Yes**	
	Packing materials		
	Plastics		
	% of total using recycled component		
Seal	What is the seal method?	Valve bag	
Dimensions	Height (mm)	545	
	Width (mm)	470	
	Depth (mm)	115	

6.7 PALLET CONFIGURATION

6.7.1 Gross weight of loaded pallet 1000.0 kg

6.7.2 Stack height of loaded pallet cm

6.7.3 Specify the type of pallet [X] Wooden [ ] Plastic [ ] Other

6.7.4 What is the pallet pattern [ ] Column stack [ ] Interlocking

6.7.5 Number of : units per shipper shippers per pallet 50

layers per pallet 10

7 SPECIFICATIONS FOR COMPLIANCE

Test Methods are mandatory and must quote AOAC methods or recognised independent Australian or International standards. Where a supplier's internal test method is quoted a copy must be attached. Also state if Certificate of Analysis (C of A) or Certificate of Conformance (C of C) can be provided.

7.1 ORGANOLEPTIC SPECIFICATIONS

(Examples may include flavour, colour, aroma, texture etc)

			AVAILABILITY	
TEST / PARAMETER	SPECIFICATION	TEST METHOD	C of A	C of C

7.2 PHYSICAL SPECIFICATIONS

(Examples may include particle size, shape, specific gravity, metal detection, foreign matter tolerances, physical defect tolerances etc as appropriate for the product)

			AVAILABILITY	
TEST / PARAMETER	SPECIFICATION	TEST METHOD	C of A	C of C
Particle size:		Sieves	**Yes**	
>765 um	6.0 - 13.0			
>500 um	5.0 - 10.0			

7.3 MICROBIOLOGICAL SPECIFICATIONS

(Examples may include standard plate count, yeasts & moulds, coliforms, salmonella, listeria etc)

			AVAILABILITY	
TEST / PARAMETER	SPECIFICATION	TEST METHOD	C of A	C of C

7.4 CHEMICAL SPECIFICATIONS

(Examples may include pesticide residue screen, antibiotic residue screen, heavy metal screen, aflatoxins screen, salt, acid, pH, moisture, brix, Aw, Nutrition Information Test, etc)

TEST / PARAMETER	SPECIFICATION	TEST METHOD	AVAILABILITY	
			C of A	C of C
Moisture	Maximum 14.9%	NIR, Calibrated AACC 44-15A	Yes	
Protein	Minimum 11.0%	NIR, Calibrated AACC 39-11	Yes	
Falling number	Minimum 250 seconds	AACC 56-81b	Yes	
Water absorption	Minimum 65.0%	AACC 54-21	Yes	
Development time	4.0-7.0 minutes	AACC 54-21	Yes	
Stability time	Minimum 2.0 minutes	AACC 54-21	Yes	

8 COMMENTS / ADDITIONAL INFORMATION

8.1 Do you have any comments or additional information ? **No** Yes/No

Question Number	Line Number	Comments

8.2 ADDITIONAL MANUFACTURING SITE INFORMATION (if required)

When nominating product is supplied from more than one manufacturing site, the details provided must be applicable to product coming from any of the sites. For example, if particular allergens occur at only one site then the information provided in the form should identify that the allergens are present even though batches of product made at other sites may be allergen free.

	COMPANY NAME			
SITE: #4	NUMBER / STREET / SUBURB			
	STATE / COUNTRY / POST CODE			
	COMPANY NAME			
SITE: #5	NUMBER / STREET / SUBURB			
	STATE / COUNTRY / POST CODE			
	COMPANY NAME			
SITE: #6	NUMBER / STREET / SUBURB			
	STATE / COUNTRY / POST CODE			

A 1.3 Raw material specifications for 3G snack ancient grain claim

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CERTIFIED QUALITY MANAGEMENT SYSTEM ISO 9001
CERTIFIED HACCP MANAGEMENT SYSTEM

LIVE

TECHNICAL SPECIFICATION
Amaranth Grain
(AMARAN03)

VERSION: 1	DATE: 15/6/2009
SUPERSEDES	
AUTHORISED:	Sumeet Dhaliwal (16/06/2009)
AUTHORISED:	Bramleigh Hewitt (16/06/2009)
AUTHORISED:	Hari Srinivas (16/06/2009)

Disclaimer:
The information contained in this specification should not be construed as recommending the use of our product's fitness for any particular purpose. Prospective purchasers are invited to conduct their own tests and studies to determine suitability for a particular purpose and specific applications. This product is an agricultural product and as such Scalzo cannot guarantee zero foreign material.

DESCRIPTION

Fresh Amaranth seeds which have been sorted, cleaned and packed.

This is an all natural product, containing no additives or preservatives, and may therefore be subject to seasonal colour and flavour variations.

Botanical Name: Amaranthus caudathus

Country of Origin: Peru

PHYSICAL STANDARDS

Flavour: Typical of amaranth grain, free from off or objectionable flavours

Appearance: Free Flowing - Small round grains

Colour: Creamy

Odour: Typical of amaranth grain, free from off or objectionable odours

Sieve Analysis:

Sieve	RetainedOn	Passed Thru	Min (%)	Max (%)	Typical
N/A	☐	☐			

Defects:

Defect	Defect Range
Contrasting varieties	1.0 % maximum
Atypical grains	1.0 % maximum
Black grains	1.0 % maximum
Deformed grains	1.0 % maximum

LIVE TECHNICAL SPECIFICATION Amaranth Grain (AMARAN03)	VERSION: 1 DATE: 15/6/2009 SUPERSEDES AUTHORISED: Sumeet Dhaliwal (16/06/2009) AUTHORISED: Bramleigh Hewitt (16/06/2009) AUTHORISED: Hari Srinivas (16/06/2009)

Foreign Materials:

Foreign Matter	Level	Min (%)	Max (%)
Foreign Material	Target Nil		0.01

CHEMICAL PARAMETERS

Property	Min	Max	Typical	Test Meth	Comments
Moisture		13.0%			
Saponinas		Absent			

MICROBIOLOGICAL PARAMETERS

Property	No of samples per batch (n)	Accept. # samp. b/n m and M (c)	GMP (m)	Max (M) Rejection Limit	Test Method
Aerobic Mesophiles				1000,000cfu/g	
Yeast				10,000cfu/g	
Mould				10,000cfu/g	
E. coli				3/g	
Salmonella				Negative/125g	

NUTRITIONAL INFORMATION

Nutrient	Avg Qty Per Serving	Avg Qty Per 100g
WEIGHT		100.0g
ENERGY		1540.0kJ (368Cal)
PROTEIN		14.0g
TOTAL FAT		7.1g
- SATURATED		1.7g
CARBOHYDRATE		58.6g
- SUGARS		0.0g
DIETARY FIBRE		9.3g
SODIUM		21.0mg
POTASSIUM		365.0mg

Comments: Water: 11.3g/100g ; Ash: 3.0g/100g
Source: USDA Nutrition Database

DIETARY CLAIMS

LIVE

TECHNICAL SPECIFICATION
Amaranth Grain
(AMARAN03)

VERSION: 1	DATE: 15/6/2009
SUPERSEDES	
AUTHORISED:	Sumeet Dhaliwal (16/06/2009)
AUTHORISED:	Bramleigh Hewitt (16/06/2009)
AUTHORISED:	Hari Srinivas (16/06/2009)

Suitable for Vegetarians	☑	Suitable for Lacto-ovo Vegetarians	☑	Suitable for Lacto Vegetarians	☑
Suitable for Vegans	☑	Suitable for Coeliacs	☑		
Halal	☐	Halal Certification	☐	Date	
Kosher	☑	Kosher Certification	☑	Date	1/10/2009
Genetically Modified	☐	Contains GM Processing aids	☐	Contains additives which are GM	☐

FOOD ALLERGENS

Property	Present In Raw Material	Present On Site
No Known Allergens	☐	☐

FOOD SENSITIVITIES

Property	Present In Raw Material	Present On Site
No Known Food Sensitivities	☐	☐

INGREDIENTS

Ingredient	Labelling
Amaranth	

PACKAGING DETAILS

Packaging: Multi-walled paper bags

Pack Type: Bags Weight: 25kg

Storage Cond.: See Product Information (below)

Shelf Life: 12 Months from date of manufacture/packing
(under recommended storage conditions)

Product Info: Storage conditions: Store in a cool (18°C), dry and dark area.

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www.scalzofoods.com.au

CERTIFIED QUALITY MANAGEMENT SYSTEM ISO 9001 — CERTIFIED HACCP MANAGEMENT SYSTEM

LIVE TECHNICAL SPECIFICATION Hulled White French Millet (MILLET06)	VERSION: 1 DATE: 13/4/2007 SUPERSEDES AUTHORISED: Cassie Higham (16/04/2007) AUTHORISED: Anthony Pavlovic (16/04/2007) AUTHORISED: Hari Srinivas (16/04/2007)

Disclaimer:
The information contained in this specification should not be construed as recommending the use of our product's fitness for any particular purpose. Prospective purchasers are invited to conduct their own tests and studies to determine suitability for a particular purpose and specific applications. This product is an agricultural product and as such Scalzo cannot guarantee zero foreign material.

DESCRIPTION

Whole-grain, raw, hulled, White French Millet, which has been machine cleaned.

This is an all natural product, containing no additives or preservatives, and may therefore be subject to seasonal colour and flavour variations.

Country of Origin: Australia

PHYSICAL STANDARDS

Flavour: Typical of hulled millet, free from off or objectionable flavours

Appearance: Free Flowing - Meal

Colour: Yellow

Odour: Typical of hulled millet, free from off or objectionable odours

Size/Count: Milled through 1.5mm screen

Sieve Analysis:

Sieve	RetainedOn	Passed Thru	Min (%)	Max (%)	Typical
N/A	☐	☐			

Defects:

Defect	Defect Range
Mould	Absent
Discolouration	Absent

LIVE TECHNICAL SPECIFICATION Hulled White French Millet (MILLET06)	VERSION: 1 DATE: 13/4/2007 SUPERSEDES AUTHORISED: Cassie Higham (16/04/2007) AUTHORISED: Anthony Pavlovic (16/04/2007) AUTHORISED: Hari Srinivas (16/04/2007)

Foreign Materials:

Foreign Matter	Level	Min (%)	Max (%)
Insect and Rodent Contamination	Absent		
Foreign Material	1.0% by weight or 1 stone/kg maximum		

Comments: Hulled millet may contain other seeds that are of similar size, which are difficult to remove. Foreign Material includes unmilled material, other seeds and all vegetable matter other than millet plant.

CHEMICAL PARAMETERS

Property	Min	Max	Typical	Test Meth	Comments
Moisture	5.0%	9.0%			
Purity			99.0%		

MICROBIOLOGICAL PARAMETERS

Property	No of samples per batch (n)	Accept. # samp. b/n m and M (c)	GMP (m)	Max (M) Rejection Limit	Test Method
N/A					

NUTRITIONAL INFORMATION

Nutrient	Avg Qty Per Serving	Avg Qty Per 100g
WEIGHT		100.0g
ENERGY	1500kJ (359Cal)	1500.0kJ (358Cal)
PROTEIN	11.0g	11.0g
TOTAL FAT	4.2g	4.2g
- SATURATED	0.7g	0.7g
CARBOHYDRATE	64.4g	64.4g
- SUGARS	1.4g	1.4g
DIETARY FIBRE		8.0g
SODIUM	5mg	5.0mg

Comments: Source: Provided by supplier

DIETARY CLAIMS

Suitable for Vegetarians	☑	Suitable for Lacto-ovo Vegetarians	☑	Suitable for Lacto Vegetarians	☑
Suitable for Vegans	☑	Suitable for Coeliacs	☐		

LIVE TECHNICAL SPECIFICATION Hulled White French Millet (MILLET06)	VERSION: 1 DATE: 13/4/2007 SUPERSEDES AUTHORISED: Cassie Higham (16/04/2007) AUTHORISED: Anthony Pavlovic (16/04/2007) AUTHORISED: Hari Srinivas (16/04/2007)

Halal	☐	Halal Certification	☐	Date	
Kosher	☐	Kosher Certification	☐	Date	
Genetically Modified	☐	Contains GM Processing aids	☐	Contains additives which are GM	☐

FOOD ALLERGENS

Property	Present In Raw Material	Present On Site
Cereals Containing Gluten & Derivatives (Includes Wheat, Rye, Barley, Oats, Spelt, Triticale, Malt and their hybridised strains)	☐	☑

FOOD SENSITIVITIES

Property	Present In Raw Material	Present On Site
No Known Food Sensitivities	☐	☐

INGREDIENTS

Ingredient	Labelling
Millet	

PACKAGING DETAILS

Packaging: Woven poly bags

Pack Type: Bags Weight: 25kg

Storage Cond.: See Product Information (below)

Shelf Life: 12 Months from date of manufacture/packing
(under recommended storage conditions)

Product Info: Stoarge Conditions:
Store in a cool, dry area (recommended storage between 8-10°C), keep away from direct sunlight, strong odours and rodent infestation.

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CERTIFIED QUALITY MANAGEMENT SYSTEM ISO 9001 | CERTIFIED HACCP MANAGEMENT SYSTEM

TECHNICAL SPECIFICATION Quinoa Grain (QUINOA04) LIVE	VERSION: 1 DATE: 15/6/2009 SUPERSEDES AUTHORISED: Sumeet Dhaliwal (16/06/2009) AUTHORISED: Bramleigh Hewitt (16/06/2009) AUTHORISED: Hari Srinivas (16/06/2009)

Disclaimer:
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DESCRIPTION

Quinoa seeds are cleaned, washed to remove saponin, dried, sorted and then packed.

This is an all natural product, containing no additives or preservatives, and may therefore be subject to seasonal colour and flavour variations.

Botanical Name: Chenopoduin quinoa Wildenow

Country of Origin: Peru

PHYSICAL STANDARDS

Flavour: Mild, early flavour, typical of quinoa grain, free from off or objectionable flavours

Appearance: Free Flowing - Small round flattened grains

Colour: Creamy Biege

Odour: Typical of quinoa grain, free from off or objectionable odours

Sieve Analysis:

Sieve	RetainedOn	Passed Thru	Min (%)	Max (%)	Typical
N/A	☐	☐			

Defects:

Defect	Defect Range
Contrasting varieties	1.0% maximum
Atypical grains	1.0% maximum
Black grains	1.0% maximum
Deformed grains	1.0% maximum

LIVE TECHNICAL SPECIFICATION Quinoa Grain (QUINOA04)	VERSION: 1 DATE: 15/6/2009 SUPERSEDES AUTHORISED: Sumeet Dhaliwal (16/06/2009) AUTHORISED: Bramleigh Hewitt (16/06/2009) AUTHORISED: Hari Srinivas (16/06/2009)

Foreign Materials:

Foreign Matter	Level	Min (%)	Max (%)
Foreign Material	Target Nil		0.01

CHEMICAL PARAMETERS

Property	Min	Max	Typical	Test Meth	Comments
Moisture		14.0%			
Saponinas		0.0%			(free of saponin)

MICROBIOLOGICAL PARAMETERS

Property	No of samples per batch (n)	Accept. # samp. b/n m and M (c)	GMP (m)	Max (M) Rejection Limit	Test Method
Aerobic Mesophiles				1000,000cfu/g	
Yeast				10,000cfu/g	
Mould				10,000cfu/g	
E. coli				3/g	
Salmonella				Negative/125g	

NUTRITIONAL INFORMATION

Nutrient	Avg Qty Per Serving	Avg Qty Per 100g
WEIGHT		100.0g
ENERGY		1510.0kJ (360Cal)
PROTEIN		14.3g
TOTAL FAT		6.2g
- SATURATED		0.7g
CARBOHYDRATE		58.0g
- SUGARS		0.0g
DIETARY FIBRE		7.1g
SODIUM		5.0mg

Comments: Water: 12.0g/100g ;
Ash: 2.42g/100g
Source: USDA Nutrition Database

DIETARY CLAIMS

LIVE TECHNICAL SPECIFICATION Quinoa Grain (QUINOA04)	VERSION: 1 DATE: 15/6/2009 SUPERSEDES AUTHORISED: Sumeet Dhaliwal (16/06/2009) AUTHORISED: Bramleigh Hewitt (16/06/2009) AUTHORISED: Hari Srinivas (16/06/2009)

Suitable for Vegetarians	☑	Suitable for Lacto-ovo Vegetarians	☑	Suitable for Lacto Vegetarians	☑
Suitable for Vegans	☑	Suitable for Coeliacs	☑		
Halal	☐	Halal Certification	☐	Date	
Kosher	☑	Kosher Certification	☑	Date	1/10/2009
Genetically Modified	☐	Contains GM Processing aids	☐	Contains additives which are GM	☐

FOOD ALLERGENS

Property	Present In Raw Material	Present On Site
No Known Allergens	☐	☐

FOOD SENSITIVITIES

Property	Present In Raw Material	Present On Site
No Known Food Sensitivities	☐	☐

INGREDIENTS

Ingredient	Labelling
Quinoa seed	

PACKAGING DETAILS

Packaging: Multi-walled paper bags

Pack Type: Bags Weight: 25kg

Storage Cond.: See Product Information (below)

Shelf Life: 12 Months from date of manufacture/packing

Product Info: Storage conditions: Store in a cool (18°C), dry and dark area.

A 1.4 Raw material specifications for 3G snack fibre claim

National Starch
FOOD INNOVATION

Natural Hi-maize

NUTRITIONAL DATA

CONFIDENTIAL

Hi-maize™ 1043

	Per 100g ('as is' basis)
Energy[1]	1004kJ (251kcal)
Moisture (g)	13
Protein (g)	0.8
Total Fat (g)	0.1
Carbohydrate[2] (g)	33.5
Total Dietary Fibre (g) AOAC 985.29	52.2
Ash (g)	0.4
Sodium (mg)	6.5

[1]Calculated as defined by Food Standard Australia and New Zealand, Standard 1.2.8 Nutrition Information Requirements, November 2004. For nutrition calculation outside of Australia and NZ, please follow own country food regulations.

[2]Carbydrate level was derived by difference

The above information is considered to be typical and not part of the product specification.

Issue date: April 2008

National Starch
FOOD INNOVATION

Natural Hi-maize
The 5-in-1 Fiber

PRODUCT DATA SHEET

CONFIDENTIAL

Hi-maize™1043

Label Designation	Hi-maize™ or Corn Starch
Source	High Amylose Corn

Physical and Chemical Characteristics (*):

Colour	White to Off-white
Form	Fine Powder
Particle Size	
Retained 212 micron	1.0% max

Physical and Chemical Specifications:

Moisture	10-13%
pH (10% solution)	4.0 – 6.5
Sulphur Dioxide	10 ppm maximum

Microbiological Specifications:

Total Plate Count	10,000/g maximum
Yeast	200/g maximum
Mould	200/g maximum
E. coli	negative
Salmonella	negative

Nutritional Characteristics (*):

Total Dietary Fibre (AOAC 985.29)	60-75% (dry basis)
Protein (N x 6.25)	1.0% max
Ash	0.5% max (dry basis)

Packaging and Storage:

Hi-maize™1043 is packaged in 25 kgs and 50 lbs moisture barrier, multi-wall paper bags. We recommend that Hi-maize™1043 be stored in a clean, dry area at ambient temperature and away from heavily aromatic material. The best before date for Hi-maize™1043 is 24 months from the date of manufacture.

(*) While this information is typical of Hi-maize™1043 it should not be considered as a specification.

Revised on 30 September 2010 (AP)
560943 (AP)

Product Sheet

Orafti®GR

DOC.A4-03*09/07

Description

Orafti®GR	is a food ingredient consisting mainly of chicory inulin. Orafti®GR is a GRanulated powder.
chicory inulin	is a mixture of oligo- and polysaccharides which are composed of fructose units linked together by ß(2-1)linkages. Almost every molecule is terminated by a glucose unit. The total number of fructose or glucose units (= Degree of Polymerisation or DP) of chicory inulin ranges mainly between 2 and 60.

Compositional Specifications

All values expressed on dry matter.
Analytical Methods : see our Technical Brochures.

Inulin	> 90 %
Glucose + fructose	≤ 4 %
Sucrose	≤ 8 %
Dry Matter (d.m.)	97 ± 1.5 %
Carbohydrate content	> 99.5 %
Average DP of the inulin	≥ 10
Ash (sulphated)	< 0.2 %
Conductivity (15 Brix)	< 250 µS
Heavy Metals	Pb, As each < 0.1 mg/kg Cd, Hg each < 0.01mg/kg
pH (10°Brix)	5.0 - 7.0

Microbiological Specifications

All values expressed on dry matter.
Analytical Methods : see our Technical Brochures.

Mesophilic bacteria - total count	max. 1000/g
Yeasts	max. 20/g
Moulds	max. 20/g
Thermophilic aerobic spores	max. 1000/g
Anaerobic H_2S producing thermophilic spores	max. 25/g
Enterobacteriaceae	absent in 1 g
Bacillus cereus	max. 100/g
Staphilococcus aureus	absent in 1 g
Escherichia coli	absent in 1 g
Clostridium perfringens	absent in 1 g
Clostridium botulinum	absent in 1 g
Salmonella	absent in 100 g
Listeria	Absent in 25 g

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Labelling

All values are average values expressed per 100 g commercial product.

Carbohydrates	8 (97 1))	Gluten	absent
Sugars	8	Lactose	absent
Dietary Fibre 2)	89	Milk/meat/egg components	absent
Protein	absent	Seed/soy components	absent
Fat	absent	Insecticides, pesticides	absent
Vitamins and Minerals	Negligeable	Nuts, nut components	absent
Caloric value 3)	120 kcal/505 kJ	Colza	absent
Broteinheite 4)	0.65	Other allergens	absent
		Enzymatic activity	absent
		Folate	absent

N.D. = Not Detectable   N/A = Not Applicable
1) including dietary fibre
2) measured by AOAC Method 997.08
3) based on a caloric value of 1 kcal/g for pure inulin. To be adapted to local regulations.
4) in accordance with German regulations.

Other Information (see also our Technical Brochures)

Aspect	Fine white granulated powder
Behaviour	Hygroscopic
Taste	Slightly sweet, without aftertaste
Solubility in water	120 g/l at 25°C - 350 g/l at 90°C
Wettability in water	Good.
Dispersability in water	Good. May require stirring.
Properties and Applications	See our Technical Brochures.
Particle Sizes	See document "Particle Sizes".
Density	Approx. 580 ± 50 g/l
Labelling - Ingredients List	Inulin
Safety	Safe. Not toxic. Not dangerous. Excessive consumption may cause laxative effects. Is, like other fine powders, when mixed with air and ignited, capable of causing an explosion.
Packaging	Paper bags on pallets, see 'Packaging Sheet Powders'
Optimal storage conditions	Cool and dry, in its original airtight packaging.
Maximum durability	See packaging (minimum 18 months upon delivery)
Transport conditions	According to document 'Transport Conditions'
Irradiation	Not irradiated
GMO	Not containing GMOs or GMO-derived components. Not produced using GMO-based technology.
Kosher	Certified, Orthodox Union
Halal	Certified, Halal Feed and Food Inspection Authority
Plant origin	Suitable for vegetarians & vegans
Produced by	BENEO-Orafti – see address on packaging label

Represented by :

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Data sheet

Grade
WF 600

VITACEL®

Wheat Fibre

Characteristics

VITACEL® Wheat Fibre WF 600 is a bright, microfine dietary fibre produced by a special process from the structure building components of the wheat plant.

Its multifunctional and physical characteristics give VITACEL® Wheat Fibre a wide range of applications in the food industry.

Analysis

dietary fibre content (acc. to AOAC-method)*	min.	97 % i. d.s.
of which: insoluble dietary fibre		94.5 %
soluble dietary fibre		2.5 %
loss on drying	max.	8 %
ash	max.	3 %
protein*		0.4 %
fat*		0.2 %
phytic acid*		negative
gluten*		negative
pH-value (10 % suspension)		6.5 +/- 1,5
average fibre length		80 µm
average fibre thickness		20 µm

Composition of dietary fibre*

cellulose		74 %
hemicellulose		26 %
lignin	max.	0.5 %

Microbiological analysis

standard plate count	max.	5×10^3 cfu/g
yeasts and moulds	max.	2×10^2 cfu/g
aflatoxines*		not detectable
Salmonella*		negative in 25 g

(* typical values)

Heavy metals*

lead (Pb)		0.14 ppm
cadmium (Cd)	max.	0.01 ppm (detection limit)
mercury (Hg)	max.	0.01 ppm (detection limit)
arsenic (As)		0.01 ppm

Pesticides and fungicides*

chlorinated hydrocarbons	max.	0.002 ppm (detection limit)

Physical data

water binding capacity (AACC-method)*		4.2 – 5.5 g H_2O/g d.s.
oil absorption*	min.	3.7 g oil/g d.s.
a_w-value*		0.44
calorific value/g*		0.09 kcal resp. 0.39 kJ
bulk density (in accordance with DIN 53 468)		200 g/l - 240 g/l
fineness		90 % < 70 µm

Sensory properties

appearance	white, powder
flavour	neutral
odour	neutral
very good mouth-feel due to fine particle size	

Screen analysis (in accordance with DIN 53 734/air jet sieve)

> 100 µm	0 % - 2 %
> 32 µm	15 % - 45 %

Declaration

VITACEL® Wheat Fibre WF 600 is a foodstuff which can be added to all other foodstuffs, provided that no other special instructions have to be observed due to the composition of these foodstuffs.

We recommend a declaration as Wheat Fibre or Wheat Plant Fibre.

Customs tariff number

4706 92 00

Packaging and storage

Packed in multi-layer 20 kgs paper-bags with PE-liner.
480 kgs/palett; average measurement (in cm): 130 x 90 x 120.
960 kgs/palett; average measurement (in cm): 130 x 90 x 215.
Shelf life is at least 5 years if stored at room temperature in dry conditions.

(* typical values)

J. RETTENMAIER & SÖHNE GMBH + CO
Fibers designed by Nature
Holzmühle 1
D-73494 Rosenberg

Telephone: 0 79 67/1 52-0
Telefax: 0 79 67/1 52-222

0411

A 1.5 Flavour enhancer specifications for 3G snack

Halcyon Proteins Pty Ltd

FOOD INDUSTRY - PRODUCT INFORMATION FORM

AUSTRALIAN FOOD AND GROCERY COUNCIL

Use the TAB key to work through this document electronically. Click once in the check box (or hit the "space" bar) for the cross to appear ☒ or to insert text.

1 PRODUCT & CONTACT DETAILS

CUSTOMER'S PRODUCT NAME		CUSTOMER'S PRODUCT CODE	
SUPPLIER'S PRODUCT NAME	Flavex Powder Standard	SUPPLIER'S PRODUCT CODE	FPS

1.1 SUPPLIER INFORMATION

COMPANY NAME		Halcyon Proteins Pty Ltd			
ABN		31 004 698 720			
TRADING NAME		As above			
BUSINESS ADDRESS		430 Hammond road Dandenong 3175 VIC Australia			
POSTAL ADDRESS		As above			
TECHNICAL CONTACT PERSON		Patricia Hale			
POSITION TITLE		Sales Executive			
PHONE		(03) 9768 2021			
FAX		(03) 9768 2291			
EMAIL		patricia@halcyonproteins.com.au			
DATE FORM COMPLETED		4/08/2009			
DOCUMENT NO:	1	ISSUE NO:	3	ISSUE DATE:	4.08.09

1.2 MANUFACTURER/S INFORMATION *(complete only when manufacturer is different to supplier)*

COMPANY NAME	SITE OF MANUFACTURE (City & Country)

1.3 DEFINITIONS / REFERENCES

References to the "Code" or specific "Standards" throughout this document refer to the standards outlined in the Australia New Zealand Food Standards Code. The Australia New Zealand Food Standards Code can be viewed at http://www.foodstandards.gov.au/foodstandardscode/

Additional related documents including the AFGC Allergen Management Guide and VITAL (Voluntary Incidental Trace Allergen Labelling) documents can be viewed at http://www.allergenbureau.net/allergen-guide/

1.4 CHECKLIST

- ☒ All sections of questionnaire complete
- ☒ **Page 2 has been signed and dated (Section 1.5)**
- ☐ Supplier Test Methods attached - if applicable (Section 7)
- ☒ Current Halal / Kosher / Organic Certificate attached - if applicable (Section 4.2)
- ☒ Other associated documents attached as requested by the customer (e.g. MSDS, HACCP certification, product specification, and related documents)

FOOD INDUSTRY - PRODUCT INFORMATION FORM

1.5 SUPPLIER DECLARATION AND WARRANTY

The Supplier –

- certifies that this product complies with the Australia New Zealand Food Standards Code;
- acknowledges that the Customer, and Supply Chain Customers of the Customer, will rely on the accuracy of the Product Information for food quality, safety and labelling purposes, and that errors or omissions in the above information may cause significant loss and damage;
- certifies that the Product Information contained herein is true and accurate to the following degree –
    - that the Product Information in relation to ingredients that it buys in from a third party relies in good faith on Product Information provided by that third party;
    - that the information is unconditionally true and accurate in relation to all other substances and processes;
- agrees that all Product it supplies to the Customer will conform with the Product Information unless otherwise agreed to in writing and in advance by the Customer;
- will immediately inform the Customer (and confirm in writing as soon as possible) if it becomes aware of any error or omission in the Product Information;
- will inform the Customer in writing and in advance of any change to the Product Information provided herein (including any changes that result from new or modified processes); and
- acknowledges that the Customer may provide the Product Information to –

    (a) regulatory agencies in relation to any matter raised by such agencies;
    (b) courts and other legal tribunals for the purposes of any proceedings;
    (c) to its related businesses and partners who are involved in the acquisition, use, sale or compliance of the Product, under this same restriction as to disclosure; and
    (d) to its own customers, under this same restriction as to disclosure;

    but will otherwise make reasonable efforts to not disclose the Product Information

Click into the "COMPANY NAME" field to continue inserting information

COMPANY NAME Signed for and on behalf of	Halcyon Proteins Pty Ltd
NAME (Please print)	Vicki Alesci
JOB TITLE (Please print)	Quality Control Manager
AUTHORISED SIGNATURE	Vicki Alesci
DATE OF AUTHORISATION	4 August 2009

Click on the field name "2.1 PRODUCT DESCRIPTION" to continue to tab through the document.

Customer Internal Use Only	
Internal Product Code / Description	
Version No.	
Approved	☐ YES ☐ NO
Reason for Update	
Received and Reviewed By	
Date:	
Signature:	

FOOD INDUSTRY - PRODUCT INFORMATION FORM

AUSTRALIAN FOOD AND GROCER COUNCIL

2 PRODUCT INFORMATION & INGREDIENTS

2.1 PRODUCT DESCRIPTION *(Physical and technological description)*

Flavex Powder Standard is a food ingredient produced by the acid hydrolysis of vegetable proteins. It is a dry free flowing product. Flavex Powder Standard has an intense savoury flavour.

2.2 LEGAL DESCRIPTION / SUGGESTED LABELLING DESCRIPTION

Vegetable Protein Extract

2.3 INGREDIENT DECLARATION INCLUDING PERCENTAGE LABELLING

(Full list of ingredients including food additives in descending order, including percentage labelling of characterising components or ingredients, and full break down of compound ingredients. Ensure all relevant information such as additive code numbers are included)

INGREDIENT NAME	INGREDIENT LIST (Include a full breakdown of any compound ingredients including additive code numbers)	INGREDIENT PERCENTAGE (%)	% CHARACTERISING COMPONENTS (As a percentage of the ingredient) (%)
Vegetable Protein Extract	Vegetable Protein Extract	99%	99%
Vegetable Oil	Rice Bran Oil	1%	1%

2.4 PROCESSING AIDS

(Full list of processing aids used in the manufacture of this product and not declared in the ingredient listing)

FOOD INDUSTRY - PRODUCT INFORMATION FORM

AUSTRALIAN FOOD AND GROCERY COUNCIL

2.5 COUNTRY OF ORIGIN

STATEMENT (Select 1 option only)		INSERT COUNTRY BELOW		SPECIFY % IMPORTED INGREDIENTS	SPECIFY COUNTRY/IES OF IMPORTED INGREDIENTS
☐	Product of				
☒	Made in	Australia		0	
☐	Made in		from local and imported ingredients		
☐	Made in		from imported and local ingredients		
☐	Other - Specify				

3 ALLERGEN & COMPOSITIONAL INFORMATION

3.1 MANDATORY ADVISORY OR WARNING STATEMENTS & DECLARATIONS

(" Yes" response triggers a mandatory advisory or warning statement. Refer Standard 1.2.3 of the Code)

FOOD / COMPONENT	PRESENT YES / NO
Bee pollen presented as a food or ingredient	No
Propolis presented as a food or ingredient	No
Unpasteurised milk and unpasteurised liquid milk products	No
Aspartame or aspartame-acesulphame salt	No
Unpasteurised egg products	No
Quinine	No
Kola beverages containing added caffeine	No
Guarana or extracts of guarana	No
Phytosterol esters	No
Tall oil phytosterols.	No
Cereal-based beverages, where these foods contain no more than 2.5% m/m fat and less than 3% m/m protein, or less than 3% m/m protein only.	No
Evaporated and dried products made from cereals, where these foods contain no more than 2.5% m/m fat and less than 3% m/m protein, or less than 3% m/m protein only, as reconstituted according to directions for direct consumption.	No
Milk, and beverages made from soy or cereals, where these foods contain no more than 2.5% m/m fat.	No
Evaporated milks, dried milks and equivalent products made from soy or cereals, where these foods contain no more than 2.5% m/m fat as reconstituted according to directions for direct consumption.	No
Royal jelly presented as a food or ingredient	No
Polyols, Isomalts, Polydextrose (Lactitol, Maltitol, Maltitol syrup, Mannitol, Xylitol, Erythritol, Isomalt, Polydextrose, Sorbitol) *If "yes" specify type/s and levels*	No

Type	Level (g/100g)

FOOD INDUSTRY - PRODUCT INFORMATION FORM

AUSTRALIAN FOOD AND GROCERY COUNCIL

3.2 MANDATORY DECLARATION OF CERTAIN SUBSTANCES (Refer Standard 1.3.2 of the Code)

Please insert YES OR NO to indicate if the product contains any ingredient, additive or processing aid which has been derived from the food source. Highly processed derivatives must always be declared. ***Carefully assess compound ingredients for hidden allergens.***

All columns must be completed when a "YES" response is provided

FOOD (present as an ingredient, additive or processing aid)	**PRESENT IN PRODUCT** (Yes*/No)	*** IF YES, ADDITIONAL INFORMATION MUST BE INSERTED WHERE PROMPTED**		
Cereals containing gluten & their products, namely, wheat, rye, barley, oats, spelt & their hybridized strains	No	Specify name of **cereal** and type of derivative/s:	Specify % of derivative in product	Specify % gluten in allergen derivative
		Has the product been rendered gluten free by processing (no detectable gluten)? *(Yes / No)*	Blank	
		Has the product been rendered free of all wheat proteins by processing? *(Yes / No)*	Blank	
Crustacea & crustacea products	No	Specify name of **crustacea** and type of derivative/s:	Specify % of derivative in product	Specify % total protein in allergen derivative
Egg & egg products	No	Specify type of **egg** derivative/s:	Specify % of derivative in product	Specify % total protein in allergen derivative
Fish & fish products (Including mollusc and fish oils)	No	Specify name of **fish** and type of derivative/s:	Specify % of derivative in product	Specify % total protein in allergen derivative

FOOD INDUSTRY - PRODUCT INFORMATION FORM

AUSTRALIAN FOOD AND GROCERY COUNCIL

3.2 MANDATORY DECLARATION OF CERTAIN SUBSTANCES (*continued*)

FOOD (present as an ingredient, additive or processing aid)	**PRESENT IN PRODUCT** (Yes*/No)	*** IF YES, ADDITIONAL INFORMATION MUST BE INSERTED WHERE PROMPTED**		
Milk & milk products	No	Specify type of **milk** derivative/s:	Specify % of derivative in product	Specify % total protein in allergen derivative
Tree nuts & tree nut products	No	Specify type of **tree nut** derivative/s	Specify % of derivative in product	Specify % total protein in allergen derivative
Sesame Seed & sesame seed products	No	Specify type of **sesame seed** derivative/s	Specify % of derivative in product	Specify % total protein in allergen derivative
Peanuts & peanut products (including peanut oil)	No	Specify type of **peanut** derivative/s	Specify % of derivative in product	Specify % total protein in allergen derivative
Soybean & soybean products (including soybean oils)	No	Specify type of **soybean** derivative/s	Specify % of derivative in product	Specify % total protein in allergen derivative
Sulphites	No	Total level of **sulphites** in product (mg/kg):		
		Total level of **added sulphites** in product (mg/kg):		
		Specify type of **added sulphite/s** and additive number/s		

FOOD INDUSTRY - PRODUCT INFORMATION FORM

AUSTRALIAN FOOD AND GROCERY COUNCIL

3.3 ALLERGEN CROSS CONTACT

Please complete ALL columns with respect to the potential cross contact allergens based on the information you have received through your supply chain AND your manufacturing processes.

*Refer to **VITAL** procedure and decision tree.* http://www.allergenbureau.net/allergen-guide/ *All columns must be completed.*

FOOD	PRESENT ON SAME LINE (Yes/No)	PRESENT IN SAME FACILITY (Yes/No)	SPECIFY NAME AND TYPE OF DERIVATIVE	Estimate total protein from the allergenic derivative in mg/kg (ppm) (Using VITAL Procedure)
Cereals containing gluten & their products	No	Yes	Specify name of **cereal** and type of derivative in carry over material:	
			Hydrolysed Wheat Protein. Due to the process, all allergenic material is broken down.	0
Crustacea & crustacea products	No	No	Specify name of **crustacea** and type of derivative/s in carry over material:	
Egg & egg products	No	No	Specify type of **egg** derivative/s in carry over material:	
Fish & fish products (Including mollusc & fish oils)	No	No	Specify name of **fish** and type of derivative/s in carry over material:	
Milk & milk products	No	No	Specify type of **milk** derivative/s in carry over material:	
Tree nuts & tree nut products	No	No	Specify type of **tree nut** derivative/s in carry over material:	
Sesame Seed & sesame seed products	No	No	Specify type of **sesame seed** derivative/s in carry over material:	
Peanuts & peanut products (including peanut oil)	No	No	Specify type of **peanut** derivative/s in carry over material:	
Soybeans & soybean products (including soybean oils)	No	Yes	Specify type of **soybean** derivative/s in carry over material:	
			Hydrolysed Soy Protein. Due to the process, all allergenic matter is broken down.	0
Sulphites	No	No	Specify source of **sulphite** in carry over material:	

3.3 ALLERGEN CROSS CONTACT Cont.

3.3.1 Does your company handle, process or have onsite any allergen causing components? (Yes/No) Yes
(Carefully assess compound ingredients for hidden allergens)

3.3.2 Has your company addressed cross contact from allergen containing components? (Yes/No) Yes

If no, by what date do you plan to address allergen cross contact within your manufacturing premises?

3.3.3 How is allergen cross contact avoided within your manufacturing premises? (Select appropriate boxes)

- ☒ validated cleaning procedures
- ☒ production scheduling
- ☒ control of personnel movement in factory
- ☒ staff training
- ☒ documented procedures and controls
- ☒ isolated storage of allergens
- ☒ raw material sourcing & tracing
- ☐ dedicated equipment
- ☐ other _____

3.3.4 Has your company used the VITAL Procedure and Decision Tree to determine cross contact? (Yes/No) Yes
http://www.allergenbureau.net/allergen-guide/

Comments

All products made from any allergenic material is checked for allergens at each batch, including Hydrolysed Soy and Hydrolysed Wheat Products.

Contact name for requesting clarification on information provided in Sections 3.2 and 3.3	
NAME (Please Print)	Vicki Alesci
JOB TITLE (Please Print)	Quality Control Manager
TELEPHONE - Work	03 9768 2021
TELEPHONE - Mobile	
Email	halcyonproteins@iprimus.com.au

FOOD INDUSTRY - PRODUCT INFORMATION FORM

AUSTRALIAN FOOD AND GROCERY COUNCIL

3.4 ADDITIONAL ALLERGEN, LABELLING & CONSUMER INFORMATION REQUIREMENTS

	FOOD / COMPONENT		PRESENT IN PRODUCT (Yes* /No)	* IF YES, ADDITIONAL INFORMATION MUST BE INSERTED WHERE PROMPTED
INTERNATIONAL REQUIREMENTS	Beef		No	
	Chicken		No	
	Pork		No	
	Gelatin		No	Specify type/s of gelatin:
	Mollusc		No	
	Buckwheat		No	
	Apple		No	
	Kiwifruit		No	
	Orange		No	
	Peach		No	
	Tomato		No	
	Matsutake Mushroom		No	
	Yam		No	
	Mustard		No	
	Lupin		No	
	Legumes *(other than peanuts, soybeans and lupins). Eg. Peas,*		No	Specify name and type of derivative/s:
	Umbelliferae family *(celery, celeriac, carrot, parsnip, coriander, aniseed, cumin, parsley, fennel, dill, chervil etc)*		No	Specify name and type of derivative/s:
	Antioxidants	Added BHA	No	
		Added BHT	No	
		Other Antioxidants	No	Specify type/s of antioxidant/s:
LABELLING REQUIREMENTS	Added Caffeine *(does not include naturally occurring caffeine)*		No	
	Added Flavour Enhancers		No	Specify type of flavour enhancer/s and additive number/s:
	Alcohol *(Residual)*		No	Specify level % v/v:
				Specify specific gravity of product:
	Added Fats & Oils	Animal	No	Specify type of fats & oils:
				If applicable specify the name of any process used to alter the fatty acid composition:
		Vegetable	Yes	Specify types of fats and oils: Rice Bran Oil
				If applicable specify the name of any process used to alter the fatty acid composition:

FOOD INDUSTRY - PRODUCT INFORMATION FORM

AUSTRALIAN FOOD AND GROCERY COUNCIL

3.4 ADDITIONAL ALLERGEN, LABELLING & CONSUMER INFORMATION REQUIREMENTS

	FOOD / COMPONENT		PRESENT IN PRODUCT (Yes* /No)	* IF YES, ADDITIONAL INFORMATION MUST BE INSERTED WHERE PROMPTED	
CONSUMER INFORMATION REQUIREMENTS	Allium Genus *(Onion, garlic, spring onion, leek, chives etc)*		No	Specify name and type of derivative/s:	
	Intense Sweeteners		No	Specify types of intense sweetener/s and additive number/s:	
	Preservatives		No	Specify type/s of preservative/s, additive numbers & level/s in mg/kg:	
	Seeds *(sunflower, poppy, cottonseed, etc)*		No	Specify name and type of derivative/s:	
	Yeast & Yeast Products *(including yeast extracts)*		No	Specify type of yeast product/s:	
				If applicable specify if hydrolysed or autolysed:	
	Herbs		No	Specify name of herbs/s:	
				☐ Herb	☐ Herb Extract
	Spices		No	Specify name of spice/s:	
				☐ Spice	☐ Spice Extract
	Hydrolysed Vegetable Proteins	Acid Hydrolysed	Yes	Specify type/s of protein/s: Maize	
				100 % Hydrolysis Yes	
		Enzyme Hydrolysed	No	Specify type/s of protein/s:	
				100 % Hydrolysis Blank	
	Added Flavours *(If the product is a flavour, answer YES)*		No	Specify type/s of flavour/s: ☐ Natural ☐ Nature Identical ☐ Artificial	
	Added Colours *(If the product is a colour, answer YES)*		No	Specify Type/s	Specify Additive Number/s
				☐ Natural	
				☐ Artificial	
				☐ Not Defined	
	Added Salt *(If the product is salt, answer YES)*		No		
	Added Sugar *(If the product is a sugar, answer YES)*		No		
INSERT ANY OTHER FOOD/ COMPONENT			Blank		
			Blank		
			Blank		
			Blank		
			Blank		
			Blank		
			Blank		

3.4 ADDITIONAL ALLERGEN, LABELLING & CONSUMER INFORMATION REQUIREMENTS

	FOOD / COMPONENT	PRESENT IN PRODUCT (Yes* /No)	* IF YES, ADDITIONAL INFORMATION MUST BE INSERTED WHERE PROMPTED
IMPORT / EXPORT REQUIREMENTS	Animal & Animal products *(e.g. animal flesh, organs, stock, gelatin, animal fat, tallow, milk, eggs, collagen from skin and / or hides etc)*	No	Specify type/s of animals:
			Specify type/s of animal derivatives:
			Specify country/ies of origin:
			Describe any heat processing used in the manufacture of this product (temperature/time):
	Meat & Meat products *(e.g. animal flesh, animal organs, meat extracts)*	No	Specify type/s of animals:
			Specify type/s of meat derivatives:
			Specify country/ies of origin:
			Describe any heat processing used in the manufacture of this product (temperature/time):
			Bovine meat /meat products are derived from animals free of bovine spongiform encephalopathy (BSE)? Blank
	Bird & Bird products *(e.g. chicken meat, fat, stock, eggs, duck extracts, quail etc.)*	No	Specify type/s of bird/s:
			Specify type/s of bird derivative/s:
			Specify source of bird products (i.e. Country and city):
			Describe any heat processing in the manufacture of this product (temperature/time):
	Fish & Fish products *(e.g. smoked salmon, pilchards, shark fin, fish roe, etc)*	No	Specify type/s of fish:
			Specify type/s of fish derivative/s:
			Specify country/ies of origin:
			Describe any heat processing used in the manufacture of this product (temperature/time):
	Honey & Honey products	No	Specify type/s of honey or honey derivatives:
			Specify country/ ies and state/s of origin:
			Describe any heat processing in the manufacture of this product (temperature/time):

4 NUTRITION INFORMATION & DIETARY SUITABILITY

4.1 NUTRITION INFORMATION – NUTRIENTS HIGHLIGHTED IN BOLD MUST BE COMPLETED.

If the information on a mandatory nutrient (In BOLD) is not known insert "Not Available". Do not leave blank or insert a zero.

NUTRIENT	AVERAGE QUANTITY PER 100 ☐ mL SG = ☒ g	
Moisture		g
Total Ash		g
Energy	655	kJ
Protein	30.2	g
Fat, total	<1	g
- saturated	<0.02	g
- trans	0.0	g
- polyunsaturated	<1	g
- monounsaturated	<1	g
Cholesterol	<3	mg
Carbohydrate	8.3	g
- sugars	<1	g
Dietary fibre, total	<0.5	g
Sodium	20100	mg
Potassium	28	mg
Vitamins – insert information on additional vitamins		mg
Minerals – insert information on additional minerals		mg
Insert any other nutrient or biologically active substance		mg

NUTRITION INFORMATION BASED ON - *mark all appropriate boxes*

☐ 100g Drained Product ☐ 100g Undrained Product ☒ Not Applicable

☐ 100g Uncooked product as packed ☐ 100g Product Cooked / reconstituted in accordance with directions ☒ Not Applicable

REHYDRATION RATE: (For example 10g of product + 100mL water = reconstituted product)

CARBOHYDRATE HAS BEEN DETERMINED BY

☐ Difference as defined in Standard 1.2.8 ☐ Available Carbohydrate as defined in Standard 1.2.8 ☐ Other - Specify ☒ Unknown

DATA SOURCE

☒ Analytical – e.g. Laboratory Tested Date Tested 2002

☐ Theoretical – e.g. By Calculation.
Please specify the source of data used for the theoretical calculations (e.g. Nuttab, AusNut, NZ Food Composition Tables etc) _____

4.2 DIETARY SUITABILITY

	(YES*/NO)	* IF YES, ADDITIONAL INFORMATION MUST BE INSERTED WHERE PROMPTED
Vegan Suitable	Yes	
Lacto Vegetarian Suitable	Yes	
Ovo Lacto Vegetarian Suitable	Yes	
Halal Suitable	Yes	Is this product Halal certified? Yes YES - Attach copy of valid certification
Kosher Suitable	Yes	Is this product Kosher certified? Yes YES - Attach copy of valid certification
Organic	No	Is this product Organic certified? Blank YES - Attach copy of valid certification

5 FOODS REQUIRING PRE MARKET CLEARANCE

5.1 NOVEL FOODS

	YES* / NO	* IF YES, ADDITIONAL INFORMATION MUST BE INSERTED WHERE PROMPTED
Does this product or any of its components contain any novel foods (Refer Standard 1.5.1 of the Code)	No	Specify novel food components: Specify conditions for use:

5.2 FOOD IRRADIATION / STERILISATION

Has this product or any of its components been treated with:	YES* / NO	* IF YES, ADDITIONAL INFORMATION MUST BE INSERTED WHERE PROMPTED
Steam Sterilisation	No	Specify treated ingredient/s:
Ionising Radiation	No	Specify treated ingredient/s:
Ethylene Oxide	No	Specify treated ingredient/s:
Other fumigants or sterilants	No	Specify fumigant/s or sterilant/s: Specify treated ingredients:

5.3 CONTAMINANTS & RESIDUES

This product complies with:	YES / NO
Standard 1.4.1 of the Code Contaminants & Natural Toxicants	Yes
In Australia Standard 1.4.2 of the Code Maximum Residue Limits in Food In New Zealand (Maximum Residue Limits of Agricultural Compounds) Mandatory Food Standard 1999 (and subsequent amendments) issued under sections 11C and 11Z of the Food Act 1981	Yes
Standard 1.4.3 of the Code Articles & Materials in Contact with Food	Yes
Standard 1.4.4 of the Code Prohibited & Restricted Plants & Fungi	Yes
What measures are in place to determine compliance with these requirements? **Approved Supplier Program and Raw material specifications.**	

FOOD INDUSTRY - PRODUCT INFORMATION FORM

AUSTRALIAN FOOD AND GROCERY COUNCIL

5.4 FOOD PRODUCED USING GENE TECHNOLOGY

5.4.1. Are there any ingredients in this product (including food additives, processing aids and enzymes), which contain or have been derived from genetically modified (GM) material or have been produced using, either directly or indirectly, of genetically modified substrates or genetically modified organisms? (Yes/No) No
If "yes", then go to 5.4.2.

If "no" specify how this has been verified

- ☐ No GM varieties of this food / ingredient available
- ☒ Non GM variety used
- ☐ Identity preservation program in place
- ☐ Analytical testing confirming absence
- ☒ Verifiable documentation
- ☐ Other – Specify ____

Go to Question 5.4.6 and continue

5.4.2. Does this product contain genetically modified novel DNA or novel protein? (Yes/No) Blank

5.4.3. The genetically modified components of this product are classified as: (*Select appropriate boxes*)

- ☐ GM food – containing novel DNA & /or novel protein - Complete table in 5.4.4
- ☐ GM food – containing DNA & or protein which is not novel – Complete table in 5.4.4
- ☐ GM food - highly refined to remove novel DNA & or novel protein – Complete table in 5.4.4
- ☐ GM food additives where novel DNA & or novel protein is present
- ☐ GM food additives where novel DNA & or novel protein is not present
- ☐ GM processing aids where novel DNA & or novel protein is present
- ☐ GM processing aids where novel DNA & or novel protein is not present
- ☐ Flavours used at no more than 1g/kg where GM novel DNA & or novel protein present
- ☐ Flavours used at greater than 1g/kg where GM novel DNA & or novel protein is present
- ☐ Enzymes originating from GM organisms where no novel DNA & or novel protein is present
- ☐ GM food unintentionally present at less than 10g/kg
- ☐ Other – specify ____

5.4.4. Are the GM components in this product approved for sale? (Yes/No) Blank

If "yes" List the GM food/s by their description in the Table to Clause 2 of Standard 1.5.2 of the Code

5.4.5. Do any of the GM components / derivatives of this product have altered characteristics? (Yes/No) Blank

If "yes" list the GM components and altered characteristics.	
GM COMPONENT	ALTERED CHARACTERISTICS

5.4.6. Does this product require labelling in accordance with Standard 1.5.2 Food Produced Using Gene Technology ? (Yes/No) No

If "no" explain why GM component is exempt from labelling.
Non GM raw material used

5.4.7. Does this product contain any ingredient derived from an animal or other organism, which has been fed GM feedstock? (Yes/No) No

5.4.8. Is this product manufactured or stored in a production site where genetically modified proteins or DNA are used for the manufacture of other products? (Yes/No) No

5.4.9. Is there an identity preservation system separating non GM and GM components to ensure the absence of Genetically modified material in this product? (Yes/No) No
Specify details

FOOD INDUSTRY - PRODUCT INFORMATION FORM

AUSTRALIAN FOOD AND GROCERY COUNCIL

6 PREPARATION, STORAGE PACKAGING & CODING INFORMATION

6.1 STORAGE & TRANSPORTATION

Recommended Storage Conditions	Unopened	Cool, dry conditions away from direct sunlight.
	Opened	
Shelf Life	Unopened	360 days from date of manufacture.
	Opened	
Recommended Transportation Requirements		
List potential handling or storage hazards. (Where hazards exist a MSDS must be attached)		

6.2 PACKAGING

Pack Size – Net Weight or Net Volume	20kg Carton
Target Fill Weight *(If applicable)*	
Drained Weight *(if applicable)*	

PACKAGING	UNIT	SHIPPER *(if applicable)*
Pack Type	Polythene bag	Fibre carton
Sealing Method	Knot tied on bag	Taped
Tamper Evidence		
Dimensions (H x W x D)		
General Packaging Requirements		

PALLET CONFIGURATION				
Gross weight per pallet (kg)	1000 maximum			
Units per shipper	1			
Shippers per pallet	50 maximum			
Pallet configuration	10	PER LAYER	5	LAYERS

6.3 CODING

General Coding information:

CODING	UNIT	SHIPPER *(If applicable)*
Barcode	EAN:	TUN:
Type of Code *(Best before date, use by date, date packed, Julian code, baked on code etc)*		Date of Manufacture
Method of Coding *(sticker, embossed, inkjet, stamped, etc)*		Stamped
Location of Code		Label
Size of Code (mm)		
Coding Format *(Insert an example of the coding format applied to the product)*		
Coding Translation		

AUSTRALIAN FOOD AND GROCERY COUNCIL

7 SPECIFICATIONS

Test Methods are mandatory and must quote AOAC methods or recognised independent Australian or International standards. Where a supplier's internal test method is quoted a copy must be attached.

7.1 PHYSICAL SPECIFICATIONS *(Examples may include particle size, shape, specific gravity, metal detection, foreign matter tolerances, physical defect tolerances etc as appropriate for the product)*

TEST / PARAMETER	SPECIFICATION	TEST METHOD	READILY AVAILABLE FOR INCLUSION on C of A
			Blank
			Blank
			Blank
			Blank
			Blank
			Blank
			Blank
			Blank
			Blank
			Blank
			Blank
			Blank

7.2 CHEMICAL SPECIFICATIONS

(Examples may include salt, acid, pH, moisture, brix, Aw, pesticide compliance etc as appropriate)

TEST / PARAMETER	SPECIFICATION	TEST METHOD	READILY AVAILABLE FOR INCLUSION on C of A
pH (5% sol.)	4.8-5.4	HM2-8.3	Yes
Salt	49.0%-52.0%	HM2-6.3	Yes
Protein	28.0%-31.0%	HM2-6.1	Yes
Moisture	Max 5.0%	HM2-6.5	Yes
			Blank
			Blank
			Blank
			Blank
			Blank
			Blank
			Blank
			Blank

7.3 ORGANOLEPTIC SPECIFICATIONS

(Examples may include flavour, colour, aroma, texture etc as appropriate for the product)

TEST / PARAMETER	SPECIFICATION	TEST METHOD	READILY AVAILABLE FOR INCLUSION on C of A
Taste	Intense savoury flavour.	4% solution.	Yes
Colour	Light tan	Visually, against known sample	No
Appearance	Dry, free flowing powder	Visually, against known sample	No
			Blank
			Blank
			Blank
			Blank
			Blank
			Blank
			Blank

7.4 MICROBIOLOGICAL SPECIFICATIONS

(Examples may include standard plate count, yeasts & moulds, coliforms, salmonella, listeria, etc as appropriate)

TEST / PARAMETER	SPECIFICATION	TEST METHOD	READILY AVAILABLE FOR INCLUSION on C of A
Standard Plate Count	<7500/g	AS1766.2.1-1991	No
Coliforms	<10/g	AS1766.2.3-1992	No
Salmonella	ND/25g	VIDAS	No
Yeast and Mould	<50/g	AS1766.2.2-1997	No
			Blank
			Blank
			Blank
			Blank
			Blank
			Blank
			Blank
			Blank

8 COMMENTS / ADDITIONAL INFORMATION

Insert comments here

Return to Section 1.4. to complete the checklist and sign Section 1.5 "Supplier Declaration and Warranty"

PRODUCT SPECIFICATION and NUTRITIONAL DATA

Muntons
Malted Ingredients

NUT BROWN FLOUR

25kg Paper Sack

Muntons Material Code:	80562
Description:	A flour produced by milling crystal malted barley.
Appearance:	Light to medium brown flour.
Odour:	Pleasant and characteristic of roasted cereal.
Taste:	Characteristically roasted, slightly bitter and slightly sweet.
Ingredient Declaration:	Crystal Malted Barley
Allergen Information:	Contains Gluten
Suggested Ingredient Declaration for Retail Product Labelling:	Barley Malt Flour

Analytical Specification:

Moisture %	≤ 7
Wort Colour, IoB (515ml mash)	120 to 175 EBC

Microbiological:

Muntons do not apply microbiological specifications to mill products

Nutritional Information:

Typical Values Per 100g

Energy	330	kcal
	1408	kj
Moisture (loss on drying)	3.1	g
Total Carbohydrate (by difference)	81.6	g
Available Carbohydrate (by difference)	66.2	g
Total Sugars (expressed as Glucose)	7.3	g
Total Dietary Fibre (AOAC)	15.4	g
Protein (N x 6.25)	10.7	g
Fat (Acid Hydrolysis)	2.7	g
Saturated Fatty Acids	1.34	g
Monounsaturated Fatty Acids	0.51	g
Polyunsaturated Fatty Acids	0.73	g
Ash	1.9	g
Sodium	6.50	mg

Nutritional values are for information only and do not indicate a specification parameter or a guarantee of composition.

Issue:	1 *(New Format)*	Compiled by:	S. Brown
Date:	29/01/2009	Position:	Technical Sales Support

FOOD INDUSTRY - PRODUCT INFORMATION FORM

VERSION 5.0 - released 10 February 2012

1 CONTACT DETAILS & DECLARATION

SUPPLIER'S PRODUCT NAME	Grade 27 Solar Salt	SPECIFY COUNTRY IMPORTED INTO	
SUPPLIER'S PRODUCT CODE	102271653	SPECIFY COUNTRY EXPORTED FROM	
BARCODE - UNIT GTIN	9416872200546	SPECIFY IMPORT TARIFF CODE	

1.1 SUPPLIER INFORMATION

	COMPANY NAME	Dominion Salt Ltd			
	BUSINESS NUMBER (ABN)	?			
	TRADING NAME	Dominion Salt Ltd			
BUSINESS ADDRESS	NUMBER / STREET / SUBURB	89	Totara Street	Mt Maunganui	
	STATE / COUNTRY / POST CODE	Bay of Plenty	New Zealand	3116	
POSTAL ADDRESS	POST ADDRESS / SUBURB	PO Box 4249		Mt Maunganui South	
	CITY / COUNTRY / POST CODE	Bay of Plenty	New Zealand	3149	
KEY CONTACT FOR QUERIES	NAME	Brent Cunliffe			
	POSITION TITLE	Quality Manager			
	EMAIL ADDRESS	brent.cunliffe@domsalt.co.nz			
	PHONE	07 575 6193	FAX	07 575 3017	
	DATE FORM COMPLETED	29-April-2013	ISSUE DATE	29-April-2013	
	DOCUMENT NO:	N/A	ISSUE NUMBER	2	

1.2 MANUFACTURING INFORMATION

Provide details where the manufacturer or site location differ to above:

	COMPANY NAME			
SITE: #1	NUMBER / STREET / SUBURB			
	STATE / COUNTRY / POST CODE			
	COMPANY NAME			
SITE: #2	NUMBER / STREET / SUBURB			
	STATE / COUNTRY / POST CODE			
	COMPANY NAME			
SITE: #3	NUMBER / STREET / SUBURB			
	STATE / COUNTRY / POST CODE			

If more than three manufacturing sites, provide additional site information in Section 8.2

1.3 CONTACT DETAILS FOR TECHNICAL & ALLERGEN INFORMATION

Please specify the contact details if further information related to technical or allergen information is needed:

NAME	Brent Cunliffe		
JOB TITLE	Quality Manager		
EMAIL	brent.cunliffe@domsalt.co.nz		
TELEPHONE - WORK	07 574 5794 ext 739	TELEPHONE - MOBILE	

1.4 SUPPLIER DECLARATION AND WARRANTY

The Supplier -

1) certifies that this product complies with the Australia New Zealand Food Standards Code; and, in addition to the information provided specifically in this form, and without limitation to compliance with any other part of the Code, that the product complies with:

(a) Standard 1.3.4 - Identity and Purity
(b) Standard 1.4.1 - Contaminants & Natural Toxicants
(c) Standard 1.4.2 - Maximum Residue Limits in Food (In Australia), or
(d) Maximum Residue Limits of Agricultural Compounds, Mandatory Food Standard 1999 (and subsequent amendments) issued under sections 11C and 11Z of the Food Act 1981 in New Zealand
(e) Standard 1.4.3 - Articles & Materials in Contact with Food
(f) Standard 1.4.4 - Prohibited & Restricted Plants & Fungi

where applicable, and that where such certification relies on third party audits, analysis, industry codes, or equivalence of international standards to demonstrate compliance, that certificates are current and available;

2) acknowledges that the Customer, and Supply Chain Customers of the Customer, will rely on the accuracy of the Product Information for food quality, safety and labelling purposes;

3) certifies that the accuracy of the Product Information is limited to the following degree: –

(a) that the Product Information in relation to ingredients obtained from a third party relies in good faith on Product Information provided by that third party;
(b) that the information is, to the best of the supplier's knowledge (having undertaken all reasonable verification procedures), true and accurate in relation to all other substances and processes;

4) agrees that all Product it supplies to the Customer will conform with the Product Information unless otherwise agreed to in writing and in advance by the Customer;

5) will immediately inform the Customer (and confirm in writing as soon as possible) if the supplier becomes aware of any error or omission in the Product Information;

6) will inform the Customer in writing and in advance of any change to the Product Information provided herein (including any changes that result from new or modified processes) if and when the supplier becomes aware of such changes; and

7) acknowledges that the Customer may provide the Product Information to –

(a) regulatory agencies in relation to any matter raised by such agencies;
(b) courts and other legal tribunals for the purposes of any proceedings; and
(c) to its related businesses and partners who are involved in the acquisition, use, sale or compliance of the Product, under this same restriction as to disclosure.

but will otherwise NOT disclose the Product Information.

8) acknowledges that, subject to the prior written agreement of the supplier and any restrictions nominated by the supplier in regard to disclosure of confidential information, the Customer may provide the Product Information to its own customers subject to those customers ensuring the information is not further disclosed.

COMPANY NAME Signed for and on behalf of	Dominion Salt Ltd
NAME (Please print)	Matt Ford
JOB TITLE (Please print)	Account Manager
AUTHORISED SIGNATURE	MFord
DATE OF AUTHORISATION	29-April-2013

1.5 CUSTOMER DETAILS (WHERE KNOWN)

COMPANY NAME			
NUMBER / STREET / SUBURB			
CITY / COUNTRY / POST CODE			
CUSTOMER CONTACT NAME			
CUSTOMER'S PRODUCT NAME			
CUSTOMER'S PRODUCT CODE			

Customer Internal Use Only			
Internal Product Code/Description			
Version No.			
Reason for Update			
Received and Reviewed By			
Approved [Yes / No]	_	**Date:**	
Signature:	**Insert signature here**		

1.6 DEFINITIONS / REFERENCES

References to the "Code" or specific "Standards" throughout this document refer to the standards outlined in the Australia New Zealand Food Standards Code. The Australia New Zealand Food Standards Code can be viewed at: http://www.foodstandards.gov.au/foodstandardscode/

The AFGC provides some industry guides, specifically on how to apply date marking, and the AFGC Allergen Management and Labelling Guide which are available from the AFGC website: http://www.afgc.org.au/

Additional related documents on allergen management and VITAL (Voluntary Incidental Trace Allergen Labelling) documents can be viewed at: http://www.allergenbureau.net/vital/

1.7 CHECKLIST AND ATTACHMENTS

- X **Page 2 has been signed and dated (Section 1.4)**
- X Current Certificates attached - if applicable (Section 3.2.3 and Section 5.2)
- Supplier C of C, or C of A for analysis - if applicable (Section 7)
- X Other associated documents attached as requested by the customer (e.g. MSDS, HACCP certification, product specification, and related documents)

1.8 Status of completion for each section:

COMPLETED	Section 1 - Contact details and declaration
COMPLETED	Section 2 - Product Information & Ingredients
COMPLETED	Section 3 - Compositional information
COMPLETED	Section 4 - Foods requiring pre-market clearance
COMPLETED	Section 5 - Nutrients & consumer information claims
COMPLETED	Section 6 - Product shelf life, storage & packaging
COMPLETED	Section 7 - Chemical, microbial, organoleptic & physical specifications
COMPLETED	Section 8 - Additional comments

Check Box if help is needed identify mandatory sections of form which have NOT been completed:

2 PRODUCT INFORMATION & INGREDIENTS

2.1 PRODUCT DESCRIPTION (Physical and technological description)

Fine food grade sodium chloride, Solar Salt.

2.2 LEGAL DESCRIPTION / SUGGESTED LABELLING DESCRIPTION

Salt (Sodium Chloride)

2.3 PRODUCT APPLICATION AND INTENDED USE

2.3.1 Specify the intended use of the product

Food supplied as an ingredient for use in further manufacturing or processing

2.3.2 Specify which best describes the product

Solid, semi-solid or powder substance, intended for use in further preparation

2.4 COUNTRY OF ORIGIN

2.4.1 Specify the most appropriate overarching country of origin declaration which applies to this product :

Declaration:	Country:
Product of	New Zealand

2.4.2 Indicate if the local content of ingredients/components originating from New Zealand on average exceeds 95% **Yes** Yes/No

2.4.3 Are the primary components, from which this product is made or derived, sourced from more than one country? **No** Yes/No

2.4.4 Indicate if the following apply in determining country of origin declaration in 2.4.1:

The IMPORTED COMPONENTS have undergone substantial transformation		Yes/No
The PRODUCT has undergone substantial transformation		Yes/No
50% or more of total product costs are incurred in the country stated		Yes/No
Essential characteristic of the product is the result of local processing conditions		Yes/No

2.5 COMPONENT TYPE

Specify the type of the components present in product (Tick ONLY ONE check box below)

- [X] product is **a single component** substance
- [ ] product contains ingredients, which may include **compound** substances
- [ ] product consists of various ingredients which are **NOT compound** substances

2.6 INGREDIENT DECLARATION

Specify all ingredients including food additives in descending order, including percentage labelling of characterising components or ingredients. Compound substances must specify all ingredients and additives present and the characterising ingredient or component. Food additives must specify a functional class name and the food additive name or code number [e.g. antioxidants (304, 306), or food acid (citric)]

How many components are in this product? 1

COMPONENT NAME	PERCENT OF TOTAL %
Sodium Chloride	100.00%

2.6 INGREDIENT DECLARATION INCLUDING PERCENTAGE LABELLING (continued)

COMPONENT NAME	PERCENT OF TOTAL %

2.7 PROCESSING AIDS

Specify all processing aids used in the manufacture of this product not otherwise declared in the ingredient list.

NAME OF PROCESSING AID	FSC ADDITIVE NUMBER OR EC *(as applicable)*	PERMITTED USE AND CLASS NAME
Sodium Ferrocyanide	E-535	Anti-caking agent (max 50mg/kg)

3 COMPOSITIONAL INFORMATION

3.1 MANDATORY ADVISORY OR WARNING STATEMENTS & DECLARATIONS

(" Yes" response triggers a mandatory advisory or warning statement. Refer Standard 1.2.3 of the Code)

FOOD / COMPONENT	PRESENT YES / NO
Bee pollen presented as a food or ingredient	No
Propolis presented as a food or ingredient	No
Unpasteurised milk and unpasteurised liquid milk products	No
Aspartame or aspartame-acesulphame salt (or phenylalanine)	No
Unpasteurised egg products	No
Quinine	No
Kola beverages containing added caffeine	No
Guarana or extracts of guarana	No
Phytosterol esters	No
Tall oil phytosterols.	No
Cereal-based beverages, where these foods contain no more than 2.5% m/m fat and less than 3% m/m protein, or less than 3% m/m protein only.	No
Evaporated and dried products made from cereals, where these foods contain no more than 2.5% m/m fat and less than 3% m/m protein, or less than 3% m/m protein only, as reconstituted according to directions for direct consumption.	No
Milk, and beverages made from soy or cereals, where these foods contain no more than 2.5% m/m fat.	No
Evaporated milks, dried milks and equivalent products made from soy or cereals, where these foods contain no more than 2.5% m/m fat as reconstituted according to directions for direct consumption.	No
Royal jelly presented as a food or ingredient	No
Polyols, Isomalts, Polydextrose (Lactitol, Maltitol, Maltitol syrup, Mannitol, Xylitol, Erythritol, Isomalt, Polydextrose, Sorbitol)	No

3.2 ALLERGEN MANAGEMENT & CONTROL Yes/No

3.2.1 Does the facility have a Food Safety Program? **Yes**

3.2.2 Does the facility have a documented allergen management plan? **No**

IF NO, SPECIFY DATE to implement allergen management plan: N/A

3.2.3 Has the Food Safety Program been independently audited and certified? **Yes**

If Yes provide name of Certifying Body: Asure Quality

Date of most recent audit / inspection: 27-September-2012 Provide copy of certificate

3.2.4 Indicate if any of the following is applied in order to manage allergens and minimise allergen cross contact within the manufacturing facility: *(Select all appropriate checkboxes)*

- [ ] validated cleaning procedures
- [ ] control of personnel movement in factory
- [ ] documented procedures and controls
- [ ] raw material sourcing & tracing
- [X] other: No Allergens on site
- [ ] production scheduling
- [ ] staff training
- [ ] isolated storage of allergens
- [ ] dedicated equipment

3.3 INGREDIENTS TO BE DECLARED AS ALLERGENS OR SULPHITE

Please insert **YES** or **NO** to indicate if the product contains, or was manufactured using, any ingredient, additive or processing aid which has been derived from the following food sources. Highly processed derivatives must always be declared. Carefully assess compound ingredients for hidden allergens. [** Lupin included as a possible future addition to the Food Standards Code.]

Yes/No	
No	**Cereals containing gluten** & their products [*wheat, rye, barley, oats, spelt*]
No	**Crustacea** & crustacea products
No	**Egg** & egg products
No	**Fish** & fish products (including mollusc with or without shells and fish oils)
No	**Lupin** & lupin products [** not a mandatory labelling allergen at this time]
No	**Milk** & milk products
No	**Peanut** & peanut products
No	**Sesame seed** & sesame seed products
No	**Soybean** & soybean products
No	**Tree nuts** & tree nut products
	Reserved for future allergen - left blank intentionally

No	**Sulphites,** present **in** ingredients, additives or processing aids

3.3.1 Complete all coloured rows corresponding with "YES" declaration provided above.

ALLERGENIC SUBSTANCE	SOURCE NAME The allergenic food from which ingredient is derived (e.g. wheat)	DERIVATIVE NAME Ingredient, additive or processing aid (e.g. maltodextrin)	PROPORTION (%)		PROCESS Allergenic protein is removed?
			Derivative in product	Protein in derivative	
Cereals containing gluten and their products [wheat, rye, barley, oats, spelt & derived product e.g. wheat maltodextrin]					
Crustacea & crustacea products					
Egg & egg products					
Fish & fish products (including mollusc extract and fish oils)					
Lupin & lupin products					
Milk & milk products					
Peanut & peanut products (including peanut oil)					
Sesame Seed & sesame seed products (including sesame oils)					
Soybean & soybean products (including soybean oils)					
Tree nuts & tree nut products					
Reserved for future allergen					

3.4 ALLERGEN CROSS CONTACT

Yes/No

3.4.1 Except for any allergens listed in Section 3.3, does your company have on site and handle ANY OTHER allergenic substances listed below? **No**

IF NO, specify "No" to indicate allergens are NOT IN THE SAME FACILITY then go to Section 3.4

***Refer to VITAL procedure and decision tree.* http://www.allergenbureau.net/vital/

3.4.2 All columns must be completed WHERE HIGHLIGHTED

ALLERGENIC SUBSTANCE	PRESENT IN SAME FACILITY Yes/No	PRESENT ON SAME LINE Yes/No	SOURCE FOOD The allergenic food from which ingredient is derived (e.g. wheat)	DERIVATIVE NAME Ingredient, additive or processing aid (e.g. maltodextrin)	TOTAL PROTEIN** protein level by VITAL , or specify "particulate" mg/kg
Cereals containing gluten & their products	No				
Crustacea & crustacea products	No				
Egg & egg products	No				
Fish & fish products (inc mollusc & oils)	No				
Lupin & lupin products	No				
Milk & milk products	No				
Peanuts & peanut products (inc peanut oil)	No				
Sesame Seed & sesame products	No				
Soybeans & soybean products (inc soybean oil)	No				
Tree nuts & tree nut products	No				
Reserved for future allergen					

IF NO, Provide appropriate precautionary statement for this product in box below:

Salt is not a listed allergen

3.5 INTERNATIONAL ALLERGEN, LABELLING & INFORMATION REQUIREMENTS

FOOD / COMPONENT		PRESENT (Yes/No)	NAME OF FOOD (e.g. apple)	DERIVATIVE NAME (e.g. cider vinegar)
Gelatine	beef - collagen	**No**		
	other source	**No**		
Seafood products	Algae/carrageenan	**No**		
	Shellfish (Mollusc)	**No**		
Fungi	Matsutake mushroom	**No**		
	Other mushroom	**No**		
Fruits	Avocado	**No**		
	Banana	**No**		
	Pome fruit - apples, pears	**No**		
	Stone fruit - cherry, peach, plum, apricot	**No**		
	Berry Fruits - blueberry, kiwifruit, strawberry	**No**		
	Citrus Fruits - grapefruit, lemon, lime, orange	**No**		
Grains, Seeds, Nuts & Spices	Buckwheat	**No**		
	Coconut, poppy, sunflower, etc	**No**		
	Mustard	**No**		
Vegetables	Tomato	**No**		
	Yam	**No**		
	Allium genus - chive, leek, onion, garlic, spring onion	**No**		
	Legumes - other than peanut soybeans & lupins	**No**		
	Umbelliferae - aniseed, carrot, celery, celeriac, chervil, cumin, dill, coriander, fennel, parsley, parsnip	**No**		
Yeast & Yeast Products *(including yeast extracts)* *Tick box if hydrolysed or autolysed*		**No**		
Herbs *Tick box if herb / herb extract*		**No**		
Spice *(excluding mustard)* *Tick box if spice / spice extract*		**No**		

3.6 ADDITIONAL LABELLING & INFORMATION REQUIREMENTS

FOOD / COMPONENT		PRESENT (Yes/No)	ADDITIONAL INFORMATION TO BE PROVIDED WHERE PROMPTED		
Antioxidants	Butylated hydroxyanisole (BHA)	No	amount added (milligram/kilogram)		
	Butylated hydroxytoluene (BHT)	No	amount added (milligram/kilogram)		
	Other antioxidants	No	Specify type:		
			amount added (milligram/kilogram)		
Added Caffeine *(exclude naturally occurring)*		No	amount added (milligram/kilogram)		
Alcohol (Residual)		No	level % v/v:		
			specific gravity if product is alcohol:		
Added Fats & Oils	Animal	No	Specify types of fats and oils:		
			Has fatty acid composition been altered?		Yes/No
			Specify the process used to alter composition:		
	Vegetable	No	Specify types of fats and oils:		
			If Palm oil is present, is this RSPO certified?		Yes/No
			Has fatty acid composition been altered?		Yes/No
			Specify the process used to alter composition:		
Hydrolysed Vegetable Proteins	Acid Hydrolysed	No	Specify type of vegetable protein:		
			100% hydrolysis		
	Enzyme Hydrolysed	No	Specify type of vegetable protein:		
			100% hydrolysis		
Intense sweetener		No	Name of sweetener	Number	Amount (mg/kg)
Preservatives		No	Name of preservative	Number	Amount (mg/kg)
Flavour enhancers		No	Name of flavour enhancer	Additive number	
Added Colours		No			
Added Flavours		No			
Added Salt		Yes	amount added (milligram/100g)	100000.00	
Added Sugar		No	amount added (gram/100g)		

ANY OTHER COMPONENT	List specific component:		Provide relevant details necessary for consumer advice:

3.7 QUARANTINE & IMPORT/EXPORT INFORMATION REQUIREMENTS

FOOD / COMPONENT	PRESENT (Yes/No)	ADDITIONAL INFORMATION TO BE PROVIDED WHERE PROMPTED	
Animal & Animal products (e.g. animal flesh, organs, stock, gelatine, animal fat, tallow, milk, collagen from skin and / or hides etc)	**No**	Specify type of animals	
		Specify type of animal derivatives	
		Specify country/ies of origin	
		Describe any heat processing used in the manufacture of this product (temperature/time):	
Meat & Meat products (e.g. animal flesh, animal organs, meat extracts)	**No**	Specify type of animals *(tick appropriate box)*	
		Specify type of meat derivatives	
		Specify source of meat products (i.e. Country and city):	
		Describe any heat processing used in the manufacture of this product (temperature/time):	
		How do you ensure products are derived from animals free of bovine spongiform encephalopathy (BSE)?	
Bird & Bird products (e.g. meat, fat, eggs, extracts, feathers, feet, etc.)	**No**	Specify type of birds *(tick appropriate box)*	
		Specify type of bird derivatives	
		Specify source of bird products (i.e. Country and city):	
		Describe any heat processing used in the manufacture of this product (temperature/time):	
Fish & Fish products (e.g. smoked salmon, pilchards, shark fin, fish roe, etc)	**No**	Specify type of fish:	
		Specify type of fish derivatives	
		Specify source of fish products (i.e. Country and city):	
		Describe any heat processing used in the manufacture of this product (temperature/time):	
Honey & Honey products	**No**	Specify type of honey or honey derivatives	
		Specify source of honey products (i.e. Country and State):	
		Describe any heat processing used in the manufacture of this product (temperature/time):	

4 FOODS REQUIRING PRE-MARKET CLEARANCE

4.1 NOVEL FOODS (Refer Standard 1.5.1 of the Code)

4.1.1 Is this product (or any of its components) listed as a novel food in the standard? **No** Yes/No

4.2 QUARANTINE TREATMENTS

Specify if this product (or any of its components) has been treated with the following:

TREATMENT METHOD	USED ON ANY COMPONENT	SPECIFY TREATED INGREDIENT
Steam sterilisation	No	
Ionising (gamma) irradiation	No	
Ethylene oxide	No	
Other fumigants or sterilants	No	

4.3 FOOD PRODUCED USING GENE TECHNOLOGY (Standard 1.5.2)

4.3.1 Are there any ingredients (including food additives, processing aids and enzymes) in this product that come from genetically modified (GM) plants or animals, or are the result of synthesis by GM micro-organisms, but with the exemption of use of GM feedstock? **No** Yes/No

IF NO, specify which of the following are applicable:

- [X] No GM varieties of this food / ingredient available
- [ ] Non GM variety is used
- [ ] Identity preservation program in place
- [ ] Analytical testing confirms absence
- [ ] Verifiable documentation of status
- [ ] Other – Specify

Go to Question 4.3.7 and continue

GM CROSS CONTAMINATION IN FOODS AND INGREDIENTS **Yes/No**

4.3.7. Is this a raw/bulk commodity which is transported by freight/tanker AND where the freight/tanker could have previously been used to transport other GM product? **No**

4.3.8. Is this product manufactured or stored at a production site where genetically modified protein or DNA is used for the manufacture of other products? **No**

4.3.9. Is there an identity preservation system separating non GM and GM components to ensure the absence of genetically modified material in this product?

