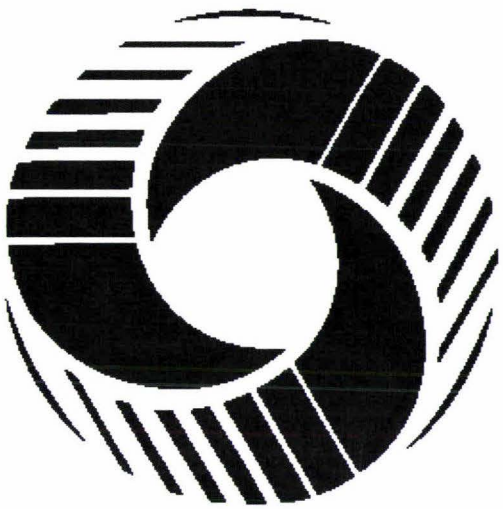
# DEVELOPMENT OF A NUTRACEUTICAL CONFECTIONERY FOR CONSUMER MARKET USING MANUKA HONEY AND PROPOLIS



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A Thesis presented in partial fulfilment
of the requirements for the
Degree of Master of Technology in
Food Technology at
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**DINESH SOFAT**

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# DEDICATION

**to my parents, Surendra and Ranjit Singh**
**my brothers and sisters Vipan, Goldie, Neelam, and Sweety**
**for their understanding and encouragement always.**

*Everybody's a mad scientist, and life is their lab. We are all trying to experiment to find a way to live, to solve problems, to fend off madness and chaos.*

**David Cronenberg, Canadian film-maker**

# Abstract

As consumers have become proactive in health and medical issues, sales of healthy foods have recorded higher growth rate. Therefore, the concept of everyday foods containing ingredients with defined health benefits will significantly influence the types of new foods developed. New Zealanders are among the world's largest consumers of honey, propolis, and other bee products. Further, confirmation of antibacterial properties of a unique NZ honey, manuka honey, has increased its price manifolds.

A market research study indicated that potential exists for a familiar confectionery with nutraceutical properties. As a result, jellybeans with added functional properties were developed. Flavour, texture, antibacterial properties, and price were the important attributes to consumers. Lemon flavour was identified as the most acceptable flavour.

Jellybeans containing 'active' manuka honey, propolis, were developed using bench top facilities available at the Massey University. The antibacterial properties of manuka honey were found to be stable at $85^0$ C for an hour, and for propolis they were stable at $95^0$ C for 2 hours. In the literature, no procedure was found for testing the antibacterial properties of confectionery products. A 3-step method was developed for the removal of the interfering substances other than sugar, reduction of sugar, and final estimation of antibacterial properties. This gives extract, largely free of interfering substances and antibacterial components in a measurable quantity. The product and process were optimized by Response Surface Methodology (Echip). Using $TAXT_2$ for testing the texture, prototypes were screened down to suitable 8 formulations. Cost was then used as a screening factor to determine the prototypes for sensory testing.

Eight prototypes were evaluated with a trained panel as well as consumer panel. External (PREFMAP) and internal preference mapping (MDPREF) was used to interpret the data collected from these two panels. No consensus was reached for the most preferred product. Further, cluster analysis was performed on the results of MDPREF to understand

preferences of specific consumers. The study indicated that about half the consumer panel did not have marked differences in liking for the various jellybean prototypes. The product that was preferred by second largest cluster and at the same time well liked by the largest cluster was therefore selected for commercial trial. The product was low in hardness, chewiness, and denseness. The most preferred product was made from 9.2% starch, 5% gelatin, 10.2% honey, 1.8% propolis extract, 20% sugar, and 42% corn syrup. At deposition in the starch the product had 71-72% dissolved solids.

The optimized product formulation was scaled up at Cadbury's Confectionery Limited, Auckland. The jellybeans were processed in a Terbraak static cooker. The slurry was cooked to 135-140$^0$ C and was then rapidly cooled under vacuum to 95$^0$ C. Total solids of slurry were kept at 65-66% due to about 5% moisture evaporation in the plant to get final dissolved solids at 71-72% before deposition in starch. The antibacterial components and lemon flavour was added to the slurry before deposition. The slurry was taken out of the starch at 12-14% moisture and soft panned. The jellybeans were found to have antibacterial properties.

The commercially produced developed product was tested with 51 consumers using a Central Location Test (CLT). The developed product had an overall liking comparable to the commercially available jellybeans. About 69% of the panelists showed their willingness to buy this product. The Home Use Test (HUT) held over 8 weeks verified the results of CLT. In HUT 66% of the consumers liked this unique idea and showed preference over the currently available product. About 65% showed willingness to replace the current product. HUT provided validity of the results from CLT and liking of the product did not drop over time ($p>0.05$) and to the repeated exposure. The results also indicated that immediate use response (Week-0, CLT) for the consumer acceptance could be used as a valid predictor of the extended use responses (Week -8, HUT).

As the product's overall liking score is very high (7.5), it is ready for a launch. However, minor changes in the attributes may be considered after market trial. The developed product has antibacterial properties, which were tested by a method developed during the study. As the product offers lot of potential, a food company has shown interest to market this product.

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## PUBLICATION

**Sofat, D., Pound, C.J. and Duizer L.M. (1999)** Change in consumer response to written and physical product concepts. Annual New Zealand Engineering and Technology Postgraduate Conference 5 184-89.

# Chapter 1

# Introduction

Living longer and better is on the mind of most people, and diet is one of the facets of a healthy life. There has been an increase in consumer interest in food products with health giving properties. In addition to their basic nutritive value nutraceutical products contain ingredients, which will help to prevent and treat illness and disease. This project deals with the development of a nutraceutical confectionery product for the consumer market, using manuka honey and propolis as antibacterial agents. The acceptance and use of functional food depend mainly on two factors. First is the credibility of the claims made. The products with measurable benefits will have a longer life cycle than products with perceived benefits. But education of the consumer to establish the credibility of the claims made is a long-term process. The second factor is the development of "no compromise" products, meaning that taste and convenience are not compromised. The reasons for development of this product are that, "active manuka" honey and propolis have significant amounts of antibacterial properties, which are active against a wide spectrum of bacteria and many New Zealanders understand the benefits and are using other honey and propolis products. At the same time these two ingredients are readily available in New Zealand.

## 1.1 Product Development Process

The process where an idea is turned into a marketable commodity is called product development (Anderson, 1994). Product development is an industrial research system for both the continuous improvement of a product and the introduction of a new product to satisfy a known or anticipated consumer need (Earle, 1994).

The role of product development includes creating new products, improving existing products, adding new products to existing product lines and entering to an established market (Anderson, 1994). At the same time, the company may want to maintain the market

share by adopting cost cutting measures like reduction in formulation cost, cost of new processing technologies. Furthermore, Anderson (1994) noted that industrial companies could reach their growth targets more easily through new products, rather than through the increase on sales of existing products.

The product development process involves the integration of different research techniques such as consumer research, marketing research, product formulation, process development, and process engineering research to develop new products or to improve the existing products already in the market (Upahithak, 1994, Pound, 1996).

The product development process is divided by several stages (Booz, Allen and Hamilton, 1982; Meyer, 1984; Earle & Anderson, 1985; Dolan, 1993; Hnat, 1994; Earle, 1994; Rudolph, 1995; Pound, 1996 and Earle, 1997). The main steps of a systematic product development process is the six step process described by Booz, Allen and Hamilton, 1982; and Earle, 1994. Once the new product strategy is determined, the systematic product development process progresses through the various steps as shown in Figure 1.1.

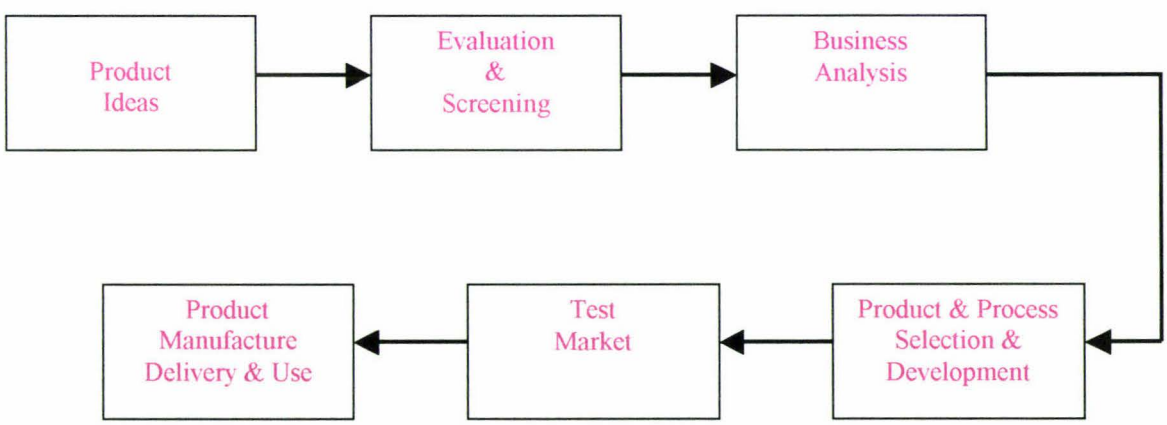



**Figure 1.1: Product Development Process**

Nevertheless, this project did not encompass the complete product development process. The work concentrated on the development of the prototype product through to preliminary commercialization of the process.

## 1.2 Consumer Involvement in the Product Development Process

Martin (1985) noted that, today's consumers are interested in products, which are more relevant to their needs and wants. Understanding the key attributes the consumer wants and translating them into the finished product (Buisson, 1993) can create the products with higher consumer acceptance. Therefore, consumer input is an essential ingredient for creating products, which have high market success.

Traditionally, in food product development, there are three stages at which consumer input can be included. These are the initial market and consumer research, sensory testing, and the final market test (Wan, 1987; Earle, 1994; Uaphithak, 1994). Consumer panels are used throughout the product development process for identifying the product characteristics at the start of product development and testing the products to determine the acceptability of the various characteristics (Uaphithak, 1994).

Best practice is now to use consumer panels throughout the product development process for identifying the product characteristics at the start of product development and testing the developed products to determine the acceptability of the various characteristics.

Consumer input has been used at various stages of the product development process: product formulation (In house), prototype product testing (Consumer panel), and product testing (Central location test and Home use test). The number of consumers depends on the size of the population. But this is limited by the availability of funds, time, product, and test facility. Due to these factors the size of panel varies a lot. In this present study 4-6

consumers were used in the product formulation stage and about 50 consumers were used in prototype and product testing.

## 1.3 Prototype Development and Optimization

Once a new product idea has been identified as having potential for development, it is further developed with consumers to determine its acceptance without necessarily involving any cost of manufacture (Crawford, 1994).

Once the concept for a new product is established, technical legal and marketing considerations or constraints are considered in order to clearly assess the technical feasibility of the concept (Crawford, 1994). Finally the legal and consumer requirements in the form of attributes are turned into a physical product. The prototype need not only meet the consumer requirements but also be produced within a reasonable timeline and at a predetermined cost (Kotler and Armstrong, 1991). By applying an experimental design, companies can decrease the time between concept and marketplace by efficiently optimizing ingredients and critical process variables (Joglekar and May, 1987; Arteaga *et al.*, 1994).

Optimization is the choice of a best alternative from a specified set of alternatives, which allows the developer to understand and to control the product, thereby creating products which appeal to the consumers (Moskowitz, 1997). Achieving optimization, therefore, requires a way of deciding which of the alternatives is best (Norback & Evans, 1983). When the prototypes are ready they are tested with the intended consumer for acceptance of the prototype, and any required modifications are carried out (Crawford, 1994; Matz, 1994). The trained panel provides a basis for determining the intensity of sensory characteristics that are important to acceptance of a product (Stone & Sidel, 1993[b]). The product storage stability studies are carried out and variables affecting the shelf life are determined (Matz, 1994). After the prototype is ready and capable of being reproduced, the product is manufactured commercially and any variations in the quality are identified and

corrected (Meyer, 1984). The product to be marketed is tested under actual conditions of distribution and storage before it is released for sale (Matz, 1994).

In this project the product was optimized using response surface methodology. A trained as well as consumer panel was used to optimize the product. The results of this study were analyzed using preference mapping. Once the product was optimized a production trial was conducted and the resulting product was tested with consumers in central location as well as home use test to identify need for any modifications required.

## 1.4 Selection of Jellybeans as the Prototype Product

An average New Zealander consumes around 7.5 kg of sugar confectionery in a year and makes them among one of the biggest consumers in the world (Anonymous, 1992). It is predicted that there is scope for further increase in the per capita consumption (Berrell, 1994). In the sugar confectionery segment, the panned sugar confectionery dominates, and jellybean is one of the important members of this category. Licorice that is known to have functional properties recorded 22% sales growth in the year 1998 (Balasoglou, 1999). Therefore, jellybeans, a product that falls in the panned sugar confectionery (Bianco, 1993) and at the same time possess the functional properties was considered.

Sugar based confectionery are considered as highly concentrated solutions of carbohydrates containing stabilizers, texture, acids, colours, and flavours. All of these low value components provide unique properties to the product and can produce highly acceptable and value added products after processing (Carr *et al.,* 1995; Carr, 1996). But in sugar confectionery further value addition is hard to come by, and innovation remains the key to the continuing success of the confectionery products. Therefore, added functionality remains as one of the few alternatives available to product developer in the confectionery products (Blenford, 1994; Balasoglou, 1999).

The New Zealand market for sugar confectionery is quite mature but functional products are limited to throat products, licorice and chewing gums (Balasoglou, 1999). When nutraceutical ingredients are used the success of these products depends upon overcoming off-flavours contributed by its constituents. The jellybeans solved overcome this problem by soft coating the centers with different kind of sugars. This offered a possibility of developing a new product with functional properties, which could be acceptable to the consumers.

While processing, the properties of the confectionery are affected by the interaction between raw materials and the processing conditions, thus producing products with different characteristics. The antibacterial properties of manuka honey are sensitive to process conditions and the majority of them are destroyed at the prevailing temperatures for confectionery production. But in panned confectionery there was possibility of retaining the antibacterial properties.

New Zealand has a unique flora, which is responsible for mono-floral honeys and bee products and an image for clean green agricultural products. Using honey and bee products as a food ingredient in premium products confers definite advantages with the trend towards healthy and natural foods (Collier, 1999).

## 1.5 Significance of Honey and Propolis to the Project

Propolis has been used since ancient times in folk medicines (Ghisalberti, 1979; Marcucci, 1995; Burdock, 1998) in many parts of the world. Amongst the bee products, the usage of propolis by man is predated only by honey (Ghisalberti, 1979). Propolis or bee glue (Ivanovska *et al.*, 1995) is the universal name for the resinous substance that is collected by honeybees from the leaf buds and cracks in the surface of tree (Ghisalberti, 1979). This resin is chewed, salivary enzymes added and the partially metabolized material is mixed with the beeswax and used as a general-purpose sealer in the hive.

The primary function of propolis in the hive is to act as a biocide, may act against invasive insects and also function in preventing the decomposition of the invading insect (Ghisalberti, 1979; Marcucci, 1995).

Propolis is believed to have antibacterial properties (Ghisalberti, 1979; Brumfitt *et al.*, 1990; Dobrowolski *et al.,* 1991). The favorable properties of both raw and alcoholic extracts of propolis led to its diversified application in home remedies and personal products. These applications include dermatological products, where it has been claimed useful in wound healing, tissue regeneration, treatment of burns, leg ulcers, herpes simplex and genitalis and activity against dermatophytes (Ghisalberti, 1979; Ayala *et al.,* 1985; Marcucci, 1995). It is claimed to be an anaesthetic agent five times as effective as cocaine (Ghisalberti, 1979). It has also found its way into cosmetic and pharmaceutical products such as face creams, ointments, lotions and solutions. It is marketed in tablets, powder and chewing gum (Ghisalberti, 1979; Dobrowolski *et al.,* 1991; Bjorkner, 1994).

A water-soluble preparation obtained from propolis showed significant bacteriostatic effect on acid resistant organisms at 0.001% (Tikhonov *et al.,* 1975). Similarly an alcohol-water mixture was used for the treatment of candidiosis (Todorov *et al.*, 1973).

The antibacterial properties of manuka honey are due to a number of factors including the very low water activity, acidity, hydrogen peroxide, and antibacterial substances produced by certain species of plants. The activity of honey varies widely among different sources of honey samples. Manuka honey has been found to have antibacterial properties and can provide relief from stomach ulcers that is caused by a bacterium, *Helicobacter pylori. H. pylori* is an organism which can grow in the human stomach, and was found to completely halt the growth of this bacterium at 5% of its original strength (Somal *et al.,* 1994).

Manuka honey is produced from bushes growing in large areas of wild brushwood in New Zealand. Considering assured availability of propolis and honey and their tested

antibacterial activity, it was decided to develop a new product with substantial value addition.

## 1.6 Aim, Objectives and Constraints

### *1.6.1 Aim*

The aim of this work was to investigate the feasibility of using NZ produced manuka honey and propolis to produce an acceptable confectionery for the New Zealand market, and with potential to export to other countries.

### *1.6.2 Objectives*

- To conduct a literature review on honey and propolis as an antimicrobial agent and factors affecting this antibacterial activity
- To develop a method for testing the antibacterial properties of the developed product
- Conduct a market research for confectionery product in NZ
- To develop a product concept through market survey and survey conducted on similar product
- Develop a product using the experimental design techniques
- To conduct consumer testing of the prototype
- To train a panel and test the prototype using the trained panel
- Analysis of consumer and descriptive data by using multivariate analysis techniques such as internal and external preference mapping
- Commercial production of the product and retention of antibacterial properties in the finished product
- Product optimization in central location testing and subsequent verification and calibration in home use testing

### *1.6.3 Project Constraints*

#### *1.6.3.1 Product constraints*

- The product must be made from NZ produced manuka honey and propolis having antibacterial properties
- Product should have sufficient quantity of honey and propolis to ensure it has antibacterial properties
- The product must be gel type product
- The product taste must be accepted by NZ consumers

#### *1.6.3.2 Processing Constraints*

- Processing must not destroy the antibacterial properties of honey and propolis
- The product should be capable of being processed on the existing equipment in the Institute of Food Nutrition and Human Health at Massey university Palmerston North.