Specify details:

4.3.10. Has Polymerase Chain Reaction (PCR) testing for GM materials been carried out? **No**

4.3.11. Is any GM food or GM ingredient unintentionally present at MORE THAN 10g/kg **No**

4.3.12. (OPTIONAL) Are any ingredients derived from an animal which has been fed with feedstock containing GM ingredients or ingredients derived from GM micro-organisms? **No**

Specify details:

5 NUTRIENTS & CONSUMER INFORMATION CLAIMS

5.1 NUTRITION INFORMATION

5.1.1 Serve size is not relevant for this product.

5.1.2 For nutrition information below, please specify the **UNITS of measure**: [X] grams

Complete nutrient table below. Mandatory nutrients highlighted in blue and bolded, others optional.

NUTRIENT	AVG QUANTITY per 100 g
Energy	0 kJ
Protein, total	0 g
- Gluten	0 mg
Fat, total	0 g
- saturated	0 g
- transfat	0 g
- polyunsaturated	0 g
- monounsaturated	0 g
Cholesterol	0 mg
Carbohydrate	0 g
- sugars	0 g
Dietary fibre, total	0 g
Sodium	39100 mg
Potassium	10 to 20

Nutrient information is relevant to product AS SUPPLIED

DO NOT leave bolded NIP fields blank. Use numbers, or text "less than" with value; or "unavailable" or "not detected" for gluten.

5.1.3 Additional nutrients - vitamins, minerals and other nutritive substances

Specify only one target population for product *(selection ONLY ONE check box)* :

[X] **Adults** [ ] **Young Children** [ ] **Infants**

VITAMINS specify which vitamin	AVG QUANTITY per 100 g

MINERALS specify which minerals	AVG QUANTITY per 100 g

NOTE: there is no permission to FORTIFY foods with this substance indicated with **

Insert any other nutrient or biologically active substance

NAME OF SUBSTANCE	AVG QUANTITY per 100 g	%RDI / serve

5.1.4 Please provide the following analytical data:

% Ash	99.98%
% Moisture	0.02%

Estimation content accounted for per 100 g: **N/A**

5.1.5 Please specify how the carbohydrate value has been determined:

[X] Difference as defined in Standard 1.2.8 [ ] Available Carbohydrate as defined in Standard 1.2.8 [ ] Other - specify: [ ] Unknown

5.1.6 Please nominate the source used to provide nutrition data in the tables above

Analytical – e.g. Laboratory Tested [ ] Theoretical – e.g. By Calculation. [X]

Please specify the source of data used for the theoretical calculations (e.g. Nuttab, AusNut, NZ food tables, etc)

NZ food tables

5.2 SUITABILITY TO MAKE CERTAIN CLAIMS

Specify if the product is suitable for use in product intended for the following consumer uses.

SPECIFY IF SUITABLE FOR ...	Yes / No	HOW HAS THIS BEEN VALIDATED?	CERTIFICATE AVAILABLE (Yes/No)
Halal	Yes	Certified by FIANZ	Yes
Kosher	Yes	Certified by Rabbinate of AHC	Yes
Organic	No		
Biodynamic	No		
Ovo-lacto-vegetarian	Yes	Product assessment	No
Lacto-vegetarian	Yes	Product assessment	No
Vegan	Yes	Product assessment	No

A copy of relevant certificates must be provided as attachments to form

PRODUCT SUITABILITY FOR ...	Yes / No	SPECIFY PARTICULAR CLAIMS	HOW IS CLAIM VALIDATED?
"Free" claims	No		
Sustainability claims	No		
Humane treatment	No		
Any other claims	No		

6 DURABILITY, PACKAGING AND SUPPLY CHAIN

6.1 SHELF LIFE

6.1.1 Please complete the following details:

	PRODUCT AS SUPPLIED unopened pack or bulk container		PRODUCT - ONCE IN USE resealable pack or bulk container	
Specify shelf life	5	Years	5	Years
Temperature control during storage	Is required ?	No	Is required ?	No
			Specify range:	
Temperature control during transport	Is required ?	No		
Specify any OTHER storage requirements:				

6.1.2 Specify the type of date mark to be used: **Date packed**

Please provide details as appropriate in Section 6.5 - Tracking

6.2 POTENTIAL HAZARDS

6.2.1 Are there any potential hazards associated with the product ? **No** Yes/No

6.3 TRANSPORT

How is product transported and packaged? Packaged for catering/manufacturing supply

6.4 TRADE MEASUREMENT

6.4.1 Specify which method of trade measurement is used: **Average quantity**

6.4.2 What is the package size	25.00	kg	(specify unit of measure)
6.4.3 Target Fill (if applicable)	25.10	kg	(specify unit of measure)
6.4.4 Drained Weight (if applicable)			(specify unit of measure)

6.4.5 IF AQS is used, what is the statistical variance in the fill measurement?

6.5 TRACEABILITY

Please provide any general comments about the traceability coding used on the product:

Batch number is manufacture date and is traceable through internal records

Please specify the following where applicable:

TRACKING CODE	UNIT				SHIPPER (if applicable)			
Type of Primary Coding (*Please TICK as appropriate*)	X	Date code		Batch number		Date code		Batch number
		Product code		Lot number		Product code		Lot number
Method of coding	Inkjet							
Location of code	Side							
Number of characters in code	8.00							
Example of coding format	02 12 10MM							
Coding translation	2/12/10 Mount Maunganui							

6.6 PRODUCT PACKAGING

6.6.1 Are tamper evident controls included in the packaging design? **Yes** Yes/No

6.6.2 Has unit packaging been assessed for migration of substances into food? **Yes** Yes/No

6.6.3 Are engineered nanoparticles present in unit packaging? **No** Yes/No

6.6.4 Are you a signatory to relevant packaging stewardship in Australian or NZ ? **No** Yes/No

6.6.5 Provide a general description of unit packaging:

Polyethylene bag

6.6.6 Complete the following table for questions related to packaging of unit package and/or shipper

PACKAGING		UNIT	SHIPPER
Type	Packaging format	bag	
Specify components / material used in packaging	Ceramic	No	
	Glass	No	
	Metal	No	
	Paper / cardboard	No	
	Packing materials	No	
	Plastics	Yes	
	Specify plastic coding symbol number		
	% of total using recycled component		
Seal	What is the seal method?	heat	
Dimensions	Height (mm)	680	
	Width (mm)	100	
	Depth (mm)	320	

6.7 PALLET CONFIGURATION

6.7.1 Gross weight of loaded pallet 1240.0 kg

6.7.2 Stack height of loaded pallet cm

6.7.3 Specify the type of pallet [X] Wooden [ ] Plastic [ ] Other

6.7.4 What is the pallet pattern [ ] Column stack [X] Interlocking

6.7.5 Number of : units per shipper 1 shippers per pallet 48

layers per pallet 6

7 SPECIFICATIONS FOR COMPLIANCE

Test Methods are mandatory and must quote AOAC methods or recognised independent Australian or International standards. Where a supplier's internal test method is quoted a copy must be attached. Also state if Certificate of Analysis (C of A) or Certificate of Conformance (C of C) can be provided.

7.1 ORGANOLEPTIC SPECIFICATIONS

(Examples may include flavour, colour, aroma, texture etc)

TEST / PARAMETER	SPECIFICATION	TEST METHOD	AVAILABILITY	
			C of A	C of C
Flavour	Typical Salty taste	taste	No	No
Appearance	White, Fine Crystals	Visual	No	No

7.2 PHYSICAL SPECIFICATIONS

(Examples may include particle size, shape, specific gravity, metal detection, foreign matter tolerances, physical defect tolerances etc as appropriate for the product)

TEST / PARAMETER	SPECIFICATION	TEST METHOD	AVAILABILITY	
			C of A	C of C
Passing 0.71mm	Typically 80-100%	ISO2591-1	No	Yes

7.3 MICROBIOLOGICAL SPECIFICATIONS

(Examples may include standard plate count, yeasts & moulds, coliforms, salmonella, listeria etc)

TEST / PARAMETER	SPECIFICATION	TEST METHOD	AVAILABILITY	
			C of A	C of C
N/A				

7.4 CHEMICAL SPECIFICATIONS

(Examples may include pesticide residue screen, antibiotic residue screen, heavy metal screen, aflatoxins screen, salt, acid, pH, moisture, brix, Aw, Nutrition Information Test, etc)

TEST / PARAMETER	SPECIFICATION	TEST METHOD	AVAILABILITY C of A	AVAILABILITY C of C
Sodium Chloride	97% min		No	No
Moisture	<0.05%	ISO 2483	No	Yes
Cadmium	0.5mg/kg Max	EuSalt/AS 011-2005	No	Yes
Arsenic	0.5mg/kg Max	EuSalt/AS 013-2005	No	Yes
Lead	2mg/kg Max	EuSalt/AS 014-2005	No	Yes
Mercury	0.1mg/kg Max	EuSalt/AS 012-2005	No	Yes
Anticake 535	50mg/kg Max	ISO 2479	No	Yes

8 COMMENTS / ADDITIONAL INFORMATION

8.1 Do you have any comments or additional information ? **No** Yes/No

Question Number	Line Number	Comments

8.2 ADDITIONAL MANUFACTURING SITE INFORMATION (if required)

When nominating product is supplied from more than one manufacturing site, the details provided must be applicable to product coming from any of the sites. For example, if particular allergens occur at only one site then the information provided in the form should identify that the allergens are present even though batches of product made at other sites may be allergen free.

	COMPANY NAME			
SITE: #4	NUMBER / STREET / SUBURB			
	STATE / COUNTRY / POST CODE			
	COMPANY NAME			
SITE: #5	NUMBER / STREET / SUBURB			
	STATE / COUNTRY / POST CODE			
	COMPANY NAME			
SITE: #6	NUMBER / STREET / SUBURB			

A 1.6 Seasoning specifications for 3G snack

Givaudan

Product Regulatory Information Rev 2.1 Date: 24.07.15

TOMATO SALSA FLAVOUR
QF13045

1. DESCRIPTION: An orange free flowing powder with characteristic flavour.

2. REGULATORY STATUS: ☐ Natural Flavour ☒ Flavour

containing : ☒ Natural flavouring substances and/or complexes
☒ Synthetic flavouring substances
☒ Thermal process flavouring
☐ Smoke Flavouring

(According to the definition of the International Organisation of the Flavour Industry-IOFI)
This flavour complies with the Australia and New Zealand Food Standards Code.

3. MANDATORY ALLERGEN DECLARATION & ADVISORY STATEMENTS:

Allergens:	**Present Yes/No**
Cereals containing gluten and product of these (Wheat, Rye, Barley, Oats, Spelt)	Wheat
Dairy and Dairy Products	Yes
Egg and Egg Products	No
Fish and Crustacea and their Products	No
Peanut and Peanut Extracts	No
Nut and Nut Extracts (ie: Cashew, Almond, Macadamia, Pecan, Hazelnut, and Brazilnut)	No
Sesame and Sesame Seed Products	No
Soybean and Soybean Products	Yes
Sulphur Dioxide and Sulphites > 10ppm	No

Mandatory Advisory Statements:	**Present**
Bee Products: bee pollen, propolis, royal jelly	No
Aspartame	No
Caffeine or Guarana	No

As defined in standard 1.2.3 of Australia and New Zealand Food Standards Code

4. GM STATUS: Non – GM
This flavour does not require labeling according to Standard 1.5.2 of the Australia New Zealand Food Standards Code.

5. DIETARY: Halal suitable - Yes
Vegan suitable - No

Givaudan Australia Pty Limited ABN# 87 000 470 280
12 Britton St Smithfield NSW 2164, Australia
Tel: 61 (2) 9827 4000
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TOMATO SALSA FLAVOUR
QF13045

6. NUTRITIONAL ESTIMATES:

Component	Percentages
Energy	1200 kJ/100g
Protein	7 % wt
Fat, Total	<2 % wt
Fat, Saturated (Short Chain)	<1 % wt
Carbohydrate, Total	56 % wt
Sugars, Total	44 % wt
Dietary Fibre	3 % wt
Sodium	9200 mg/100g

(Theoretical values calculated using FSANZ, FDA and supplier documentation)

7. COMPOSITION:

Sugar	25 – 50%
Lactose	10 – 25%
Salt	10 – 25%
Onion powder	5 – 10%
Hydrolysed corn protein	5 – 10%
Sodium diacetate 262(ii)	2 – 5%
Garlic powder	2 – 5%
Tomato powder	2 – 5%
Natural flavouring complexes	2 – 5%
Spice	2 – 5%
Corn maltodextrin	2 – 5%
Soy sauce powder	< 2%
Citric acid 330	< 2%
Herbs	< 1%
Colour (paprika extract 160c,caramel 150c)	< 1%
Thermal process flavouring(s)	< 1%
Disodium guanylate 627	< 1%
Disodium inosinate 631	< 1%
Silicon dioxide 551	< 1%
Synthetic flavouring substance(s)	< 1%
Natural flavouring substance(s)	< 0.1%

Please consult relevant country legislation for end product labelling.

Givaudan Australia Pty Limited ABN# 87 000 470 280
12 Britton St Smithfield NSW 2164, Australia
Tel: 61 (2) 9827 4000

Givaudan

Technical Data Sheet

QF13045 **Tomato & Salsa Flavour**

Product information

Color	orange
Appearance	powder

Parameters for positive release

Analysis	Specification Limits	Method
Appearance	Conform	ISO 5495 visual
Sensory evaluation	Conform	ISO 5495 Comparison against std
Salt (NaCl)	19.00 - 23.00 %	ISO 9297 Silver Nitrate Titration
Total plate count	<= 100,000 /g	ISO 4833-1
Yeasts and moulds	<= 1,000 /g	ISO 4833-1

Parameters not routinely tested

Analysis	Specification Limits	Method
Bulk density	0.53 - 0.73 g/ml	ISO 60
Loss on drying	<= 5.0 %	
Enterobacteriaceae	<= 100 /g	ISO 21528-2
Salmonella	Negative /25g	ISO 4833-1
Staphylococcus aureus	<= 10 /g	ISO 4833-1
Bacillus cereus	<= 100 /g	ISO 21528-2
E. coli	Negative /g	

Heavy metals	Conform to regulatory requirements.

Storage and handling

Shelf life	180 Days
Storage conditions	Preferably full, hermetically sealed
Temperature conditions	Ambient / 10-30°C (50-85°F)

Miscellaneous

Custom Tariff number	3302.10

Givaudan Australia Pty Ltd 12 Britton Street, Smithfield NSW 2164, Australia
Quality Management TEL: +61 2 9827 4083 FAX: +61 29827 4043
australia.qm@givaudan.com

Issue date: 24 Jul 2015 - 12:45
ruanr-150724044008

International Flavors & Fragrances Inc.

Nutritional data Calculated per 100 grams

SC236534 SOUR CREAM & CHIVES

Create Date: Aug 27, 2013

Kilojoules	1361.3	
Protein	15.9	g/100g
Total fat	6.6	g/100g
Saturated fat	4.7	g/100g
Monounsaturated fat	1.5	g/100g
Polyunsaturated fat	0.2	g/100g
Trans fatty acids	< 0.1	g/100g
Cholesterol	14.6	mg/100g
Carbohydrates	45.9	g/100g
Sugars	22.6	g/100g
Dietary fiber	2.3	g/100g
Moisture	2.9	g/100g
Ash	24.4	g/100g
Sodium	8672.5	mg/100g
Potassium	601.6	mg/100g

These approximate results have been calculated from supplier`s raw material data, nutritional tables and some analytical data.

International Flavors & Fragrances Inc.

Nutritional data Calculated per 100 grams

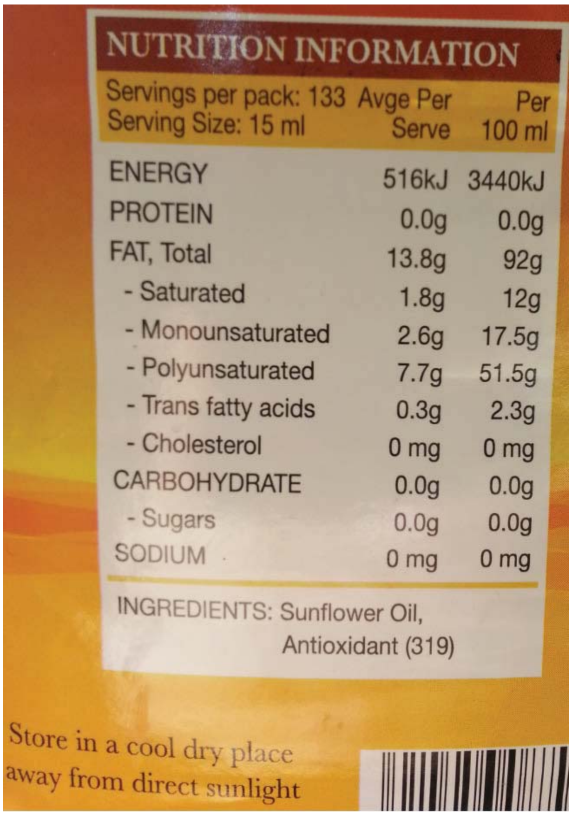
SC273864 CHEESE

Create Date: Aug 27, 2013

Kilojoules	1446.4	
Protein	6.8	g/100g
Total fat	4.8	g/100g
Saturated fat	3.0	g/100g
Monounsaturated fat	1.4	g/100g
Polyunsaturated fat	0.4	g/100g
Trans fatty acids	< 0.1	g/100g
Cholesterol	15.6	mg/100g
Carbohydrates	67.3	g/100g
Sugars	34.3	g/100g
Dietary fiber	0.7	g/100g
Moisture	2.9	g/100g
Ash	15.3	g/100g
Sodium	4894.8	mg/100g
Potassium	1705.2	mg/100g

These approximate results have been calculated from supplier`s raw material data, nutritional tables and some analytical data.

A 1.7 Sunflower oil used for 3G snack seasoning



Appendix 2: Die conductance (k) calculation details

Die Conductance (k) calculation details for Table 3.3

Slit die with one 15.0mm × 1.6 mm opening used in the preliminary trial work:

The rectangular opening die conductance can be calculated according to Eq. 2.5:

$$k = \frac{WH^3 / L}{12 + 16.6(H/W)^{1.5}} \approx \frac{WH^3}{12L} \quad \text{(when W > 6 H)} \qquad \text{(Eq. 2.5)}$$

W = 15.0 mm

H = 1.6 mm

L = 10.3 mm

For one die opening:

k ≈ (15.0 × 1.6^3) / (12 × 10.3) = 0.50

The special wave shaped die conductance can be calculated according to Eq. 2.5 and Figure 3.5

Srinivasa Ramanujan gives a good approximation for the circumference (C) of an ellipse

$$C \approx \pi\,(a+b)\left(1 + \frac{3h}{10 + \sqrt{4-3h}}\right).$$

Where a is the major axis of the ellipse

b is the minor axis of the ellipse

h = $[\frac{(a-b)}{(a+b)}]^2$

According to Figure 3.5, the large ellipse's circumference is:

a = 2.8 mm

b = 1.7 mm

h = $[\frac{(2.8-1.7)}{(2.8+1.7)}]^2$=0.060

C ≈ 3.14 × (2.8+1.7) × (1+$\frac{3 \times 0.06}{10+\sqrt{4-3\times 0.06}}$) = 14.3 mm

Circumference (C) of a circle is

$$C = 2\pi r = \pi d.$$

Where r is the radius of the circle

d is the diameter of the circle

According to Figure 3.5, the small ring's circumference is:
d = 1.4 mm

C = 3.14 × 1.4 = 4.40 mm

The approximate width of the die opening is half of the ellipse's circumference and a full ring's circumference W = 14.3 / 2 + 4.4 = 11.6 mm

$$k = \frac{WH^3/L}{12 + 16.6(H/W)^{1.5}} \approx \frac{WH^3}{12L} \text{ (when W > 6 H)} \qquad \text{(Eq. 2.5)}$$

Where W is the width of the die opening (mm);
H is height of the die opening (mm);
L is the length of the die land (mm)

W = 11.6 mm
H = 0.8 mm
L = 10.3 mm
For one die opening:
k ≈ (11.6 × 0.8^3) / (12 × 10.3) = 0.048

Because there are two die opening, hence

k ≈ 0.048 × 2 = 0.096

Appendix 3: Minitab one-way ANOVA of pasting properties for main raw ingredients in Chapter 4

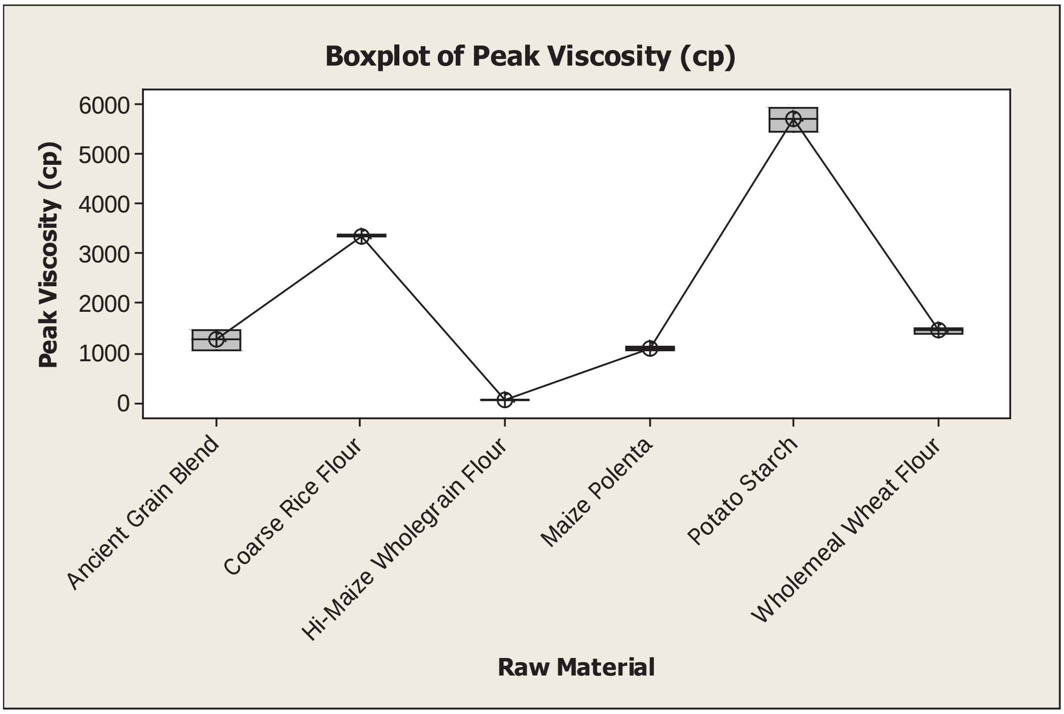
A 3.1 Minitab one-way ANOVA: Pasting properties versus unground raw ingredients

One-way ANOVA: Peak Viscosity (cP) versus Raw Material

```
Source        DF        SS       MS       F      P
Raw Material   5  41853187  8370637  233.79  0.000
Error          6    214826    35804
Total         11  42068013

S = 189.2   R-Sq = 99.49%   R-Sq(adj) = 99.06%


Level                      N    Mean  StDev
Ancient Grain Blend        2  1268.5  290.6
Coarse Rice Flour          2  3350.0   21.2
Hi-Maize Wholegrain Flou   2    37.5    0.7
Maize Polenta              2  1090.5   38.9
Potato Starch              2  5703.0  349.3
Wholemeal Wheat Flour      2  1442.5   79.9

                           Individual 95% CIs For Mean Based on
                           Pooled StDev
Level                      --+---------+---------+---------+-------
Ancient Grain Blend                (-*-)
Coarse Rice Flour                              (-*-)
Hi-Maize Wholegrain Flou   (-*-)
Maize Polenta                     (-*-)
Potato Starch                                                 (-*-)
Wholemeal Wheat Flour               (-*-)
                           --+---------+---------+---------+-------
                             0      1600      3200      4800

Pooled StDev = 189.2


Grouping Information Using Tukey Method

Raw Material                N    Mean  Grouping
Potato Starch               2  5703.0  A
Coarse Rice Flour           2  3350.0    B
Wholemeal Wheat Flour       2  1442.5      C
Ancient Grain Blend         2  1268.5      C
Maize Polenta               2  1090.5      C
Hi-Maize Wholegrain Flour   2    37.5        D

Means that do not share a letter are significantly different.

Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Raw Material

Individual confidence level = 99.27%


Raw Material = Ancient Grain Blend subtracted from:

Raw Material                Lower   Centre   Upper
Coarse Rice Flour          1328.2   2081.5  2834.8
Hi-Maize Wholegrain Flou  -1984.3  -1231.0  -477.7
Maize Polenta              -931.3   -178.0   575.3
Potato Starch              3681.2   4434.5  5187.8
Wholemeal Wheat Flour      -579.3    174.0   927.3
```

```
Raw Material              --------+---------+---------+---------+-
Coarse Rice Flour                               (-*-)
Hi-Maize Wholegrain Flou              (-*--)
Maize Polenta                            (-*--)
Potato Starch                                          (-*-)
Wholemeal Wheat Flour                     (-*--)
                          --------+---------+---------+---------+-
                              -3500         0      3500      7000


Raw Material = Coarse Rice Flour subtracted from:

Raw Material                Lower   Centre    Upper
Hi-Maize Wholegrain Flou  -4065.8  -3312.5  -2559.2
Maize Polenta             -3012.8  -2259.5  -1506.2
Potato Starch              1599.7   2353.0   3106.3
Wholemeal Wheat Flour     -2660.8  -1907.5  -1154.2

Raw Material              --------+---------+---------+---------+-
Hi-Maize Wholegrain Flou        (--*-)
Maize Polenta                      (--*-)
Potato Starch                                    (-*-)
Wholemeal Wheat Flour               (--*-)
                          --------+---------+---------+---------+-
                              -3500         0      3500      7000
Raw Material = Hi-Maize Wholegrain Flour subtracted from:

Raw Material            Lower  Centre   Upper
Maize Polenta           299.7  1053.0  1806.3
Potato Starch          4912.2  5665.5  6418.8
Wholemeal Wheat Flour   651.7  1405.0  2158.3

Raw Material           --------+---------+---------+---------+-
Maize Polenta                             (-*-)
Potato Starch                                          (-*-)
Wholemeal Wheat Flour                      (-*-)
                       --------+---------+---------+---------+-
                           -3500         0      3500      7000


Raw Material = Maize Polenta subtracted from:

Raw Material            Lower  Centre   Upper
Potato Starch          3859.2  4612.5  5365.8
Wholemeal Wheat Flour  -401.3   352.0  1105.3

Raw Material           --------+---------+---------+---------+-
Potato Starch                                       (-*-)
Wholemeal Wheat Flour                   (-*-)
                       --------+---------+---------+---------+-
                           -3500         0      3500      7000


Raw Material = Potato Starch subtracted from:

Raw Material             Lower   Centre    Upper
Wholemeal Wheat Flour  -5013.8  -4260.5  -3507.2

Raw Material           --------+---------+---------+---------+-
Wholemeal Wheat Flour      (-*-)
                       --------+---------+---------+---------+-
                           -3500         0      3500      7000
```

Boxplot of Peak Viscosity (cP)



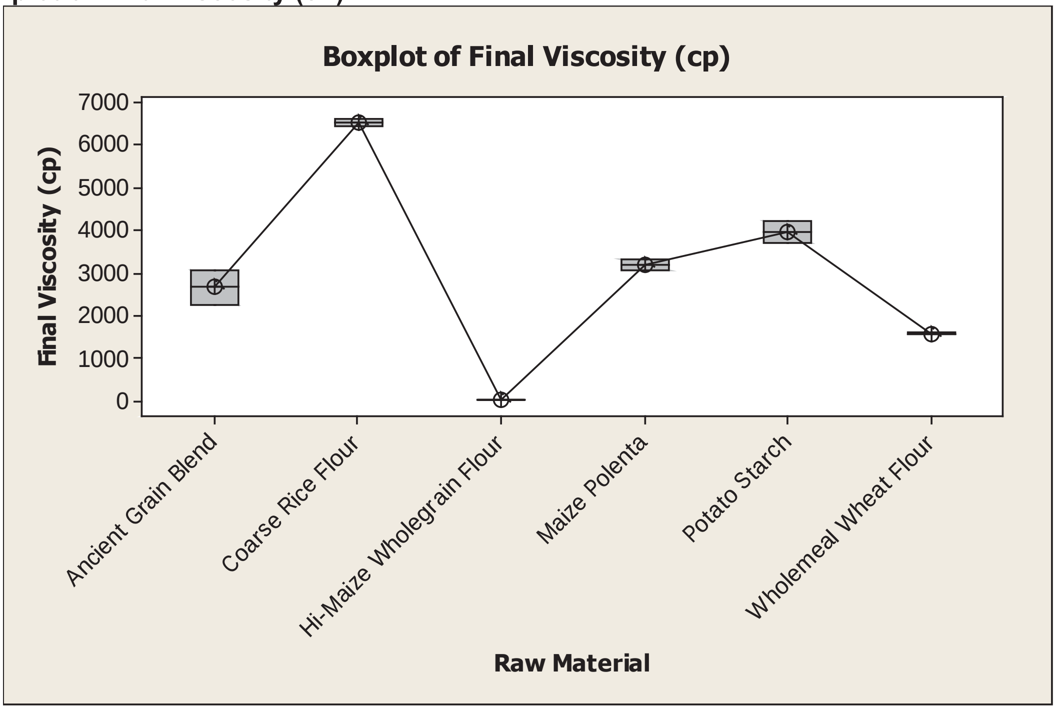
One-way ANOVA: Final Viscosity (cP) versus Raw Material

```
Source        DF        SS       MS       F      P
Raw Material   5  48629453  9725891  109.23  0.000
Error          6    534230    89038
Total         11  49163683

S = 298.4   R-Sq = 98.91%   R-Sq(adj) = 98.01%

Level                      N    Mean  StDev
Ancient Grain Blend        2  2667.0  586.9
Coarse Rice Flour          2  6527.0  106.1
Hi-Maize Wholegrain Flou   2    39.5    0.7
Maize Polenta              2  3200.5  167.6
Potato Starch              2  3964.5  386.8
Wholemeal Wheat Flour      2  1575.5   29.0


                           Individual 95% CIs For Mean Based on
                           Pooled StDev
Level                      --+---------+---------+---------+-------
Ancient Grain Blend                     (-*--)
Coarse Rice Flour                                          (--*-)
Hi-Maize Wholegrain Flou   (-*--)
Maize Polenta                             (--*--)
Potato Starch                                 (--*-)
Wholemeal Wheat Flour             (--*-)
                           --+---------+---------+---------+-------
                             0      2000      4000      6000

Pooled StDev = 298.4

Grouping Information Using Tukey Method

Raw Material                N    Mean  Grouping
Coarse Rice Flour           2  6527.0  A
Potato Starch               2  3964.5    B
Maize Polenta               2  3200.5    B C
Ancient Grain Blend         2  2667.0      C D
Wholemeal Wheat Flour       2  1575.5        D
```

```
Hi-Maize Wholegrain Flour  2    39.5          E
Means that do not share a letter are significantly different.

Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Raw Material

Individual confidence level = 99.27%

Raw Material = Ancient Grain Blend subtracted from:

Raw Material                Lower   Centre    Upper
Coarse Rice Flour          2672.1   3860.0   5047.9
Hi-Maize Wholegrain Flou  -3815.4  -2627.5  -1439.6
Maize Polenta              -654.4    533.5   1721.4
Potato Starch               109.6   1297.5   2485.4
Wholemeal Wheat Flour     -2279.4  -1091.5     96.4

Raw Material              ---------+---------+---------+---------+
Coarse Rice Flour                                   (--*--)
Hi-Maize Wholegrain Flou           (--*--)
Maize Polenta                              (--*--)
Potato Starch                                (--*--)
Wholemeal Wheat Flour                  (--*--)
                          ---------+---------+---------+---------+
                               -4000         0      4000      8000

Raw Material = Coarse Rice Flour subtracted from:

Raw Material                Lower   Centre    Upper
Hi-Maize Wholegrain Flou  -7675.4  -6487.5  -5299.6
Maize Polenta             -4514.4  -3326.5  -2138.6
Potato Starch             -3750.4  -2562.5  -1374.6
Wholemeal Wheat Flour     -6139.4  -4951.5  -3763.6

Raw Material              ---------+---------+---------+---------+
Hi-Maize Wholegrain Flou  (--*--)
Maize Polenta                     (--*--)
Potato Starch                       (--*--)
Wholemeal Wheat Flour         (--*--)
                          ---------+---------+---------+---------+
                               -4000         0      4000      8000


Raw Material = Hi-Maize Wholegrain Flour subtracted from:

Raw Material             Lower  Centre   Upper
Maize Polenta          1973.1  3161.0  4348.9
Potato Starch          2737.1  3925.0  5112.9
Wholemeal Wheat Flour   348.1  1536.0  2723.9

Raw Material           ---------+---------+---------+---------+
Maize Polenta                                   (--*--)
Potato Starch                                     (--*--)
Wholemeal Wheat Flour                       (--*--)
                       ---------+---------+---------+---------+
                            -4000         0      4000      8000


Raw Material = Maize Polenta subtracted from:

Raw Material              Lower   Centre   Upper
Potato Starch           -423.9    764.0  1951.9
Wholemeal Wheat Flour  -2812.9  -1625.0  -437.1

Raw Material           ---------+---------+---------+---------+
Potato Starch                            (--*--)
Wholemeal Wheat Flour              (--*--)
                       ---------+---------+---------+---------+
```

```
                            -4000         0      4000      8000
Raw Material = Potato Starch subtracted from:

Raw Material             Lower   Centre    Upper
Wholemeal Wheat Flour  -3576.9  -2389.0  -1201.1

Raw Material           ---------+---------+---------+---------+
Wholemeal Wheat Flour           (--*--)
                       ---------+---------+---------+---------+
                            -4000         0      4000      8000
```

Boxplot of Final Viscosity (cP)



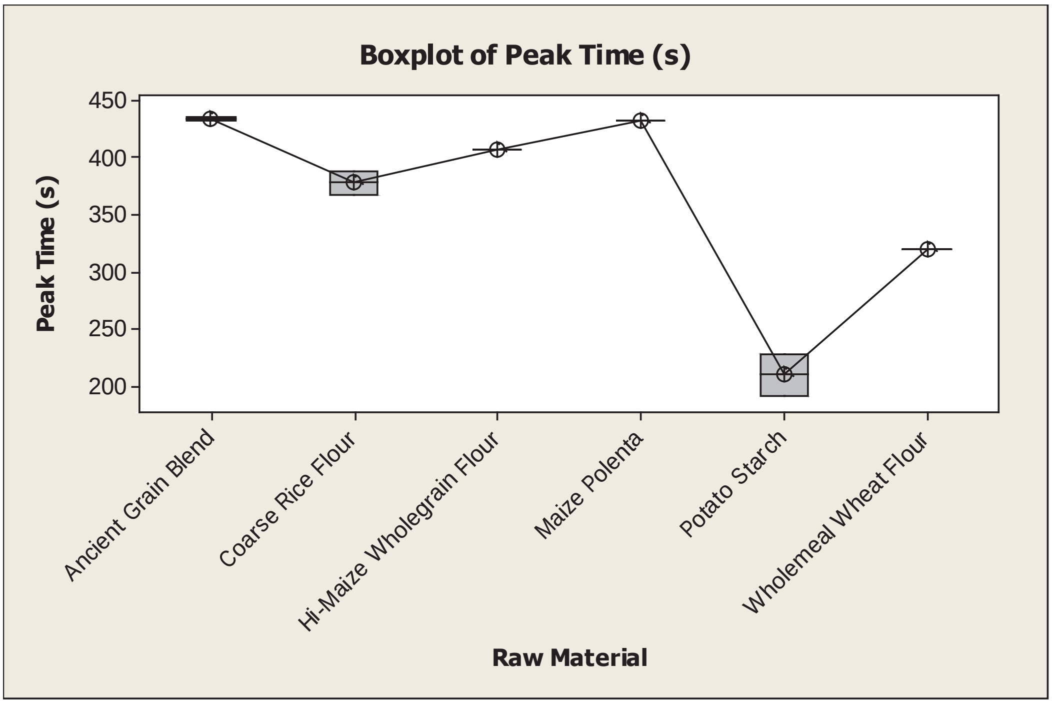
One-way ANOVA: Peak Time (s) versus Raw Material

```
Source        DF     SS     MS       F      P
Raw Material   5  74615  14923  104.60  0.000
Error          6    856    143
Total         11  75471

S = 11.94   R-Sq = 98.87%   R-Sq(adj) = 97.92%

Level                     N    Mean  StDev
Ancient Grain Blend       2  434.00   2.83
Coarse Rice Flour         2  378.00  14.14
Hi-Maize Wholegrain Flou  2  408.00   0.00
Maize Polenta             2  432.00   0.00
Potato Starch             2  210.00  25.46
Wholemeal Wheat Flour     2  320.00   0.00

                          Individual 95% CIs For Mean Based on
                          Pooled StDev
Level                     ---+---------+---------+---------+------
Ancient Grain Blend                                     (--*--)
Coarse Rice Flour                               (--*--)
Hi-Maize Wholegrain Flou                            (--*--)
Maize Polenta                                       (--*--)
Potato Starch             (--*--)
Wholemeal Wheat Flour                   (--*--)
                          ---+---------+---------+---------+------
```

```
                          210       280       350       420
Pooled StDev = 11.94

Grouping Information Using Tukey Method

Raw Material                N    Mean  Grouping
Ancient Grain Blend         2  434.00  A
Maize Polenta               2  432.00  A
Hi-Maize Wholegrain Flour   2  408.00  A B
Coarse Rice Flour           2  378.00    B
Wholemeal Wheat Flour       2  320.00      C
Potato Starch               2  210.00        D
Means that do not share a letter are significantly different.

Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Raw Material

Individual confidence level = 99.27%

Raw Material = Ancient Grain Blend subtracted from:

Raw Material                 Lower   Centre    Upper
Coarse Rice Flour          -103.55   -56.00    -8.45
Hi-Maize Wholegrain Flou    -73.55   -26.00    21.55
Maize Polenta               -49.55    -2.00    45.55
Potato Starch              -271.55  -224.00  -176.45
Wholemeal Wheat Flour      -161.55  -114.00   -66.45

Raw Material               --------+---------+---------+---------+-
Coarse Rice Flour                    (--*--)
Hi-Maize Wholegrain Flou               (--*--)
Maize Polenta                            (--*--)
Potato Starch              (--*--)
Wholemeal Wheat Flour             (--*---)
                           --------+---------+---------+---------+-
                                -150         0       150       300


Raw Material = Coarse Rice Flour subtracted from:

Raw Material                 Lower   Centre    Upper
Hi-Maize Wholegrain Flou    -17.55    30.00    77.55
Maize Polenta                 6.45    54.00   101.55
Potato Starch              -215.55  -168.00  -120.45
Wholemeal Wheat Flour      -105.55   -58.00   -10.45

Raw Material               --------+---------+---------+---------+-
Hi-Maize Wholegrain Flou                   (--*--)
Maize Polenta                               (---*--)
Potato Starch                  (--*--)
Wholemeal Wheat Flour                (--*--)
                           --------+---------+---------+---------+-
                                -150         0       150       300

Raw Material = Hi-Maize Wholegrain Flour subtracted from:

Raw Material              Lower   Centre    Upper
Maize Polenta            -23.55    24.00    71.55
Potato Starch           -245.55  -198.00  -150.45
Wholemeal Wheat Flour   -135.55   -88.00   -40.45

Raw Material            --------+---------+---------+---------+-
Maize Polenta                          (---*--)
Potato Starch             (--*--)
Wholemeal Wheat Flour            (--*--)
                        --------+---------+---------+---------+-
                             -150         0       150       300
```

```
Raw Material = Maize Polenta subtracted from:

Raw Material             Lower   Centre    Upper
Potato Starch          -269.55  -222.00  -174.45
Wholemeal Wheat Flour  -159.55  -112.00   -64.45

Raw Material           --------+---------+---------+---------+-
Potato Starch          (--*--)
Wholemeal Wheat Flour         (---*--)
                       --------+---------+---------+---------+-
                            -150         0       150       300
Raw Material = Potato Starch subtracted from:

Raw Material           Lower  Centre   Upper
Wholemeal Wheat Flour  62.45  110.00  157.55

Raw Material           --------+---------+---------+---------+-
Wholemeal Wheat Flour                        (--*---)
                       --------+---------+---------+---------+-
                            -150         0       150       300
```

Boxplot of Peak Time (s)



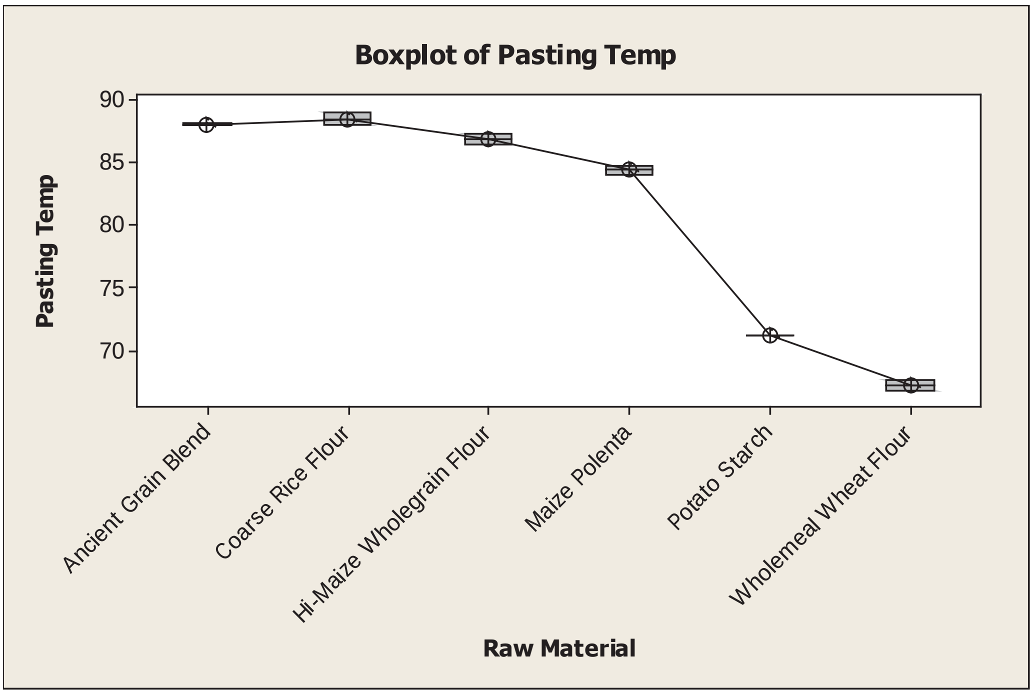
One-way ANOVA: Pasting Temp versus Raw Material

```
Source        DF       SS       MS       F      P
Raw Material   5  877.717  175.543  767.40  0.000
Error          6    1.373    0.229
Total         11  879.090

S = 0.4783   R-Sq = 99.84%   R-Sq(adj) = 99.71%

Level                      N    Mean  StDev
Ancient Grain Blend        2  88.050  0.071
Coarse Rice Flour          2  88.500  0.636
Hi-Maize Wholegrain Flou   2  86.925  0.601
Maize Polenta              2  84.425  0.530
Potato Starch              2  71.150  0.000
Wholemeal Wheat Flour      2  67.250  0.566
```

```
                          Individual 95% CIs For Mean Based on
                          Pooled StDev
Level                     ---------+---------+---------+---------+
Ancient Grain Blend                                         (-*)
Coarse Rice Flour                                            (-*)
Hi-Maize Wholegrain Flou                                  (-*)
Maize Polenta                                         (-*)
Potato Starch                   (-*)
Wholemeal Wheat Flour     (*)
                          ---------+---------+---------+---------+
                                72.0      78.0      84.0      90.0
Pooled StDev = 0.478

Grouping Information Using Tukey Method

Raw Material               N    Mean  Grouping
Coarse Rice Flour          2  88.500  A
Ancient Grain Blend        2  88.050  A
Hi-Maize Wholegrain Flour  2  86.925  A
Maize Polenta              2  84.425    B
Potato Starch              2  71.150      C
Wholemeal Wheat Flour      2  67.250        D

Means that do not share a letter are significantly different.

Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Raw Material

Individual confidence level = 99.27%

Raw Material = Ancient Grain Blend subtracted from:

Raw Material                Lower   Centre    Upper
Coarse Rice Flour          -1.454    0.450    2.354
Hi-Maize Wholegrain Flou   -3.029   -1.125    0.779
Maize Polenta              -5.529   -3.625   -1.721
Potato Starch             -18.804  -16.900  -14.996
Wholemeal Wheat Flour     -22.704  -20.800  -18.896

Raw Material              ---------+---------+---------+---------+
Coarse Rice Flour                           (*-)
Hi-Maize Wholegrain Flou                  (-*-)
Maize Polenta                           (-*-)
Potato Starch                (-*-)
Wholemeal Wheat Flour     (-*)
                          ---------+---------+---------+---------+
                                 -12         0        12        24


Raw Material = Coarse Rice Flour subtracted from:

Raw Material                Lower   Centre    Upper
Hi-Maize Wholegrain Flou   -3.479   -1.575    0.329
Maize Polenta              -5.979   -4.075   -2.171
Potato Starch             -19.254  -17.350  -15.446
Wholemeal Wheat Flour     -23.154  -21.250  -19.346

Raw Material              ---------+---------+---------+---------+
Hi-Maize Wholegrain Flou                  (-*)
Maize Polenta                           (-*)
Potato Starch                (-*)
Wholemeal Wheat Flour     (*-)
                          ---------+---------+---------+---------+
                                 -12         0        12        24


Raw Material = Hi-Maize Wholegrain Flour subtracted from:
```

```
Raw Material              Lower   Centre    Upper
Maize Polenta            -4.404   -2.500   -0.596
Potato Starch           -17.679  -15.775  -13.871
Wholemeal Wheat Flour   -21.579  -19.675  -17.771

Raw Material            ---------+---------+---------+---------+
Maize Polenta                          (-*-)
Potato Starch               (-*)
Wholemeal Wheat Flour    (-*)
                        ---------+---------+---------+---------+
                               -12         0        12        24
Raw Material = Maize Polenta subtracted from:

Raw Material              Lower   Centre    Upper
Potato Starch           -15.179  -13.275  -11.371
Wholemeal Wheat Flour   -19.079  -17.175  -15.271

Raw Material            ---------+---------+---------+---------+
Potato Starch                 (-*-)
Wholemeal Wheat Flour      (-*)
                        ---------+---------+---------+---------+
                               -12         0        12        24

Raw Material = Potato Starch subtracted from:

Raw Material             Lower  Centre   Upper
Wholemeal Wheat Flour   -5.804  -3.900  -1.996

Raw Material            ---------+---------+---------+---------+
Wholemeal Wheat Flour                 (-*)
                        ---------+---------+---------+---------+
                               -12         0        12        24
```

Boxplot of Pasting Temp

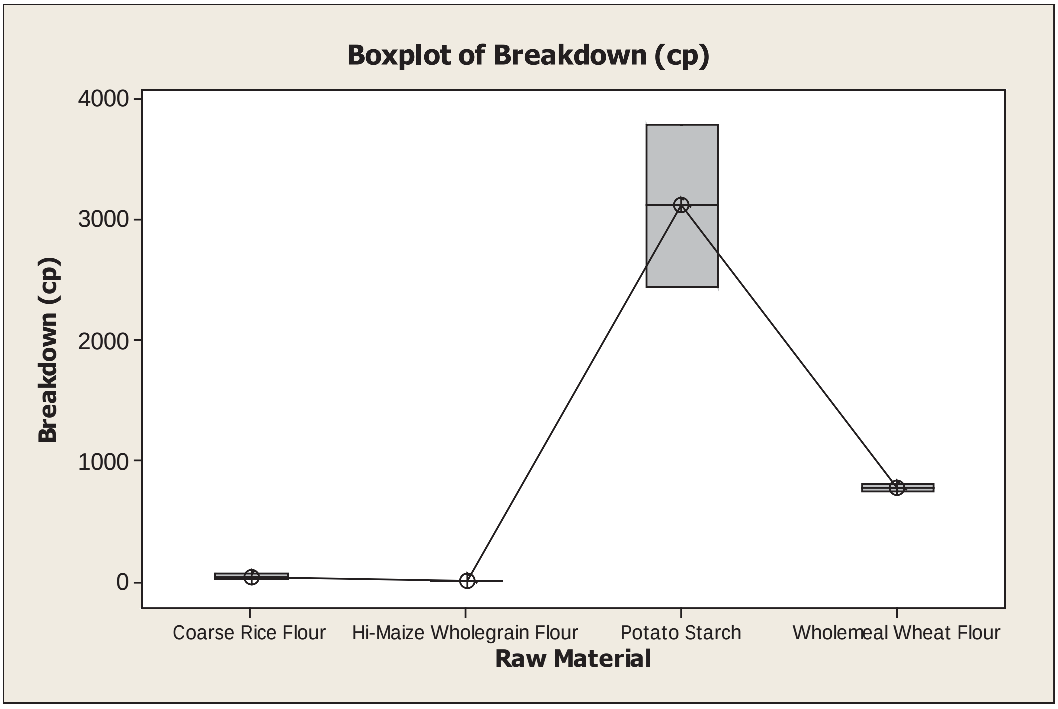


One-way ANOVA: Breakdown (cP) versus Raw Material

```
Source        DF        SS       MS      F      P
Raw Material   3  12911721  4303907  18.88  0.008
Error          4    912007   228002
Total          7  13823728

S = 477.5   R-Sq = 93.40%   R-Sq(adj) = 88.45%

Level                      N    Mean  StDev
Coarse Rice Flour          2    41.0   25.5
Hi-Maize Wholegrain Flou   2     5.5    0.7
Potato Starch              2  3120.5  953.9
Wholemeal Wheat Flour      2   773.0   38.2
                           Individual 95% CIs For Mean Based on
                           Pooled StDev
Level                      ------+---------+---------+---------+---
Coarse Rice Flour          (-----*------)
Hi-Maize Wholegrain Flou   (-----*-----)
Potato Starch                                   (-----*-----)
Wholemeal Wheat Flour           (-----*-----)
                           ------+---------+---------+---------+---
                                 0      1500      3000      4500

Pooled StDev = 477.5

Grouping Information Using Tukey Method

Raw Material                N    Mean  Grouping
Potato Starch               2  3120.5  A
Wholemeal Wheat Flour       2   773.0    B
Coarse Rice Flour           2    41.0    B
Hi-Maize Wholegrain Flour   2     5.5    B

Means that do not share a letter are significantly different.


Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Raw Material

Individual confidence level = 98.48%


Raw Material = Coarse Rice Flour subtracted from:

Raw Material                Lower  Centre   Upper
Hi-Maize Wholegrain Flou  -1980.3   -35.5  1909.3
Potato Starch              1134.7  3079.5  5024.3
Wholemeal Wheat Flour     -1212.8   732.0  2676.8

Raw Material               -------+---------+---------+---------+--
Hi-Maize Wholegrain Flou             (------*-----)
Potato Starch                                   (-----*------)
Wholemeal Wheat Flour                   (-----*------)
                           -------+---------+---------+---------+--
                              -3000         0      3000      6000

Raw Material = Hi-Maize Wholegrain Flour subtracted from:

Raw Material             Lower  Centre   Upper
Potato Starch           1170.2  3115.0  5059.8
Wholemeal Wheat Flour  -1177.3   767.5  2712.3

Raw Material            -------+---------+---------+---------+--
Potato Starch                                (-----*------)
Wholemeal Wheat Flour                (------*-----)
                        -------+---------+---------+---------+--
                           -3000         0      3000      6000
```

```
Raw Material = Potato Starch subtracted from:

Raw Material             Lower   Centre   Upper
Wholemeal Wheat Flour  -4292.3  -2347.5  -402.7

Raw Material           -------+---------+---------+---------+--
Wholemeal Wheat Flour     (-----*------)
                       -------+---------+---------+---------+--
                          -3000         0      3000      6000
```

Boxplot of Breakdown (cP)

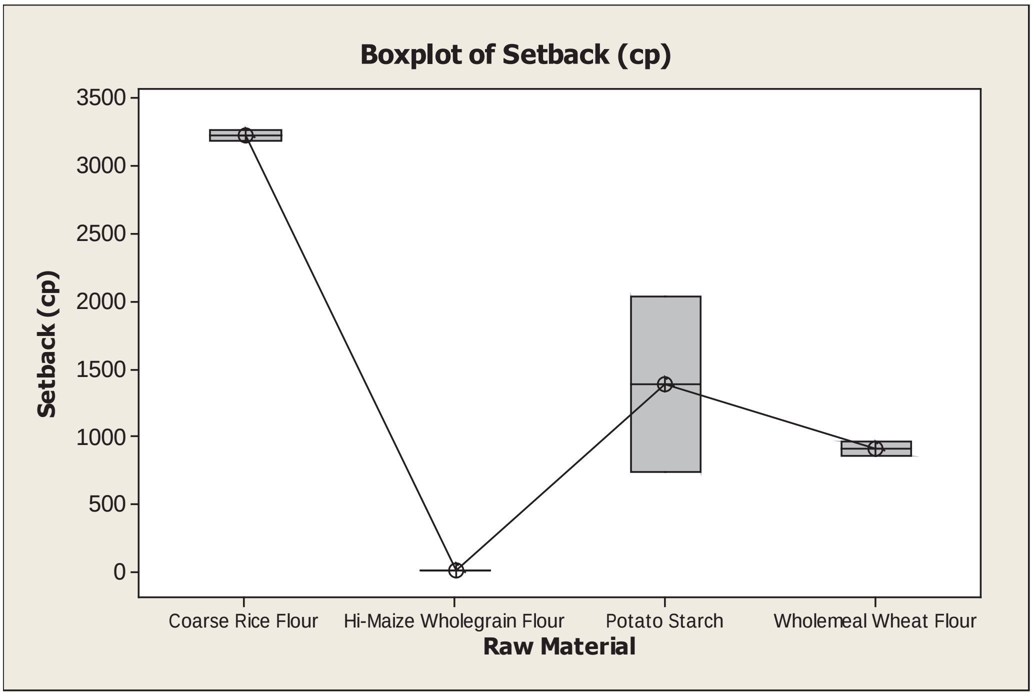


One-way ANOVA: Setback (cP) versus Raw Material

```
Source        DF        SS       MS      F      P
Raw Material   3  10973339  3657780  17.25  0.009
Error          4    848337   212084
Total          7  11821676

S = 460.5   R-Sq = 92.82%   R-Sq(adj) = 87.44%


Level                      N    Mean  StDev
Coarse Rice Flour          2  3218.0   59.4
Hi-Maize Wholegrain Flou   2     7.5    0.7
Potato Starch              2  1382.0  916.4
Wholemeal Wheat Flour      2   906.0   70.7

                           Individual 95% CIs For Mean Based on
                           Pooled StDev
Level                      ------+---------+---------+---------+---
Coarse Rice Flour                                 (-----*-----)
Hi-Maize Wholegrain Flou   (-----*-----)
Potato Starch                       (-----*-----)
Wholemeal Wheat Flour            (-----*-----)
                           ------+---------+---------+---------+---
                                 0      1500      3000      4500

Pooled StDev = 460.5
```

```
Grouping Information Using Tukey Method

Raw Material               N    Mean  Grouping
Coarse Rice Flour          2  3218.0  A
Potato Starch              2  1382.0  A B
Wholemeal Wheat Flour      2   906.0    B
Hi-Maize Wholegrain Flour  2     7.5    B

Means that do not share a letter are significantly different.
Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Raw Material

Individual confidence level = 98.48%


Raw Material = Coarse Rice Flour subtracted from:

Raw Material                Lower   Centre    Upper
Hi-Maize Wholegrain Flou  -5086.2  -3210.5  -1334.8
Potato Starch             -3711.7  -1836.0     39.7
Wholemeal Wheat Flour     -4187.7  -2312.0   -436.3

Raw Material                  +---------+---------+---------+---------
Hi-Maize Wholegrain Flou      (------*-------)
Potato Starch                      (-------*------)
Wholemeal Wheat Flour            (-------*------)
                              +---------+---------+---------+---------
                          -5000     -2500         0      2500


Raw Material = Hi-Maize Wholegrain Flour subtracted from:

Raw Material            Lower  Centre   Upper
Potato Starch          -501.2  1374.5  3250.2
Wholemeal Wheat Flour  -977.2   898.5  2774.2

Raw Material               +---------+---------+---------+---------
Potato Starch                                 (------*-------)
Wholemeal Wheat Flour                       (-------*------)
                           +---------+---------+---------+---------
                       -5000     -2500         0      2500


Raw Material = Potato Starch subtracted from:

Raw Material             Lower  Centre   Upper
Wholemeal Wheat Flour  -2351.7  -476.0  1399.7

Raw Material               +---------+---------+---------+---------
Wholemeal Wheat Flour                (------*-------)
                           +---------+---------+---------+---------
                       -5000     -2500         0      2500
```

Boxplot of Setback (cP)



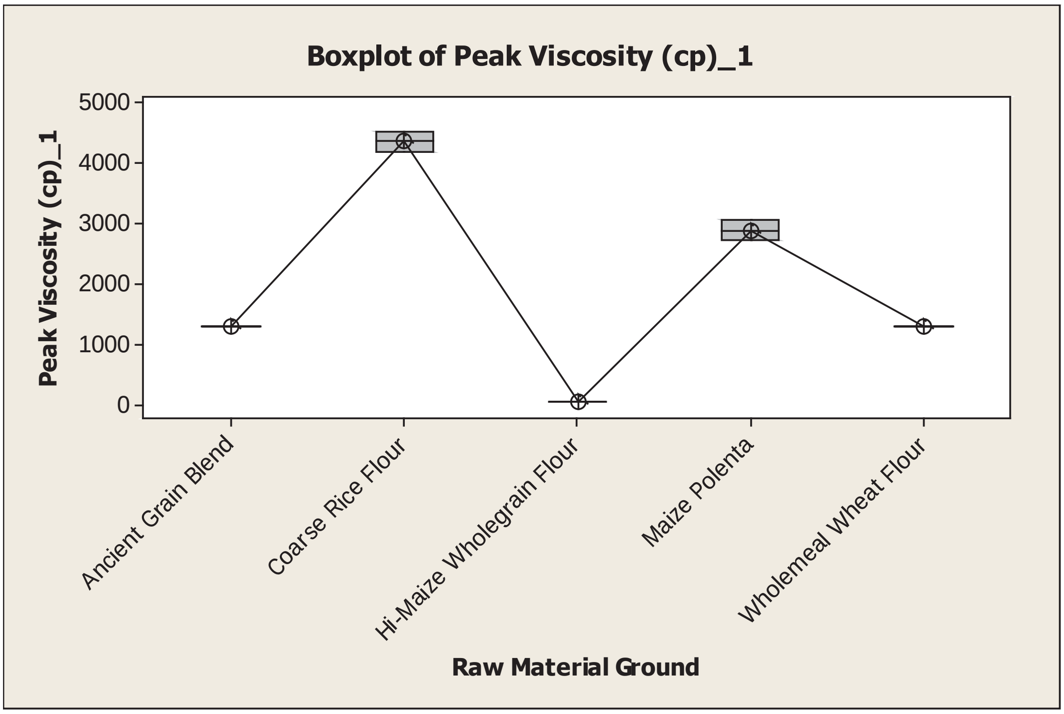
A 3.2 Minitab One-way ANOVA: Pasting properties versus ground cereal ingredients

One-way ANOVA: Peak Viscosity (cP)_1 versus Raw Material Ground

```
Source               DF        SS       MS       F      P
Raw Material Ground   4  22116051  5529013  256.00  0.000
Error                 5    107989    21598
Total                 9  22224040

S = 147.0   R-Sq = 99.51%   R-Sq(adj) = 99.13%

Level                      N    Mean  StDev
Ancient Grain Blend        2  1299.5    3.5
Coarse Rice Flour          2  4351.0  244.7
Hi-Maize Wholegrain Flou   2    61.0    2.8
Maize Polenta              2  2892.0  219.2
Wholemeal Wheat Flour      2  1302.5    7.8

                           Individual 95% CIs For Mean Based on
                           Pooled StDev
Level                      -+---------+---------+---------+--------
Ancient Grain Blend                (-*)
Coarse Rice Flour                                    (-*-)
Hi-Maize Wholegrain Flou   (*-)
Maize Polenta                                (-*-)
Wholemeal Wheat Flour              (-*)
                           -+---------+---------+---------+--------
                            0      1500      3000      4500

Pooled StDev = 147.0

Grouping Information Using Tukey Method

Raw Material Ground        N    Mean  Grouping
Coarse Rice Flour          2  4351.0  A
Maize Polenta              2  2892.0    B
Wholemeal Wheat Flour      2  1302.5      C
Ancient Grain Blend        2  1299.5      C
Hi-Maize Wholegrain Flour  2    61.0        D
```

```
Means that do not share a letter are significantly different.


Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Raw Material Ground

Individual confidence level = 98.98%


Raw Material Ground = Ancient Grain Blend subtracted from:

Raw Material Ground         Lower   Centre   Upper
Coarse Rice Flour          2462.3   3051.5  3640.7
Hi-Maize Wholegrain Flou  -1827.7  -1238.5  -649.3
Maize Polenta              1003.3   1592.5  2181.7
Wholemeal Wheat Flour      -586.2      3.0   592.2

Raw Material Ground           +---------+---------+---------+---------
Coarse Rice Flour                                         (-*--)
Hi-Maize Wholegrain Flou                   (-*-)
Maize Polenta                                        (-*--)
Wholemeal Wheat Flour                          (-*-)
                              +---------+---------+---------+---------
                          -5000     -2500         0      2500


Raw Material Ground = Coarse Rice Flour subtracted from:

Raw Material Ground         Lower   Centre    Upper
Hi-Maize Wholegrain Flou  -4879.2  -4290.0  -3700.8
Maize Polenta             -2048.2  -1459.0   -869.8
Wholemeal Wheat Flour     -3637.7  -3048.5  -2459.3

Raw Material Ground           +---------+---------+---------+---------
Hi-Maize Wholegrain Flou      (--*-)
Maize Polenta                             (-*--)
Wholemeal Wheat Flour              (--*-)
                              +---------+---------+---------+---------
                          -5000     -2500         0      2500


Raw Material Ground = Hi-Maize Wholegrain Flour subtracted from:

Raw Material Ground     Lower  Centre   Upper
Maize Polenta          2241.8  2831.0  3420.2
Wholemeal Wheat Flour   652.3  1241.5  1830.7

Raw Material Ground        +---------+---------+---------+---------
Maize Polenta                                           (-*--)
Wholemeal Wheat Flour                             (-*-)
                           +---------+---------+---------+---------
                       -5000     -2500         0      2500


Raw Material Ground = Maize Polenta subtracted from:

Raw Material Ground      Lower   Centre    Upper
Wholemeal Wheat Flour  -2178.7  -1589.5  -1000.3

Raw Material Ground        +---------+---------+---------+---------
Wholemeal Wheat Flour                (--*-)
                           +---------+---------+---------+---------
                       -5000     -2500         0      2500
```

Boxplot of Peak Viscosity (cP)_1

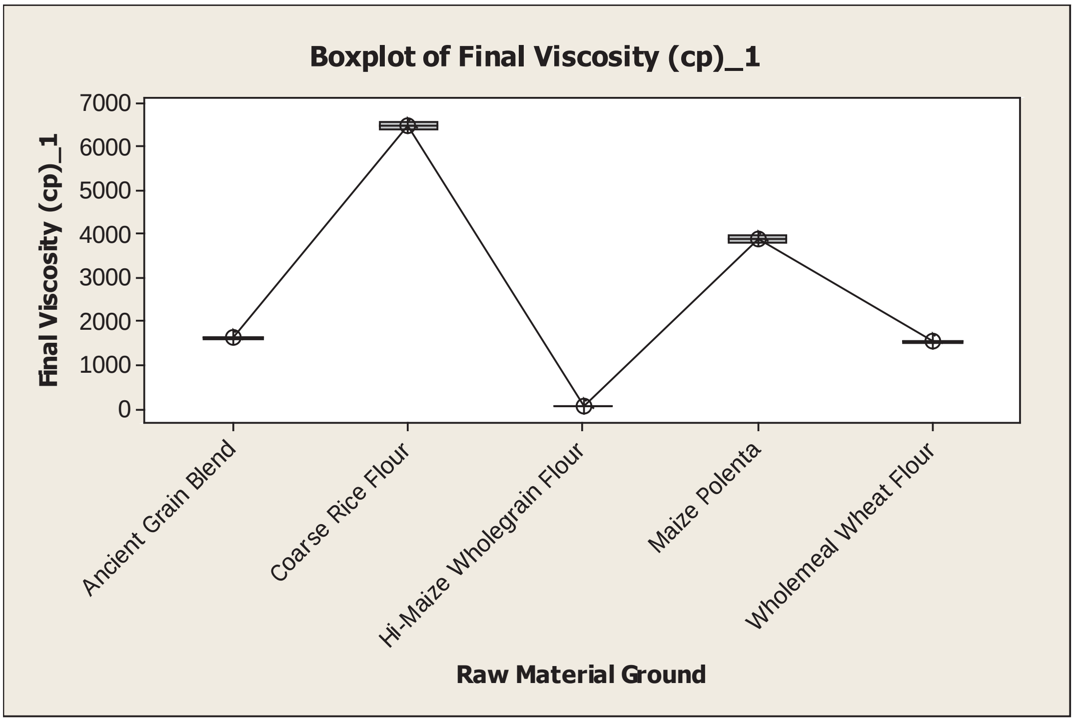


One-way ANOVA: Final Viscosity (cP)_1 versus Raw Material Ground

```
Source              DF        SS        MS        F      P
Raw Material Ground  4  50168379  12542095  1962.22  0.000
Error                5     31959      6392
Total                9  50200338

S = 79.95   R-Sq = 99.94%   R-Sq(adj) = 99.89%


Level                     N    Mean  StDev
Ancient Grain Blend       2  1632.5   27.6
Coarse Rice Flour         2  6477.5  126.6
Hi-Maize Wholegrain Flou  2    68.0    2.8
Maize Polenta             2  3885.0  118.8
Wholemeal Wheat Flour     2  1540.0   32.5

                          Individual 95% CIs For Mean Based on
                          Pooled StDev
Level                     +---------+---------+---------+---------
Ancient Grain Blend              (*)
Coarse Rice Flour                                 *)
Hi-Maize Wholegrain Flou  *)
Maize Polenta                                   *)
Wholemeal Wheat Flour            (*
                          +---------+---------+---------+---------
                          0      2000      4000      6000

Pooled StDev = 79.9


Grouping Information Using Tukey Method

Raw Material Ground        N    Mean  Grouping
Coarse Rice Flour          2  6477.5  A
Maize Polenta              2  3885.0    B
Ancient Grain Blend        2  1632.5      C
Wholemeal Wheat Flour      2  1540.0      C
Hi-Maize Wholegrain Flour  2    68.0        D
```

```
Means that do not share a letter are significantly different.


Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Raw Material Ground

Individual confidence level = 98.98%


Raw Material Ground = Ancient Grain Blend subtracted from:

Raw Material Ground          Lower   Centre    Upper
Coarse Rice Flour           4524.5   4845.0   5165.5
Hi-Maize Wholegrain Flou   -1885.0  -1564.5  -1244.0
Maize Polenta               1932.0   2252.5   2573.0
Wholemeal Wheat Flour       -413.0    -92.5    228.0

Raw Material Ground        ---------+---------+---------+---------+
Coarse Rice Flour                                             (*)
Hi-Maize Wholegrain Flou                (*
Maize Polenta                                           *)
Wholemeal Wheat Flour                       (*)
                           ---------+---------+---------+---------+
                                -3500         0      3500      7000


Raw Material Ground = Coarse Rice Flour subtracted from:

Raw Material Ground          Lower   Centre    Upper
Hi-Maize Wholegrain Flou   -6730.0  -6409.5  -6089.0
Maize Polenta              -2913.0  -2592.5  -2272.0
Wholemeal Wheat Flour      -5258.0  -4937.5  -4617.0

Raw Material Ground        ---------+---------+---------+---------+
Hi-Maize Wholegrain Flou   (*)
Maize Polenta                         (*)
Wholemeal Wheat Flour          (*)
                           ---------+---------+---------+---------+
                                -3500         0      3500      7000


Raw Material Ground = Hi-Maize Wholegrain Flour subtracted from:

Raw Material Ground     Lower  Centre   Upper
Maize Polenta          3496.5  3817.0  4137.5
Wholemeal Wheat Flour  1151.5  1472.0  1792.5

Raw Material Ground     ---------+---------+---------+---------+
Maize Polenta                                        (*)
Wholemeal Wheat Flour                           (*)
                        ---------+---------+---------+---------+
                             -3500         0      3500      7000


Raw Material Ground = Maize Polenta subtracted from:

Raw Material Ground      Lower   Centre    Upper
Wholemeal Wheat Flour  -2665.5  -2345.0  -2024.5

Raw Material Ground     ---------+---------+---------+---------+
Wholemeal Wheat Flour               (*)
                        ---------+---------+---------+---------+
                             -3500         0      3500      7000
```

Boxplot of Final Viscosity (cP)_1

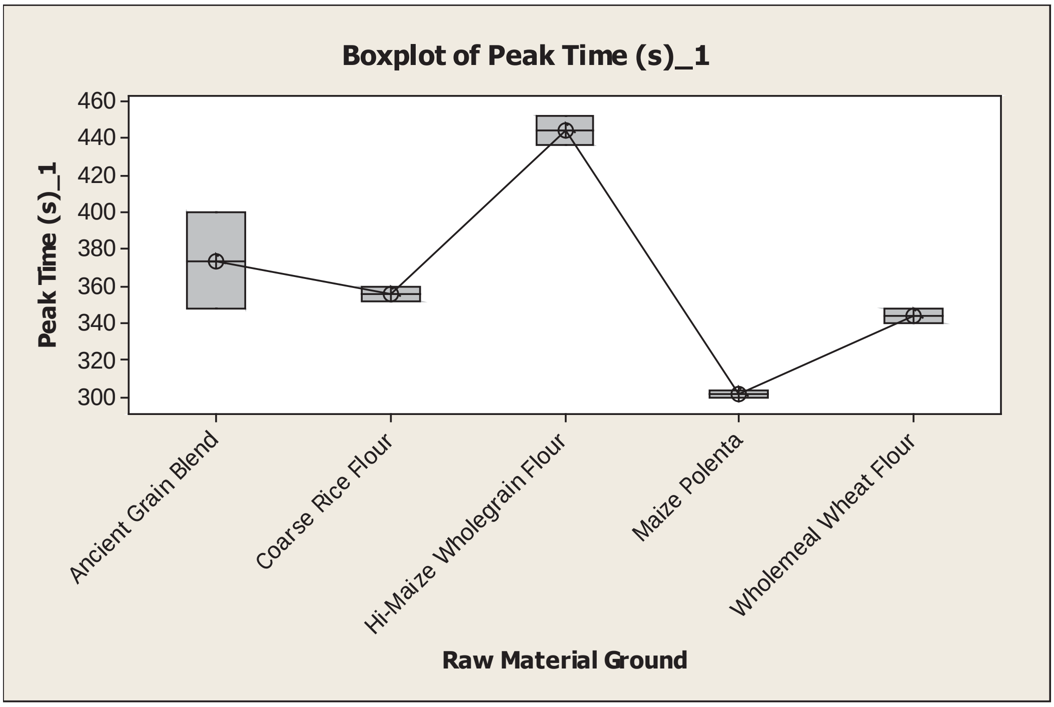


One-way ANOVA: Peak Time (s)_1 versus Raw Material Ground

```
Source               DF     SS    MS      F      P
Raw Material Ground   4  21616  5404  17.41  0.004
Error                 5   1552   310
Total                 9  23168

S = 17.62   R-Sq = 93.30%   R-Sq(adj) = 87.94%


Level                     N    Mean  StDev
Ancient Grain Blend       2  374.00  36.77
Coarse Rice Flour         2  356.00   5.66
Hi-Maize Wholegrain Flou  2  444.00  11.31
Maize Polenta             2  302.00   2.83
Wholemeal Wheat Flour     2  344.00   5.66

                          Individual 95% CIs For Mean Based on
                          Pooled StDev
Level                     -----+---------+---------+---------+----
Ancient Grain Blend                   (----*-----)
Coarse Rice Flour                  (----*-----)
Hi-Maize Wholegrain Flou                        (----*----)
Maize Polenta             (----*-----)
Wholemeal Wheat Flour            (----*-----)
                          -----+---------+---------+---------+----
                             300       360       420       480

Pooled StDev = 17.62


Grouping Information Using Tukey Method

Raw Material Ground        N    Mean  Grouping
Hi-Maize Wholegrain Flour  2  444.00  A
Ancient Grain Blend        2  374.00  A B
Coarse Rice Flour          2  356.00    B C
Wholemeal Wheat Flour      2  344.00    B C
Maize Polenta              2  302.00      C
```

```
Means that do not share a letter are significantly different.


Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Raw Material Ground

Individual confidence level = 98.98%


Raw Material Ground = Ancient Grain Blend subtracted from:

Raw Material Ground          Lower  Centre   Upper
Coarse Rice Flour           -88.64  -18.00   52.64
Hi-Maize Wholegrain Flou     -0.64   70.00  140.64
Maize Polenta              -142.64  -72.00   -1.36
Wholemeal Wheat Flour      -100.64  -30.00   40.64

Raw Material Ground        --------+---------+---------+---------+-
Coarse Rice Flour                    (-----*----)
Hi-Maize Wholegrain Flou                    (-----*-----)
Maize Polenta                   (-----*-----)
Wholemeal Wheat Flour               (-----*----)
                           --------+---------+---------+---------+-
                                -120         0       120       240


Raw Material Ground = Coarse Rice Flour subtracted from:

Raw Material Ground          Lower  Centre   Upper
Hi-Maize Wholegrain Flou     17.36   88.00  158.64
Maize Polenta              -124.64  -54.00   16.64
Wholemeal Wheat Flour       -82.64  -12.00   58.64

Raw Material Ground        --------+---------+---------+---------+-
Hi-Maize Wholegrain Flou                     (-----*-----)
Maize Polenta                      (-----*----)
Wholemeal Wheat Flour                (-----*-----)
                           --------+---------+---------+---------+-
                                -120         0       120       240


Raw Material Ground = Hi-Maize Wholegrain Flour subtracted from:

Raw Material Ground       Lower   Centre   Upper
Maize Polenta           -212.64  -142.00  -71.36
Wholemeal Wheat Flour   -170.64  -100.00  -29.36

Raw Material Ground     --------+---------+---------+---------+-
Maize Polenta           (-----*-----)
Wholemeal Wheat Flour       (-----*-----)
                        --------+---------+---------+---------+-
                             -120         0       120       240


Raw Material Ground = Maize Polenta subtracted from:

Raw Material Ground      Lower  Centre   Upper
Wholemeal Wheat Flour   -28.64   42.00  112.64

Raw Material Ground     --------+---------+---------+---------+-
Wholemeal Wheat Flour                   (-----*----)
                        --------+---------+---------+---------+-
                             -120         0       120       240
```

Boxplot of Peak Time (s)_1

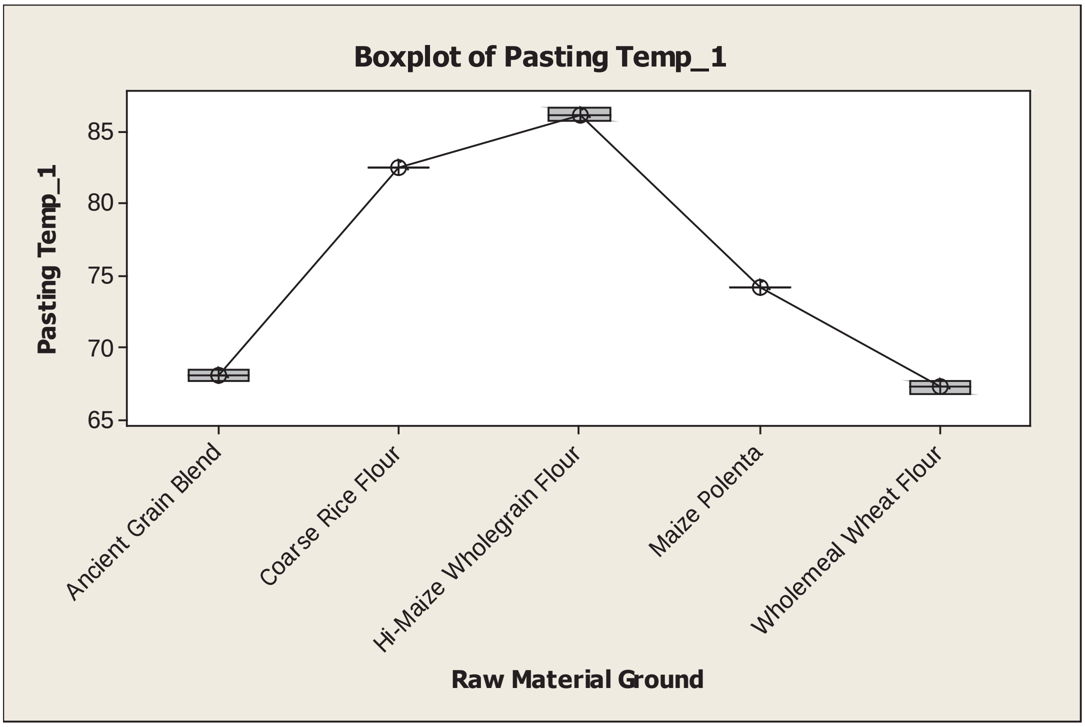


One-way ANOVA: Pasting Temp_1 versus Raw Material Ground

```
Source               DF       SS       MS       F      P
Raw Material Ground   4  568.476  142.119  603.48  0.000
Error                 5    1.177    0.235
Total                 9  569.654

S = 0.4853   R-Sq = 99.79%   R-Sq(adj) = 99.63%


Level                      N    Mean  StDev
Ancient Grain Blend        2  68.150  0.566
Coarse Rice Flour          2  82.475  0.035
Hi-Maize Wholegrain Flou   2  86.125  0.672
Maize Polenta              2  74.250  0.000
Wholemeal Wheat Flour      2  67.300  0.636

                           Individual 95% CIs For Mean Based on
                           Pooled StDev
Level                      ---------+---------+---------+---------+
Ancient Grain Blend         (-*)
Coarse Rice Flour                                    (*-)
Hi-Maize Wholegrain Flou                                   (-*)
Maize Polenta                         (-*)
Wholemeal Wheat Flour      (*-)
                           ---------+---------+---------+---------+
                                 72.0      78.0      84.0      90.0

Pooled StDev = 0.485


Grouping Information Using Tukey Method

Raw Material Ground         N    Mean  Grouping
Hi-Maize Wholegrain Flour   2  86.125  A
Coarse Rice Flour           2  82.475    B
Maize Polenta               2  74.250      C
Ancient Grain Blend         2  68.150        D
Wholemeal Wheat Flour       2  67.300        D
```

```
Means that do not share a letter are significantly different.


Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Raw Material Ground

Individual confidence level = 98.98%


Raw Material Ground = Ancient Grain Blend subtracted from:

Raw Material Ground         Lower  Centre   Upper
Coarse Rice Flour          12.379  14.325  16.271
Hi-Maize Wholegrain Flou   16.029  17.975  19.921
Maize Polenta               4.154   6.100   8.046
Wholemeal Wheat Flour      -2.796  -0.850   1.096

Raw Material Ground        -------+---------+---------+---------+--
Coarse Rice Flour                                     (-*-)
Hi-Maize Wholegrain Flou                                 (-*-)
Maize Polenta                                   (-*-)
Wholemeal Wheat Flour                      (*-)
                           -------+---------+---------+---------+--
                                -12         0        12        24


Raw Material Ground = Coarse Rice Flour subtracted from:

Raw Material Ground          Lower   Centre    Upper
Hi-Maize Wholegrain Flou     1.704    3.650    5.596
Maize Polenta              -10.171   -8.225   -6.279
Wholemeal Wheat Flour      -17.121  -15.175  -13.229

Raw Material Ground        -------+---------+---------+---------+--
Hi-Maize Wholegrain Flou                      (-*-)
Maize Polenta                       (*-)
Wholemeal Wheat Flour         (*-)
                           -------+---------+---------+---------+--
                                -12         0        12        24


Raw Material Ground = Hi-Maize Wholegrain Flour subtracted from:

Raw Material Ground       Lower   Centre    Upper
Maize Polenta           -13.821  -11.875   -9.929
Wholemeal Wheat Flour   -20.771  -18.825  -16.879

Raw Material Ground     -------+---------+---------+---------+--
Maize Polenta                (-*-)
Wholemeal Wheat Flour   (*-)
                        -------+---------+---------+---------+--
                             -12         0        12        24


Raw Material Ground = Maize Polenta subtracted from:

Raw Material Ground      Lower  Centre   Upper
Wholemeal Wheat Flour   -8.896  -6.950  -5.004

Raw Material Ground     -------+---------+---------+---------+--
Wholemeal Wheat Flour             (*-)
                        -------+---------+---------+---------+--
                             -12         0        12        24
```

Boxplot of Pasting Temp_1



One-way ANOVA: Breakdown (cP)_1 versus Raw Material Ground

```
Source               DF       SS      MS      F      P
Raw Material Ground   4  2264065  566016  14.12  0.006
Error                 5   200440   40088
Total                 9  2464505

S = 200.2   R-Sq = 91.87%   R-Sq(adj) = 85.36%


Level                      N    Mean  StDev
Ancient Grain Blend        2   383.0  427.1
Coarse Rice Flour          2  1127.5   33.2
Hi-Maize Wholegrain Flou   2     9.0    1.4
Maize Polenta              2  1309.5  128.0
Wholemeal Wheat Flour      2   701.5   23.3

                           Individual 95% CIs For Mean Based on
                           Pooled StDev
Level                      ------+---------+---------+---------+---
Ancient Grain Blend              (-----*-----)
Coarse Rice Flour                            (-----*-----)
Hi-Maize Wholegrain Flou   (-----*-----)
Maize Polenta                                   (-----*-----)
Wholemeal Wheat Flour                  (-----*-----)
                           ------+---------+---------+---------+---
                                 0       600      1200      1800

Pooled StDev = 200.2


Grouping Information Using Tukey Method

Raw Material Ground        N    Mean  Grouping
Maize Polenta              2  1309.5  A
Coarse Rice Flour          2  1127.5  A B
Wholemeal Wheat Flour      2   701.5  A B C
Ancient Grain Blend        2   383.0    B C
Hi-Maize Wholegrain Flour  2     9.0      C
```

Means that do not share a letter are significantly different.

Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Raw Material Ground

Individual confidence level = 98.98%

Raw Material Ground = Ancient Grain Blend subtracted from:

Raw Material Ground	Lower	Centre	Upper
Coarse Rice Flour	-58.2	744.5	1547.2
Hi-Maize Wholegrain Flou	-1176.7	-374.0	428.7
Maize Polenta	123.8	926.5	1729.2
Wholemeal Wheat Flour	-484.2	318.5	1121.2

```
Raw Material Ground       --------+---------+---------+---------+-
Coarse Rice Flour                            (-----*------)
Hi-Maize Wholegrain Flou             (------*------)
Maize Polenta                                 (------*-----)
Wholemeal Wheat Flour                    (------*-----)
                          --------+---------+---------+---------+-
                               -1200         0      1200      2400
```

Raw Material Ground = Coarse Rice Flour subtracted from:

Raw Material Ground	Lower	Centre	Upper
Hi-Maize Wholegrain Flou	-1921.2	-1118.5	-315.8
Maize Polenta	-620.7	182.0	984.7
Wholemeal Wheat Flour	-1228.7	-426.0	376.7

```
Raw Material Ground       --------+---------+---------+---------+-
Hi-Maize Wholegrain Flou     (------*-----)
Maize Polenta                           (------*-----)
Wholemeal Wheat Flour                (-----*------)
                          --------+---------+---------+---------+-
                               -1200         0      1200      2400
```

Raw Material Ground = Hi-Maize Wholegrain Flour subtracted from:

Raw Material Ground	Lower	Centre	Upper
Maize Polenta	497.8	1300.5	2103.2
Wholemeal Wheat Flour	-110.2	692.5	1495.2

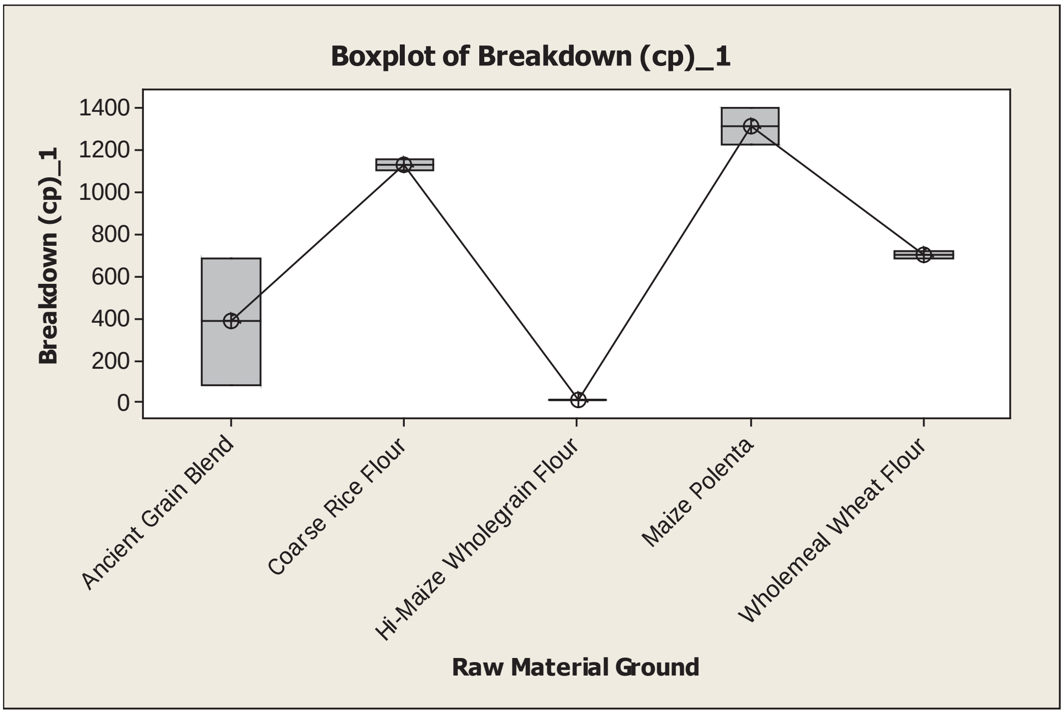
```
Raw Material Ground    --------+---------+---------+---------+-
Maize Polenta                                 (------*------)
Wholemeal Wheat Flour                    (------*-----)
                       --------+---------+---------+---------+-
                            -1200         0      1200      2400
```

Raw Material Ground = Maize Polenta subtracted from:

Raw Material Ground	Lower	Centre	Upper
Wholemeal Wheat Flour	-1410.7	-608.0	194.7

```
Raw Material Ground    --------+---------+---------+---------+-
Wholemeal Wheat Flour         (------*------)
                       --------+---------+---------+---------+-
                            -1200         0      1200      2400
```

Boxplot of Breakdown (cP)_1

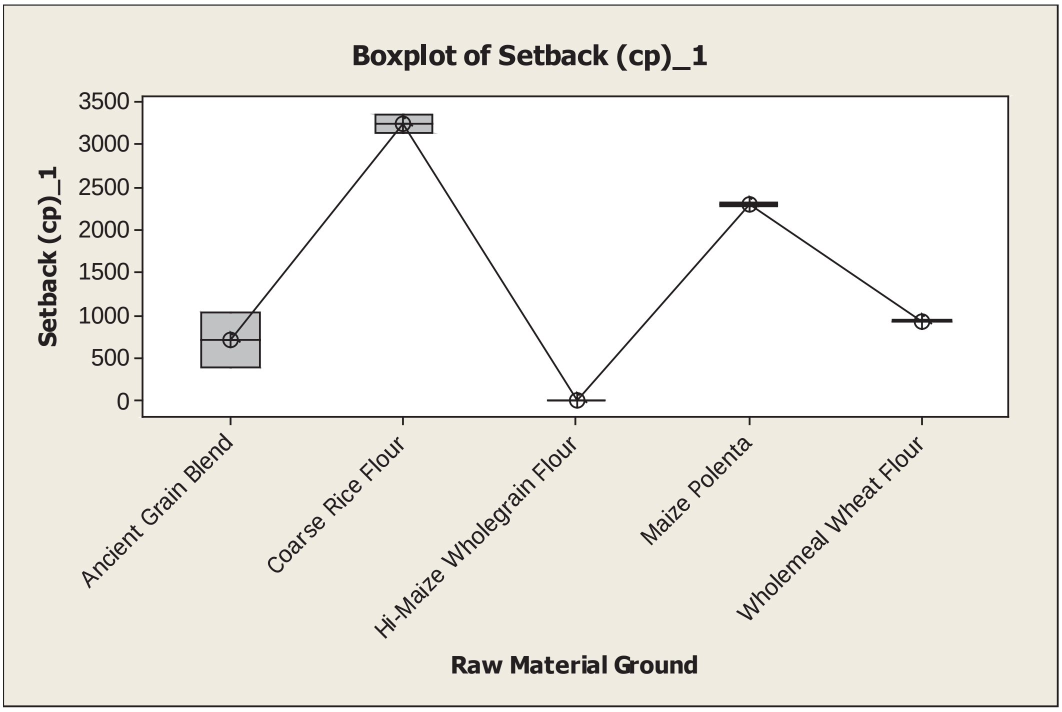


One-way ANOVA: Setback (cP)_1 versus Raw Material Ground

```
Source               DF        SS       MS      F      P
Raw Material Ground   4  13674608  3418652  73.08  0.000
Error                 5    233901    46780
Total                 9  13908509

S = 216.3   R-Sq = 98.32%   R-Sq(adj) = 96.97%


Level                      N    Mean  StDev
Ancient Grain Blend        2   716.0  458.2
Coarse Rice Flour          2  3254.0  151.3
Hi-Maize Wholegrain Flou   2    16.0    1.4
Maize Polenta              2  2302.5   27.6
Wholemeal Wheat Flour      2   939.0   17.0

                           Individual 95% CIs For Mean Based on
                           Pooled StDev
Level                      ---+---------+---------+---------+------
Ancient Grain Blend              (--*--)
Coarse Rice Flour                                    (--*--)
Hi-Maize Wholegrain Flou   (--*--)
Maize Polenta                                (--*--)
Wholemeal Wheat Flour              (--*--)
                           ---+---------+---------+---------+------
                              0      1200      2400      3600

Pooled StDev = 216.3


Grouping Information Using Tukey Method

Raw Material Ground         N    Mean  Grouping
Coarse Rice Flour           2  3254.0  A
Maize Polenta               2  2302.5    B
Wholemeal Wheat Flour       2   939.0      C
Ancient Grain Blend         2   716.0      C D
Hi-Maize Wholegrain Flour   2    16.0        D
```

```
Means that do not share a letter are significantly different.


Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Raw Material Ground

Individual confidence level = 98.98%


Raw Material Ground = Ancient Grain Blend subtracted from:

Raw Material Ground         Lower  Centre   Upper
Coarse Rice Flour          1670.8  2538.0  3405.2
Hi-Maize Wholegrain Flou  -1567.2  -700.0   167.2
Maize Polenta               719.3  1586.5  2453.7
Wholemeal Wheat Flour      -644.2   223.0  1090.2

Raw Material Ground       ------+---------+---------+---------+---
Coarse Rice Flour                                  (--*---)
Hi-Maize Wholegrain Flou            (--*---)
Maize Polenta                                  (--*---)
Wholemeal Wheat Flour                  (---*--)
                          ------+---------+---------+---------+---
                            -2500         0      2500      5000


Raw Material Ground = Coarse Rice Flour subtracted from:

Raw Material Ground         Lower   Centre    Upper
Hi-Maize Wholegrain Flou  -4105.2  -3238.0  -2370.8
Maize Polenta             -1818.7   -951.5    -84.3
Wholemeal Wheat Flour     -3182.2  -2315.0  -1447.8

Raw Material Ground       ------+---------+---------+---------+---
Hi-Maize Wholegrain Flou  (--*---)
Maize Polenta                      (--*---)
Wholemeal Wheat Flour        (---*--)
                          ------+---------+---------+---------+---
                            -2500         0      2500      5000


Raw Material Ground = Hi-Maize Wholegrain Flour subtracted from:

Raw Material Ground     Lower  Centre   Upper
Maize Polenta          1419.3  2286.5  3153.7
Wholemeal Wheat Flour    55.8   923.0  1790.2

Raw Material Ground    ------+---------+---------+---------+---
Maize Polenta                               (--*---)
Wholemeal Wheat Flour                 (---*--)
                       ------+---------+---------+---------+---
                         -2500         0      2500      5000


Raw Material Ground = Maize Polenta subtracted from:

Raw Material Ground      Lower   Centre   Upper
Wholemeal Wheat Flour  -2230.7  -1363.5  -496.3

Raw Material Ground    ------+---------+---------+---------+---
Wholemeal Wheat Flour         (---*--)
                       ------+---------+---------+---------+---
                         -2500         0      2500      5000
```

Boxplot of Setback (cP)_1


Boxplot of Setback (cp)_1
Setback (cp)_1
3500
3000
2500
2000
1500
1000
500
0
Ancient Grain Blend
Coarse Rice Flour
Hi-Maize Wholegrain Flour
Maize Polenta
Wholemeal Wheat Flour
Raw Material Ground

Appendix 4: Nutrient calculation and statistical analysis for fibre enriched 3G formulations in Chapter 5

A 4.1 Theoretical starch and fibre content calculation details for Table 5.1

Table A.1: Typical starch content of in raw ingredients

Raw Ingredients	***Carbohydrate[1] (g/100g)***	***Sugar[1] (g/100g)***	***Starch[2] (g/100g)***
Ancient Grain Flour Blend[3]	60.3	0.5	59.8
Wholemeal Wheat Flour	60.9	1.0	59.9
Coarse Rice Flour	78.5	1.0	77.5
Potato Starch (Elian™ 100)	80.0	0	80.0
Wheat Fibre 600	0	0	0
Beneo GR	8.0	8.0	0
Hi-Maize™ 1043	33.5	NA[4]	≤ 33.5
White sugar	100.0	100.0	0
Salt	0	0	0
Nut brown flour	81.6	7.3	74.3

[1] Information provided in raw material specifications from supplier

[2] Calculated by subtracting sugar from carbohydrate

[3] Calculated by average nutrient values of amaranth, quinoa and millet.

[4] Information is not available on the raw material specification

Table A.2: Approximate starch contents of fibre enriched 3G formulations

	Percentage of each base ingredient w/w										
ID	*Coarse Rice Flour*	*Potato Starch*	*WM Wheat Flour*	*Ancient Grain Blend*	*White Sugar*	*Nut Brown Flour*	*Salt*	*Wheat Fibre 600*	*Beneo GR*	*Hi-Maize 1043*	*Starch Content* [1]
Control	33.0	27.5	31.0	5.0	2.0	1.0	0.5	0	0	0	69.9
WF Lo	31.0	27.5	31.0	5.0	2.0	1.0	0.5	2.0	0	0	68.3
WF Hi	29.0	27.5	31.0	5.0	2.0	1.0	0.5	4.0	0	0	66.8
Beneo Lo	31.0	27.5	31.0	5.0	2.0	1.0	0.5	0	2.0	0	68.3
Beneo Hi	29.0	27.5	31.0	5.0	2.0	1.0	0.5	0	4.0	0	66.8
Hi-Maize Lo	29.5	27.5	31.0	5.0	2.0	1.0	0.5	0	0	3.5	68.3
Hi-Maize Hi	26.0	27.5	31.0	5.0	2.0	1.0	0.5	0	0	7.0	66.8

[1] Starch content is the sum of percentage of each ingredient w/w multiply by its starch content from Table A.1.

Starch content calculation example of: control recipe:

ID	Coarse Rice Flour	Potato Starch	WM Wheat Flour	Ancient Grain Blend	White Sugar	Nut Brown Flour	Salt	Sum of Starch content
Control	33.0 % × 77.5	27.5 % × 80.0	31.0 % × 59.9	5.0 % × 59.8	2.0 % × 0	1.0 % × 74.3	0.5 % × 0	69.9

Table A.3: Typical fibre and moisture contents of raw ingredients

Raw Material	***Dietary Fibre[1] (g/100g)***	***Moisture (%)***
Ancient Grain Flour Blend[3]	8.1	10.1[2]
Wholemeal Wheat Flour	11.8	12.7[2]
Coarse Rice Flour	0.5	12.5[2]
Potato Starch (Elian™ 100)	0	13.2[2]
Wheat Fibre 600	89.3	4.0[4]
Beneo GR	89.0	3.0[4]
Hi-Maize™ 1043	52.2	11.5[4]
White sugar	0	0[4]
Salt	0	0[4]
Nut brown flour	15.4	3.1[4]

[1] Information provided in raw material specifications from supplier

[2] Moisture content determined as described in Section 3.6.1

[3] Calculated by average fibre values of amaranth, quinoa and millet.

[4] Typical value or middle point of the moisture range provided in raw material specifications from supplier

Table A.4: Typical dry matter content of the fibre enriched 3G formulations

Raw Ingredients	*Ingredient Solid [1] (%)*	*'Control' Solid content [2] (g/100g)*	*'WF Lo' Solid Content [2] (g/100g)*	*'WF Hi' Solid Content [2] (g/100g)*	*'Beneo Lo' Solid Content [2] (g/100g)*	*'Beneo Hi' Solid Content [2] (g/100g)*	*'Hi-Maize' Lo Solid Content [2] (g/100g)*	*'Hi-Maize Hi' Solid Content [2] (g/100g)*
Ancient Grain Flour Blend	89.9	4.50	4.50	4.50	4.50	4.50	4.50	4.50
Wholemeal Wheat Flour	87.3	27.06	27.06	27.06	27.06	27.06	27.06	27.06
Coarse Rice Flour	87.5	28.88	27.13	25.38	27.13	25.38	25.81	22.75
Potato Starch (Elian™ 100)	86.8	23.87	23.87	23.87	23.87	23.87	23.87	23.87
White Fibre	96.0	0	1.92	3.84	0	0	0	0
Beneo GR	97.0	0	0	0	1.94	3.88	0	0
Hi-Maize™ 1043	88.5	0	0	0	0	0	3.10	6.20
White sugar	100	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Salt	100	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Nut brown flour	96.9	0.97	0.97	0.97	0.97	0.97	0.97	0.97
	TOTAL SOLID	87.77	87.94	88.11	87.96	88.15	87.81	87.84

[1] Ingredient solid = 100 % – ingredient moisture %

[2] Calculated by multiplying ingredient solid with the percentage of each base ingredient from Table A.2

[3] Sum of solid contents of all ingredients.

Calculation example of fibre content:

According to mass balance, the mass enters the system must be the same as the mass leaves the system. The typical moisture of puffed products is 4.0 %.

Hence, to produce 100 g of puffed 3G 'Control' products, the raw ingredients required is 100 × (100% - 4.0 %) ÷ 87.77% = 109.38 g

Table A.5: Calculation example of 'Control' fibre content

Raw Ingredients	***Ingredient Content (%)***	***Ingredients required to produce 100 g of puffed products [1] (g)***	***Fibre Content [2] (g/100g)***
Ancient Grain Flour Blend	5.0	5.47	0.44
Wholemeal Wheat Flour	31.0	33.91	4.00
Coarse Rice Flour	33.0	36.09	0.18
Potato Starch (Elian™ 100)	27.5	30.08	0
White sugar	2.0	2.19	0
Salt	0.5	0.55	0
Nut brown flour	1.0	1.09	0.17
	TOTAL	109.38	4.79

[1] Calculated by multiplying ingredient content (%) with the raw ingredients required (109.38 g)

[2] Calculated by multiplying 'ingredient required to product 100g of puffed products' with the dietary fibre content of each base ingredient from Table A.3

A 4.2 Minitab One-way ANOVA of raw ingredient blend pasting properties with different fibre enriched formulations

One-way ANOVA: Peak Viscosity versus Treatment

```
Source     DF       SS      MS     F      P
Treatment   6   922274  153712  7.39  0.009
Error       7   145527   20790
Total      13  1067801

S = 144.2   R-Sq = 86.37%   R-Sq(adj) = 74.69%


                               Individual 95% CIs For Mean Based on
                               Pooled StDev
Level         N    Mean  StDev  --------+---------+---------+---------+-
Beneo Hi      2  1410.0   45.3   (------*------)
Beneo Lo      2  1674.5  342.9         (------*------)
Control       2  2129.5  109.6                   (------*------)
Hi-Maize Hi   2  1539.5   12.0      (------*------)
Hi-Maize Lo   2  1370.5   30.4  (------*------)
WF Hi         2  1805.5   77.1            (------*-----)
WF Lo         2  1916.5   82.7              (------*------)
                                --------+---------+---------+---------+-
                                     1400      1750      2100      2450

Pooled StDev = 144.2
```

Grouping Information Using Tukey Method

Treatment	N	Mean	Grouping
Control	2	2129.5	A
WF Lo	2	1916.5	A B
WF Hi	2	1805.5	A B
Beneo Lo	2	1674.5	A B
Hi-Maize Hi	2	1539.5	B
Beneo Hi	2	1410.0	B
Hi-Maize Lo	2	1370.5	B

Means that do not share a letter are significantly different.

Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Treatment

Individual confidence level = 99.46%

Treatment = Beneo Hi subtracted from:

```
Treatment     Lower  Centre   Upper  ---------+---------+---------+---------+
Beneo Lo     -307.5   264.5   836.5                 (-------*-------)
Control       147.5   719.5  1291.5                       (-------*-------)
Hi-Maize Hi  -442.5   129.5   701.5               (-------*-------)
Hi-Maize Lo  -611.5   -39.5   532.5            (-------*--------)
WF Hi        -176.5   395.5   967.5                  (--------*-------)
WF Lo         -65.5   506.5  1078.5                    (-------*-------)
                                     ---------+---------+---------+---------+
                                           -700         0       700      1400
```

Treatment = Beneo Lo subtracted from:

```
Treatment     Lower  Centre   Upper  ---------+---------+---------+---------+
Control      -117.0   455.0  1027.0                   (--------*-------)
Hi-Maize Hi  -707.0  -135.0   437.0           (-------*-------)
Hi-Maize Lo  -876.0  -304.0   268.0        (--------*-------)
WF Hi        -441.0   131.0   703.0               (-------*-------)
WF Lo        -330.0   242.0   814.0                (-------*--------)
                                     ---------+---------+---------+---------+
                                           -700         0       700      1400
```

Treatment = Control subtracted from:

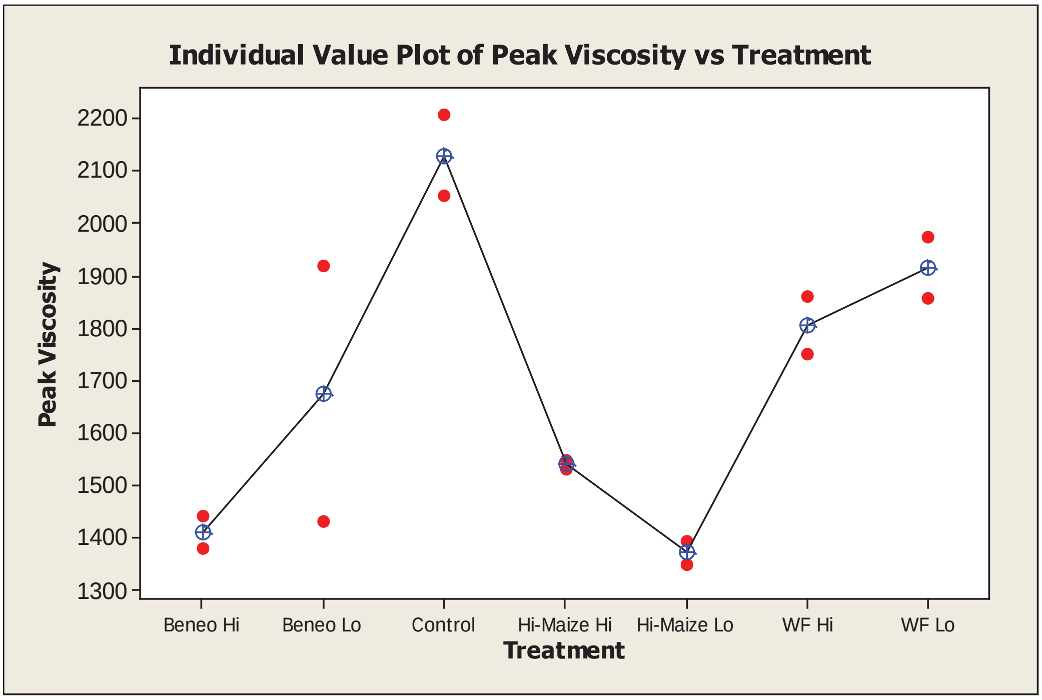
```
Treatment      Lower  Centre   Upper  ---------+---------+---------+---------+
Hi-Maize Hi  -1162.0  -590.0   -18.0    (--------*-------)
Hi-Maize Lo  -1331.0  -759.0  -187.0  (-------*-------)
WF Hi         -896.0  -324.0   248.0        (-------*--------)
WF Lo         -785.0  -213.0   359.0          (-------*-------)
                                      ---------+---------+---------+---------+
                                            -700         0       700      1400
```

Treatment = Hi-Maize Hi subtracted from:

```
Treatment     Lower  Centre  Upper  ---------+---------+---------+---------+
Hi-Maize Lo  -741.0  -169.0  403.0          (--------*-------)
WF Hi        -306.0   266.0  838.0                 (-------*-------)
WF Lo        -195.0   377.0  949.0                  (-------*--------)
                                    ---------+---------+---------+---------+
                                          -700         0       700      1400
```

```
Treatment = Hi-Maize Lo subtracted from:

Treatment    Lower  Centre   Upper  ---------+---------+---------+---------+
WF Hi       -137.0   435.0  1007.0                  (-------*-------)
WF Lo        -26.0   546.0  1118.0                    (-------*-------)
                                    ---------+---------+---------+---------+
                                          -700         0       700      1400


Treatment = WF Hi subtracted from:

Treatment    Lower  Centre  Upper  ---------+---------+---------+---------+
WF Lo       -461.0   111.0  683.0             (--------*-------)
                                   ---------+---------+---------+---------+
                                         -700         0       700      1400
```

Individual Value Plot of Peak Viscosity vs Treatment



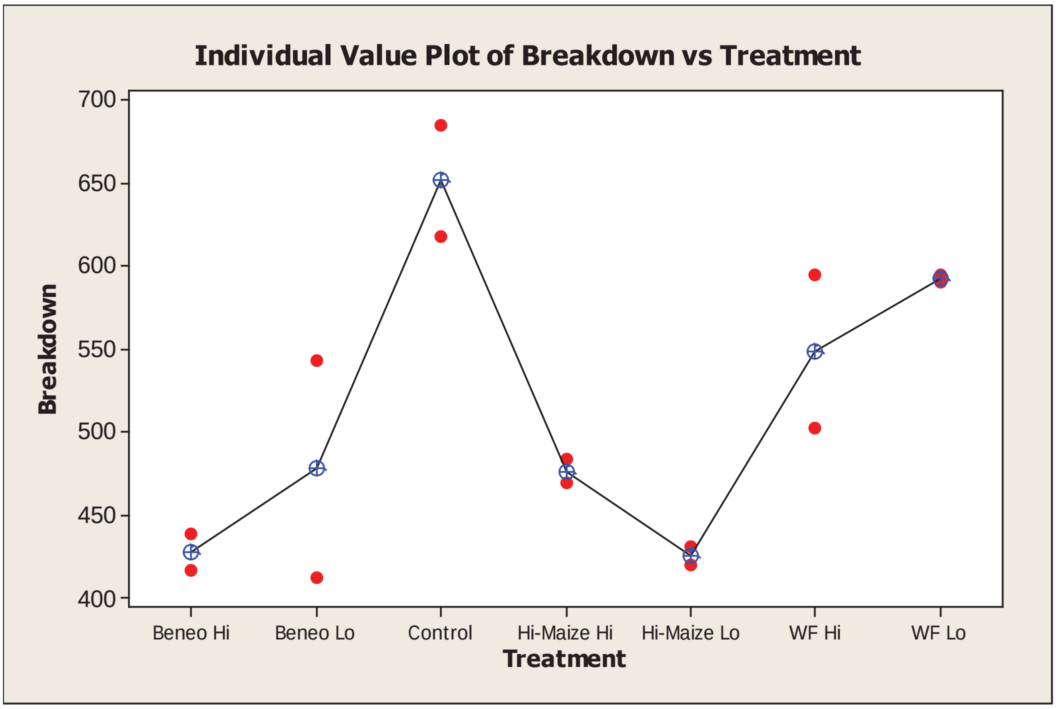
One-way ANOVA: Breakdown versus Treatment

```
Source     DF      SS     MS     F      P
Treatment   6   88458  14743  6.67  0.012
Error       7   15470   2210
Total      13  103928

S = 47.01   R-Sq = 85.11%   R-Sq(adj) = 72.36%

                               Individual 95% CIs For Mean Based on
                               Pooled StDev
Level         N    Mean  StDev  -----+---------+---------+---------+----
Beneo Hi      2  428.00  15.56  (-------*-------)
Beneo Lo      2  477.50  92.63       (-------*-------)
Control       2  651.50  47.38                        (-------*-------)
Hi-Maize Hi   2  476.00   9.90       (-------*------)
Hi-Maize Lo   2  425.50   7.78  (-------*------)
WF Hi         2  548.00  65.05              (-------*-------)
WF Lo         2  592.50   3.54                  (-------*-------)
                                -----+---------+---------+---------+----
                                   400       500       600       700
```

```
Pooled StDev = 47.01


Grouping Information Using Tukey Method

Treatment    N    Mean  Grouping
Control      2  651.50  A
WF Lo        2  592.50  A B
WF Hi        2  548.00  A B
Beneo Lo     2  477.50  A B
Hi-Maize Hi  2  476.00  A B
Beneo Hi     2  428.00    B
Hi-Maize Lo  2  425.50    B

Means that do not share a letter are significantly different.


Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Treatment

Individual confidence level = 99.46%


Treatment = Beneo Hi subtracted from:

Treatment      Lower  Centre   Upper  ------+---------+---------+---------+---
Beneo Lo     -136.99   49.50  235.99             (------*------)
Control        37.01  223.50  409.99                   (-------*------)
Hi-Maize Hi  -138.49   48.00  234.49            (-------*------)
Hi-Maize Lo  -188.99   -2.50  183.99          (-------*------)
WF Hi         -66.49  120.00  306.49               (-------*------)
WF Lo         -21.99  164.50  350.99                 (-------*------)
                                      ------+---------+---------+---------+---
                                         -250         0       250       500


Treatment = Beneo Lo subtracted from:

Treatment      Lower  Centre   Upper  ------+---------+---------+---------+---
Control       -12.49  174.00  360.49                  (------*------)
Hi-Maize Hi  -187.99   -1.50  184.99          (-------*------)
Hi-Maize Lo  -238.49  -52.00  134.49        (-------*------)
WF Hi        -115.99   70.50  256.99             (-------*------)
WF Lo         -71.49  115.00  301.49               (-------*------)
                                      ------+---------+---------+---------+---
                                         -250         0       250       500


Treatment = Control subtracted from:

Treatment      Lower   Centre   Upper  ------+---------+---------+---------+---
Hi-Maize Hi  -361.99  -175.50   10.99    (------*------)
Hi-Maize Lo  -412.49  -226.00  -39.51  (------*------)
WF Hi        -289.99  -103.50   82.99      (-------*------)
WF Lo        -245.49   -59.00  127.49        (-------*------)
                                       ------+---------+---------+---------+---
                                          -250         0       250       500


Treatment = Hi-Maize Hi subtracted from:

Treatment      Lower  Centre   Upper  ------+---------+---------+---------+---
Hi-Maize Lo  -236.99  -50.50  135.99         (------*------)
WF Hi        -114.49   72.00  258.49             (-------*------)
WF Lo         -69.99  116.50  302.99               (-------*------)
                                      ------+---------+---------+---------+---
                                         -250         0       250       500
```

```
Treatment = Hi-Maize Lo subtracted from:

Treatment   Lower  Centre   Upper  ------+---------+---------+---------+---
WF Hi      -63.99  122.50  308.99              (-------*------)
WF Lo      -19.49  167.00  353.49                (-------*------)
                                   ------+---------+---------+---------+---
                                      -250         0       250       500


Treatment = WF Hi subtracted from:

Treatment    Lower  Centre   Upper  ------+---------+---------+---------+---
WF Lo      -141.99   44.50  230.99            (-------*------)
                                    ------+---------+---------+---------+---
                                       -250         0       250       500
```

Individual Value Plot of Breakdown vs Treatment



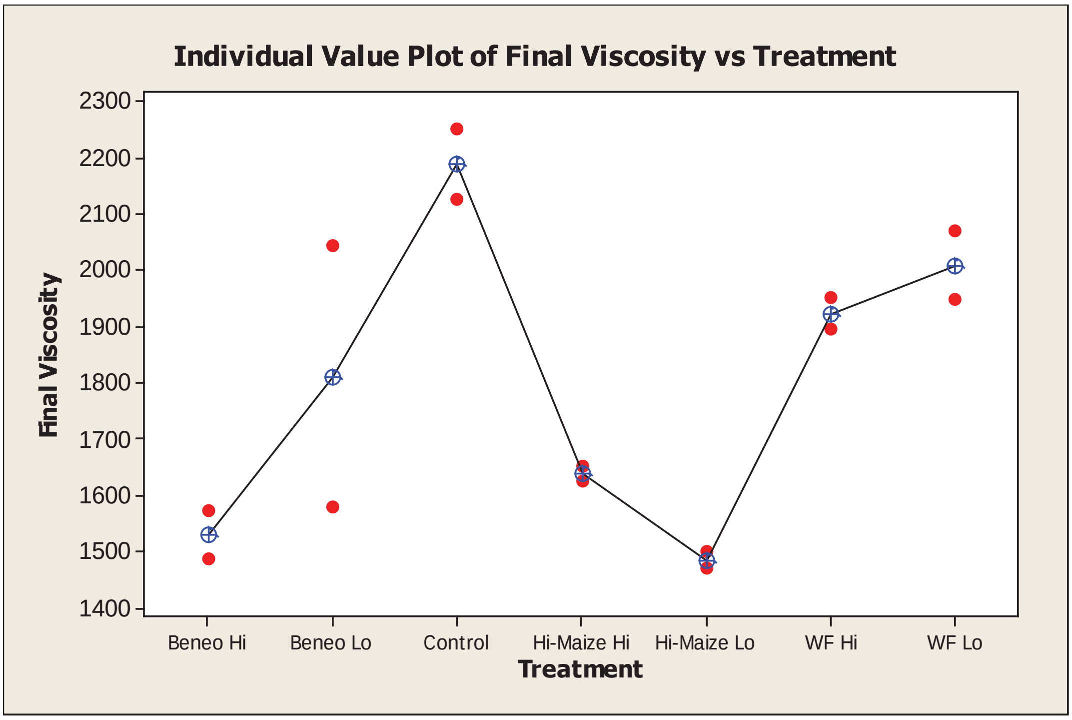
One-way ANOVA: Final Viscosity versus Treatment

```
Source     DF      SS      MS     F      P
Treatment   6  817205  136201  7.35  0.009
Error       7  129636   18519
Total      13  946840

S = 136.1   R-Sq = 86.31%   R-Sq(adj) = 74.57%

                               Individual 95% CIs For Mean Based on
                               Pooled StDev
Level        N    Mean  StDev  --------+---------+---------+---------+-
Beneo Hi     2  1530.0   59.4   (-------*-------)
Beneo Lo     2  1811.0  329.5            (------*-------)
Control      2  2189.0   89.1                        (-------*-------)
Hi-Maize Hi  2  1640.0   18.4      (-------*------)
Hi-Maize Lo  2  1484.5   20.5  (------*-------)
WF Hi        2  1923.5   38.9               (------*-------)
WF Lo        2  2009.5   85.6                 (-------*-------)
                               --------+---------+---------+---------+-
                                    1500      1800      2100      2400
```

```
Pooled StDev = 136.1


Grouping Information Using Tukey Method

Treatment    N    Mean  Grouping
Control      2  2189.0  A
WF Lo        2  2009.5  A B
WF Hi        2  1923.5  A B
Beneo Lo     2  1811.0  A B
Hi-Maize Hi  2  1640.0    B
Beneo Hi     2  1530.0    B
Hi-Maize Lo  2  1484.5    B

Means that do not share a letter are significantly different.


Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Treatment

Individual confidence level = 99.46%


Treatment = Beneo Hi subtracted from:

Treatment     Lower  Centre   Upper  --------+---------+---------+---------+-
Beneo Lo     -258.8   281.0   820.8                (-------*-------)
Control       119.2   659.0  1198.8                      (------*-------)
Hi-Maize Hi  -429.8   110.0   649.8              (-------*------)
Hi-Maize Lo  -585.3   -45.5   494.3            (------*-------)
WF Hi        -146.3   393.5   933.3                  (-------*------)
WF Lo         -60.3   479.5  1019.3                   (-------*-------)
                                     --------+---------+---------+---------+-
                                          -700         0       700      1400


Treatment = Beneo Lo subtracted from:

Treatment     Lower  Centre  Upper  --------+---------+---------+---------+-
Control      -161.8   378.0  917.8                  (------*-------)
Hi-Maize Hi  -710.8  -171.0  368.8          (-------*------)
Hi-Maize Lo  -866.3  -326.5  213.3        (------*-------)
WF Hi        -427.3   112.5  652.3              (-------*------)
WF Lo        -341.3   198.5  738.3               (-------*-------)
                                    --------+---------+---------+---------+-
                                         -700         0       700      1400


Treatment = Control subtracted from:

Treatment      Lower  Centre   Upper  --------+---------+---------+---------+-
Hi-Maize Hi  -1088.8  -549.0    -9.2    (-------*-------)
Hi-Maize Lo  -1244.3  -704.5  -164.7  (-------*-------)
WF Hi         -805.3  -265.5   274.3        (-------*-------)
WF Lo         -719.3  -179.5   360.3          (------*-------)
                                      --------+---------+---------+---------+-
                                           -700         0       700      1400


Treatment = Hi-Maize Hi subtracted from:

Treatment     Lower  Centre  Upper  --------+---------+---------+---------+-
Hi-Maize Lo  -695.3  -155.5  384.3          (-------*------)
WF Hi        -256.3   283.5  823.3                (-------*-------)
WF Lo        -170.3   369.5  909.3                  (------*-------)
                                    --------+---------+---------+---------+-
                                         -700         0       700      1400
```

```
Treatment = Hi-Maize Lo subtracted from:

Treatment    Lower  Centre   Upper  --------+---------+---------+---------+-
WF Hi       -100.8   439.0   978.8                  (------*-------)
WF Lo        -14.8   525.0  1064.8                   (-------*------)
                                    --------+---------+---------+---------+-
                                         -700         0       700      1400


Treatment = WF Hi subtracted from:

Treatment    Lower  Centre  Upper  --------+---------+---------+---------+-
WF Lo       -453.8    86.0  625.8             (------*-------)
                                   --------+---------+---------+---------+-
                                        -700         0       700      1400
```

Individual Value Plot of Final Viscosity vs Treatment



One-way ANOVA: Setback versus Treatment

```
Source      DF     SS    MS     F      P
Treatment    6  56559  9427  7.44  0.009
Error        7   8868  1267
Total       13  65427

S = 35.59   R-Sq = 86.45%   R-Sq(adj) = 74.83%


Level         N    Mean  StDev
Beneo Hi      2  548.00  29.70
Beneo Lo      2  614.00  79.20
Control       2  711.00  26.87
Hi-Maize Hi   2  576.50  16.26
Hi-Maize Lo   2  539.50   2.12
WF Hi         2  666.00  26.87
WF Lo         2  685.50   0.71
```

```
             Individual 95% CIs For Mean Based on Pooled StDev
Level          +---------+---------+---------+---------
Beneo Hi        (-------*------)
Beneo Lo                (-------*------)
Control                             (-------*------)
Hi-Maize Hi         (------*-------)
Hi-Maize Lo    (------*-------)
WF Hi                          (------*-------)
WF Lo                            (-------*------)
               +---------+---------+---------+---------
             480       560       640       720
```

Pooled StDev = 35.59

Grouping Information Using Tukey Method

Treatment	N	Mean	Grouping
Control	2	711.00	A
WF Lo	2	685.50	A B
WF Hi	2	666.00	A B C
Beneo Lo	2	614.00	A B C
Hi-Maize Hi	2	576.50	A B C
Beneo Hi	2	548.00	B C
Hi-Maize Lo	2	539.50	C

Means that do not share a letter are significantly different.
Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Treatment

Individual confidence level = 99.46%

Treatment = Beneo Hi subtracted from:

Treatment	Lower	Centre	Upper
Beneo Lo	-75.19	66.00	207.19
Control	21.81	163.00	304.19
Hi-Maize Hi	-112.69	28.50	169.69
Hi-Maize Lo	-149.69	-8.50	132.69
WF Hi	-23.19	118.00	259.19
WF Lo	-3.69	137.50	278.69

```
Treatment       +---------+---------+---------+---------
Beneo Lo                       (--------*--------)
Control                              (--------*--------)
Hi-Maize Hi                  (--------*--------)
Hi-Maize Lo                (-------*--------)
WF Hi                              (-------*--------)
WF Lo                               (--------*-------)
                +---------+---------+---------+---------
             -320      -160         0       160
```

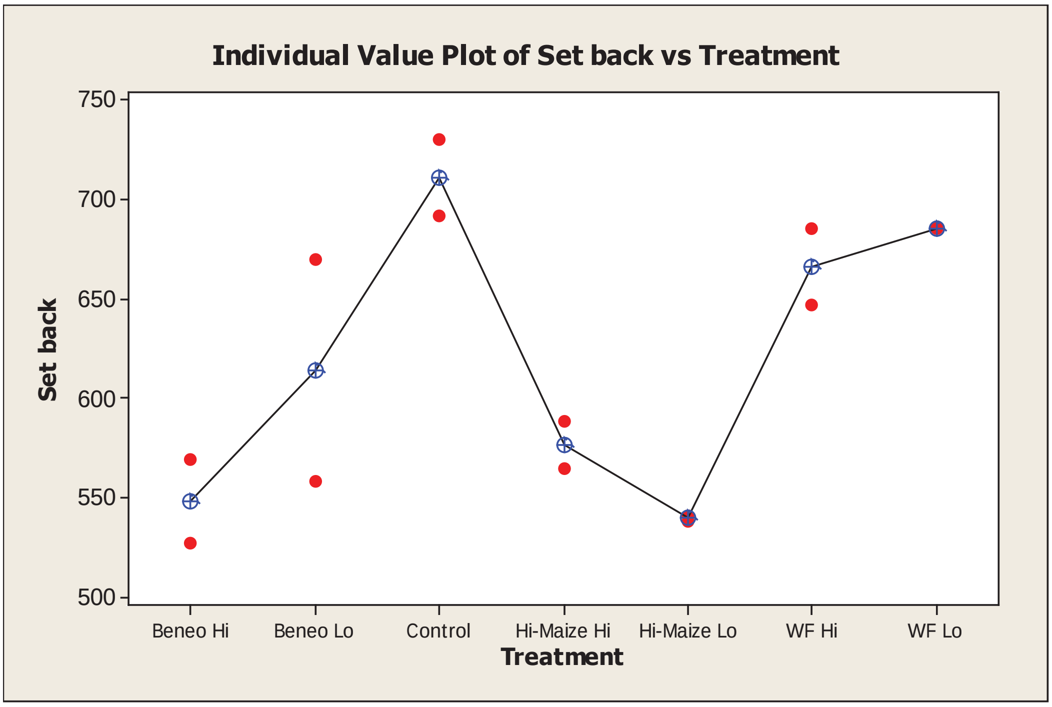
Treatment = Beneo Lo subtracted from:

Treatment	Lower	Centre	Upper
Control	-44.19	97.00	238.19
Hi-Maize Hi	-178.69	-37.50	103.69
Hi-Maize Lo	-215.69	-74.50	66.69
WF Hi	-89.19	52.00	193.19
WF Lo	-69.69	71.50	212.69

```
Treatment       +---------+---------+---------+---------
Control                          (--------*--------)
Hi-Maize Hi              (--------*-------)
Hi-Maize Lo            (-------*--------)
WF Hi                         (--------*--------)
WF Lo                           (-------*--------)
                +---------+---------+---------+---------
             -320      -160         0       160
```

```
Treatment = Control subtracted from:

Treatment      Lower   Centre   Upper
Hi-Maize Hi  -275.69  -134.50    6.69
Hi-Maize Lo  -312.69  -171.50  -30.31
WF Hi        -186.19   -45.00   96.19
WF Lo        -166.69   -25.50  115.69

Treatment       +---------+---------+---------+---------
Hi-Maize Hi        (--------*-------)
Hi-Maize Lo     (--------*--------)
WF Hi                   (--------*--------)
WF Lo                     (-------*--------)
                +---------+---------+---------+---------
             -320      -160         0       160


Treatment = Hi-Maize Hi subtracted from:

Treatment      Lower  Centre   Upper
Hi-Maize Lo  -178.19  -37.00  104.19
WF Hi         -51.69   89.50  230.69
WF Lo         -32.19  109.00  250.19

Treatment       +---------+---------+---------+---------
Hi-Maize Lo              (--------*--------)
WF Hi                            (--------*-------)
WF Lo                             (--------*--------)
                +---------+---------+---------+---------
             -320      -160         0       160


Treatment = Hi-Maize Lo subtracted from:

Treatment   Lower  Centre   Upper     +---------+---------+---------+---------
WF Hi      -14.69  126.50  267.69                       (--------*--------)
WF Lo        4.81  146.00  287.19                        (--------*--------)
                                      +---------+---------+---------+---------
                                   -320      -160         0       160


Treatment = WF Hi subtracted from:

Treatment    Lower  Centre   Upper     +---------+---------+---------+---------
WF Lo      -121.69   19.50  160.69                 (--------*--------)
                                       +---------+---------+---------+---------
                                    -320      -160         0       160
```

Individual Value Plot of Setback vs Treatment

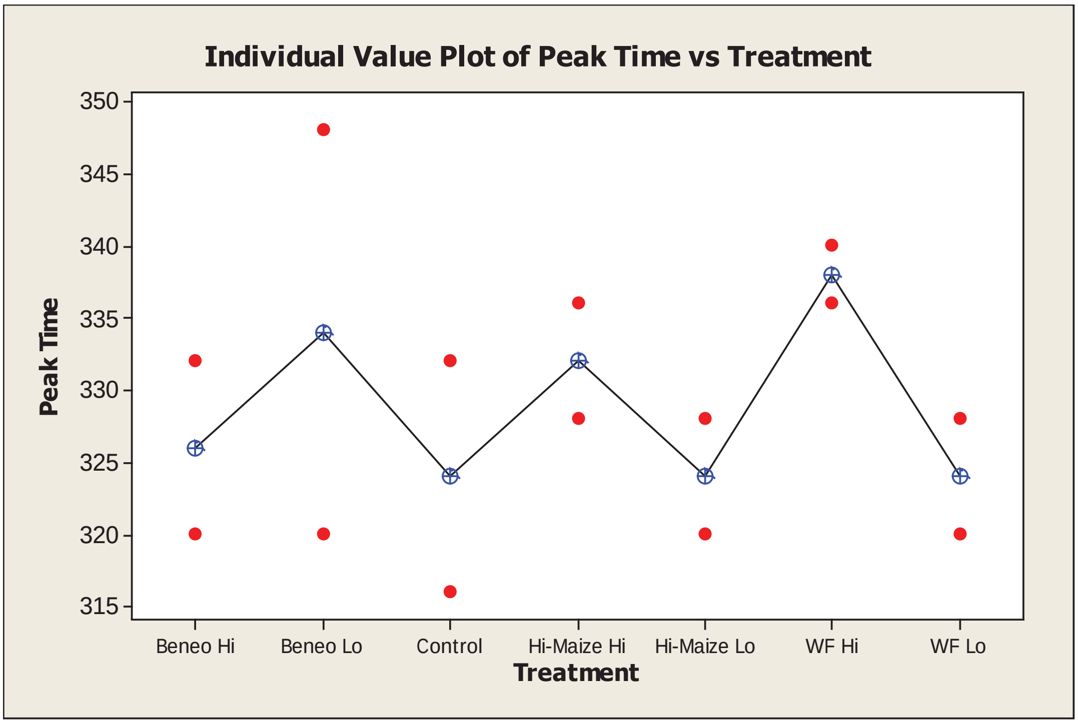


One-way ANOVA: Peak Time versus Treatment

```
Source     DF      SS    MS     F      P
Treatment   6   397.7  66.3  0.67  0.681
Error       7   696.0  99.4
Total      13  1093.7

S = 9.971   R-Sq = 36.36%   R-Sq(adj) = 0.00%

                               Individual 95% CIs For Mean Based on
                               Pooled StDev
Level        N    Mean  StDev  ----+---------+---------+---------+-----
Beneo Hi     2  326.00   8.49    (-------------*-------------)
Beneo Lo     2  334.00  19.80          (-------------*-------------)
Control      2  324.00  11.31  (-------------*-------------)
Hi-Maize Hi  2  332.00   5.66         (-------------*-------------)
Hi-Maize Lo  2  324.00   5.66  (-------------*-------------)
WF Hi        2  338.00   2.83              (-------------*-------------)
WF Lo        2  324.00   5.66  (-------------*-------------)
                               ----+---------+---------+---------+-----
                                 312       324       336       348

Pooled StDev = 9.97


Grouping Information Using Tukey Method

Treatment    N     Mean  Grouping
WF Hi        2  338.000  A
Beneo Lo     2  334.000  A
Hi-Maize Hi  2  332.000  A
Beneo Hi     2  326.000  A
WF Lo        2  324.000  A
Hi-Maize Lo  2  324.000  A
Control      2  324.000  A

Means that do not share a letter are significantly different.
```

```
Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Treatment

Individual confidence level = 99.46%

Treatment = Beneo Hi subtracted from:

Treatment      Lower  Centre   Upper  --------+---------+---------+---------+-
Beneo Lo     -31.555   8.000  47.555         (-------------*------------)
Control      -41.555  -2.000  37.555      (------------*-------------)
Hi-Maize Hi  -33.555   6.000  45.555         (------------*------------)
Hi-Maize Lo  -41.555  -2.000  37.555      (------------*-------------)
WF Hi        -27.555  12.000  51.555           (------------*------------)
WF Lo        -41.555  -2.000  37.555      (------------*-------------)
                                      --------+---------+---------+---------+-
                                            -30         0        30        60


Treatment = Beneo Lo subtracted from:

Treatment      Lower   Centre   Upper  --------+---------+---------+---------+-
Control      -49.555  -10.000  29.555   (-------------*------------)
Hi-Maize Hi  -41.555   -2.000  37.555      (------------*-------------)
Hi-Maize Lo  -49.555  -10.000  29.555   (-------------*------------)
WF Hi        -35.555    4.000  43.555        (------------*-------------)
WF Lo        -49.555  -10.000  29.555   (-------------*------------)
                                       --------+---------+---------+---------+-
                                             -30         0        30        60


Treatment = Control subtracted from:

Treatment      Lower  Centre   Upper  --------+---------+---------+---------+-
Hi-Maize Hi  -31.555   8.000  47.555         (-------------*------------)
Hi-Maize Lo  -39.555   0.000  39.555       (------------*------------)
WF Hi        -25.555  14.000  53.555           (-------------*------------)
WF Lo        -39.555   0.000  39.555       (------------*------------)
                                      --------+---------+---------+---------+-
                                            -30         0        30        60


Treatment = Hi-Maize Hi subtracted from:

Treatment      Lower  Centre   Upper  --------+---------+---------+---------+-
Hi-Maize Lo  -47.555  -8.000  31.555    (------------*-------------)
WF Hi        -33.555   6.000  45.555         (------------*------------)
WF Lo        -47.555  -8.000  31.555    (------------*-------------)
                                      --------+---------+---------+---------+-
                                            -30         0        30        60


Treatment = Hi-Maize Lo subtracted from:

Treatment    Lower  Centre   Upper  --------+---------+---------+---------+-
WF Hi      -25.555  14.000  53.555           (-------------*------------)
WF Lo      -39.555   0.000  39.555       (------------*------------)
                                    --------+---------+---------+---------+-
                                          -30         0        30        60


Treatment = WF Hi subtracted from:

Treatment    Lower   Centre   Upper  --------+---------+---------+---------+-
WF Lo      -53.555  -14.000  25.555  (------------*------------)
                                     --------+---------+---------+---------+-
                                           -30         0        30        60
```

Individual Value Plot of Peak Time vs Treatment

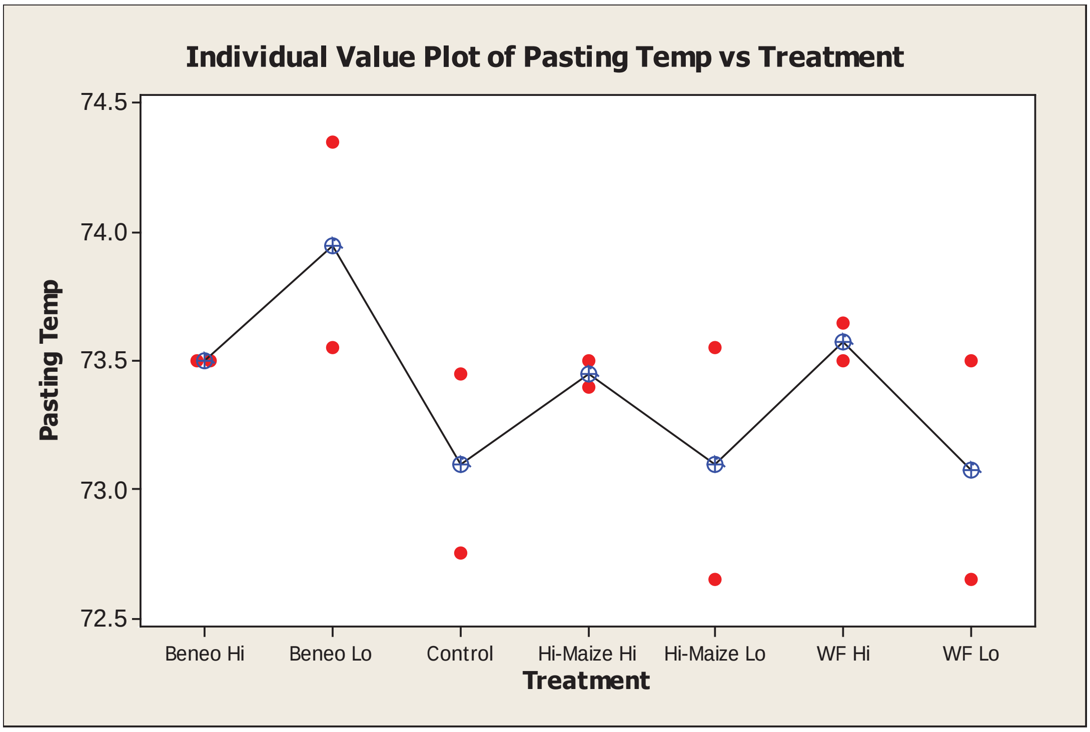


One-way ANOVA: Pasting Temp versus Treatment

```
Source      DF     SS     MS     F      P
Treatment    6  1.262  0.210  1.09  0.449
Error        7  1.347  0.192
Total       13  2.609

S = 0.4387   R-Sq = 48.36%   R-Sq(adj) = 4.09%


                               Individual 95% CIs For Mean Based on
                               Pooled StDev
Level        N    Mean  StDev  ----+---------+---------+---------+-----
Beneo Hi     2  73.500  0.000         (-----------*-----------)
Beneo Lo     2  73.950  0.566                (-----------*------------)
Control      2  73.100  0.495  (-----------*------------)
Hi-Maize Hi  2  73.450  0.071        (-----------*-----------)
Hi-Maize Lo  2  73.100  0.636  (-----------*------------)
WF Hi        2  73.575  0.106          (-----------*-----------)
WF Lo        2  73.075  0.601  (-----------*-----------)
                               ----+---------+---------+---------+-----
                                72.60     73.20     73.80     74.40

Pooled StDev = 0.439

Grouping Information Using Tukey Method

Treatment    N     Mean  Grouping
Beneo Lo     2  73.9500  A
WF Hi        2  73.5750  A
Beneo Hi     2  73.5000  A
Hi-Maize Hi  2  73.4500  A
Hi-Maize Lo  2  73.1000  A
Control      2  73.1000  A
WF Lo        2  73.0750  A

Means that do not share a letter are significantly different.
```

```
Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Treatment

Individual confidence level = 99.46%


Treatment = Beneo Hi subtracted from:

Treatment      Lower   Centre   Upper  -------+---------+---------+---------+--
Beneo Lo     -1.2905   0.4500  2.1905          (-----------*-----------)
Control      -2.1405  -0.4000  1.3405     (----------*-----------)
Hi-Maize Hi  -1.7905  -0.0500  1.6905       (-----------*----------)
Hi-Maize Lo  -2.1405  -0.4000  1.3405     (----------*-----------)
WF Hi        -1.6655   0.0750  1.8155        (-----------*----------)
WF Lo        -2.1655  -0.4250  1.3155     (----------*-----------)
                                       -------+---------+---------+---------+--
                                           -1.5       0.0       1.5       3.0


Treatment = Beneo Lo subtracted from:

Treatment      Lower   Centre   Upper  -------+---------+---------+---------+--
Control      -2.5905  -0.8500  0.8905  (----------*-----------)
Hi-Maize Hi  -2.2405  -0.5000  1.2405    (-----------*----------)
Hi-Maize Lo  -2.5905  -0.8500  0.8905  (----------*-----------)
WF Hi        -2.1155  -0.3750  1.3655     (-----------*----------)
WF Lo        -2.6155  -0.8750  0.8655  (----------*-----------)
                                       -------+---------+---------+---------+--
                                           -1.5       0.0       1.5       3.0


Treatment = Control subtracted from:

Treatment      Lower   Centre   Upper  -------+---------+---------+---------+--
Hi-Maize Hi  -1.3905   0.3500  2.0905          (----------*-----------)
Hi-Maize Lo  -1.7405   0.0000  1.7405       (-----------*-----------)
WF Hi        -1.2655   0.4750  2.2155           (----------*-----------)
WF Lo        -1.7655  -0.0250  1.7155       (-----------*----------)
                                       -------+---------+---------+---------+--
                                           -1.5       0.0       1.5       3.0


Treatment = Hi-Maize Hi subtracted from:

Treatment      Lower   Centre   Upper  -------+---------+---------+---------+--
Hi-Maize Lo  -2.0905  -0.3500  1.3905     (-----------*----------)
WF Hi        -1.6155   0.1250  1.8655        (-----------*----------)
WF Lo        -2.1155  -0.3750  1.3655     (-----------*----------)
                                       -------+---------+---------+---------+--
                                           -1.5       0.0       1.5       3.0


Treatment = Hi-Maize Lo subtracted from:

Treatment    Lower   Centre   Upper  -------+---------+---------+---------+--
WF Hi      -1.2655   0.4750  2.2155           (----------*-----------)
WF Lo      -1.7655  -0.0250  1.7155       (-----------*----------)
                                     -------+---------+---------+---------+--
                                         -1.5       0.0       1.5       3.0


Treatment = WF Hi subtracted from:

Treatment    Lower   Centre   Upper  -------+---------+---------+---------+--
WF Lo      -2.2405  -0.5000  1.2405    (-----------*----------)
                                     -------+---------+---------+---------+--
                                         -1.5       0.0       1.5       3.0
```

Individual Value Plot of Pasting Temp vs Treatment



A 4.3 Minitab One-way ANOVA of extruded pellet pasting properties with different fibre enriched formulations

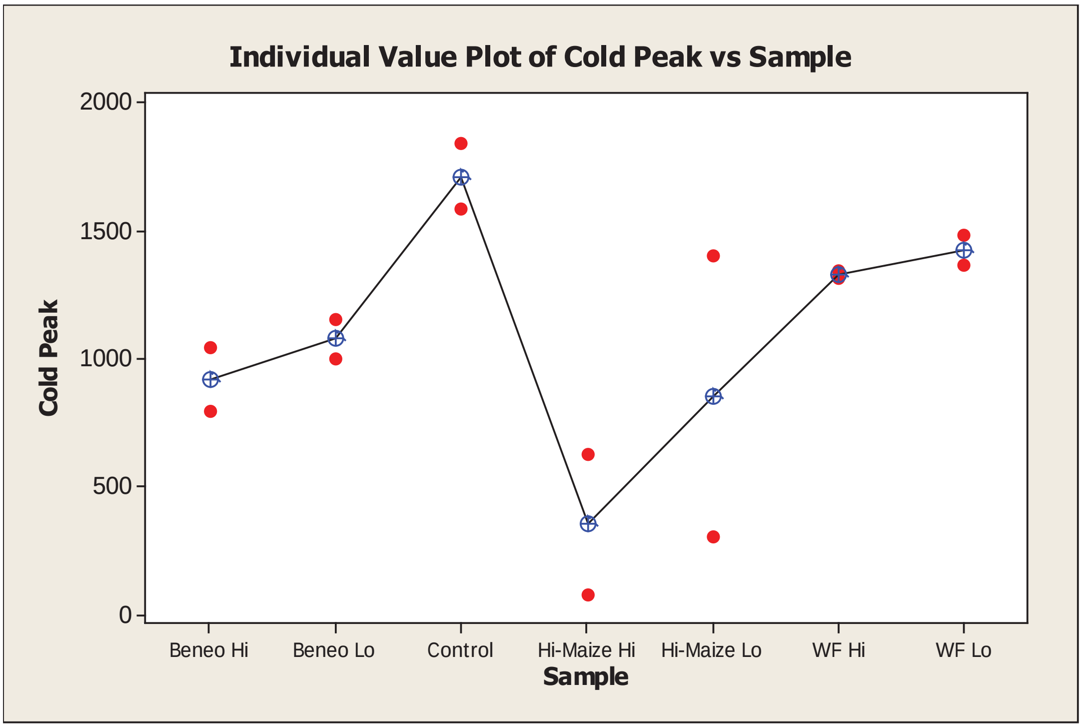
One-way ANOVA: Cold Peak versus Sample

```
Source  DF       SS      MS     F      P
Sample   6  2367343  394557  3.31  0.071
Error    7   833352  119050
Total   13  3200695

S = 345.0   R-Sq = 73.96%   R-Sq(adj) = 51.65%


                               Individual 95% CIs For Mean Based on
                               Pooled StDev
Level         N    Mean  StDev ---+---------+---------+---------+------
Beneo Hi      2   916.5  174.7         (-------*-------)
Beneo Lo      2  1073.5  105.4           (-------*--------)
Control       2  1707.5  181.7                    (-------*--------)
Hi-Maize Hi   2   349.0  386.1 (-------*-------)
Hi-Maize Lo   2   848.0  776.4        (-------*-------)
WF Hi         2  1325.5   19.1               (-------*-------)
WF Lo         2  1420.0   80.6                (-------*--------)
                               ---+---------+---------+---------+------
                                  0       700      1400      2100

Pooled StDev = 345.0


Grouping Information Using Tukey Method
```

```
Sample       N    Mean  Grouping
Control      2  1707.5  A
WF Lo        2  1420.0  A
WF Hi        2  1325.5  A
Beneo Lo     2  1073.5  A
Beneo Hi     2   916.5  A
Hi-Maize Lo  2   848.0  A
Hi-Maize Hi  2   349.0  A

Means that do not share a letter are significantly different.

Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Sample

Individual confidence level = 99.46%

Sample = Beneo Hi subtracted from:

Sample         Lower  Centre   Upper  --------+---------+---------+---------+-
Beneo Lo     -1211.7   157.0  1525.7            (--------*--------)
Control       -577.7   791.0  2159.7                (--------*--------)
Hi-Maize Hi  -1936.2  -567.5   801.2       (--------*--------)
Hi-Maize Lo  -1437.2   -68.5  1300.2          (---------*--------)
WF Hi         -959.7   409.0  1777.7              (--------*--------)
WF Lo         -865.2   503.5  1872.2              (--------*--------)
                                      --------+---------+---------+---------+-
                                          -1500         0      1500      3000

Sample = Beneo Lo subtracted from:

Sample         Lower  Centre   Upper  --------+---------+---------+---------+-
Control       -734.7   634.0  2002.7               (--------*--------)
Hi-Maize Hi  -2093.2  -724.5   644.2      (--------*--------)
Hi-Maize Lo  -1594.2  -225.5  1143.2         (--------*---------)
WF Hi        -1116.7   252.0  1620.7             (--------*--------)
WF Lo        -1022.2   346.5  1715.2             (--------*--------)
                                      --------+---------+---------+---------+-
                                          -1500         0      1500      3000

Sample = Control subtracted from:

Sample         Lower   Centre   Upper  --------+---------+---------+---------+-
Hi-Maize Hi  -2727.2  -1358.5    10.2  (--------*--------)
Hi-Maize Lo  -2228.2   -859.5   509.2     (--------*--------)
WF Hi        -1750.7   -382.0   986.7        (--------*---------)
WF Lo        -1656.2   -287.5  1081.2         (--------*--------)
                                       --------+---------+---------+---------+-
                                           -1500         0      1500      3000

Sample = Hi-Maize Hi subtracted from:

Sample        Lower  Centre   Upper  --------+---------+---------+---------+-
Hi-Maize Lo  -869.7   499.0  1867.7              (--------*--------)
WF Hi        -392.2   976.5  2345.2                 (---------*--------)
WF Lo        -297.7  1071.0  2439.7                  (--------*--------)
                                     --------+---------+---------+---------+-
                                         -1500         0      1500      3000

Sample = Hi-Maize Lo subtracted from:

Sample   Lower  Centre   Upper  --------+---------+---------+---------+-
WF Hi   -891.2   477.5  1846.2              (--------*--------)
WF Lo   -796.7   572.0  1940.7               (--------*--------)
                                --------+---------+---------+---------+-
                                    -1500         0      1500      3000
```

```
Sample = WF Hi subtracted from:

Sample     Lower  Centre    Upper  --------+---------+---------+---------+-
WF Lo    -1274.2    94.5   1463.2           (--------*--------)
                                   --------+---------+---------+---------+-
                                       -1500         0      1500      3000

 -1500         0      1500      3000
```

Individual Value Plot of Cold Peak vs Sample



One-way ANOVA: Final Viscosity versus Sample

```
Source  DF     SS    MS      F      P
Sample   6  57622  9604  29.13  0.000
Error    7   2308   330
Total   13  59930

S = 18.16   R-Sq = 96.15%   R-Sq(adj) = 92.85%


                                Individual 95% CIs For Mean Based on
                                Pooled StDev
Level        N    Mean  StDev  -----+---------+---------+---------+----
Beneo Hi     2  444.50  26.16         (---*--)
Beneo Lo     2  501.00  11.31                (---*--)
Control      2  608.00  14.14                             (---*---)
Hi-Maize Hi  2  464.00  22.63           (---*---)
Hi-Maize Lo  2  525.50  20.51                   (---*--)
WF Hi        2  386.50   4.95  (--*---)
WF Lo        2  497.00  18.38              (---*---)
                               -----+---------+---------+---------+----
                                  400       480       560       640

Pooled StDev = 18.16


Grouping Information Using Tukey Method
```

```
Sample       N    Mean  Grouping
Control      2  608.00  A
Hi-Maize Lo  2  525.50    B
Beneo Lo     2  501.00    B C
WF Lo        2  497.00    B C
Hi-Maize Hi  2  464.00    B C
Beneo Hi     2  444.50      C D
WF Hi        2  386.50        D
```

Means that do not share a letter are significantly different.

Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Sample

Individual confidence level = 99.46%

Sample = Beneo Hi subtracted from:

Sample	Lower	Centre	Upper
Beneo Lo	-15.52	56.50	128.52
Control	91.48	163.50	235.52
Hi-Maize Hi	-52.52	19.50	91.52
Hi-Maize Lo	8.98	81.00	153.02
WF Hi	-130.02	-58.00	14.02
WF Lo	-19.52	52.50	124.52

```
Sample          +---------+---------+---------+---------
Beneo Lo                           (----*----)
Control                                   (----*----)
Hi-Maize Hi                     (----*----)
Hi-Maize Lo                          (---*----)
WF Hi                      (----*----)
WF Lo                              (----*---)
                +---------+---------+---------+---------
             -300      -150         0       150
```

Sample = Beneo Lo subtracted from:

Sample	Lower	Centre	Upper
Control	34.98	107.00	179.02
Hi-Maize Hi	-109.02	-37.00	35.02
Hi-Maize Lo	-47.52	24.50	96.52
WF Hi	-186.52	-114.50	-42.48
WF Lo	-76.02	-4.00	68.02

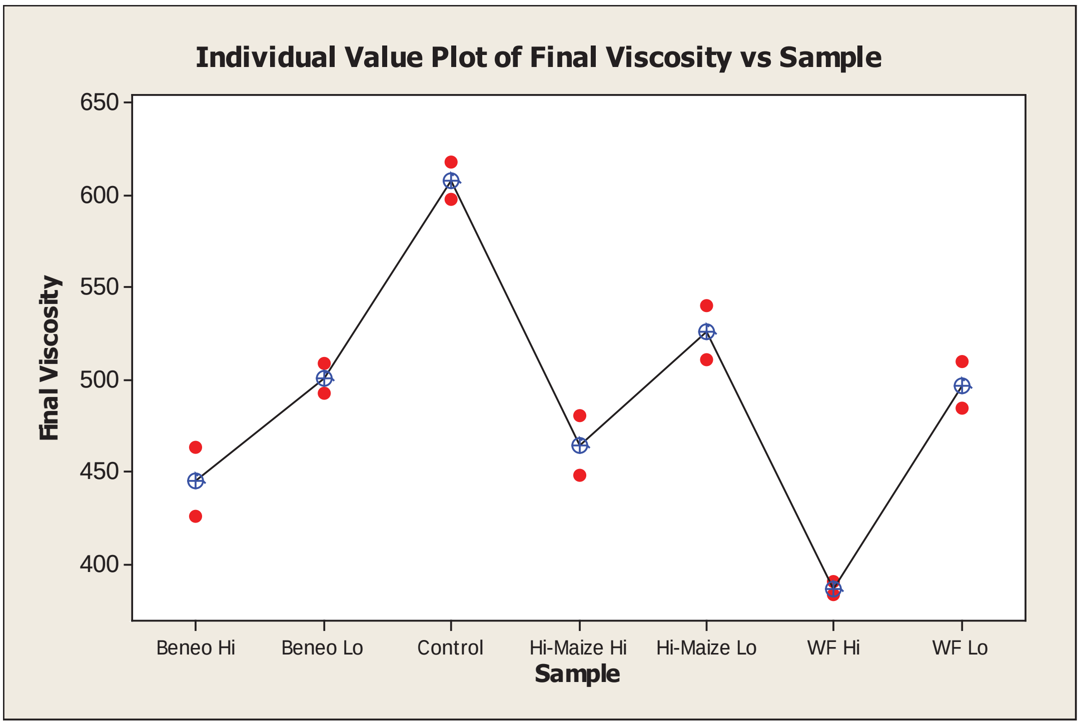
```
Sample          +---------+---------+---------+---------
Control                               (----*----)
Hi-Maize Hi                  (----*---)
Hi-Maize Lo                      (----*---)
WF Hi                   (---*----)
WF Lo                          (----*----)
                +---------+---------+---------+---------
             -300      -150         0       150
```

Sample = Control subtracted from:

Sample	Lower	Centre	Upper
Hi-Maize Hi	-216.02	-144.00	-71.98
Hi-Maize Lo	-154.52	-82.50	-10.48
WF Hi	-293.52	-221.50	-149.48
WF Lo	-183.02	-111.00	-38.98

```
Sample          +---------+---------+---------+---------
Hi-Maize Hi          (---*----)
Hi-Maize Lo              (----*---)
WF Hi           (----*----)
WF Lo                  (----*---)
                +---------+---------+---------+---------
             -300      -150         0       150

Sample = Hi-Maize Hi subtracted from:

Sample         Lower  Centre   Upper
Hi-Maize Lo   -10.52   61.50  133.52
WF Hi        -149.52  -77.50   -5.48
WF Lo         -39.02   33.00  105.02

Sample          +---------+---------+---------+---------
Hi-Maize Lo                       (----*----)
WF Hi                     (----*----)
WF Lo                           (----*----)
                +---------+---------+---------+---------
             -300      -150         0       150

Sample = Hi-Maize Lo subtracted from:

Sample    Lower   Centre   Upper     +---------+---------+---------+---------
WF Hi   -211.02  -139.00  -66.98          (----*----)
WF Lo   -100.52   -28.50   43.52                 (----*----)
                                     +---------+---------+---------+---------
                                  -300      -150         0       150

Sample = WF Hi subtracted from:

Sample  Lower  Centre   Upper     +---------+---------+---------+---------
WF Lo   38.48  110.50  182.52                            (---*----)
                                  +---------+---------+---------+---------
                               -300      -150         0       150
```

Individual Value Plot of Final Viscosity vs Sample

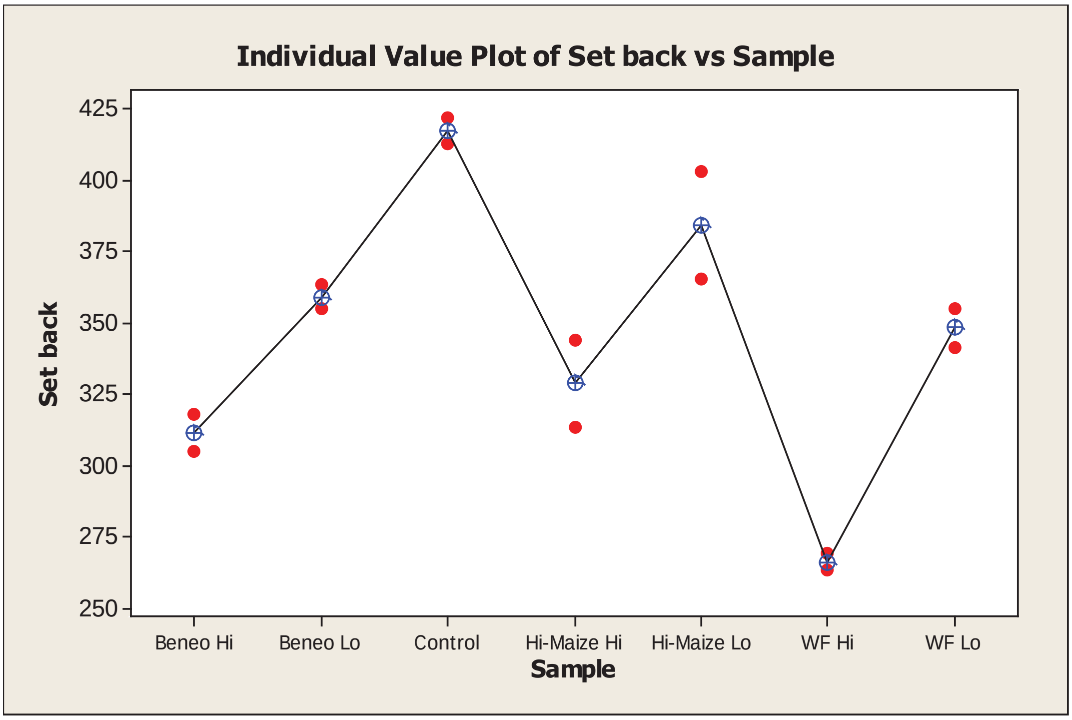


One-way ANOVA: Setback versus Sample

```
Source  DF     SS    MS      F      P
Sample   6  29235  4873  23.12  0.000
Error    7   1476   211
Total   13  30711

S = 14.52   R-Sq = 95.20%   R-Sq(adj) = 91.08%



Level         N    Mean  StDev
Beneo Hi      2  311.50   9.19
Beneo Lo      2  359.00   5.66
Control       2  417.50   6.36
Hi-Maize Hi   2  328.50  21.92
Hi-Maize Lo   2  384.00  26.87
WF Hi         2  266.00   4.24
WF Lo         2  348.00   9.90

             Individual 95% CIs For Mean Based on Pooled StDev
Level          +---------+---------+---------+---------
Beneo Hi               (---*---)
Beneo Lo                       (---*---)
Control                                  (---*---)
Hi-Maize Hi               (---*---)
Hi-Maize Lo                        (---*---)
WF Hi          (---*---)
WF Lo                        (---*---)
               +---------+---------+---------+---------
             240       300       360       420

Pooled StDev = 14.52


Grouping Information Using Tukey Method

Sample        N    Mean  Grouping
Control       2  417.50  A
Hi-Maize Lo   2  384.00  A B
Beneo Lo      2  359.00    B C
WF Lo         2  348.00    B C
Hi-Maize Hi   2  328.50    B C
Beneo Hi      2  311.50      C D
WF Hi         2  266.00        D

Means that do not share a letter are significantly different.


Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Sample

Individual confidence level = 99.46%


Sample = Beneo Hi subtracted from:

Sample          Lower  Centre   Upper  -------+---------+---------+---------+--
Beneo Lo       -10.09   47.50  105.09                 (----*----)
Control         48.41  106.00  163.59                      (----*----)
Hi-Maize Hi    -40.59   17.00   74.59               (---*----)
Hi-Maize Lo     14.91   72.50  130.09                   (----*----)
WF Hi         -103.09  -45.50   12.09         (----*----)
WF Lo          -21.09   36.50   94.09                (----*----)
                                       -------+---------+---------+---------+--
                                           -120         0       120       240
```

```
Sample = Beneo Lo subtracted from:

Sample          Lower  Centre   Upper  -------+---------+---------+---------+--
Control          0.91   58.50  116.09                  (----*----)
Hi-Maize Hi    -88.09  -30.50   27.09           (---*----)
Hi-Maize Lo    -32.59   25.00   82.59               (----*----)
WF Hi         -150.59  -93.00  -35.41     (----*----)
WF Lo          -68.59  -11.00   46.59            (----*----)
                                       -------+---------+---------+---------+--
                                           -120         0       120       240


Sample = Control subtracted from:

Sample          Lower   Centre   Upper  -------+---------+---------+---------+--
Hi-Maize Hi  -146.59   -89.00  -31.41       (----*---)
Hi-Maize Lo   -91.09   -33.50   24.09           (----*----)
WF Hi        -209.09  -151.50  -93.91  (---*----)
WF Lo        -127.09   -69.50  -11.91        (----*----)
                                        -------+---------+---------+---------+--
                                            -120         0       120       240


Sample = Hi-Maize Hi subtracted from:

Sample          Lower  Centre   Upper  -------+---------+---------+---------+--
Hi-Maize Lo     -2.09   55.50  113.09                  (----*---)
WF Hi         -120.09  -62.50   -4.91        (----*----)
WF Lo          -38.09   19.50   77.09               (----*---)
                                       -------+---------+---------+---------+--
                                           -120         0       120       240


Sample = Hi-Maize Lo subtracted from:

Sample    Lower   Centre   Upper  -------+---------+---------+---------+--
WF Hi   -175.59  -118.00  -60.41    (----*----)
WF Lo    -93.59   -36.00   21.59           (----*----)
                                  -------+---------+---------+---------+--
                                      -120         0       120       240


Sample = WF Hi subtracted from:

Sample  Lower  Centre   Upper  -------+---------+---------+---------+--
WF Lo   24.41   82.00  139.59                    (----*----)
                               -------+---------+---------+---------+--
                                   -120         0       120       240
```

Individual Value Plot of Setback vs Sample



A 4.4 Minitab One-way ANOVA of average cell length with different fibre enriched rice and wheat based 3G formulations

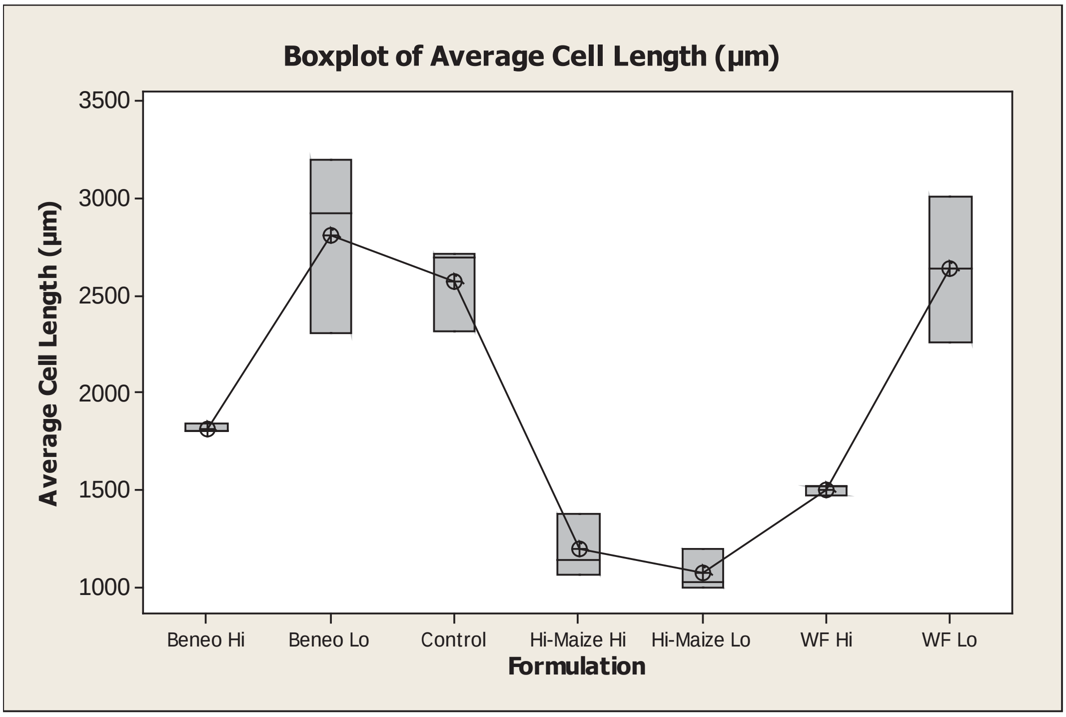
One-way ANOVA: Average Cell Length (µm) versus Formulation

```
Source       DF        SS       MS      F      P
Formulation   6   9550962  1591827  25.31  0.000
Error        14    880586    62899
Total        20  10431548

S = 250.8   R-Sq = 91.56%   R-Sq(adj) = 87.94%

                               Individual 95% CIs For Mean Based on
                               Pooled StDev
Level        N    Mean  StDev  -------+---------+---------+---------+--
Beneo Hi     3  1815.9   20.3              (----*----)
Beneo Lo     3  2813.8  457.6                                (----*----)
Control      3  2578.0  224.7                            (----*----)
Hi-Maize Hi  3  1190.9  166.3    (----*----)
Hi-Maize Lo  3  1069.8  108.0  (----*----)
WF Hi        3  1503.9   24.9         (----*----)
WF Lo        3  2639.4  374.2                             (----*----)
                               -------+---------+---------+---------+--
                                   1200      1800      2400      3000

Pooled StDev = 250.8

Grouping Information Using Tukey Method

Formulation  N    Mean  Grouping
Beneo Lo     3  2813.8  A
WF Lo        3  2639.4  A
Control      3  2578.0  A
Beneo Hi     3  1815.9    B
WF Hi        3  1503.9    B C
Hi-Maize Hi  3  1190.9    B C
Hi-Maize Lo  3  1069.8      C
```

```
Means that do not share a letter are significantly different.

Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Formulation

Individual confidence level = 99.58%

Formulation = Beneo Hi subtracted from:

Formulation    Lower  Centre   Upper  ------+---------+---------+---------+---
Beneo Lo       298.6   997.9  1697.3                  (----*---)
Control         62.7   762.1  1461.5                (----*----)
Hi-Maize Hi  -1324.4  -625.0    74.4       (----*---)
Hi-Maize Lo  -1445.4  -746.1   -46.7      (----*----)
WF Hi        -1011.4  -312.0   387.4         (----*----)
WF Lo          124.2   823.5  1522.9                 (---*----)
                                      ------+---------+---------+---------+---
                                        -1500         0      1500      3000


Formulation = Beneo Lo subtracted from:

Formulation    Lower   Centre    Upper
Control       -935.2   -235.8    463.6
Hi-Maize Hi  -2322.3  -1622.9   -923.6
Hi-Maize Lo  -2443.4  -1744.0  -1044.6
WF Hi        -2009.3  -1309.9   -610.6
WF Lo         -873.8   -174.4    525.0

Formulation  ------+---------+---------+---------+---
Control                (---*----)
Hi-Maize Hi   (---*----)
Hi-Maize Lo  (---*----)
WF Hi           (---*----)
WF Lo                  (----*---)
             ------+---------+---------+---------+---
               -1500         0      1500      3000


Formulation = Control subtracted from:

Formulation    Lower   Centre   Upper  ------+---------+---------+---------+---
Hi-Maize Hi  -2086.5  -1387.1  -687.7    (----*---)
Hi-Maize Lo  -2207.6  -1508.2  -808.8   (----*----)
WF Hi        -1773.5  -1074.1  -374.7      (----*----)
WF Lo         -637.9     61.4   760.8              (---*----)
                                       ------+---------+---------+---------+---
                                         -1500         0      1500      3000


Formulation = Hi-Maize Hi subtracted from:

Formulation   Lower  Centre   Upper  ------+---------+---------+---------+---
Hi-Maize Lo  -820.4  -121.1   578.3            (---*----)
WF Hi        -386.4   313.0  1012.4              (----*----)
WF Lo         749.2  1448.6  2147.9                      (----*---)
                                     ------+---------+---------+---------+---
                                       -1500         0      1500      3000


Formulation = Hi-Maize Lo subtracted from:

Formulation   Lower  Centre   Upper  ------+---------+---------+---------+---
WF Hi        -265.3   434.1  1133.5               (----*----)
WF Lo         870.2  1569.6  2269.0                       (---*----)
                                     ------+---------+---------+---------+---
                                       -1500         0      1500      3000
```

```
Formulation = WF Hi subtracted from:

Formulation  Lower  Centre   Upper  ------+---------+---------+---------+---
WF Lo        436.2  1135.5  1834.9                     (----*---)
                                    ------+---------+---------+---------+---
                                      -1500         0      1500      3000
```

Boxplot of Average Cell Length (µm)



A 4.5 Minitab One-way ANOVA of number of cells per mm^2 with different fibre enriched rice and wheat based 3G formulations

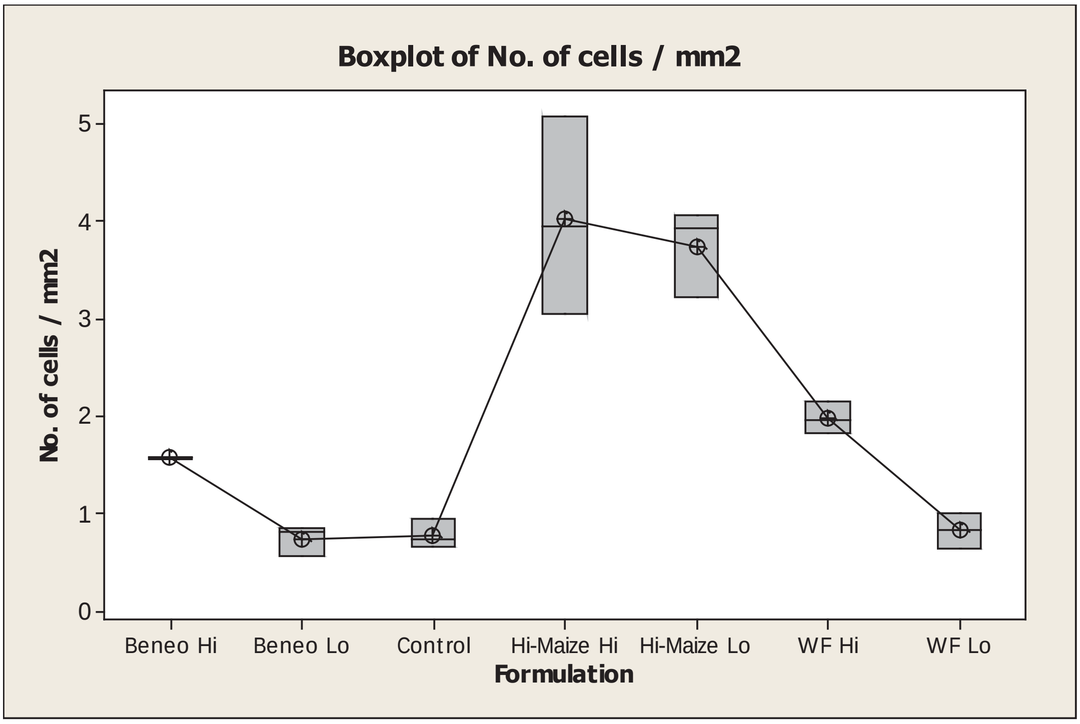
One-way ANOVA: No. of cells / mm^2 versus Formulation

```
Source       DF      SS     MS      F      P
Formulation   6  35.160  5.860  30.26  0.000
Error        14   2.711  0.194
Total        20  37.871

S = 0.4400   R-Sq = 92.84%   R-Sq(adj) = 89.77%


                                Individual 95% CIs For Mean Based on
                                Pooled StDev
Level        N    Mean   StDev  --------+---------+---------+---------+-
Beneo Hi     3  1.5659  0.0118         (---*----)
Beneo Lo     3  0.7402  0.1503  (---*----)
Control      3  0.7737  0.1557  (---*----)
Hi-Maize Hi  3  4.0173  1.0179                           (---*----)
Hi-Maize Lo  3  3.7352  0.4584                         (---*----)
WF Hi        3  1.9783  0.1707            (---*----)
WF Lo        3  0.8258  0.1819  (----*---)
                                --------+---------+---------+---------+-
                                      1.2       2.4       3.6       4.8

Pooled StDev = 0.4400
```

```
Grouping Information Using Tukey Method

Formulation  N    Mean  Grouping
Hi-Maize Hi  3  4.0173  A
Hi-Maize Lo  3  3.7352  A
WF Hi        3  1.9783    B
Beneo Hi     3  1.5659    B C
WF Lo        3  0.8258    B C
Control      3  0.7737    B C
Beneo Lo     3  0.7402      C

Means that do not share a letter are significantly different.

Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Formulation

Individual confidence level = 99.58%


Formulation = Beneo Hi subtracted from:

Formulation    Lower   Centre   Upper  --------+---------+---------+---------+-
Beneo Lo     -2.0528  -0.8257  0.4014            (----*----)
Control      -2.0193  -0.7922  0.4348            (----*----)
Hi-Maize Hi   1.2243   2.4514  3.6784                         (----*----)
Hi-Maize Lo   0.9422   2.1693  3.3964                        (----*----)
WF Hi        -0.8146   0.4124  1.6395                 (----*----)
WF Lo        -1.9672  -0.7401  0.4870            (----*----)
                                       --------+---------+---------+---------+-
                                            -2.5       0.0       2.5       5.0


Formulation = Beneo Lo subtracted from:

Formulation    Lower  Centre   Upper  --------+---------+---------+---------+-
Control      -1.1936  0.0335  1.2605             (----*----)
Hi-Maize Hi   2.0500  3.2771  4.5041                          (----*----)
Hi-Maize Lo   1.7679  2.9950  4.2221                         (----*----)
WF Hi         0.0111  1.2381  2.4652                  (----*----)
WF Lo        -1.1415  0.0856  1.3127             (----*----)
                                      --------+---------+---------+---------+-
                                           -2.5       0.0       2.5       5.0


Formulation = Control subtracted from:

Formulation    Lower  Centre   Upper  --------+---------+---------+---------+-
Hi-Maize Hi   2.0165  3.2436  4.4707                          (----*----)
Hi-Maize Lo   1.7345  2.9616  4.1886                         (----*----)
WF Hi        -0.0224  1.2047  2.4317                  (----*----)
WF Lo        -1.1749  0.0521  1.2792             (----*----)
                                      --------+---------+---------+---------+-
                                           -2.5       0.0       2.5       5.0


Formulation = Hi-Maize Hi subtracted from:

Formulation    Lower   Centre    Upper
Hi-Maize Lo  -1.5091  -0.2821   0.9450
WF Hi        -3.2660  -2.0389  -0.8119
WF Lo        -4.4185  -3.1915  -1.9644

Formulation  --------+---------+---------+---------+-
Hi-Maize Lo              (----*----)
WF Hi              (----*----)
WF Lo        (----*----)
             --------+---------+---------+---------+-
                  -2.5       0.0       2.5       5.0
```

```
Formulation = Hi-Maize Lo subtracted from:

Formulation    Lower   Centre    Upper
WF Hi        -2.9839  -1.7569  -0.5298
WF Lo        -4.1365  -2.9094  -1.6823

Formulation  --------+---------+---------+---------+-
WF Hi              (----*----)
WF Lo         (----*----)
             --------+---------+---------+---------+-
                  -2.5       0.0       2.5       5.0


Formulation = WF Hi subtracted from:

Formulation    Lower   Centre   Upper  --------+---------+---------+---------+-
WF Lo        -2.3796  -1.1525  0.0745          (----*----)
                                       --------+---------+---------+---------+-
                                            -2.5       0.0       2.5       5.0
```

Boxplot of No. of cells / mm^2



A 4.6 Minitab One-way ANOVA of cells size distribution with different fibre enriched rice and wheat based 3G formulations

One-way ANOVA: Cells % above 3000 µm versus Formulation

```
Source       DF       SS       MS      F      P
Formulation   6  0.30531  0.05089  31.31  0.000
Error        14  0.02275  0.00163
Total        20  0.32806

S = 0.04031   R-Sq = 93.06%   R-Sq(adj) = 90.09%
```

```
                                  Individual 95% CIs For Mean Based on
                                  Pooled StDev
Level        N     Mean    StDev  --+---------+---------+---------+-------
Beneo Hi     3  0.19167  0.00737                (---*---)
Beneo Lo     3  0.36467  0.09222                              (---*----)
Control      3  0.30700  0.02778                         (----*---)
Hi-Maize Hi  3  0.06600  0.02425     (----*---)
Hi-Maize Lo  3  0.02467  0.00306  (---*---)
WF Hi        3  0.10767  0.02572         (---*---)
WF Lo        3  0.28000  0.02805                       (---*---)
                                  --+---------+---------+---------+-------
                                  0.00      0.12      0.24      0.36
Pooled StDev = 0.04031

Grouping Information Using Tukey Method

Formulation  N     Mean  Grouping
Beneo Lo     3  0.36467  A
Control      3  0.30700  A
WF Lo        3  0.28000  A B
Beneo Hi     3  0.19167    B C
WF Hi        3  0.10767      C D
Hi-Maize Hi  3  0.06600        D
Hi-Maize Lo  3  0.02467        D

Means that do not share a letter are significantly different.
Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Formulation

Individual confidence level = 99.58%

Formulation = Beneo Hi subtracted from:

Formulation     Lower    Centre     Upper
Beneo Lo      0.06058   0.17300   0.28542
Control       0.00291   0.11533   0.22775
Hi-Maize Hi  -0.23809  -0.12567  -0.01325
Hi-Maize Lo  -0.27942  -0.16700  -0.05458
WF Hi        -0.19642  -0.08400   0.02842
WF Lo        -0.02409   0.08833   0.20075

Formulation  --------+---------+---------+---------+-
Beneo Lo                         (----*---)
Control                        (----*---)
Hi-Maize Hi           (----*---)
Hi-Maize Lo          (---*----)
WF Hi                  (----*---)
WF Lo                         (----*---)
             --------+---------+---------+---------+-
                  -0.25      0.00      0.25      0.50

Formulation = Beneo Lo subtracted from:

Formulation     Lower    Centre     Upper
Control      -0.17009  -0.05767   0.05475
Hi-Maize Hi  -0.41109  -0.29867  -0.18625
Hi-Maize Lo  -0.45242  -0.34000  -0.22758
WF Hi        -0.36942  -0.25700  -0.14458
WF Lo        -0.19709  -0.08467   0.02775

Formulation  --------+---------+---------+---------+-
Control                 (----*---)
Hi-Maize Hi    (---*----)
Hi-Maize Lo  (---*----)
WF Hi           (----*---)
WF Lo                  (----*---)
             --------+---------+---------+---------+-
                  -0.25      0.00      0.25      0.50
```

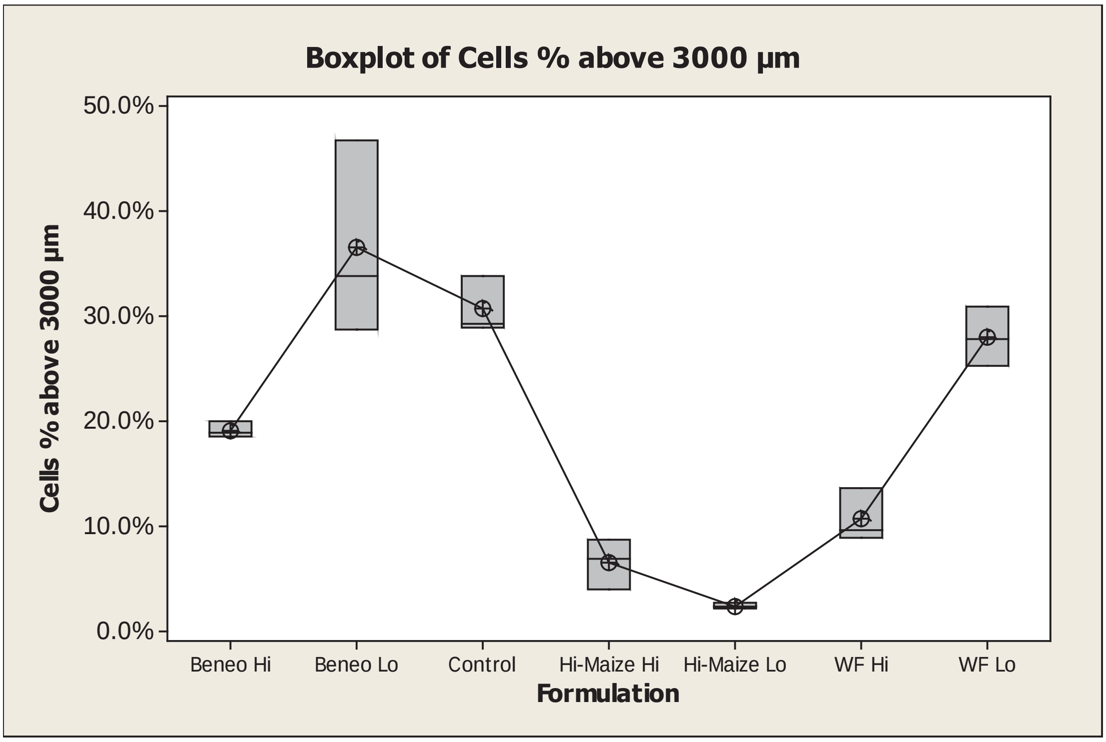
```
Formulation = Control  subtracted from:

Formulation     Lower    Centre     Upper
Hi-Maize Hi  -0.35342  -0.24100  -0.12858
Hi-Maize Lo  -0.39475  -0.28233  -0.16991
WF Hi        -0.31175  -0.19933  -0.08691
WF Lo        -0.13942  -0.02700   0.08542

Formulation  --------+---------+---------+---------+-
Hi-Maize Hi      (---*----)
Hi-Maize Lo    (----*---)
WF Hi              (---*----)
WF Lo                    (----*---)
             --------+---------+---------+---------+-
                 -0.25      0.00      0.25      0.50
```

```
Formulation = Hi-Maize Hi subtracted from:

Formulation     Lower    Centre    Upper
Hi-Maize Lo  -0.15375  -0.04133  0.07109
WF Hi        -0.07075   0.04167  0.15409
WF Lo         0.10158   0.21400  0.32642

Formulation  --------+---------+---------+---------+-
Hi-Maize Lo              (---*----)
WF Hi                       (----*---)
WF Lo                              (----*---)
             --------+---------+---------+---------+-
                 -0.25      0.00      0.25      0.50
```

```
Formulation = Hi-Maize Lo subtracted from:

Formulation     Lower   Centre    Upper
WF Hi        -0.02942  0.08300  0.19542
WF Lo         0.14291  0.25533  0.36775

Formulation  --------+---------+---------+---------+-
WF Hi                          (---*----)
WF Lo                                 (---*----)
             --------+---------+---------+---------+-
                 -0.25      0.00      0.25      0.50
```

```
Formulation = WF Hi subtracted from:

Formulation    Lower   Centre    Upper
WF Lo        0.05991  0.17233  0.28475

Formulation  --------+---------+---------+---------+-
WF Lo                            (----*---)
             --------+---------+---------+---------+-
                 -0.25      0.00      0.25      0.50
```

Boxplot of Cells % above 3000 μm



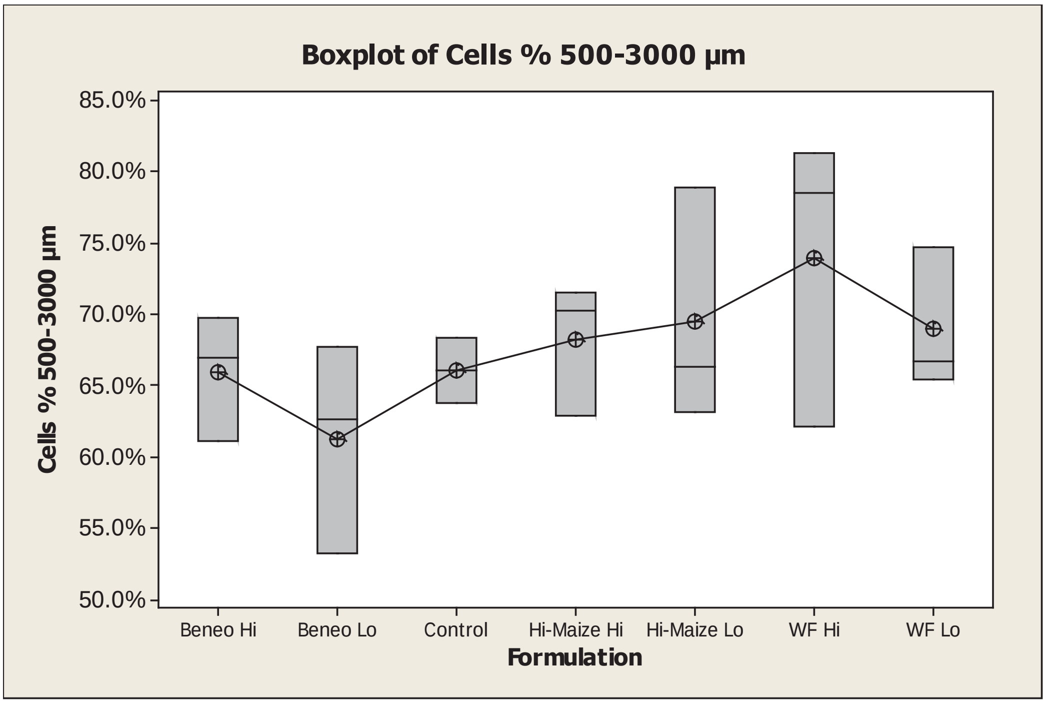
One-way ANOVA: Cells % 500-3000 µm versus Formulation

```
Source       DF       SS       MS     F      P
Formulation   6  0.02754  0.00459  1.06  0.430
Error        14  0.06060  0.00433
Total        20  0.08814

S = 0.06579   R-Sq = 31.25%   R-Sq(adj) = 1.78%


                                  Individual 95% CIs For Mean Based on
                                  Pooled StDev
Level        N     Mean    StDev  ----+---------+---------+---------+-----
Beneo Hi     3  0.65967  0.04441        (---------*----------)
Beneo Lo     3  0.61267  0.07355  (----------*---------)
Control      3  0.66100  0.02300        (----------*---------)
Hi-Maize Hi  3  0.68267  0.04693           (---------*----------)
Hi-Maize Lo  3  0.69500  0.08296             (---------*---------)
WF Hi        3  0.74000  0.10394                  (---------*----------)
WF Lo        3  0.68967  0.05001            (---------*---------)
                                  ----+---------+---------+---------+-----
                                    0.560     0.640     0.720     0.800

Pooled StDev = 0.06579


Grouping Information Using Tukey Method

Formulation  N     Mean  Grouping
WF Hi        3  0.74000  A
Hi-Maize Lo  3  0.69500  A
WF Lo        3  0.68967  A
Hi-Maize Hi  3  0.68267  A
Control      3  0.66100  A
Beneo Hi     3  0.65967  A
Beneo Lo     3  0.61267  A

Means that do not share a letter are significantly different.
```

```
Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Formulation

Individual confidence level = 99.58%

Formulation = Beneo Hi subtracted from:

Formulation     Lower    Centre    Upper
Beneo Lo     -0.23047  -0.04700  0.13647
Control      -0.18214   0.00133  0.18480
Hi-Maize Hi  -0.16047   0.02300  0.20647
Hi-Maize Lo  -0.14814   0.03533  0.21880
WF Hi        -0.10314   0.08033  0.26380
WF Lo        -0.15347   0.03000  0.21347

Formulation  ---------+---------+---------+---------+
Beneo Lo          (----------*-----------)
Control              (----------*-----------)
Hi-Maize Hi           (----------*-----------)
Hi-Maize Lo            (----------*-----------)
WF Hi                     (----------*----------)
WF Lo                 (-----------*----------)
             ---------+---------+---------+---------+
                   -0.16      0.00      0.16      0.32

Formulation = Beneo Lo subtracted from:

Formulation     Lower   Centre    Upper
Control      -0.13514  0.04833  0.23180
Hi-Maize Hi  -0.11347  0.07000  0.25347
Hi-Maize Lo  -0.10114  0.08233  0.26580
WF Hi        -0.05614  0.12733  0.31080
WF Lo        -0.10647  0.07700  0.26047

Formulation  ---------+---------+---------+---------+
Control                 (----------*----------)
Hi-Maize Hi              (----------*-----------)
Hi-Maize Lo               (----------*-----------)
WF Hi                       (-----------*----------)
WF Lo                    (-----------*----------)
             ---------+---------+---------+---------+
                   -0.16      0.00      0.16      0.32


Formulation = Control  subtracted from:

Formulation     Lower   Centre    Upper
Hi-Maize Hi  -0.16180  0.02167  0.20514
Hi-Maize Lo  -0.14947  0.03400  0.21747
WF Hi        -0.10447  0.07900  0.26247
WF Lo        -0.15480  0.02867  0.21214

Formulation  ---------+---------+---------+---------+
Hi-Maize Hi           (----------*-----------)
Hi-Maize Lo            (----------*-----------)
WF Hi                    (-----------*----------)
WF Lo                 (-----------*----------)
             ---------+---------+---------+---------+
                   -0.16      0.00      0.16      0.32


Formulation = Hi-Maize Hi subtracted from:

Formulation     Lower   Centre    Upper
Hi-Maize Lo  -0.17114  0.01233  0.19580
WF Hi        -0.12614  0.05733  0.24080
WF Lo        -0.17647  0.00700  0.19047
```

```
Formulation  ---------+---------+---------+---------+
Hi-Maize Lo          (-----------*----------)
WF Hi                   (-----------*----------)
WF Lo                (----------*-----------)
             ---------+---------+---------+---------+
                  -0.16      0.00      0.16      0.32

Formulation = Hi-Maize Lo subtracted from:

Formulation     Lower    Centre    Upper
WF Hi        -0.13847   0.04500  0.22847
WF Lo        -0.18880  -0.00533  0.17814

Formulation  ---------+---------+---------+---------+
WF Hi                  (-----------*----------)
WF Lo               (-----------*----------)
             ---------+---------+---------+---------+
                  -0.16      0.00      0.16      0.32

Formulation = WF Hi subtracted from:

Formulation     Lower    Centre    Upper
WF Lo        -0.23380  -0.05033  0.13314

Formulation  ---------+---------+---------+---------+
WF Lo            (-----------*----------)
             ---------+---------+---------+---------+
                  -0.16      0.00      0.16      0.32
```

Boxplot of Cells % 500-3000 µm



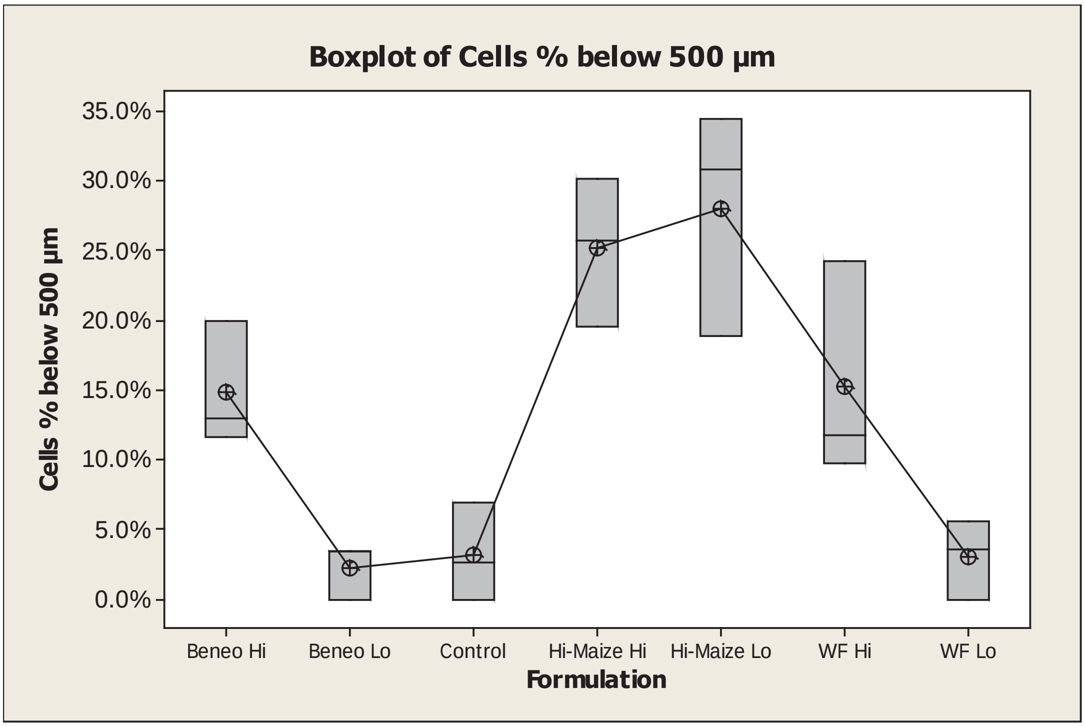
One-way ANOVA: Cells % below 500 µm versus Formulation

```
Source       DF       SS       MS      F      P
Formulation   6  0.20765  0.03461  12.17  0.000
Error        14  0.03982  0.00284
Total        20  0.24748

S = 0.05333   R-Sq = 83.91%   R-Sq(adj) = 77.01%
```

```
                                  Individual 95% CIs For Mean Based on
                                  Pooled StDev
Level         N     Mean    StDev  ----+---------+---------+---------+-----
Beneo Hi      3  0.14867  0.04500            (------*-----)
Beneo Lo      3  0.02267  0.01963  (-----*------)
Control       3  0.03167  0.03485   (-----*------)
Hi-Maize Hi   3  0.25133  0.05273                       (-----*------)
Hi-Maize Lo   3  0.28033  0.08112                         (------*------)
WF Hi         3  0.15233  0.07823             (-----*------)
WF Lo         3  0.03067  0.02838  (------*------)
                                   ----+---------+---------+---------+-----
                                     0.00      0.10      0.20      0.30
Pooled StDev = 0.05333

Grouping Information Using Tukey Method

Formulation  N     Mean  Grouping
Hi-Maize Lo  3  0.28033  A
Hi-Maize Hi  3  0.25133  A
WF Hi        3  0.15233  A B
Beneo Hi     3  0.14867  A B
Control      3  0.03167    B
WF Lo        3  0.03067    B
Beneo Lo     3  0.02267    B

Means that do not share a letter are significantly different.
Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Formulation

Individual confidence level = 99.58%

Formulation = Beneo Hi subtracted from:

Formulation     Lower    Centre    Upper
Beneo Lo     -0.27473  -0.12600  0.02273
Control      -0.26573  -0.11700  0.03173
Hi-Maize Hi  -0.04606   0.10267  0.25139
Hi-Maize Lo  -0.01706   0.13167  0.28039
WF Hi        -0.14506   0.00367  0.15239
WF Lo        -0.26673  -0.11800  0.03073

Formulation  ------+---------+---------+---------+---
Beneo Lo         (-----*-----)
Control          (-----*-----)
Hi-Maize Hi               (-----*-----)
Hi-Maize Lo                (-----*-----)
WF Hi                 (-----*-----)
WF Lo            (-----*-----)
             ------+---------+---------+---------+---
                -0.25      0.00      0.25      0.50

Formulation = Beneo Lo subtracted from:

Formulation     Lower   Centre    Upper
Control      -0.13973  0.00900  0.15773
Hi-Maize Hi   0.07994  0.22867  0.37739
Hi-Maize Lo   0.10894  0.25767  0.40639
WF Hi        -0.01906  0.12967  0.27839
WF Lo        -0.14073  0.00800  0.15673

Formulation  ------+---------+---------+---------+---
Control               (-----*-----)
Hi-Maize Hi                    (-----*-----)
Hi-Maize Lo                     (-----*-----)
WF Hi                      (-----*-----)
WF Lo                 (-----*-----)
             ------+---------+---------+---------+---
                -0.25      0.00      0.25      0.50
```

```
Formulation = Control  subtracted from:

Formulation     Lower    Centre    Upper
Hi-Maize Hi   0.07094   0.21967  0.36839
Hi-Maize Lo   0.09994   0.24867  0.39739
WF Hi        -0.02806   0.12067  0.26939
WF Lo        -0.14973  -0.00100  0.14773

Formulation  ------+---------+---------+---------+---
Hi-Maize Hi                     (-----*-----)
Hi-Maize Lo                      (-----*-----)
WF Hi                      (-----*-----)
WF Lo                 (-----*-----)
             ------+---------+---------+---------+---
                 -0.25      0.00      0.25      0.50


Formulation = Hi-Maize Hi subtracted from:

Formulation     Lower    Centre     Upper
Hi-Maize Lo  -0.11973   0.02900   0.17773
WF Hi        -0.24773  -0.09900   0.04973
WF Lo        -0.36939  -0.22067  -0.07194

Formulation  ------+---------+---------+---------+---
Hi-Maize Lo            (-----*-----)
WF Hi             (-----*-----)
WF Lo        (-----*-----)
             ------+---------+---------+---------+---
                 -0.25      0.00      0.25      0.50


Formulation = Hi-Maize Lo subtracted from:

Formulation     Lower    Centre     Upper
WF Hi        -0.27673  -0.12800   0.02073
WF Lo        -0.39839  -0.24967  -0.10094

Formulation  ------+---------+---------+---------+---
WF Hi            (-----*-----)
WF Lo        (-----*-----)
             ------+---------+---------+---------+---
                 -0.25      0.00      0.25      0.50


Formulation = WF Hi subtracted from:

Formulation     Lower    Centre    Upper
WF Lo        -0.27039  -0.12167  0.02706

Formulation  ------+---------+---------+---------+---
WF Lo            (-----*-----)
             ------+---------+---------+---------+---
                 -0.25      0.00      0.25      0.50
```

Boxplot of Cells % below 500 µm



Boxplot of Cells % below 500 µm
Cells % below 500 µm
35.0%
30.0%
25.0%
20.0%
15.0%
10.0%
5.0%
0.0%
Beneo Hi
Beneo Lo
Control
Hi-Maize Hi
Hi-Maize Lo
WF Hi
WF Lo
Formulation

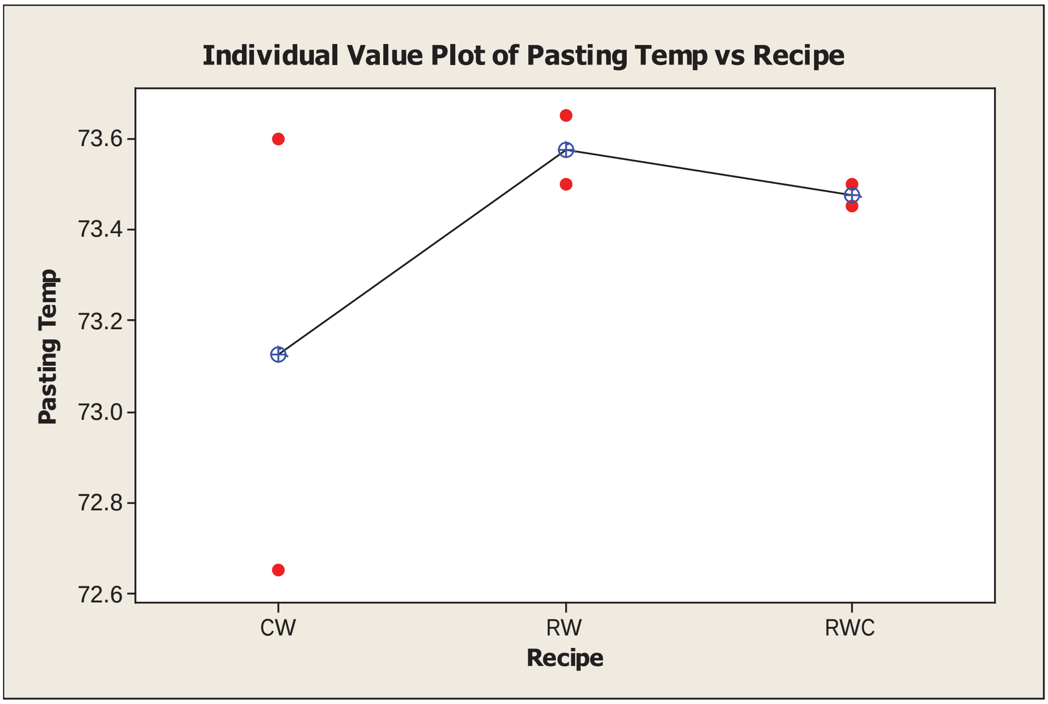
Appendix 5: Statistical analysis and calculation details for 3G snack formulation and process improvements in Chapter 6

A 5.1 Minitab One-way ANOVA of raw ingredient blend pasting properties with 3G formulation RW, CW and RWC

One-way ANOVA: Pasting Temp versus Recipe

```
Source  DF     SS     MS     F      P
Recipe   2  0.223  0.112  0.72  0.555
Error    3  0.464  0.155
Total    5  0.687

S = 0.3932   R-Sq = 32.50%   R-Sq(adj) = 0.00%


                         Individual 95% CIs For Mean Based on
                         Pooled StDev
Level  N    Mean  StDev  ------+---------+---------+---------+---
CW     2  73.125  0.672  (--------------*-------------)
RW     2  73.575  0.106          (-------------*--------------)
RWC    2  73.475  0.035        (--------------*-------------)
                         ------+---------+---------+---------+---
                            72.60     73.20     73.80     74.40

Pooled StDev = 0.393


Grouping Information Using Tukey Method

Recipe  N     Mean  Grouping
RW      2  73.5750  A
RWC     2  73.4750  A
CW      2  73.1250  A

Means that do not share a letter are significantly different.


Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Recipe

Individual confidence level = 97.50%


Recipe = CW subtracted from:

Recipe    Lower  Centre   Upper  -------+---------+---------+---------+--
RW      -1.1931  0.4500  2.0931      (----------------*---------------)
RWC     -1.2931  0.3500  1.9931     (---------------*----------------)
                                 -------+---------+---------+---------+--
                                     -1.0       0.0       1.0       2.0


Recipe = RW subtracted from:

Recipe    Lower   Centre   Upper  -------+---------+---------+---------+--
RWC     -1.7431  -0.1000  1.5431  (---------------*---------------)
                                  -------+---------+---------+---------+--
                                      -1.0       0.0       1.0       2.0
```

Individual Value Plot of Pasting Temp vs Recipe

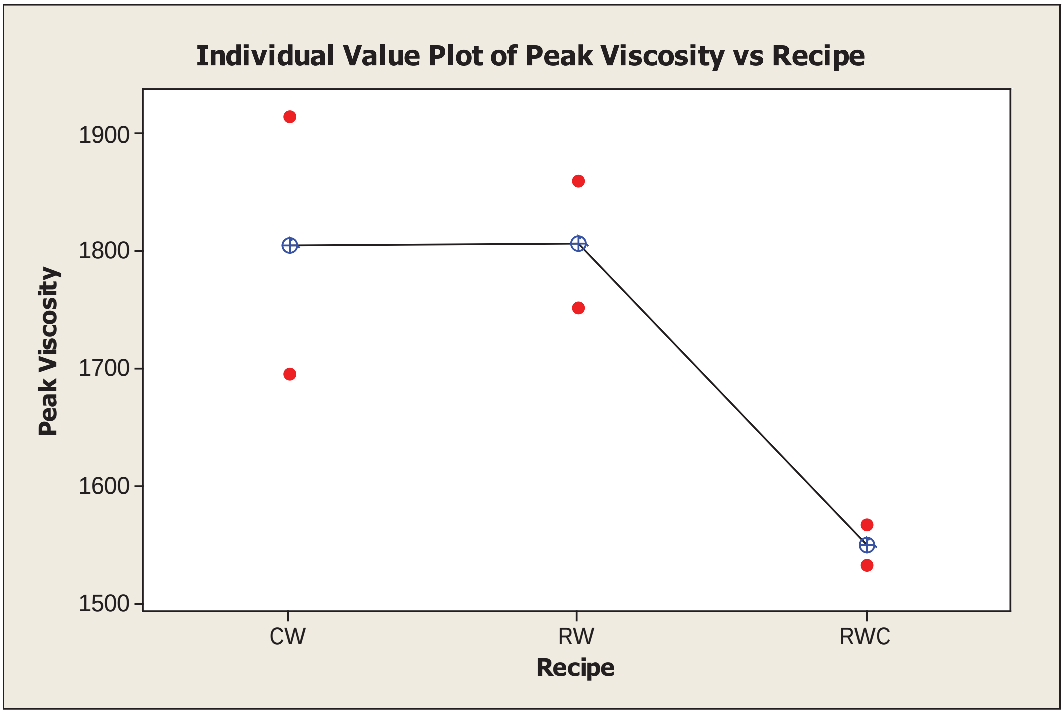


One-way ANOVA: Peak Viscosity versus Recipe

```
Source  DF      SS     MS     F      P
Recipe   2   87552  43776  4.28  0.132
Error    3   30719  10240
Total    5  118271

S = 101.2   R-Sq = 74.03%   R-Sq(adj) = 56.71%

                          Individual 95% CIs For Mean Based on
                          Pooled StDev
Level  N    Mean  StDev  ----+---------+---------+---------+-----
CW     2  1805.0  155.6              (----------*-----------)
RW     2  1805.5   77.1              (----------*-----------)
RWC    2  1549.0   24.0  (----------*-----------)
                         ----+---------+---------+---------+-----
                          1400      1600      1800      2000

Pooled StDev = 101.2

Grouping Information Using Tukey Method

Recipe  N    Mean  Grouping
RW      2  1805.5  A
CW      2  1805.0  A
RWC     2  1549.0  A

Means that do not share a letter are significantly different.

Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Recipe

Individual confidence level = 97.50%

Recipe = CW subtracted from:

Recipe   Lower  Centre  Upper  ---------+---------+---------+---------+
RW      -422.4     0.5  423.4         (-----------*-----------)
RWC     -678.9  -256.0  166.9  (-----------*-----------)
                               ---------+---------+---------+---------+
                                     -350         0       350       700
```

```
Recipe = RW subtracted from:

Recipe    Lower  Centre  Upper  ---------+---------+---------+---------+
RWC      -679.4  -256.5  166.4  (-----------*-----------)
                                ---------+---------+---------+---------+
                                      -350         0       350       700
```

Individual Value Plot of Peak Viscosity vs Recipe

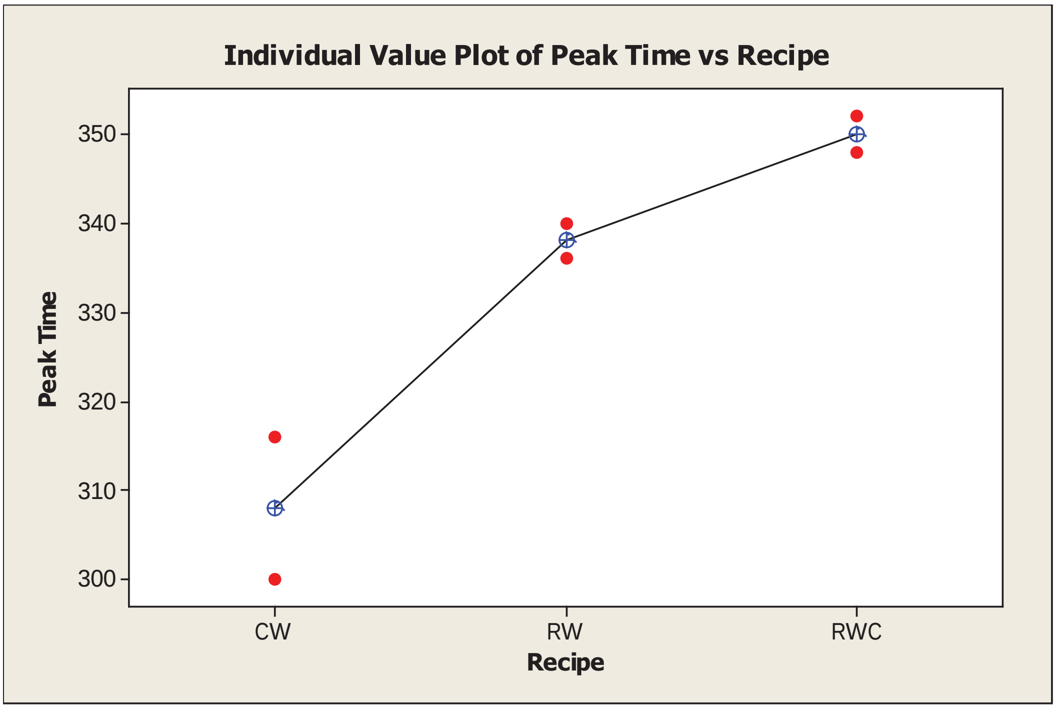


One-way ANOVA: Peak Time versus Recipe

```
Source  DF      SS     MS      F      P
Recipe   2  1872.0  936.0  19.50  0.019
Error    3   144.0   48.0
Total    5  2016.0

S = 6.928   R-Sq = 92.86%   R-Sq(adj) = 88.10%


                               Individual 95% CIs For Mean Based on
                               Pooled StDev
Level  N    Mean  StDev  ----+---------+---------+---------+-----
CW     2  308.00  11.31  (-------*-------)
RW     2  338.00   2.83                (-------*-------)
RWC    2  350.00   2.83                      (-------*-------)
                         ----+---------+---------+---------+-----
                           300       320       340       360

Pooled StDev = 6.93

Grouping Information Using Tukey Method

Recipe  N     Mean  Grouping
RWC     2  350.000  A
RW      2  338.000  A
CW      2  308.000    B

Means that do not share a letter are significantly different.
```

```
Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Recipe

Individual confidence level = 97.50%

Recipe = CW subtracted from:

Recipe    Lower  Centre   Upper  ----+---------+---------+---------+-----
RW        1.047  30.000  58.953              (---------*---------)
RWC      13.047  42.000  70.953                  (---------*---------)
                                 ----+---------+---------+---------+-----
                                   -30         0        30        60

Recipe = RW subtracted from:

Recipe     Lower  Centre   Upper  ----+---------+---------+---------+-----
RWC      -16.953  12.000  40.953          (---------*---------)
                                  ----+---------+---------+---------+-----
                                    -30         0        30        60
```

Individual Value Plot of Peak Time vs Recipe

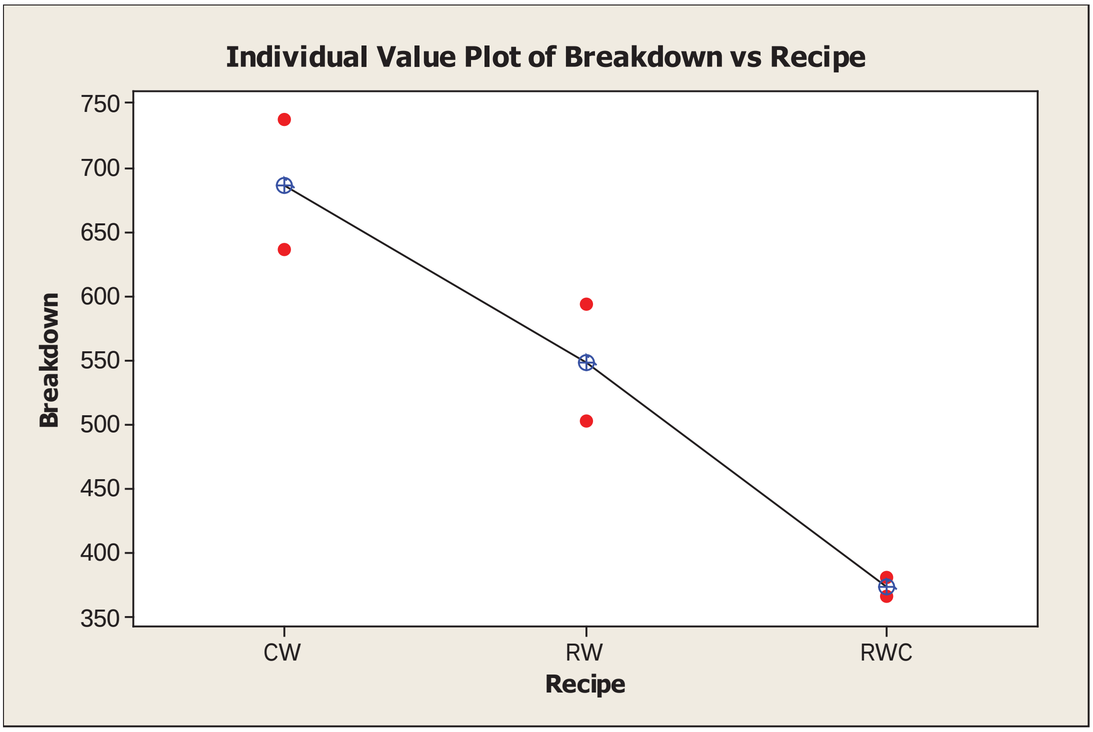


One-way ANOVA: Breakdown versus Recipe

```
Source  DF      SS     MS      F      P
Recipe   2   98726  49363  15.70  0.026
Error    3    9431   3144
Total    5  108157

S = 56.07   R-Sq = 91.28%   R-Sq(adj) = 85.47%

                         Individual 95% CIs For Mean Based on
                         Pooled StDev
Level  N    Mean  StDev  ----+---------+---------+---------+-----
CW     2  686.50  71.42                      (--------*-------)
RW     2  548.00  65.05             (--------*-------)
RWC    2  373.00   9.90  (--------*-------)
                         ----+---------+---------+---------+-----
                           300       450       600       750
```

```
Pooled StDev = 56.07


Grouping Information Using Tukey Method

Recipe  N    Mean  Grouping
CW      2  686.50  A
RW      2  548.00  A B
RWC     2  373.00    B

Means that do not share a letter are significantly different.


Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Recipe

Individual confidence level = 97.50%


Recipe = CW subtracted from:

Recipe    Lower   Centre   Upper   --+---------+---------+---------+-------
RW      -372.80  -138.50   95.80          (--------*---------)
RWC     -547.80  -313.50  -79.20   (--------*---------)
                                   --+---------+---------+---------+-------
                                  -500      -250         0       250


Recipe = RW subtracted from:

Recipe    Lower   Centre  Upper   --+---------+---------+---------+-------
RWC     -409.30  -175.00  59.30         (--------*--------)
                                  --+---------+---------+---------+-------
                                 -500      -250         0       250
```

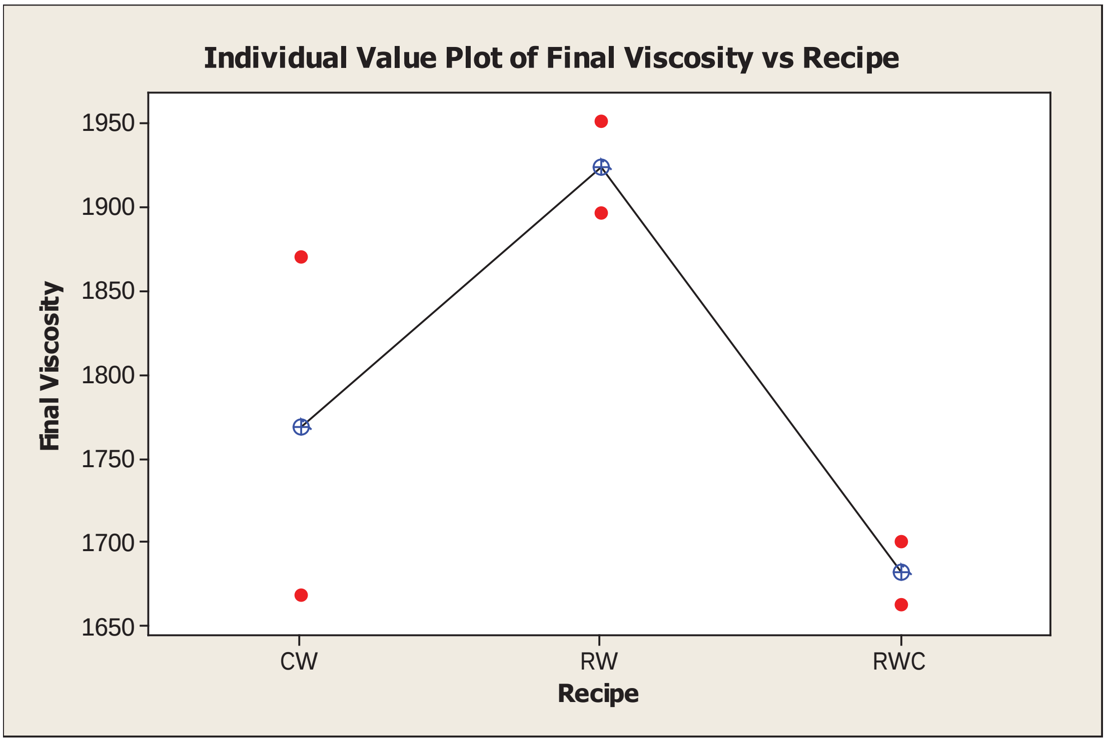
Individual Value Plot of Breakdown vs Recipe



One-way ANOVA: Final Viscosity versus Recipe

```
Source  DF     SS     MS     F      P
Recipe   2  60060  30030  3.99  0.143
Error    3  22599   7533
Total    5  82659

S = 86.79   R-Sq = 72.66%   R-Sq(adj) = 54.43%


                         Individual 95% CIs For Mean Based on
                         Pooled StDev
Level  N    Mean  StDev  -------+---------+---------+---------+--
CW     2  1769.0  142.8       (------------*-----------)
RW     2  1923.5   38.9                 (-----------*-----------)
RWC    2  1681.5   26.2  (-----------*-----------)
                         -------+---------+---------+---------+--
                             1600      1760      1920      2080

Pooled StDev = 86.8


Grouping Information Using Tukey Method

Recipe  N     Mean  Grouping
RW      2  1923.50  A
CW      2  1769.00  A
RWC     2  1681.50  A

Means that do not share a letter are significantly different.


Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Recipe

Individual confidence level = 97.50%


Recipe = CW subtracted from:

Recipe    Lower  Centre   Upper  -------+---------+---------+---------+--
RW      -208.21  154.50  517.21            (---------*----------)
RWC     -450.21  -87.50  275.21     (----------*---------)
                                 -------+---------+---------+---------+--
                                     -350         0       350       700


Recipe = RW subtracted from:

Recipe    Lower   Centre   Upper  -------+---------+---------+---------+--
RWC     -604.71  -242.00  120.71  (---------*---------)
                                  -------+---------+---------+---------+--
                                      -350         0       350       700
```

Individual Value Plot of Final Viscosity vs Recipe

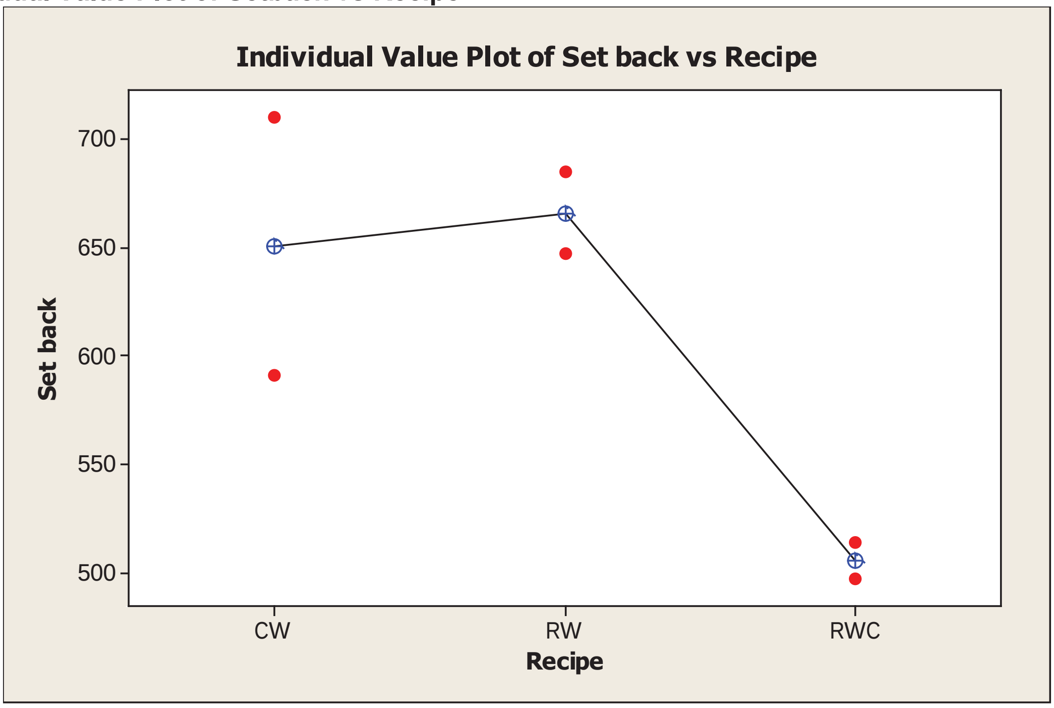


One-way ANOVA: Setback versus Recipe

```
Source  DF     SS     MS     F      P
Recipe   2  31350  15675  5.92  0.091
Error    3   7947   2649
Total    5  39297

S = 51.47   R-Sq = 79.78%   R-Sq(adj) = 66.30%


                         Individual 95% CIs For Mean Based on
                         Pooled StDev
Level  N    Mean  StDev  -+---------+---------+---------+--------
CW     2  650.50  84.15                (-----------*-----------)
RW     2  666.00  26.87                  (-----------*----------)
RWC    2  505.50  12.02  (-----------*----------)
                         -+---------+---------+---------+--------
                         400       500       600       700

Pooled StDev = 51.47


Grouping Information Using Tukey Method

Recipe  N    Mean  Grouping
RW      2  666.00  A
CW      2  650.50  A
RWC     2  505.50  A

Means that do not share a letter are significantly different.


Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Recipe

Individual confidence level = 97.50%


Recipe = CW subtracted from:
```

```
Recipe    Lower   Centre   Upper  ---------+---------+---------+---------+
RW      -199.59    15.50  230.59           (-----------*----------)
RWC     -360.09  -145.00   70.09   (----------*----------)
                                  ---------+---------+---------+---------+
                                        -200         0       200       400

Recipe = RW subtracted from:

Recipe    Lower   Centre  Upper  ---------+---------+---------+---------+
RWC     -375.59  -160.50  54.59  (----------*----------)
                                 ---------+---------+---------+---------+
                                       -200         0       200       400
```

Individual Value Plot of Setback vs Recipe



A 5.2 Minitab One-way ANOVA of extruded pellet pasting properties with 3G formulation RW, CW and RWC at two different water injection rate

One-way ANOVA: Cold Peak versus Recipe

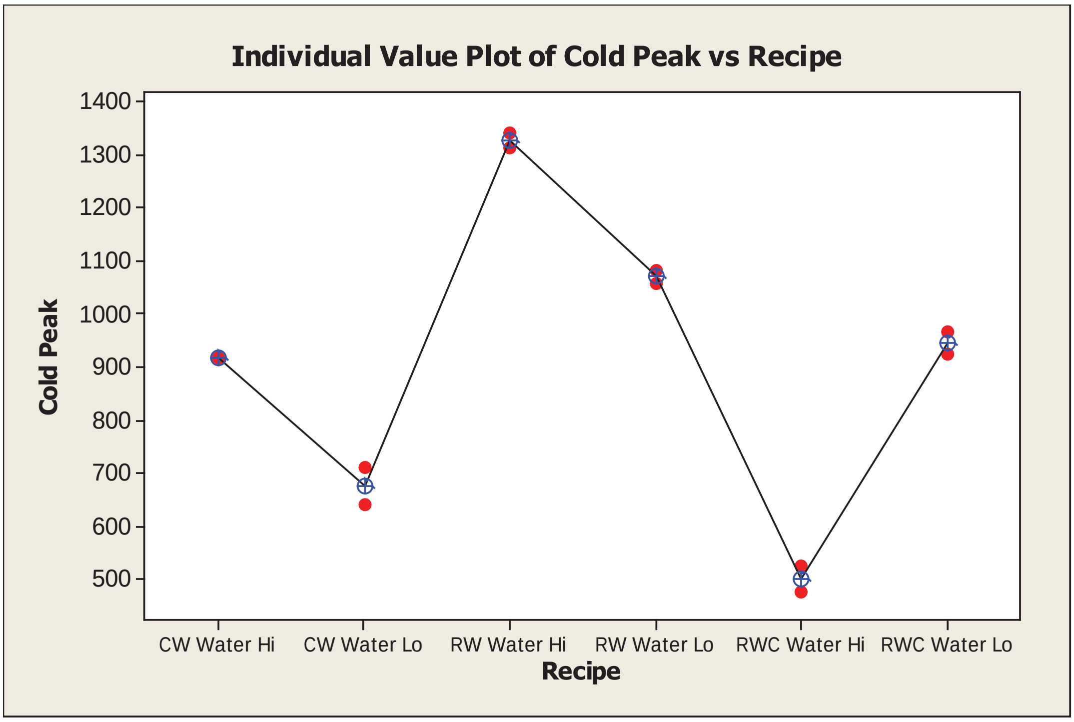
```
Source  DF      SS      MS       F      P
Recipe   5  845207  169041  197.42  0.000
Error    6    5138     856
Total   11  850345

S = 29.26   R-Sq = 99.40%   R-Sq(adj) = 98.89%

                                Individual 95% CIs For Mean Based on
                                Pooled StDev
Level         N    Mean  StDev  --+---------+---------+---------+-------
CW Water Hi   2   916.5    2.1                   (-*-)
CW Water Lo   2   674.5   48.8         (-*-)
RW Water Hi   2  1325.5   19.1                                 (-*-)
RW Water Lo   2  1069.0   18.4                        (-*-)
RWC Water Hi  2   500.0   35.4  (-*-)
RWC Water Lo  2   945.0   28.3                   (-*-)
                                --+---------+---------+---------+-------
                                500       750      1000      1250
```

```
Pooled StDev = 29.3

Grouping Information Using Tukey Method

Recipe        N     Mean  Grouping
RW Water Hi   2  1325.50  A
RW Water Lo   2  1069.00    B
RWC Water Lo  2   945.00      C
CW Water Hi   2   916.50      C
CW Water Lo   2   674.50        D
RWC Water Hi  2   500.00          E

Means that do not share a letter are significantly different.

Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Recipe

Individual confidence level = 99.27%

Recipe = CW Water Hi subtracted from:

Recipe          Lower   Centre    Upper
CW Water Lo   -358.49  -242.00  -125.51
RW Water Hi    292.51   409.00   525.49
RW Water Lo     36.01   152.50   268.99
RWC Water Hi  -532.99  -416.50  -300.01
RWC Water Lo   -87.99    28.50   144.99

Recipe        ---------+---------+---------+---------+
CW Water Lo                (-*-)
RW Water Hi                             (-*--)
RW Water Lo                        (-*-)
RWC Water Hi           (--*-)
RWC Water Lo                    (--*-)
              ---------+---------+---------+---------+
                    -500         0       500      1000


Recipe = CW Water Lo subtracted from:

Recipe          Lower   Centre   Upper
RW Water Hi    534.51   651.00  767.49
RW Water Lo    278.01   394.50  510.99
RWC Water Hi  -290.99  -174.50  -58.01
RWC Water Lo   154.01   270.50  386.99

Recipe        ---------+---------+---------+---------+
RW Water Hi                                  (-*-)
RW Water Lo                             (-*-)
RWC Water Hi                (--*-)
RWC Water Lo                         (-*--)
              ---------+---------+---------+---------+
                    -500         0       500      1000


Recipe = RW Water Hi subtracted from:

Recipe          Lower   Centre    Upper
RW Water Lo   -372.99  -256.50  -140.01
RWC Water Hi  -941.99  -825.50  -709.01
RWC Water Lo  -496.99  -380.50  -264.01

Recipe        ---------+---------+---------+---------+
RW Water Lo                (-*-)
RWC Water Hi  (-*--)
RWC Water Lo           (-*--)
              ---------+---------+---------+---------+
                    -500         0       500      1000
```

```
Recipe = RW Water Lo subtracted from:

Recipe          Lower   Centre    Upper
RWC Water Hi  -685.49  -569.00  -452.51
RWC Water Lo  -240.49  -124.00    -7.51

Recipe        ---------+---------+---------+---------+
RWC Water Hi       (--*-)
RWC Water Lo                (--*-)
              ---------+---------+---------+---------+
                    -500         0       500      1000
```

```
Recipe = RWC Water Hi subtracted from:

Recipe         Lower  Centre   Upper  ---------+---------+---------+---------+
RWC Water Lo  328.51  445.00  561.49                           (-*-)
                                      ---------+---------+---------+---------+
                                            -500         0       500      1000
```

Individual Value Plot of Cold Peak vs Recipe



One-way ANOVA: Peak Viscosity versus Recipe

Source	DF	SS	MS	F	P
Recipe	5	508594	101719	70.97	0.000
Error	6	8600	1433		
Total	11	517194			

S = 37.86   R-Sq = 98.34%   R-Sq(adj) = 96.95%

Level	N	Mean	StDev
CW Water Hi	2	1176.5	3.5
CW Water Lo	2	674.5	48.8
RW Water Hi	2	1325.5	19.1
RW Water Lo	2	1069.0	18.4
RWC Water Hi	2	1151.5	68.6
RWC Water Lo	2	945.0	28.3

```
               Individual 95% CIs For Mean Based on Pooled StDev
Level            +---------+---------+---------+---------
CW Water Hi                                (--*--)
CW Water Lo      (---*--)
RW Water Hi                                       (--*---)
RW Water Lo                          (--*---)
RWC Water Hi                             (---*--)
RWC Water Lo                   (--*---)
                 +---------+---------+---------+---------
               600       800      1000      1200
```

Pooled StDev = 37.9

Grouping Information Using Tukey Method

```
Recipe        N     Mean  Grouping
RW Water Hi   2  1325.50  A
CW Water Hi   2  1176.50  A B
RWC Water Hi  2  1151.50    B
RW Water Lo   2  1069.00    B C
RWC Water Lo  2   945.00      C
CW Water Lo   2   674.50        D
```

Means that do not share a letter are significantly different.

Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Recipe

Individual confidence level = 99.27%

Recipe = CW Water Hi subtracted from:

```
Recipe          Lower   Centre    Upper
CW Water Lo   -652.72  -502.00  -351.28
RW Water Hi     -1.72   149.00   299.72
RW Water Lo   -258.22  -107.50    43.22
RWC Water Hi  -175.72   -25.00   125.72
RWC Water Lo  -382.22  -231.50   -80.78

Recipe        ------+---------+---------+---------+---
CW Water Lo      (--*--)
RW Water Hi                   (--*--)
RW Water Lo              (--*--)
RWC Water Hi              (---*--)
RWC Water Lo          (--*--)
              ------+---------+---------+---------+---
                 -500         0       500      1000
```

Recipe = CW Water Lo subtracted from:

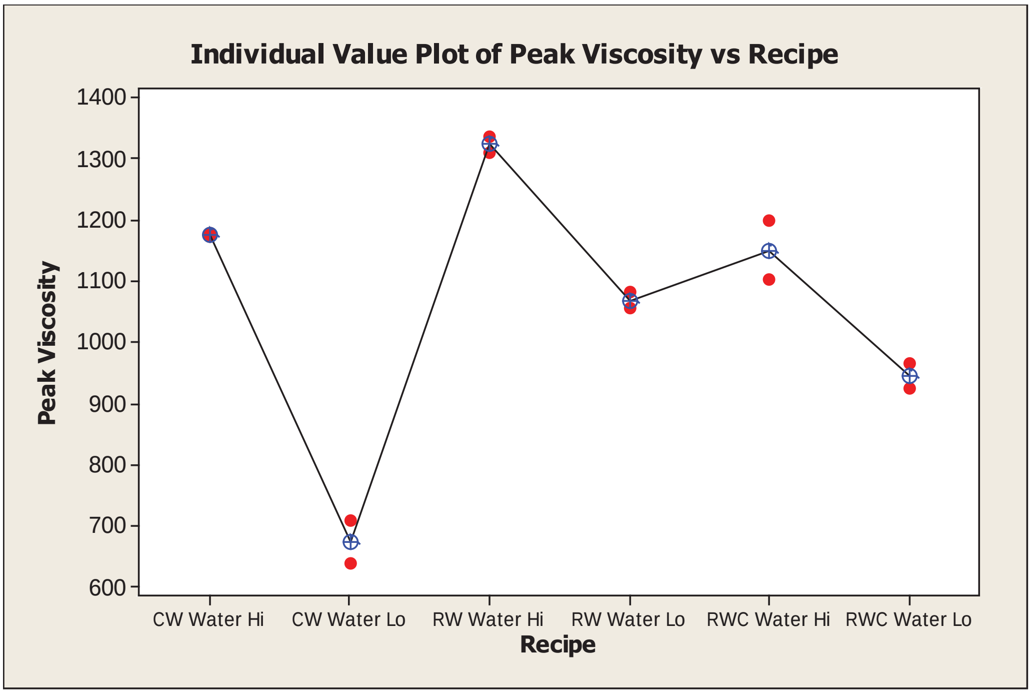
```
Recipe         Lower  Centre   Upper  ------+---------+---------+---------+---
RW Water Hi   500.28  651.00  801.72                          (--*--)
RW Water Lo   243.78  394.50  545.22                     (--*--)
RWC Water Hi  326.28  477.00  627.72                       (--*--)
RWC Water Lo  119.78  270.50  421.22                  (--*--)
                                      ------+---------+---------+---------+---
                                         -500         0       500      1000
```

Recipe = RW Water Hi subtracted from:

```
Recipe          Lower   Centre    Upper
RW Water Lo   -407.22  -256.50  -105.78
RWC Water Hi  -324.72  -174.00   -23.28
RWC Water Lo  -531.22  -380.50  -229.78
```

```
Recipe        ------+---------+---------+---------+---
RW Water Lo           (--*--)
RWC Water Hi            (--*--)
RWC Water Lo       (--*--)
              ------+---------+---------+---------+---
                  -500         0       500      1000

Recipe = RW Water Lo subtracted from:

Recipe          Lower   Centre   Upper
RWC Water Hi   -68.22    82.50  233.22
RWC Water Lo  -274.72  -124.00   26.72

Recipe        ------+---------+---------+---------+---
RWC Water Hi                 (--*--)
RWC Water Lo             (--*--)
              ------+---------+---------+---------+---
                  -500         0       500      1000

Recipe = RWC Water Hi subtracted from:

Recipe          Lower   Centre   Upper
RWC Water Lo  -357.22  -206.50  -55.78

Recipe        ------+---------+---------+---------+---
RWC Water Lo           (--*--)
              ------+---------+---------+---------+---
                  -500         0       500      1000
```

Individual Value Plot of Peak Viscosity vs Recipe



One-way ANOVA: Breakdown versus Recipe

```
Source  DF      SS     MS      F      P
Recipe   5  418272  83654  60.24  0.000
Error    6    8333   1389
Total   11  426605

S = 37.27   R-Sq = 98.05%   R-Sq(adj) = 96.42%
```

```
                                Individual 95% CIs For Mean Based on
                                Pooled StDev
Level         N    Mean  StDev  ---+---------+---------+---------+------
CW Water Hi   2  1055.0    1.4                       (--*--)
CW Water Lo   2   607.0   48.1  (--*---)
RW Water Hi   2  1205.0   19.8                              (--*--)
RW Water Lo   2   994.0   19.8                   (---*--)
RWC Water Hi  2  1024.5   67.2                     (--*--)
RWC Water Lo  2   859.0   26.9             (--*--)
                                ---+---------+---------+---------+------
                                 600       800      1000      1200

Pooled StDev = 37.3
```

Grouping Information Using Tukey Method

```
Recipe        N     Mean  Grouping
RW Water Hi   2  1205.00  A
CW Water Hi   2  1055.00    B
RWC Water Hi  2  1024.50    B
RW Water Lo   2   994.00    B C
RWC Water Lo  2   859.00      C
CW Water Lo   2   607.00        D
```

Means that do not share a letter are significantly different.

Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Recipe

Individual confidence level = 99.27%

Recipe = CW Water Hi subtracted from:

```
Recipe          Lower   Centre    Upper
CW Water Lo   -596.36  -448.00  -299.64
RW Water Hi      1.64   150.00   298.36
RW Water Lo   -209.36   -61.00    87.36
RWC Water Hi  -178.86   -30.50   117.86
RWC Water Lo  -344.36  -196.00   -47.64

Recipe        ---------+---------+---------+---------+
CW Water Lo       (---*---)
RW Water Hi                    (---*--)
RW Water Lo               (--*---)
RWC Water Hi               (--*---)
RWC Water Lo          (---*---)
              ---------+---------+---------+---------+
                    -400         0       400       800
```

Recipe = CW Water Lo subtracted from:

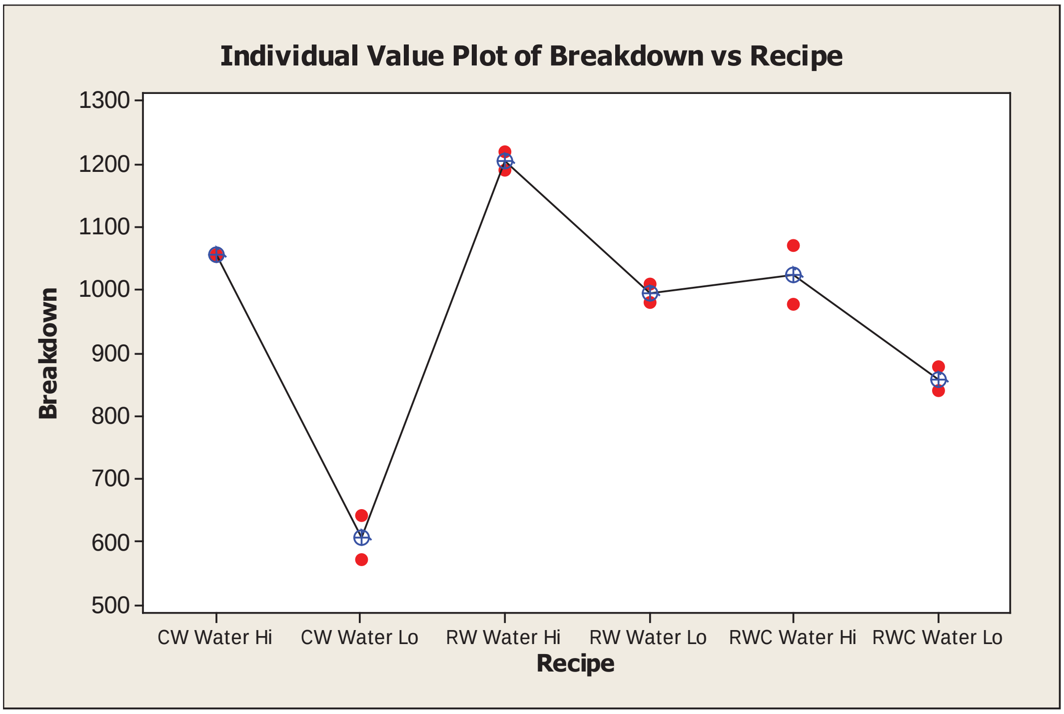
```
Recipe         Lower  Centre   Upper  ---------+---------+---------+---------+
RW Water Hi   449.64  598.00  746.36                              (---*---)
RW Water Lo   238.64  387.00  535.36                         (---*--)
RWC Water Hi  269.14  417.50  565.86                          (--*---)
RWC Water Lo  103.64  252.00  400.36                      (--*---)
                                      ---------+---------+---------+---------+
                                            -400         0       400       800
```

Recipe = RW Water Hi subtracted from:

```
Recipe          Lower   Centre    Upper
RW Water Lo   -359.36  -211.00   -62.64
RWC Water Hi  -328.86  -180.50   -32.14
RWC Water Lo  -494.36  -346.00  -197.64
```

```
Recipe         ---------+---------+---------+---------+
RW Water Lo             (---*--)
RWC Water Hi             (--*---)
RWC Water Lo         (--*---)
               ---------+---------+---------+---------+
                     -400         0       400       800

Recipe = RW Water Lo subtracted from:

Recipe          Lower   Centre   Upper
RWC Water Hi  -117.86    30.50  178.86
RWC Water Lo  -283.36  -135.00   13.36

Recipe         ---------+---------+---------+---------+
RWC Water Hi                  (---*--)
RWC Water Lo              (---*--)
               ---------+---------+---------+---------+
                     -400         0       400       800

Recipe = RWC Water Hi subtracted from:

Recipe          Lower   Centre   Upper
RWC Water Lo  -313.86  -165.50  -17.14

Recipe         ---------+---------+---------+---------+
RWC Water Lo             (---*---)
               ---------+---------+---------+---------+
                     -400         0       400       800
```

Individual Value Plot of Breakdown vs Recipe



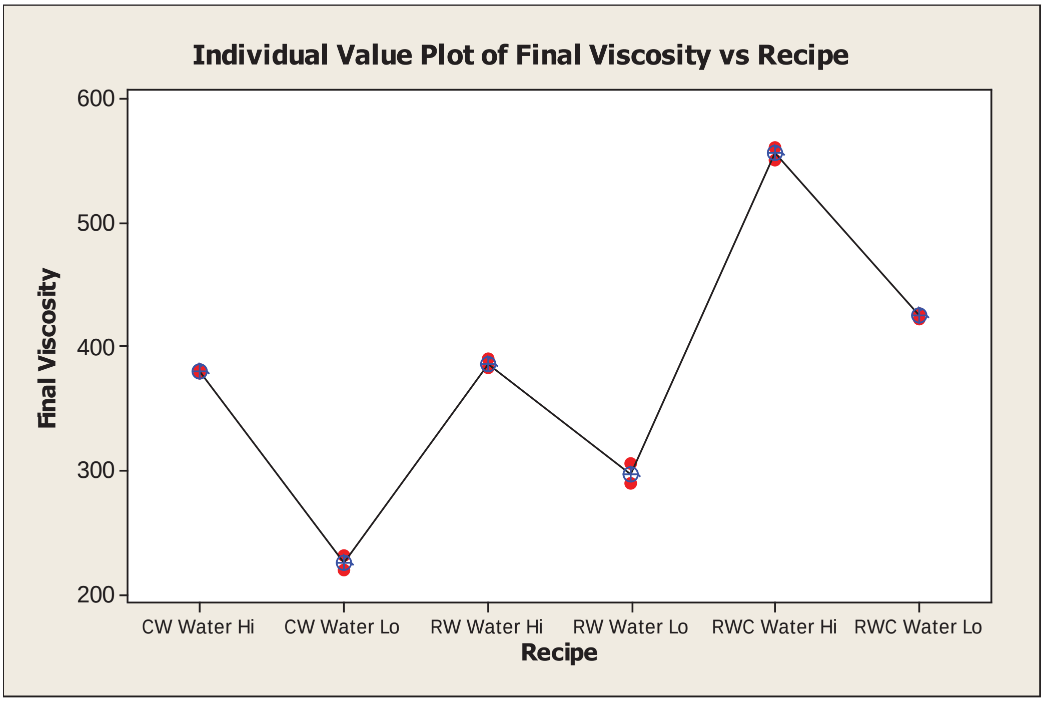
One-way ANOVA: Final Viscosity versus Recipe

```
Source  DF        SS       MS       F      P
Recipe   5  128071.4  25614.3  549.86  0.000
Error    6     279.5     46.6
Total   11  128350.9

S = 6.825   R-Sq = 99.78%   R-Sq(adj) = 99.60%
```

```
                                Individual 95% CIs For Mean Based on
                                Pooled StDev
Level         N    Mean  StDev  ---------+---------+---------+---------+
CW Water Hi   2  380.00   1.41                  (*)
CW Water Lo   2  225.00   8.49  (-*)
RW Water Hi   2  386.50   4.95                  (-*)
RW Water Lo   2  297.50  10.61          (*)
RWC Water Hi  2  556.50   7.78                                   (-*)
RWC Water Lo  2  425.00   2.83                      (-*)
                                ---------+---------+---------+---------+
                                       300       400       500       600

Pooled StDev = 6.83

Grouping Information Using Tukey Method

Recipe        N    Mean  Grouping
RWC Water Hi  2  556.50  A
RWC Water Lo  2  425.00    B
RW Water Hi   2  386.50      C
CW Water Hi   2  380.00      C
RW Water Lo   2  297.50        D
CW Water Lo   2  225.00          E

Means that do not share a letter are significantly different.

Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Recipe

Individual confidence level = 99.27%

Recipe = CW Water Hi subtracted from:

Recipe          Lower   Centre    Upper
CW Water Lo   -182.17  -155.00  -127.83
RW Water Hi    -20.67     6.50    33.67
RW Water Lo   -109.67   -82.50   -55.33
RWC Water Hi   149.33   176.50   203.67
RWC Water Lo    17.83    45.00    72.17


Recipe        --------+---------+---------+---------+-
CW Water Lo            (*-)
RW Water Hi                    (*-)
RW Water Lo                (*)
RWC Water Hi                           (-*)
RWC Water Lo                     (*-)
              --------+---------+---------+---------+-
                   -200         0       200       400


Recipe = CW Water Lo subtracted from:

Recipe         Lower  Centre   Upper  --------+---------+---------+---------+-
RW Water Hi   134.33  161.50  188.67                          (*)
RW Water Lo    45.33   72.50   99.67                     (-*)
RWC Water Hi  304.33  331.50  358.67                                  (-*)
RWC Water Lo  172.83  200.00  227.17                            (*)
                                      --------+---------+---------+---------+-
                                           -200         0       200       400

Recipe = RW Water Hi subtracted from:

Recipe          Lower  Centre   Upper  --------+---------+---------+---------+-
RW Water Lo   -116.17  -89.00  -61.83             (-*)
RWC Water Hi   142.83  170.00  197.17                          (-*)
RWC Water Lo    11.33   38.50   65.67                    (*)
                                       --------+---------+---------+---------+-
                                            -200         0       200       400
```

```
Recipe = RW Water Lo subtracted from:

Recipe         Lower  Centre   Upper  --------+---------+---------+---------+-
RWC Water Hi  231.83  259.00  286.17                                 (*)
RWC Water Lo  100.33  127.50  154.67                          (*-)
                                      --------+---------+---------+---------+-
                                           -200         0       200       400

Recipe = RWC Water Hi subtracted from:

Recipe          Lower   Centre    Upper
RWC Water Lo  -158.67  -131.50  -104.33

Recipe        --------+---------+---------+---------+-
RWC Water Lo           (*-)
              --------+---------+---------+---------+-
                   -200         0       200       400
```

Individual Value Plot of Final Viscosity vs Recipe



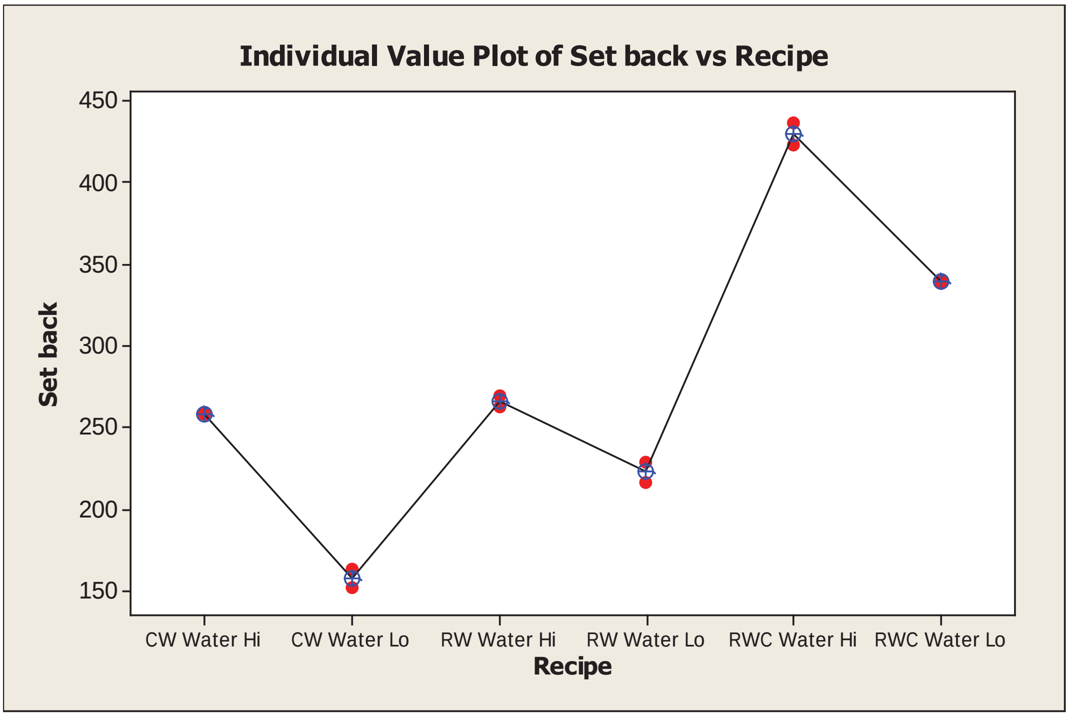
One-way ANOVA: Setback versus Recipe

```
Source  DF       SS       MS       F      P
Recipe   5  89587.7  17917.5  430.02  0.000
Error    6    250.0     41.7
Total   11  89837.7

S = 6.455   R-Sq = 99.72%   R-Sq(adj) = 99.49%

                                Individual 95% CIs For Mean Based on
                                Pooled StDev
Level         N    Mean  StDev  --+---------+---------+---------+-------
CW Water Hi   2  258.50   0.71             (*-)
CW Water Lo   2  157.50   7.78  (-*)
RW Water Hi   2  266.00   4.24              (*-)
RW Water Lo   2  222.50   9.19        (-*)
RWC Water Hi  2  429.50   9.19                                  (-*)
RWC Water Lo  2  339.00   1.41                       (*-)
                                --+---------+---------+---------+-------
                                160       240       320       400
```

```
Pooled StDev = 6.45

Grouping Information Using Tukey Method

Recipe        N    Mean  Grouping
RWC Water Hi  2  429.50  A
RWC Water Lo  2  339.00    B
RW Water Hi   2  266.00      C
CW Water Hi   2  258.50      C
RW Water Lo   2  222.50        D
CW Water Lo   2  157.50          E

Means that do not share a letter are significantly different.

Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Recipe

Individual confidence level = 99.27%

Recipe = CW Water Hi subtracted from:

Recipe          Lower   Centre   Upper
CW Water Lo   -126.70  -101.00  -75.30
RW Water Hi    -18.20     7.50   33.20
RW Water Lo    -61.70   -36.00  -10.30
RWC Water Hi   145.30   171.00  196.70
RWC Water Lo    54.80    80.50  106.20

Recipe           +---------+---------+---------+---------
CW Water Lo                 (*-)
RW Water Hi                        (-*)
RW Water Lo                     (-*)
RWC Water Hi                                  (*-)
RWC Water Lo                            (*-)
                 +---------+---------+---------+---------
              -300      -150         0       150


Recipe = CW Water Lo subtracted from:

Recipe         Lower  Centre   Upper
RW Water Hi    82.80  108.50  134.20
RW Water Lo    39.30   65.00   90.70
RWC Water Hi  246.30  272.00  297.70
RWC Water Lo  155.80  181.50  207.20

Recipe           +---------+---------+---------+---------
RW Water Hi                               (*-)
RW Water Lo                            (*-)
RWC Water Hi                                        (-*-)
RWC Water Lo                                  (-*-)
                 +---------+---------+---------+---------
              -300      -150         0       150


Recipe = RW Water Hi subtracted from:

Recipe         Lower  Centre   Upper
RW Water Lo   -69.20  -43.50  -17.80
RWC Water Hi  137.80  163.50  189.20
RWC Water Lo   47.30   73.00   98.70

Recipe           +---------+---------+---------+---------
RW Water Lo                    (-*-)
RWC Water Hi                                 (-*-)
RWC Water Lo                           (-*-)
                 +---------+---------+---------+---------
              -300      -150         0       150
```

```
Recipe = RW Water Lo subtracted from:

Recipe          Lower  Centre   Upper
RWC Water Hi   181.30  207.00  232.70
RWC Water Lo    90.80  116.50  142.20

Recipe          +---------+---------+---------+---------
RWC Water Hi                                  (-*-)
RWC Water Lo                            (-*)
                +---------+---------+---------+---------
             -300      -150         0       150


Recipe = RWC Water Hi subtracted from:

Recipe           Lower  Centre   Upper
RWC Water Lo   -116.20  -90.50  -64.80

Recipe          +---------+---------+---------+---------
RWC Water Lo                (-*-)
                +---------+---------+---------+---------
             -300      -150         0       150
```

Individual Value Plot of Setback vs Recipe



A 5.3 Minitab One-way ANOVA of average cell length with 3G formulation RW, CW and RWC at two different water injection rate

One-way ANOVA: Average Cell Length (µm) versus Formulation

```
Source       DF       SS      MS      F      P
Formulation   5  1671252  334250  61.66  0.000
Error        12    65051    5421
Total        17  1736303

S = 73.63   R-Sq = 96.25%   R-Sq(adj) = 94.69%
```

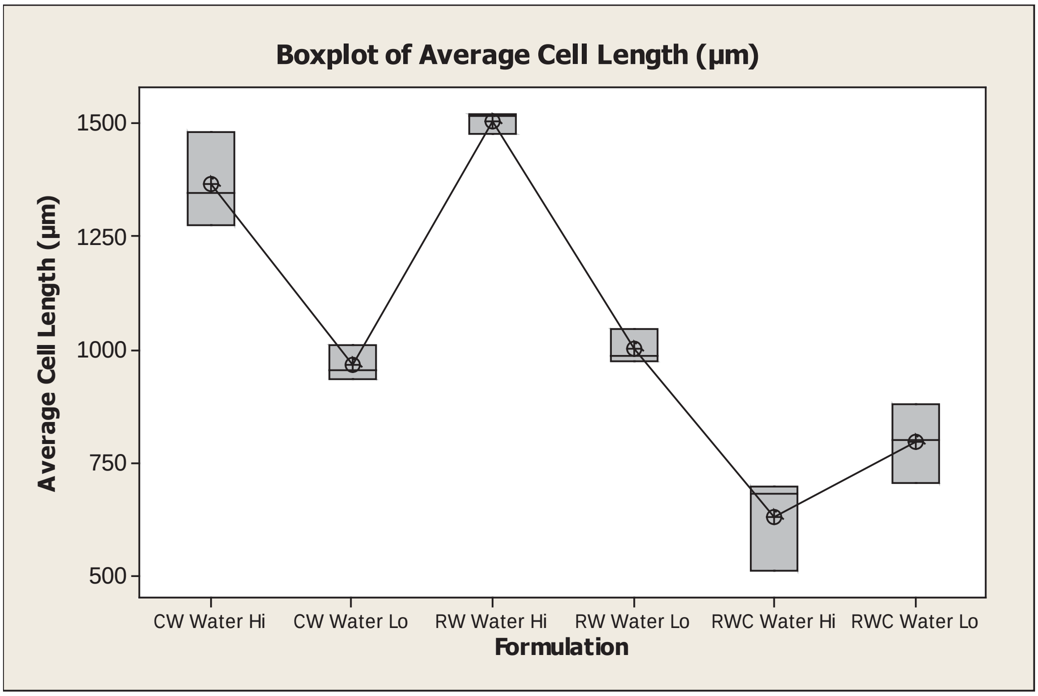
```
                                Individual 95% CIs For Mean Based on
                                Pooled StDev
Level         N    Mean  StDev  --+---------+---------+---------+-------
CW Water Hi   3  1366.4  103.4                          (---*--)
CW Water Lo   3   965.3   40.2             (--*--)
RW Water Hi   3  1503.9   24.9                               (--*--)
RW Water Lo   3  1001.5   37.1              (--*--)
RWC Water Hi  3   630.1  102.6  (--*--)
RWC Water Lo  3   794.5   87.7       (--*---)
                                --+---------+---------+---------+-------
                                600       900      1200      1500

Pooled StDev = 73.6


Grouping Information Using Tukey Method

Formulation   N    Mean  Grouping
RW Water Hi   3  1503.9  A
CW Water Hi   3  1366.4  A
RW Water Lo   3  1001.5    B
CW Water Lo   3   965.3    B C
RWC Water Lo  3   794.5      C D
RWC Water Hi  3   630.1        D

Means that do not share a letter are significantly different.


Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Formulation

Individual confidence level = 99.43%


Formulation = CW Water Hi subtracted from:

Formulation    Lower  Centre   Upper  --------+---------+---------+---------+-
CW Water Lo   -603.0  -401.1  -199.2          (--*---)
RW Water Hi    -64.5   137.5   339.4                   (--*---)
RW Water Lo   -566.9  -365.0  -163.1           (--*--)
RWC Water Hi  -938.3  -736.4  -534.5    (---*--)
RWC Water Lo  -773.9  -572.0  -370.0       (--*---)
                                      --------+---------+---------+---------+-
                                           -600         0       600      1200


Formulation = CW Water Lo subtracted from:

Formulation    Lower  Centre   Upper  --------+---------+---------+---------+-
RW Water Hi    336.7   538.6   740.5                          (--*--)
RW Water Lo   -165.8    36.1   238.1                 (---*--)
RWC Water Hi  -537.2  -335.3  -133.4           (--*---)
RWC Water Lo  -372.8  -170.8    31.1              (--*---)
                                      --------+---------+---------+---------+-
                                           -600         0       600      1200


Formulation = RW Water Hi subtracted from:

Formulation     Lower  Centre   Upper  --------+---------+---------+---------+-
RW Water Lo    -704.4  -502.4  -300.5        (---*--)
RWC Water Hi  -1075.8  -873.8  -671.9  (--*---)
RWC Water Lo   -911.3  -709.4  -507.5     (--*---)
                                       --------+---------+---------+---------+-
                                            -600         0       600      1200

Formulation = RW Water Lo subtracted from:
```

```
Formulation    Lower  Centre   Upper  --------+---------+---------+---------+-
RWC Water Hi  -573.3  -371.4  -169.5          (---*--)
RWC Water Lo  -408.9  -207.0    -5.1             (---*--)
                                      --------+---------+---------+---------+-
                                           -600         0       600      1200
```

Formulation = RWC Water Hi subtracted from:

```
Formulation   Lower  Centre  Upper  --------+---------+---------+---------+-
RWC Water Lo  -37.5   164.4  366.3                   (---*--)
                                    --------+---------+---------+---------+-
                                         -600         0       600      1200
```

Boxplot of Average Cell Length (µm)



A 5.4 Minitab One-way ANOVA of average cell length with 3G formulation RW, CW and RWC at two different water injection rate

One-way ANOVA: No. of cells/mm^2 versus Formulation

```
Source       DF      SS     MS      F      P
Formulation   5  248.30  49.66  19.43  0.000
Error        12   30.67   2.56
Total        17  278.97

S = 1.599   R-Sq = 89.01%   R-Sq(adj) = 84.43%

Level         N    Mean  StDev
CW Water Hi   3   2.841  0.201
CW Water Lo   3   5.764  0.407
RW Water Hi   3   1.978  0.171
RW Water Lo   3   5.301  0.281
RWC Water Hi  3  13.331  3.689
RWC Water Lo  3   7.557  1.187
```

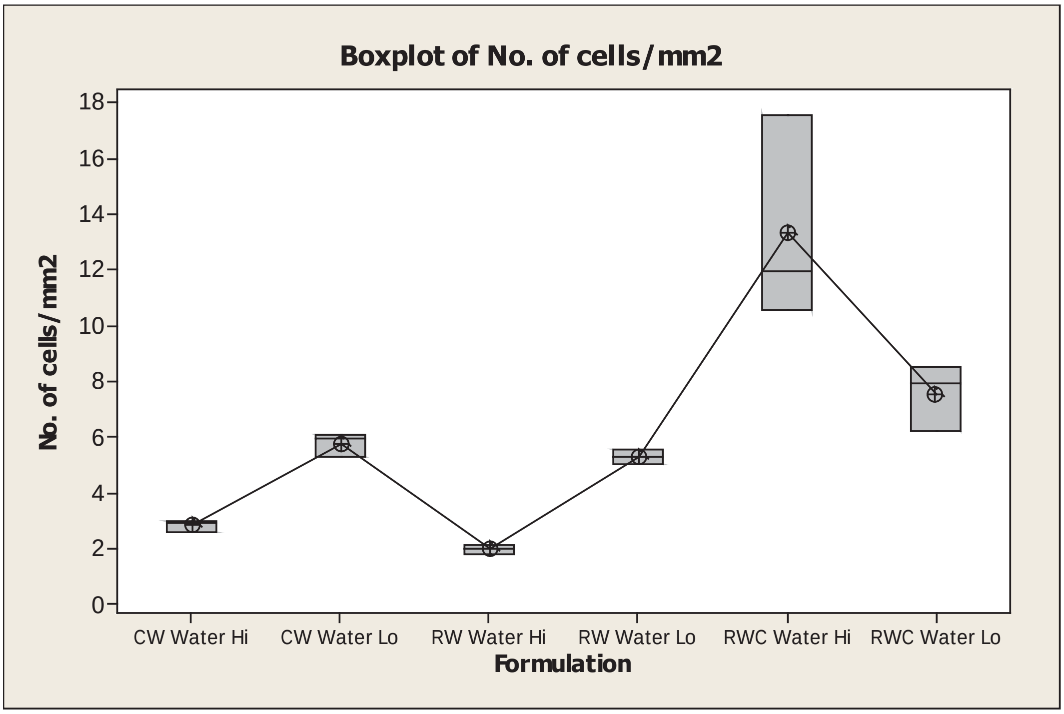
```
              Individual 95% CIs For Mean Based on Pooled StDev
Level           +---------+---------+---------+---------
CW Water Hi       (----*----)
CW Water Lo              (----*----)
RW Water Hi     (----*----)
RW Water Lo             (----*----)
RWC Water Hi                                (----*----)
RWC Water Lo                  (----*----)
                +---------+---------+---------+---------
              0.0       4.0       8.0      12.0
Pooled StDev = 1.599
```

```
Grouping Information Using Tukey Method

Formulation   N    Mean  Grouping
RWC Water Hi  3  13.331  A
RWC Water Lo  3   7.557    B
CW Water Lo   3   5.764    B C
RW Water Lo   3   5.301    B C
CW Water Hi   3   2.841      C
RW Water Hi   3   1.978      C

Means that do not share a letter are significantly different.
```

```
Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Formulation

Individual confidence level = 99.43%

Formulation = CW Water Hi subtracted from:

Formulation    Lower  Centre   Upper
CW Water Lo   -1.462   2.922   7.306
RW Water Hi   -5.247  -0.863   3.521
RW Water Lo   -1.924   2.460   6.844
RWC Water Hi   6.106  10.490  14.874
RWC Water Lo   0.332   4.716   9.100

Formulation       +---------+---------+---------+---------
CW Water Lo                         (-----*----)
RW Water Hi                    (-----*----)
RW Water Lo                         (----*-----)
RWC Water Hi                                  (----*-----)
RWC Water Lo                          (-----*----)
                  +---------+---------+---------+---------
              -16.0      -8.0       0.0       8.0


Formulation = CW Water Lo subtracted from:

Formulation    Lower  Centre   Upper
RW Water Hi   -8.169  -3.785   0.599
RW Water Lo   -4.846  -0.462   3.922
RWC Water Hi   3.184   7.568  11.952
RWC Water Lo  -2.590   1.794   6.178

Formulation       +---------+---------+---------+---------
RW Water Hi                 (----*-----)
RW Water Lo                     (----*-----)
RWC Water Hi                              (----*-----)
RWC Water Lo                       (----*-----)
                  +---------+---------+---------+---------
              -16.0      -8.0       0.0       8.0


Formulation = RW Water Hi subtracted from:
```

```
Formulation    Lower  Centre   Upper
RW Water Lo   -1.061   3.323   7.707
RWC Water Hi   6.969  11.353  15.737
RWC Water Lo   1.195   5.579   9.963

Formulation       +---------+---------+---------+---------
RW Water Lo                        (----*-----)
RWC Water Hi                                 (----*-----)
RWC Water Lo                         (-----*----)
                  +---------+---------+---------+---------
              -16.0      -8.0       0.0       8.0
Formulation = RW Water Lo subtracted from:

Formulation    Lower  Centre   Upper
RWC Water Hi   3.646   8.030  12.414
RWC Water Lo  -2.128   2.256   6.640

Formulation       +---------+---------+---------+---------
RWC Water Hi                             (----*-----)
RWC Water Lo                       (-----*----)
                  +---------+---------+---------+---------
              -16.0      -8.0       0.0       8.0


Formulation = RWC Water Hi subtracted from:

Formulation     Lower  Centre   Upper
RWC Water Lo  -10.158  -5.774  -1.390

Formulation       +---------+---------+---------+---------
RWC Water Lo               (-----*----)
                  +---------+---------+---------+---------
              -16.0      -8.0       0.0       8.0
```

Boxplot of No. of cells/mm^2



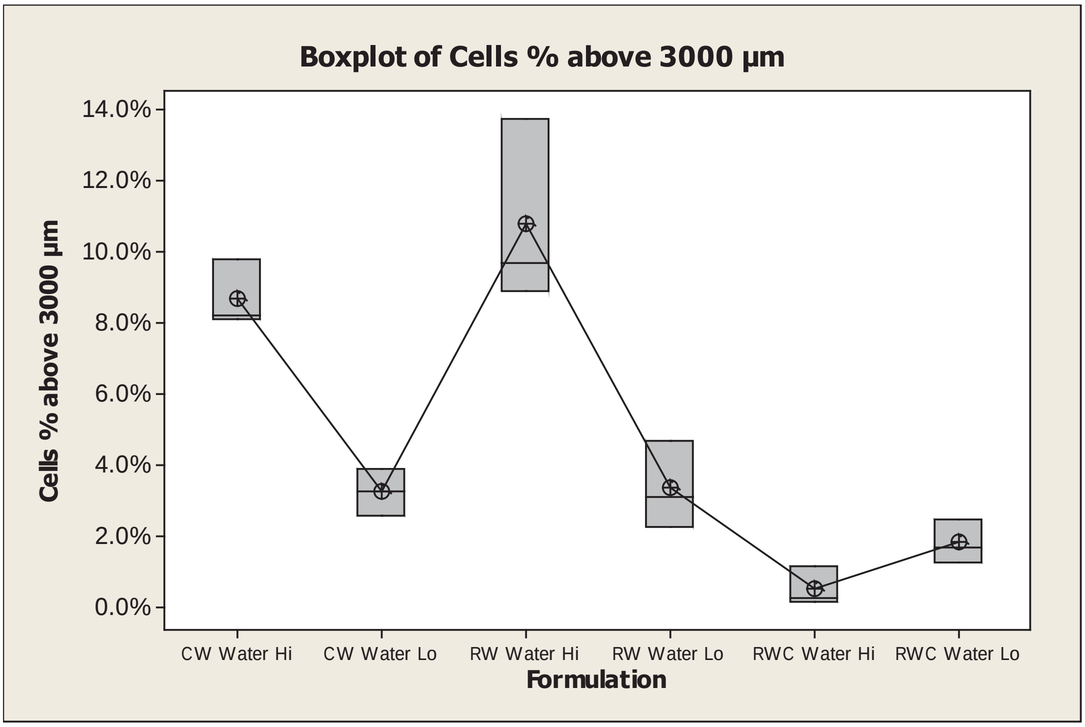
A 5.5 Minitab One-way ANOVA of cells size distribution with 3G formulation RW, CW and RWC at two different water injection rate

One-way ANOVA: Cells % above 3000 µm versus Formulation

```
Source       DF        SS        MS      F      P
Formulation   5  0.024577  0.004915  29.15  0.000
Error        12  0.002023  0.000169
Total        17  0.026601

S = 0.01299   R-Sq = 92.39%   R-Sq(adj) = 89.22%

                                   Individual 95% CIs For Mean Based on
                                   Pooled StDev
Level         N     Mean    StDev  ---+---------+---------+---------+------
CW Water Hi   3  0.08700  0.00954                         (----*----)
CW Water Lo   3  0.03267  0.00651          (---*----)
RW Water Hi   3  0.10767  0.02572                               (----*---)
RW Water Lo   3  0.03367  0.01222          (----*---)
RWC Water Hi  3  0.00567  0.00551  (----*---)
RWC Water Lo  3  0.01833  0.00611      (---*----)
                                   ---+---------+---------+---------+------
                                    0.000     0.035     0.070     0.105
Pooled StDev = 0.01299

Grouping Information Using Tukey Method

Formulation   N     Mean  Grouping
RW Water Hi   3  0.10767  A
CW Water Hi   3  0.08700  A
RW Water Lo   3  0.03367    B
CW Water Lo   3  0.03267    B
RWC Water Lo  3  0.01833    B
RWC Water Hi  3  0.00567    B

Means that do not share a letter are significantly different.

Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Formulation

Individual confidence level = 99.43%

Formulation = CW Water Hi subtracted from:

Formulation      Lower    Centre     Upper
CW Water Lo   -0.08994  -0.05433  -0.01872
RW Water Hi   -0.01494   0.02067   0.05628
RW Water Lo   -0.08894  -0.05333  -0.01772
RWC Water Hi  -0.11694  -0.08133  -0.04572
RWC Water Lo  -0.10428  -0.06867  -0.03306

Formulation      +---------+---------+---------+---------
CW Water Lo             (----*----)
RW Water Hi                        (----*----)
RW Water Lo             (----*----)
RWC Water Hi        (----*----)
RWC Water Lo          (----*----)
                 +---------+---------+---------+---------
              -0.140    -0.070     0.000     0.070

Formulation = CW Water Lo subtracted from:

Formulation      Lower    Centre    Upper
RW Water Hi    0.03939   0.07500  0.11061
RW Water Lo   -0.03461   0.00100  0.03661
RWC Water Hi  -0.06261  -0.02700  0.00861
RWC Water Lo  -0.04994  -0.01433  0.02128
```

```
Formulation      +---------+---------+---------+---------
RW Water Hi                               (----*----)
RW Water Lo                     (----*----)
RWC Water Hi                (----*----)
RWC Water Lo                  (----*----)
                 +---------+---------+---------+---------
              -0.140    -0.070     0.000     0.070

Formulation = RW Water Hi subtracted from:

Formulation      Lower    Centre     Upper
RW Water Lo   -0.10961  -0.07400  -0.03839
RWC Water Hi  -0.13761  -0.10200  -0.06639
RWC Water Lo  -0.12494  -0.08933  -0.05372

Formulation      +---------+---------+---------+---------
RW Water Lo          (----*-----)
RWC Water Hi     (----*-----)
RWC Water Lo       (----*----)
                 +---------+---------+---------+---------
              -0.140    -0.070     0.000     0.070


Formulation = RW Water Lo subtracted from:

Formulation      Lower    Centre    Upper
RWC Water Hi  -0.06361  -0.02800  0.00761
RWC Water Lo  -0.05094  -0.01533  0.02028

Formulation      +---------+---------+---------+---------
RWC Water Hi                (----*----)
RWC Water Lo                  (----*----)
                 +---------+---------+---------+---------
              -0.140    -0.070     0.000     0.070


Formulation = RWC Water Hi subtracted from:

Formulation      Lower   Centre    Upper
RWC Water Lo  -0.02294  0.01267  0.04828

Formulation      +---------+---------+---------+---------
RWC Water Lo                      (----*----)
                 +---------+---------+---------+---------
              -0.140    -0.070     0.000     0.070
```

Boxplot of Cells % above 3000 μm



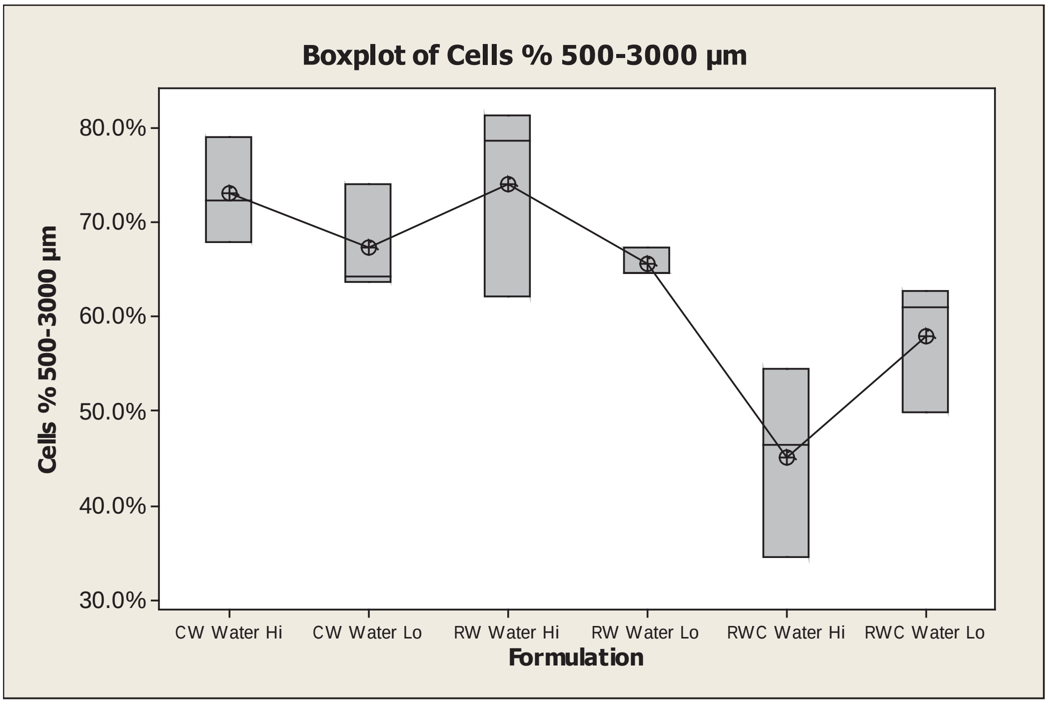
One-way ANOVA: Cells % 500-3000 µm versus Formulation

```
Source       DF       SS       MS     F      P
Formulation   5  0.17573  0.03515  6.54  0.004
Error        12  0.06447  0.00537
Total        17  0.24020

S = 0.07330   R-Sq = 73.16%   R-Sq(adj) = 61.98%


Level         N     Mean    StDev
CW Water Hi   3  0.73033  0.05537
CW Water Lo   3  0.67267  0.05839
RW Water Hi   3  0.74000  0.10394
RW Water Lo   3  0.65500  0.01473
RWC Water Hi  3  0.45200  0.09914
RWC Water Lo  3  0.57833  0.07009

              Individual 95% CIs For Mean Based on Pooled StDev
Level           +---------+---------+---------+---------
CW Water Hi                         (-------*-------)
CW Water Lo                    (-------*-------)
RW Water Hi                          (-------*------)
RW Water Lo                   (-------*------)
RWC Water Hi    (-------*------)
RWC Water Lo             (------*-------)
                +---------+---------+---------+---------
              0.36      0.48      0.60      0.72

Pooled StDev = 0.07330

Grouping Information Using Tukey Method

Formulation   N     Mean  Grouping
RW Water Hi   3  0.74000  A
CW Water Hi   3  0.73033  A
CW Water Lo   3  0.67267  A
RW Water Lo   3  0.65500  A
RWC Water Lo  3  0.57833  A B
RWC Water Hi  3  0.45200    B
```

```
Means that do not share a letter are significantly different.


Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Formulation

Individual confidence level = 99.43%

Formulation = CW Water Hi subtracted from:

Formulation      Lower    Centre     Upper
CW Water Lo   -0.25868  -0.05767   0.14335
RW Water Hi   -0.19135   0.00967   0.21068
RW Water Lo   -0.27635  -0.07533   0.12568
RWC Water Hi  -0.47935  -0.27833  -0.07732
RWC Water Lo  -0.35301  -0.15200   0.04901

Formulation      +---------+---------+---------+---------
CW Water Lo                (-------*-------)
RW Water Hi                  (-------*-------)
RW Water Lo               (-------*-------)
RWC Water Hi      (-------*-------)
RWC Water Lo           (-------*-------)
                 +---------+---------+---------+---------
              -0.50     -0.25      0.00      0.25
Formulation = CW Water Lo subtracted from:

Formulation      Lower    Centre     Upper
RW Water Hi   -0.13368   0.06733   0.26835
RW Water Lo   -0.21868  -0.01767   0.18335
RWC Water Hi  -0.42168  -0.22067  -0.01965
RWC Water Lo  -0.29535  -0.09433   0.10668

Formulation      +---------+---------+---------+---------
RW Water Hi                     (-------*-------)
RW Water Lo                 (-------*-------)
RWC Water Hi        (-------*-------)
RWC Water Lo             (-------*-------)
                 +---------+---------+---------+---------
              -0.50     -0.25      0.00      0.25


Formulation = RW Water Hi subtracted from:

Formulation      Lower    Centre     Upper
RW Water Lo   -0.28601  -0.08500   0.11601
RWC Water Hi  -0.48901  -0.28800  -0.08699
RWC Water Lo  -0.36268  -0.16167   0.03935

Formulation      +---------+---------+---------+---------
RW Water Lo               (-------*-------)
RWC Water Hi     (-------*--------)
RWC Water Lo          (--------*-------)
                 +---------+---------+---------+---------
              -0.50     -0.25      0.00      0.25


Formulation = RW Water Lo subtracted from:

Formulation      Lower    Centre     Upper
RWC Water Hi  -0.40401  -0.20300  -0.00199
RWC Water Lo  -0.27768  -0.07667   0.12435

Formulation      +---------+---------+---------+---------
RWC Water Hi         (-------*-------)
RWC Water Lo              (-------*-------)
                 +---------+---------+---------+---------
              -0.50     -0.25      0.00      0.25
```

```
Formulation = RWC Water Hi subtracted from:

Formulation      Lower   Centre    Upper
RWC Water Lo  -0.07468  0.12633  0.32735

Formulation      +---------+---------+---------+---------
RWC Water Lo                      (-------*-------)
                 +---------+---------+---------+---------
              -0.50     -0.25      0.00      0.25
```

Boxplot of Cells % 500-3000 µm



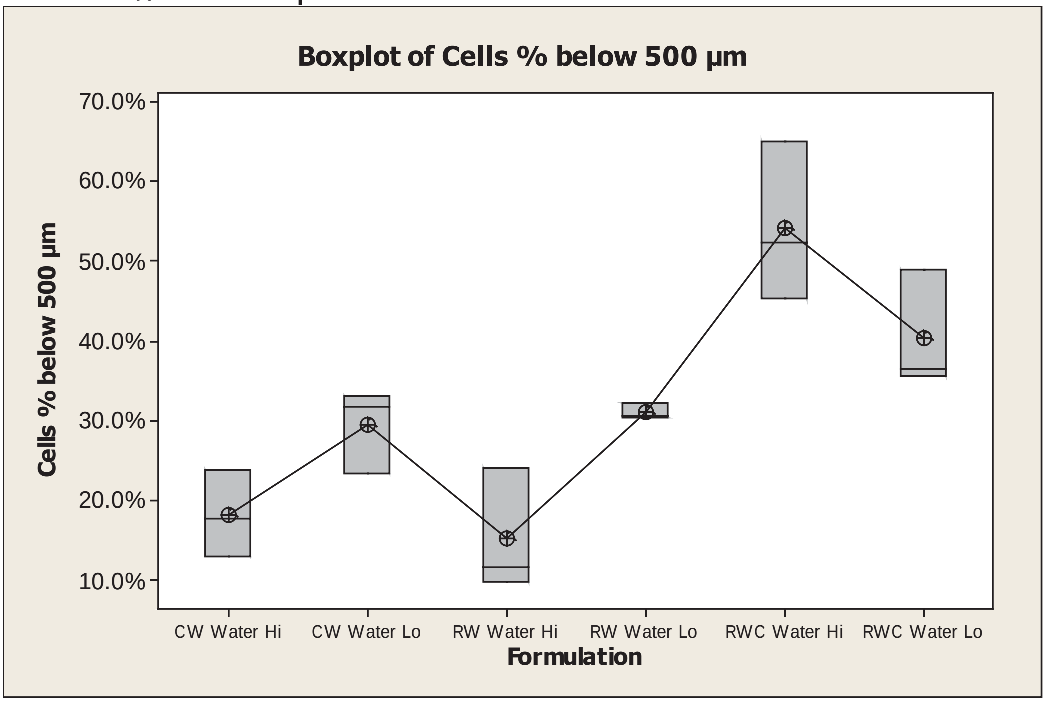
One-way ANOVA: Cells % below 500 µm versus Formulation

```
Source       DF       SS       MS      F      P
Formulation   5  0.31119  0.06224  13.69  0.000
Error        12  0.05457  0.00455
Total        17  0.36576

S = 0.06743   R-Sq = 85.08%   R-Sq(adj) = 78.86%


                                   Individual 95% CIs For Mean Based on
                                   Pooled StDev
Level         N     Mean    StDev  -----+---------+---------+---------+----
CW Water Hi   3  0.18267  0.05459    (----*-----)
CW Water Lo   3  0.29467  0.05288           (-----*----)
RW Water Hi   3  0.15233  0.07823  (----*-----)
RW Water Lo   3  0.31133  0.00929            (-----*----)
RWC Water Hi  3  0.54200  0.09888                           (-----*-----)
RWC Water Lo  3  0.40333  0.07433                  (-----*-----)
                                   -----+---------+---------+---------+----
                                      0.15      0.30      0.45      0.60

Pooled StDev = 0.06743


Grouping Information Using Tukey Method
```

```
Formulation   N     Mean  Grouping
RWC Water Hi  3  0.54200  A
RWC Water Lo  3  0.40333  A B
RW Water Lo   3  0.31133    B C
CW Water Lo   3  0.29467    B C
CW Water Hi   3  0.18267      C
RW Water Hi   3  0.15233      C

Means that do not share a letter are significantly different.

Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Formulation

Individual confidence level = 99.43%

Formulation = CW Water Hi subtracted from:
Formulation      Lower    Centre    Upper
CW Water Lo   -0.07293   0.11200  0.29693
RW Water Hi   -0.21527  -0.03033  0.15460
RW Water Lo   -0.05627   0.12867  0.31360
RWC Water Hi   0.17440   0.35933  0.54427
RWC Water Lo   0.03573   0.22067  0.40560

Formulation   ---------+---------+---------+---------+
CW Water Lo                    (-----*-----)
RW Water Hi               (-----*-----)
RW Water Lo                    (-----*-----)
RWC Water Hi                           (-----*-----)
RWC Water Lo                      (-----*------)
              ---------+---------+---------+---------+
                    -0.30      0.00      0.30      0.60

Formulation = CW Water Lo subtracted from:

Formulation      Lower    Centre    Upper
RW Water Hi   -0.32727  -0.14233  0.04260
RW Water Lo   -0.16827   0.01667  0.20160
RWC Water Hi   0.06240   0.24733  0.43227
RWC Water Lo  -0.07627   0.10867  0.29360

Formulation   ---------+---------+---------+---------+
RW Water Hi           (-----*-----)
RW Water Lo                (------*-----)
RWC Water Hi                       (-----*-----)
RWC Water Lo                  (------*-----)
              ---------+---------+---------+---------+
                    -0.30      0.00      0.30      0.60

Formulation = RW Water Hi subtracted from:

Formulation      Lower   Centre    Upper
RW Water Lo   -0.02593  0.15900  0.34393
RWC Water Hi   0.20473  0.38967  0.57460
RWC Water Lo   0.06607  0.25100  0.43593

Formulation   ---------+---------+---------+---------+
RW Water Lo                     (-----*-----)
RWC Water Hi                            (-----*-----)
RWC Water Lo                       (-----*------)
              ---------+---------+---------+---------+
                    -0.30      0.00      0.30      0.60

Formulation = RW Water Lo subtracted from:

Formulation      Lower   Centre    Upper
RWC Water Hi   0.04573  0.23067  0.41560
RWC Water Lo  -0.09293  0.09200  0.27693
Formulation   ---------+---------+---------+---------+
```

```
RWC Water Hi                       (-----*-----)
RWC Water Lo                  (-----*-----)
              ---------+---------+---------+---------+
                    -0.30      0.00      0.30      0.60

Formulation = RWC Water Hi subtracted from:

Formulation       Lower    Centre    Upper
RWC Water Lo  -0.32360  -0.13867  0.04627

Formulation   ---------+---------+---------+---------+
RWC Water Lo         (-----*------)
              ---------+---------+---------+---------+
                    -0.30      0.00      0.30      0.60
```

Boxplot of Cells % below 500 µm



A 5.6 Minitab One-way ANOVA of die swell and SEI with 3G formulation RW, CW and RWC at two different water injection rate

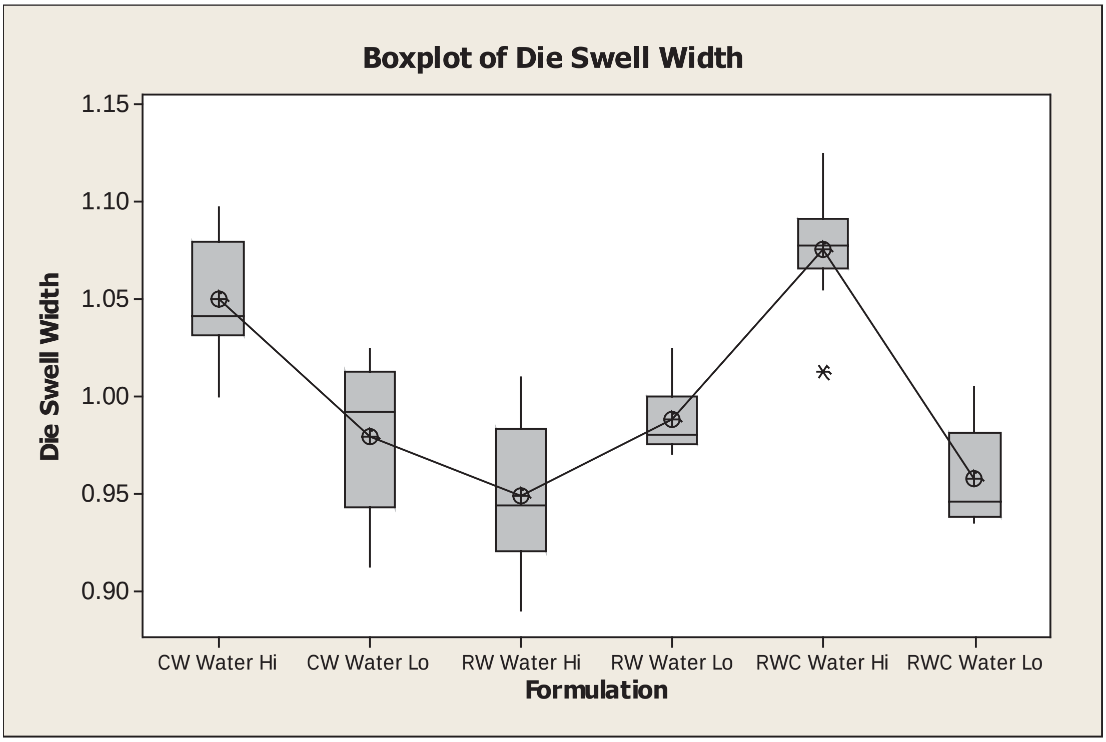
One-way ANOVA: Die Swell Width versus Formulation

```
Source       DF        SS        MS      F      P
Formulation   5  0.133437  0.026687  27.40  0.000
Error        54  0.052592  0.000974
Total        59  0.186029

S = 0.03121   R-Sq = 71.73%   R-Sq(adj) = 69.11%

                                  Individual 95% CIs For Mean Based on
                                  Pooled StDev
Level          N    Mean   StDev  ----+---------+---------+---------+-----
CW Water Hi   10  1.0505  0.0307                      (---*---)
CW Water Lo   10  0.9797  0.0386        (---*---)
RW Water Hi   10  0.9485  0.0392  (---*---)
RW Water Lo   10  0.9885  0.0172          (---*---)
RWC Water Hi  10  1.0762  0.0295                           (---*---)
RWC Water Lo  10  0.9577  0.0265    (---*---)
                                  ----+---------+---------+---------+-----
```

```
                                   0.950     1.000     1.050     1.100

Pooled StDev = 0.0312

Grouping Information Using Tukey Method

Formulation    N     Mean  Grouping
RWC Water Hi  10  1.07625  A
CW Water Hi   10  1.05050  A
RW Water Lo   10  0.98850    B
CW Water Lo   10  0.97975    B
RWC Water Lo  10  0.95775    B
RW Water Hi   10  0.94850    B

Means that do not share a letter are significantly different.

Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Formulation


Individual confidence level = 99.54%

Formulation = CW Water Hi subtracted from:

Formulation      Lower    Centre     Upper
CW Water Lo   -0.11200  -0.07075  -0.02950
RW Water Hi   -0.14325  -0.10200  -0.06075
RW Water Lo   -0.10325  -0.06200  -0.02075
RWC Water Hi  -0.01550   0.02575   0.06700
RWC Water Lo  -0.13400  -0.09275  -0.05150

Formulation   -------+---------+---------+---------+--
CW Water Lo         (---*---)
RW Water Hi      (---*---)
RW Water Lo          (---*---)
RWC Water Hi                 (----*---)
RWC Water Lo      (---*---)
              -------+---------+---------+---------+--
                  -0.10      0.00      0.10      0.20

Formulation = CW Water Lo subtracted from:

Formulation      Lower    Centre    Upper
RW Water Hi   -0.07250  -0.03125  0.01000
RW Water Lo   -0.03250   0.00875  0.05000
RWC Water Hi   0.05525   0.09650  0.13775
RWC Water Lo  -0.06325  -0.02200  0.01925

Formulation   -------+---------+---------+---------+--
RW Water Hi            (---*---)
RW Water Lo                (---*---)
RWC Water Hi                        (---*---)
RWC Water Lo            (---*---)
              -------+---------+---------+---------+--
                  -0.10      0.00      0.10      0.20

Formulation = RW Water Hi subtracted from:

Formulation      Lower   Centre    Upper
RW Water Lo   -0.00125  0.04000  0.08125
RWC Water Hi   0.08650  0.12775  0.16900
RWC Water Lo  -0.03200  0.00925  0.05050

Formulation   -------+---------+---------+---------+--
RW Water Lo                   (---*---)
RWC Water Hi                           (---*---)
RWC Water Lo               (---*---)
              -------+---------+---------+---------+--
```

```
                 -0.10      0.00      0.10      0.20

Formulation = RW Water Lo subtracted from:

Formulation      Lower    Centre    Upper
RWC Water Hi   0.04650   0.08775  0.12900
RWC Water Lo  -0.07200  -0.03075  0.01050

Formulation   -------+---------+---------+---------+--
RWC Water Hi                        (---*---)
RWC Water Lo            (---*---)
              -------+---------+---------+---------+--
                 -0.10      0.00      0.10      0.20

Formulation = RWC Water Hi subtracted from:

Formulation      Lower    Centre     Upper
RWC Water Lo  -0.15975  -0.11850  -0.07725

Formulation   -------+---------+---------+---------+--
RWC Water Lo   (---*---)
              -------+---------+---------+---------+--
                 -0.10      0.00      0.10      0.20
```

Boxplot of Die Swell Width



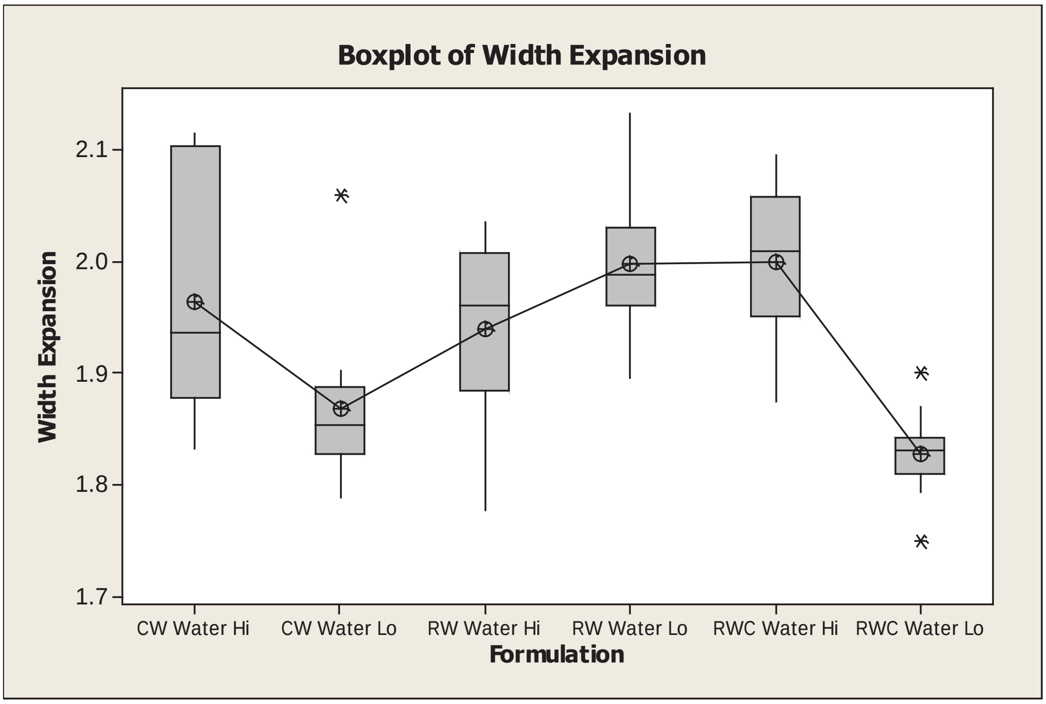
One-way ANOVA: Width Expansion versus Formulation

```
Source       DF       SS       MS     F      P
Formulation   5  0.24920  0.04984  8.68  0.000
Error        54  0.31003  0.00574
Total        59  0.55923

S = 0.07577   R-Sq = 44.56%   R-Sq(adj) = 39.43%
```

```
                                  Individual 95% CIs For Mean Based on
                                  Pooled StDev
Level          N    Mean   StDev  ------+---------+---------+---------+---
CW Water Hi   10  1.9642  0.1082                      (------*-----)
CW Water Lo   10  1.8685  0.0766        (------*------)
RW Water Hi   10  1.9397  0.0792                  (------*------)
RW Water Lo   10  1.9985  0.0622                           (-----*------)
RWC Water Hi  10  1.9995  0.0716                           (------*------)
RWC Water Lo  10  1.8280  0.0402  (------*------)
                                  ------+---------+---------+---------+---
                                      1.820     1.890     1.960     2.030

Pooled StDev = 0.0758


Grouping Information Using Tukey Method

Formulation    N     Mean  Grouping
RWC Water Hi  10  1.99950  A
RW Water Lo   10  1.99850  A
CW Water Hi   10  1.96425  A B
RW Water Hi   10  1.93975  A B
CW Water Lo   10  1.86850    B C
RWC Water Lo  10  1.82800      C

Means that do not share a letter are significantly different.


Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Formulation

Individual confidence level = 99.54%


Formulation = CW Water Hi subtracted from:

Formulation      Lower    Centre     Upper
CW Water Lo   -0.19591  -0.09575   0.00441
RW Water Hi   -0.12466  -0.02450   0.07566
RW Water Lo   -0.06591   0.03425   0.13441
RWC Water Hi  -0.06491   0.03525   0.13541
RWC Water Lo  -0.23641  -0.13625  -0.03609

Formulation   --------+---------+---------+---------+-
CW Water Lo        (------*-----)
RW Water Hi             (-----*------)
RW Water Lo                 (-----*------)
RWC Water Hi                (-----*------)
RWC Water Lo     (------*------)
              --------+---------+---------+---------+-
                  -0.15      0.00      0.15      0.30


Formulation = CW Water Lo subtracted from:

Formulation      Lower    Centre    Upper
RW Water Hi   -0.02891   0.07125  0.17141
RW Water Lo    0.02984   0.13000  0.23016
RWC Water Hi   0.03084   0.13100  0.23116
RWC Water Lo  -0.14066  -0.04050  0.05966

Formulation   --------+---------+---------+---------+-
RW Water Hi                 (------*-----)
RW Water Lo                     (------*-----)
RWC Water Hi                    (------*-----)
RWC Water Lo           (-----*------)
              --------+---------+---------+---------+-
                  -0.15      0.00      0.15      0.30
```

```
Formulation = RW Water Hi subtracted from:

Formulation      Lower    Centre     Upper
RW Water Lo   -0.04141   0.05875   0.15891
RWC Water Hi  -0.04041   0.05975   0.15991
RWC Water Lo  -0.21191  -0.11175  -0.01159

Formulation   --------+---------+---------+---------+-
RW Water Lo                (------*------)
RWC Water Hi               (------*------)
RWC Water Lo      (------*-----)
              --------+---------+---------+---------+-
                   -0.15      0.00      0.15      0.30
Formulation = RW Water Lo subtracted from:

Formulation      Lower    Centre     Upper
RWC Water Hi  -0.09916   0.00100   0.10116
RWC Water Lo  -0.27066  -0.17050  -0.07034

Formulation   --------+---------+---------+---------+-
RWC Water Hi             (------*------)
RWC Water Lo  (------*-----)
              --------+---------+---------+---------+-
                   -0.15      0.00      0.15      0.30


Formulation = RWC Water Hi subtracted from:

Formulation      Lower    Centre     Upper
RWC Water Lo  -0.27166  -0.17150  -0.07134

Formulation   --------+---------+---------+---------+-
RWC Water Lo  (------*-----)
              --------+---------+---------+---------+-
                   -0.15      0.00      0.15      0.30
```

Boxplot of Width Expansion



One-way ANOVA: Die Swell Thickness versus Formulation

```
Source       DF       SS       MS      F      P
Formulation   5  2.18318  0.43664  77.45  0.000
Error        54  0.30444  0.00564
Total        59  2.48761

S = 0.07508   R-Sq = 87.76%   R-Sq(adj) = 86.63%
```

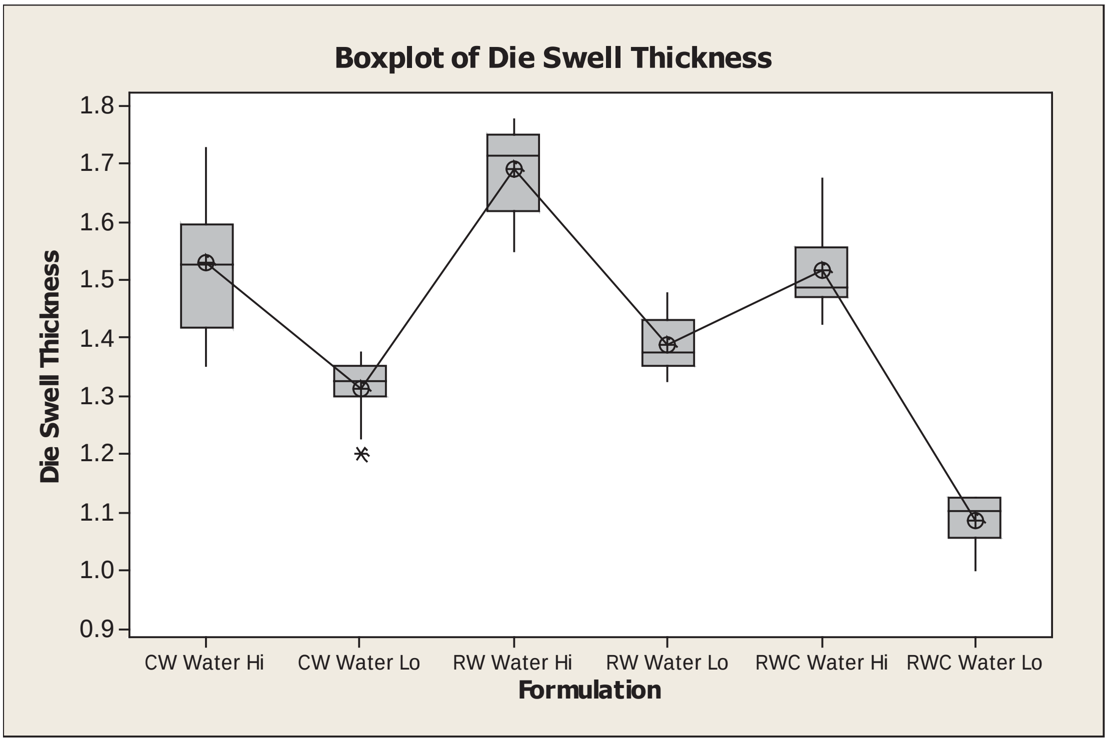
```
                                  Individual 95% CIs For Mean Based on
                                  Pooled StDev
Level          N    Mean   StDev  --------+---------+---------+---------+-
CW Water Hi   10  1.5275  0.1239                        (-*--)
CW Water Lo   10  1.3125  0.0556             (--*-)
RW Water Hi   10  1.6900  0.0738                                (-*--)
RW Water Lo   10  1.3875  0.0475                 (-*--)
RWC Water Hi  10  1.5150  0.0738                       (--*-)
RWC Water Lo  10  1.0850  0.0474  (-*--)
                                  --------+---------+---------+---------+-
                                        1.20      1.40      1.60      1.80

Pooled StDev = 0.0751
```

```
Grouping Information Using Tukey Method

Formulation    N     Mean  Grouping
RW Water Hi   10  1.69000  A
CW Water Hi   10  1.52750    B
RWC Water Hi  10  1.51500    B
RW Water Lo   10  1.38750      C
CW Water Lo   10  1.31250      C
RWC Water Lo  10  1.08500        D

Means that do not share a letter are significantly different.
```

```
Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Formulation

Individual confidence level = 99.54%


Formulation = CW Water Hi subtracted from:

Formulation      Lower    Centre     Upper
CW Water Lo   -0.31425  -0.21500  -0.11575
RW Water Hi    0.06325   0.16250   0.26175
RW Water Lo   -0.23925  -0.14000  -0.04075
RWC Water Hi  -0.11175  -0.01250   0.08675
RWC Water Lo  -0.54175  -0.44250  -0.34325

Formulation   --------+---------+---------+---------+-
CW Water Lo             (--*-)
RW Water Hi                       (-*--)
RW Water Lo               (-*--)
RWC Water Hi                 (--*-)
RWC Water Lo      (--*-)
              --------+---------+---------+---------+-
                   -0.40      0.00      0.40      0.80
```

```
Formulation = CW Water Lo subtracted from:

Formulation      Lower    Centre     Upper
RW Water Hi    0.27825   0.37750   0.47675
RW Water Lo   -0.02425   0.07500   0.17425
RWC Water Hi   0.10325   0.20250   0.30175
RWC Water Lo  -0.32675  -0.22750  -0.12825

Formulation   --------+---------+---------+---------+-
RW Water Hi                         (-*--)
RW Water Lo                   (--*-)
RWC Water Hi                      (-*--)
RWC Water Lo            (-*--)
              --------+---------+---------+---------+-
                   -0.40      0.00      0.40      0.80
Formulation = RW Water Hi subtracted from:

Formulation      Lower    Centre     Upper
RW Water Lo   -0.40175  -0.30250  -0.20325
RWC Water Hi  -0.27425  -0.17500  -0.07575
RWC Water Lo  -0.70425  -0.60500  -0.50575

Formulation   --------+---------+---------+---------+-
RW Water Lo           (-*--)
RWC Water Hi             (--*-)
RWC Water Lo  (--*-)
              --------+---------+---------+---------+-
                   -0.40      0.00      0.40      0.80


Formulation = RW Water Lo subtracted from:

Formulation      Lower    Centre     Upper
RWC Water Hi   0.02825   0.12750   0.22675
RWC Water Lo  -0.40175  -0.30250  -0.20325

Formulation   --------+---------+---------+---------+-
RWC Water Hi                    (-*--)
RWC Water Lo          (-*--)
              --------+---------+---------+---------+-
                   -0.40      0.00      0.40      0.80


Formulation = RWC Water Hi subtracted from:

Formulation      Lower    Centre     Upper
RWC Water Lo  -0.52925  -0.43000  -0.33075

Formulation   --------+---------+---------+---------+-
RWC Water Lo       (-*--)
              --------+---------+---------+---------+-
                   -0.40      0.00      0.40      0.80
```

Boxplot of Die Swell Thickness



One-way ANOVA: Thickness Expansion versus Formulation

```
Source       DF      SS     MS      F      P
Formulation   5  48.600  9.720  35.70  0.000
Error        54  14.701  0.272
Total        59  63.302

S = 0.5218   R-Sq = 76.78%   R-Sq(adj) = 74.63%


                                  Individual 95% CIs For Mean Based on
                                  Pooled StDev
Level          N    Mean   StDev   -+---------+---------+---------+--------
CW Water Hi   10  6.3100  0.7073                        (--*--)
CW Water Lo   10  5.6100  0.5198                 (--*--)
RW Water Hi   10  6.9100  0.5168                              (--*--)
RW Water Lo   10  6.1350  0.6606                      (--*---)
RWC Water Hi  10  4.9600  0.3254          (---*--)
RWC Water Lo  10  4.1900  0.2316   (--*--)
                                   -+---------+---------+---------+--------
                                  4.0       5.0       6.0       7.0

Pooled StDev = 0.5218

Grouping Information Using Tukey Method

Formulation    N    Mean  Grouping
RW Water Hi   10  6.9100  A
CW Water Hi   10  6.3100  A B
RW Water Lo   10  6.1350    B C
CW Water Lo   10  5.6100      C D
RWC Water Hi  10  4.9600        D
RWC Water Lo  10  4.1900          E

Means that do not share a letter are significantly different.

Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Formulation

Individual confidence level = 99.54%
```

```
Formulation = CW Water Hi subtracted from:

Formulation     Lower   Centre    Upper
CW Water Lo   -1.3897  -0.7000  -0.0103
RW Water Hi   -0.0897   0.6000   1.2897
RW Water Lo   -0.8647  -0.1750   0.5147
RWC Water Hi  -2.0397  -1.3500  -0.6603
RWC Water Lo  -2.8097  -2.1200  -1.4303

Formulation   -------+---------+---------+---------+--
CW Water Lo             (--*---)
RW Water Hi                    (--*--)
RW Water Lo                (--*---)
RWC Water Hi         (--*---)
RWC Water Lo     (--*---)
              -------+---------+---------+---------+--
                  -2.0       0.0       2.0       4.0
```

```
Formulation = CW Water Lo subtracted from:

Formulation     Lower   Centre    Upper
RW Water Hi    0.6103   1.3000   1.9897
RW Water Lo   -0.1647   0.5250   1.2147
RWC Water Hi  -1.3397  -0.6500   0.0397
RWC Water Lo  -2.1097  -1.4200  -0.7303
Formulation   -------+---------+---------+---------+--
RW Water Hi                       (---*--)
RW Water Lo                   (---*--)
RWC Water Hi            (---*--)
RWC Water Lo        (---*--)
              -------+---------+---------+---------+--
                  -2.0       0.0       2.0       4.0
```

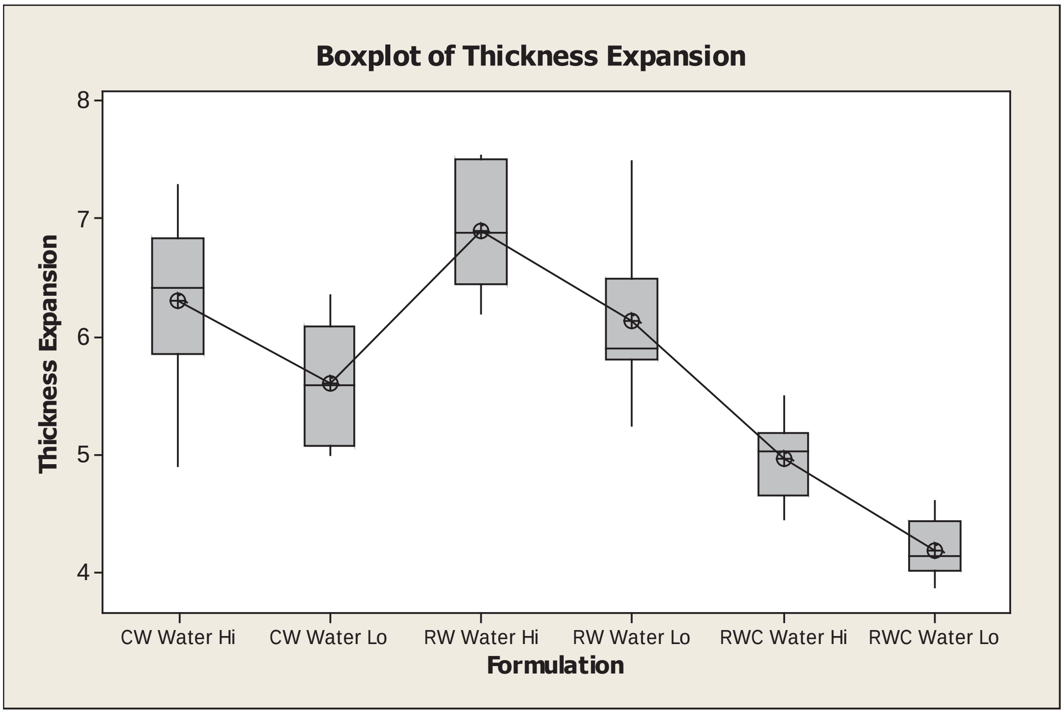
```
Formulation = RW Water Hi subtracted from:

Formulation     Lower   Centre    Upper
RW Water Lo   -1.4647  -0.7750  -0.0853
RWC Water Hi  -2.6397  -1.9500  -1.2603
RWC Water Lo  -3.4097  -2.7200  -2.0303

Formulation   -------+---------+---------+---------+--
RW Water Lo             (--*---)
RWC Water Hi      (--*---)
RWC Water Lo  (--*---)
              -------+---------+---------+---------+--
                  -2.0       0.0       2.0       4.0
```

```
Formulation = RW Water Lo subtracted from:

Formulation     Lower   Centre    Upper
RWC Water Hi  -1.8647  -1.1750  -0.4853
RWC Water Lo  -2.6347  -1.9450  -1.2553

Formulation   -------+---------+---------+---------+--
RWC Water Hi          (--*---)
RWC Water Lo      (--*---)
              -------+---------+---------+---------+--
                  -2.0       0.0       2.0       4.0
```

```
Formulation = RWC Water Hi subtracted from:

Formulation     Lower   Centre    Upper
RWC Water Lo  -1.4597  -0.7700  -0.0803
```

```
Formulation    -------+---------+---------+---------+--
RWC Water Lo            (--*---)
               -------+---------+---------+---------+--
                   -2.0       0.0       2.0       4.0
```

Boxplot of Thickness Expansion



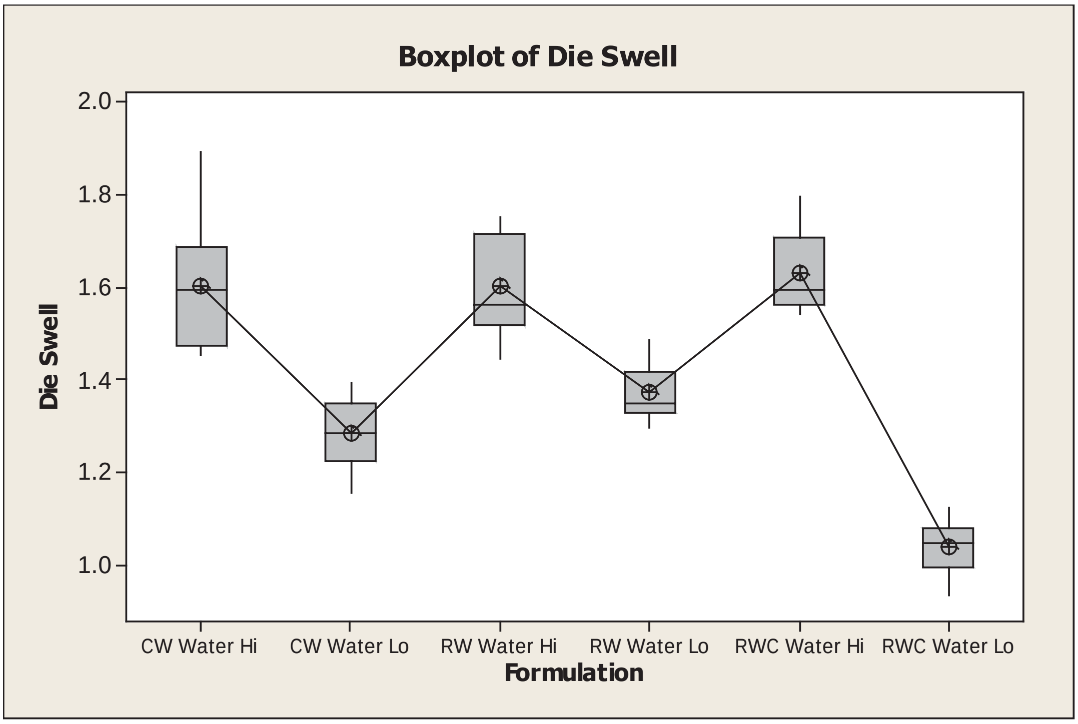
One-way ANOVA: Die Swell versus Formulation

```
Source       DF        SS        MS      F      P
Formulation   5   2.77388   0.55478  61.18  0.000
Error        54   0.48964   0.00907
Total        59   3.26353

S = 0.09522   R-Sq = 85.00%   R-Sq(adj) = 83.61%

                                  Individual 95% CIs For Mean Based on
                                  Pooled StDev
Level          N    Mean   StDev   -+---------+---------+---------+--------
CW Water Hi   10  1.6049  0.1429                             (--*--)
CW Water Lo   10  1.2858  0.0733             (--*--)
RW Water Hi   10  1.6039  0.1130                             (--*--)
RW Water Lo   10  1.3719  0.0635                  (--*--)
RWC Water Hi  10  1.6305  0.0909                               (--*--)
RWC Water Lo  10  1.0394  0.0595   (--*--)
                                   -+---------+---------+---------+--------
                                  1.00      1.20      1.40      1.60
Pooled StDev = 0.0952

Grouping Information Using Tukey Method

Formulation    N     Mean  Grouping
RWC Water Hi  10  1.63048  A
CW Water Hi   10  1.60487  A
RW Water Hi   10  1.60391  A
RW Water Lo   10  1.37194    B
CW Water Lo   10  1.28584    B
```

```
RWC Water Lo  10  1.03944      C

Means that do not share a letter are significantly different.

Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Formulation

Individual confidence level = 99.54%

Formulation = CW Water Hi subtracted from:
Formulation      Lower    Centre     Upper
CW Water Lo   -0.44490  -0.31903  -0.19316
RW Water Hi   -0.12684  -0.00097   0.12490
RW Water Lo   -0.35881  -0.23294  -0.10707
RWC Water Hi  -0.10026   0.02561   0.15148
RWC Water Lo  -0.69130  -0.56543  -0.43956

Formulation   --------+---------+---------+---------+-
CW Water Lo          (--*--)
RW Water Hi                  (--*--)
RW Water Lo            (--*--)
RWC Water Hi                 (---*--)
RWC Water Lo   (--*--)
              --------+---------+---------+---------+-
                   -0.40      0.00      0.40      0.80

Formulation = CW Water Lo subtracted from:

Formulation      Lower    Centre     Upper
RW Water Hi    0.19219   0.31806   0.44393
RW Water Lo   -0.03978   0.08609   0.21196
RWC Water Hi   0.21877   0.34464   0.47051
RWC Water Lo  -0.37227  -0.24640  -0.12053

Formulation   --------+---------+---------+---------+-
RW Water Hi                          (--*--)
RW Water Lo                    (--*--)
RWC Water Hi                         (---*--)
RWC Water Lo           (--*--)
              --------+---------+---------+---------+-
                   -0.40      0.00      0.40      0.80

Formulation = RW Water Hi subtracted from:

Formulation      Lower    Centre     Upper
RW Water Lo   -0.35784  -0.23197  -0.10610
RWC Water Hi  -0.09929   0.02657   0.15244
RWC Water Lo  -0.69033  -0.56446  -0.43859

Formulation   --------+---------+---------+---------+-
RW Water Lo            (--*--)
RWC Water Hi                  (--*--)
RWC Water Lo   (--*--)
              --------+---------+---------+---------+-
                   -0.40      0.00      0.40      0.80

Formulation = RW Water Lo subtracted from:

Formulation      Lower    Centre     Upper
RWC Water Hi   0.13267   0.25854   0.38441
RWC Water Lo  -0.45836  -0.33249  -0.20662

Formulation   --------+---------+---------+---------+-
RWC Water Hi                       (--*---)
RWC Water Lo         (--*--)
              --------+---------+---------+---------+-
                   -0.40      0.00      0.40      0.80
```

```
Formulation = RWC Water Hi subtracted from:

Formulation      Lower    Centre     Upper
RWC Water Lo  -0.71691  -0.59104  -0.46517

Formulation   --------+---------+---------+---------+-
RWC Water Lo  (--*--)
              --------+---------+---------+---------+-
                   -0.40      0.00      0.40      0.80
```

Boxplot of Die Swell

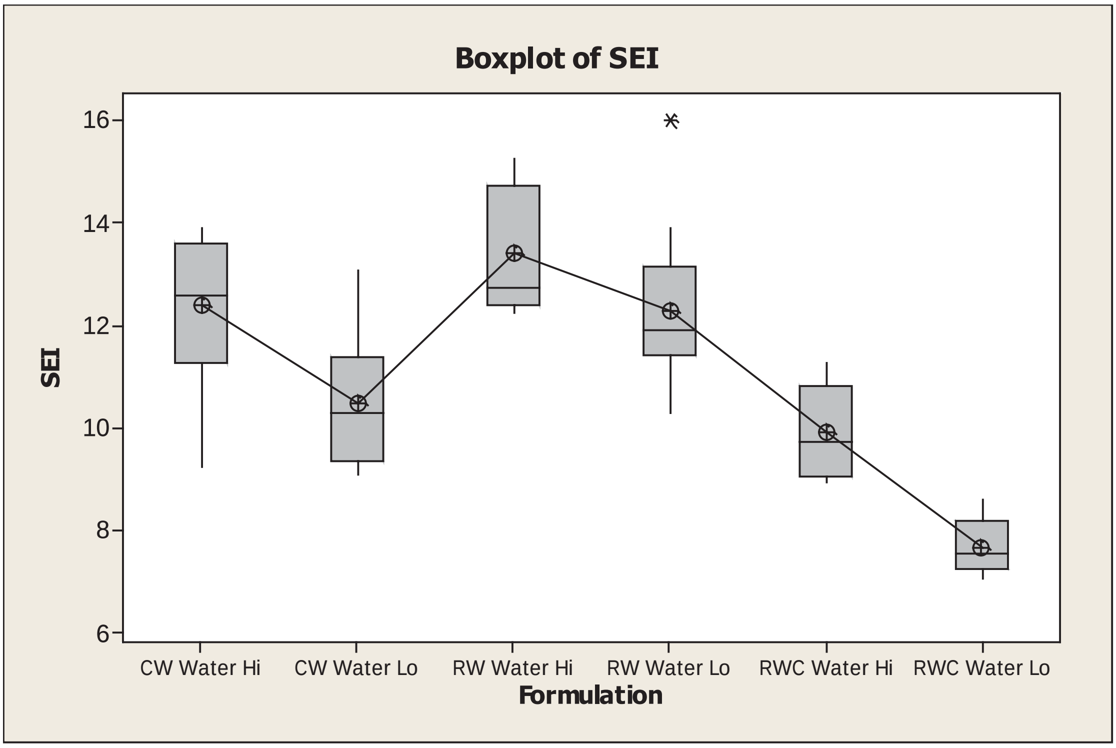


One-way ANOVA: SEI versus Formulation

```
Source       DF      SS     MS      F      P
Formulation   5  219.16  43.83  29.13  0.000
Error        54   81.26   1.50
Total        59  300.42

S = 1.227   R-Sq = 72.95%   R-Sq(adj) = 70.45%


                                 Individual 95% CIs For Mean Based on
                                 Pooled StDev
Level          N    Mean  StDev  ------+---------+---------+---------+---
CW Water Hi   10  12.391  1.475                         (---*---)
CW Water Lo   10  10.498  1.248                (--*---)
RW Water Hi   10  13.409  1.226                              (---*---)
RW Water Lo   10  12.287  1.648                         (--*---)
RWC Water Hi  10   9.927  0.880             (---*---)
RWC Water Lo  10   7.665  0.550  (---*---)
                                 ------+---------+---------+---------+---
                                     8.0      10.0      12.0      14.0

Pooled StDev = 1.227


Grouping Information Using Tukey Method
```

```
Formulation    N    Mean  Grouping
RW Water Hi   10  13.409  A
CW Water Hi   10  12.391  A
RW Water Lo   10  12.287  A
CW Water Lo   10  10.498    B
RWC Water Hi  10   9.927    B
RWC Water Lo  10   7.665      C

Means that do not share a letter are significantly different.

Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Formulation

Individual confidence level = 99.54%


Formulation = CW Water Hi subtracted from:

Formulation    Lower  Centre   Upper  --------+---------+---------+---------+-
CW Water Lo   -3.514  -1.893  -0.271           (---*---)
RW Water Hi   -0.603   1.018   2.640                  (----*---)
RW Water Lo   -1.725  -0.104   1.518                (---*---)
RWC Water Hi  -4.085  -2.464  -0.842          (---*---)
RWC Water Lo  -6.348  -4.726  -3.104    (---*---)
                                      --------+---------+---------+---------+-
                                           -4.0       0.0       4.0       8.0


Formulation = CW Water Lo subtracted from:

Formulation    Lower  Centre   Upper  --------+---------+---------+---------+-
RW Water Hi    1.289   2.911   4.532                       (---*---)
RW Water Lo    0.167   1.789   3.411                    (---*----)
RWC Water Hi  -2.193  -0.571   1.051               (---*---)
RWC Water Lo  -4.455  -2.833  -1.212         (---*---)
                                      --------+---------+---------+---------+-
                                           -4.0       0.0       4.0       8.0


Formulation = RW Water Hi subtracted from:

Formulation    Lower  Centre   Upper  --------+---------+---------+---------+-
RW Water Lo   -2.743  -1.122   0.500             (---*---)
RWC Water Hi  -5.103  -3.482  -1.860       (---*---)
RWC Water Lo  -7.366  -5.744  -4.123  (---*---)
                                      --------+---------+---------+---------+-
                                           -4.0       0.0       4.0       8.0


Formulation = RW Water Lo subtracted from:

Formulation    Lower  Centre   Upper  --------+---------+---------+---------+-
RWC Water Hi  -3.982  -2.360  -0.738          (---*---)
RWC Water Lo  -6.244  -4.622  -3.001    (---*---)
                                      --------+---------+---------+---------+-
                                           -4.0       0.0       4.0       8.0


Formulation = RWC Water Hi subtracted from:

Formulation    Lower  Centre   Upper  --------+---------+---------+---------+-
RWC Water Lo  -3.884  -2.262  -0.641          (---*---)
                                      --------+---------+---------+---------+-
                                           -4.0       0.0       4.0       8.0
```

Boxplot of SEI



A 5.7 Minitab Pearson correlation analysis of die swell and pellet expansion

```
                         Die Swell   Die Swell Width  Die Swell Thickn
Die Swell Width              0.574
                             0.000

Die Swell Thickn             0.937             0.253
                             0.000             0.051

SEI                          0.557             0.025             0.660
                             0.000             0.848             0.000

Width Expansion              0.482             0.374             0.417
                             0.000             0.003             0.001

Thickness Expans             0.520            -0.057             0.651
                             0.000             0.665             0.000


                               SEI   Width Expansion
Width Expansion              0.586
                             0.000

Thickness Expans             0.972             0.385
                             0.000             0.002


Cell Contents: Pearson correlation
               P-Value
```

A 5.8 Calculation details for the effect of temperature on diffusion coefficient in the Section 6.3.5

$$\frac{D_{v1}}{D_{v2}} = \left(\frac{T_1}{T_2}\right)^{1.5} \qquad \text{(Eq. 2.13)}$$

Where T is the temperature in Kevin.

Drying Method 3 holding temperature 30 ± 5 °C

Drying Method 4 holding temperature 60 ± 5 °C

The effect of the holding temperature on the diffusion coefficient:

$Dv_{60} / Dv_{30} = [(60 + 273.15) / (30 + 273.15)]^{1.5} = 1.15$

Appendix 6: Focus group forms and analysis details for Chapter 7

A 6.1 Low Risk Notification record for focus group study

MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA

4 November 2011

Ruoling Xiao
124 Pah Road
Royal Oak
AUCKLAND 1023

Dear Ruoling

Re: Evaluation of Extruded Indirect Expanded Healthy Snack with Ancient Grains

Thank you for your Low Risk Notification which was received on 25 October 2011.

Your project has been recorded on the Low Risk Database which is reported in the Annual Report of the Massey University Human Ethics Committees.

The low risk notification for this project is valid for a maximum of three years.

Please notify me if situations subsequently occur which cause you to reconsider your initial ethical analysis that it is safe to proceed without approval by one of the University's Human Ethics Committees.

Please note that travel undertaken by students must be approved by the supervisor and the relevant Pro Vice-Chancellor and be in accordance with the Policy and Procedures for Course-Related Student Travel Overseas. In addition, the supervisor must advise the University's Insurance Officer.

A reminder to include the following statement on all public documents:

"This project has been evaluated by peer review and judged to be low risk. Consequently, it has not been reviewed by one of the University's Human Ethics Committees. The researcher(s) named above are responsible for the ethical conduct of this research.

If you have any concerns about the conduct of this research that you wish to raise with someone other than the researcher(s), please contact Professor John O'Neill, Director (Research Ethics), telephone 06 350 5249, e-mail humanethics@massey.ac.nz".

Please note that if a sponsoring organisation, funding authority or a journal in which you wish to publish requires evidence of committee approval (with an approval number), you will have to provide a full application to one of the University's Human Ethics Committees. You should also note that such an approval can only be provided prior to the commencement of the research.

Yours sincerely

J.O'Neill

John G O'Neill (Professor)
Chair, Human Ethics Chairs' Committee and
Director (Research Ethics)

cc Assoc Prof Marie Wong
Institute of Food, Nutrition and Human Health
Albany

Prof Richard Archer, HoI
Institute of Food, Nutrition and Human Health
Albany

Massey University Human Ethics Committee
Accredited by the Health Research Council

Research Ethics Office, Massey University, Private Bag 11222, Palmerston North 4442, New Zealand
T +64 6 350 5573 +64 6 350 5575 **F** +64 6 350 5622
E humanethics@massey.ac.nz animalethics@massey.ac.nz gtc@massey.ac.nz
www.massey.ac.nz

A 6.2 Focus Group Participant Recruitment Flyer

Hi there. My name is XXX and I'm currently studying for my Master degree in Food Technology at Massey University. I have been given a project to develop a healthy cereal-based extruded product that may be consumed as snack or breakfast cereals. If you are a regular consumer (at least once a month) of any of the below products, you are welcome to join my focus group study (pre-screening criteria applies).

Bluebirds Biguns Cheese
Bluebirds Grainwave
Bluebirds Twisties
Bluebirds Doritos
Bluebirds Cheezels
Bluebirds Rashuns
Bluebirds Burgerrings
ETA SKOF (any flavours)
ETA Good bites
Pams Burger hoops
Pams Cheesy Aliens
Pams Cheesy Twists
Healtheries Corn tubes
Healtheries Kidscare potato stix
Healtheries Kidscare rice wheels
Hula hoops
Pretzel Bows

When?
The study may take place on a weekday evening or during the weekend between 28th October 2011~19th November 2011 depends on the number of responses. I will try to arrange a time that suits everyone.

Where?
There are two options: Massey University Albany North Shore or Onehunga

Length of the study
The session will take approximately one hour.

What is involved in the study?
You will be presented some commercial products. We can taste them and have a relaxing chat around this topic. There is no right or wrong answer, everyone's opinion counts.

There will be a bag of goodies to thank you for your participation.

My contact details:
Name: XXX
Mobile: XXX
Email: XXX

A 6.3 Snack Focus Group Screening Questionnaire

NAME: _______________ **Contact Details: _______________**

S1 Which of the following product/products do you consume? (Please tick all that applies)

Snack Group
Bluebirds Biguns Cheese
Bluebirds Grainwave
Bluebirds Twisties
Bluebirds Doritos
Bluebirds Cheezels
Bluebirds Rashuns
Bluebirds Burgerrings
ETA SKOF (any flavours)
ETA Good bites
Pams Burger hoops
Pams Cheesy Aliens
Pams Cheesy Twists
Healtheries Corn tubes
Healtheries Kidscare potato stix
Healtheries Kidscare rice wheels
Hula hoops
Pretzel Bows
Other puffed snacks:____________(specify)

Yes	Continue
No	Terminate

S2 How often do you have it/them?

At least once a week	01
At least fortnightly	02
At least once per month	03
Less often	04

01, 02, 03	Continue
04	Terminate

S3 What is your gender?

Male	01
Female	02

S4 Could you please circle which of the following age groups you fall into?

Under 16 years	01
16 – 24 years	02
25 – 34 years	03
35 – 44 years	04
45 years and over	05

S5 Which of the ethnic group are you falling into? (You may choose to identify with more than one ethnic group)

Caucasian	01
Asian	02
Latin American	03
Maori	04
Pacific Islanders	05
African	06
Middle Eastern	07
Others	08

A 6.4 Focus Group Discussion Guide (Approximately 1 hrs)

1. **Introduction (Phase 1)** **+/- 3 min**

- Introduce and thank for attendance

Good evening & welcome. Many thanks for joining the discussion on extruded/puffed snack today. I have been given a project to develop extruded breakfast cereals. You're here today, because you consume extruded/puffed snacks regularly and I need your help to develop an ideal extruded product profile. This group discussion might last up to 1 hour.

- Explain confidentiality
- Record

As I cannot take notes fast enough during the discussion, I will record the whole session. Is this ok with everyone?

- Not looking for group consensus, no wrong or right answers. Everyone's option counts.

2. **Rapport (Phase 2)** **+/- 12 min**

Objective: gain insight into attitude and motivation towards extruded snacks

Warm-up question

- Firstly, if we could just start off by saying a little about ourselves (name, your favourite cereal based snack and when was the last time you had it). I'll start…
- Spontaneous reactions when think about puffed cereal based snacks? What are key associations, top of mind? At what occasion would you have snacks?
- Who in your family makes the purchase decision
- Why buy extruded snacks? Why not crackers or biscuit?

- When you are in a supermarket, what are your main criteria when choosing extruded/puffed snacks – what do you look for?
- Will you or will you not pay attention to product claims? What about NIP/ingredient list?
- Have you ever heard of ancient grains? What do you know about them?
- How would you rank the key criteria from last question (distribute sheet)?

Need: paper + pens

3. Competitor Analysis (Phase 3) +/- 25 min

Objective: Gain insight into what message, executions, claims etc attract consumers – explore perceptions, motivations and usage.

Now I am going to introduce some products that you can currently buy in the supermarkets

Firstly, look at these products
- Which products do you like and why?
- How are they different from other products?
- Which one would you buy? Why so? What made you try it? What does it offer? What is the benefit?
- To what extent is the offer attractive to you? What is it lacking? How to make it more attractive?

Moderator: understand motivations and reasons to buy

Need: product list + pens

4. Product Concepts (Phase 4) +/- 15 min

Objective: gain insight into appeal of the product texture and shapes. Any improvements that may be needed and possible new ideas for the product range

Please try the products in front of you and rate the acceptance against each attributes
- Discuss product issues
- Which product is best? Is there anything that may help enhance the way you feel about the products?

Need: product list + pens

5. Warm down and close: +/- 5 min

- Review concept and issues. Ask for clarification
- Last chance for suggestions.
- Close, thanks, distribute incentives, dismissal

A 6.5 Main Criteria for Extruded/puffed snacks

1.
2.
3.
4.
5.
6.
7.
8.
9.

A 6.6 Product Claims that are attractive/unattractive to you

Name: ________________________

1. 75% less fat than potato chips *(Please tick ONE box only)*

☐	☐	☐	☐	☐	☐	☐	☐	☐
Not attractive at all	Very unattractive	Moderately unattractive	Slightly unattractive	Neither / nor	Slightly attractive	Moderately attractive	Very attractive	Extremely attractive

2. Baked Not Fried *(Please tick ONE box only)*

☐	☐	☐	☐	☐	☐	☐	☐	☐
Not attractive at all	Very unattractive	Moderately unattractive	Slightly unattractive	Neither / nor	Slightly attractive	Moderately attractive	Very attractive	Extremely attractive

3. Made with Ancient Grains *(Please tick ONE box only)*

☐	☐	☐	☐	☐	☐	☐	☐	☐
Not attractive at all	Very unattractive	Moderately unattractive	Slightly unattractive	Neither / nor	Slightly attractive	Moderately attractive	Very attractive	Extremely attractive

4. No MSG *(Please tick ONE box only)*

☐	☐	☐	☐	☐	☐	☐	☐	☐
Not attractive at all	Very unattractive	Moderately unattractive	Slightly unattractive	Neither / nor	Slightly attractive	Moderately attractive	Very attractive	Extremely attractive

5. Gluten Free *(Please tick ONE box only)*

☐	☐	☐	☐	☐	☐	☐	☐	☐
Not attractive at all	Very unattractive	Moderately unattractive	Slightly unattractive	Neither / nor	Slightly attractive	Moderately attractive	Very attractive	Extremely attractive

6. No artificial colours or flavours *(Please tick ONE box only)*

☐	☐	☐	☐	☐	☐	☐	☐	☐
Not attractive at all	Very unattractive	Moderately unattractive	Slightly unattractive	Neither / nor	Slightly attractive	Moderately attractive	Very attractive	Extremely attractive

7. Source of wholegrain *(Please tick ONE box only)*

☐	☐	☐	☐	☐	☐	☐	☐	☐
Not attractive at all	Very unattractive	Moderately unattractive	Slightly unattractive	Neither / nor	Slightly attractive	Moderately attractive	Very attractive	Extremely attractive

8. High in fibre (≥ 3g/serve) *(Please tick ONE box only)*

☐	☐	☐	☐	☐	☐	☐	☐	☐
Not attractive at all	Very unattractive	Moderately unattractive	Slightly unattractive	Neither / nor	Slightly attractive	Moderately attractive	Very attractive	Extremely attractive

9. Low in saturated fat (no more than 1.5 g per 100g) *(Please tick ONE box only)*

☐	☐	☐	☐	☐	☐	☐	☐	☐
Not attractive at all	Very unattractive	Moderately unattractive	Slightly unattractive	Neither / nor	Slightly attractive	Moderately attractive	Very attractive	Extremely attractive

10. Low in sugar (no more than 5 g per 100 g) *(Please tick ONE box only)*

☐	☐	☐	☐	☐	☐	☐	☐	☐
Not attractive at all	Very unattractive	Moderately unattractive	Slightly unattractive	Neither / nor	Slightly attractive	Moderately attractive	Very attractive	Extremely attractive

11. Is there any other claim you PARTICULARLY LIKE/DISLIKE?

____

____

____

A 6.7 Competitor Product Analysis Form

EXTRUDED SNACK GROUP

Name: ____________________

Score 1: Not important at all	Score 1: Not Acceptable at all
Score 5: Neither/nor	Score 5: Neither/nor
Score 9: Extremely important	Score 9: Extremely acceptable

	Importance	**328**	**973**	**252**	**791**	**940**	**736**	**564**	**409**	**387**
Appearance										
Size										
Crispiness/Crunchiness										
Flavour										
Flavour strength										

A 6.8 Product Nutrition Information Panels

Serving Size 18g

Twisties		Quantity per Serving	Quntity per 100g
Energy		373kJ	2070kJ
Protein		1.2g	6.4g
Fat	Total	4.5g	25.0g
	Saturated	2.0g	11.0g
Carbohydrate		10.9g	60.7g
	Sugar	1.4g	8.0g
Dietary Fibre		NA	NA
Sodium		118mg	657mg

Serving Size 40g

Bluebird Biguns		Quantity per Serving	Quntity per 100g
Energy		915kJ	2290kJ
Protein		2.1g	5.2g
Fat	Total	13.1g	32.7g
	Saturated	5.8g	14.5g
Carbohydrate		22.8g	57.0g
	Sugar	2.4g	6.1g
Dietary Fibre		NA	NA
Sodium		229mg	572mg

Serving Size 18g

Burger Rings		Quantity per Serving	Quntity per 100g
Energy		402kJ	2230kJ
Protein		1.1g	6.1g
Fat	Total	5.8g	32.1g
	Saturated	2.6g	14.3g
Carbohydrate		10.1g	55.9g
	Sugar	0.6g	3.2g
Dietary Fibre		NA	NA
Sodium		180mg	1000mg

Serving Size 40g

Tomato Salsa (Givaudan QF13045)

694		Quantity per Serving	Quntity per 100g
Energy		624kJ	1560kJ
Protein		2.6g	6.6g
Fat	Total	2.3g	5.8g
	Saturated	0.4g	0.9g
Carbohydrate		28.2g	70.6g
	Sugar	1.9g	4.8g
Dietary Fibre		3.2g	7.9g
Sodium		263mg	658mg

Serving Size 18g

Rice Wheels		Quantity per Serving	Quntity per 100g
Energy		324kJ	1800kJ
Protein		1.6g	8.7g
Fat	Total	1.5g	8.5g
	Saturated	0.1g	0.6g
Carbohydrate		14.1g	78.3g
	Sugar	0.5g	2.8g
Dietary Fibre		0.2g	1.0g
Sodium		127mg	706mg

Serving Size 40g

Tomato Salsa (Givaudan QF13045)

119 (736)		Quantity per Serving	Quntity Per 100g
Energy		624kJ	1560kJ
Protein		2.6g	6.6g
Fat	Total	2.5g	6.2g
	Saturated	0.4g	0.9g
Carbohydrate		27.9g	69.7g
	Sugar	2.3g	5.7g
Dietary Fibre		3.5g	8.7g
Sodium		263mg	658mg

Serving Size 35g

SKOF Chicken		Quantity per Serving	Quntity per 100g
Energy		850kJ	2420kJ
Protein		1.5g	4.3g
Fat	Total	14.2g	40.7g
	Saturated	6.8g	19.5g
Carbohydrate		17.3g	49.4g
	Sugar	2.1g	5.9g
Dietary Fibre		NA	NA
Sodium		440mg	1270mg

Serving Size 40g

Tomato Salsa (Givaudan QF13045)

515		Quantity per Serving	Quntity per 100g
Energy		620kJ	1550kJ
Protein		2.6g	6.4g
Fat	Total	2.4g	6.1g
	Saturated	0.4g	1.0g
Carbohydrate		27.6g	69.1g
	Sugar	1.9g	4.7g
Dietary Fibre		3.7g	9.2g
Sodium		263mg	657mg

Serving Size 40g

GrainWaves S&C		Quantity per Serving	Quntity per 100g
Energy		812kJ	2030kJ
Protein		2.9g	7.1g
Fat	Total	9.1g	22.8g
	Saturated	1.8g	4.4g
Carbohydrate		25.1g	62.7g
	Sugar	2.9g	7.2g
Dietary Fibre		2.3g	5.8g
Sodium		225mg	563mg

Serving Size 40g

Cheese Flavour (IFF SC273864)

694		Quantity per Serving	Quntity per 100g
Energy		628kJ	1570kJ
Protein		2.6g	6.6g
Fat	Total	2.4g	6.0g
	Saturated	0.4g	1.0g
Carbohydrate		28.5g	71.1g
	Sugar	1.7g	4.4g
Dietary Fibre		3.1g	7.8g
Sodium		178mg	445mg

Serving Size 37g

Pams Aliens		Quantity per Serving	Quntity per 100g
Energy		881kJ	2380kJ
Protein		2.0g	5.5g
Fat	Total	14.3g	38.6g
	Saturated	6.7g	18.0g
Carbohydrate		18.6g	50.2g
	Sugar	2.3g	6.2g
Dietary Fibre		NA	NA
Sodium		407mg	1100mg

Serving Size 40g

Cheese Flavour (IFF SC273864)

119 (736)		Quantity per Serving	Quntity Per 100g
Energy		628kJ	1570kJ
Protein		2.6g	6.6g
Fat	Total	2.5g	6.3g
	Saturated	0.4g	1.0g
Carbohydrate		28.1g	70.3g
	Sugar	2.1g	5.2g
Dietary Fibre		3.4g	8.6g
Sodium		178mg	445mg

Serving Size 12g

Goodbites Cheddar		Quantity per Serving	Quntity per 100g
Energy		214kJ	1780kJ
Protein		<1g	7.8g
Fat	Total	1.0g	8.3g
	Saturated	<1g	1.6g
Carbohydrate		9.5g	79.1g
	Sugar	<1g	0.6g
Dietary Fibre		NA	NA
Sodium		65mg	530mg

Serving Size 40g

Cheese Flavour (IFF SC273864)

515		Quantity per Serving	Quntity per 100g
Energy		626kJ	1565kJ
Protein		2.6g	6.4g
Fat	Total	2.5g	6.3g
	Saturated	0.4g	1.1g
Carbohydrate		27.9g	69.7g
	Sugar	1.7g	4.2g
Dietary Fibre		3.6g	9.0g
Sodium		176mg	440mg

A 6.9 Product Prototype Assessment Form

Product Concept

Name: ______________________

Score 1: Not Acceptable at all
Score 5: Neither/nor
Score 9: Extremely acceptable

	694	**119**	**515**
Appearance			
Size			
Hardness			
Crispiness/crunchiness			

Overall, which sample do you prefer __________

A 6.10 Focus Group Transcript

A 6.10.1 Group 1 Transcript

Introduction

Moderator: Let's start with what's your name, what kind of snack you normally eat or your favourite snack and when was the last time you had it? For example, my name is Gracie, my favourite snack is Grainwaves and I had it last week.

Hi, my name is Participant 1. My favourite snack is chocolate, lollies, chips, twistis, Grainwaves, you name it, and I'll like it.

Hi, my name is Participant 2, my favourite snack is twisties and I think I had it last week.

My name is Participant 3. My favourite snack is chips and I had them last week.

Hi, my name is Participant 4, and my favourite snack is the Burger Ring and I have them occasionally.

Hi, I'm Participant 5 and my favourite will be SKOFs and I had them last week.

Hi, I'm Participant 6 and my favourite snacks are at the moment maybe ready salted slim chips, and I had them just before I came down here.

Hi, my name is Participant 7; my favourite will be Grainwaves as well, cause they've got different variety and I think I had them about 2 weeks ago.

Key social associations with extruded snacks

Moderator: Ok, that's great. So when we talk about snacks, what are the key associations on top of your mind? Just give you an example, when I talk about ice cream, something typically pop into my mind will be summer, or walk in front of the beach to have some enjoyable time. So, when we talk about your favourite snacks, what is your spontaneous reaction?

Participant 1: For me, I always had wine gum lollies, ever since I was young, very young. I used to go buy my own, cause it was only two cents back in the day, I never stopped eating Wine gums to this day. Of all the snacks I've eaten, that's my most favourite and I eat them daily.

Participant 2: I think it was Twisties. I started from my childhood, like you'll have it in your snack for lunch. It has been ongoing.

Participant 3: For me, I was chips. Going back it would only be on special occasions, parties. Yeah, sort like good time, yum.

Participant 4: Oh well, Burger ring. I just never thought a... salty sort of. I like the BBQ one. (It was) probably the best, the BBQ flavour, and I'm mad about that. So…

Participant 5: Yeah, I just like to grab a lot in front of the TV, on a couch of the.. Snacking away. That's kind of thing I think of. Yeah, when I'm being lazy and that's the thing to think about. More like casual, yeah, without even think about it really when you're watching TV.

Before you never hope your head goes up.

Participant 6: For me, it's a convenient treat. Basically that's what it is. If it's there and I can have it quickly, open the bag, yeah, and I'm happy.

Participant 7: I probably think about the snacks while watching a movie or something on TV, or maybe something between meals. Just something to do until dinner is ready.

Why prefer extruded snacks over biscuits and crackers?

Moderator: Then I come up with another question: why you prefer to buy this kind of snacks, for example Grainwaves or Burger Ring instead of buying biscuits or crackers, which can also fill up your hunger gap. Why you buy this not that?

Participant 1: For me, crackers are less attractive, cause it's plain to having, the others, which are flavoured.

Others: Yeah… crackers are boring.

Participant 6: The thing with biscuits, you have to make a cup of tea or something… For chips, you just rip the bag and there you go.

Participant 3: It's the savoury I think (others: yeah, savoury); and I think you can eat more savoury than you can for sweet (laughing).

Others: Oh yeah, that's true.

Participant 7: Look a pack of chips, it's light. It doesn't weight very much like a pack of biscuits, and senses healthier. It's a big pack, but it tends to get a lot of air in the packs too. So..

Participant 5: Some snack during the day, and I don't really wanna some sweet, just savoury.

Who makes the purchase decision and what are the key purchase criteria?

Moderator: So, do you, actually yourself go there or who else in your family makes the purchase decision?

Me definitely me

Me

And me

I do

Participant 5: My flatmate got me on the SKOF, and then I start eating it.

Participant 7: I probably buy Grainwaves myself and my mum would buy other types of chips

Moderator: Since most of you are the purchase decision makers, when you go to the supermarket, what are the main criteria you look for?

Participant 3: I really don't buy in the supermarket. When I tend to get them is when I shot petrol in the car. I'll grab a little packet. If I buy a big packet, then I'll eat the whole big packet. So, I just buy a little packet

Participant 5: The thing I'm looking for is the flavour I suppose. The flavours that I want.

Participant 3: If there is a party though, there is a plate of chips, I will sit there until the bowl is empty, or I have to physically move the bowl away from me.

Participant 2: Yeah, I have to stand somewhere else.

Participant 1: I would stand in front of the bowl.

Participant 3: If it's the cheese or cracker, or corn chips or… it's not a problem. It's the chips.

Participant 5: In the supermarkets, there are certain a few flavours that I like, and then I will see what is on special. I'll grab that one. Like a lot few different ones.
Participant 6: Especially there's a lot of people in my family, you can't just get one pack.
Participant 3: When my husband was still alive, I used to buy salt and vinegar, cause I hated them, so I won't have any chips (laughing)
Moderator: Can you please turn over the page. Since we have discussed a little bit, just for the normal extruded snacks, what's the main criteria including what we have talked before and what we haven't discussed about that will affect your purchase decision?
Participant 5: Are the numbers and the orders of importance?
Moderator: No, just anything in your mind. Once you've finished, we'll discuss a bit further on what you've noted on the sheet. What do you think that is important to you not someone else.

Questionnaire Part One

Moderator: Participant 7, would you like to start since you've finished.
Participant 7: Ok, I thought another one as well. First one I put down is something on special, also the flavour variety, cause I have to get the same flavour each time. The brand, cause I do like Grainwaves better than most of the other ones. The fact that see it on the shelf, cause sometimes it does remind me. Sometimes you buy for special occasions, like a birthday party, you gonna buy something. So, you're going to the supermarket on purpose to buy a bunch of packets. Sometimes, I think about whether I have time to eat it without getting the flavour all over my hands, but Burger Rings and Cheezels stuff, you've got that orange stuff all over my hands, so I can't eat it a week or anything. That's about all I had.
Moderator: Ok, if you have some points that are not already on the list, would you like to share with us?
Participant 5: Flavour strength, I'm not sure if he's already said that. If it's really strong, I'd be less likely to have it or I gonna buy small packet of it or something, I could never get a big pack, like the really strong cheesy ones kind of thing. I think that's what I'd buy. Something likes texture. I really like SKOF, which have different kind of texture. All of my friends would like watch a movie together. They'll go get some snacks. They'll get some that everyone would like kind of thing. I also like buy specials on flavours like Participant 7 as well.
Participant 1: I had something to do with brand names. I don't like cheap. If you get a brand that's really cheap, nasty, the flavour they got in it is quite disgusting. With bluebird or somebody like that top brand, the flavour is better. Cause I've tried both. I had big packet of chips, cause I only had a small packet, I wanna get it into my pie. When I got a cheap packet that was disgusting. I didn't like the brand, so it comes down also the brand definitely and name behind it. Bluebirds may be a good brand, so does ETA, but some really funny names that you don't really know of them, such as in Asian, not big names but Asian names on it. I don't know what it is. It's chips or something. Some of them are quite nasty.
Participant 3: I only buy really salted, I don't like flavoured chips. With Twisties and Cheezels, I like Twistis and Cheezels, but I don't like Burger Rings. It's got bacon flavour or whatever,

cause it doesn't taste real, more artificial flavour. I like the texture more, the crunchiness of them, like Kettle Fried I suppose, and also smaller packs so not tempted to eat big bags.
Participant 6: I put size down, cause sometimes size is important. New products, sometimes you look out for what's new, and what's requested by, usually I get a request, when I get out to the shop.
Moderator: When you talked about new products, what kind of new products you're look for. For this new product that you've never seen it before and never tried it before, what the things you're looking for and what will make you want to try it?
Participant 4: In fact, that's new.
Participant 6: Yeah, cause it's different.
Participant 5: You don't know what it's like, so give it go.
Participant 7: Packaging may be.
Participant 6: I thought something we had seen before. These Pam's one came out a couple of months ago, everyone just went crazy for them, because it was new and they tasted it. They were different from Twisties but it was like Twistis. Twist I think that was called, so that was something what we went for, but we have gone off them and just gone back to our really salted ones we like until we found something else.
Moderator: Some of you mentioned about packaging. What kind of packaging will attract your attention? What do you mean the packaging is quite important?
Participant 7: I think if it's gonna attract your attention, it's gonna be bright and colourful, may be shinny. That's metallic/ foil packaging.
Participant 1: Something to draw your eyes for, ah? Cause it's boring packaging, you won't go and read it. Not bored, looks nice.
Participant 7: Something you can recognise. Some of them are different brands and some of them look the same.
Participant 6: If they have a picture in the front and it looks good. The picture of them, like pieces of the chips that makes you wanna eat it.
Participant 7: So you know what it looks like
Participant 3: If you get the ones they sell at Nosh, and they're about $5 per packet. They've got a bag of potato on the front, so they will look more natural, better for you. They're very nice chips. But it has got that natural look, which makes you think these ones are better for you, cause they come from these potatos.
Participant 2: Have they got that 99% fat free as well?
Participant 3: No, it will be quite good.
Moderator: Does that mean you're looking for some natural message?
Participant 3: Yeah, I quite like the Kettle fried bag, cause it's got that sort of natural look of the bag. Some worms sort of stuff. So you…
Moderator: So, you look for pictures to judge the product? Will you or will you not look somewhere else to find out the information you're looking for?

Participant 3: Yes, then you look at the ingredient thing, this has got this much of fat than other ones. Then you know it's not what's on the bag.
Participant 1: It's not really good for you, but you still buy it.
Participant 3: Packaging can really foul your mind. It can make the decision for you. That's not necessarily the right one.

The impact of NIP and product claims
Moderator: Do you or do you not read the nutritional information panel.
Participant 3: I do, I do. Sometimes.
Participant 4: Yes, I'd like to compare how much sodium it's in them, any preservatives or MSG or whatever
Participant 1: I just eat them. I don't wanna know
Participant 3: I'm constantly trying to find the low fat chips that are good for you, but I haven't found it yet.
Participant 1: No, I haven't found them yet, so I do actually eat every one of them (laughing).
Participant 7: Yes, maybe look at it for the first time, for something new, but you're not bothered looking for it every time.
Participant 3: You could seriously make money by inventing low fat chips
Participant 5: I'll be more likely looking at the nutritional information on something that we had arranged things on something helping. I though all those snack foods are unhealthy, but I don't bother looking.
Moderator: Will you or will you not look at the product claims making in front of the packaging?
Participant 5: Things like fat free
Participant 3: Occasionally, sometime I do.
Participant 5: If it's on the front of the pack.
Participant 2: Yeah, I do read it.
Moderator: But will that affect your purchase decision?
Participant 6: No
Participant 3: Sometime it'll do.
Participant 2: Yeah.
Participant 5: If both ones are similar, but one is healthier, I'll get the healthier one.
Participant 7: Yeah. But taste must be good.
Participant 3: Unfortunately, fat improves the flavour.
Others: True
Participant 3: That's why cheeses don't cut the fat off until after they've been cooked.
Participant 7: You have to believe the claims though. Something is reliable.
Participant 3: Not by law these days you're allowed to put these things on. They used to do it, people got fine.
Participant 7: Yeah, you hope so.
Participant 4: I read them, but I don't really believe them.

Participant 7: Yeah, just be cautious.
Moderator: Now I gonna give you a list of claims, I put down 9 there. Some of them you may not have thought about. If you don't believe in it, then you can say it's not attracted to you, If you do believe it'll affect your decision, then you tick it's very attractive to you. Just your spontaneous reaction to it, you don't have to think too hard.

Product Claim Questionnaire.
Participant 3: When you say a source of wholegrain, does that mean whether it's corn or wheat or whatever?
Moderator: It means it was made from whole source, the whole food, for instance, according to FSANZ, people was suggested to eat 48 g of wholegrain per day. That's why we put down on the packaging says it's a source of wholegrain, which contributes to your wholegrain daily intake.
Participant 7: Like brown bread and white bread.
Moderator: Yeah, it's good for your heart.
Participant 2: What does MSG means?
Moderator: MSG is monosodium glutamate.
Participant 3: Historically, the Asian takeaways have high MSG, because it's…
Participant 4: Originally, it's in the tomatoes and mushrooms. Japan finds a way on how to make it artificially.
Moderator: it's a flavour enhancer; it makes you feel the food tastes nicer. However, some people believe it may give you side effects.
Participant 3: does it also maintain the colour?
Moderator: no
Participant 3: I thought it also maintains the colour
Moderator: Ok, let's say if you don't really understand the claim, which means you probably won't pay much attention to it. Then you can tick the box accordingly.
Participant 1: Yep, I probably will tick the middle, cause I don't really understand that one.

Competitor Analysis
Moderator: Now, let's go to the next stage. We will try some commercial products. Can you please turn to the second page which I have provided to you earlier. We have talked about the factors that will affect your purchase decision when you go to the supermarket, can you please write down the factors that we have discussed earlier. On the left column, we discussed flavour variety. We have talked about flavour strength, the brand, then we talked about the texture, I just want to clarify here. What kind of texture you are looking for?
Participant 3: I like crunchy myself
Others: yeah, crunchy
Participant 5: If you wanna buy a specific product, you want to have the texture you kind of expect, not soggy or stale or something, then you.

Moderator: in other word, hardiness or crispiness or crunchiness. Can we please split the column into two here, one is hardiness, another one is crispiness or crunchiness.

Participant 3: what do you mean by hardness?

Moderator: how hard the product it is, the opposite of sogginess.

Participant 5: if it's soggy, it's not gonna be crunchy. It's kind of overlapped.

Participant 2: They're not fresh, sometimes like Twist is…

Participant 5: Yeah, if the bag was left open, it's gonna absorb water or something.

Participant 3: then it's really crispness.

Moderator: ok, if the term hardiness is not easier to understand, let's forget about it. The next one is size; I don't know what do you mean by size?

Others: the size of the overall packet. Sometimes you've got large packet, sometime, you've got small packet.

Moderator: how about the product itself, do you think the size is important or not?

Others: no

Moderator: then we talked about looks natural; will that be part of the appearance, right?

Participant 3: or even natural flavour sort of.

Participant 5: the naturalness of the packaging when you look at it.

Moderator: then we also talked about product claims, can you put this down as well. And then nutrition information panel. That's probably about it, right? Is there anything else anybody wants to add in, the things we have discussed before.

Participant 3: the flavours. A lot of them don't taste natural, for me the naturalness of the flavour is important to me.

Moderator: ok, you can write it down, as long as you think it's important for you. So, now everyone has got the whole list, I'd like you to rate the importance of each factor to you to the left column. If you think it's not important to you at all, you rate 1. If you think neither/nor, then you rate 5. If you think it's very important to you, you rate 9. It's a 9 point scale. 1 is not important at all, 9 is very important to you. Can you please finish the rating for this task for now and then we'll try the commercial products.

Participant 5: so you don't wanna do anything about the front of the packaging?

Moderator: Because we don't have any packaging here, we can't really discuss about it at all. However, you can put it down, if you think it's very important to you. If you've thought anything else that is important to you, just talk it out loud to share with others.

Participant 3: another thing somebody mentioned earlier. I think it's sort of important cause you are out. It's the fact that you often tend to have cleaner things, like chips, or maybe SKOFS or Grainwaves, or something because you're not in somewhere that you can handily wash your hands. With Twisties or Cheezels, it got stuck in it.

Others: yeah, it's messy.

Participant 3: It could be a problem, so that can be important.

Moderator: yeah, just put it down. How can we describe it, the stickiness to your hands?

Participant 3: yeah, just say the messiness.

Moderator: ok, cool. The messiness.

Rating Factor importance.

Moderator: I've got some products in front of you. I've also printed out the NIP information, if you think it's important to you. If it's not important to you, then don't worry about it. Please try the products, then just score the acceptability to you between 1 to 9. 1 is not acceptable at all, 9 is very acceptable. 5 is neither/nor. Some of the factors may not apply.

Rating commercial products.

Participant 3: the 409 is high in fat, the highest one, which left the greasy mark on the paper.

Participant 1: but it's crunchy. It's always important it's not stale.

Moderator: what are you looking at on that piece of paper with NIP information?

Participant 3: basically, I'm mainly looking at the fat, generally.

Moderator: anybody else has anything to say?

Participant 1: Sorry I don't look at those. I've never looked at them in the shop. I just buy it, if it's look good. These ones look ugly, so I totally won't buy them.

Participant 4: Salt and fibre.

Participant 7: I usually compare two products and then decide. So, I don't know what does it mean by themselves.

Participant 3: the 328 for me tastes far better than the 409. The 409 is just full of fat.

Participant 1: It looks ugly anyway.

Moderator: it's from the pack, maybe it's just broken pieces you had. The product itself may be fragile. The whole piece may look different, you never know.

Moderator: If you have finished, can you please write down which one is your favourite. Just tick on the one you like is fine. Once you've done that, we can stop and talk about it. But it's not in a rush.

Participant 3: I actually quite like 252, cause I don't like strong flavours.

Moderator: If you have finished, can you please tell me why you chose this one as your favourite. Why it is better than others based on your point of view.

Participant 3: I put down 973, because the flavour is not too strong, not too unnatural flavour. It doesn't get stuck in your teeth.

Participant 7: I think the flavour is most important to me. I like strong flavours. I think it's probably different to you.

Moderator: So which one did you choose?

Participant 7: 791.I likes everything else and that one as well.

Participant 1: I've got a few favourites. 564, 940, 791 and 328. The least favourites are 252, and I don't like 409.

Participant 3: My least favourite were 736 and 387. Too strong flavours and yuck.

Moderator: Participant 7, do you have anything that you really hate?

Participant 7: One or two I really don't like, but I can't remember which ones. I think they are maybe 940 and 328.
Participant 4: 328 I quite like that , but flavour wasn't strong enough. It was quite crispy, I like the crispy. My least favourite one is probably 252 I suppose.
Moderator: why don't you like it?
Participant 1: That one got stuck in teeth too much.
Participant 4: I think it doesn't have enough flavour with it and it wasn't really crispy.
Participant 2: Honestly, it's not as crunch as it could be.
Participant 1: 252 is too bland, don't have enough flavour in it and it stuck in your teeth.
Participant 5: My favourite was 791. I really liked the flavour and it was crunchy. The flavour wasn't very strong. I don't really like strong ones. The least favourite one was 252. Texture was pretty horrible, like it's got moisture in the pack and it stick to your teeth it's kind of, not very crunchy it's kind of, it was soft and soggy it's kind of. 409 was way too strong for me as well, really cheesy,
Participant 1: Yeah, those two 409, 252.
Participant 3: I thought this flavour is too strong for me.
Participant 6: My favourite was 791. That was because it was really crunchy, like the flavour and that was the best thing for Tuesday, ah Participant 3? 252 was my least favourite. It was just boring.

Product Concepts
Moderator: Please drink some water before we start the last session. This is the product concepts, first, let's just talk about it. What do you think about the products and just by looking at it, what do you like or dislike about it?
Participant 1: Colour is nice.
Participant 2/Participant 6: Too small.
Others: yeah, too small.
Participant 3: you have to have a handful of like, like having nuts.
Participant 5: like having peanuts.
Participant 1: but the colour is nice.
Participant 5: yeah 515 is kind of goldenly.
Participant 7: look a bit dense. Not fluffy enough.
Participant 1: Look like the off cuts (scrag ends).
Moderator: what do you think about the shape of the products?
Participant 6: you need a bit bigger than that.
Participant 2: too small.
Participant 3: might be too small for young children. They might choke on that size.
Moderator: Now if I tell you the claims the product can make: 75% less fat than potato chips; baked not fried; no MSG; a source of wholegrain; high in fibre and low in sugar. I have nutrition information for the products here with me. Products are quite similar, if you think there's no

difference, then score there's no differences, if you think there're different, then score differently. Other than the factors on the list, can you please also add on flavour strength, messiness, stick to the teeth, which you've mentioned earlier. The product claims, which I have said to you earlier. Now everyone should have a list of 9. Can you please try the products and score accordingly. If you don't have the flavour, can you please ignore the flavour when you score other factors? Please don't let flavour overwrite your judgement for other things.

Participant 1: I don't like the flavour.

Moderator: If you don't like the favour, what flavours do you like.

Participant 1: Something like on Grainwaves.

Moderator: There are three flavours for Grainwaves, the original, Chilli and …

Participant 1: I like the original, or even some of the twisties flavours on that. But it's too small. Out of the all three, that will be the nicest one, but I still won't go out buy that. Even it's healthier, I still didn't like any of them really. But overall out of the 3, that's one I would go for, that number.

Participant 7: For snacks, you're not actually buying it for the healthiness.

Others: No.

Participant 7: you buy it for …

Participant 3: but the actually is that if that one is healthier, I'll buy that one.

Participant 1: and nice flavour, yep, then I would buy it.

Participant 5: just like the new Grainwaves come out. It's exactly the same as the others but it's healthier for you. Did you get it?

Participant 3: for me, the texture and everything was good except for me again it's too small. I would prefer like the plain salted one or maybe a cheesy flavour and 515 was the one stood out of them. But I wouldn't buy, if tasted them at a party, I think it was bad, I wouldn't go back to get anymore, so it would be really good, if people had all of those.

Participant 2: yeah, I'm pretty much the same. 119 was the one I liked, but the size is too small.

Participant 6: they're nice and crunchy, had a bit flavour but too small.

Participant 3: The thing is that in terms of kindi teachers, people often puts small bags of chips or twisties for their kids lunch, but they're not allowed to have chips and twisties, they have Ricewheels and rice crackers and popcorn. So, they're allowed to bring healthy things, but I don't think people like the flavour.

Participant 2: I don't like the size.

Participant 3: yeah, too small.

Moderator: so what kind of size you think will be ideal for this kind of product?

Participant 2: Twisties size?

Participant 3: or the Ricewheel size minimal.

Participant 7: maybe twice or three times bigger than it were. I quite like the taste and the crispiness. It looks a bit too healthy before I ate it.

Participant 3: it wasn't looking healthy or anything like that. It's just the size and…

Participant 1: I think it looks good, but it should be bigger. They're too small. They appear to be nice. Like the other one, the one I thought it was so ugly, don't like it anyway. It just put me off just by looking at it. The flavour is good making me want to eat them, but I want them bigger. I think they're too small.
Participant 2: you have to put 5 in your mouth to get the same results as you would with one. Maybe it's the math thing. Thinking I'm eating five compare to one…
Participant 3: and it's harder work.
Moderator: so other than the size and maybe it's not your favourite flavour, how about the texture?
Everyone: No, the texture was good.
Participant 7: very crunchy.
Participant 6: with other snack foods, we just use our fingers. With these, we have to use a spoon. If you go for a party, you can't go like that.
Participant 1: I thought it's stuck to the teeth too.
Participant 4: yes, a little bit.
Participant 2/Participant 6: yes, a bit more than the others.
Participant 3: I don't think it stuck to your teeth that much. Like the other thing, the Twist.
Moderator: please turn to the next page, if it's in your favourite flavour, how likely would you buy it? If will be great if you can write down what is your favourite flavour.
Participant 1: Flavour is alright, I would buy. But I wouldn't buy, because of the size.
Moderator: yeah, then you can just note it down.
Participant 7: I think you need healthy snacks to go with it, cause it looks too healthy. You need variety.
Participant 5: I think if you've seen in the supermarket as well. Next to other things we've tried. It looks dense, so small, look really small amount in a pack for the same weight, so you kind of feeling you've been ripped off. You get a big pack of chips, same weight as the little one. Quite dense.
Moderator: Thanks everyone for your contribution. That's the end of the focus group.

A 6.10.2 Group 2 Transcript

Introduction:

Moderator: Welcome to my focus group study. Today's topic is about puffed snake or extruded snack. You are here today because I believe you are regular puffed or extruded snack consumers. Regular means at least once a month. Because this is a commercially funded project, what we discussed today will remain confidential and please do not talk outside of this focus group. There is no right or wrong answer. Everyone's opinion counts. What I want to get out of this is what you truly think about the products; what the motivation is behind and your comments on my products.

Let's start with introducing ourselves. Just talk about our names, what snack you normally eat and when was last time you had it?

I will start first. My name is Moderator. I like bluebirds Grainwave and the last time I had it was yesterday.

My name is Participant 1. I am not allowed too many snacks anymore, because my wife put me on a diet, but I like Biguns. They are pretty cool and I sneak them whenever I can.

My name is Participant 2 and I love eating Doritos, especially the green pack. The last time I had some was a few days ago.

My name is Participant 3. I like Burge Rings and I had some today.

My name is Participant 4 and I don't have snacks. I get takeaway a lot.

My name is Participant 5. I don't have a favourite snack. I eat a variation of snack. The last snack I had was today, a pack of, I can't remember the brand is, but it was slim chip, desalted and it was very nice.

My name is Participant 6. I love Doritos, the salted ones. They are my favourite one. I had it three days ago.

I am Participant 7. I like eating Grainwaves. I had them just before I came here.

Key social associations with extruded snacks

Moderator: When we talk about snacks, especially the puffed snacks, things like the Twisties, Grainwaves, what is the spontaneous reaction when you talk about this kind of product, so what is on the top of your mind that associate with this kind of product? In other words, at what occasion you will have this kind of snack. I can give you an example. If you talk about Ice Cream, my spontaneous reaction will be in front of the beach in summer time theme. So when we talk about this kind of snack, what is your spontaneous reaction? Anybody can talk, doesn't matter.

Participant 1: sitting down and watching a cheap B great movie, really old Peggy's 70th movie.

Participant 7: Popcorn with a DVD

Everyone Oh~~~ yeah, yes, yes

Participant 2: Just eat it

Moderator: So it is a kind of relaxing theme.

Participant 5: If I need five minutes away from my kids. That's how I get the quiet out.

Moderator: you mean a convenient treat?

Participant 6: Yes it is.

Who makes the purchase decision and why prefer extruded snacks over biscuits and crackers?

Moderator: Anyone still have things to say? No? Ok! Who in your family makes purchase decision when you are buying this kind of product?

Everyone: Me

Moderator: Ok, so why you buy extruded snack? Why you don't go for, for example, crackers or biscuits instead? Why you have to have this kind of product.

Participant 7 and Participant 1: the taste

Participant 1: the taste you like.

Participant 7: Convenient as well. They are not crumbly. If you eat crackers, they are falling on the coach.

Participant 6: exactly

Participant 1: While the snack I can fill in my mouth. Just like I have a chocolate biscuit or shortbread or something. You wanna buy the chocolate one.

Participant 5: Sometimes for me if it's on special, I'll buy it. Or if it's a new brand, I will try it.

Moderator: So any new brand?

Participant 5: Yes any. If I don't like it, I will just pass on to the kids.

What are the key purchase criteria?

Moderator: If you are going to supermarket, because you are all buyers, you are looking at the products on the shelves, what the criteria you are looking for before you are buying this product?

Participant 2: Price

Participant 7: yeah

Participant 2: it depends. Sometimes, the higher the price, the better, depends on what it is.

Moderate: but what you are looking for, what is your expectation and what are the key criteria you looking for. What drives you to buy this product?

Participant 2: like what is the better brand? Sometimes home brand might be better taste.

Participant 1: I tend not to go for something new. I tend to go for something I recognise. I like familiarity. If I know something a lot, I will go for that rather than trying something new. And for the week, if it is a treat, I will buy extra something rather than not trying to eat so many things. I need to justify it to myself this. If I am good enough for that treat.

Participant 3: I tend to decide whether I'm hungry for it at that moment. Do I want to eat that at that moment, otherwise, I can walk pass it. If my stomach says I really need it, I will go and buy it.

Participant 5: yes, depends on how you feel at the time.

Participant 3: agrees

The impact of NIP and product claims

Moderator: Will you pay attention to the product claims in front of the pack? Or you don't think it is important at all.

Participant 7: do a little bit, not excessively.

Participant 1: for me it is the familiarity and I don't believe a lot of the words. It only means it taste worst or not true anyway. You read the label, just got the same stuff in it.

Participant 5: yep, and I like look at the flavour as well.

Participant 6: yes

Moderator: what kind of flavour do you like?

Participant 7: it tastes like what they say.

Participant 5: yeah and the texture

Participant 5: it depends on how I feel at that moment, do I feel like something salty or sweet.

Moderate: Would you or would you not look at the nutritional information panel?

Participant 5: for snacks, no

Everyone: No

Moderate: Yeah ok, how about ingredient list

Participant 1: No. It is only making up the numbers anyway.

Moderator: Assuming there is a new snack product, it claims to be healthier than other products. Will you consider buying it?

Participant 6: Yeah.

Participant 5: Sometimes, I will probably consider buying it and try it. If it tastes crap, I won't buy it again.

Moderator: so you will try.

Ladies: yeah

Participant 7: You will try but the taste is important. If you can try it before, like those tasting things, here you go.

Moderator: When you are talking about taste, does it purely mean flavour or mean some other components as well?

Participant 6: like how crunchy the chip is

Moderator: you mean texture?

Participant 6: Yes.

Participant 7: you don't wanna soggy chips.

Participant 1: there are too many flavours. Some of them only have half of the taste or they taste chemically. I know there are a lot of artificial flavours, but a lot of them have artificial taste straight away. When they say bacon flavour, you can tell it is not bacon. It's shit.

Others: yep, that's right

Previous knowledge about ancient grain and attitude towards it

Moderator: Have you guys ever heard about ancient grains?

Everyone: ancient grains? No.

Moderator: so you have never heard anything about it. If people say ancient grains are better for your

, would you consider trying it?

Participant 1: unless you know what it is?

Moderator: Ancient grain is from South America. Why it is called ancient grain is because people use it in old days. They cultivated this kind of grain centuries ago. They have been replaced by other grains nowadays. But people believe it has better nutrition, has better protein level and amino acids.

Participant 7: it comes back to price

Participant 6: price is important.

Moderator: now if you can turn over the paper, based on what we discussed about before and what is in your mind, please write down you the criteria for this kind of puffed snack you are looking for. The order doesn't matter, just anything you can think of. Then we can discuss about it later.

Fill Out Questionnaire

Moderator: For those who have finished, can you please speak out and share with us your opinions on their list.

Participant 6: I put Price, the taste, the flavour, the texture and the Packaging

Participant 4: I got Price, Taste and how it looks.

Moderator: "How it looks" is the packaging or product itself?

Participant 4: Product

Participant 5: I got all the others, and size. So depends on it's a big pack or small one

Moderator: so you mean the packaging size not the product size?

Participant 5: what do you mean?

Participant 1: big pack or little pack

Moderator: only the packaging size?

Participant 5: yes

Moderator: Is there anything else to add, anybody?

Participant 1: I put not too greasy. I tried something some SKOF a while ago, they were really greasy. They're not very nice. I don't think. Freshness when I open the packet. Fresh not when it is put on the shelf for 10 years.

Moderator: Freshness means appearance wise or the smell

Participant 1: yes both, the smell and the initial taste. Also I put familiarity, which is packaging.

Participant 7: I put crunch and crumbly, you don't like something integrate, like a power

Moderate: The greasy means stick to your hand, which it is really massy to eat, or something you put into your mouth, you feel really greasy.

Participant 5: the taste is it? Yeah, put it to your hand, feel greasy. Obviously you gonna feel really greasy when you put in your mouth.

Participant 1: bit of both. When you pick it up, it is really oily; obviously you will feel the same when you put it in your month, I don't like them at all.

Moderator: Before I give you some commercial products to try, we gonna look at some product claims. I know some of you don't really pay attention to product claims. I have a list of 10 claims. Please have a look at it and determine whether the claim will drive you to purchase the product or you are not bothered at all. It's a 9 point scale. 1 is not attractive at all, 9 means extremely attractive to you.

Fill out Questionnaire

Competitor Analysis

Moderator: if you have finished, please put the questionnaire aside and look and the products in front of you. Firstly, I'd like you to give me some comments on by looking at them, which product you like and why you like it.

Participant 1: you can't see it.

Moderator: Just by looking at it, which one is attractive to you and why. Anyone can start.

Participant 6: I like that one

Participant 1: I'm kind of looking at the Biguns, too. They look big and puffy, filling.

Participant 7: Good colour, crunchy, filling

Moderator: Participant 5, which one you like

Participant 5: I was pointing to the 328

Moderator: so you like the size

Participant 5: yes the size and colour

Moderator: Anyone else to add? Everyone likes the same on?

Participant 4: same one.

Participant 3: I go for the Burger Ring, because it is hard. It's gonna get soft when you eat it up. More softer than a burger

Moderate: Is it because of the appearance or because you know the product?

Participant 3: Yes I know

Participant 7: 387 is the Burger Rings.

Participant 2: same 387

Moderate: will you pay attention to the product shape at all? Or will you not

Participant 7: I like the size of it straight away draws your attention to these things. It is bigger than any others. And the colour

Participant 5: a bit brighter and big.

Moderator: I put the product NIP information here, if you'd like to have a look. If you don't bother, then just ignore it.

Moderate: Please turn to the page, based on what we discussed before; I have already put something there. We talked about appearance, size of the product, Crispiness, texture. We talked about flavour and flavour strength. Since we don't know about the price, we can't talk about it. Please put price down, also greasiness hand and greasiness mouth feel, and freshness, Is there anything else we talked about? Yes, the packaging size, the size of the packet. Is there anything else anyone wants to add? When we talk about the flavour, is there a particular flavour you like or a range of flavour you like.

Participant 1: I don't like the flavour to be too strong. The Burger Ring is too strong.

Participant 7: like what Participant 5 said, depends on what feel like while you are in the shop.

Moderate: so it is a range of flavour. You feel like different things at different time. So can you please put down the flavour variety and also the brand, it means the familiarness to the product.

The first thing I'd like you to do as explained on the sheet, the importance of each factor. If you can rate on a 9 point scale, score 1 is not important at all and the score 9 means extremely important, score 5 is neither nor. Please score all the attributes which were written down. You may score two attributes the same, as long as you score between 1 to 9.

Score attributes.

Moderate: If you finish the column, please help yourself and try these products. I'd like you to score the attributes against each product. Obviously, you can't talk about the packaging, please ignore that. I believe you can score the appearance, size, crispiness, flavour, flavour strength, and of course, you can't do the price, but you can do the greasiness on both hand and mouth, and you can do the freshness, you can't do the packaging size. You also can't do the flavour variety and brand. So, there will be 8 attributes and ignore the rest. This time is to score the acceptability. This is only to you not anybody else. If you want to use the nutritional information, it is in front of you. If you don't want to use it, you don't need to.

Tasting Commercial Products

Moderator: if you have finished scoring, can you please tick which one is your favourite. You can tick on top or at the bottom, it doesn't matter.

Moderator: if you have finished, can you please speak out which one is favourite and why it is your favourite. Anyone may start.

Participant 1: Did anyone look at the nutrition chart?

Moderator: yes. I looked at it, but didn't love it

Participant 1: I haven't looked at mine at all

Participant 7: No me neither

Moderator: For the one like the most, give a tick. For the one you hate the most, give a cross.

Participant 6: My favourite one is still the original one I picked – 328. The one I didn't like was 252 because of the taste and colour. Not too much about the size, but the taste is bland.

Participant 7: 252's taste is bland. The flavour disappeared very quickly. A little hidden taste, all of the sudden, it is gone. Not fresh.

Participant 6: sort of taste stale, ah?

Participant 1: I don't like the 736. It tastes stale. And the after taste is not good.

Participant 7: After taste was like the little rice cake one.

Participant 4: I like Grainwaves and it's my favourite one too. I gave 9 for everything.

Participant 4: I don't like 252

Moderator: when you taste it, it's bland, but when you look at the nutritional information, will you assume it a bit healthier than other products?

Participant 4: but I'll still be after taste.

Participant 1: I like bland food normally, but when you want snack you want something full of flavour.

Most of the people: agree

Participant 7: I don't like 940, didn't appeal to me
Participant 2: I like 940 for some reason. I'm used to Honey puffs

Product Concepts

Moderator: Now we will be talking about the product concepts. I'll still provide the product nutritional information even though you may not look at it.
Moderator: I'd like to introduce the product to you. It's only at the concept stage, not yet commercialised. Firstly, it's a very healthy snack, what I can claim for this product are 70% less fat than potato chips, baked not fried, so if you look at the nutritional information. You'll notice the fat level of this product is a lot lower. It's made with ancient grains, contain no MSG. It's also got no artificial colours and flavours. It's source of wholegrain, does everyone understand what wholegrain is? If you don't understand, please speak out.
Everyone understands.
Moderator: It's also high in fibre, low in saturated fat and low in sugar. The flavour may not be your favourite colour at all. So in your scoring sheet, please ignore the flavour, purely score on the appearance, on the size and texture is split into two. For hardness, I mean hard is when you bite on Grainwaves, it's really hard, but when you bite on Twisties, it's much softer. And the crunchiness is something very crispy when you use your incisors to bite it. It's different from hardness. Hardness is more about use your molar teeth. As explained on the sheet, 1 means not acceptable at all and 9 mean extremely acceptable. Now can you please try and score them. Also at the bottom of the attributes, please write down the product claims. All the product claims are the same. I also want to know if the product is very attractive or not attractive at all.

Tasting the products

Moderator: if you have finished, please speak out your comments, just anything you wanna say about it.
Participant 6: are they all the same?
Moderate: it depends on your personal taste. If you think they are the same, just score the same. If you think they're different, then just score differently.
Participant 7: For me 515 was more crunchy, other ones were softer.
Participant 5: I didn't like the 694.
Participant 7: No I didn't
Participant 5: it either hit my palate or taste like …
Moderator: is it because of the flavour part or something else?
Participant 5: yeah, it's the flavour. Actually I scored these all three really low.
Moderator: Just because of the flavour, it affects everything?
Participant 5: yeah, if I don't like the flavour I don't like it at all, regardless of the size or whatever.
Participant 1: The size is important. If you want snack, you want something you can grab. These products have odd size.

Moderator: what if the size can be three or four times bigger, for example, half of the size of the Grainwaves. What do you think about the product?
Participant 1: not with that flavour.
Moderate: What kind of flavour you would like?
Participant 7: I think it is personal preference in flavour. In fact, most of us are used to the commercial one, like corn chips where these ones have got flavour of their own, because you are used to it, you are going to buy it. You buy something you know and you like and you are going back to it. But these ones you don't know, you don't like straight away. Unless somebody else bought them, you won't go for them.
Participant 1: I like those new Eta. I try to think the name of it. They like chip, the new Eta chips. But they are not made of potato or something.
Participant 3: they're like summer chips, sort of ah?
Participant 1: yeah, they are very nice, they are quite bland but I can't stop eating them for some reason. They have got a strong after taste as well.
Moderate: What kind of the after taste you got?
Participant 1: Taste like the other ones you've got. Like strange chilly or something
Participant 5: I think the size as well. I won't give it to my one-year-old. He may get chocked.
Participant 1: I haven't thought about that. They can swallow that straight down.
Participant 3: if they are at a party, you won't go for it. You will go for bigger crackers.
Moderator: The size can be upgraded easily. Regardless of the flavour, and the size upgrade to the ideal size, what other things you want to improve for this product? For example, what do you think about the product texture?
Participant 1: I quite like the crunch and texture of them. 515 is a bit soft, but other ones quite crunchy.
Participant 7: I prefer 515 to the other two.
Participant 5: 515
Moderate: Did you write down which one you prefer? What kind of flavour you think would be good to go with this kind of product.
Participant 7: if you had it when you are little, it won't matter too much.
Participant 3: taste old.
Moderate: What about the product claims?
Everyone: No
Moderator: I mean if you haven't tried, you see it on the supermarket shelves with the claims. Would you consider giving it a try? Change the flavour and change the size.
Participant 5: yeah
Participant 1: fat less. Something like that.
Participant 7: If it came to the market with the right price, yes probably will try it.
Participant 1: with the trendy things like ancient grains, Trendy, that's something really different. So, yeah probably.

Participant 7: I think the more you eat, the more you are used to it. You probably would, coz it new.
Participant 5: I am happy to eat it with a nice dip.
Moderator: The size won't be a factor. It can be scaled up easily. The flavour can be combined with others. I ask you about the base, what other factors can be improved to this product.
Participant 1: I don't know how it will go bigger, when it's small bite. But it's alright.
Moderator: thank you very much! That's the end of the focus group.

A 6.10.3 Group 3 Transcript

Introduction

Moderator: Thanks for participating my focus group. You are here today because I believe all of you are regular extruded snack consumers. This is a commercially founded project, so everything we discuss today will totally remain confidential. What we are going to do today is firstly I'd like to understand the motivation as to why you want to buy extruded or puffed snacks. Later on, we will try some commercial products and I'd get your feedback on these products: what you like and what your dislike, and finally, I will present the product concepts I developed. Again, I'd like you to try and provide me feedback as to what you like and what you dislike, so that I can make improvement later on. The whole session will probably last for an hour. If you don't understand anything during the session, please feel free to ask. Everyone's opinion counts, there's no right or wrong answer. Please just talk as much as you can and actively participate the discussion.
Ok, let's start with talking a little bit about ourselves. Your name, what is your favourite puffed or extruded snack and when was the last time you had it. For example, my name is Moderator. My favourite snack is Grainwaves and the last time I had it was probably yesterday.
My name is Participant 1, and I'm the electricians by trade, my favourite snack is the Cheezels.
My name is Participant 2 and I think I eat Cheezels as well. I had them last week.
My name is Participant 3 and my favourite is Pringles.
Participant 4 and I think my favourite is Rashuns. It would be a couple of weeks ago
My name is Participant 5 and I had yesterday the Bluebird a few things.

Key social associations with extruded snacks

Moderator: When we talk about the snack, what is your spontaneous reaction associate with this kind of food? In what kind of typical occasion will you have it?
Participant 1: When I'm peckish, but not hungry enough for a big meal and when you're having a drink and you know just general, leisures times more than whatever
Participant 2: Social, social occasions maybe, like watching a movie and hang over?
Participant 1: That's another occasion, aren't they?
Participant 4: Some sort of afternoon. Something you stay with. I think the social time what you have it for. Like more recently, we've got the whole pack for Hallowing for the kid's thing. You just eat them all.

Participant 5: I finish a whole pack in front of TV
Participant 3: For studying
Participant 4: You know food disappears while you are studying. If you have it in the cupboard, it goes.

Who makes the purchase decision and what are the key purchase criteria?
Moderator: Who in your family will make the purchase decision?
Participant 6 and Participant 7 come in
Participant 7: My dad
I do
Me
Participant 1: It usually go with who is shopping.
Moderator: When you are in the supermarket, what kind of criteria you're looking at for this kind of snack?
Participant 3: Price
Participant 2: I pick for taste.
Participant 4: Yep, previous experience. I know the ones I like
Participant 7: Nutritional value. The one is good for you or not.
Participant 4: After I've eaten it, I check it out (laughing).
Participant 5: I do look at the shape.
Participant 1: When it comes to snacks, you just buy them because you feel like it and recognise it and that's your favourite. You won't actually look at the nutritional values, because you've already known.
Participant 4: If you're good person, you will.
Participant 1: I don't think so because you know snack is more a repetitive thing. You had some before, so you go to what you like and what you preference is.
Participant 6: Yep, I always choose Grainwaves. Personally, I think it's healthier than others. They're just cheese.
Participant 1: What I'm saying is every time when you go to the supermarket or to buy those snacks, you don't actually go and check the nutritional values of it, because you've already known that's your favourite, because of the flavour and because it's the best out of the lot.
Participant 6: Yep, if you see a new product, what I do read the nutrition thing. If it's better than my favourite, I will try, if it looks better.
Participant 3: I also look the different flavours that could be novel kind of flavour.
Moderator: So do you mean the variety of flavours?
Participant 3: Yep.
Participant 4: so you will try sometime new?
Participant 3: Yep.
Participant 2: I think of the packaging as well.
Participant 6: Yep

Participant 4: you are advertiser's dream
Participant 2: If it's on special, something in… it's rugby world cup
Participant 4: yep, if you say special packaging for special occasion. That will catch my attention. I'll admit to that.
Participant 6: Yep, I agree
Moderator: Other than that, what kind of packaging you will really like?
Participant 3: Bright colours
Participant 3: Not like the homebrand stuff. Like the real different one.
Participant 7: Homebrand is really cheap though.
Others: Yep, cheap
Participant 4: Exactly.
Participant 7: we will pay attention to ads like if it is in ads.
Moderator: You will pay attention to ads
Participant 7: Yep

Why prefer extruded snacks over other healthier options?
Moderator: Why you will choose the extruded snacks. Have you ever thought about some healthier options or not?
Participant 4: No
Participant 2: Yep
Participant 3: Yes
Participant 1: Like a carrot or something like that. Oh, that's what I do, I sometimes I have to make up my mind between either a little pack of snacks or carrots because to me the carrot, unlike the taste of carrot, it's the crispiness and of course, it's healthier.
Participant 8 comes in
Participant 3: Pop corn
Participant 7: Yep, pop corn, actually it's better for you.
Participant 4: Like a pack of chips or something, but makes it better for you.
Participant 2: I think Healtheries kind of stuff
Yep, healthy alternative.
Home made not fried.
Participant 2: At the Innovation show, they have vegetable extruded snacks. Is that yours?
Moderator: No
Participant 6: I often think, chips are like a treat. For me it is. When I have a treat, why I have carrots or vegetables?
Participant 4: Yep, I agree that.
Participant 2: If I'm going to have chips, I'm not gonna go ahead with healthy somehow.
Participant 6: Yep, otherwise I won't feel happy. Yes, it's no point to have chips.
Participant 7: For normal people, chips there, they have chips even they are high in.
Participant 4: For me, chips are the potatoes. Potatoes are good for you.

Participant 7: you don't have to fry the chips.
Participant 4: No, it gonna be fried.
Moderator: If you just want to fill up your hunger gaps, why you buy extruded snack? Have you ever thought buying biscuit or rice crackers?
Participant 2: Cheese goes with rice crackers.
Participant 7: You buy it for the kids. Chips, kids just like it.
Participant 4: And also it's just the taste.
Participant 1: I think it comes down to the taste. Most of the snacks are very salty, very artificially enhanced sort of flavours, and unfortunately I think I agree we getting a little bit addicted to it.
Participant 4: The whole thing I find it when we went to a small packet. You open one, you finish that. You don't want it. You can't stop.
Participant 7: yep, it's something we'll addict to it.
Participant 3: Pringles
Participant 2: Pringles are yum.
Participant 4: I think I pick up a food colour 550. It gives the product bright orange colour.
Participant 6: Yep, if my baby, he is just 3 year old. I always buy the small packet for him. Once he opens one, he will finish it and ask mum, can I have another one? Yep, it's just really you can't stop it
Participant 1: Yep, it's addictive.

The impact of NIP and product claims

Moderator: Will you or will you not pay attention to the product claims in front of the packaging?
Participant 3: Yep, I do
Participant 2: I do
Participant 5: I do, that draws my attentions a lot. For example, like the Grainwave, it's 1/3 of grain I have, so I go for it.
Moderator: So now, can you please turn over the page in front of you. We have discussed a lot. Now, I'd like you to write down what're the main criteria for you to purchase extruded snacks. Just something top of your mind. You don't have to fill out the page, if you only have one, just write one, If you have two or three, just write down 2 or 3. Can be something we have discussed that's true for you or something we haven't mentioned about and you'd like to note it down.
Participant 4: Is that why we buy our favourite or something you buy for the first time.
Moderator: why you want to buy it for the first time.
Participant 1: Is it buy or eat?
Moderator: Can be both.

Part one questionnaire

Moderator: If you have finished, you can read out your points. Anyone can start.

Discussion around key purchase criteria

Participant 3: Taste, texture, shape and volume and reputable brand.

Moderator: anyone will like to add on top of that? Sometime, she hasn't mentioned about.

Participant 7: What is in the advertisement, you probably want to try it.

Participant 4: You buy it for special occasions, for a party or something. Is that what we talk about?

Moderator: Participant 3 already talked about taste, texture, shape and volume, how big the pack is. Is that what you mean?

Participant 3: No, the individual product size.

Participant 5: Price

Participant 5: I like have snacks during the day, so the portable packaging is good.

Moderator: anything else?

Participant 8: Colour should be nice.

Moderator: What do you mean by colour?

Participant 8: The colour of the food, like colour in the Twisties or something, not dark

Participant 7: Probably the shape of the snack.

Moderator: ok, Participant 3 mentioned about texture, what kind of texture you are looking for?

Participant 2: crunchy?

Participant 3: no, crispy more than crunchy.

Participant 4: It's nothing worse than like you open a pack of Twisties or something, it will go soggy.

Others: yep

Participant 1: yep, you buy a big pack of something, close it up half way through the eating, it will go slightly towards that…

Participant 4: yep, disgusting, if it gets soggy.

Participant 3/Participant 2: It will be chewy.

Previous knowledge about ancient grain and attitude towards it

Moderator: Previously we talked about product claims. Have you ever heard about ancient grains? Can you put up your hand if you understand what ancient grain is?

Moderator: Oh, none of you. Ok, then how many of you have heard about ancient grains.

Moderator: Only 4 of you. What do you think about ancient grains?

Participant 1: From Egypt?

Participant 7: Grains, good grains?

Participant 2: Bread

Participant 3: I think of farm land.

Participant 7: I think about Grainwaves.

Moderator: Any pictures on top of your mind?

Participant 2: Bread

Participant 1: Ancient butterflies.

Participant 7: Flours, or fly
Participant 1: Oats?
Participant 5: Corn?
Moderator: Oat is, corn isn't. Ancient grains are a group of grains which were commonly consumed in old days, typically can be found in South America. These days being replaced by more common grains like rice, wheat and corn. In recent year, scientists have found that these grains have higher nutritional values comparing to normal grains, typically higher in protein and they have more essential amino acids. Therefore, some people reckon food contain ancient grains is healthier.
Participant 7: Can people be allergic to amino acids?
Moderator: No, if you're allergic to wheat, you may be also allergic to spelt (one of the ancient grains), which belongs to wheat species, but you may not allergic to amaranth or chia. It's different.
Moderator: Ok, if you still don't really understand, please don't worry. I have now a list of 10 claims, if you don't understand it or don't have any association with it, just tick it's not attractive at all. It's a 9 point scale. If you understand the claim well and you think it's going to affect your purchase decision, then tick it's very attractive to you. If you think this claim doesn't matter to you, then tick neither/nor.

Part Two: Product Claim Form
Participant 7: What is MSG?
Moderator: It's monosodium glutaminate. If you don't really understand, then just tick it's not attractive at all.

Competitor Analysis
Moderator: If you have finished, just take a look of the products in front of you. Before you go ahead to try them, I'd like you to tell me what you think the appearance of the products. What you like and dislike about them?
Participant 3: Cute
Participant 2: Yep, cute.
Moderator: Ok, which one do you like?
Participant 4: Only the orange ones.
Participant 7: Yep, the orange one
Participant 4: What's this one?
Participant 5: SKOFs
Participant 4: They look really cool. That's what I mean, colour 550. They're very attractive.
Participant 2: Yes, they're tasty but not very good.
Participant 4: I find that colour very…
Participant 2: I think the colours aren't very nice.
Participant 7: I found that orange stuff has different shape

Participant 8: I like the Grainwaves, they look really cool.
Participant 3/Participant 2: I find them actually quite ugly.
Participant 4: I don't.
Participant 8: Normally they look perfect in light waves, but it doesn't get it right…
Participant 2: Does anybody think it's quite dull?
Participant 3: It never looks quite
Participant 8: But it looks much healthier.
Participant 4: Yes, definitely right, I agree with you. It's something about the colour you shouldn't be eating, if that's in your food. Yeah.
Participant 8: Have they all got the same colour?
Participant 4: Honestly, I don't know.
Moderator: May I get some clarification. You like this one is because of the colour?
Participant 2: It can't agree more.
Participant 4: With this I find them tempting.
Participant 3: Make them look tasty.
Participant 4: The light one made them pretty extreme.
Participant 6: The light colour one does have a good shape, the colour is too boring.
Participant 1: Does it associate with the colours that we are attracted to, was related to food greater than yellow, apparently. The orange is sort of combination of.
Participant 4: Pretty much all the orange ones I've tried before, and I know I like the Twisties. I know I like Rashun, I like Cheezel.
Moderator: Other than the colour, anything else you'll pay attention to.
Participant 5: I like the big ones. I don't like the small ones.
Participant 8: These ones just like the deep fried.
Others: Yeah.
Yep, that's what I was thinking.
Participant 4: Grab this little one, they look too hard.
Participant 1: They're a bit tiny.
Participant 2: They're cute. I think they're female.
Participant 4: I think I'd rather grab a pack of chip, I haven't tried them
Participant 6: It's kind of like eating pills
Moderator: Now, please turn to the second page, everyone please write down price, smell, then you talked about the variety of flavour, you also talked about packaging, appearance, size means the individual size, nutritional value, product claims.
What is product claims?
Moderator: They are typically made in front of the packaging
Moderator: Can you please rate on 9 point scale. 1 is not important to you at all and 9 is very important to you on the next column
Participant 5: But we don't have the packaging

Moderator: Not product specific, that just means in general. Rate on each attributes. This means the importance of each attributes to you not someone else.
Participant 7: What is flavour strength?
Moderator: How strong the flavour is to you. You may think it's too mild or too strong.

Score attributes.
Moderator: If you have finished, please try these products in front of you and score against these attributes. But you don't have to worry about price, flavour variety and product packaging. Nutritional value is here in front of you. If you think it's important, then have a look. If don't care, then don't worry about it. Just score the attributes that have some meanings. If you don't have anything to say, then you don't have to score it. It's also on 9 point scale, 1 is not acceptable at all and 9 is very acceptable.

Tasting Commercial Products
Moderator: I saw some of you have wiped your hands a lot, do you or do you not think this will affect your likeness on the products.
Participant 1/Participant 8: shouldn't weighing
Participant 4: Can be annoying, Main reason I don't wanna contaminate the trying stuff, but can be annoying. That's one of the problems the orange ones I like.
Participant 3: I can't currently smell.
Moderator: Don't worry. If you have finished, please tick the one you like the most and give a cross on the ones you don't like.
Participant 4: Tick all the ones I like or the one I like the best.
Moderator: Maybe tick one you like the most, then give another tick and write 2 beside the tick to indicate that's your second preference.
Moderator: If you have finished, can you please tell us which ones do you like and what're the reasons you like it; which ones you dislike the most and what're the reasons you dislike about it. Anyone can start.
Participant 3: I like 328 the most, cause it has nice appearance, good size, I really like the texture and the flavour was good. You know the Burger Rings for proactive, I think it likes the Burger Rings. I don't like 252, had participant 5rd texture and it looks ugly and the flavour kind of gross. They look really small compare with the other ones.
Participant 1: Not much going for it.
Participant 2: I like 409 the best, really good flavour and texture. I don't 940 the most, cause I don't like the texture.
Moderator: Is it just because of the texture, you don't like it?
Participant 2: Sort of flavour first then the popped...
Participant 4: but I think texture can ruin the food completely.
Participant 2: Definitely.
Moderator: what do you think is more important, the flavour or the texture.

Participant 2: I think on chips is the texture, cause you don't get that crunch, it's not like the chips product.
Participant 8: I dislike 736 the most. Umm, the little one, the little pill. The smells, it tastes a little bit rancid.
Participant 2: I think it tastes just right.
Participant 8: Oh no, gross. Sorry.
Participant 5: Yep, me too. It tastes the worst to me. It tastes bland and kind like stick to my teeth. The texture is too crunchy.
Participant 8: Kind of like eating teeth.
Participant 6: I like 328 the most because of the taste. The crunchiness when you bite it, it feels really good, and I like when you bite it, the sounds just make me feel, I don't know how to say it.
Participant 6: Yep. I don't like 252, not at all. It sticks to the teeth and it has no taste.
Participant 4: I found my favourite was 409, followed by 328. I like the flavour and I like the texture and they're good size. Two I don't like was 791, the Grainwaves. I never keen on Grainwaves. I found even though that's crunchy, but I found it's too hard. I don't like the flavour. And I didn't like 736, too small, too mild flavour.
Participant 5: But one thing I satisfied with the 736 is they have fibre in the nutritional.
Participant 4: I haven't sight. I will look at it.
Participant 5: Although it is 40g per serving, it's ok. But, it still says high in fibre content.
Participant 1: It still gonna use my saliva water? I was really surprise though cause it smaller than the average. It does pack to my teeth. My favourite one was 564. That's just for the taste, flavour and the shape and crunchiness. I'm a little bit Cheezel lovers. The 736 was definitely the least. Too small, didn't taste right.
Participant 8: Does any particular colour and sodium on the nutritional label (48:30)?
Moderator: No, it comes in front of the pack, the claim. You won't notice from the nutritional information panel.
Participant 8: I see.
Participant 2: That's participant 5rd.
Participant 1: Will it be labelled at all?
Moderator: it does, it says contain additives. They have an E number.
Participant 1: but people aren't familiar with it.
Moderator: that's right.
Participant 1: Can this E, everybody sort of knows, although I might not know what exactly what it is. But To hide the number of differences, it's a bit cheeky.
Moderator: that's why some manufacturers make a claim in front of the pack says containing no additives. Now let's talk about product concepts now.