#### *1.6.3.3 Marketing Constraints*

- The product should be marketed in NZ and should claim its nutraceutical properties
- The product price should be comparable with the existing products in the market
- The product should fit into the NZ market niche
- The price of the product should ensure a competitive alternative for existing products in the market

#### *1.6.3.4 Financial constraints*

- No capital available for buying or carrying modifications on the existing equipment

## 1.7 Project Strategy

The development of nutraceutical product was planned by following a product development process. Preliminary research was carried for information on confectionery as

well as nutraceutical products available in the market and concept was developed. Consumer input was solicited for optimization of the product. The data obtained from consumer as well as trained panel was combined using the technique of Preference Mapping. The most preferred product was scaled up for a commercial run and the developed product was tested using central location as well as home use test. A method was developed to test the antibacterial properties for the sugar-based confectionery. The finished product tested for antibacterial properties. A schematic diagram showing the project strategy is shown in Figure 1.2. The product development project was scheduled and tracked using the Microsoft's Project-98. The Gantt chart is shown in Appendix 1.1 (page 211)

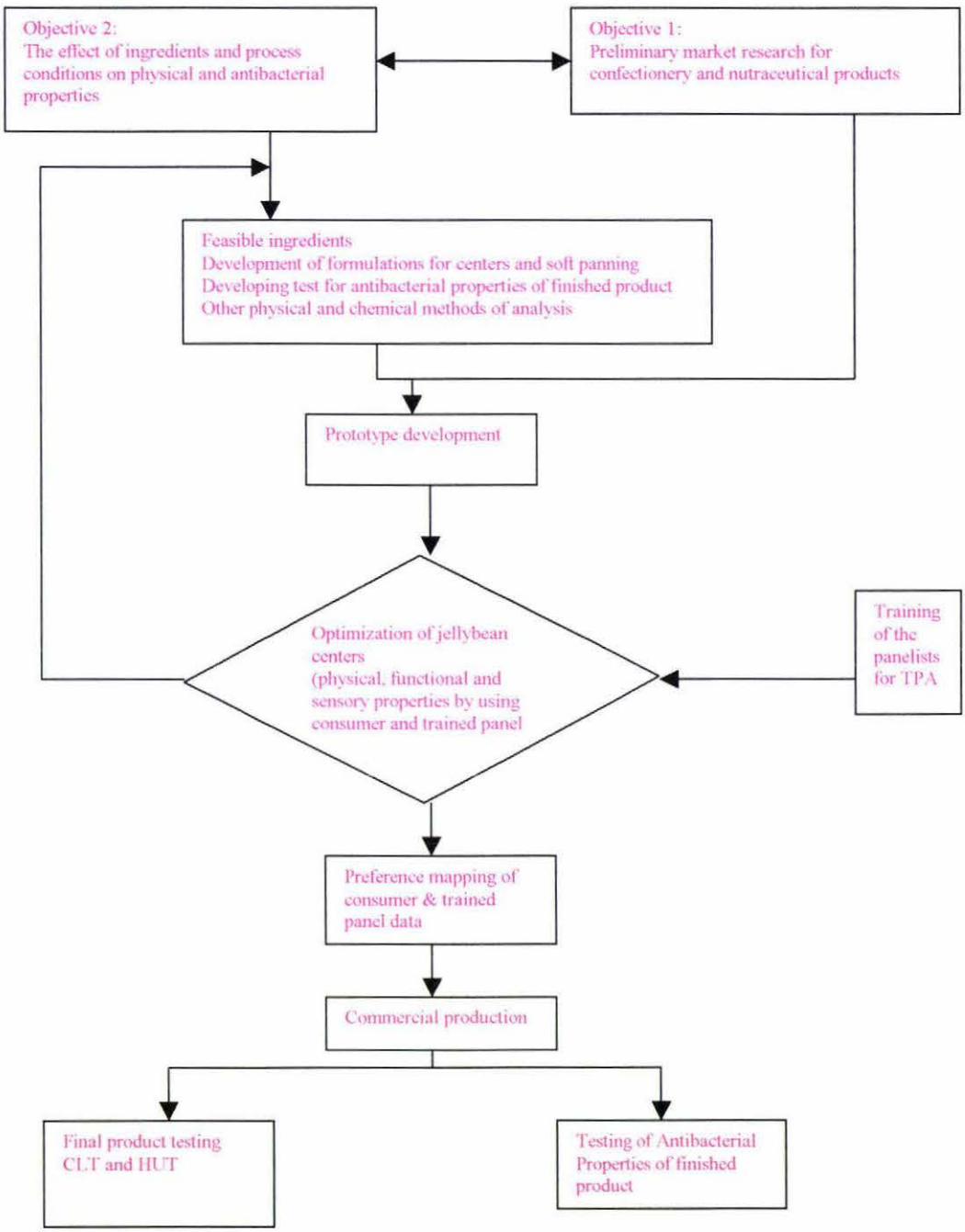



**Figure 1.2: Project Strategy for Nutraceutical Jellybeans**

# Chapter 2

# Literature Review

This chapter reviews the antibacterial properties of propolis and honey as described in the literature, and also describes the techniques used in this project for formulation, optimization, commercial production, sensory evaluation and testing of the prototypes. Methods for extraction of the antibacterial properties of the propolis and texture measurement are also discussed.

## 2.1 Functional Properties of Ingredients

Sugar based confectionery is regarded as highly concentrated solutions of carbohydrates containing stabilizers, texture, acids, colours and flavours. All these components provide unique properties to the product but stabilizers and texture agents play an important role (Carr *et al.*, 1995; Carr, 1996). Sugar, glucose, starches and water are usually mixed to make the jellybean centers. In this project, Manuka honey and propolis extracts were used to get the antibacterial properties. The superior gelling properties of gelatin provide gumminess to the product and ensured a gum free of stickiness, tails and air bubbles. In the soft panning process corn syrup, panning sugars and stabilizer are used to give the engrossing and sealing properties. The functional properties of these ingredients are discussed below in detail.

### *2.1.1 Sucrose, Corn Syrup and Maltodextrin*

Sucrose imparts sweetness and tenderness to the product. At 16% moisture, a product should not contain more than 40% sucrose to prevent crystallization during the storage (Cooley, 1993). In soft panning, the quality of sugar used for coating has a direct bearing on the finished product. The sugar used is fine and granulated with a particle size of 0.2 mm and jellybeans are finished with powdered sugar having a particle size of 0.03mm (Lynch, 1987).

Reducing sugars such as dextrose, maltose, levulose and lactose are added to inhibit graining of the sucrose and regulate the moisture content and texture of the product through control of its equilibrium humidity (Zallie, 1989; Cooley, 1993).

A range of corn syrups and maltodextrins are available that contain varying amount of dextrine and reducing sugars. A product with a DE of 20 and above is called a corn syrup whereas DE of 19 or less is called maltodextrin. A 34-DE glucose contains a considerable amount of dextrin and corresponding less amount of reducing sugars and produces a very tough and gummy product. Medium textured starch jellies are possible from 42-DE glucose, which contains less dextrose and a corresponding increase in reducing sugars. The jellies produced with high dextrose glucose (63 DE) were consistently more tender than other two. Invert sugars can be added to retain moisture, increase sweetness and inhibit grain formation in the product (Anonymous, 1986; Cooley, 1993). Maltodextrins are widely used as bulking, flavour carriers and fat replacers. Agglomerated maltodextrins are well suited as bulking agent, exhibit excellent flow ability and aid in the dispersion of hard to disperse ingredients. A minimum jelling concentration of 12% is required (Cho and Prosky, 1999).

In this project, maltodextrin was used as a bulking agent to help the formulation add up to 100 by keeping all the other ingredients in the design to be constant. This helped to design all the formulations with desired levels of variables, processing conditions and without disturbing the ratio of each ingredient. The other option is to use the mixture design, which specifically is designed for formula problems without studying the impact of process conditions (Khuri and Cornell, 1990). With mixture design, at least one more ingredient would have to be changed in all the formulations thereby making a real comparison between the products an impossible task. Maltodextrin was the only commercially available ingredient that did not add much to the sweetness and texture of the jellybean centers. Once the contribution of the each ingredient to the attributes of the product was studied and final formulation arrived at, this bulking agent was removed from the final

formulation at the commercialisation stage.

### *2.1.2 Honey and Propolis*

Honey has a very low water content, which rarely exceeds 20%. Of the dry matter in honey, glucose and fructose are the major carbohydrates and contribute 80-90% of the total sugars. Other components include sucrose 1.5%; water 15-20%; maltose 7.5%; vitamin B and minerals (White, 1978). Honey increases overall sugar solubility and gives humectant properties and tenderness. It is typically 5-10% of the total sweeteners in confectionery products (Cooley, 1993).

The major antibacterial factor in most honey is hydrogen peroxide. This is produced in honey by the action of glucose-oxidase, which is added to the honey by bees. Some activity is due to the phytochemical's antibacterial factors (Allen *et al.,* 1991).

In honey, pinocembrine is principal non-volatile antibacterial substance in most honeys. Russell (1983) found, in manuka honey, 3 antibacterial, thermostable and relatively non-volatile derivatives of benzoic acid. Further investigation lead to the identification of some components with antibacterial activity: 3, 4, 5-trimethoxy benzoic acid and 3, 5-dimethoxybenzoic acid (Russell *et al.,* 1990). Therefore, it seems that different classes of thermostable substances play a role in the antibacterial activity of honey.

Pinocembrine is also one of the main antibacterial substances of propolis (Dimov *et al.,* 1992; Markham *et al.,* 1996). In this project both honey and propolis were used as a source of antibacterial activity.

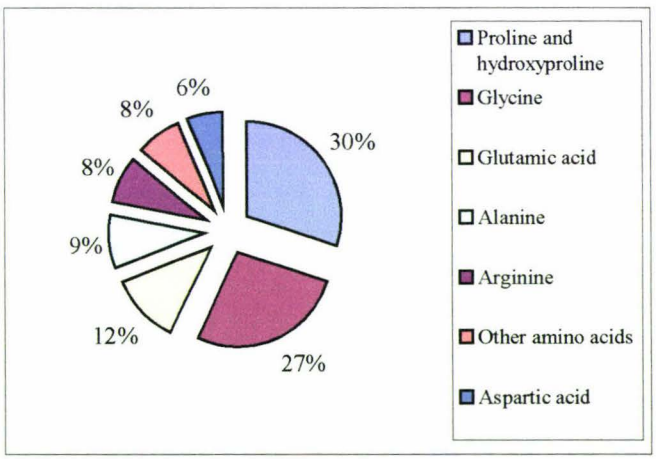
### *2.1.3 Hydrocolloids*

Functionally, hydrocolloids are high molecular-weight polymers and impart thickening or gelling effect to the texture (Burger, 1982). Undesirable changes such as sugar re-

crystallization, moisture migration, gas cell coalescence and textural profile changes can be prevented through proper formulation and the choice of hydrocolloid stabilizers (Carr *et al.*, 1995; Carr, 1996). Hydrocolloids also perform other functions in confectionery products, such as film forming, adhesion, gelling, bulking, aeration, and emulsification (Carr *et al.*, 1995). The widely used hydrocolloids in the confectionery industry include gelatin, pectin, starch, and gum arabic or combination of these gums (Carr *et al.*, 1995; Shinsato, 1996; Carr, 1996).

### *2.1.4 Gelatin*

Gelatin is obtained from collagen present in bones and hides of animals. Collagen is a rod like protein that when unfastened from its triple spiral is very flexible and gives thermo-reversible gels (Burroughs, 1996). Like all proteins, gelatin is composed of around 20 amino acids, linked together by the peptide bonds. Gelatin contains all the amino acids essential to man, and the predominant amino acids are shown in Figure 2.1.




(Poppe, 1995; Burroughs, 1996)

**Figure 2.1: Amino Acids Composition of Gelatin**

Gelatin has both positive and negative charges all along the backbone of the molecules. This allows gelatin to be reactive with other molecules in the foods and restrain

crystallization, reducing surface tension, to aid foam formation, emulsify fats, react with other proteins (Burroughs, 1996). In gelatin jellies the gel structure relies on the development of a link between the different polymeric substances of the raw material and this process is termed as bond formation (Lees, 1997). Gelatin has some very positive attributes, in its unique texture and flexibility, bright gel clarity and good flavour release (Moore, 1996).

The gelation potential of gelatin is normally measured by a Bloom test and is a measure of the force required to compress a 6.67% concentration gelatin gel a distance of 4 mm under controlled conditions. 80 to 100 blooms are considered as a low strength and above 200 is a high strength gelatin (Carr *et al.*, 1995). A wide range of texture can be achieved by using either a lower concentration of high bloom gelatin or a higher concentration of a low bloom gelatin. High bloom gelatin gives a harder smoother texture, while low bloom produces a more chewy elastic texture (Lees, 1997).

Two types of gelatin, Type A and Type B are commercially available. Type A gelatin is produced by the acid processing of raw material known as collagen from animal origin and exhibits an iso-electric point between 7 and 9. Type B gelatin is produced by alkaline process and exhibits an iso-electric point between 4.6 and 5.2. The behaviour of these two gelatins is shown in Table 2.1.

**Table 2.1: Behaviour of Type A and Type B Gelatin**

| Sugar/Corn Syrup Ratio | 50/50 | | | | 30/70 | | | |
|---|---|---|---|---|---|---|---|---|
| **Gelatin Type** | **Type A** | | **Type B** | | **Type A** | | **Type B** | |
| | With Acid | Without Acid | With Acid | Without Acid | With Acid | Without Acid | With Acid | Without Acid |
| Hardness 8%, 200 bloom (Stevens 5 mm) | 500 | 340 | 400 | 360 | 320 | 220 | 210 | 200 |

(Poppe, 1995)

Due to low viscosity Type A gelatin is used which help in making tailless candies (Carr *et al.*, 1995).

As a function of sugar/corn syrup ratio, hardness increases when sugar/corn syrup ratio varies from 70/30 to 50/50, while a 20/80 ratio gives softer products. Similarly, chewiness of the product increases when changing the ratio from 70/30 to 50/50. When corn syrup is increased further, a softer and cloudy product with a short texture is formed (Poppe, 1995). At temperatures higher than 80° C the hydrolysis of gelatin may take place and lead to softer products. The gel strength deteriorates significantly over 100° C (Poppe, 1995; Lees, 1997).

### *2.1.5 Starch*

The main use of starch is as a viscosity agent, but it also functions as an adhesive, binder, encapsulating agent, film former, gelling agent, water binder, and texturiser. Starch has two carbohydrate molecules, amylose and amylopectin. Amylose the straight-chained molecule is functional in confectionery and amylopectin provides the viscosity (O'Mara, 1994; Mauro, 1996).

#### *2.1.5.1 Selection of Starch*

It is a carbohydrate extracted from different varieties of corn, potato and tapioca with different levels of amylose. The high amylose cornstarch has greater internal bonding forces than other maize varieties due to the high degree of linearity and crystallinity within the granule (O' Mara, 1994). There are two-carbohydrate molecules, amylose and amylopectin, which are present in different ratios in starch (Mauro, 1996; O' Mara, 1994). This bonding force is responsible for the inability of high amylose cornstarch to cook under atmospheric conditions. Starch functionality depends to a great extent on the ratio of amylose and amylopectin components as well as molecular structure and size of the amylose and amylopectin components (Mua and Jackson, 1997).

The rheology of starch, when cooked in excess water, depends on the ratio of amylose to amylopectin and also on the arrangements of these polymers within granules (Morrison

and Tester, 1991; Takeda *et al.,* 1992). Amylose and amylopectin differ in molecular weight distribution and molecular structure (Hizukuri, 1985; Takeda *et al.,* 1992), hence they display different rheological and viscoelastic properties (Wang and White, 1994). Starch granules are insoluble in water, although they can swell slightly and become partially hydrated.

The higher the amylose content in the starch the firmer the gel and greater the energy requirement in cooking (Zallie, 1989). Since amylopectin is a larger polymer than amylose, it can inactivate more water in solution and hence contribute more viscosity than amylose (Zallie, 1989; O' Mara, 1994).

The selection of starch will, therefore, depend upon the process limitations. The fluidity starches that have low amylose are compatible with open kettle as well as continuous cooking. All other starches require higher temperature of cooking and hence cannot be open kettle cooked (O' Mara, 1994). The ultra-set LT starch that was used in the development of jellybeans has the ability to yield high gel strength under atmospheric conditions. The functionality of this starch can be obtained by cooking dilute preparations (50% solids) to 93-100° C (Zallie, 1989) and the product curing time was also substantially reduced.

### *2.1.6 Colouring Agents*

A product must look good to be purchased and taste good to encourage repeat sales. Colour and flavours are added in the confectionery product to increase the consumer appeal (Cooley, 1993). Colours and flavours are added after cooking to decrease the flashing off of flavours and diversity in depositing (Cooley, 1993).

Colour gives a powerful influence on consumer acceptance of a food product and serves as a visual indication of quality. Food colours play an important role in the taste thresholds, flavour identification, food liking, and acceptability (Clydesdale, 1980). The colour

agents include natural and artificial colours. Natural colouring materials are derived from vegetable, animal and mineral origin. These colours are more accepted by consumers, but tend to be more expensive and less stable during processing and have less colouring power than certified colours. They are also more readily affected by light, temperature, pH, and other processing conditions.

The synthetic or certified colours are the FD&C dyes and lakes. The FD&C dyes are water-soluble colourants that colour by dissolution. The FD&C lakes are water insoluble pigments that colour by dispersion throughout a food material. The dyes are available as powders, granules, liquids, pastes, and blends. These colours are extensively used because of their superior properties and cost effectiveness. Colours enhance the appearance of nutritious but unattractive foods. The synthetic food colours permitted in food differ from country to country and the list is gradually getting eroded. In sugar confectionery the colours should not only be stable at boiling temperature of sugar but also to the usual concentration of sulphur dioxide present in cane sugar and glucose syrups. The commonly used colours are Ponceau 4R, Carmoisine, Tartrazine and Brilliant Blue FCF (Coulson, 1980). For jellybeans tartrazine was used.

### *2.1.7 Flavouring Agents*

Flavours are added to confectionery products to increase their acceptability. Flavours are classified into three groups: natural source, nature-identical and artificial. The natural flavours are derived by physically extracting from natural source. The nature-identical flavours are made by chemicals identical to those in nature but artificially synthesized. The artificial flavours are made from chemicals, which have not yet been identified in foods (Fenton, 1991). Flavours are very volatile in nature and a substantial portion of their potency is lost when the steam is flashed off during the cooking process (Popplewell *et al.*, 1995). Further, the addition of flavour during processing can undergo significant changes since interaction and chemical decomposition of the flavour agent may occur as a result of the high processing temperature (Pszczola, 1998). But addition of optimum flavour level

before the cooling process resulted in acceptable retention of flavour in the confectionery product.

A slight off-flavour was experienced in the product due to the presence of flavonoids. Micro-encapsulation of flavours was explored to overcome this problem (Popplewell *et al.*, 1995; Pszczola, 1998). Encapsulation is the enclosure or encasement of a substrate in microcapsules or continuous non-interrupted film. This protects the substrate from premature reaction and provides for controlled release when desired conditions is met. This product has some success in chewing gum and confectionery (Pszczola, 1998). However, non-availability of encapsulated propolis product prevented its application (Giese, 1993; Popplewell *et al.*, 1995; Pszczola, 1998).

## 2.2 Jellybean Manufacturing Process

The jellybean manufacturing process involves the cooking of starch in dilute preparation with less than 50% soluble solids and by heating to 91-96$^0$ C and holding for required time to gelatinise the starch. Then the remainder of ingredients (corn syrup, sugar) are added and the mixture is boiled until the desired depositing solids (70-72%) are reached. The flavour, colour and citric acid are added and casted in starch. The next step in processing is the drying of the deposited product. This is carried out in large hot rooms until a final moisture of 10-12% is achieved (Anonymous, 1986). The product is shaken out of the starch and subsequently sugar coated and allowed to tray dry overnight prior to grossing.

The pieces are transferred to a smooth grossing pan, which is run continuously during the shell building process. Grossing syrup is applied until pieces are wetted at which point the pan is dry charged with caster sugar until the pieces appear to be dry. The colour and flavours may be added directly into the syrup. As the pieces tumble they become sticky and dry sugar is added again. This process is repeated until desired shell thickness is

reached. The jellybeans are dried and then the surface is smoothed with sucrose solution. Once again the beans are dried with dry air, and polished with polishing waxes.

### *2.2.1 Cooking Method*

Quality of jellybeans depends largely on the cooking method employed. Cooking of the jelly may be achieved by one of the four methods: open kettle, jet cooking, swept surface heat exchanger and static cooker (Zallie, 1989; Cooley, 1993). In the open kettle method cooking is done under atmospheric pressure, while other three methods involves cooking under pressure.

In the Massey University an open kettle process was used for development of the product due to non-availability of other methods. Open kettle cooking requires an excess of water for complete gelatinization of the starch. Usually 65% of water is kept in the formulation. To reach the desired solids, all excess water is boiled off. Open kettle jellies are normally cooked to 225-230° F, depending on the desired final texture. It takes quite a long time to reach the desired solids level. Because of lower temperatures achieved, only thin boiling starches are compatible with this process, which restricts the variability in the texture. The other three cooking methods involve cooking the jelly while under pressure, which offers several advantages such as reduction of cooking time, automatic process control and efficient steam utilization and a complete gelatinisation of the starch. As compared with open kettle processing, these processes are very versatile and can cook many different formulations to 300-340$^0$ F (Cooley, 1993). These results in lower production costs as well as higher production volumes.

Open kettle formulas are cooked to 71% total solids before depositing in warm dry starch. After drying to 85-86% solids the product will be shaken out of starch, steamed and sanded in sucrose (Zallie, 1989).

### 2.2.2 *Panning Process*

Soft panned pieces such as jellybeans tend to be the most time consuming and complex pieces to finish (Lynch, 1987). Jellybean pieces are transferred to a smooth grossing pan, which is run continuously at 22 r.p.m. during the shell building process. In the panning process, corn syrups, sucrose, water and stabilizer are combined in the 70-80% solids range and applied to the centers at about 100° F. This temperature is used so that the crystalline material (sugar) will adhere to the center (Lynch, 1987; Isganitis, 1993; Brisson, 1994). The process involves the uniform application of a charge of syrup sufficient to cover the centers. The colours and the flavours for the panning process are added via the panning syrup. As soon as the syrup is uniformly distributed, the fine sugar crystals (0.2 mm-0.4 mm) are scooped into the surface forming the coating (Lynch, 1987). In the tumbling action the syrup is released and surface of jellybean becomes sticky again. More sugar is applied to make it dry again. When the correct level of drying has been achieved, a fine white dust forms on the surface instead of becoming sticky again. Once the surface is dry a second charge of the syrup is applied and cycle is repeated (Isganitis, 1993; Brisson, 1994). For the third and the final cycle powdered sugar (0.03mm) is used instead of fine granulated sugar (Lynch, 1987). The pieces are again dried overnight to equilibrate moisture prior to finishing of the centers.

The polishing is accomplished in the ribbed polishing pans with dry, cool air available. The surface of engrossed beans is smoothed using a 65-70% sucrose solution. The polishing is applied with a carnuba wax and bees wax mixture in a controlled atmosphere of 60° F and 50% RH (Lynch, 1987; Isganitis, 1993; Brisson, 1994). The final coating step is to seal the pieces with confectionery glaze, which helps to hold the shine developed in the waxing process. Commercially available glazes are currently used (Brisson, 1994).

## 2.3 Changes in Raw Material Properties during the Cooking Process

### *2.3.1 Starch Degradation*

During the cooking process, starch may be subjected to high temperature, pressure and shear conditions depending upon the equipment used during processing. These conditions produce starch transformation; such as gelatinization, melting and fragmentation. Gelatinization occurs if moisture is available in the system, while melting occurs at a moisture content of less than 30% (Keetels, 1996).

The starch granule structure contains both amorphous and crystalline regions (Collison; 1968). In the starch gelatinization process, in an excess-water environment, water first penetrates in the amorphous region swelling occurs and the structure is altered. This allows the low molecular component amylose to leach into the water medium and this continues throughout the heating process. The viscosity of the suspension dramatically increases. During heating, a temperature is achieved known as gelatinization temperature (Guraya and Toledo, 1993). This is the point when amylose flows freely out of the cells and the solution begins to lose its cloudy appearance (Lees, 1996). During cooking, hydrogen bonds of amylose are broken but re-associate because of intermolecular forces. This phenomenon is known as retro-gradation. It is this amylose fraction which is responsible for developing the gel in the final product (O' Mara, 1994).

During processing, the secondary crystalline bonds that maintain the granule structure are broken and promote the transformation of crystalline regions by pulling the crystallites apart. Therefore gelatinization results in the loss of crystallinity of the granules (Greenwood, 1979). The remaining swollen grains of starch, rich in amylopectin, are dispersed through out the confectionery product. The presence of large number of swollen grains containing amylopectin leads to a high viscosity (Lees, 1996) and leads to a tailing problem in the confectionery.

In a low moisture environment complete gelatinization does not occur, but when heating is continued the crystalline region melts. The hydrogen bond of starch combine with water through adsorption process. The adsorption of water results in the growth of the crystalline regions, which inhibits moisture penetration. As a result, the gelatinisation temperature range is increased (Wang *et al.*, 1991).

The compositions of confectionery mix such as amylose and amylopectin ratio, heating time, temperature, and moisture content have also a profound influence on the mechanical disruption and starch transformation. Table 2.2 shows the effect of holding time and moisture on the different systems.

**Table 2.2: Comparison between Degree of Gelatinization of Various Systems**

| System | Moisture | Heating Time | Degree of gelatinization |
|---|---|---|---|
| Starch water | 35% | 120 | 10.6 ± 0.36 |
| | | 150 | 13.5 ± 1.3 |
| | | 180 | 14.1 ± 2.4 |
| Starch water | 65% | 120 | 96.4 ± 0.4 |
| | | 150 | 100.0 ± 0.3 |
| | | 180 | 98.5 ± 1.3 |
| Starch-sucrose (40%) | 55% | 120 | 5.0 ± 0.3 |
| | | 150 | 7.1 ± 0.5 |
| | | 180 | 66.4 ± 0.9 |

(Mendes Da Silva *et al.*, 1996)

The overall gelatinization obeys first order kinetics and depends upon temperature (Lund, 1989). The gelatinization process of a starch slurry can be followed using several experimental approaches like polarized light microscopy, swelling and solubility measurements, amylose-iodine blue value, viscoamylograph, scanning and electron microscopy, nuclear magnetic resonance and differential scanning colorimetry (Wotton and Bamunuarachchi, 1980; Lund, 1983). These methods give qualitative (polarized

microscopy) and quantitative results (calorimetry), the assessment of cooking is more accurate in the case of complex foods systems by rheological (viscosity measurements) or optical (loss of birefringence crosses) methods (Riva *et al.*, 1991). The differential scale calorimetry is supposed to be more adequate to study starch gelatinization and retrogradation of pure starch samples. However no specific literature was found on complex starch formulations like jellybeans. Therefore, gelatinization in the present study was followed by optical methods for the loss of birefringence crosses (polarized microscopy).

## 2.4 Measurement of Jellybean Centers and Finished Product

### *2.4.1 Texture Measurement*

Texture is an important attribute affecting consumer acceptance of food, especially foods that need high sensory impact. It is measured when the food is exposed to a certain stress and shear strain rate (Szczesniak, 1998). Texture is one of the important quality attributes of confectionery. A large number of techniques have been proposed for texture measurements. The texture of the confectionery product is affected by the type of ingredients and processing conditions required for chemical cross-linking of the molecules (Pye, 1996).

Both sensory evaluation techniques and instrumental measurements are used in food texture research to assess texture parameters. Several methods are used to measure the extruded profile instrumentally. Two widely used computerized instruments for instrumental TPA are the Instron (Instron Corporation, Canton), and the TA-$XT_2$ Texture analyser (Texture Technologies Corporation, Scarsdale). The TPA method includes the measurement of fracturability, cohesiveness, springiness, gumminess, chewiness and hardness. These parameters are basically measured during a 2 bite compression test (Pye, 1996). Texture descriptive panels are trained using the standard reference scales and which are hardness, adhesiveness, fracturability, cohesiveness and denseness etc. (Szczesniak *et*

*al.*, 1963; Munoz, 1986).

### *2.4.2 Colour Measurement*

Colour and overall appearance are also important attributes of confectionery. An inappropriately coloured product may lead to a decrease in product acceptance and perhaps outright rejection. The colour of the product depends upon the ingredients and the effect of the process on those ingredients. Colour is normally measured through analysis of light reflection from a food surface or light transmission through food (Francis, 1977).

A product colour can be identified by one of the methods like hunter L*, a*, b* system, Munsell notation system and CIE system. The colour sensation is regarded as the union of three distinct qualities, defined as hue, lightness and saturation (Hunter, 1975; Anonymous, 1994).

Hue is defined as the intensity of a particular type of colour. Lightness is the impression of the relative amount of the incident light reflected from the surface. Saturation is defined as the degree of difference from gray at the same lightness.

In the Hunter L*, a*, b* colour measurement system, L* refers to lightness or darkness, a* refers to the degree of redness/greenness and b* refers to the degree of yellowness/blueness. A colour difference parameter ($\Delta E^*$) among L*, a*, b* could be calculated.

The colour of the jellybeans was measured by a Hunter L*, a*, b* colour scale using a Minolta Chromameter CR-200. The lightness or darkness is defined as L* value. The value of L* varies from 0 to 100, where 0 represents black and 100 represents white colour. The degree of redness/greenness is defined as a* and its scale ranges from –80 to +100. Where as a positive a* indicates higher degree of redness and a negative a* indicates a higher degree of greenness. The degree of yellowness/blueness is defined as b* and its scale

ranges from –80 to +70 (Hunter, 1975). A positive b* indicates more degree of yellowness while a negative b* indicates more degree of blueness (Anonymous, 1994). A total difference in colour, ΔE* was measured using the following equation:

$$\Delta E^* = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$$

Where, $\Delta L^* = L^*$ reference – $L^*$ sample

$\Delta a^* = a^*$ reference – $a^*$ sample

$\Delta b^* = b^*$ reference – $b^*$ sample

## 2.5 Antibacterial Activity of Propolis and Honey

The antibacterial properties of honey and propolis can be tested by various methods available in the literature (Linton, 1983; Bogdanov, 1984; Molan and Russell, 1988; Allen *et al.,* 1991; Ivanovska *et al.,* 1995). But no technique is available for testing the antibacterial properties of confectionery products.

Propolis is a lipophilic material, hard and brittle when cold but sticky when warm (Ghisalberti, 1979; Hausen *et al.,* 1987). The precise composition of raw propolis varies with the source and time of collection (Ghisalberti *et al.*, 1978; Bankova *et al.,* 1992). But in general, it is composed of 50% resin and vegetable balsam, 30% wax, 10% essential and aromatic oils, 5% pollen and 5% various other substances, including organic debris (Monti *et al.,* 1983; Cirasino *et al.,* 1987).

### *2.5.1 Sources of Propolis*

New Zealand has a unique natural flora due to geographic isolation, but no studies have been carried out on the flora source of NZ propolis. Phenolic compounds in propolis were similar to that found elsewhere in the world. This indicated that the introduced species like pine, oaks, willows and native flora may contain phenolic compounds (Markham *et al.*, 1996).

The poplar bud secretions may contain several hundred phenolic compounds (Greenaway *et al.*, 1990; Markham *et al.*, 1996) and each species of poplar exudes a characteristic mixture of the compounds (Greenaway *et al.*, 1990). The compounds in raw unprocessed propolis originate from three sources: plant secretions collected by bees, secreted substances from bee metabolism and materials, which get introduced during propolis refinement (Marcucci, 1995).

### 2.5.2 *Processing of Propolis*

As propolis is a very complex compound (Ghisalberti *et al.*, 1978) it cannot be easily extracted. The usual method is to extract the fraction soluble in 70% alcohol, called propolis balsam and leaving the alcohol insoluble or wax fraction (Ghisalberti, 1979). The ethanol extract of propolis (EEP) is the most common (Marcucci, 1995) and is known as propolis tincture. These extracts contain bulk of the organic constituents (Greenaway *et al.*, 1990) and their components have shown to exhibit antibacterial properties (Brumfitt *et al.*, 1990; Dobrowolski *et al.*, 1991). Although ethanol (Amoros *et al.*, 1992) is the most common solvent used in the extraction of antibacterial properties, extract with other solvents has been carried out for identification of many constituents (Bankova *et al.*, 1983, 1989).

Nikolov *et al.* (1987) provided a method for elimination of waxes and obtained a fully water-soluble derivative from the residual extract of propolis with L-lysine. This derivative was water-soluble and found to possess the natural antibacterial and antifungal activity of raw propolis.

Sosnowski (1983) developed a water soluble propolis derivative by putting the raw propolis (500 grams) in an amber container and putting 1 litre of 15% aqueous ethanol solution as solvent. The mixture was allowed to sit for 10 days and agitated periodically. The mixture was filtered through whatman No 1 filter paper. The resulting propolis containing filtrate was incubated at 70° C until a dry powder was obtained. The material

remaining after incubation is dry propolis powder and is water-soluble. If propolis-containing filtrate was freeze dried a gummy propolis residue was obtained. The water-soluble derivative was found to have antibacterial and antioxidative properties.

In this study the water-soluble derivative of propolis was extracted by the method used by Sosnowski (1983).

### *2.5.3 Antibacterial Properties of Propolis*

Propolis is believed to have antibacterial (Ghisalberti, 1979; Brumfitt *et al.*, 1990; Dobrowolski *et al.*, 1991), antiviral (Debiaggi *et al.*, 1990; Amoros *et al.*, 1994) anti-ulcer, anti-inflammatory (Dobrowolski *et al.*, 1991), anesthetic and antioxidant properties (Ghisalberti, 1979; Dobrowolski *et al.*, 1991; Bjorkner, 1994). The antibacterial activity of propolis is due to flavonoids and aromatic acids and esters present in resin (Grange *et al.*, 1990). Galangin, pinocembrin and pinobanksin have been recognised as the most effective flavonoids against bacteria. Aromatic acids, ferulic and caffeic contribute to bactericidal action of propolis (Dimov *et al.*, 1992).

Propolis has been successfully used in cosmetic and pharmaceutical products such as face creams, ointments, lotions and solutions. It is marketed in tablets, powder and chewing gum (Ghisalberti, 1979; Dobrowolski *et al.*, 1991; Bjorkner, 1994). A water-soluble preparation obtained from propolis showed significant bacteriostatic effect on acid resistant organisms at 0.001% (Tikhonov *et al.*, 1975). Similarly an alcohol-water mixture was used for the treatment of candidiosis (Todorov *et al.*, 1973). These results suggest that, in these preparations at least the active matter must be water-soluble.

New Zealand propolis has the distinctive characteristic due to unusual high proportion of di-hydroflavonoids. Di-hydroflavonoids comprise 70% of flavonoids and is dominated by pinocembrin, pinobanksin and pinobanksin 3-accetate (Markham *et al.*, 1996). The antibacterial activity of the propolis extract was found to be extraordinarily stable, with no

reduction observed even after storage for 3-4 years at 0-4° C or at room temperature (Ghisalberti, 1979).

### 2.5.4 *Toxicity of Propolis*

The major constituents in propolis that exhibit toxicity are hydroquinone 0.1% (Burdock, 1998) caffeic acid and its esters 2-20% (Bankova *et al.*, 1995) and quercetin 0.1-0.7% (Greenaway *et al.*, 1990), each of which has exhibited the carcinogenic properties when fed to rodents. However, all of these occur naturally in food. Hydroquinone is present in beer and coffee at level of 1.25 to 40 p.p.m and is approved as an indirect additive to food. While quercetin and caffeic acids are not approved for use in food, the contribution of these substances through consumption of propolis is little when compared to consumption from other natural resources. The estimated daily intake of quercetin by an individual in the US is 25 mg (Burdock, 1998). Also a daily intake of caffeic acid through lettuce is 27-56 mg (IARC, 1993). Therefore, propolis contributes an insignificant amount of these substances when compared with the daily intake of regular sources of vegetables and fruits. Pinocembrin, the predominant in flavonoids in several extracts, showed no toxicity when administered orally to mice at 1000 mg propolis/kg of rat weight (Metzner *et al.*, 1977).

### 2.5.5 *Variation in the Activity of Propolis*

Pepeljnjak *et al.* (1985) correlated the flavonoids content of propolis in different parts of Croatia and found that they varied considerably and even the method of extraction produced variability of results from the same samples of propolis. Spiridonov *et al.* (1992) compared the propolis extracts made with water, 40% ethanol water and 96 % ethanol water mixtures and found that they completely suppressed the cell growth at 50-500 μg/ml. Although the reported degree and scope of activity among the general categories of susceptible organisms is variable it is, in a sense, markedly similar, with activities generally below 10 mg/ml. The difference might be attributed to a difference in severity in the test organisms and to a difference in the flavonoids content. The efficacy of flavonoids

was also compared with propolis, and it was found that efficacy of pinocembrin the main flavonoid of propolis is approximately 10 times stronger than propolis extract (Metzner *et al.,* 1977). But activity of propolis extracts can be standardised on the basis of quantitative estimation of prominent components of the extracts by biochemical activity tests (Volpert & Elstner, 1993).

### *2.5.6 Source of Antibacterial Activity in Honey*

Honey is a complex mixture of compounds including phenolics, which contribute to sensory qualities such as bitterness and colour. Honey phenolics may be divided into three groups: benzoic acid and their esters, cinnamic acids and their esters and flavonoid aglycones. The mono-floral honeys are rich in flavonoids and they account for 42% of total phenolics.

In honey there are two types of antibacterial agents. One of them is heat unstable and light sensitive and has its origin in the $H_2O_2$ produced by honey glucose oxidase (White, 1963). The other consists of thermostable substances like flavonoids (Russell, 1983; Bogdanov, 1984). The flavonoid patterns of honey extracts are similar to those of propolis extracts. This could indicate that most, if not all of honey flavonoids have their origin in propolis. Propolis, being a natural constituent of honeycomb, has components that are probably distributed between the relatively lipophilic beeswax and the more hydrophilic honey. As the flavonoids are relatively lipophilic, their concentration in honey is much lower than in propolis.

The heat stable and light-insensitive antibacterial activity of honey correlates with honey's amylase and saccharase activity, but does not correlate with the origin of honey (Bogdanov, 1989). Molan and Russell (1988) found that for a range of New Zealand honey samples the thermostable antibacterial activity varied from nil in some samples, to almost the whole of the activity in other samples. They also noted that a clear correlation existed between the level of thermostable antibacterial activity and the overall activity of the

individual honey samples. Manuka honey was tested to have thermostable antibacterial activity.