Product Concepts

Moderator: Can you please have a look the products first. I know the product size is probably not ideal, as it was made on a very small machine. What I wanna know is other than the size, which can be upgraded very easily, what else you like and dislike about them.
Participant 7: I like the product looks really cute, but it's really small.
Moderator: Ok, firstly, what do you think it's the ideal size for this product?
Participant 3: maybe like the size of the Grainwaves.
Participant 4: not sure about that, cause there is too many broken pieces.
Moderator: ok, let me show you what the actual size of the Grainwaves is. Ok, do you think this size is ideal?
Participant 4: I'll say yes.
Moderator: as for the flavour, it can be any flavour you would like. Ok, what kind of flavour will attract you but fit in a healthy snack?
Participant 7: probably like sour or a bit like spicy.
Someone: lemon & pepper.
Participant 5: definitely not cheesy flavour
Participant 2: sour cream and chives is good.
Participant 7: I know the product is healthy but not necessarily tasty.
Participant 8: I'm tasting blue cheese.
Participant 7: this is more sour cream flavour.
Moderator: actually, they are all coated with the same flavour. Is there anything else other than the flavour?
Participant 8: I found they're a little too crunchy, a little too hard.
Moderator: can you please try all three and which one is matching more with your expectation?
Participant 4: yep, I agree with you, a little bit too hard.
Participant 2: this one is a little bit too soft.
Participant 4: oh good, I like soft one actually.
Moderator: what are the improvements to make this product better?
Participant 7: I taste like salty. I feel it's a bit over salty.
Participant 3: it's a little bit too hard.
Participant 4: I actually quite like 119. I do find it's a bit too hard, but I do like 119. If it tasted like chicken, it may be different as well. It's a little bit crunchy. So yeah, just for the texture, 119.
Participant 7: the texture is good, I wish it was a little bit sour, it was too salty.
Moderator: does any of you eat rice cracker at all.
Participant 2: yeah
Participant 5: Yeah.
Participant 6: yeah
Moderator: Will you or will you not eat this instead to replace the rice cracker?
A few participants: yeah, yeah
Participant 1: I don't think so and the shape, the shape of the rice cracker will probably better for this product in my opinion. I think it's because the rice cracker is flatten and thin, that would

overcome some of the hardness and that makes the whole thing softer maybe, I'm not sure. A bit more palatable.
Moderator: ok, do you think the size should be also similar to the rice cracker as well.
Participant 3: just a bit bigger than what it is now.
Participant 5: yeah
Moderator: anything else you'd like to change? Some of you have mentioned the texture is a little bit too hard, you want it to be softer?
Participant 7: may be a variety of the flavour, some of the nuggets are so sour and salty. Maybe make it a bit more spicy and cheesy.
Participant 1: I put here a different shape, so that's could go in with the rice cracker shape, larger, that's sweet about 3 times the size of the sample and a slightly softer and we could made it not sticking to the teeth that much.
Participant 6: yeah, I feel it's really annoying sticking to the teeth.
Participant 8: Ummm, the colour, not too bad but it's kind of half way between some of the other ones.
Participant 1: but it's sort of its own identity colour like in between, you know difference between the rice cracker and the most of other…
Participant 4: I thought it's better than Grainwaves.
Participant 2: I think it's quite a nice colour.
Participant 4: I'm getting the flavour from the orange bits, is that right?
Moderator: ok, if now I tell you this product is 75% less fat than potato chips, just give you a head up how much fat in potato chips, it's normally about 31~32% fat. This only contains 6.5 gram fat per 100 gram product; it's baked not fried, normally fried product will puff more; It also made with ancient grains, but most of you don't understand it, it doesn't matter.
Others: laugh
Participant 1: but we understand where you come from and which direction you wanna..
Moderator: it also low in saturated fat, which means it less than 1.5 g saturated fat per 100g product and it's low in sugar, which means there's less than 5 gram sugar per 100 grams. So after known all of that, if this product was available in the supermarket with an ideal size, will you compromise on something else for this product.
Participant 1: I would I think.
A few other girls: yeah
Participant 1: because that's what made me change from eating Grainwaves instead of Cheezels for instance you know, because of that perspective. I still like, for the comfort, the Cheezels more than Grainwaves, but I go for the Grainwaves.
Moderator: it's also a source of wholegrain and high in fibre.
Participant 1: and the sodium?
Moderator: sodium will be normal, because it comes with the taste.
Participant 8: what about, cause corn chips are deep fried, aren't they?
Moderator: yes

Participant 8: so what if make the shape like corn chips. You can make this like triangle…
Moderator: do you prefer the shape to be triangle.
Participant 8: because that's probably what I would replace these with. Maybe corn chips and ..
Participant 7: you mean nacho.
Participant 8: yeah, maybe
Participant 4: I don't know, that's a good idea, but I always consider corn chip different than a snack personally. I reckon I don't some much of the added shape versus...That's doesn't mean I have the verdict, but I don't usually classify corn chips with my Rashuns and my Cheezel.
Participant 1: Snack is more as a supplement through food.
Participant 4: The idea is good. That's more like what you have after.
Participant 1: I thought if you could promote like in addition to or part of a cheese ?? or something like that (1:03:08), you normally use the baked cracker. But then you do away with the nutritional advantages, offsetting the cheese which actually you can promote with healthy cheese or something like that.
Participant 5: Otherwise, you can also make it like a long stick, and then you pack into either a small plastic bag or shaped finger nail stuff. Then you go with the dip.
Participant 6: like the crispy bread with small cheese
Participant 1: but then it's more like a complicated snack and the actually the snack anymore. That's not something you grab from your pantry straight away.
Participant 6: that's more like alternative to cheese, you can eat in the same way but healthier. But if you have with Cheezel or something, it adds more fat and the moderator recommended it's 75% less fat than potato chips. Like you add that fat on and don't make any change.
Participant 1: yep, you should basically try to utilise it as a replacement for a snack still eating it with feeling good about yourself.
Participant 4: you eat rice crackers or anything?
Participant 1: I do.
Participant 4: you put stuff on?
Participant 1: I do quite often though depends on the rice crackers than to the ..
Participant 6: it's like you feel it like potato chips but you have the feeling like eating a carrot.
Moderator: Does that mean you won't comprise the taste for a healthier option.
Participant 7: if the healthier one is also yummy.
Participant 4: Unfortunately, I'm not being nutritious. Generally I won't pay attention to nutrition at all. I eat very poor. I feel like something, I'll eat it. So that's what I will do.
Participant 3: I'll definitely choose a healthier option even if I like it a little bit less, I will still choose it.
Participant 6: But you know the grain stuff doesn't sound tasty, chewy and…
Participant 8: What grains are they specifically?
Moderator: Amaranth, Qunioa, which are two very common ones and also millet.
Participant 8: oh, ok.
Participant 4: I don't think I've heard any of them.

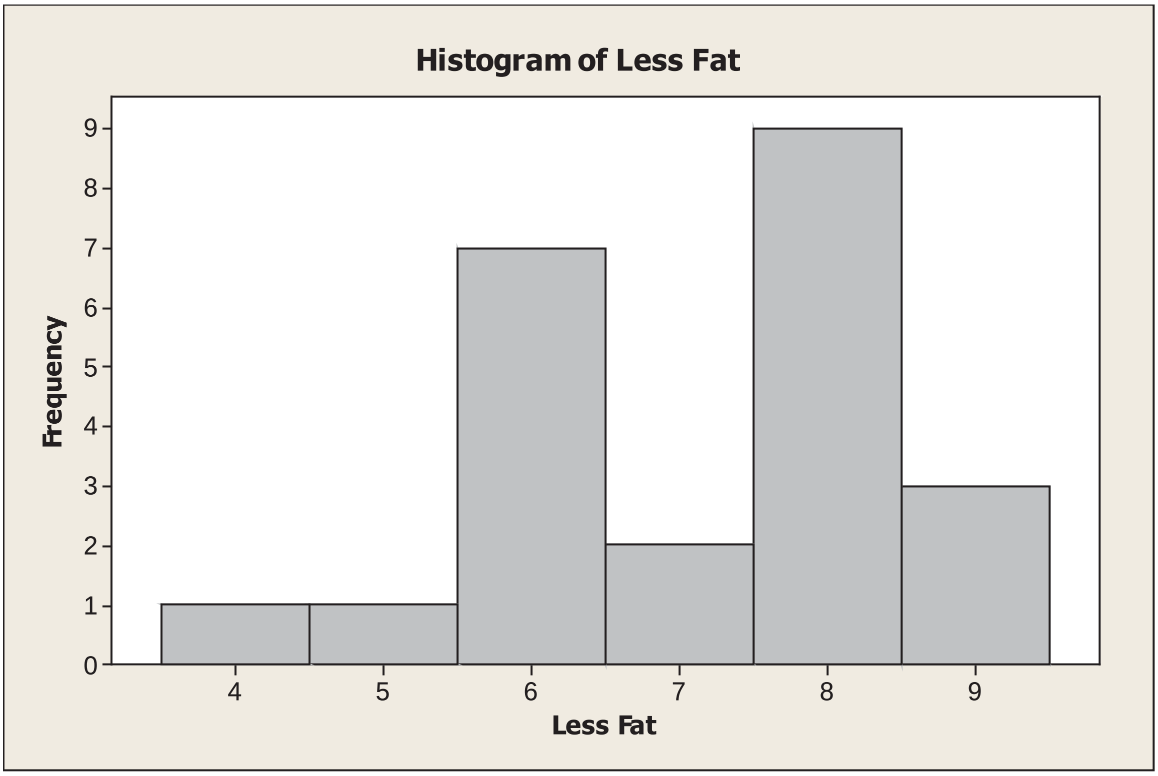
Participant 1: hasn’t it got spelt?
Moderator: Spelt is a slightly less known ancient grain. It’s variety of wheat and amaranth and quinoa are premium ancient grains, cause they’re very rich in protein and amino acids.
Participant 6: is it easy to digest, like for baby.
Moderator: yes. Ok. You think the size of the product is definitely needed to change and the texture?
Participant 4: I don’t mind the texture so much myself.
Participant 8: I think the texture of 119 was quite good for me.
Participant 4: I think the easy things to change are the size and the taste. The texture itself I don’t mind so much, otherwise 119, seems a different one. That was my favourite.
Moderator: thank you very much! That’s the end of the focus group.

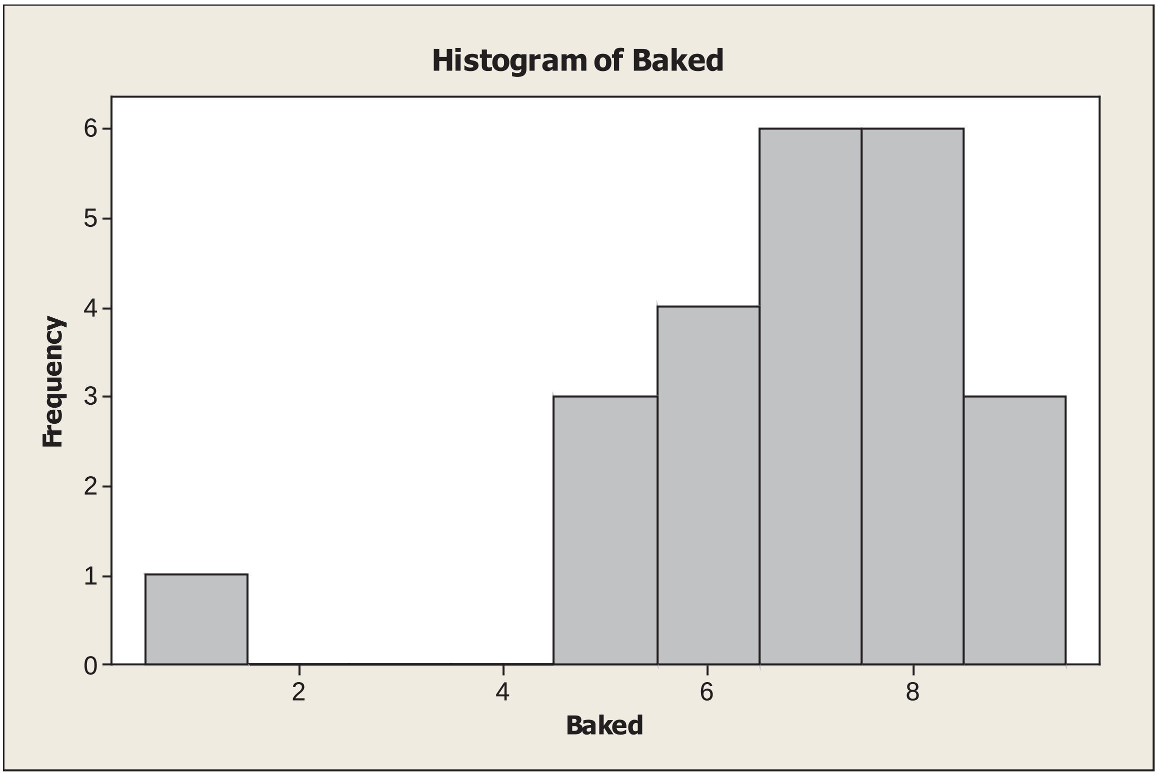
A 6.11 Data Analysis for the Product Claims

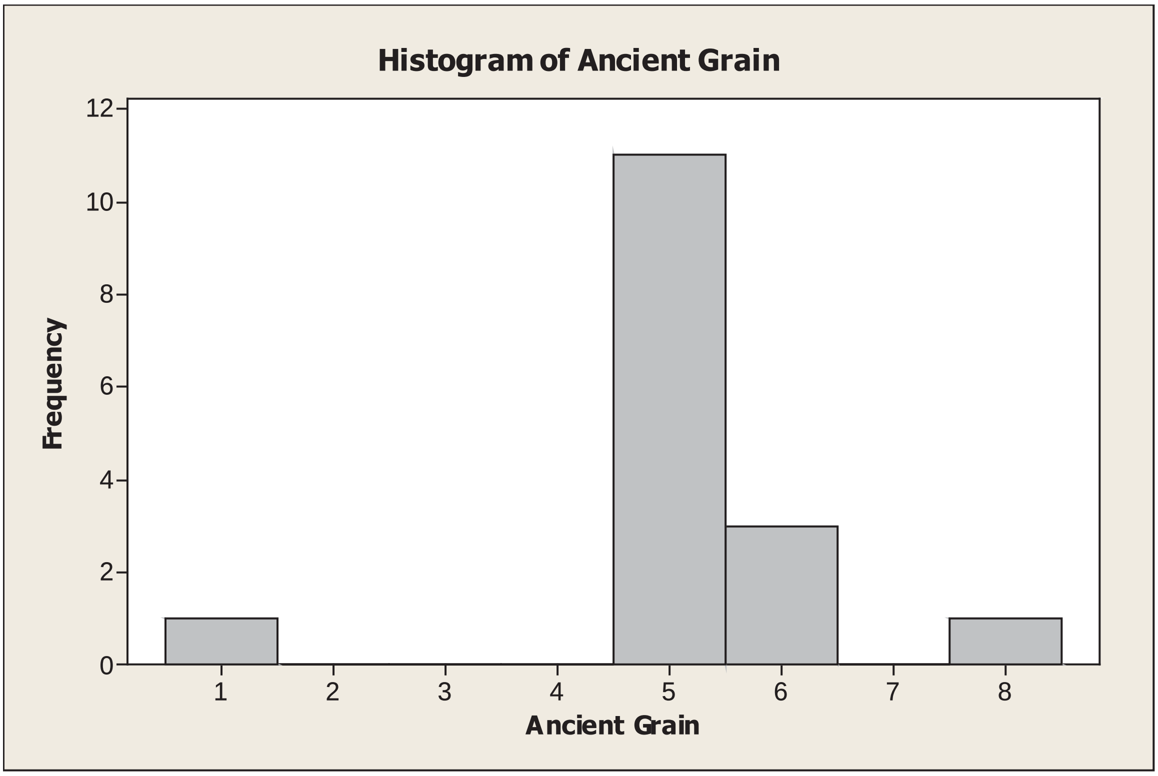
A 6.11.1 Descriptive data analysis for the attractiveness of different product claims

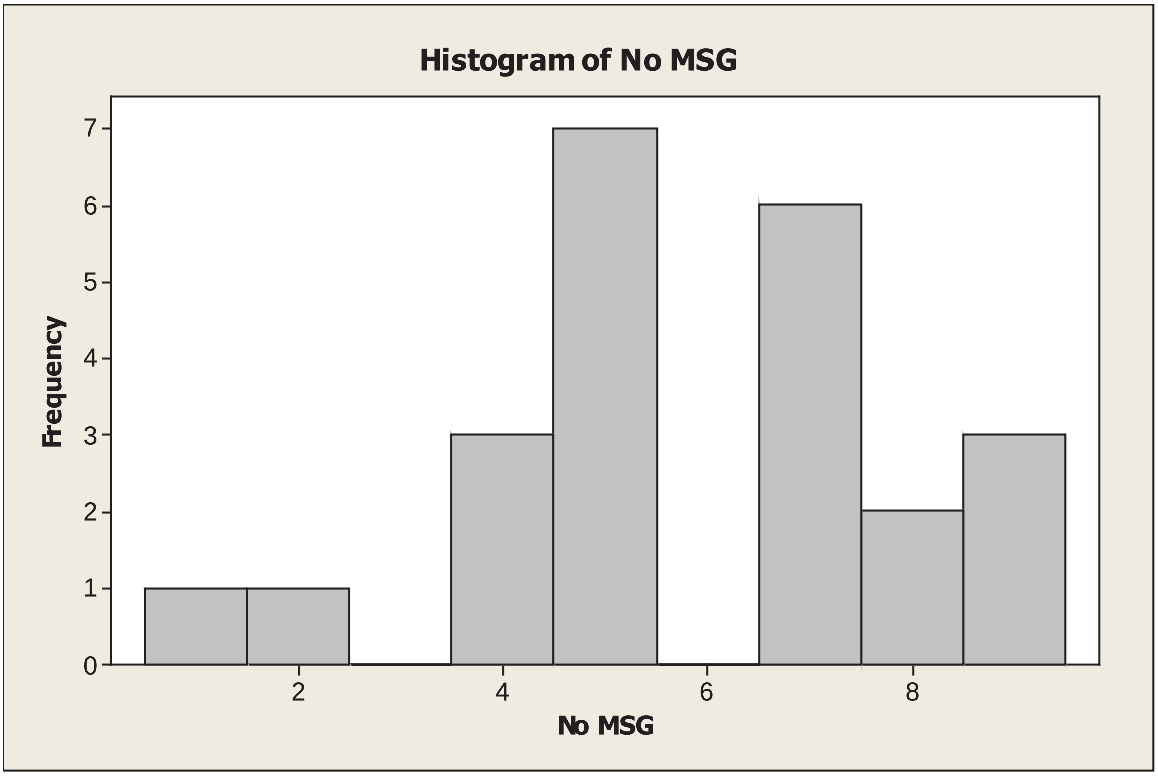
Variable	N	N*	Mean	SE Mean	StDev	Minimum	Q1	Median
Less Fat	23	0	7.130	0.283	1.359	4.000	6.000	8.000
Baked	23	0	6.826	0.370	1.775	1.000	6.000	7.000
Ancient Grain	16	7	5.125	0.340	1.360	1.000	5.000	5.000
No MSG	23	0	5.870	0.446	2.138	1.000	5.000	5.000
Gluten Free	23	0	4.739	0.437	2.094	1.000	3.000	5.000
No artifical Colour&Flav	23	0	6.304	0.364	1.743	1.000	5.000	7.000
Wholegrain	23	0	6.304	0.311	1.490	3.000	5.000	6.000
High in Fibre	23	0	6.870	0.346	1.660	3.000	6.000	7.000
Low in Sat Fat	23	0	7.261	0.276	1.322	4.000	6.000	7.000
Low in Sugar	23	0	7.130	0.316	1.517	3.000	6.000	8.000

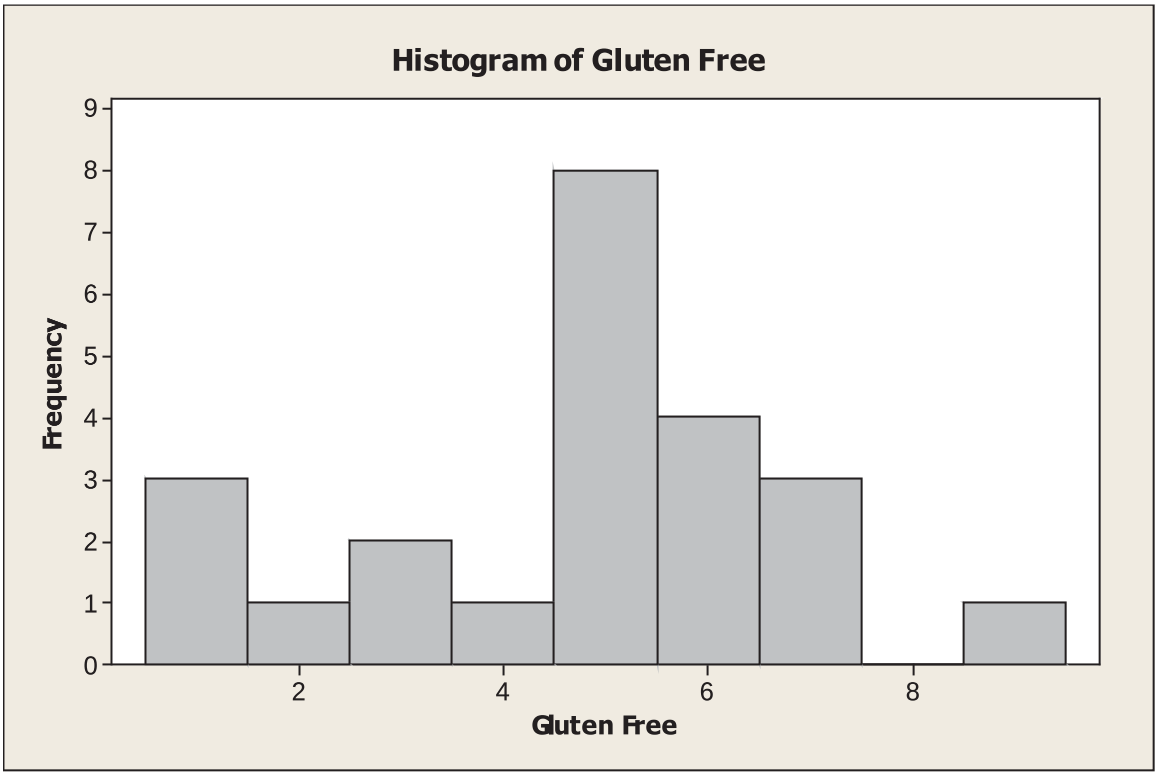
Variable	Q3	Maximum
Less Fat	8.000	9.000
Baked	8.000	9.000
Ancient Grain	5.750	8.000
No MSG	7.000	9.000
Gluten Free	6.000	9.000
No artifical Colour&Flav	8.000	9.000
Wholegrain	8.000	9.000
High in Fibre	8.000	9.000
Low in Sat Fat	8.000	9.000
Low in Sugar	8.000	9.000

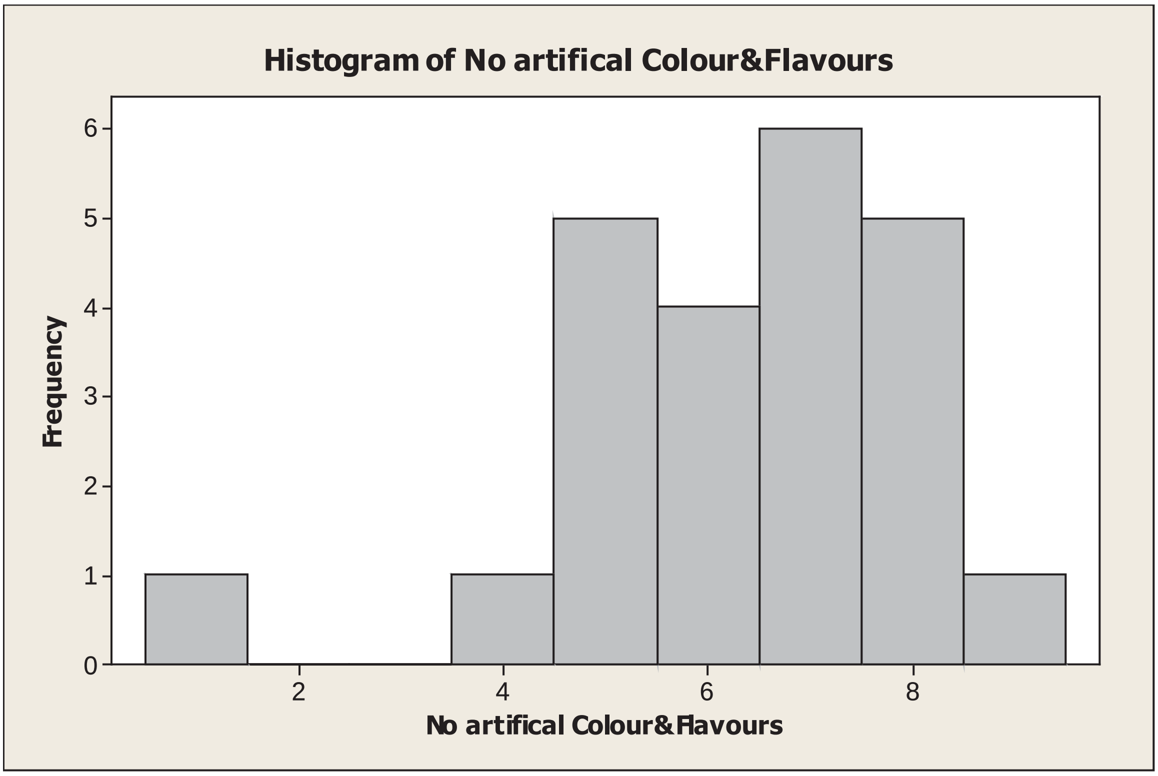


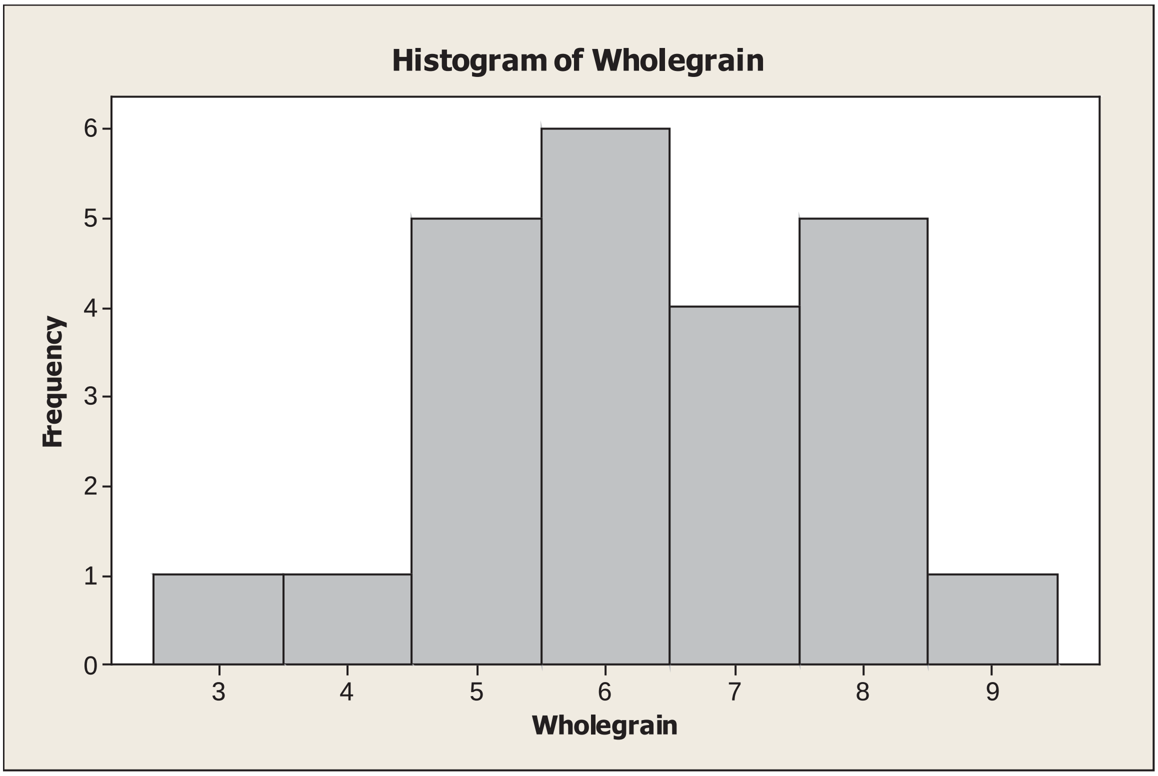

Histogram of Baked
Frequency
0
1
2
3
4
5
6
2
4
6
8
Baked

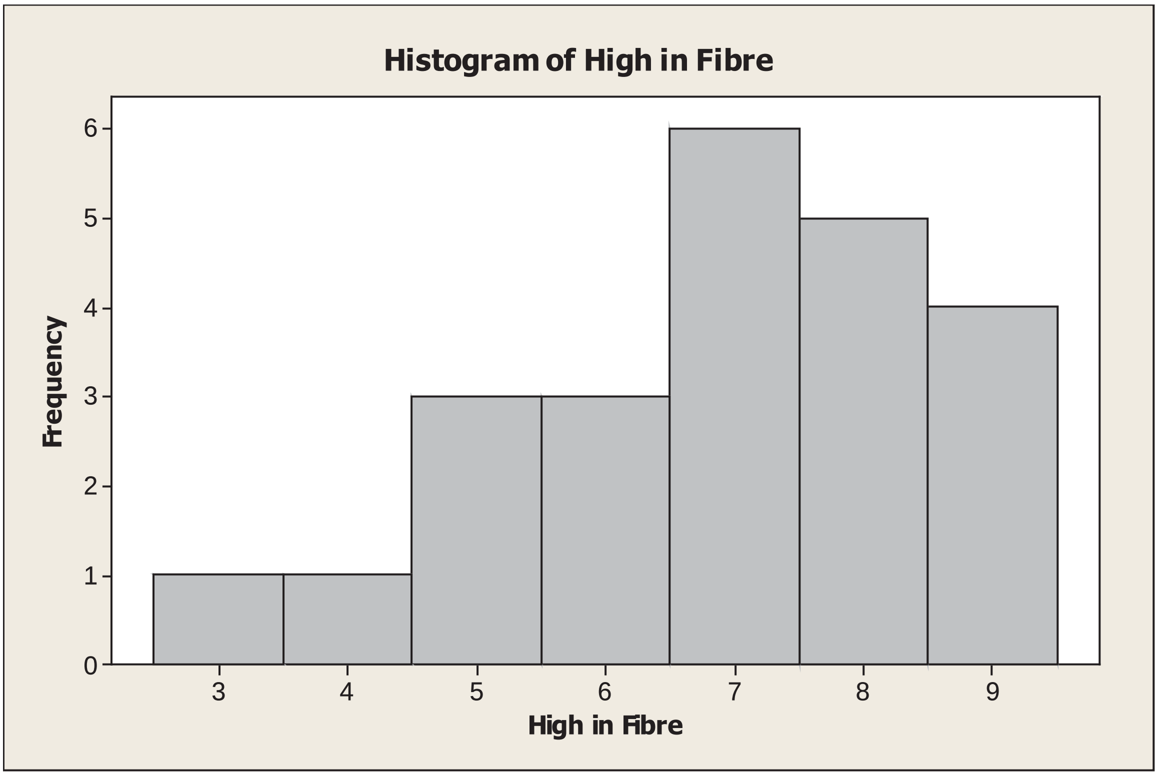

Histogram of Ancient Grain
Frequency
0
2
4
6
8
10
12
1
2
3
4
5
6
7
8
Ancient Grain

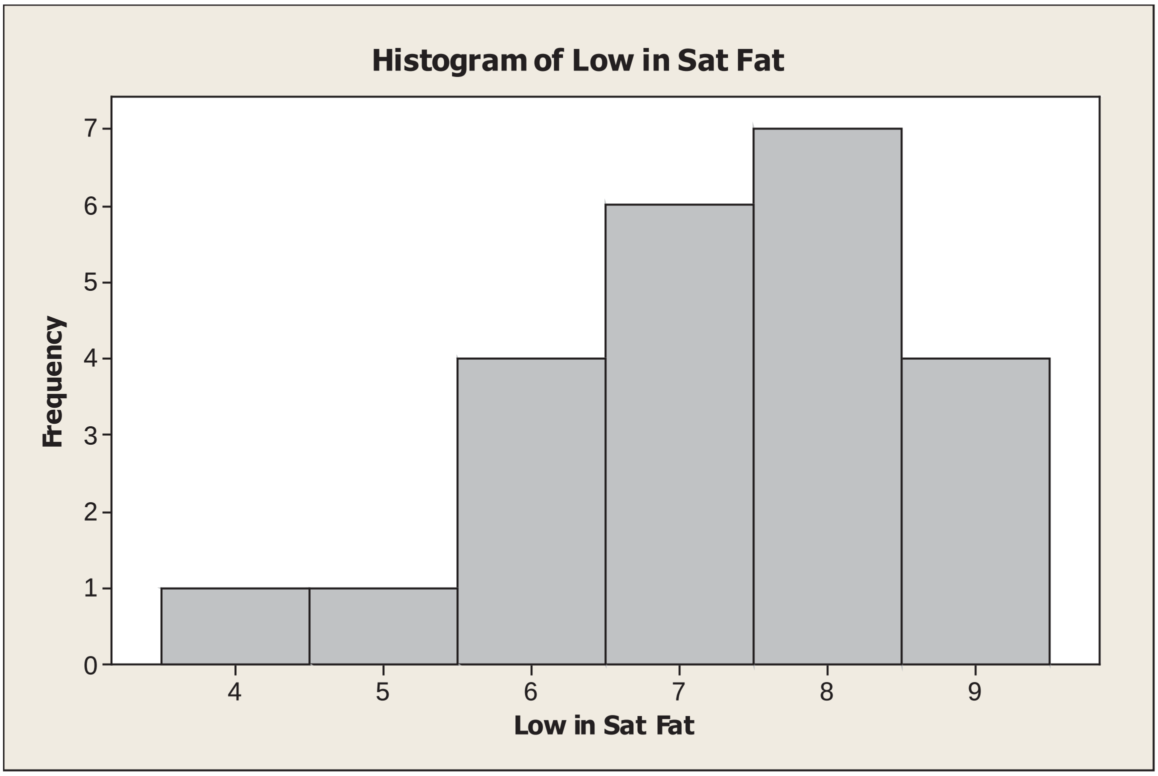

Histogram of No MSG
Frequency
7
6
5
4
3
2
1
0
2
4
6
8
No MSG

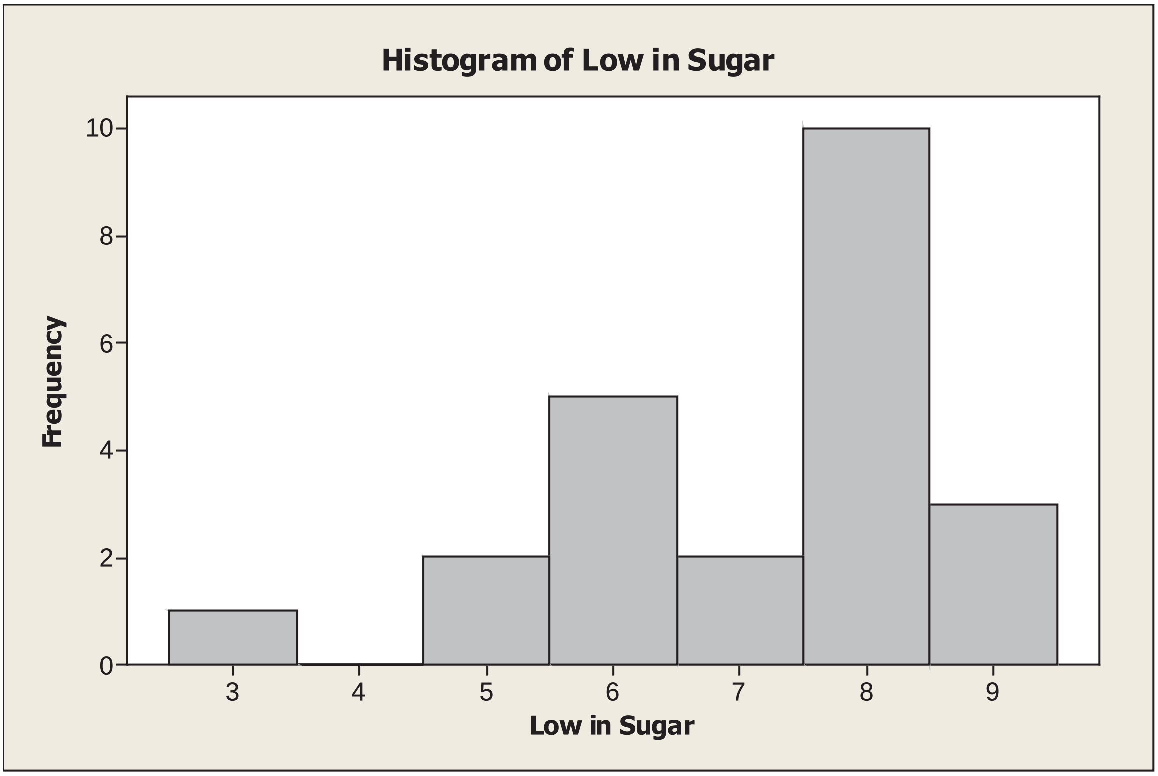

Histogram of Gluten Free
Frequency
9
8
7
6
5
4
3
2
1
0
2
4
6
8
Gluten Free


Histogram of No artifical Colour&Flavours
Frequency
0
1
2
3
4
5
6
2
4
6
8
No artifical Colour&Flavours


Histogram of Wholegrain
Frequency
0
1
2
3
4
5
6
3
4
5
6
7
8
9
Wholegrain

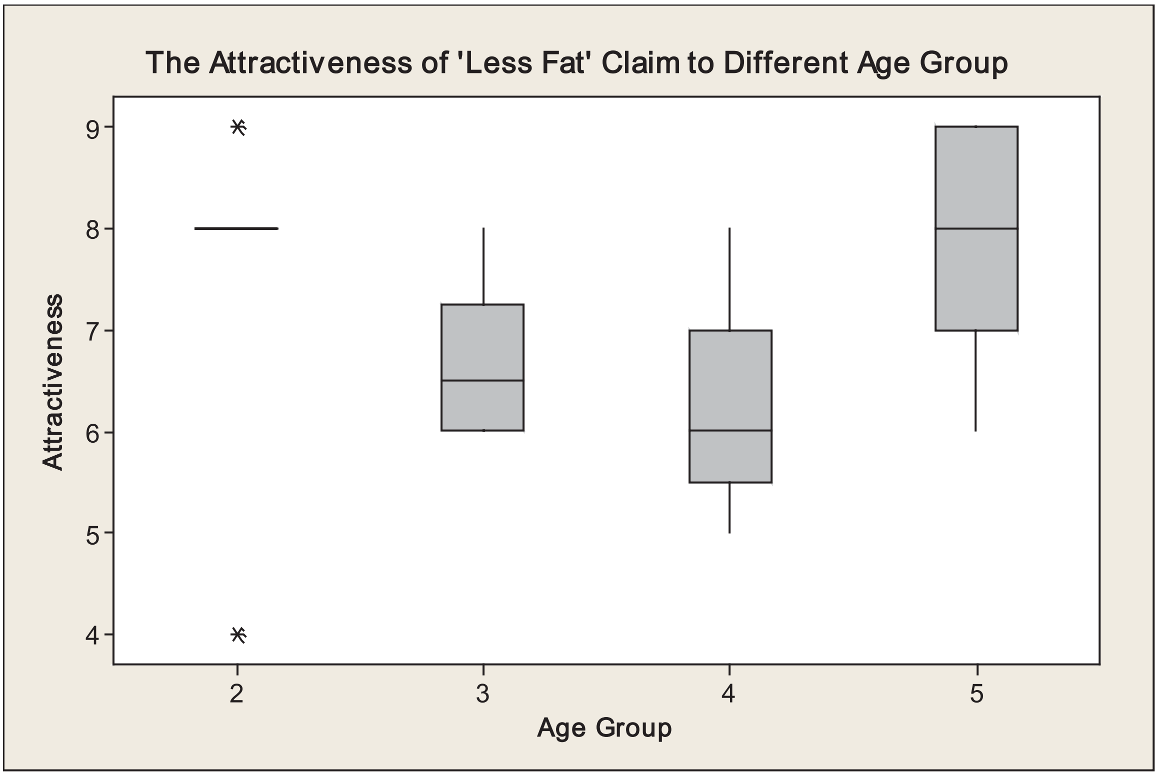

Histogram of High in Fibre
Frequency
0
1
2
3
4
5
6
3
4
5
6
7
8
9
High in Fibre

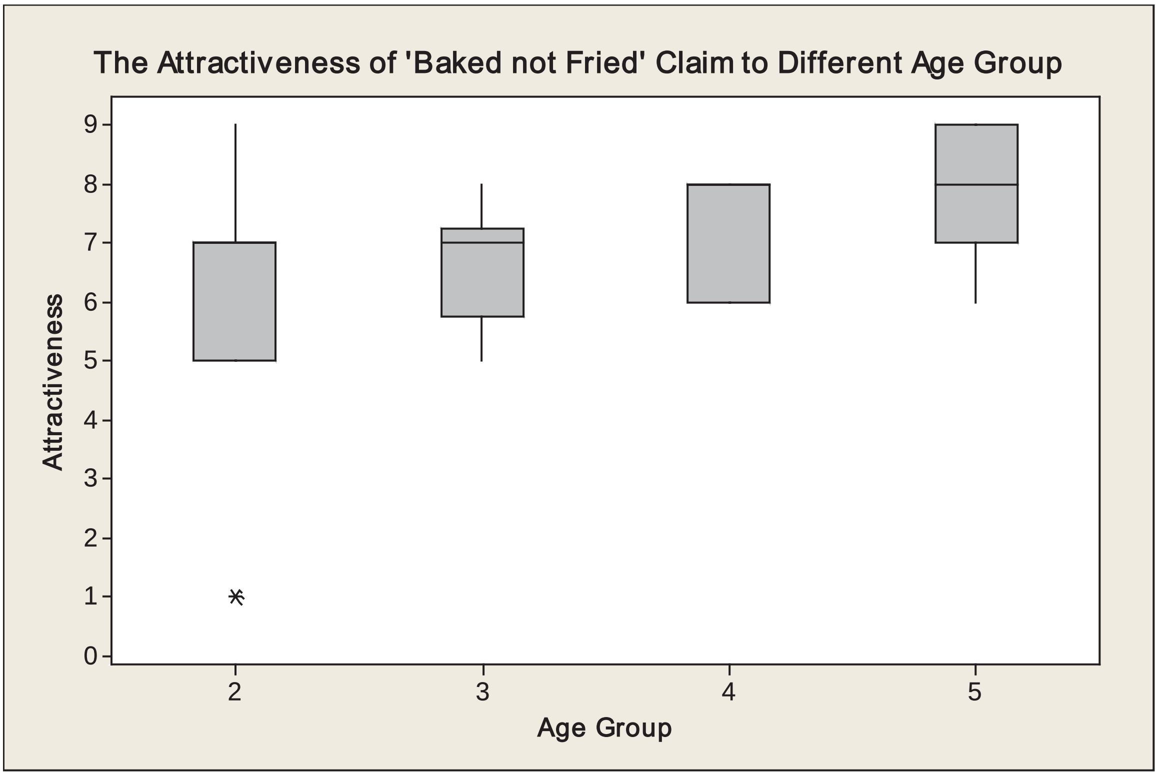

Histogram of Low in Sat Fat
Frequency
0
1
2
3
4
5
6
7
4
5
6
7
8
9
Low in Sat Fat

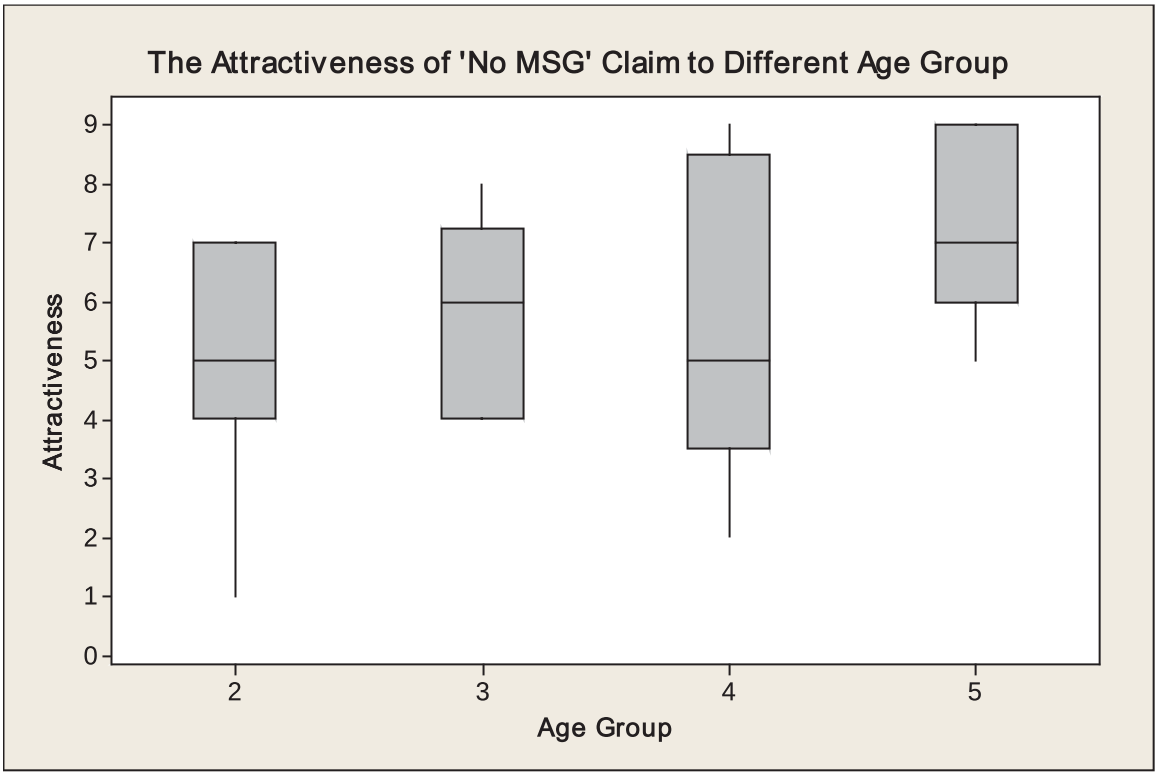


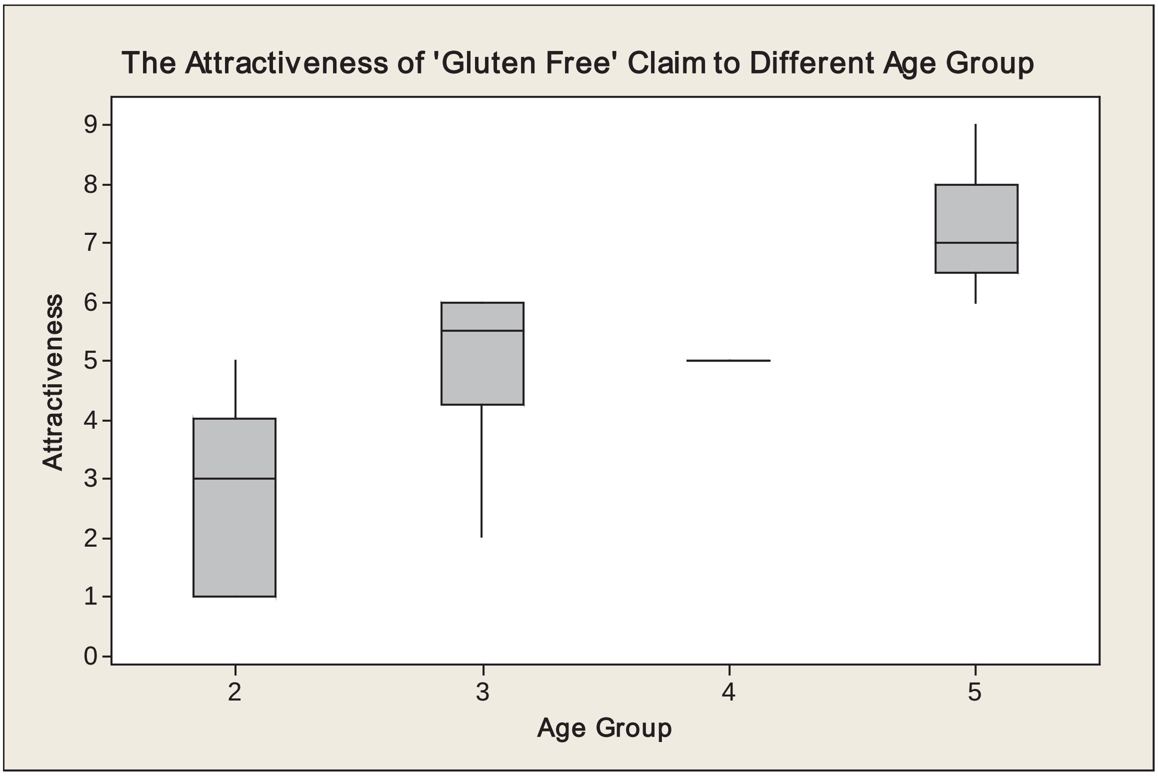
A 6.11.2 The attractiveness of product claims to different age groups

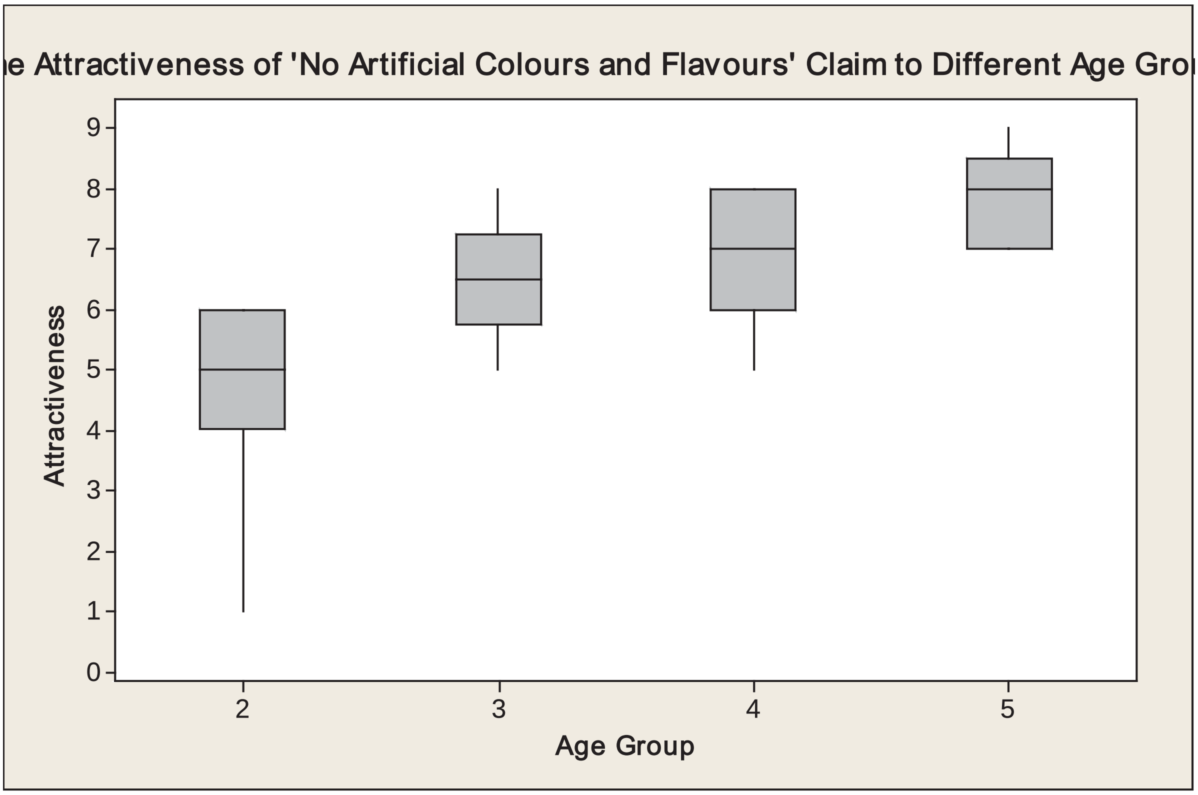
Age Range	Age Group
16 – 24 years	2
25 – 34 years	3
35 – 44 years	4
45 years and over	5


The Attractiveness of 'Less Fat' Claim to Different Age Group
Attractiveness
Age Group
9
8
7
6
5
4
2
3
4
5

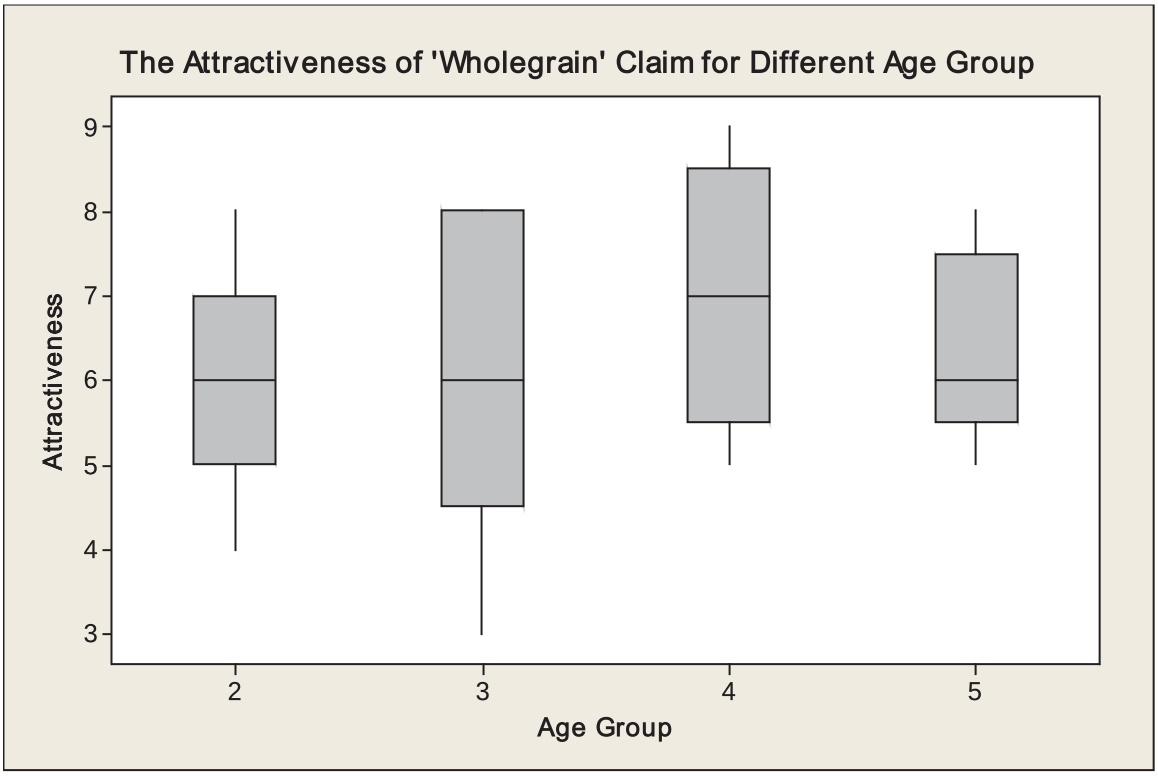

The Attractiveness of 'Baked not Fried' Claim to Different Age Group
Attractiveness
Age Group
9
8
7
6
5
4
3
2
1
0
2
3
4
5


The Attractiveness of 'No MSG' Claim to Different Age Group
Attractiveness
0
1
2
3
4
5
6
7
8
9
2
3
4
5
Age Group

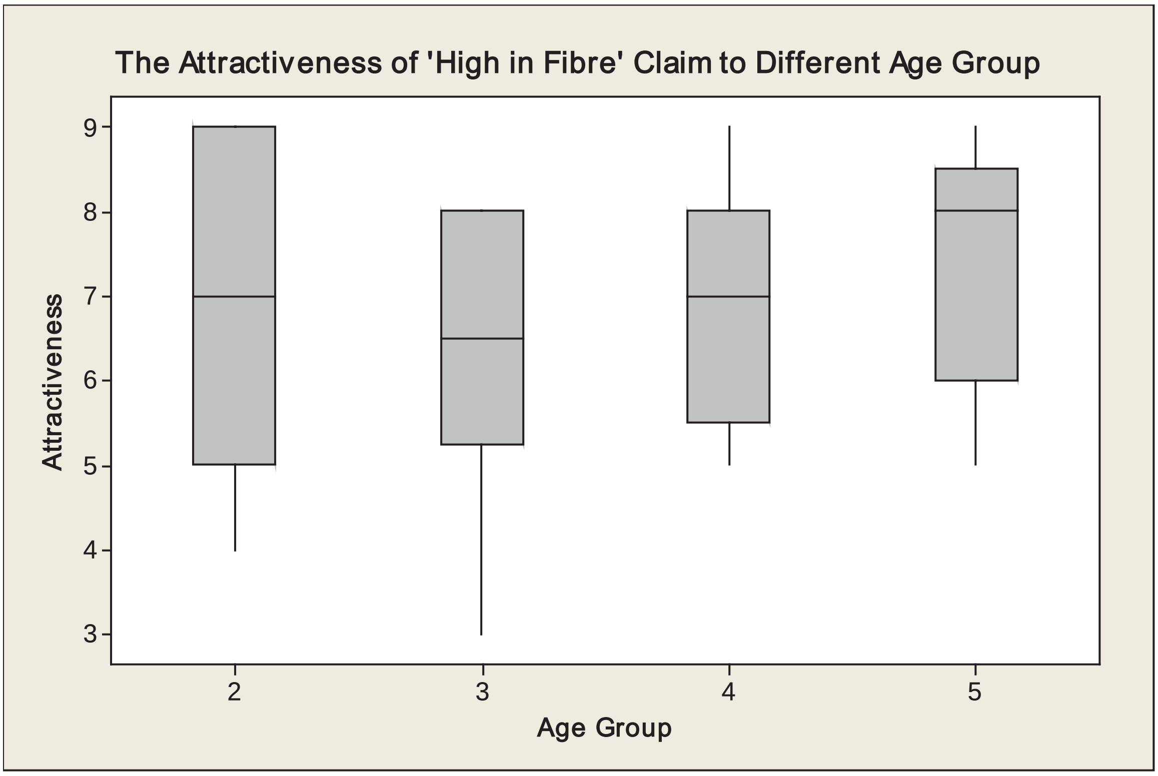

The Attractiveness of 'Gluten Free' Claim to Different Age Group
Attractiveness
0
1
2
3
4
5
6
7
8
9
2
3
4
5
Age Group

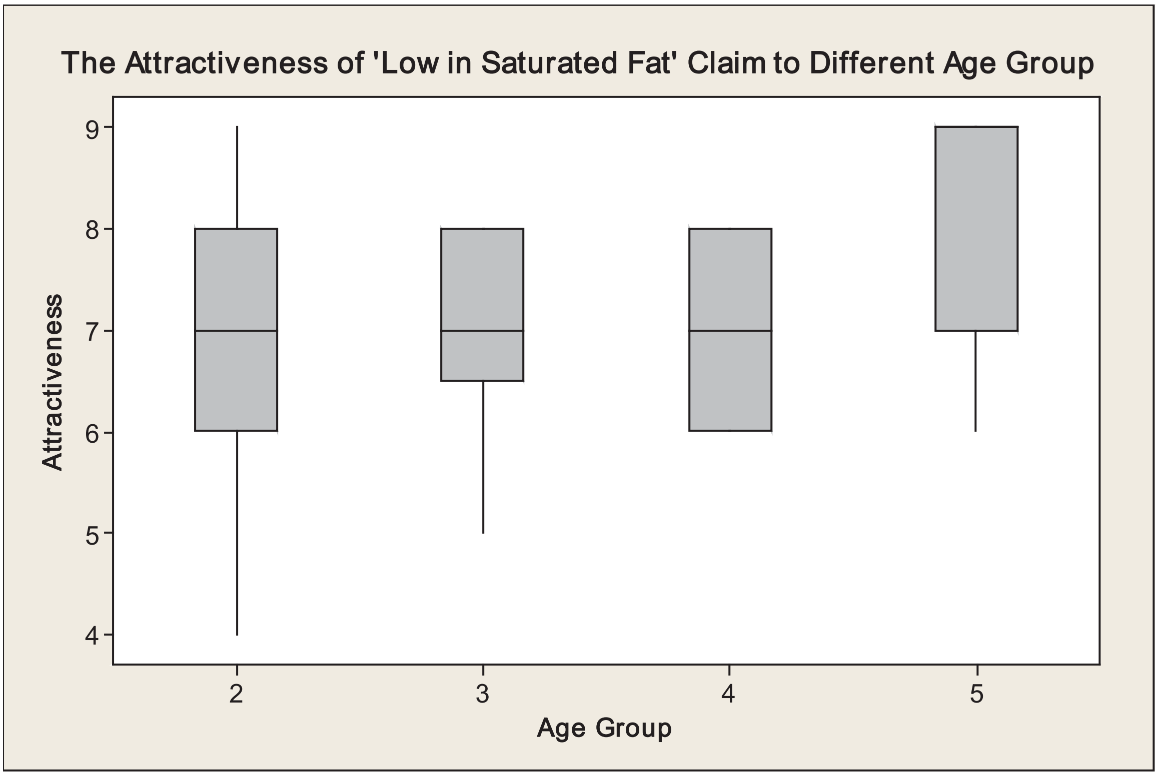


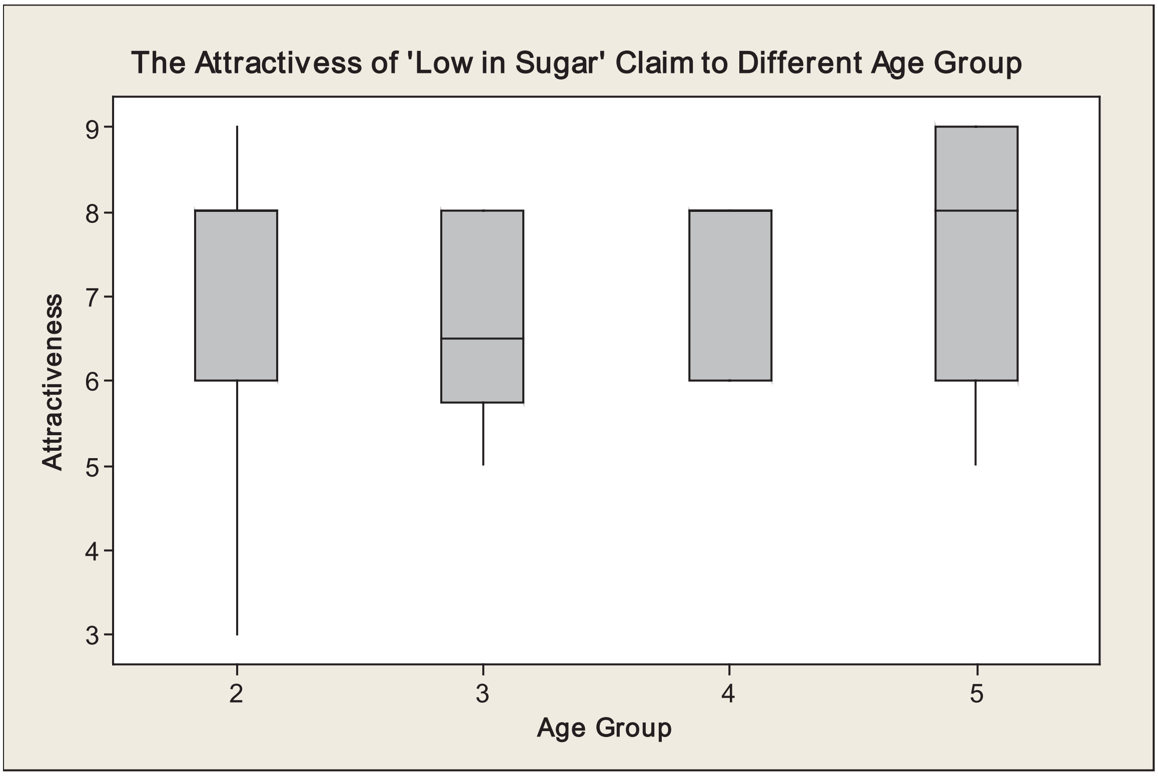
he Attractiveness of 'No Artificial Colours and Flavours' Claim to Different Age Gro
Attractiveness
9
8
7
6
5
4
3
2
1
0
2
3
4
5
Age Group



The Attractiveness of 'Wholegrain' Claim for Different Age Group
Attractiveness
9
8
7
6
5
4
3
2
3
4
5
Age Group


The Attractiveness of 'High in Fibre' Claim to Different Age Group
Attractiveness
9
8
7
6
5
4
3
2
3
4
5
Age Group


The Attractiveness of 'Low in Saturated Fat' Claim to Different Age Group
Attractiveness
9
8
7
6
5
4
2
3
4
5
Age Group



A 6.12 Mintel GNPD Search by Claims or Ingredients (Retrieved 30 January 2013)

A 6.12.1 Australia and New Zealand Market

Search details:

Search for products where country matches one or more of Australia, New Zealand and sub-category matches one or more of corn-based snacks, potato snacks, rice snacks, wheat & other grain-based snacks and date published is between Jan 2008 and Dec 2012 and claims matches High/Added Fibre as the claim

Date Published	Number of Variants
2008	5
2009	4
2010	0
2011	15
2012	4
Total Sample	28

Search details:

Search for products where country matches one or more of Australia, New Zealand and sub-category matches one or more of corn-based snacks, potato snacks, rice snacks, wheat & other grain-based snacks and date published is between Jan 2008 and Dec 2012 and claims matches wholegrain as the claim

Date Published	Number of Variants
2008	10
2009	9
2010	4
2011	13
2012	11
Total Sample	47

Search details:

Search for products where country matches one or more of Australia, New Zealand and sub-category matches one or more of corn-based snacks, potato snacks, rice snacks, wheat & other grain-based snacks and ingredient search matches one or more of [Amaranth Grain, Amaranth Seed, Quinoa and all child ingredients, Sorghum and all child ingredients, Teff, Buckwheat and all child ingredients, Millet and all child ingredients] as the ingredients and date published is between Jan 2008 and Dec 2012

Date Published	Number of Variants
2008	0
2009	0
2010	1
2011	0
2012	2
Total Sample	3

Search details:

Search for products where country matches one or more of Australia, New Zealand and sub-category matches one or more of corn-based snacks, potato snacks, rice snacks, wheat & other grain-based snacks and date published is between Jan 2008 and Dec 2012 and claims matches one or more of [Low/No/Reduced Fat, Low/No/Reduced Saturated Fat] as the claim

Date Published	Number of Variants
2008	37
2009	41
2010	31
2011	38
2012	38
Total Sample	185

A 6.12.2 Global market

Search details:

Search for products where sub-category matches one or more of corn-based snacks, potato snacks, rice snacks, wheat & other grain-based snacks and date published is between Jan 2008 and Dec 2012 and claims matches High/Added Fibre as the claim

Date Published	Number of Variants
2008	58
2009	13
2010	36
2011	106
2012	92
Total Sample	305

Search details:

Search for products where sub-category matches one or more of corn-based snacks, potato snacks, rice snacks, wheat & other grain-based snacks and date published is between Jan 2008 and Dec 2012 and claims matches wholegrain as the claim

Date Published	Number of Variants
2008	111
2009	91
2010	145
2011	187
2012	216
Total Sample	750

Search details:

Search for products where sub-category matches one or more of corn-based snacks, potato snacks, rice snacks, wheat & other grain-based snacks and ingredient search matches one or more of [Amaranth Grain, Amaranth Seed, Quinoa and all child ingredients, Sorghum and all child ingredients, Teff, Buckwheat and all child ingredients, Millet and all child ingredients] as the ingredients and date published is between Jan 2008 and Dec 2012

Date Published	Number of Variants
2008	15
2009	12
2010	31
2011	32
2012	69
Total Sample	159

Search details:

Search for products where sub-category matches one or more of corn-based snacks, potato snacks, rice snacks, wheat & other grain-based snacks and date published is between Jan 2008 and Dec 2012 and claims matches one or more of [Low/No/Reduced Fat, Low/No/Reduced Saturated Fat] as the claim

Date Published	Number of Variants
2008	471
2009	363
2010	422
2011	396
2012	424
Total Sample	2076

Appendix 7: Statistical analysis details for 3G snack taste and texture improvements in Chapter 8

A 7.1 Minitab One-way ANOVA of raw ingredient blend pasting properties with reformulated 'CW' with salt and Flavex

One-way ANOVA: Pasting Temp versus Treatment

```
Source     DF     SS     MS     F      P
Treatment   3  0.811  0.270  1.33  0.382
Error       4  0.814  0.203
Total       7  1.625

S = 0.4510   R-Sq = 49.91%   R-Sq(adj) = 12.35%

                                  Individual 95% CIs For Mean Based on
                                  Pooled StDev
Level           N    Mean  StDev  ---------+---------+---------+---------+
Salt Hi         2  73.975  0.601               (------------*-----------)
Salt Hi&Flavex  2  73.500  0.000        (------------*------------)
Salt Lo         2  73.075  0.672  (------------*------------)
Salt Lo&Flavex  2  73.525  0.035         (-----------*------------)
                                  ---------+---------+---------+---------+
                                       72.80     73.50     74.20     74.90

Pooled StDev = 0.451

Grouping Information Using Tukey Method

Treatment       N     Mean  Grouping
Salt Hi         2  73.9750  A
Salt Lo&Flavex  2  73.5250  A
Salt Hi&Flavex  2  73.5000  A
Salt Lo         2  73.0750  A

Means that do not share a letter are significantly different.


Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Treatment

Individual confidence level = 98.48%


Treatment = Salt Hi subtracted from:

Treatment         Lower   Centre   Upper
Salt Hi&Flavex  -2.3121  -0.4750  1.3621
Salt Lo         -2.7371  -0.9000  0.9371
Salt Lo&Flavex  -2.2871  -0.4500  1.3871

Treatment       --------+---------+---------+---------+-
Salt Hi&Flavex     (-----------*-----------)
Salt Lo         (-----------*-----------)
Salt Lo&Flavex     (-----------*-----------)
                --------+---------+---------+---------+-
                     -1.5       0.0       1.5       3.0


Treatment = Salt Hi&Flavex subtracted from:

Treatment         Lower   Centre   Upper
Salt Lo         -2.2621  -0.4250  1.4121
Salt Lo&Flavex  -1.8121   0.0250  1.8621
```

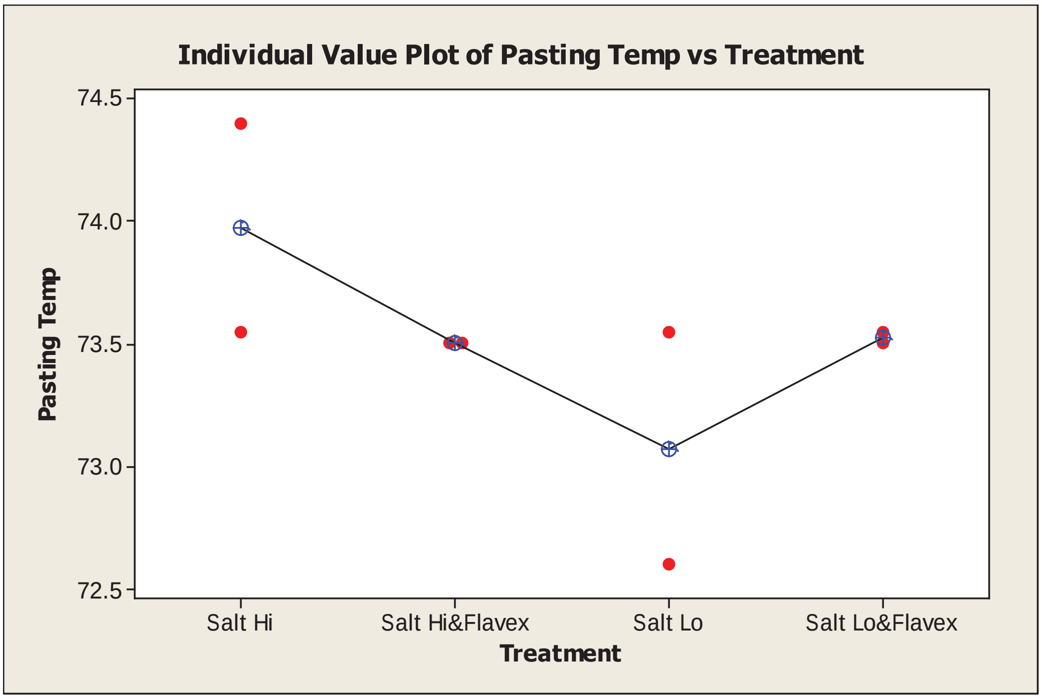
```
Treatment        --------+---------+---------+---------+-
Salt Lo             (-----------*-----------)
Salt Lo&Flavex         (-----------*-----------)
                 --------+---------+---------+---------+-
                      -1.5       0.0       1.5       3.0
```

Treatment = Salt Lo subtracted from:

Treatment	Lower	Centre	Upper
Salt Lo&Flavex	-1.3871	0.4500	2.2871

```
Treatment        --------+---------+---------+---------+-
Salt Lo&Flavex            (-----------*-----------)
                 --------+---------+---------+---------+-
                      -1.5       0.0       1.5       3.0
```

Individual Value Plot of Pasting Temp vs Treatment



One-way ANOVA: Peak Viscosity versus Treatment

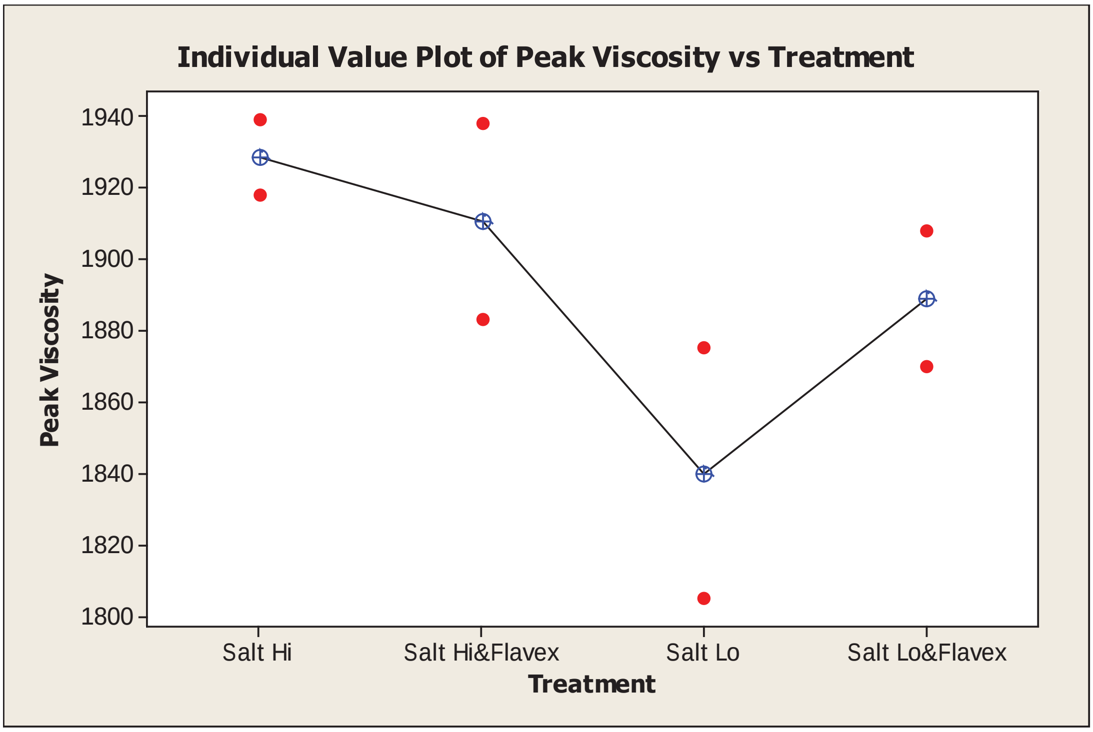
Source	DF	SS	MS	F	P
Treatment	3	8775	2925	2.39	0.210
Error	4	4905	1226		
Total	7	13680			

S = 35.02   R-Sq = 64.14%   R-Sq(adj) = 37.25%

```
                                    Individual 95% CIs For Mean Based on
                                    Pooled StDev
Level            N    Mean  StDev   -----+---------+---------+---------+----
Salt Hi          2  1928.5   14.8                  (-----------*-----------)
Salt Hi&Flavex   2  1910.5   38.9               (-----------*-----------)
Salt Lo          2  1840.0   49.5   (-----------*-----------)
Salt Lo&Flavex   2  1889.0   26.9           (-----------*----------)
                                    -----+---------+---------+---------+----
                                      1800      1860      1920      1980
```

```
Pooled StDev = 35.0


Grouping Information Using Tukey Method

Treatment        N     Mean  Grouping
Salt Hi          2  1928.50  A
Salt Hi&Flavex   2  1910.50  A
Salt Lo&Flavex   2  1889.00  A
Salt Lo          2  1840.00  A

Means that do not share a letter are significantly different.


Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Treatment

Individual confidence level = 98.48%


Treatment = Salt Hi subtracted from:

Treatment         Lower  Centre   Upper
Salt Hi&Flavex  -160.63  -18.00  124.63
Salt Lo         -231.13  -88.50   54.13
Salt Lo&Flavex  -182.13  -39.50  103.13

Treatment       ---------+---------+---------+---------+
Salt Hi&Flavex        (-----------*----------)
Salt Lo         (-----------*-----------)
Salt Lo&Flavex      (-----------*-----------)
                ---------+---------+---------+---------+
                      -120         0       120       240


Treatment = Salt Hi&Flavex subtracted from:

Treatment         Lower  Centre   Upper
Salt Lo         -213.13  -70.50   72.13
Salt Lo&Flavex  -164.13  -21.50  121.13

Treatment       ---------+---------+---------+---------+
Salt Lo          (-----------*-----------)
Salt Lo&Flavex       (-----------*-----------)
                ---------+---------+---------+---------+
                      -120         0       120       240


Treatment = Salt Lo subtracted from:

Treatment        Lower  Centre   Upper
Salt Lo&Flavex  -93.63   49.00  191.63

Treatment       ---------+---------+---------+---------+
Salt Lo&Flavex             (-----------*-----------)
                ---------+---------+---------+---------+
                      -120         0       120       240
```

Individual Value Plot of Peak Viscosity vs Treatment

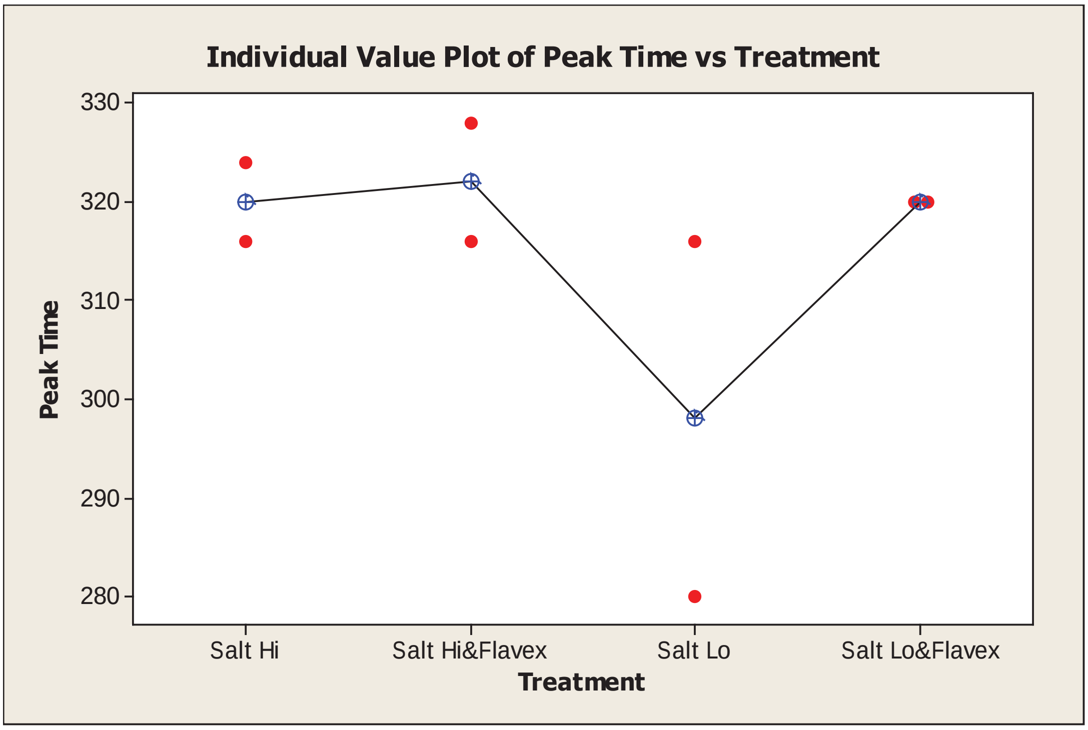


One-way ANOVA: Peak Time versus Treatment

```
Source      DF    SS   MS     F      P
Treatment    3   776  259  1.38  0.371
Error        4   752  188
Total        7  1528

S = 13.71   R-Sq = 50.79%   R-Sq(adj) = 13.87%


                                  Individual 95% CIs For Mean Based on
                                  Pooled StDev
Level            N    Mean  StDev  ----+---------+---------+---------+-----
Salt Hi          2  320.00   5.66             (------------*------------)
Salt Hi&Flavex   2  322.00   8.49              (------------*------------)
Salt Lo          2  298.00  25.46  (------------*------------)
Salt Lo&Flavex   2  320.00   0.00             (------------*------------)
                                   ----+---------+---------+---------+-----
                                     280       300       320       340

Pooled StDev = 13.71


Grouping Information Using Tukey Method

Treatment        N    Mean  Grouping
Salt Hi&Flavex   2  322.00  A
Salt Lo&Flavex   2  320.00  A
Salt Hi          2  320.00  A
Salt Lo          2  298.00  A

Means that do not share a letter are significantly different.


Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Treatment

Individual confidence level = 98.48%
```

```
Treatment = Salt Hi subtracted from:

Treatment         Lower  Centre  Upper
Salt Hi&Flavex   -53.85    2.00  57.85
Salt Lo          -77.85  -22.00  33.85
Salt Lo&Flavex   -55.85    0.00  55.85

Treatment          +---------+---------+---------+---------
Salt Hi&Flavex            (-------------*------------)
Salt Lo             (-------------*------------)
Salt Lo&Flavex           (-------------*-------------)
                   +---------+---------+---------+---------
                 -80       -40         0        40


Treatment = Salt Hi&Flavex subtracted from:

Treatment         Lower  Centre  Upper
Salt Lo          -79.85  -24.00  31.85
Salt Lo&Flavex   -57.85   -2.00  53.85

Treatment          +---------+---------+---------+---------
Salt Lo            (-------------*-------------)
Salt Lo&Flavex           (-------------*------------)
                   +---------+---------+---------+---------
                 -80       -40         0        40


Treatment = Salt Lo subtracted from:

Treatment         Lower  Centre  Upper
Salt Lo&Flavex   -33.85   22.00  77.85

Treatment          +---------+---------+---------+---------
Salt Lo&Flavex                 (-------------*------------)
                   +---------+---------+---------+---------
                 -80       -40         0        40
```