Further investigation led to the identification of some components with antibacterial activity in manuka honey: 3,4,5 trimethoxy benzoic acid and 3,5- dimethoxybenzoic acid (Russell *et al.*, 1990).

### *2.5.7 Sensitivity of Antibacterial Activity to Heat*

A 50% solution of honey heated at 90° C for 15 minutes completely destroyed the peroxide value (Adcock, 1962). While, undiluted honey samples showed that between 55° C and 70° C, the time for the loss of half the activity of peroxide nature ranged from 36 to 270 seconds at 65° C, and about 3 to 6 hours at 55° C (White and Subers, 1964[a]). Wootton *et al.* (1978) found that temperature of 60° C and above rapidly destroyed the antibacterial activity. The storage temperature in the range of 46° C–60° C also caused a reduction in the activity. However, in this study, the heat stable non-peroxide activity was not found in the honey samples that were heated to 95° C for 1 hour.

The effect of heat on the antibacterial activity of dark and light honey has different effects. While the $H_2O_2$ production capacity of light coloured honey was severely damaged, the antibacterial activity of non-$H_2O_2$ remained unchanged (Bogdanov, 1984). The effect of heat on the antibacterial activity of dark honey and light honey is shown in Table 2.3. The honey samples were heated for 15 minutes at 70° C.

**Table 2.3: Effect of Heat on Peroxide and Non-Peroxide Activity of Honey**

| Type of honey | Number of samples | % of initial activity | |
|---|---|---|---|
| | | $H_2 O_2$ production | Other inhibines |
| Light honey | 3 | 8 | 86 |
| Dark honey | 4 | 78 | 94 |

(Bogdanov, 1984)

The storage studies at room temperature found that the $H_2O_2$ production capacity was severely damaged, but non-$H_2O_2$ inhibine remained unchanged. The loss of $H_2O_2$ was 15-16% in 3 months and 24-27% in 6 months at 20-25$^0$ C. The product was kept in the chilled storage at 5$^0$ C till used.

### *2.5.8 Effect of Light*

$H_2O_2$ originates from the action of the natural glucose oxidase in honeybee's mouth on the glucose (Adcock, 1962; White and Subers, 1964[b]). The $H_2O_2$ capacity of the honey was severely damaged (Adcock, 1962; White and Subers, 1964[b]) but the antibacterial activity of the non-$H_2O_2$ inhibine remained unaffected.

The effect of light on antibacterial properties of honey is shown in Table 2.4.

**Table 2.4: Effect of Light on Peroxide Activity of Honey**

| Type of honey | Storage time | % of initial $H_2O_2$ production Storage in light | Activity $H_2O_2$ production Storage in dark | % of initial Other inhibines Storage in light | Activity Other inhibines Storage in light |
|---|---|---|---|---|---|
| Light honey | 3 months | 62 | 85 | 94 | 100 |
| Dark honey | 3 months | 76 | 84 | 104 | 104 |
| Light honey | 6 months | 47 | 73 | 100 | 107 |
| Dark honey | 6 months | 67 | 76 | 101 | 101 |

(Bogdanov, 1984)

The storage studies at room temperature found that the $H_2O_2$ production capacity was severely damaged, and no change was observed in the antibacterial activity of the non-$H_2O_2$ inhibine.

The loss of $H_2O_2$ was 15-16% in 3 months and 24-27% in 6 months at 20-25$^0$ C (Bogdanov, 1984). The antibacterial activity is inhibitory to large number of species, and is anti-fungal as well. The activity in dilute honey suggests that there are other factors than the osmolarity involved in its antibacterial activity. This additional activity is due to $H_2O_2$ and heat and light stable non-$H_2O_2$ inhibine. The products made out of 'active' manuka honey

having non-peroxide antibacterial activity will show stable activity during the designed shelf life of the product.

## 2.6 Market Research

The success rate of new products introduced in the market remains very poor with reported product failure rate at 83% (Sloan, 1994). It is of utmost importance to consider the market and the consumers to improve product success in the market. Information on the market situation and consumer behaviour can be obtained by conducting market and consumer research (Goldman, 1994).

Consumer research provides descriptive data about consumer opinion, behaviour and attitude toward the present and new products (Meiselman, 1994), while market research provides a detailed analysis to discover the reason for consumer purchasing behaviour, attitudes and intentions towards a particular product. Market research is also used to identify problems and opportunities for current and new products and market share of the company (Earle, 1994; Churchill, 1995; Churchill, 1999).

### *2.6.1 Market Research Plan*

According to Kotler and Armstrong (1991) the process of market research consists of four steps: (1) defining the research objective (2) formulating the research plan (3) executing the research plan and (4) interpreting the findings

#### *2.6.1.1 Defining the Research Objective*

The marketing research process begins with the recognition of a marketing problem or opportunity. A clearly and precisely defined problem would lead to relevant information (Kotler & Armstrong, 1991; Churchill, 1991; Churchill, 1999). The objective of the research is a statement of what information is needed. Research objective has three components namely, research question, hypothesis and the scope of the research. In this

study the market objective was to measure the market acceptance and potential of new product.

### *2.6.1.2 Formulating the Research Plan*

The specific information could be gathered from the secondary data, primary data or in combination. Secondary data consists of information that already available or has been collected for some other purpose, such as commercial database from other organisations, periodicals, magazines, government publications, internet and existing information system of the company. Secondary data are one of the cheapest and easiest means of access to information (Kotler and Armstrong, 1991).

Primary data is collected, to obtain a more relevant, accurate, current and unbiased information. The data could be approached through survey research, experimental research and qualitative research. The most prevalent survey methods are personal interviews, telephone interviews, and mail surveys. Fax surveys and e-mail surveys are also becoming popular (Kotler & Armstrong, 1991; Churchill, 1991).

In this project, the information on the confectionery market in New Zealand was obtained from secondary data: journals, newspapers, and magazines. The primary data was obtained by observing competitive products in the market, shelf space occupied in supermarkets, interviews and structured survey research with potential consumers.

### *2.6.1.3 Executing the Research Plan*

Research implementation involves collecting, processing and analysing the information (Green *et al.*, 1988; Kotler and Armstrong, 1991; Zikmund, 1994). In consumer studies sampling is mostly adopted by contacting the target population which is defined on the basis of research objectives, reproducibility and convenience (Churchill, 1991; Kotler & Armstrong, 1991).

Statistical measures are more powerful way to analyse data sets, which gives the opportunity to generalise from sample results to population characteristics. This can be done through hypothesis testing, bivariate analysis and multivariate analysis. Bivariate regression analysis is used to predict dependent variable from the knowledge about a single independent variable. Multivariate analysis refers to a group of statistical procedures that are used to simultaneously analyse multiple measurements on individual object being studied (Kotler & Armstrong, 1991; Zikmund 1994).

In this project the data was analysed by using bivariate and multivariate analysis: analysis of variance, co-variance analysis, cluster analysis, principal component analysis and multiple regression analysis.

#### *2.6.1.4 Data Interpretation*

Data interpretation is the most important phase of the marketing process. The difficulty in consumer research is not in measuring the intention, but in interpreting that intention into a decision. For example people who like a product need not necessarily buy it, and people who do not like a product might be persuaded to try it through advertisement (Meiselman, 1994[a]). This situation can cause a difficulty in determining the market size and target consumers.

### *2.6.2 Product Attributes and Characteristics*

The information obtained from the market and consumer research is used to determine whether the product development should be carried out on the product and what product characteristics the consumers expect.

Product characteristics are product features that can be recognised by the consumers. They include physical product characteristics (e.g. size, shape and colour); chemical composition; sensory characteristics (e.g. taste, sound, in mouth and aroma) safety

characteristics and nutritional value. Psychological features include healthiness, prestige and fun (Earle, 1994).

The product characteristics, which are important to consumer, are identified and most of them are communicated as benefits. A product with large number of benefits has greater chances to succeed in the market place. The benefits generally identified by the consumer includes healthy image, easy to use and tasting good (Earle, 1994).

In this project important attributes of jellybeans were identified from the previous work carried out by Sofat (1998). The study emphasised that honey was perceived as natural and healthy. Sensory attributes like flavour, hardness and appearance were as important as antibacterial properties. The market study conducted in this project indicated that propolis products were perceived as nutraceutical products. All these benefits were communicated to the consumer to get their true response for this product.

## 2.7 Product Optimization

Food product development is essential for the food industry and a large number of products are launched every year. At the same time, product development is a very risky proposition with less than 1% of projects initiated succeeding in the market place (Sloan, 1994). A systematic experimental design is required to achieve product excellence at the lowest possible cost by saving the time consumed between product concept and market place (Joglekar and May, 1987; Arteaga *et al.*, 1994; Matz, 1994). A large number of experimental designs can be used to generate products that perform as per design constraint. Achieving optimization evaluates the potential alternatives within problem constraint and way of deciding the best possible alternative (Norback & Evans, 1983; Arteaga *et al.*, 1994).

The optimization of the product can be divided into three major components: objective

function, decision variables and constraints (Norback and Evans, 1983). The objective function is used to compare the possible solutions and select the optimum. For food products the objective function includes cost optimization (Uaphithak, 1994) and maximization of consumer acceptability (Stone and Sidel, 1985; Uaphithak, 1994).

Decision variables are the inputs required for the solution of a decision problem. In product formulation, the amounts of ingredients (Norback & Evans, 1983; Cornell, 1984) and critical process variables used are the decision variables since they define the solution (Khuri and Cornell, 1990).

Constraints may limit the value of input variable or responses. Constraints include the restrictions placed in the formulation and control the solution by defining criteria that all solutions must meet. The feasible solution is that from which a value of response is obtained after satisfying all the constraints (Cornell, 1984; Norback & Evans, 1983; Cornell and Gorwan, 1984). The examples of constraints are minimum product cost/kg and acceptability score of more than 7 (Khuri and Cornell, 1990).

The various methods for product optimization are mixture design, fractional factorial design, taguchi design, response surface methodology and linear programming (Norback & Evans, 1983; Gacula, 1993; Graf and Saguy, 1991; Arteaga *et al.*, 1994).

### *2.7.1 Response Surface Methodology*

Currently RSM is the most popular optimization technique in food science because of its high efficiency, simplicity and comprehensive theory. It can be defined as a statistical method that uses quantitative data from appropriate experimental design to determine and simultaneously solve multivariate equations. These equations can be represented graphically as response surfaces (Giovanni, 1983; Khuri and Cornell, 1990). It has been used in optimization of powdered chocolate milk (Hough *et al.*, 1997); ready to eat cereal (Moskowitz, 1997); and powdered soft drink (Griffin & Stauffer, 1990).

The response surfaces methodology involves four steps: selection of system parameters, formulation of experimental plan, model fitting and finding optimum solutions (Khuri and Cornell, 1990). The important factors being optimized and responses needed are identified. The experimental space is determined by defining an upper and lower limit for each factor (Moskowitz, 1994). In the second step the design of experiment is decided. The most common experimental design used in RSM is central composite design (CCD). It has equal predictability in all the directions and the number of points in the design are sufficient to test the statistical validity of the fitted quadratic model as well as lack of fit of the model (Khuri and Cornell, 1990). A linear or quadratic model is fitted to the collected data (Schutz, 1983; Khuri and Cornell, 1990). Statistical tests are performed to evaluate the validity of the model. These tests include a lack of fit test using replicate points and residual analysis (Khuri and Cornell, 1990; Wheeler *et al.*, 1993). Optimum of the system is predicted from statistically valid data. The optimum conditions in these multi-response problems are achieved through graphs by finding the experimental region that will give desired value of the response (Wheeler *et al.*, 1993).

### *2.7.2 Echip Experimental Design*

Echip is computer software, based on statistical methodology for varieties of program such as mixture design, factorial design, response surface design and taguchi orthogonal design. The program covers the areas of design and analysis of experiments by discovering the relationship between response and control variables. The design and analysis is clearly marked in Echip by the default settings of parameters and options. The relationship is used to formulate an equation and validity of the relationship is determined (Wheeler *et al.*, 1993).

Four types of design variables can be used such as categorical, block, continuous and mixture. Continuous variables are independent variables, which could take its value between any number defined in a range. The mixture variables are described as proportion and sum of the variables is unity (Hare, 1974). Only mixture variables may be present in a

standard design. The variation in one variable at least changes one more variable and makes them interrelated (Cornell & Gorwan, 1984; Wheeler, 1993). Categorical variables are described in terms of distinct categories. The- categorical variables are treated as sequence character rather than a numeric value therefore, they can not be inserted between the levels. Block variables are categorical variables with integers for level names that don't interact with other variables. The block is usually used to separate sets of data taken at different times or under different conditions (Wheeler *et al.*, 1993). Among the four variables, the continuous variables are used in this study.

A response surface design was used in this study. RSM can be used in problems having ingredients and/or processing conditions as variables, where as mixture designs are specifically designed for formula problems (Khuri and Cornell, 1990). But if process, categorical or block variables are used then algorithmic design module must be used (Wheeler *et al.*, 1993).

Echip optimisation program requires less number of trials than standard RSM design method. Also, it has five extra trials for detecting lack of fit. If lack of fit appears for any response, it is inferred that the used model does not fit that response. This necessitates transformation of the given data or using a more complex model. Because of these reasons, Echip's pre-calculated design was chosen for the study.

## 2.8 Consumer Input in the Product Development Process

Martin (1985) noted that consumers are interested in improved products, which have more appeal to purchase or consume. Therefore, in the early stages of product development, the product specific attributes that play an important role in consumers' acceptance and buying intention have to be identified (Uaphithak, 1994). The techniques most commonly employed is consumer survey and focus groups (Earle, 1994).

Once important product specific attributes are identified, these attributes are incorporated in the new product. The developed product is tested to determine the acceptability of the various characteristics (Stone & Sidel, 1993 [b]). As the product is targeted to fulfil the consumer satisfaction, it is rational that consumers are involved in the sensory testing to obtain an optimum formulation. A product that satisfies the consumer's sensory requirements has more chances of success, because the results of the single population can be generalised to the target population (McEwan, 1996). Once an optimum formulation is obtained, the formulation is scaled up for large-scale production, which may bring change in the product characteristics (Matz, 1994; Indrawati, 1996). To identify these changes, sensory testing involving consumers is required at this stage.

Final consumer testing is conducted to reduce the risk of product failure, and involves a target population trying the product under normal usage conditions. A consumer response is recorded regarding overall acceptability, purchase intention, expected price, package design, brand name and repeat purchase intention (Kotler & Armstrong, 1991; Uaphithak, 1994). In the final product testing, developers may wish to compare the new product with the market leader or a current formula to develop the marketing strategy of the product (Uaphithak, 1994). Consumer testing helps to determine the unanticipated problems of a new product and thereby reducing the risk of failure.

## 2.9 Sensory Evaluation

Even in nutraceutical products sensory properties of the product play an important role in its success in the market place. Sensory evaluation is a powerful analytical tool, and different sensory evaluation techniques have been used in this project, affective for response of consumer panel and descriptive for response of trained panel. Sensory testing can be conducted in either supervised environment (Central location/laboratory) or unsupervised environment (in-house test) but both of them have advantages and disadvantages. Both the test methods were used to study the differences.

### *2.9.1 Measurement of Sensory Response*

Sensory evaluation is carried out using the senses of sound, taste, aroma, appearance and touch to measure reaction to characteristics of foods and materials (Larmond, 1977). Hence sensory evaluation covers food products and ingredients as well as non-food products.

Sensory evaluation being an analytical test procedure requires precision, accuracy and sensitivity. In sensory evaluation, human subjects are used as instruments and are prone to bias, are variable over time and are variable among themselves (Meiselman, 1993). Therefore, reliable sensory results depend on the precise definition of the problem, efficient test design, and proper selection and training of the test subjects. In addition it involves proper interpretation of results by using the statistical procedure, and drawing conclusions which are warranted by the results (Lawless & Heymann, 1998; Meilgaard *et al.*, 1991).

### *2.9.2 Importance of Sensory Evaluation*

Sensory evaluation is a powerful analytical technique, if properly applied. There are 5 main reasons for using sensory evaluation purposes: to evaluate quality; to study processing effects; to determine consumer reaction; the selection of qualified judges, and to study human perception of food attributes; and to correlate sensory with physical and chemical measurements (Amerine *et al.*, 1965). Sensory evaluation can be helpful when products are altered as means of improving product quality due to changes in ingredients, processing conditions and/or packaging materials and procedures. The changes in product are also made due to improving productivity and reducing production costs (Labuza & Schmidl, 1988; Lawless & Heymann, 1998).

Sensory testing can be helpful in product development by minimising the risk in decision making. Panellists can identify sensory characteristics that help to describe the product (Amerine *et al.*, 1965). They can confirm the necessary changes in ingredient formulation,

identify areas for improvement, determine if optimisation has been achieved, evaluate competitive products, observe changes occurring during processing or storage and provide data to substantiate advertising claims (Larmond, 1977).

### *2.9.3 Scaling Methods in Product Testing*

The choice of scale to measure the response of panelists is critical to the outcome and interpretation of results (Gacula, 1993). Scaling methods include the use of either numbers or words to express the strength of perceived attribute and the acceptability of products (Meilgaard *et al.,* 1987[a]) A scale has been defined as a graded arrangement, used in reporting assessments. There are three types of scales; category scales, unstructured scales and magnitude estimation (Land & Shepherd, 1988).

Scoring on category scales is used extensively due to its diversity, and ease of statistical analysis (Pangborn, 1984). This scale provides estimates of the distance between stimuli assuming that the difference between scale categories is equal. However, this scale does not possess a true zero point (Gacula, 1993). Three different hedonic scales (category scales) used in the food industry are 9-point scale, 7-point scale and 5-point scale. The consumers can easily understand this scale and results are reproducible with different set of consumers (Stone & Sidel, 1993 [b]). According to Land & Shepherd (1988) the increased number of categories will increase the discriminative ability.

To record the intensity for each attribute on the unstructured line scale, panelists make a vertical mark on a 6-in (152mm) horizontal line at that point that represents the intensity and the distance along the line is measured. The line may have two anchors, placed 0.5 inch (2.5 cm) from each end, and panelists are reminded that they can mark beyond the anchor points. Stone *et al.* (1974) has used unstructured scales in quantitative descriptive analysis, which the ratings are made on a 6-inch line with anchors at 0.5 inch from each such as soft-hard, weak-strong.

Magnitude estimation involves the use of scales in which successive points are in constant ratio to each other. In magnitude estimation, the task of the panelist is to evaluate a stimulus in comparison with another where one of them is assigned number say 10. If one stimulus is three times more intense than another the stimuli can be assigned 30 if half large then 5 (Gacula, 1993). The major advantage of this procedure is that the scale is believed to have ration properties.

In this study the unstructured line and hedonic scales were used. While line scales were found to be reliable and easy to use at the same time they have been successfully used for product development (Uaphithak, 1994). The hedonic scales were used, as they were found best to measure acceptance of the samples by the consumer panelists.

### *2.9.4 Techniques for Measuring Sensory Response*

Several different sensory evaluation techniques have been developed (Larmond, 1977; Meilgaard, 1987[a]; 1987[b]; O' Mahony, 1988). The different tests used in sensory evaluation of food and consumer products can be classified into 3 categories, namely affective testing, discrimination testing and descriptive analysis (Larmond, 1977). The selection of a technique used is dictated by that of the testing purpose and the information required. The type of techniques, panellists, test implementation, data analysis and interpretation for food sensory evaluation have been comprehensively explained by Larmond (1977) and Meilgaard *et al.* (1987[a]; 1987[b]). Furthermore, Moskowitz (1983; 1994) has described evaluation of food quality control and product optimisation, O' Mahony (1988).

In this project affective testing and descriptive testing were used to assess the product. A 9-point hedonic scale was used in the affective testing and a modified TPA was used as the descriptive test. The discriminative testing was not used as the instrumental results were used to determine product differences, and these different samples were further tested for TPA to get detailed description of the product.

### 2.9.4.1 *Affective Testing*

The most popular type of affective testing is the hedonic test. The primary purpose of affective testing is to assess the preference and/or acceptance of a product by actual and potential customers. It provides a direct link between the consumer (Poste *et al., 1991*) and other sensory responses to determine how a product will be accepted and preferred to others when released on to the market (Meilgaard *et al.,* 1991; Stone & Sidel, 1993 [b]). The consumers easily understand the hedonic scale and minimum of instructions are required to follow it. For measuring liking and the preference, the 9-point hedonic scale is the most useful method (Stone & Sidel, 1993 [b]). To measure consumer responses to a particular sensory attribute intensity, just right and hedonic scales can be used (Meilgaard *et al.,* 1994).

Usually 50 or more subjects participate to represent target population, which would exclude the use of employees due to the high risk of biased results compromising objectivity and validity of the test (Meilgaard *et al.,* 1991). But in the industry cost effectiveness compels usage of employees and local population. Therefore, employees should always be screened for their product usage, and likes/dislikes, and their responses compared to data from non-employee sources. If data matches, then only it should be used in new product development, product optimisation or product improvement (Stone & Sidel, 1993 [b]).

Similarly, subjects selected for the other tests (discrimination and descriptive) should not be used in affective tests. They tend to be more analytical in discrimination and descriptive, instead of the preference and/or acceptance of a product.

Depending upon the objectives of sensory evaluation, a sequence of different tests is required, in which case affective testing comes last, after the analytical approach has been pursued. This approach helps in reducing the number of alternative samples to test on large number of panellists (Stone & Sidel, 1993 [a]). Further details on affective testing can be

found in Amerine *et al.* (1965), Meiselman (1988), Meilgaard *et al.* (1991), Stone & Sidel (1993 [b]) and Lawless & Heymann (1998).

### 2.9.4.2 *Discrimination Testing*

This test is used to determine whether samples can be differentiated at some predetermined level of statistical probability. It is on the basis of the perceived difference between two products that one can possibly proceed to the descriptive test in order to identify the basis for difference (Stone and Sidel, 1993 [b]).

Further details on discrimination testing can be found (Amerine *et al.,* 1965; Lawless & Heymann, 1998; Meilgaard *et al.,* 1991; Pangborn, 1984; Stone & Sidel, 1993 [b]).

### 2.9.4.3 *Descriptive Analysis*

Descriptive sensory analyses are the most sophisticated tools in comparison to discrimination and acceptance testing methods (Stone & Sidel, 1985; Lawless & Heymann, 1998). It involves the detection and detailed description of both the qualitative and quantitative sensory aspects of a product or a group of products (Meilgaard *et al.,* 1991). Descriptive analyses is a total sensory description that take into account all sensations such as appearance, aroma, flavour, texture or sound properties that are perceived as the product is evaluated. The panellists must define to what degree each characteristic or qualitative note is present in a sample. From the viewpoint of product development, descriptive information is essential in finding out those product variables, that are different, and from which one can establish the cause, and effect relationship. (Poste *et al., 1991*).

The results of a descriptive analysis provide a basis for determining which sensory characteristics are important to acceptance of a product, as well as a means of identification of ingredients or processing variables (Stone & Sidel, 1985; Stone & Sidel, 1993 [b]). The techniques can be applied to shelf-life studies, product improvement, quality

control and assurance (Lawless & Heymann, 1998 and Meilgaard *et al.*, 1991). Because of its highly analytical approach, descriptive analysis is useful in relating sensory with chemical and instrumental relationships (Szczesniak, 1987; MacFie and Hedderley, 1993). The most commonly used techniques are the texture profile analysis (TPA), the quantitative descriptive analysis (QDA), and the free choice profiling (FCP). Further details on descriptive testing can be found in Amerine *et al.* (1965), Pangborn (1984), Meilgaard *et al.* (1991), Stone & Sidel (1993 [b]), Lawless & Heymann (1998).

#### *2.9.4.4 Texture Profile Analysis (TPA)*

This method was developed by Brandt *et al.* (1963) on the texture classification system (Szczesniak, 1963) developed to bridge the gap between consumer terminology and rheological properties of the product. Since then modifications has been included to this method. Further details on TPA can be found in Szczesniak *et al.*, (1963), Civille & Szczesniak (1973), Szczesniak (1975), Szczesniak *et al.* (1975), Munoz (1986).

One very important aspect of this method is the selection and training of panellists (Civille & Szczesniak, 1973; Skinner, 1988). During the training, panellists are exposed not only to the basic concepts associated to texture, but also to flavour as several properties of food product interrelate (Stone & Sidel, 1993 [a]). A considerable amount of integration of different stimuli takes place in the brains of the assessors as they evaluate a sample. If stimuli are ignored the panellists take the risk of overlooking rare but important differences.

### *2.9.5 Environment*

Sensory testing can be conducted in either supervised environment (Central location/laboratory) or in-house test (unsupervised environment) (Meiselman, 1994 [b]; Moskowitz, 1994).

Three primary types of acceptance tests are laboratory, central location and home placement. To some extent the difference between testing in a laboratory and central location is not very clear and can be considered as of one type (Stone & Sidel, 1993 [a]). Each environment has advantages and disadvantages, which are described in Table 2.5.

**Table 2.5: Advantages and Disadvantages of Central Location and Home Placement Tests**

| Advantages/ Disadvantages | Central Location | Home Placement |
|---|---|---|
| Advantages | *Controlled conditions/supervision | *Product used under natural and realistic condition of use |
| | *Several products can be tested at the same time | *Long term responsiveness to a product is measured |
| | *Response return is very high | *All family's opinion can be obtained |
| | *Careful product preparation | *Better motivation |
| Disadvantages | *Product not used under natural conditions | *Unsupervised preparation the product |
| | *Number of questions can be asked is quite limited | *Time consuming and non response is quite high |
| | *The products that needs a preparation, it may not be prepared in a manner that the respondent is accustomed to | *Expensive |
| | *Cannot measure response based on repeated use | |

(Stone and Sidel, 1993); (Meilgaard *et al.*, 1994).

### *2.9.6 Consumer Panel*

Meiselman (1994 [a]) recommended that acceptance test using hedonic and other affective scales should be done with untrained consumer panels only. The consumers participating in a test must meet specific criteria such as product purchase and usage requirements and

demographic criteria such as age, sex, income, education, and household size. This ensures that they represent a known user group or approximate an anticipated user group, in case of a new product not currently in the market (Meilgaard *et al.*, 1994). Meilgaard *et al.* (1987[a]) suggested 20 to 30 panellists are often used for sensory evaluation.

Consumer acceptance is usually measured as preference testing or monadic testing. In preference testing preference of one sample over the other is measured. But in monadic testing it is measured in relation to consumer's frame of reference. Consumer acceptance can be measured in a central location test setting or home use setting depending on the stage of product development and the intended use of the data (Meilgaard *et al.*, 1987[a]; Stone & Sidel, 1985).

But, consumer panels are likely to bring a large variability in the results. The variability in responses may occur among panellists or even within their judgement (Meilgaard *et al.*, 1987[a]). The result of consumer panels must be tested by statistical analysis, such as t-test, ANOVA and Chi-square distribution. The statistical analysis is normally expressed in degree of significance, which shows the probability that the results are caused by chance (Larmond, 1977).

### *2.9.7 Correlation between Sensory Evaluation with Objective Measurements*

Correlation is generally used to assess the relationship between the instrumental measurement and sensory perception in order to measure consumer response (Szczesniak, 1987). The value of correlation between the two methods are less than r = 0.80, when a wide range of related characteristics are measured to physical measurements (Moskowitz, 1983). Correlating sensory with instrumental TPA has recently become of renewed interest (Meullenet *et al.*, 1997). Most research indicates that the quality of correlation varies significantly depending on the parameters. Hardness has consistently been demonstrated to correlate very well. Springiness and cohesiveness give low degree of correlation. Methods has been suggested to overcome this problem but they are not tested extensively

(Meullenet *et al.,* 1997; Meullenet *et al.,* 1998). In this study correlation of sensory and physical measurements was not considered due to the lack of correlation for attributes other than hardness, and lack of published data on jellybeans.

### *2.9.8 Trained Panels*

An entire range of characteristics is involved in the total flavour and texture impact, and instruments can measure only part of it. A trained panel provides analytical information that other instruments cannot measure such as tooth packing after swallowing and sweetness. To perform the descriptive tasks to evaluate the product, typically 6 to 12 people are screened and trained.

A descriptive analysis study involves three steps namely, training of the assessors, reproducibility of the assessor and final evaluation of the samples (Lawless & Heymann, 1998).

Training of panellists, is a time consuming and expensive process. At first, the characteristics that are going to be used for the perceived sensory parameters are identified and defined. Development of the language is a group process, after evaluating a broad range of products that define the product category, panellists are able to generate a list of descriptors that is comprehensive but not overlapping (Lawless & Heymann, 1998; Stone & Sidel, 1993 [b]). All the panellists use the same concepts and able to communicate precisely with one another (Civille & Lawless, 1986).

Assigning a value along a measurement scale measure intensity of the descriptors present in the sample. Semi-structured scales are used to measure intensities of individual attributes. Panellists are provided with a frame of reference for each particular descriptor, alternatively asking them to generate reference standards needed to describe differences among the products. This is usually done by coming to some consensus among themselves (Lawless & Heymann, 1998; Meilgaard *et al.,* 1991; Stone & Sidel, 1993 [b]). To ensure

consistent results, panellists undergo training on the use of scales across samples and time, as well as on the use of reference for intensity of different descriptors (Lawless & Heymann, 1998; Meilgaard *et al.*, 1991). The validity and reliability of the quantitative assessment is also dependent upon the selection of a scaling technique that is broad enough to encompass the full range of descriptor intensities (Meilgaard *et al.*, 1991).

Just as with any instrument calibration using standard is necessary to assure precision. Likewise, panellist performance evaluations are essential to determine discriminative consistently (Lawless & Heymann, 1998). Product with known large differences in duplicate should be presented occasionally and rated on the scales developed for the actual test sessions. A need for further training is indicated by significant differences among the panellists and lack of significant differences among the samples (Meilgaard *et al.*, 1991; Stone & Sidel, 1993 [b]). One and two way analysis of variance techniques are used to assess panellist performance and data. Differences among panellists can be estimated without the influence of variance of individual subjects, because every panellist judges every product and replicate (Lawless & Heymann, 1998). However, extensive training of the panellists, skilled panel leaders, and the use of reference materials will give reproducible consensus profile data.

## 2.10 Discussion

No standard method is available for testing the antibacterial properties of confectionery products. So a method was developed to test the antibacterial properties of jellybeans. The method is based on heating to boiling with ethanol for 2 hours, which removed majority of antibacterial activity and at the same time reduced interfering substances other than antibacterial components. The less soluble component like waxes and sugars were removed by centrifugation. Ethanol extracted majority of antibacterial properties and at the same time left behind sugars and other ingredients used for development of antibacterial jellybeans.

Perception of foods is a complex sensory and interpretation processes. Human brain receives the sensation and integrates into perception relative to expectations. These processes are impossible to mimic from instrumental measurements. So sensory as well instrumental measures were considered for evaluation of the product.

During the development of the product, consumers were involved, so that the developed product meets the consumer needs. Consumer involvement in the product development established several constraints, such as cost and evaluation of the product by potential consumers.

Sensory testing can be conducted in CLT or HUT, but both of these methods have their own advantages and disadvantages. In this project, both of these methods were used to overcome disadvantages of each method. CLT gave short time response related to acceptability of the product and HUT gave long term responsiveness related to the functionality of the product. For antibacterial products, consumer belief in the functionality of the product was found to be an important attribute. The functionality of the product is important to keep consumer interest in the product and hence buying intention for a long period.

## 2.11 Conclusion

The development of nutraceutical jellybeans is categorised under functional foods. The factors for product's success are similar to that for regular foods like taste, convenience and value addition. The functional component is a value addition. To prove the functionality, the product should have proven ingredients and the positive consumer perception and acceptance of these claims. To substantiate these claims the literature helped to develop a new method for testing the antibacterial properties of the product and selection of appropriate methods for design of experiment, process development, process scale up, and consumer and sensory testing.

# Chapter 3

# Preliminary Study of Confectionery Products

## 3.1 Confectionery Market

### *3.1.1 Trend of Confectionery Market in the World*

Sugar based gelled confections can be defined as highly concentrated solutions of simple carbohydrates containing acid, colour, flavour, texture agents, and stabilizers.

Eastern Europe has the highest growth in the consumption of chocolate, chewing gum, and sugar confectionery. The volume of confectionery has increased nearly 36% every year since 1992. In Russia, the confectionery consumption has doubled every year since 1992 (Pszczola, 1997). The UK market was poised to reach 830,000 ton by 1996 to enable it to become the largest confectionery consumer in the world. According to Euromonitor, they spend 9% of the total food expenditure on the confectionery products. An average New Zealander consumes around 7.5 kg a year compared to the Australian at 10 kg and the British at 16 kg (Balasoglou, 1999). Figure 3.1 shows the per capita consumption of sugar confectionery in major countries.

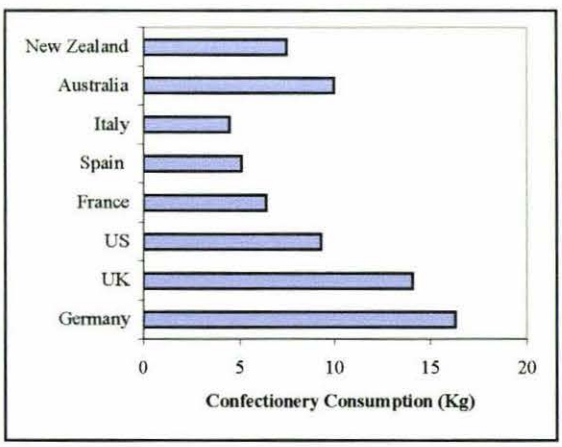



**Figure 3.1: Per Capita Consumption of Confectionery 1991**

(Source: Euromonitor Market Direction in Confectionery Production, December 1992).

As shown in Figure 3.2, the world sugar confectionery market can be broadly categorised into young, developing, and mature. Vietnam, China, and Eastern Europe had markets defined as young with a large potential for growth. China is likely to become one of the most lucrative markets in the world (Dorn, 1996). In 1995, the total confectionery production was estimated to be around 600,000 tons, and its imports increased by 50% between 1992 and 1993 (Dorn, 1996).

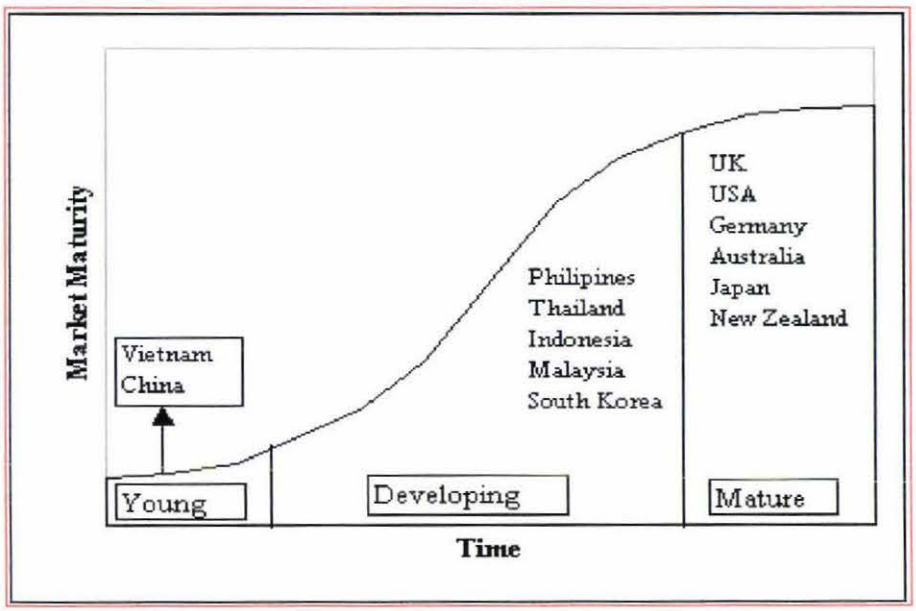



**Figure 3.2: Stages of Maturity for Confectionery Products in Important World Markets** (Source: Euromonitor Market Direction in Confectionery Production, December 1992 and Confectionery Production, May 1999).

The market in Thailand, Indonesia, and Malaysia was developing, with growth and investment both seen to be high. Due to the economic crisis in these countries, the outlook appeared to be bleak and prone to high risk and high rewards (Agos, 1998). However, the markets in UK, Australia, New Zealand, and US were mature (Anonymous, 1992). The research has shown that growth in the confectionery industry was motivated by different reasons, and it varied among the different markets (Anonymous, 1997). Increasing

availability of disposable incomes has driven growth in the developing and emerging markets (Turley *et al.*, 1999).

Growth in the developed markets such as Australia, UK, and New Zealand can be related to improvements in product quality, distribution, advertisement, and innovation (Turley *et al.*, 1999). Both product quality and variety will help to meet the consumer demands. At the same time, product should be distributed in supermarkets, shopping centers, and other possible outlets like dairy shops (Sanderson, 1997). About 70% of retail confectionery purchases are impulse buying; that makes point of sale advertisement as the most powerful tool. Equally important, the packaging has to be eye-catching and new products should be extensively sampled (Sanderson, 1997; Balasoglou, 1999). Innovation remains the key to the continuing success of current products and the introduction of the new products (Anonymous, 1997; Balasoglou, 1999; Turley *et al.*, 1999). In the past functionality featured a lot for sugar-free and tooth friendly chewing gum. This has now included decongestant properties to products as 'Airwaves' ™. In newly products launched, 'Brain Gum' ™ claims to have other amazing properties as increased brainpower and 'Buzz Gum' ™ has a high guarana content which provides revitalization and caffeine to keep awake (Hilliam, 1995; Turley *et al.*, 1999). The further addition to confectionery is herb schizandra that helps to stimulate immune defenses, balance body function, and optimize energy in times of stress (Pszczola, 1999).