Individual Value Plot of Peak Time vs Treatment

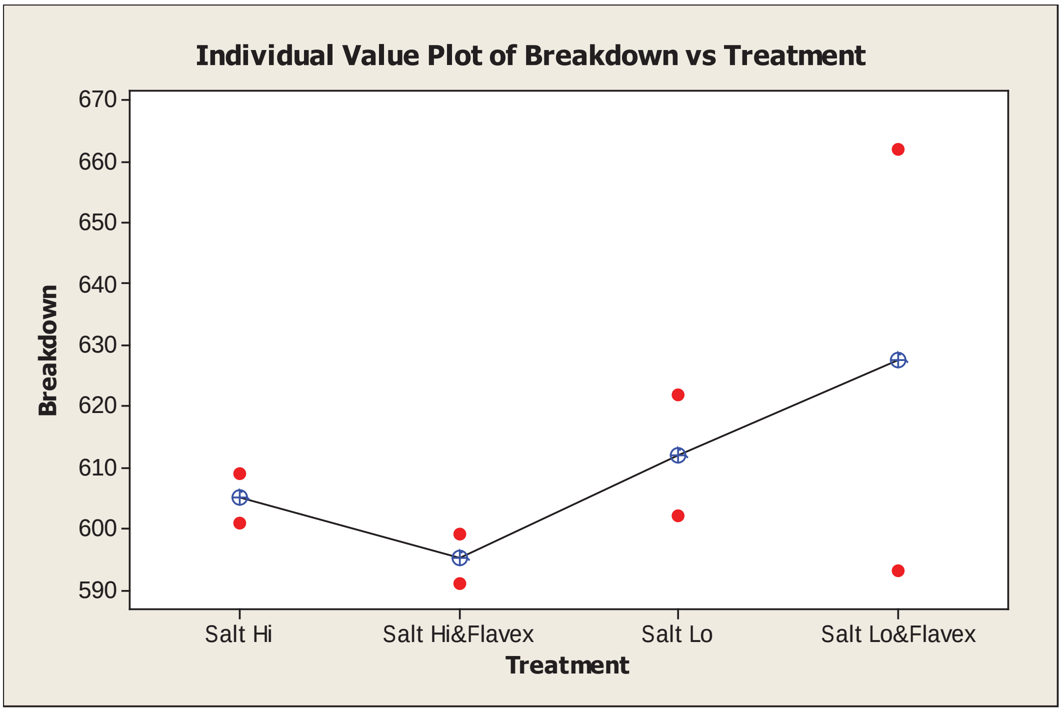


One-way ANOVA: Breakdown versus Treatment

```
Source     DF    SS   MS     F      P
Treatment   3  1120  373  0.56  0.667
Error       4  2645  661
Total       7  3765

S = 25.71   R-Sq = 29.76%   R-Sq(adj) = 0.00%


                                  Individual 95% CIs For Mean Based on
                                  Pooled StDev
Level           N    Mean  StDev  ----+---------+---------+---------+-----
Salt Hi         2  605.00   5.66    (--------------*-------------)
Salt Hi&Flavex  2  595.00   5.66  (-------------*-------------)
Salt Lo         2  612.00  14.14      (--------------*-------------)
Salt Lo&Flavex  2  627.50  48.79           (-------------*--------------)
                                  ----+---------+---------+---------+-----
                                    560       595       630       665

Pooled StDev = 25.71

Grouping Information Using Tukey Method

Treatment       N    Mean  Grouping
Salt Lo&Flavex  2  627.50  A
Salt Lo         2  612.00  A
Salt Hi         2  605.00  A
Salt Hi&Flavex  2  595.00  A

Means that do not share a letter are significantly different.

Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Treatment

Individual confidence level = 98.48%


Treatment = Salt Hi subtracted from:

Treatment         Lower  Centre   Upper
Salt Hi&Flavex  -114.72  -10.00   94.72
Salt Lo          -97.72    7.00  111.72
Salt Lo&Flavex   -82.22   22.50  127.22

Treatment          +---------+---------+---------+---------
Salt Hi&Flavex         (--------------*--------------)
Salt Lo                  (--------------*--------------)
Salt Lo&Flavex             (--------------*--------------)
                   +---------+---------+---------+---------
                -140       -70         0        70


Treatment = Salt Hi&Flavex subtracted from:

Treatment        Lower  Centre   Upper
Salt Lo         -87.72   17.00  121.72
Salt Lo&Flavex  -72.22   32.50  137.22

Treatment          +---------+---------+---------+---------
Salt Lo                   (--------------*--------------)
Salt Lo&Flavex               (--------------*--------------)
                   +---------+---------+---------+---------
                -140       -70         0        70


Treatment = Salt Lo subtracted from:
```

```
Treatment         Lower  Centre   Upper
Salt Lo&Flavex   -89.22   15.50  120.22

Treatment             +---------+---------+---------+---------
Salt Lo&Flavex               (--------------*--------------)
                      +---------+---------+---------+---------
                   -140       -70         0        70
```

Individual Value Plot of Breakdown vs Treatment

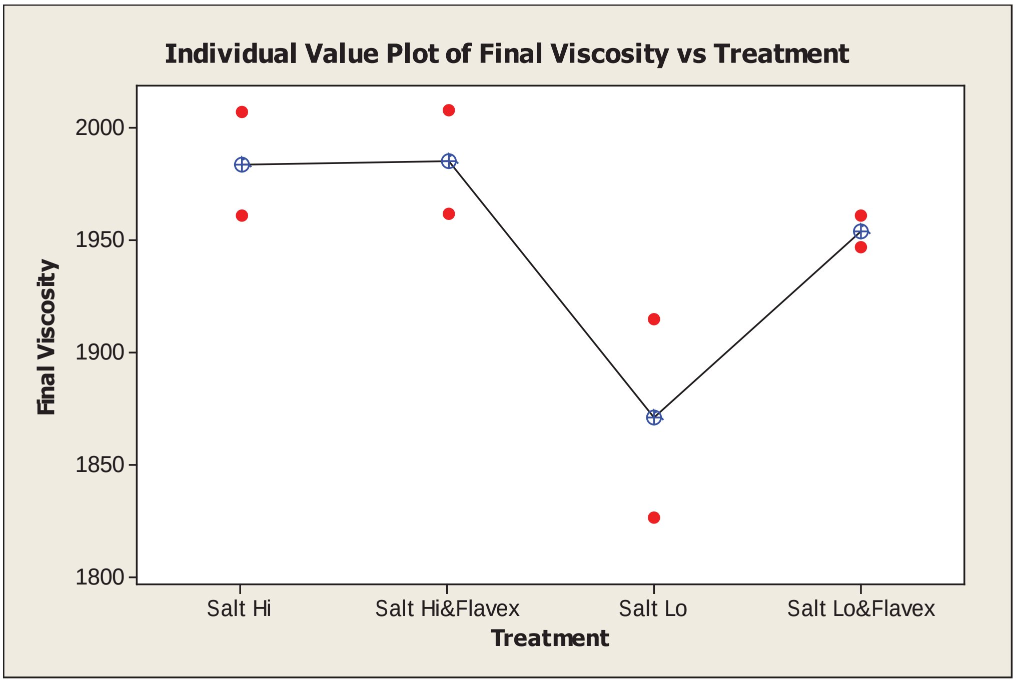


One-way ANOVA: Final Viscosity versus Treatment

```
Source     DF     SS    MS     F      P
Treatment   3  17413  5804  3.76  0.117
Error       4   6175  1544
Total       7  23588

S = 39.29   R-Sq = 73.82%   R-Sq(adj) = 54.19%

                                  Individual 95% CIs For Mean Based on
                                  Pooled StDev
Level           N    Mean  StDev  ----+---------+---------+---------+-----
Salt Hi         2  1984.0   32.5                (----------*----------)
Salt Hi&Flavex  2  1985.0   32.5                 (----------*----------)
Salt Lo         2  1870.5   62.9  (----------*----------)
Salt Lo&Flavex  2  1954.0    9.9             (----------*----------)
                                  ----+---------+---------+---------+-----
                                   1820      1890      1960      2030

Pooled StDev = 39.3

Grouping Information Using Tukey Method

Treatment       N     Mean  Grouping
Salt Hi&Flavex  2  1985.00  A
Salt Hi         2  1984.00  A
Salt Lo&Flavex  2  1954.00  A
Salt Lo         2  1870.50  A

Means that do not share a letter are significantly different.
```

```
Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Treatment

Individual confidence level = 98.48%

Treatment = Salt Hi subtracted from:

Treatment          Lower   Centre   Upper
Salt Hi&Flavex   -159.02     1.00  161.02
Salt Lo          -273.52  -113.50   46.52
Salt Lo&Flavex   -190.02   -30.00  130.02

Treatment        --------+---------+---------+---------+-
Salt Hi&Flavex          (----------*----------)
Salt Lo          (---------*----------)
Salt Lo&Flavex        (----------*----------)
                 --------+---------+---------+---------+-
                      -150         0       150       300

Treatment = Salt Hi&Flavex subtracted from:

Treatment          Lower   Centre   Upper
Salt Lo          -274.52  -114.50   45.52
Salt Lo&Flavex   -191.02   -31.00  129.02

Treatment        --------+---------+---------+---------+-
Salt Lo          (---------*----------)
Salt Lo&Flavex        (----------*----------)
                 --------+---------+---------+---------+-
                      -150         0       150       300

Treatment = Salt Lo subtracted from:

Treatment         Lower  Centre   Upper
Salt Lo&Flavex   -76.52   83.50  243.52

Treatment        --------+---------+---------+---------+-
Salt Lo&Flavex                (----------*---------)
                 --------+---------+---------+---------+-
                      -150         0       150       300
```

Individual Value Plot of Final Viscosity vs Treatment

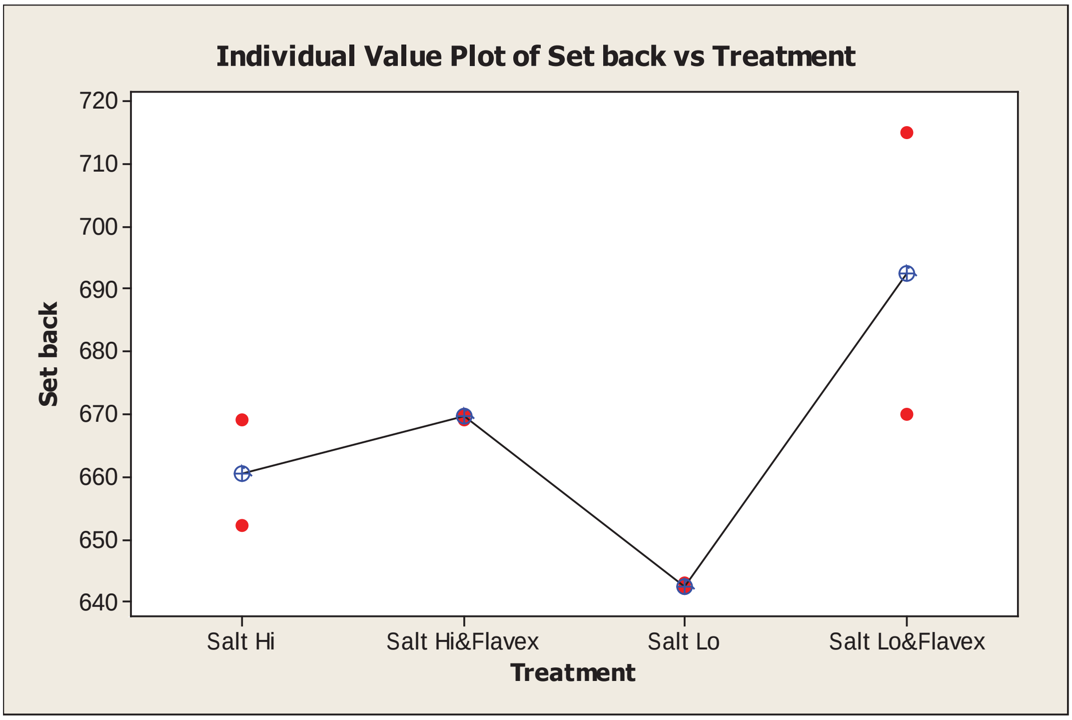


One-way ANOVA: Setback versus Treatment

```
Source     DF    SS   MS     F      P
Treatment   3  2594  865  2.99  0.159
Error       4  1158  290
Total       7  3752

S = 17.01   R-Sq = 69.13%   R-Sq(adj) = 45.98%


                                  Individual 95% CIs For Mean Based on
                                  Pooled StDev
Level            N    Mean  StDev  -------+---------+---------+---------+--
Salt Hi          2  660.50  12.02        (----------*----------)
Salt Hi&Flavex   2  669.50   0.71           (----------*----------)
Salt Lo          2  642.50   0.71  (----------*----------)
Salt Lo&Flavex   2  692.50  31.82                   (----------*----------)
                                   -------+---------+---------+---------+--
                                        630       660       690       720

Pooled StDev = 17.01


Grouping Information Using Tukey Method

Treatment        N    Mean  Grouping
Salt Lo&Flavex   2  692.50  A
Salt Hi&Flavex   2  669.50  A
Salt Hi          2  660.50  A
Salt Lo          2  642.50  A

Means that do not share a letter are significantly different.


Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Treatment

Individual confidence level = 98.48%


Treatment = Salt Hi subtracted from:

Treatment         Lower  Centre   Upper
Salt Hi&Flavex   -60.30    9.00   78.30
Salt Lo          -87.30  -18.00   51.30
Salt Lo&Flavex   -37.30   32.00  101.30

Treatment           +---------+---------+---------+---------
Salt Hi&Flavex                (-----------*----------)
Salt Lo                  (-----------*-----------)
Salt Lo&Flavex                    (----------*-----------)
                    +---------+---------+---------+---------
                 -120       -60         0        60


Treatment = Salt Hi&Flavex subtracted from:

Treatment         Lower  Centre  Upper
Salt Lo          -96.30  -27.00  42.30
Salt Lo&Flavex   -46.30   23.00  92.30

Treatment           +---------+---------+---------+---------
Salt Lo                 (-----------*----------)
Salt Lo&Flavex                  (-----------*----------)
                    +---------+---------+---------+---------
                 -120       -60         0        60
```

```
Treatment = Salt Lo subtracted from:

Treatment        Lower  Centre   Upper
Salt Lo&Flavex  -19.30   50.00  119.30

Treatment          +---------+---------+---------+---------
Salt Lo&Flavex                   (----------*-----------)
                   +---------+---------+---------+---------
                -120       -60         0        60
```

Individual Value Plot of Setback vs Treatment



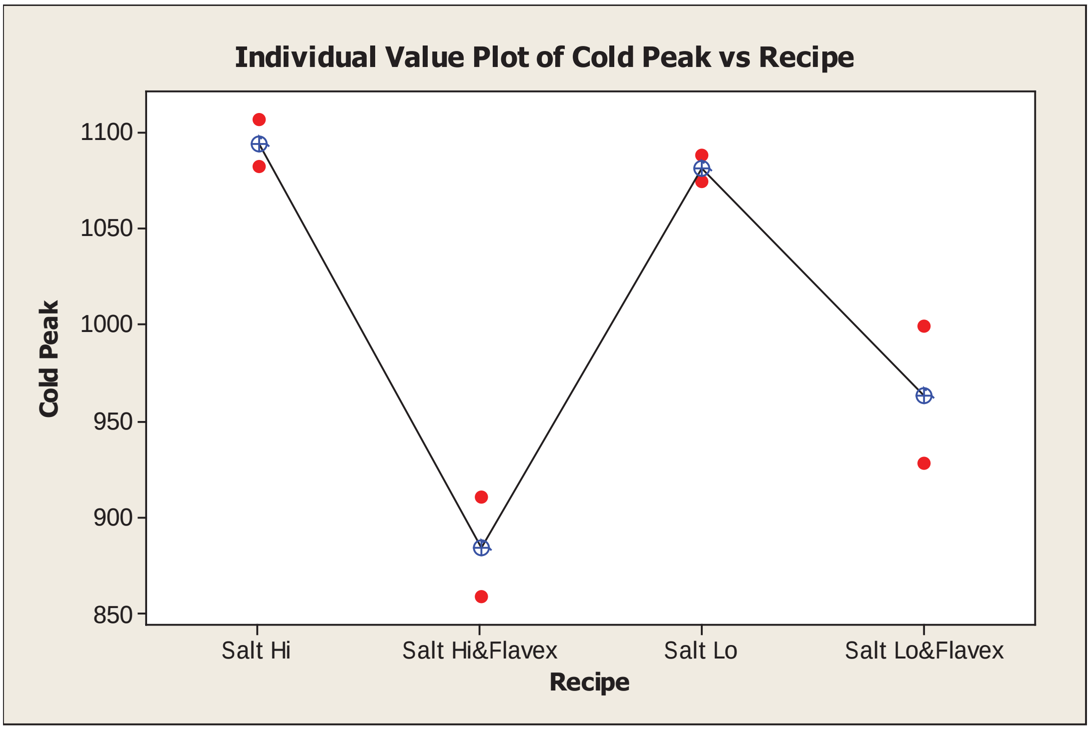
A 7.2 Minitab One-way ANOVA of extruded pellet pasting properties with reformulated 'CW' with salt and Flavex

One-way ANOVA: Cold Peak versus Recipe

```
Source  DF     SS     MS      F      P
Recipe   3  59875  19958  18.98  0.008
Error    4   4207   1052
Total    7  64082

S = 32.43   R-Sq = 93.43%   R-Sq(adj) = 88.51%


                                  Individual 95% CIs For Mean Based on
                                  Pooled StDev
Level            N    Mean  StDev  --------+---------+---------+---------+-
Salt Hi          2  1094.0   17.0                       (-----*------)
Salt Hi&Flavex   2   884.5   36.1  (-----*------)
Salt Lo          2  1081.0    9.9                     (-----*-----)
Salt Lo&Flavex   2   963.5   50.2          (-----*------)
                                   --------+---------+---------+---------+-
                                         900      1000      1100      1200

Pooled StDev = 32.4
```

```
Grouping Information Using Tukey Method

Recipe           N     Mean  Grouping
Salt Hi          2  1094.00  A
Salt Lo          2  1081.00  A
Salt Lo&Flavex  2   963.50  A B
Salt Hi&Flavex  2   884.50    B

Means that do not share a letter are significantly different.


Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Recipe

Individual confidence level = 98.48%


Recipe = Salt Hi subtracted from:

Recipe            Lower   Centre   Upper
Salt Hi&Flavex  -341.59  -209.50  -77.41
Salt Lo         -145.09   -13.00  119.09
Salt Lo&Flavex  -262.59  -130.50    1.59

Recipe          -------+---------+---------+---------+--
Salt Hi&Flavex  (------*-----)
Salt Lo                   (-----*------)
Salt Lo&Flavex      (-----*------)
                -------+---------+---------+---------+--
                    -200         0       200       400


Recipe = Salt Hi&Flavex subtracted from:

Recipe           Lower  Centre   Upper
Salt Lo          64.41  196.50  328.59
Salt Lo&Flavex  -53.09   79.00  211.09

Recipe          -------+---------+---------+---------+--
Salt Lo                             (------*-----)
Salt Lo&Flavex                (------*------)
                -------+---------+---------+---------+--
                    -200         0       200       400


Recipe = Salt Lo subtracted from:

Recipe            Lower   Centre  Upper
Salt Lo&Flavex  -249.59  -117.50  14.59

Recipe          -------+---------+---------+---------+--
Salt Lo&Flavex       (-----*------)
                -------+---------+---------+---------+--
                    -200         0       200       400
```

Individual Value Plot of Cold Peak vs Recipe

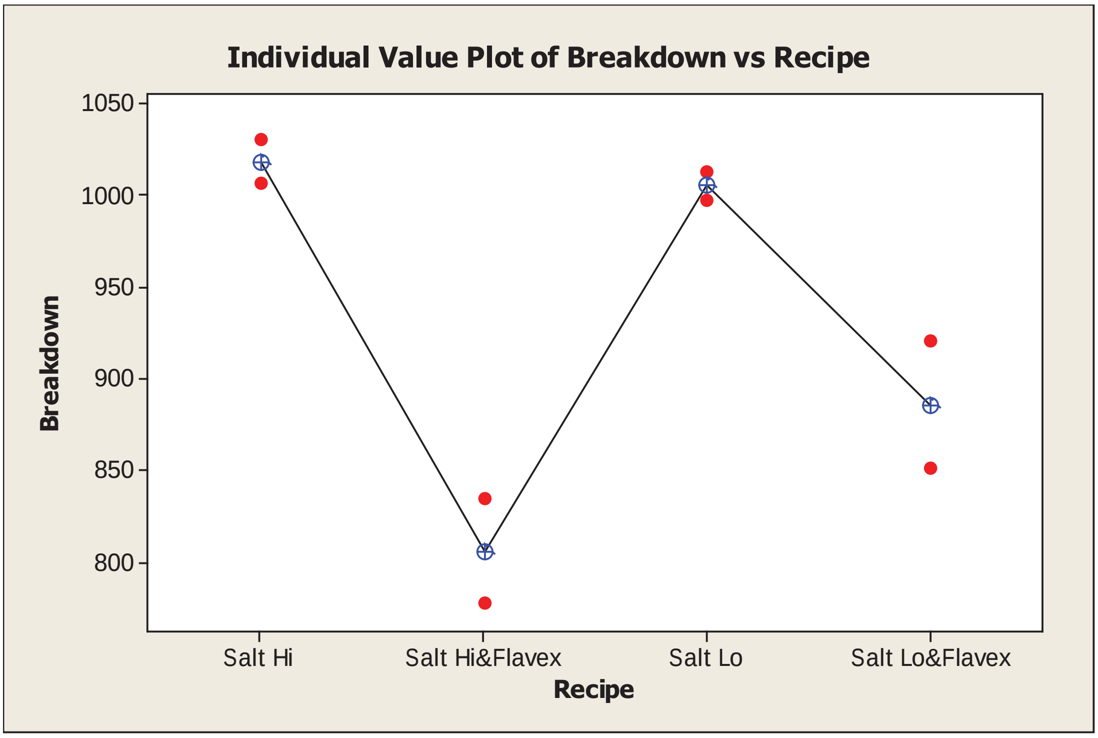


One-way ANOVA: Breakdown versus Recipe

```
Source  DF     SS     MS      F      P
Recipe   3  61681  20560  18.60  0.008
Error    4   4421   1105
Total    7  66102

S = 33.25   R-Sq = 93.31%   R-Sq(adj) = 88.30%


                                  Individual 95% CIs For Mean Based on
                                  Pooled StDev
Level            N    Mean  StDev  ------+---------+---------+---------+---
Salt Hi          2  1018.0   17.0                       (------*-----)
Salt Hi&Flavex   2   805.5   40.3  (------*-----)
Salt Lo          2  1005.0   11.3                     (------*-----)
Salt Lo&Flavex   2   885.5   48.8          (------*-----)
                                   ------+---------+---------+---------+---
                                       800       900      1000      1100

Pooled StDev = 33.2


Grouping Information Using Tukey Method

Recipe           N     Mean  Grouping
Salt Hi          2  1018.00  A
Salt Lo          2  1005.00  A
Salt Lo&Flavex   2   885.50  A B
Salt Hi&Flavex   2   805.50    B

Means that do not share a letter are significantly different.


Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Recipe

Individual confidence level = 98.48%
```

```
Recipe = Salt Hi subtracted from:

Recipe              Lower   Centre   Upper
Salt Hi&Flavex    -347.91  -212.50  -77.09
Salt Lo           -148.41   -13.00  122.41
Salt Lo&Flavex    -267.91  -132.50    2.91

Recipe            -------+---------+---------+---------+--
Salt Hi&Flavex    (-----*------)
Salt Lo                     (-----*------)
Salt Lo&Flavex        (-----*------)
                  -------+---------+---------+---------+--
                      -200         0       200       400


Recipe = Salt Hi&Flavex subtracted from:

Recipe             Lower  Centre   Upper
Salt Lo            64.09  199.50  334.91
Salt Lo&Flavex    -55.41   80.00  215.41

Recipe            -------+---------+---------+---------+--
Salt Lo                             (------*------)
Salt Lo&Flavex                (------*------)
                  -------+---------+---------+---------+--
                      -200         0       200       400


Recipe = Salt Lo subtracted from:

Recipe              Lower   Centre  Upper
Salt Lo&Flavex    -254.91  -119.50  15.91

Recipe            -------+---------+---------+---------+--
Salt Lo&Flavex        (------*------)
                  -------+---------+---------+---------+--
                      -200         0       200       400
```

Individual Value Plot of Breakdown vs Recipe

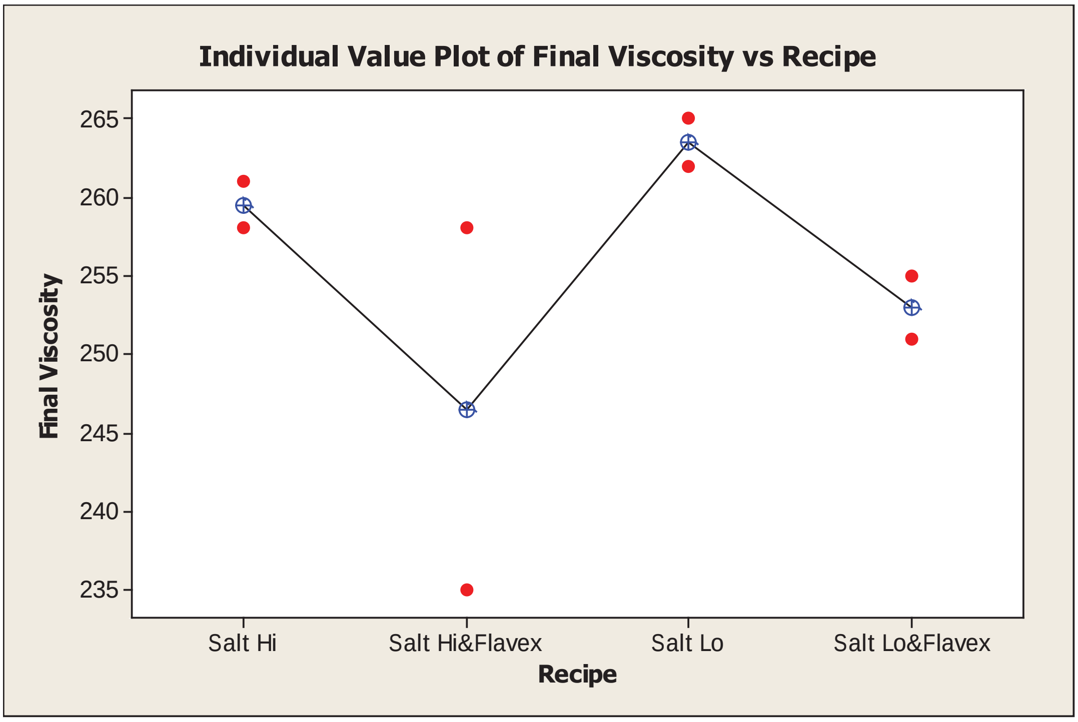


One-way ANOVA: Final Viscosity versus Recipe

```
Source  DF     SS     MS     F      P
Recipe   3  334.4  111.5  1.58  0.326
Error    4  281.5   70.4
Total    7  615.9

S = 8.389   R-Sq = 54.29%   R-Sq(adj) = 20.01%


                                  Individual 95% CIs For Mean Based on
                                  Pooled StDev
Level           N    Mean  StDev  -------+---------+---------+---------+--
Salt Hi         2  259.50   2.12           (----------*----------)
Salt Hi&Flavex  2  246.50  16.26  (----------*----------)
Salt Lo         2  263.50   2.12              (----------*----------)
Salt Lo&Flavex  2  253.00   2.83       (----------*----------)
                                  -------+---------+---------+---------+--
                                       240       255       270       285

Pooled StDev = 8.39


Grouping Information Using Tukey Method

Recipe          N     Mean  Grouping
Salt Lo         2  263.500  A
Salt Hi         2  259.500  A
Salt Lo&Flavex  2  253.000  A
Salt Hi&Flavex  2  246.500  A

Means that do not share a letter are significantly different.

Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Recipe

Individual confidence level = 98.48%


Recipe = Salt Hi subtracted from:

Recipe            Lower   Centre   Upper
Salt Hi&Flavex  -47.168  -13.000  21.168
Salt Lo         -30.168    4.000  38.168
Salt Lo&Flavex  -40.668   -6.500  27.668

Recipe          -------+---------+---------+---------+--
Salt Hi&Flavex   (-----------*----------)
Salt Lo                (----------*-----------)
Salt Lo&Flavex     (-----------*----------)
                -------+---------+---------+---------+--
                     -30         0        30        60


Recipe = Salt Hi&Flavex subtracted from:

Recipe            Lower  Centre   Upper
Salt Lo         -17.168  17.000  51.168
Salt Lo&Flavex  -27.668   6.500  40.668

Recipe          -------+---------+---------+---------+--
Salt Lo                    (-----------*----------)
Salt Lo&Flavex          (----------*-----------)
                -------+---------+---------+---------+--
                     -30         0        30        60


Recipe = Salt Lo subtracted from:
```

```
Recipe              Lower   Centre   Upper
Salt Lo&Flavex    -44.668  -10.500  23.668

Recipe            -------+---------+---------+---------+--
Salt Lo&Flavex      (-----------*----------)
                  -------+---------+---------+---------+--
                       -30         0        30        60
```

Individual Value Plot of Final Viscosity vs Recipe

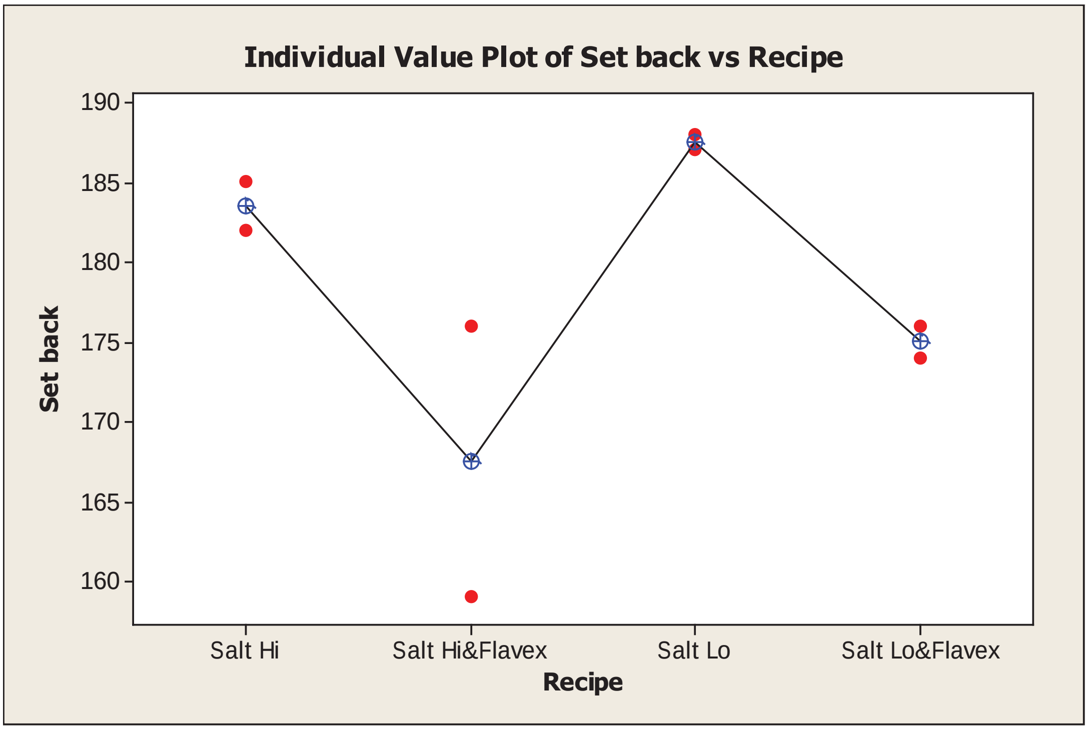


One-way ANOVA: Setback versus Recipe

```
Source  DF     SS     MS     F      P
Recipe   3  478.4  159.5  4.21  0.099
Error    4  151.5   37.9
Total    7  629.9

S = 6.154   R-Sq = 75.95%   R-Sq(adj) = 57.91%


Level           N    Mean  StDev
Salt Hi         2  183.50   2.12
Salt Hi&Flavex  2  167.50  12.02
Salt Lo         2  187.50   0.71
Salt Lo&Flavex  2  175.00   1.41

                Individual 95% CIs For Mean Based on Pooled StDev
Level             +---------+---------+---------+---------
Salt Hi                       (---------*---------)
Salt Hi&Flavex    (---------*---------)
Salt Lo                          (---------*---------)
Salt Lo&Flavex          (---------*---------)
                  +---------+---------+---------+---------
                156       168       180       192

Pooled StDev = 6.15
```

```
Grouping Information Using Tukey Method

Recipe          N     Mean  Grouping
Salt Lo         2  187.500  A
Salt Hi         2  183.500  A
Salt Lo&Flavex  2  175.000  A
Salt Hi&Flavex  2  167.500  A

Means that do not share a letter are significantly different.


Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Recipe

Individual confidence level = 98.48%


Recipe = Salt Hi subtracted from:

Recipe            Lower   Centre   Upper
Salt Hi&Flavex  -41.066  -16.000   9.066
Salt Lo         -21.066    4.000  29.066
Salt Lo&Flavex  -33.566   -8.500  16.566

Recipe          --------+---------+---------+---------+-
Salt Hi&Flavex    (---------*---------)
Salt Lo                   (---------*---------)
Salt Lo&Flavex       (---------*---------)
                --------+---------+---------+---------+-
                      -25         0        25        50


Recipe = Salt Hi&Flavex subtracted from:

Recipe            Lower  Centre   Upper
Salt Lo          -5.066  20.000  45.066
Salt Lo&Flavex  -17.566   7.500  32.566

Recipe          --------+---------+---------+---------+-
Salt Lo                         (---------*---------)
Salt Lo&Flavex             (---------*---------)
                --------+---------+---------+---------+-
                      -25         0        25        50


Recipe = Salt Lo subtracted from:

Recipe            Lower   Centre   Upper
Salt Lo&Flavex  -37.566  -12.500  12.566

Recipe          --------+---------+---------+---------+-
Salt Lo&Flavex     (---------*---------)
                --------+---------+---------+---------+-
                      -25         0        25        50
```

Individual Value Plot of Setback vs Recipe



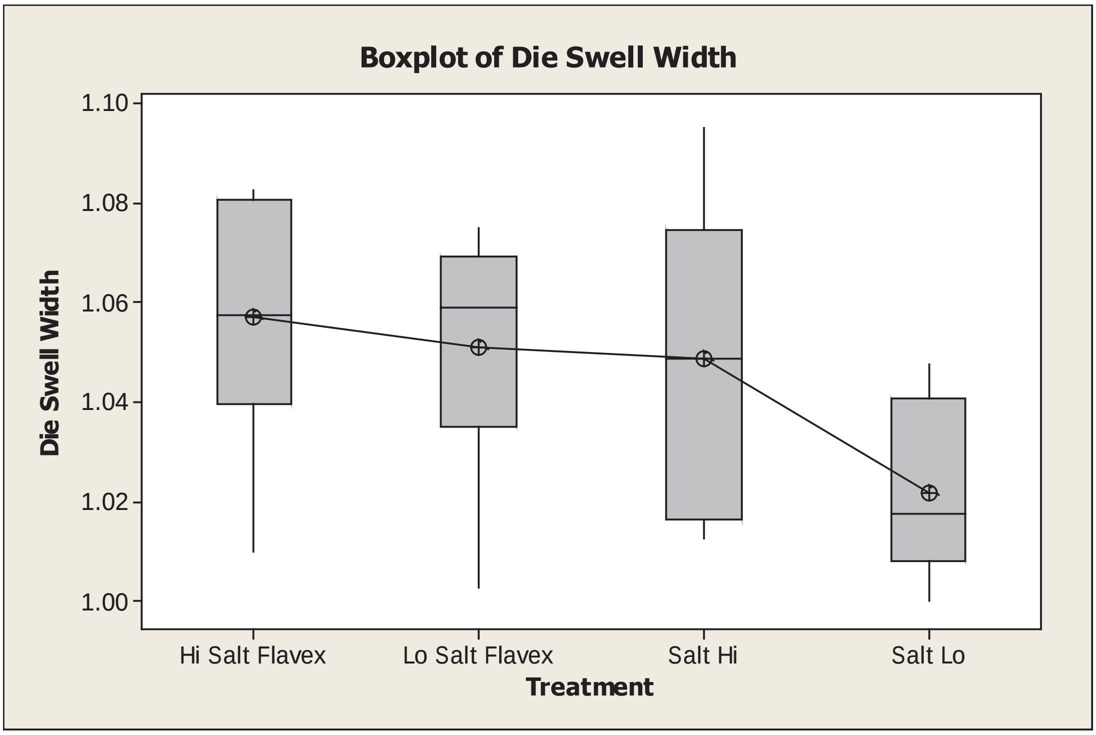
A 7.3 Minitab One-way ANOVA of die swell with reformulated 'CW' with salt and Flavex

One-way ANOVA: Die Swell Width versus Treatment

```
Source     DF        SS        MS     F      P
Treatment   3  0.007320  0.002440  4.10  0.013
Error      36  0.021428  0.000595
Total      39  0.028749

S = 0.02440   R-Sq = 25.46%   R-Sq(adj) = 19.25%


                                    Individual 95% CIs For Mean Based on
                                    Pooled StDev
Level            N    Mean   StDev  -------+---------+---------+---------+--
Hi Salt Flavex  10  1.0570  0.0243                    (------*-------)
Lo Salt Flavex  10  1.0510  0.0249                 (------*-------)
Salt Hi         10  1.0485  0.0296               (-------*-------)
Salt Lo         10  1.0217  0.0170  (-------*-------)
                                    -------+---------+---------+---------+--
                                         1.020     1.040     1.060     1.080

Pooled StDev = 0.0244

Grouping Information Using Tukey Method

Treatment        N     Mean  Grouping
Hi Salt Flavex  10  1.05700  A
Lo Salt Flavex  10  1.05100  A B
Salt Hi         10  1.04850  A B
Salt Lo         10  1.02175    B

Means that do not share a letter are significantly different.


Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Treatment

Individual confidence level = 98.93%
```

```
Treatment = Hi Salt Flavex subtracted from:

Treatment          Lower    Centre     Upper
Lo Salt Flavex  -0.03539  -0.00600   0.02339
Salt Hi         -0.03789  -0.00850   0.02089
Salt Lo         -0.06464  -0.03525  -0.00586

Treatment       --------+---------+---------+---------+-
Lo Salt Flavex          (-------*--------)
Salt Hi                (--------*-------)
Salt Lo         (-------*-------)
                --------+---------+---------+---------+-
                     -0.035     0.000     0.035     0.070


Treatment = Lo Salt Flavex subtracted from:

Treatment     Lower    Centre    Upper
Salt Hi    -0.03189  -0.00250  0.02689
Salt Lo    -0.05864  -0.02925  0.00014

Treatment  --------+---------+---------+---------+-
Salt Hi             (-------*--------)
Salt Lo     (--------*-------)
           --------+---------+---------+---------+-
                -0.035     0.000     0.035     0.070


Treatment = Salt Hi subtracted from:

Treatment     Lower    Centre    Upper
Salt Lo    -0.05614  -0.02675  0.00264

Treatment  --------+---------+---------+---------+-
Salt Lo      (-------*--------)
           --------+---------+---------+---------+-
                -0.035     0.000     0.035     0.070
```

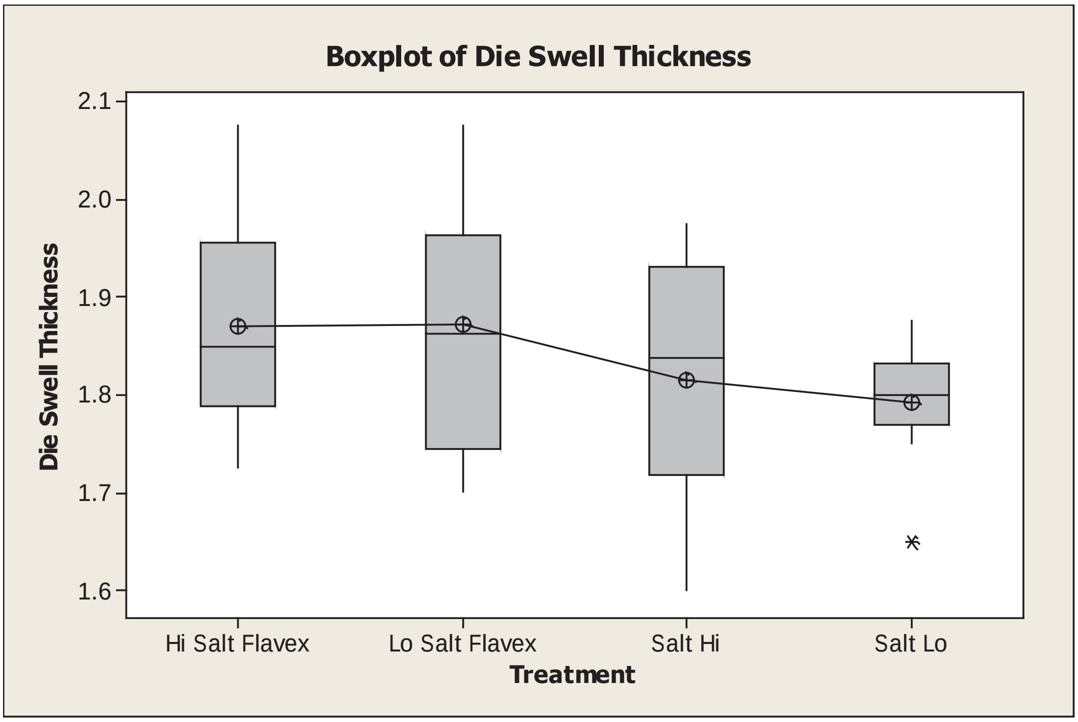
Boxplot of Die Swell Width



One-way ANOVA: Die Swell Thickness versus Treatment

```
Source     DF      SS      MS     F      P
Treatment   3  0.0481  0.0160  1.29  0.293
Error      36  0.4481  0.0124
Total      39  0.4962

S = 0.1116   R-Sq = 9.70%   R-Sq(adj) = 2.17%

                                    Individual 95% CIs For Mean Based on
                                    Pooled StDev
Level            N    Mean   StDev  ---+---------+---------+---------+------
Hi Salt Flavex  10  1.8700  0.1171               (-----------*-----------)
Lo Salt Flavex  10  1.8725  0.1304               (-----------*-----------)
Salt Hi         10  1.8150  0.1232      (-----------*----------)
Salt Lo         10  1.7925  0.0624  (-----------*-----------)
                                    ---+---------+---------+---------+------
                                     1.740     1.800     1.860     1.920

Pooled StDev = 0.1116

Grouping Information Using Tukey Method

Treatment        N    Mean  Grouping
Lo Salt Flavex  10  1.8725  A
Hi Salt Flavex  10  1.8700  A
Salt Hi         10  1.8150  A
Salt Lo         10  1.7925  A

Means that do not share a letter are significantly different.

Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Treatment

Individual confidence level = 98.93%


Treatment = Hi Salt Flavex subtracted from:

Treatment         Lower   Centre   Upper
Lo Salt Flavex  -0.1319   0.0025  0.1369
Salt Hi         -0.1894  -0.0550  0.0794
Salt Lo         -0.2119  -0.0775  0.0569

Treatment       --------+---------+---------+---------+-
Lo Salt Flavex         (----------*----------)
Salt Hi           (----------*-----------)
Salt Lo         (-----------*----------)
                --------+---------+---------+---------+-
                     -0.12      0.00      0.12      0.24


Treatment = Lo Salt Flavex subtracted from:

Treatment    Lower   Centre   Upper  --------+---------+---------+---------+-
Salt Hi    -0.1919  -0.0575  0.0769    (----------*----------)
Salt Lo    -0.2144  -0.0800  0.0544  (----------*-----------)
                                     --------+---------+---------+---------+-
                                          -0.12      0.00      0.12      0.24


Treatment = Salt Hi subtracted from:

Treatment    Lower   Centre   Upper  --------+---------+---------+---------+-
Salt Lo    -0.1569  -0.0225  0.1119      (----------*----------)
                                     --------+---------+---------+---------+-
                                          -0.12      0.00      0.12      0.24
```

Boxplot of Die Swell Thickness

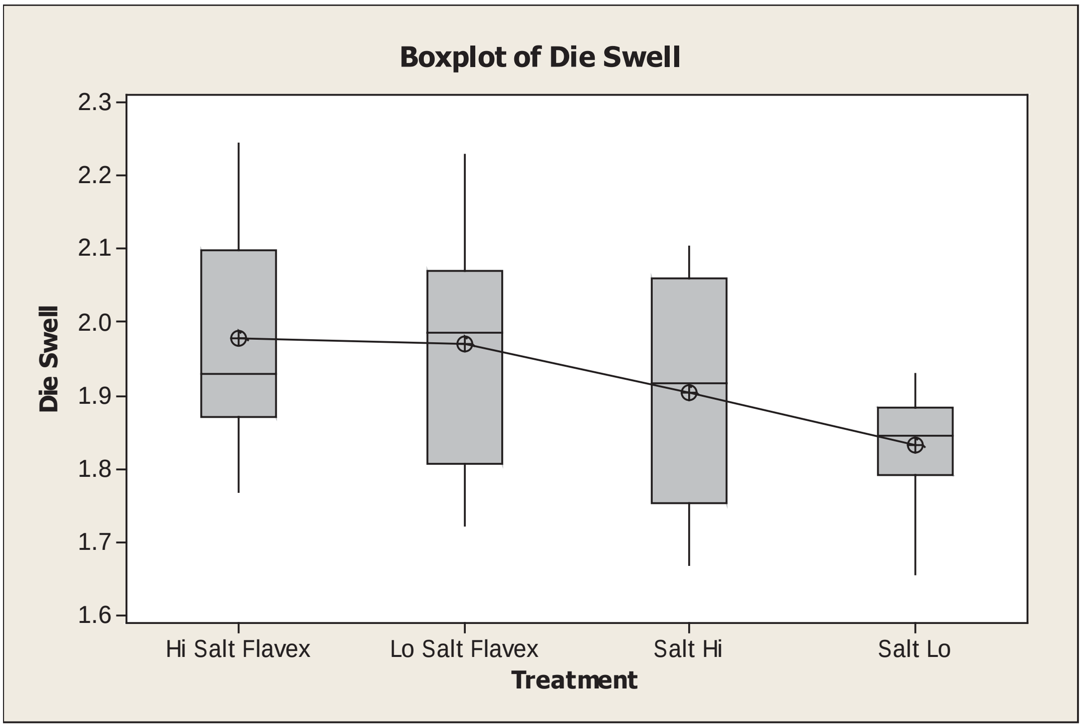


One-way ANOVA: Die Swell versus Treatment

```
Source     DF      SS      MS     F      P
Treatment   3  0.1384  0.0461  2.21  0.104
Error      36  0.7511  0.0209
Total      39  0.8895

S = 0.1444   R-Sq = 15.56%   R-Sq(adj) = 8.52%


                                    Individual 95% CIs For Mean Based on
                                    Pooled StDev
Level            N    Mean   StDev  ------+---------+---------+---------+---
Hi Salt Flavex  10  1.9778  0.1521                (--------*--------)
Lo Salt Flavex  10  1.9698  0.1691               (--------*--------)
Salt Hi         10  1.9044  0.1595         (--------*---------)
Salt Lo         10  1.8318  0.0793  (--------*--------)
                                    ------+---------+---------+---------+---
                                        1.80      1.90      2.00      2.10

Pooled StDev = 0.1444

Grouping Information Using Tukey Method

Treatment        N    Mean  Grouping
Hi Salt Flavex  10  1.9778  A
Lo Salt Flavex  10  1.9698  A
Salt Hi         10  1.9044  A
Salt Lo         10  1.8318  A

Means that do not share a letter are significantly different.

Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Treatment

Individual confidence level = 98.93%
```

```
Treatment = Hi Salt Flavex subtracted from:

Treatment         Lower   Centre   Upper
Lo Salt Flavex  -0.1821  -0.0080  0.1660
Salt Hi         -0.2475  -0.0734  0.1006
Salt Lo         -0.3201  -0.1460  0.0280

Treatment          +---------+---------+---------+---------
Lo Salt Flavex              (---------*----------)
Salt Hi                 (---------*----------)
Salt Lo            (----------*----------)
                   +---------+---------+---------+---------
                -0.32     -0.16      0.00      0.16


Treatment = Lo Salt Flavex subtracted from:

Treatment    Lower   Centre   Upper
Salt Hi    -0.2394  -0.0654  0.1086
Salt Lo    -0.3120  -0.1380  0.0361

Treatment     +---------+---------+---------+---------
Salt Hi            (----------*----------)
Salt Lo       (----------*----------)
              +---------+---------+---------+---------
           -0.32     -0.16      0.00      0.16


Treatment = Salt Hi subtracted from:

Treatment    Lower   Centre   Upper
Salt Lo    -0.2466  -0.0726  0.1014

Treatment     +---------+---------+---------+---------
Salt Lo            (---------*----------)
              +---------+---------+---------+---------
           -0.32     -0.16      0.00      0.16
```

Boxplot of Die Swell



A 7.4 Minitab General Linear Model analysis of SEI and particle density with dried pellet moisture, Flavex and salt contents

A 7.4.1 General Linear Model: SEI versus Moisture, Flavex, Salt

```
Factor    Type   Levels  Values
Moisture  fixed       3  9.5, 10.6, 12.1
Flavex    fixed       2  0.0, 0.3
Salt      fixed       2  0.5, 1.0


Analysis of Variance for SEI, using Adjusted SS for Tests

Source     DF  Seq SS  Adj SS  Adj MS       F      P
Moisture    2  205.70  205.70  102.85   72.38  0.000
Flavex      1  221.18  221.18  221.18  155.65  0.000
Salt        1   22.77   22.77   22.77   16.02  0.000
Error     115  163.41  163.41    1.42
Total     119  613.06


S = 1.19204   R-Sq = 73.34%   R-Sq(adj) = 72.42%


Unusual Observations for SEI

Obs      SEI      Fit  SE Fit  Residual  St Resid
 11  19.3489  16.8236  0.2433    2.5253      2.16 R
 15  19.4575  16.8236  0.2433    2.6339      2.26 R
 30  21.6877  18.6676  0.2433    3.0201      2.59 R
 36  16.8919  19.5388  0.2433   -2.6469     -2.27 R
 61  21.3777  17.1006  0.2433    4.2771      3.67 R

R denotes an observation with a large standardized residual.
```

A 7.4.2 General Linear Model: Particle density versus Moisture, Flavex, Salt

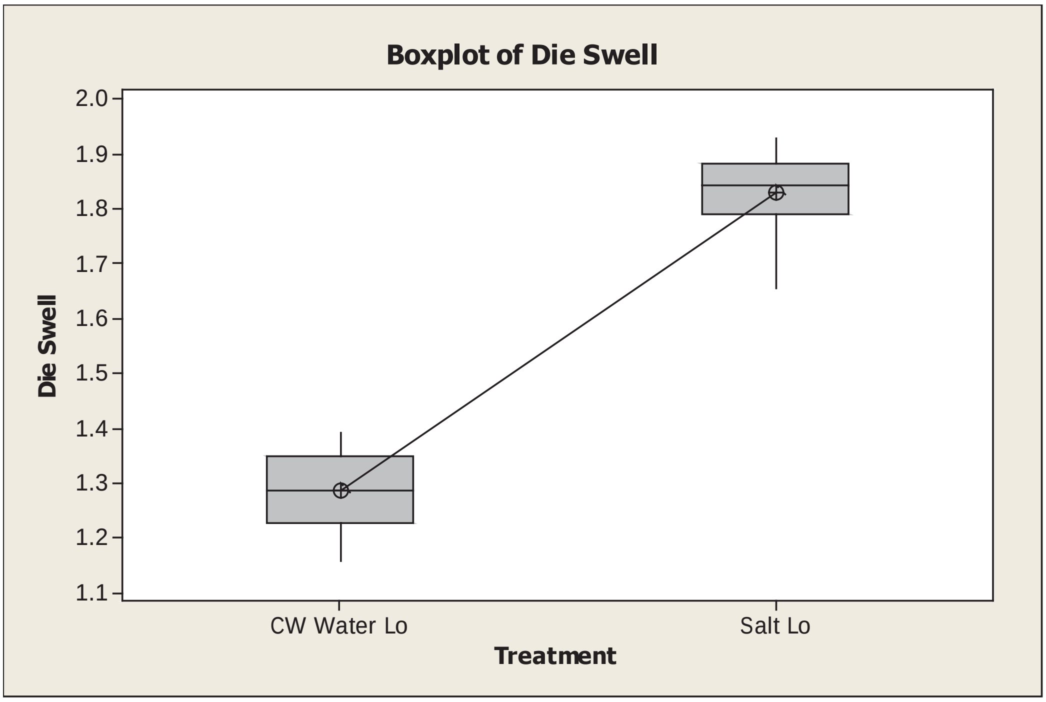
```
Factor    Type   Levels  Values
Moisture  fixed       3  9.5, 10.6, 12.1
Flavex    fixed       2  0.0, 0.3
Salt      fixed       2  0.5, 1.0


Analysis of Variance for Particle density, using Adjusted SS for Tests

Source    DF   Seq SS   Adj SS  Adj MS      F      P
Moisture   2  19849.3  19849.3  9924.7  51.90  0.000
Flavex     1   4427.1   4427.1  4427.1  23.15  0.000
Salt       1    990.5    990.5   990.5   5.18  0.030
Error     31   5927.6   5927.6   191.2
Total     35  31194.5


S = 13.8280   R-Sq = 81.00%   R-Sq(adj) = 78.55%


Unusual Observations for Particle density

     Particle
Obs   density      Fit  SE Fit  Residual  St Resid
  9   315.215  280.726   5.153    34.489      2.69 R

R denotes an observation with a large standardized residual.
```

A 7.5 Comparison of pellet die swell and product SEI on original and reformulated 3G formulation CW

One-way ANOVA: Die Swell versus Treatment

```
Source     DF       SS       MS       F      P
Treatment   1  1.49048  1.49048  255.65  0.000
Error      18  0.10494  0.00583
Total      19  1.59542

S = 0.07635   R-Sq = 93.42%   R-Sq(adj) = 93.06%


                                 Individual 95% CIs For Mean Based on
                                 Pooled StDev
Level         N    Mean   StDev  --------+---------+---------+---------+-
CW Water Lo  10  1.2858  0.0733  (-*--)
Salt Lo      10  1.8318  0.0793                             (--*-)
                                 --------+---------+---------+---------+-
                                      1.40      1.60      1.80      2.00

Pooled StDev = 0.0764


Grouping Information Using Tukey Method

Treatment     N     Mean  Grouping
Salt Lo      10  1.83182  A
CW Water Lo  10  1.28584    B

Means that do not share a letter are significantly different.


Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Treatment

Individual confidence level = 95.00%


Treatment = CW Water Lo subtracted from:

Treatment    Lower   Center    Upper  ----+---------+---------+---------+-----
Salt Lo    0.47424  0.54598  0.61772                              (--*---)
                                      ----+---------+---------+---------+-----
                                        0.00      0.20      0.40      0.60
```

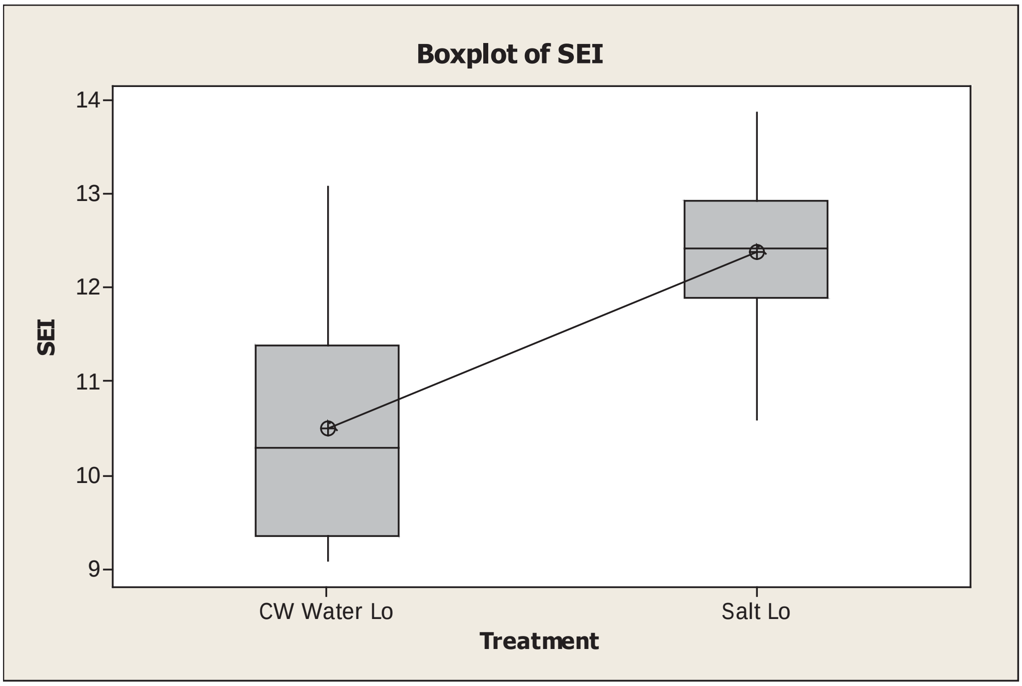
Boxplot of Die Swell



One-way ANOVA: SEI versus Treatment

```
Source     DF     SS     MS      F      P
Treatment   1  17.81  17.81  15.36  0.001
Error      18  20.88   1.16
Total      19  38.69

S = 1.077   R-Sq = 46.04%   R-Sq(adj) = 43.04%


                                Individual 95% CIs For Mean Based on
                                Pooled StDev
Level         N    Mean  StDev   --+---------+---------+---------+-------
CW Water Lo  10  10.498  1.248   (------*------)
Salt Lo      10  12.386  0.873                     (------*------)
                                 --+---------+---------+---------+-------
                                10.0      11.0      12.0      13.0

Pooled StDev = 1.077


Grouping Information Using Tukey Method

Treatment     N    Mean  Grouping
Salt Lo      10  12.386  A
CW Water Lo  10  10.498    B

Means that do not share a letter are significantly different.

Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Treatment

Individual confidence level = 95.00%

Treatment = CW Water Lo subtracted from:

Treatment  Lower  Center  Upper     +---------+---------+---------+---------
Salt Lo    0.876   1.887  2.899                        (---------*---------)
                                    +---------+---------+---------+---------
                                 -1.0       0.0       1.0       2.0
```

Boxplot of SEI



A 7.6 Minitab One-way ANOVA of max compressive load force and product bulk density with reformulated 3G product prototypes and commercial products

A 7.5.1 One-way ANOVA: Max Force Loaded versus Sample ID

```
Source     DF       SS      MS       F      P
Sample ID   9  1137437  126382  110.15  0.000
Error      20    22948    1147
Total      29  1160386

S = 33.87   R-Sq = 98.02%   R-Sq(adj) = 97.13%


                                Individual 95% CIs For Mean Based on
                                Pooled StDev
Level          N    Mean  StDev  -------+---------+---------+---------+--
Burger Ring    3   78.93   4.65  (-*--)
Cheezels       3   91.02   3.04  (--*--)
CW Salt Hi     3  586.40  18.99                                 (--*--)
Good Puffs     3  135.74   2.66     (--*--)
Grain Waves    3  310.25  55.66                 (--*-)
Rice Wheels    3  457.20  40.51                           (-*--)
RW Salt Hi     3  499.64  74.12                              (-*--)
RWC Salt Hi    3  543.34  25.94                                 (-*--)
SKOF Tripods   3  114.07   4.27    (--*-)
Twisties       3  161.49  12.31       (--*-)
                                 -------+---------+---------+---------+--
                                      150       300       450       600

Pooled StDev = 33.87


Grouping Information Using Tukey Method
```

```
Sample ID     N    Mean  Grouping
CW Salt Hi    3  586.40  A
RWC Salt Hi   3  543.34  A B
RW Salt Hi    3  499.64  A B
Rice Wheels   3  457.20    B
Grain Waves   3  310.25      C
Twisties      3  161.49        D
Good Puffs    3  135.74        D
SKOF Tripods  3  114.07        D
Cheezels      3   91.02        D
Burger Ring   3   78.93        D
```

Means that do not share a letter are significantly different.

Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Sample ID

Individual confidence level = 99.80%

Sample ID = Burger Ring subtracted from:

```
Sample ID      Lower  Centre   Upper
Cheezels      -85.89   12.09  110.07
CW Salt Hi    409.49  507.47  605.45
Good Puffs    -41.17   56.81  154.79
Grain Waves   133.34  231.32  329.30
Rice Wheels   280.29  378.27  476.25
RW Salt Hi    322.73  420.71  518.69
RWC Salt Hi   366.43  464.41  562.39
SKOF Tripods  -62.84   35.14  133.12
Twisties      -15.42   82.56  180.54

Sample ID        +---------+---------+---------+---------
Cheezels                          (--*---)
CW Salt Hi                                         (--*--)
Good Puffs                          (--*--)
Grain Waves                              (---*--)
Rice Wheels                                   (---*--)
RW Salt Hi                                      (--*--)
RWC Salt Hi                                      (--*---)
SKOF Tripods                       (--*--)
Twisties                            (---*--)
                 +---------+---------+---------+---------
              -600      -300         0       300
```

Sample ID = Cheezels subtracted from:

```
Sample ID      Lower  Centre   Upper
CW Salt Hi    397.39  495.37  593.35
Good Puffs    -53.27   44.71  142.69
Grain Waves   121.25  219.23  317.21
Rice Wheels   268.20  366.18  464.16
RW Salt Hi    310.64  408.62  506.60
RWC Salt Hi   354.34  452.32  550.30
SKOF Tripods  -74.94   23.04  121.02
Twisties      -27.51   70.47  168.45

Sample ID        +---------+---------+---------+---------
CW Salt Hi                                        (---*--)
Good Puffs                         (--*---)
Grain Waves                              (--*---)
Rice Wheels                                   (--*--)
RW Salt Hi                                     (---*--)
RWC Salt Hi                                      (--*--)
SKOF Tripods                       (--*--)
Twisties                            (--*---)
                 +---------+---------+---------+---------
              -600      -300         0       300
```

```
Sample ID = CW Salt Hi subtracted from:

Sample ID       Lower   Centre    Upper
Good Puffs    -548.64  -450.66  -352.68
Grain Waves   -374.12  -276.14  -178.16
Rice Wheels   -227.17  -129.19   -31.21
RW Salt Hi    -184.73   -86.75    11.23
RWC Salt Hi   -141.04   -43.06    54.92
SKOF Tripods  -570.31  -472.33  -374.35
Twisties      -522.88  -424.90  -326.92

Sample ID        +---------+---------+---------+---------
Good Puffs         (--*--)
Grain Waves              (--*--)
Rice Wheels                  (---*--)
RW Salt Hi                     (--*--)
RWC Salt Hi                     (---*--)
SKOF Tripods      (--*---)
Twisties            (--*--)
                 +---------+---------+---------+---------
              -600      -300         0       300

Sample ID = Good Puffs subtracted from:

Sample ID       Lower  Centre   Upper
Grain Waves     76.54  174.52  272.50
Rice Wheels    223.49  321.47  419.45
RW Salt Hi     265.93  363.91  461.89
RWC Salt Hi    309.62  407.60  505.58
SKOF Tripods  -119.65  -21.67   76.31
Twisties       -72.22   25.76  123.74

Sample ID        +---------+---------+---------+---------
Grain Waves                             (--*--)
Rice Wheels                                 (---*--)
RW Salt Hi                                    (--*--)
RWC Salt Hi                                    (---*--)
SKOF Tripods                     (--*---)
Twisties                           (--*--)
                 +---------+---------+---------+---------
              -600      -300         0       300

Sample ID = Grain Waves subtracted from:

Sample ID       Lower   Centre   Upper
Rice Wheels     48.97   146.95  244.93
RW Salt Hi      91.41   189.39  287.37
RWC Salt Hi    135.11   233.09  331.07
SKOF Tripods  -294.17  -196.19  -98.21
Twisties      -246.74  -148.76  -50.78

Sample ID        +---------+---------+---------+---------
Rice Wheels                            (--*--)
RW Salt Hi                              (--*---)
RWC Salt Hi                               (--*--)
SKOF Tripods                (--*---)
Twisties                      (--*--)
                 +---------+---------+---------+---------
              -600      -300         0       300

Sample ID = Rice Wheels subtracted from:

Sample ID       Lower   Centre    Upper
RW Salt Hi     -55.54    42.44   140.42
RWC Salt Hi    -11.84    86.14   184.12
SKOF Tripods  -441.12  -343.14  -245.16
Twisties      -393.69  -295.71  -197.73
```

```
Sample ID        +---------+---------+---------+---------
RW Salt Hi                        (--*---)
RWC Salt Hi                         (--*--)
SKOF Tripods          (---*--)
Twisties                (--*--)
                 +---------+---------+---------+---------
              -600      -300         0       300
```

Sample ID = RW Salt Hi subtracted from:

```
Sample ID       Lower   Centre    Upper
RWC Salt Hi    -54.28    43.70   141.68
SKOF Tripods  -483.56  -385.58  -287.60
Twisties      -436.13  -338.15  -240.17
```

```
Sample ID        +---------+---------+---------+---------
RWC Salt Hi                       (--*---)
SKOF Tripods         (--*--)
Twisties              (---*--)
                 +---------+---------+---------+---------
              -600      -300         0       300
```

Sample ID = RWC Salt Hi subtracted from:

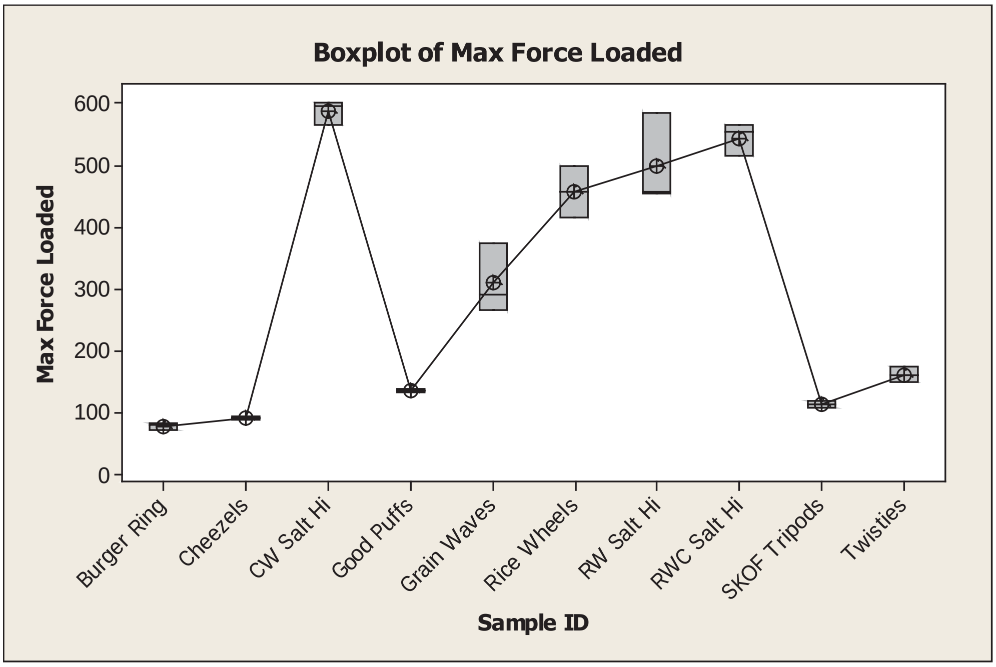
```
Sample ID       Lower   Centre    Upper
SKOF Tripods  -527.25  -429.27  -331.29
Twisties      -479.83  -381.85  -283.87
```

```
Sample ID        +---------+---------+---------+---------
SKOF Tripods       (---*--)
Twisties             (--*---)
                 +---------+---------+---------+---------
              -600      -300         0       300
```

Sample ID = SKOF Tripods subtracted from:

```
Sample ID   Lower  Centre   Upper     +---------+---------+---------+---------
Twisties   -50.55   47.43  145.41                       (---*--)
                                      +---------+---------+---------+---------
                                   -600      -300         0       300
```

Boxplot of Max Force Loaded



A 7.5.2 One-way ANOVA: Bulk Density versus Sample ID

```
Source      DF        SS       MS       F      P
Sample ID    9  34600.59  3844.51  604.83  0.000
Error       20    127.13     6.36
Total       29  34727.72

S = 2.521   R-Sq = 99.63%   R-Sq(adj) = 99.47%


                                Individual 95% CIs For Mean Based on
                                Pooled StDev
Level         N    Mean  StDev  ------+---------+---------+---------+---
Burger Ring   3   76.68   0.52             (*)
Cheezels      3  101.16   1.82                     (*)
CW Salt Hi    3  140.20   3.47                                  (*)
Good Puffs    3   44.25   0.08  (*)
Grain Waves   3  152.88   0.15                                      (*)
Rice Wheels   3  106.28   0.30                      (*)
RW Salt Hi    3  143.53   4.14                                   (*)
RWC Salt Hi   3  152.08   4.79                                      (*)
SKOF Tripods  3   95.56   2.77                   (*)
Twisties      3   97.19   0.20                   (*)
                                ------+---------+---------+---------+---
                                     60        90       120       150

Pooled StDev = 2.52

Grouping Information Using Tukey Method

Sample ID     N    Mean  Grouping
Grain Waves   3  152.88  A
RWC Salt Hi   3  152.08  A
RW Salt Hi    3  143.53    B
CW Salt Hi    3  140.20    B
Rice Wheels   3  106.28      C
Cheezels      3  101.16      C D
Twisties      3   97.19        D
SKOF Tripods  3   95.56        D
Burger Ring   3   76.68          E
Good Puffs    3   44.25            F
```

```
Means that do not share a letter are significantly different.

Tukey 95% Simultaneous Confidence Intervals
All Pairwise Comparisons among Levels of Sample ID

Individual confidence level = 99.80%


Sample ID = Burger Ring subtracted from:

Sample ID      Lower  Centre   Upper  ---------+---------+---------+---------+
Cheezels       17.19   24.48   31.77                        (*)
CW Salt Hi     56.23   63.52   70.81                              (-*)
Good Puffs    -39.72  -32.43  -25.13              (-*)
Grain Waves    68.90   76.20   83.49                                (-*)
Rice Wheels    22.31   29.60   36.90                         (*)
RW Salt Hi     59.56   66.85   74.15                               (*)
RWC Salt Hi    68.11   75.40   82.69                                (-*)
SKOF Tripods   11.59   18.88   26.17                       (*)
Twisties       13.21   20.51   27.80                       (*-)
                                      ---------+---------+---------+---------+
                                             -60         0        60       120

Sample ID = Cheezels subtracted from:

Sample ID      Lower  Centre   Upper  ---------+---------+---------+---------+
CW Salt Hi     31.75   39.04   46.33                          (-*)
Good Puffs    -64.20  -56.91  -49.61          (-*)
Grain Waves    44.42   51.72   59.01                            (-*)
Rice Wheels    -2.17    5.12   12.42                     (*)
RW Salt Hi     35.08   42.37   49.67                           (*)
RWC Salt Hi    43.63   50.92   58.21                            (*-)
SKOF Tripods  -12.89   -5.60    1.69                   (*)
Twisties      -11.27   -3.97    3.32                   (*-)
                                      ---------+---------+---------+---------+
                                             -60         0        60       120
Sample ID = CW Salt Hi subtracted from:

Sample ID       Lower  Centre   Upper  ---------+---------+---------+---------
+
Good Puffs    -103.24  -95.95  -88.65    (*)
Grain Waves      5.38   12.68   19.97                      (*)
Rice Wheels    -41.21  -33.92  -26.62              (*-)
RW Salt Hi      -3.96    3.33   10.63                    (-*)
RWC Salt Hi      4.59   11.88   19.17                      (*)
SKOF Tripods   -51.93  -44.64  -37.35            (-*)
Twisties       -50.31  -43.01  -35.72             (*)
                                       ---------+---------+---------+---------

+
                                              -60         0        60
120

Sample ID = Good Puffs subtracted from:

Sample ID      Lower  Centre   Upper  ---------+---------+---------+---------+
Grain Waves   101.33  108.62  115.92                                      (*)
Rice Wheels    54.74   62.03   69.32                              (*-)
RW Salt Hi     91.99   99.28  106.57                                    (-*)
RWC Salt Hi   100.53  107.83  115.12                                      (*)
SKOF Tripods   44.01   51.31   58.60                            (-*)
Twisties       45.64   52.93   60.23                             (*)
                                      ---------+---------+---------+---------+
                                             -60         0        60       120

Sample ID = Grain Waves subtracted from:
```

```
Sample ID      Lower  Centre   Upper  ---------+---------+---------+---------+
Rice Wheels   -53.89  -46.59  -39.30           (*)
RW Salt Hi    -16.64   -9.34   -2.05                 (*-)
RWC Salt Hi    -8.09   -0.80    6.50                   (*)
SKOF Tripods  -64.61  -57.32  -50.02         (*-)
Twisties      -62.98  -55.69  -48.40          (*)
                                      ---------+---------+---------+---------+
                                             -60         0        60       120
```

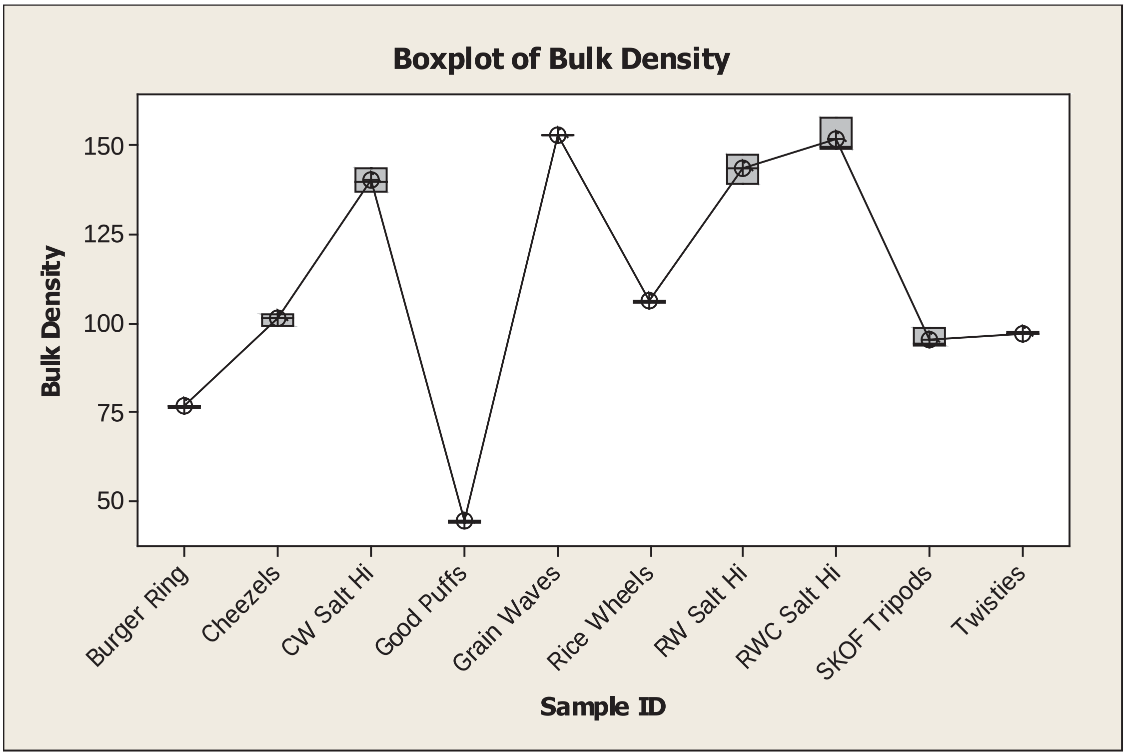
```
Sample ID = Rice Wheels subtracted from:

Sample ID      Lower  Centre  Upper  ---------+---------+---------+---------+
RW Salt Hi     29.96   37.25  44.54                        (*)
RWC Salt Hi    38.50   45.80  53.09                         (-*)
SKOF Tripods  -18.02  -10.72  -3.43                (*)
Twisties      -16.39   -9.10  -1.80                (*-)
                                     ---------+---------+---------+---------+
                                            -60         0        60       120
```

```
Sample ID = RW Salt Hi subtracted from:

Sample ID      Lower  Centre   Upper  ---------+---------+---------+---------+
RWC Salt Hi     1.25    8.55   15.84                    (*-)
SKOF Tripods  -55.27  -47.97  -40.68           (*)
Twisties      -53.64  -46.35  -39.05           (*)
                                      ---------+---------+---------+---------+
                                             -60         0        60       120
```

```
Sample ID = RWC Salt Hi subtracted from:

Sample ID      Lower  Centre   Upper  ---------+---------+---------+---------+
SKOF Tripods  -63.81  -56.52  -49.23         (-*)
Twisties      -62.19  -54.89  -47.60          (*)
                                      ---------+---------+---------+---------+
                                             -60         0        60       120
```

```
Sample ID = SKOF Tripods subtracted from:

Sample ID  Lower  Centre  Upper  ---------+---------+---------+---------+
Twisties   -5.67    1.63   8.92                  (*)
                                 ---------+---------+---------+---------+
                                        -60         0        60       120
```

Boxplot of Bulk Density



Boxplot of Bulk Density
Bulk Density
150
125
100
75
50
Burger Ring
Cheezels
CW Salt Hi
Good Puffs
Grain Waves
Rice Wheels
RW Salt Hi
RWC Salt Hi
SKOF Tripods
Twisties
Sample ID