Another important success factors in confectionery is to follow the latest trends in foods with 'specific health benefits' (Balasoglou, 1999). In the recent past, the trend was towards reduced calories food and beverages, high fiber products, and exercise. At the same time, the consumer has become proactive in health and medical issues, thereby searching for self-medication (Yalpani, 1997). Therefore, it seems likely that the concept of functional foods, everyday foods containing ingredients with defined health benefits will significantly influence food industry. Functional foods are also known as nutraceutical, designer foods, or even super foods (Potter, 1990; Clausi, 1994). After chewing gum, other confectionery

products in the functionality arena are throat soothers, vitamin enriched confectionery, amino acid 'L-arginine' enriched bars, and confectionery with omega -3 fatty acids (Berrell, 1994; Turley *et al.*, 1999; Pszczola, 1999).

### *3.1.2 Development of Nutraceutical Market in the World*

Credit for developing the functional foods industry and define functional food products based on inclusion of natural ingredient goes to Japanese. These natural ingredients define the functional characteristic of the product as well as the marketing strategy for the finished product (Ichikawa, 1994). Consumer preferences for products of natural origin and, a suspicion of processed food products resulted in the development of functional foods. The popularity closely related with the demand for herbal and homeopathic medicines. In the US the functional food, market has developed differently than Europe. The widespread availability of fast and convenience food created trends for healthy food made from botanical and herbal products, and served as healthier alternative to fast and convenient foods. The greater interest in products giving real or perceived health benefits further fuelled the growth (Gardner, 1994; Hilliam 1995).

In Europe, the market for functional foods is increasing more rapidly than the overall food market (Young, 1996). In the US, 50% of the functional food market include foods that consumers eat because of nutraceutical reasons. It is generally believed that dietary supplements, sugar and fat substitutes, fiber enriched foods, vegetables, virtually fat-less meat, skim milk, low calorie diets etc., are consumed for health or medical reasons. The Foundation for Innovation in Medicine (FIM) estimates that the size of nutraceutical products in the U.S. market at $ 250 billion (Defilice, 1995). Sales of healthy foods (low fat, low cholesterol, sodium reduced, and vitamin/mineral enriched) are projected to reach $ 45 billion in the US in 1997. The market is composed of two broad ingredients categories: traditional products - fat and sugar substitutes, high potency sweetners, bulking agents, dietary fibres, vitamins and minerals, and non traditional ingredients - amino acids, antioxidants, fish oils, phyto-medicines, oligo-saccharides, and carbohydrates (Blenford,

1994).

New Zealand is one of the major functional food markets in the world. However, a relatively small population size may force manufacturers to add widely available nutraceutical ingredients and to export to major markets. A survey conducted by New Zealand Food & Ingredient Advisory Services indicated that about 71% New Zealanders believed that honey is nutritionally better than other sugars. Over 88% of New Zealanders eat honey and are among the world's largest consumers of honey. Price of manuka honey increased dramatically after confirmation of antibacterial activity. For example honey with unique manuka factor UMF-10, has gone up from $3/kg to $20/kg (Collier, 1999, Personal communication). Usage of honey as a food ingredient in premium products presents definite market advantages, due to trend towards healthy natural foods (Syme, 1995).

As such, data about consumption of nutraceutical products is not available but the number of products available in New Zealand markets speak highly about awareness of these products (Appendix 3.1 page 212). However, easy availability of ingredients like propolis and manuka honey gives a unique advantage for local manufacturers of nutraceutical products and hence possibilities of exporting to the mature markets like Europe, Japan and US.

### *3.1.3 Consumer Attitude Towards Nutraceutical Products*

The studies conducted to identify the consumer of nutraceutical products have concluded that consumers can be identified based on sex, demographics, education, health status, and perceived susceptibility to disease. The consumer predominately were females, educated, higher income, in a 35-55 - age group, and interested in her health. Females were stronger believers than males to the health claims of food products. Similarly, respondents in higher income groups display a higher level of belief then those in the lower income groups. Education displays a strong relationship with belief in the nutraceutical promise and increasing as education level increases. Likewise, the strong age relationship indicates that

belief is significantly higher among respondent aged 35 to 64 than younger or older age groups. The age segment is in its peak earning years and again suggests the inter-relationship with the income and education factors (Wrick, 1994; Childs, 1997; Childs and Poryzees, 1998).

A survey conducted in Palmerston North, New Zealand indicated that 42% of the respondents believed in the claims of the confectionery product but a large number (53%) still remained undecided about its claims (Sofat, 1998).

### *3.1.4 Success Factors of Nutraceutical Products*

The success factors for functional foods are similar to the fundamental success factors for regular foods. Taste, convenience, and added value remain the primary factors for product success. The functional components in foods, becomes a value-added comparison, which appeals to a predisposed and targeted consumer (Childs, 1997). For products, to become repeat purchases this must offer flavour variety, convenient forms and include individualized packaging. Smaller product sizes suggest virility. Since broad distribution meeting impulse purchasing needs is essential, the product form needs to accommodate numerous distribution channels and usage situations (Childs, 1997; Katz, 1999).

Consumers find familiar products more credible as functional foods. The natural source of the active ingredient is highly desired and any reference to the naturalness of the product or ingredients would be preferred. Another product development and positioning issue that is difficult to separate is the claim, direct or implied by chosen ingredients, and their documented safety and efficacy ranges (Childs, 1997).

In all cases, the most important deciding factor influencing the development of the functional food product is actual consumer perception and acceptance. Regardless of the acceptance of a therapeutic claim by the regulatory body, if the consumer is not interested or does not believe in the product's ability to provide the stated benefits the product will

not succeed (Gardner, 1994).

Finally, the acceptance and use of functional foods depend mainly on two factors. The first is education of the consumer, which will be a long time process, to establish the credibility of the claims made. The second factor is the development of "no compromise products", meaning that taste and convenience are not compromised (Goldberg, 1994).

Considering all the factors important to a new product's success, 'jellybeans' a familiar product that is small in size and convenient to carry was chosen for further development. New Zealanders have firm belief in the antibacterial properties of manuka honey and bee products. Therefore, using these ingredients developed nutraceutical jellybeans.

### *3.1.5 Communication of Nutritional Beliefs to the Consumers*

Systematic communications in advertising and labeling are essential issues because a functional food needs to communicate its value added comparison with the similar product (Kawazoe, 1994). The ability to capture premium for nutritional functionality depends on perception of the product as a quality product. Without this quality perception, it will be difficult for the functional component, usually a future benefit, to be acknowledged. Other method of seeking product premium include the smaller serving quantities, individual servings, higher margin distribution channels, customized product, successful premium branding, and exclusive image. The products must be available anywhere at anytime (Childs, 1997).

New Zealand Beekeepers' Association spends a lot of money on promoting honey and other bee products (Syme, 1995). This publicity will inherently enhance the success of new product. Therefore, money saved in publicity and promotions will help in development of new flavours for nutraceutical jellybeans.

## 3.2 Confectionery Market in New Zealand

New Zealanders consume 7.5 kg of confectionery a year as compared to Australians at 10 kg. Despite a huge volume there is potential for growth. Every year hundreds of new confectionery products are launched and very few surviving more than 12 months? The estimated NZ market was worth $ 50 million and has grown by 5.3% in the past 12 months. Cadbury's Pascall and Nestle's Allen brands dominate the sugar confectionery market with 36% and 31% share respectively. The other significant players are Mars and Snow, and they hold 8% and 5% of the market share respectively.

The sugar confectionery market in New Zealand has eight major categories. Panned sugar confectionery (21.1%), toffees/nougat & caramels (16.1%) and boiled sugar confectionery (12.5%) are the major categories. The New Zealand market by proportion and type for sugar confectionery is shown in Figure 3.3.

The current trend is towards sugar free products. 'Extra' for Kids chewing gum has entered the children segments of the market and has been strongly supported by the New Zealand Dental Association as an alternative snack that delivers dental benefits for the children teeth (Balasoglou, 1999)

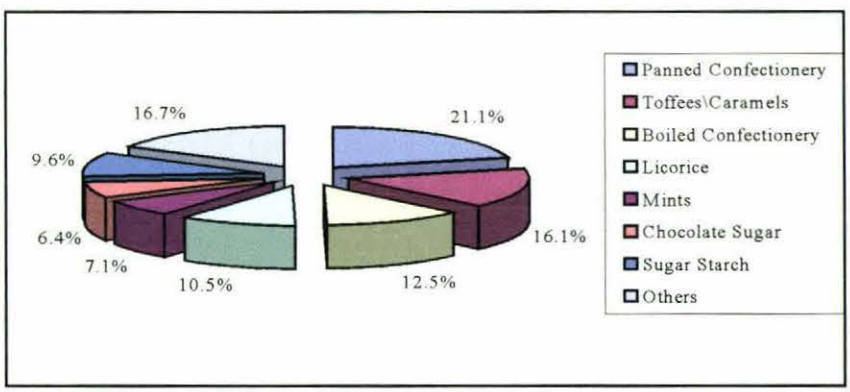



**Figure 3.3: Proportion of market by Type - Sugar Confectionery**
Source: AC Nielsen in Retail Today, March 1999.

As shown in Figure 3.4 the biggest increase in the sales were mints (up 25.9%) and licorice (up 22%). Licorice root extract has been used as medicine and flavouring in confectionery. It is supposed to have detoxification and anti-cancer effects (Nishino, 1997). While toffee and nougat, and chocolate-coated sugar confectionery fell by 3.2% and 7.3% respectively. It seems that trend is in the direction of functional confectionery.

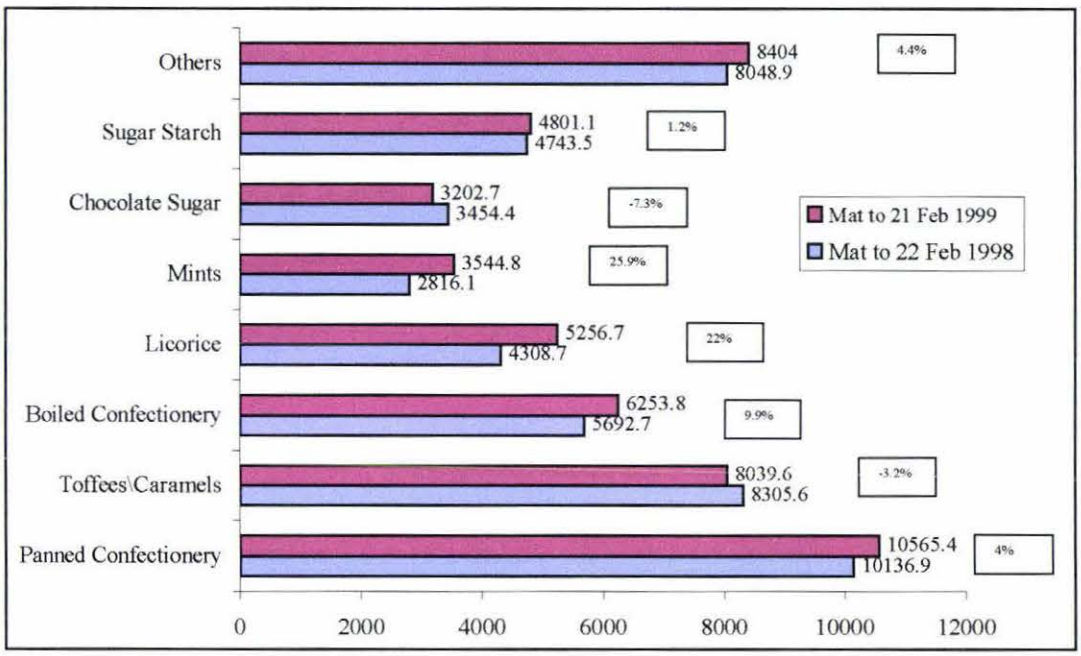



**Figure 3.4: Sugar Confectionery Growth Rates in Thousand Dollars**
Source: AC Nielsen Retail Today, March 1999.

A survey carried out in Palmerston North in 1998, showed that along with the big players manufacturing in New Zealand a sizeable market existed for the imported products. The sample of the confectionery available is shown in Figure 3.5.


**Figure 3.5: A Sample of Confectionery Products Available in the Palmerston North**

A list of confectionery products, and products made from manuka honey and propolis that are available in Palmerston North market are shown in Appendix 3.1 (page 212). The products are classified according to brand, flavour, packaging size, supplier, and consumer price.

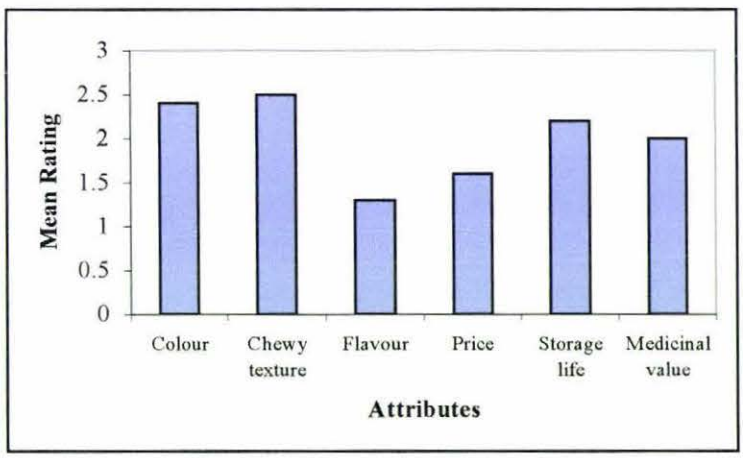
## 3.3 Important Product Attributes

Variety of confectionery products is available in the New Zealand market ranging from honey and bee by-products to throaties. Propolis is used in lozenges, capsules, immune builders, and common cold tablets. The usage of honey is wider, ranging namely, apple cider, bars, strepsils, spreads, and royal jelly. In all these products propolis and honey meet

the consumer demands by giving healthy and natural image to products. The honey and propolis play an important role by contributing functional properties without compromising with characteristics the consumers expect of the product.

In nutraceutical products, the presence of acceptable sensory properties is as important as any functional properties for the product to be successful in the market place. The consumer will buy a product that suits the wants, needs and preferences, and a repurchase decision will be made after eating the product. If consumer is satisfied, it is more likely that the product will be purchased repeatedly.

Consumer information collected by Sofat (1998) was used to identify the important attributes for jellybeans are shown in Figure 3.6. From the study, it was found that lemon flavour was the most preferred flavour for a manuka honey jellybean.




RATINGS, 1 = VERY IMPORTANT, 5 = VERY UNIMPORTANT

**Figure 3.6: Important Attributes of Manuka Honey Jellybeans**

Source: D. Sofat, 1998. Development of a confectionery product for consumer market using manuka honey having antibacterial properties.

## 3.4 Product Concept Development

A product concept is the description of a product with its characteristics and attributes in the consumer language. Ideally, the most appropriate concept presentation depends upon the purpose of the research, and should be as close as possible to the final product. In this study, the product concept was developed on the basis of previous work done and the information obtained from literature. The important success factors like familiarity of product, taste, and convenience were incorporated in the product. A smaller size product was chosen to suggest potency of the product. The claims about functionality of product were communicated through the concept and product statement.

The description of the product concept being developed is shown in the Table 3.1.

**Table 3.1: Concept of Antibacterial Confectionery Product**

| |
|---|
| The jellybean product is developed at Massey University and has derived its antibacterial properties from manuka honey and propolis. The testing of the finished product will be done in the laboratory to ascertain the antibacterial properties.<br><br>The researchers at Waikato University have determined that manuka honey has potent antibacterial properties. A joint study conducted by Institute of Industrial Research and Development, and Waikato University has also proved that New Zealand propolis is rich in polyphenols, which were found to have antibacterial, antiviral, and antifungal properties against organisms causing sore throat, stomach ulcer and dermatitis. Because of so many beneficial effects, manuka honey and propolis have found their way into many pharmaceutical and cosmetic products. |

## 3.5 Conclusion

Functional foods are foods of the future and their demand is increasing more rapidly in comparison to the overall food market. The market is divided into two segments, potential functional foods and established functional foods. A potential functional food is one that holds promise of specific health benefits and subsequently becomes an established one after sufficient clinical data is generated to demonstrate such benefits.
A market survey showed that the confectionery market in New Zealand is dominated by Cadbury's Pascall brand, closely followed by Nestle's Allen. Although, New Zealand is among largest consumers of sugar confectionery there is scope to further increase in consumption. The growth trend is towards licorice, mint and boiled confectionery, and this segment is regularly fed with new products.

In New Zealand, the market for functional foods is rapidly increasing. There are many products becoming available in the market. In these products, manuka honey and bee derivatives are a popular source of functionality. Functional foods based on these ingredients will have a good chance for success.

The study indicated that a gap exists in the confectionery market for a traditional confectionery product with added nutraceutical ingredients. It was decided to develop jellybeans, a familiar product, with added functional properties. For product success flavour, texture, antibacterial properties, and price were found important attributes to consumers. Among flavours, lemon was found the most acceptable flavour in jellybeans.

# Chapter 4

# Prototype Development and Testing

## 4.1 Jellybean Ingredients

### *4.1.1 Raw Materials*

The ingredients used for jellybeans formulation trials were: corn syrup (42 DE), granulated sugar, icing sugar, starch (ULTRA SET-LT), moulding starch, crystal gum, honey, propolis extract, gelatin A grade (175-200 bloom), citric acid, carnuba wax, mineral oil, bees wax, tartrazine and lemon flavour. The addition of these materials is approved under Article 149 of Food Regulations 1984 and amendments.

The ultra set starch was supplied by National Starch. The gelatin A grade was obtained from Leiner Davis Gelatine. Chelsea supplied the granulated and icing sugar. Carnuba and bees wax were supplied by Bronson and Jacobs. Corn syrup and moulding starch were obtained from NZ Starch. The colouring agent, tartrazine was supplied by Pointing Ltd. (NZ). The jellybeans were flavoured by nature identical lemon flavour. The flavours used in the development work were supplied by Quest International, NZ Ltd.; Bush Boake Allen, NZ Ltd.; Universal Flavours. The manuka honey samples were procured from the Gavin apiaries, while propolis was obtained from Comvita.

## 4.2 Jellybean Manufacturing

### *4.2.1 Ingredients Mixture Preparation*

Ingredients were weighed by following formulations based on the preliminary production trials as shown in Appendix 4.1 (page 217). Each batch of 0.5 kg was prepared by first mixing starch and glucose mix together. Water of the formulation was added and slurry was heated to gelatinize the starch. After completion of the gelatinization process, the

slurry was cooled and rest of the ingredients was added. The mixture of starch and glucose was freshly prepared before processing.

### *4.2.2 Process of Jellybeans Manufacture*

The development of jellybeans was completed on the hot plates available in the department of Food Technology, Massey University. The process temperature was measured with thermometers and elapsed time with a stopwatch. Once the slurry was cooked to 70-72% total solids it was ready for deposition in starch filled trays. A pattern of moulds was printed into the moulding starch filled trays by using a pre-casted shape. After drying to 84-86% solids the product was shaken out of the starch, moistened and sanded in sucrose.

After loading the engrossing pan (Figure 4.1) with a fixed weight of presorted, conditioned centers, a repetitive cycle begins and continues until the desired level of coating is achieved. The initial step is to add the first wetting of the syrup to the tumbling centers in a variable speed-engrossing pan. When the centers are uniformly wetted and sticky, fine sugar is sprinkled onto the centers. As the product tumbles, the surface becomes moist and sticky again. A further charge of sugar is made to take up this syrup. This cycle is repeated until the product reaches its desired weight, which is twice the center weight.

To ensure the surface of the product is ready for polishing, wetting syrup is applied and instead of fine sugar, powdered sugar is added. The jellybeans are allowed to dry by adding the required amount of fine sugar.

After further drying in the trays, the product is polished by using beeswax and carnuba wax. The cold air is applied to remove the frictional force. A small amount of talc is added, which helps the polishing process by lubricating and drying of the surface of the product.

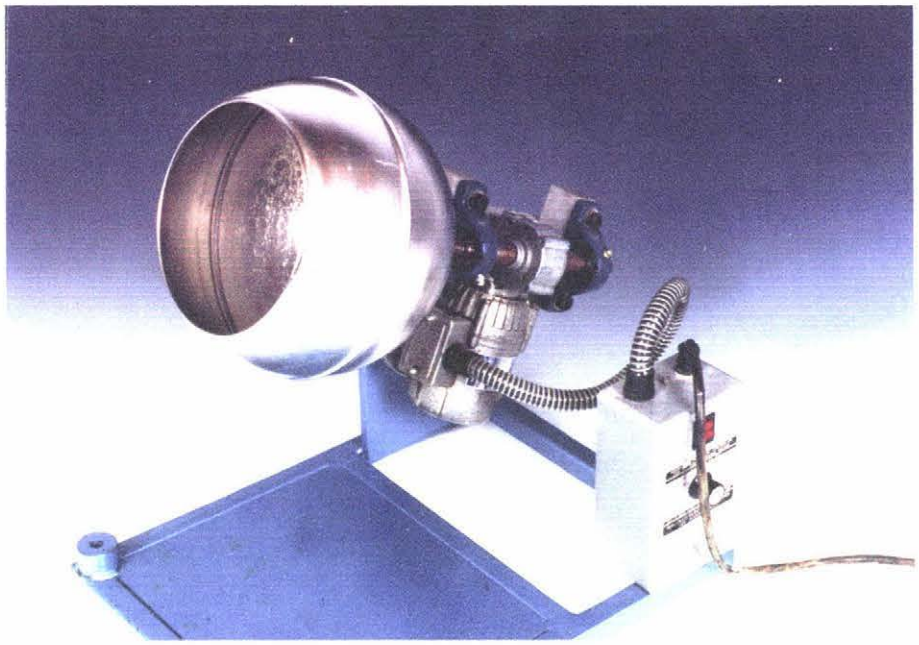


**Figure 4.1: Variable Speed Engrossing Pan**

The complete manufacturing process is shown in the Figure-4.2 and Figure-4.3.

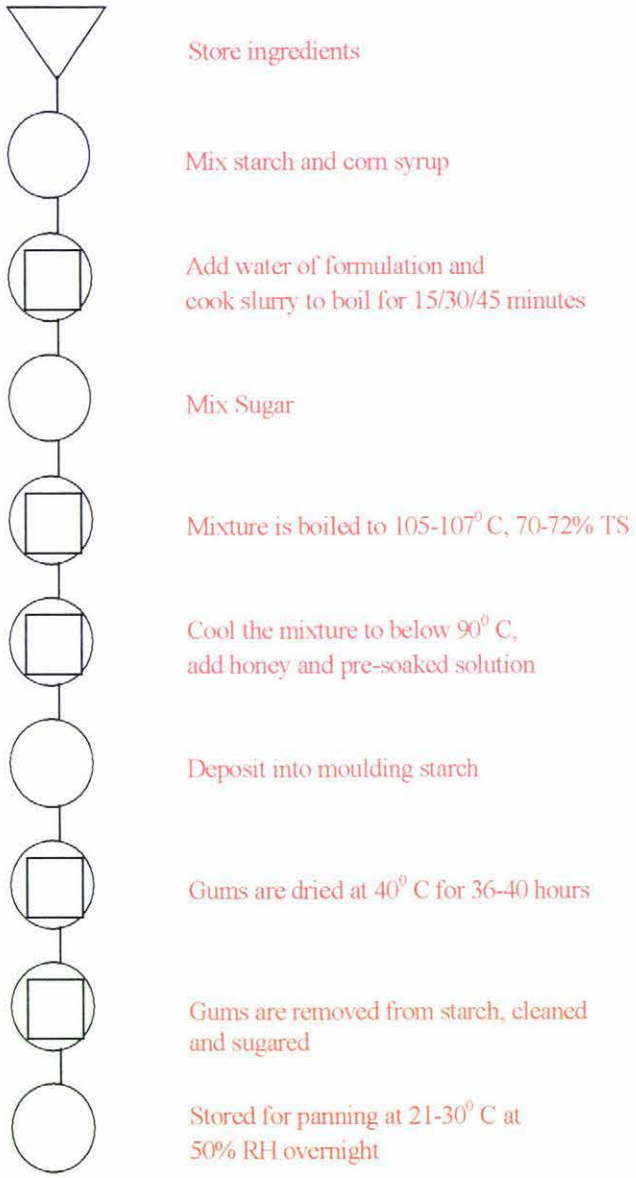



**Figure 4.2: Process flow Chart for Jellybean Centres**

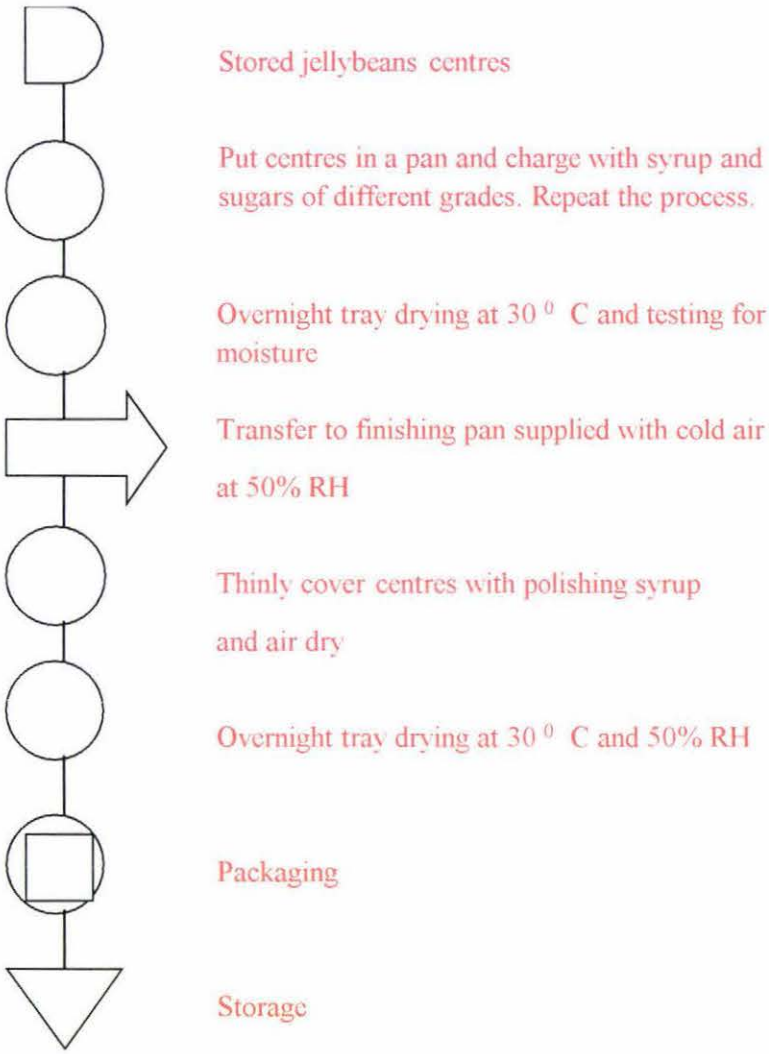



**Figure 4.3: Soft Panning of Jellybeans Centres**

### *4.2.3 Storage of Jellybean Centres*

The finished product was packed in bi-axially-oriented polypropylene (BOPP) bags and heat-sealed. The samples were stored at room temperature and kept in a dark room. The samples were analyzed within one week after production. For sensory evaluation, the samples were tested within 4 weeks after manufacture.

## 4.3 Jellybean Testing Methods

### *4.3.1 Raw Materials*

#### *4.3.1.1 Moisture Content*

The moisture content of the moulding starch was measured using moisture dish method. The moisture of the sample was determined by weighing approximately 3 gram of the sample in a cleaned, dried and tared aluminium moisture dish. The sample was dried in a conventional drying oven at $100\pm 3\ ^{\circ}$ C for 5 hours or until a constant weight was reached with (difference in weights between two reading was less than 0.001 g). The samples were cooled in the dessicator for two hours. After cooling in a dessicator, the lid was replaced and the moisture dish with the dried sample was weighed. The moisture content of the sample was calculated, using the following formula:

$$\% \text{ Moisture content} = \frac{\text{Weight of sample} - \text{Weight of dried sample}}{\text{Weight of sample}} \times 100$$

#### *4.3.1.2 Antibacterial Activity of Honey and Propolis*

The agar diffusion method has probably been the most widely used method for determination of antimicrobial activity. The honeys were supplied by the apiarist and identified as manuka honey. The honey assayed were unpasteurized and were stored in a cool dark place at $10^0$ C. The honey samples were diluted to 1/4, 1/8 and 1/16 of the original strength (w/v) with water purified by reverse osmosis. A culture of *Staphylococcus*

*aureus* was grown at $37^0$ C for 24 in 30 ml of nutrient broth (made with 25 gram/l of Oxoid broth) and was added to 450 ml of sterilized nutrient agar (made with 23gram/l of Oxoid agar) at $45^0$ C. Plates were poured on a level surface and stored at $4^0$ C before being used. Six wells of 8mm diameter were cut in all the petri plates using a cooled flamed cork borer. The honey samples were tested in duplicate plates by putting 150µl of honey in each of the six wells. A blank of water was used in two plates. The plates were incubated at $37^0$ C for 16-18 hours. The diameter of the clear zone was measured from the edge of each well using a vernier-calliper. The mean diameter of the clear zone around each honey concentration was calculated.

The antibacterial compound diffuses through the agar, resulting in a concentration gradient that is inversely proportional to the distance from the well. Under controlled conditions the size of the zones of inhibition is directly related to the potency of the antibacterial substance. The result of this test is qualitative as well as quantitative. In the qualitative results, the susceptibility of the test microorganism is related to inhibition zone size in millimeters. Microorganisms are termed susceptible when the zone > 30-35 mm in diameter, intermediate with a zone of 20-30 mm, or resistant with a zone < 15-20 mm. Measuring the size of the zone around each well around which no growth was seen assesses antibacterial activity.

#### *4.3.1.3 Extraction of Antibacterial Component from Propolis*

The antibacterial properties of propolis from raw propolis were extracted. It was seen that organic soluble propolis extract gave unpleasant taste to the jellybeans and was not liked by a small tasting panel. A water-soluble derivative of propolis was found to have antibacterial properties but at the same time was not unpalatable like the organic soluble derivative (Nikolov *et al.*, 1995; Burdock, 1998).

About 100 grams of raw clean propolis was placed in warring blender, and mixed with a litre of 95% ethanol for 10 minutes, with occasional stoppage to keep the solution from

boiling over. All the contents were put in a container and occasionally stirred for 18 hours. The solvent was filtered through a Whatman-4 filter paper. Evaporation of the solvent was done at the reduced pressure in a rotary evaporator to get 60% of solids. At this concentration the extract is sufficiently flow-able. The ethanol extract thus obtained was kept in the cold room at less than $10^0$ C to prevent loss of biological activity.

The water-soluble derivative was obtained by adding 54.7% of water to ethanol extract of propolis. It was mixed vigorously. The solution was kept at 37° C for overnight. The sample was tempered at 4° C for 1 hour. It was put in centrifuged bottles and centrifuged at 4° C at 8000 rpm for 12 minutes.

For commercial run, it was not possible to start from raw propolis; therefore, ethanol extract of propolis was directly bought. The water-soluble derivative free of any suspension was obtained as explained above.

#### *4.3.1.4 Antibacterial Activity of Propolis Extract*

The concentration of propolis extract was measured in a Hitachi U-2000 double beam spectrometer. The optical density of the water-soluble derivative of propolis was measured at 292-nm using a quartz cell with 1-cm optical path. The absorbance at 292-nm measures flavanones as pinocembrin, a major component of antibacterial activity in propolis (Martos *et al.*, 1997; Bogdanov, 1989). The propolis extract obtained by following procedure as shown in section 4.3.1.3 was diluted to $5 \times 10^{-4}$ of original concentration and values ranged between 0.56-0.58. This method is rapid test of testing antibacterial properties of propolis extracts.

#### *4.3.1.5 Turbidity Test*

The following liquid media was used as growth media for the turbidity test: 10 gm/liter peptone (Difco, Lot No. 51231JB), 10 gm/liter Lab Lemco (Oxoid, Lot No. 047-52120)

and 1 gm/liter glucose (BDH, Lot No. 101174Y). *Staphylococcus aureus* was used as a test strain. A Hitachi U-2000 double beam spectrometer capable of measuring the turbidity of the bacterial suspensions in a disposable cell suspension with 0.2 absorption units at 520-nm was used for inoculation of bacteria for growth tests (Bogdanov, 1997). 2 ml of the lysine suspension containing extract obtained from 200 grams of jellybeans was mixed with 10-ml liquid growth medium and the absorbance was read at 520-nm ($E_1$). Twenty milliliters sterile test tubes containing water soluble extract in 8% lysine solution were incubated in a thermostat controlled shaking incubator at 37° C. The standard was a 2 ml 8 % (W/V) lysine solution having 10 ml of growth medium (Ivanovska *et al.*, 1995). One drop of bacteria suspension was added in all the test tubes (each sample with duplicates) and mixed using a vortex. The tubes were incubated in shaking water-bath at a constant shake speed of 175 revolution/minute for maximum bacterial growth for 12 hours. Turbidity was then read at 520-nm ($E_2$) and $\Delta E = E_2 - E_1$ calculated.

Similarly the turbidity of the propolis extract was reconfirmed by this method. This method is time consuming but was followed to confirm the antibacterial activity of the samples.

### *4.3.2 Premix and Slurry*

#### *4.3.2.1 Degree of Cook*

Starch granules are insoluble in cold water due to hydrogen bonds. Gelatinization is the transformation that occurs when an aqueous starch suspension is heated. Gelatinization of starch granules in water is detected by the loss of birefringence, increase in optical transmittance and rise in viscosity. The process involves a loss of granule crystallinity as gauged by a loss of birefringence, hydration and swelling of the starch granules (Swinkles, 1985). The time and temperature required to gelatinize starch depends on the source of starch and other components such as moisture, protein and fat (Guraya and Toledo, 1993). The measurement of loss in birefringence is the most sensitive, accurate, and reproducible

technique for measuring the gelatinization of starch.

The jellybean syrup was dissolved in distilled water to give a 0.2% suspension of the product. A small drop of suspension was placed on the microscope slide. A continuous ring of high viscosity mineral oil surrounded the drop and a cover slip was placed so that no air bubbles were present. The polarize analyzer was used to determine the loss of polarization crosses. The completion of gelatinization was confirmed if 5 or 6 granules were left with the polarization crosses in a field (O' Mara, 1994).

Alternatively, the degree of cook was checked microscopically using a 100X microscopic magnification. A properly cooked starch will have a sandy background matrix of disintegrated starch, with 6-12 fragmented granules per field (Cooley, 1993).

#### *4.3.2.2 Total Dissolved Solids*

The Abbe refractometer was used to measure the total dissolved solids of the jellybean syrup. The syrup solids were measured regularly until 70-72% of TDS was achieved. Two to three drops of the sample was placed on the refractometer prism. The refractometer was calibrated at 20° C and temperature correction table was used to compensate for difference in temperature, if any. The table was developed for 30° C ±10° C and a value of 2% TDS was added for every 10° C increase in temperature. Two replicates were analyzed for their refractive index and the average taken.

### *4.3.3 Jellybean Centers and Finished Product*

#### *4.3.3.1 Texture Profile Analysis*

The TA-XT2 Texture Analyzer (Texture Technologies Corp., Scarsdale, N.Y.) with a data analysis software package was used for this study. This type of measuring instrument is characterized by its ability to measure several variables under controlled conditions and enables the measurement of a Texture Profile Analysis. The measuring system measures

the changes in force to compress a sample and is recorded using the software.

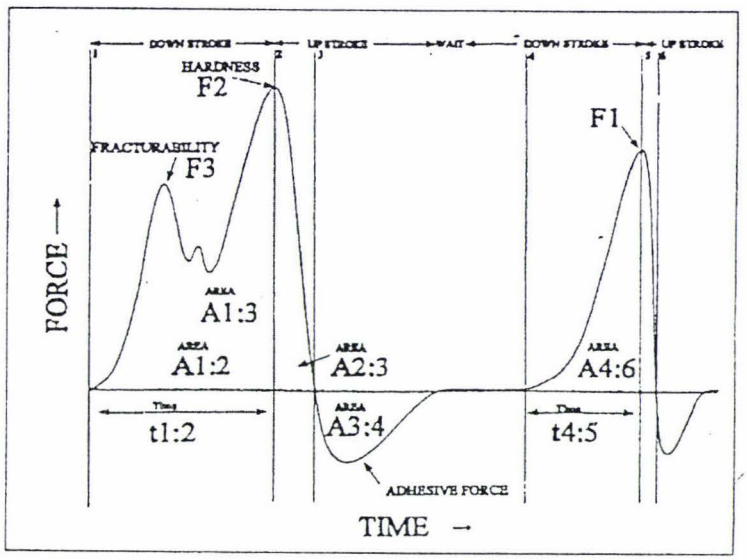



**Figure 4.4: Force Time Curve for Measurement of Texture of the Product (Manual TA-XT2 Analyzer)**

The jellybeans produced commercially are not flat in shape. Therefore, the force applied to the sample will not be uniform through out the sample and as a result, difficult to measure. To overcome this problem, wine gums commercially available were used as a pattern to print into a starch filled tray. A good print is essential to distinct product shape. The slurry was deposited into the printed moulds and dried in the hot room at 40° C. The product was removed from the starch at moisture of 12-14% and cooled overnight at 21-30° C. Except for shape, the manufacturing procedure was same that was followed for regular jellybeans. The gel sample was placed on the platform and a test cell known as plunger applied the compression force to the sample. The diameter of the plunger was 38mm and speed of compression was 10 cm/sec. The force applied was two-bite compression. The product was compressed by 50% before the compression force was removed. A number of textural parameters can be quantified from force/time curve.

*Hardness*

The height of the force peak $F_2$ (Figure 4.4) on the first compression cycle. It relates to the force within the mouth required to compress a substance between the molar teeth.

*Fracturability*

The force of the significant break $F_3$ (Figure 4.4) in the curve on the first bite. It is the force when a sample cracks or shatters.

*Cohesiveness*

The ratio of the positive force areas ($A_{4:6}$ : $A_{1:3}$, Figure 4.4) under the first and second compression. It is the extent to which a material can be stretched before it ruptures irreversibly.

*Adhesiveness*

The negative force area ($A_{3:4}$, Figure 4.4) of the first bite which represents the force necessary to pull the plunger away from the sample. In the mouth it relates to the force required to remove material that adheres to the palate during the normal eating process.

*Springiness*

The extent to which the food recovers its height ($T_{4:5}$ : $T_{1:2}$, Figure 4.4) during the time between the end of the first bite and start of the second.

*Gumminess*

The denseness that persists, when chewing to disintegrate (Cohesiveness×F1, Figure 4.4) a semi-solid food to a state ready for swallowing.

*Chewiness*

The length of time (Gumminess×$T_{4:5}$ : $T_{1:2}$, Figure 4.4) required to chew a sample at a constant rate of force, reducing it to a consistency suitable for swallowing.

### *4.3.3.2 Colour Measurement*

The colour of the jellybeans was assessed by a Hunter L*, a*, b* colour measurement system using a Minolta Chromameter CR-200.

The Minolta chromameter CR-200 was calibrated against a standard plate. The sample was directly placed on the colour detector and covered with a black surface. By taking account of the standard values, the colour was calculated as L*, a*, b* and a difference in colour value ΔE*. The ΔE* was calculated using the equations shown in Table 4.1.

**Table 4.1: The Equations Used for Calculation of Colour and Difference in Colour**

$$\Delta E^* = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$$

Where, $\Delta L^* = L^*$ reference $- L^*$ sample

$\Delta a^* = a^*$ reference $- a^*$ sample

$\Delta b^* = b^*$ reference $- b^*$ sample

### *4.3.3.3 Sugar Content*

The quantitative determination of total sugar was based on AOAC 31.021(1984). The analysis of the sugar in the jellybeans involved three steps: removal of interferences, hydrolysis of sugars (unreduced sugar) and final estimation. The finely chopped and weighed (3 gm) sample of jellybean center was put in 10 ml alcohol at 45° C -50° C so that the final concentration of alcohol was approximately 80% v/v. Enough precipitated chalk

(0.5 gm) was added to neutralize the acidity. This solution was heated to boiling in a water bath for 1 hour, stirring frequently. The solution was decanted into a volumetric flask and mixed in a high-speed blender with 80% alcohol.-The blended material was boiled in a water bath for 30 minutes, cooled to room temperature and transferred to 250-ml volumetric flask. It was diluted to final volume of 250 ml with 80% v/v ethanol at room temperature. This was then filtered and evaporated with additional water as added as necessary to prevent the solution evaporating to dryness. The odour of alcohol disappeared in 60-70 minutes, then 100 ml of water was added and heated to 80° C to soften gummy precipitates and break insoluble masses. After passing the sample solution through the celite, the latter was washed with water and diluted with the combined filtrate to a suitable volume was transferred to the 250 volumetric flask.

The aqueous extract of the sample was obtained after all alcohol was removed by evaporation. This solution was diluted to 100-120 ml with distilled water and enough saturated neutral lead accetate solution was added to produce a flocculent precipitate. This was shaken thoroughly and left to stand 15 minutes. The supernatant was tested with a few drops of lead accetate solution and if a new precipitate formed it was shaken and left to stand again. If no further precipitate formed, the sample was diluted to the mark with water, mixed thoroughly and filtered through a dry paper. Solid sodium oxalate was added to the filtrate to precipitate all the lead and then the sample was re-filtered through a dry paper. Sodium oxalate was added to the filtrate to check for the absence of lead.
The sample was diluted to provide 250 ml of aqueous solution. Standard titration as described in AOAC was followed to calculate reducing as well as total sugars.

Calculations:

$$\text{Reducing sugar as D-glucose (gm/100gm product)} = \frac{972\ F}{C \times T}$$

$$\text{Total sugars (gm/100 gm product)} = \frac{972\ F}{C \times T}$$

Where C = Sample concentration in titrant solution (gm/100ml)

T = Titre in final titration (ml)

F = Sucrose correction factor, from table 0.9974 for reducing sugar and 1.00 for total sugars.

#### *4.3.3.4 Moisture Content*

The moisture content of the jellybean centers and the finished product were measured using moisture dish method as explained in 4.3.1.1.

#### *4.3.3.5 Extraction of Antibacterial Component from Jellybeans*

Extraction of the antibacterial component involved three steps: removal of interfering substances other than sugar, reduction of sugar, and estimation of antibacterial properties present. The antibacterial jellybeans contained ingredients like corn syrup, sugar, starch, gelatin, honey, and water-soluble derivative of propolis, colouring (tartrazine) and flavouring agents. Small amounts of bees-wax, carnuba-wax and mineral oil were also present. The removal of these ingredients will give extract largely free of interfering substances and antibacterial components in a measurable quantity.

200 grams of jellybean/100 grams of jellybean centers were homogenized with of 95% ethanol (400 ml) in a warring blender for 5 minutes. The mixture was extracted in Soxhlet apparatus for two hours. The extract was filtered through Whatman 4 filter paper when hot. The ethanol extract was kept in the cooler to separate the wax, which was separated by centrifugation at 8000 rpm for 15 minutes and at 5° C. The extract was concentrated to thick syrup like consistency under reduced pressure in a rotary evaporator at 37° C, and freeze-dried. The dried extract was taken up in (200 ml) absolute alcohol (96% v/v) and

shaken for 2 minute in a vortex mixer, after which diethyl ether (300 ml) was added and shaking repeated. Precipitated sugars were removed by centrifugation at 8000 rpm for 15 minutes. After removal of the solvent (a mix of alcohol and ether) in the rotary evaporator at 37° C, the remaining moisture was removed by freeze-drying again. The extractives were dissolved in 15 ml of absolute alcohol (96% v/v) and freeze-dried again. This left a dried mass of antibacterial material with little or no dissolved sugar. As explained earlier, this method is based on the solubility of different sugars in ethanol and ethers. The subsequent reduction in alcohol level (200 ml to 15 ml) leaves very less dissolved sugars in solvent. The moisture getting entry from sample and alcohol are freeze-dried to remove both water and solvent. Finally, the anhydrous antibacterial component was dissolved in 8% solution of L-lysine Hcl and was stored under sterile conditions, protected from light in a dry and cool place (4-6$^0$ C) until use. The dried extract varied from 1.44 ± 0.14 grams.

The water-soluble extract obtained thus can be used directly for testing antibacterial properties of jellybeans by two widely used standard methods (Agar diffusion or Turbidity method).

The developed method is fairly accurate (1.44 ± 0.14 grams) to give qualitative or quantitative estimation of the antibacterial properties. In qualitative agar diffusion method, where constant volume (150µl) was injected in the wells, a reduction in value due to less proportion of antibacterial component is expected. However, when measured quantity (mg/ml) of extract was added in the growth medium (turbidity test) this limitation could be overcome by varying the volume. In brief, this method has potential to be used in testing the antibacterial properties of jellybeans in particular, and may be used for similar confectionery products.

The extraction of antibacterial substance from jellybeans is based on the principle that sugars proteins and other polysaccharides are soluble in water but very less soluble in organic solvents. Honey consists of an invert sugar 80% (38% fructose and 31% glucose;

sucrose 1.5%; maltose 7.5% and other carbohydrates); vitamin B and minerals, and 15-20% water (Syme, 1995). Extraction with 80 percent ethanol dissolves sugars, amino acids, salts, organic acids and other small molecules, leaving polysaccharides precipitated by or insoluble in 80 percent ethanol (FAO, 1990). Diethyl ether facilitates the sugar precipitation that can be separated with centrifugation. One gram of fructose is dissolved in 15ml alcohol. But glucose, which was added through corn syrup, is sparingly soluble in 95% alcohol. Cane sugar is slightly soluble in alcohol and 170 ml dissolves 1 gram of sugar (Stecher, 1968).

Similarly, gelatin is a protein and contains very small amount of amino acids. Gelatin is insoluble in all the organic solvents. Starch is insoluble in alcohol (Stecher, 1968) and heating to nearly boiling for one and a half hour does not breaks down the starch molecules and used for separation of starch from sugars in the confectionery (FAO, 1990). Tartrazine was used as a colouring agent and is sparingly soluble in alcohol (JECFA, 1992).

It can be summarized that ethanol is a good solvent for antibacterial properties and is extensively used as a solvent, and only sugar added, as ingredients are sparingly soluble in it. These sugars have to be further reduced to get an extract largely of antibacterial components only. Once water-soluble derivative dries completely it can easily dissolve in 8% aqueous solution of L-lysine at 50-60 $^{o}$ C (Ivanovska *et al.*, 1995).

## 4.4 Sensory Evaluation

### *4.4.1 Flavour and Taste Testing*

Six flavours were received from commercial flavour companies. These flavours were screened down using consumer preferences. Similarly, sugar level was determined using the consumer preferences.

A small group of 3-5 panelists was used for the preliminary screening of flavour and sweetness of the centers and finished product. This group was invited to contribute any suggestions on the basic taste perceptions, such as the balance in the flavour intensity, the acceptable dosage level for jellybean centers, and the finished product. Similarly, their views were also taken for the degree of sweetness of centers and finished product.

### *4.4.2 Trained Panel Testing*

For sensory evaluation of a new product, it is not always convenient to use a large number of participants in order to gather data, which are to be statistically analyzed and generalised to the population. To overcome this problem, 9 panelists were trained to analyse the texture of the prototypes. The panelists were trained to work as instruments. Before testing the samples they were calibrated to check for the reproducibility and agreement between the panelists.

#### *4.4.3.2 Assessment of Texture*

A line scale was carried out to assess the texture of the product. The product measures the intensity of a given stimulus attribute by making a mark on a horizontal line. The marks in the line are converted to numbers by manually measuring the position of each mark from the left end of the scale. The data then analysed using ANOVA (Meilgaard *et al.*, 1987).

A 15-cm scale was used to evaluate the texture of the jellybean centers. The panelists were asked to give a mark on the 15-cm line to indicate their degree of presence of a particular textural attribute. The attributes were springiness, cohesiveness, hardness, denseness, chewiness and adhesiveness. Each mark was measured from the left-hand end and converted into millimeter scale. A mark on the right side of the scale indicated larger presence of that attribute.

### *4.4.3 Final Consumer Testing*

A group of 20-30 panelists can provide reliable data to evaluate a product (Meilegard *et al.,* 1987[a]). 53 consumer panelists, comprising students and staff of Massey University participated in the formulation development.

A large number of panelists are required for the final consumer product test. The panelists were defined before their actual recruitment. The panelists had to consume jellybeans once a month to be selected. After prescreening the panelists, the defined target consumers were invited to participate. In this study, 51 consumers participated in the central location test and 48 consumers participated in the home use test. Students and staff Massey University, Palmerston North participated in the central location test. And in the home use test two groups of panelists were involved. First, group comprised of panelists from Pahiatua, a small town in New Zealand, and second group was of students and staff of Massey University, Albany in Auckland City.

#### *4.4.3.1 Hedonic Liking Test*

A hedonic scale is used to indicate the degree of acceptability of the product. Panelists are presented nine-point scale and are asked to indicate their product acceptance by writing the number that reflects their liking. Table 4.2 shows a nine point verbal hedonic scale.

For this research, a nine point hedonic scale was used to evaluate the product liking. The attributes evaluated in the test included overall liking, flavour, colour, sweetness, appearance. The data obtained were statistically analyzed using ANOVA or the t-test. The assessment using ANOVA was carried out when the number of samples was more than two, while the t-test was for testing two samples. When a significant difference was detected with ANOVA, further data analysis was carried out using a Tukey's Honestly Significant Difference test to find out the product or the product with different attributes.

**Table 4.2: Nine Point Hedonic Scale**

| | |
|---|---|
| 1 | Dislike extremely |
| 2 | Dislike very much |
| 3 | Dislike moderately |
| 4 | Dislike slightly |
| 5 | Neither like nor dislike |
| 6 | Like slightly |
| 7 | Like moderately |
| 8 | Like very much |
| 9 | Like extremely |

## 4.5 Data Processing Method

Three computer software programs used for data processing during the study were:

- Echip 6.04 (ECHIP, Inc., Hockessin, DE, USA)
- Minitab 12 (Minitab, Inc., Pennsylvania, USA)
- SAS 6.12 (SAS Institute, Inc. USA)

Data were entered on Excel worksheet before being analyzed further. The software was used to calculate means, standard deviations and variances of the product attributes and sensory evaluation data.

Echip was used to carry out the experimental design to set the jellybeans centers formulation. Echip generated the formulation and process conditions using a response surface methodology and generated coefficients that can fit into the mathematical models. These coefficients were used to generate the contour plots.

Minitab was used for sample ANOVA and multiple comparison tests on the jellybeans

centers formulation. SAS was used for the relating consumer and trained panel data for internal and external preference mapping.

# Chapter 5

# Study of the Properties of Jellybeans Centres

## 5.1 Introduction

A Jellybean is a soft panned confectionery, which involves the application of an adhesive solution to the centres as they are tumbled in a revolving pan. The centres are starch and other hydrocolloids deposited gums and are of uniform shape (Lynch, 1987). During the jellybean gelatinisation process, a great deal of interdependency exists between the processing conditions and the characteristics of raw materials that affect the properties of the centres (Lees, 1996). Repeated application of adhesive and sugar builds up uniform coatings around the centres. Flavours and colours are added during the coating operation.

A study of the effect of processing conditions and raw material characteristics on the functional and physical properties of the jellybeans was conducted in this research.

Response Surface Methodology is a method for fast and efficient development of food products. It combines experimental design, evaluation, modelling, and optimisation in order to find out the relationship between development work and consumer or instrumental response.

Instrumentation measurements were conducted to screen the optimum basic formulation and process conditions to produce the final jellybeans centre base that was used in the preference mapping study (Chapter 6).

The specific objectives of the study were:

- To investigate the effects of the ingredients on the jellybeans properties.
- To investigate the effects of operating conditions on the antibacterial properties of the product.

- To create and use models relating product ingredients to product characteristics.

## 5.2 Experimental Plan

In the preliminary phase of the study, seven different physical variables were identified to control the product properties. The ingredient variables included sweetener type, sweetener level, starch level, gelatine level, and added antibacterial agents (honey & propolis). The process variables were holding time of the gel and temperature at which antibacterial agents were added.

A response surface design was used in this experiment to provide the different combination of ingredients and process conditions. The Echip, statistical software, in which, honey, starch and gelatine were varied at three levels, created the experimental design. The process variables considered were continuous variables and were varied at three levels. After assessing the viability of each prototype, small changes to the formulation were made. It was found that the total of ingredients was not equal to hundred, so a bulking agent was added to the formulation to make it up to hundred. The ingredient used was malto-dextrin, which is generally identified as a bulking agent in the food industry. Raw material was combined in a range of formulations and under several process conditions, using bench top facilities available at Massey University. The formulation and process conditions were set by design of experiment as described in Section 5.3.

## 5.3 Experimental Design for the Jellybeans Base Formulation

Response surface methodology was used to develop the design of the experiment. In order to develop this design following four assumptions were made:

1. The sum of the design variables and the bulking agent is 100.

2. The number of prototypes had to be limited to as few as possible by considering only those variables that were most likely to have largest effect on the properties of jellybeans.
3. The relation between the attribute and formulation level is a quadratic function. If higher order relationship is there it is assumed to be non-significant.
4. There is only pair-wise interaction between the variables and higher order terms are not important to the analysis.

The equation underlying the design comprised linear and quadratic terms for starch, gelatin, holding time, cooling temperature and source of antibacterial properties. There were pair-wise interactions between ingredients and the process variables (starch-gelatin, starch-holding time, starch-cooling temperature, starch-antibacterial properties, gelatin-holding time, gelatin-cooling temperature, gelatin-antibacterial properties).

Raw materials used to produce the jellybean centres were starch, gelatin, honey, propolis extract, sucrose, corn syrup, citric acid, and lemon flavour. As said earlier, the malto-dextrin was used as a bulking agent and varied in formulation to keep the sum of ingredients to unity.

To eliminate an excessive number of experiments, variables, which have larger effects on the jellybean properties, were selected from the preliminary experiments and the work completed by Sofat (1998).

Sucrose, corn syrup, citric acid, colours and flavour were kept at the constant level, and gelatin, starch and the antibacterial component were varied according to the design of experiment. The level of colour was constrained by the legislation and flavour level was used at the manufacturers' recommendations for similar products. Sucrose, corn syrup, and citric acid were used at a level recommended by ingredient suppliers and experience with the sensory panel. The lists of variables used in the experimental design are shown in Table

5.1. Maltodextrin (DE 17-20) was used as a bulker to make the formulation total to unity. To make the formulation total to unity, different level of maltodextrin was added in all the 26-formulations. Maltodextrin is recognised in the industry due to very little contribution to sweetness and does not contribute to texture as well. The process conditions included holding time after addition of starch and cooling temperature at which the antibacterial agents comprised of manuka honey and propolis extract were added to the jellybean base.

**Table 5.1: Variables Used in the Experimental Design**

| Types of variables | Variable | Value |
|---|---|---|
| Fixed variables | Sucrose | 18 |
| | Corn syrup | 40 |
| | Water | 11 |
| | Citric acid | 0.2 |
| | Colour E-102 (10% solution) | 0.1 |
| | Lemon Essence Soluble D | 0.1 |
| | Sub total | 69.4 |
| Design variables | | |
| | Starch | 6-12.5 |
| | Gelatine | 2-8 |
| | Antibacterial component | 12-15 |
| | (Honey 85% & Propolis extract 15%) | |
| Bulking agent | | |
| | Maltodextrin | 0-10.6% |
| | Sub total | 30.6 |
| | Total | 100.0 |
| Process variables | | |
| | Cooling temperature | 85-95$^0$ C |
| | Holding time | 15-45 minute |

A total of 31 trials were carried out in this design which consisted of 26 different trials and replicates of the first five treatments. The first five treatments in the design determine the

standard error among trials. The details of the 31 trials are shown in Appendix 5.1 (page 223).

Properties of samples obtained from the trials were determined. The results were analysed using the Echip software to determine the variables that produce significant effects on the product characteristics and the equation models. Quadratic equations were used for the models.

## 5.4 Analysis of Raw Material, Pre-Mix, and Jellybean Centres

### *5.4.1 Raw Materials*

#### *5.4.1.1 Propolis and Honey*

The antibacterial properties of honey and propolis are important to retain the finished product properties. If the antibacterial activity of water-soluble derivative of propolis is not uniform the end product will vary as well. The batches of honey and propolis were tested for its antibacterial activities prior to its addition to the product. Only one batch of honey was used in the development stage of the product. The antibacterial properties of propolis were tested at 292 nm. The method for measuring the antibacterial properties is explained in Section 4.3. The antibacterial properties of the extract were found to be fairly constant (Table 5.2) as it was derived from the same batch of the raw propolis.

**Table 5.2: Antibacterial Properties of Propolis and Honey**

| Date | Ingredient | Concentration % (v/v) | Zone diameter (mm) |
|---|---|---|---|
| 10/10/99 | Manuka Honey | 28.3 | 9.5 ± 1.0 |
| 05/01/99 | Manuka Honey | 28.3 | 9.0 ± 0.7 |
| 05/01/99 | Propolis-1 | 7.61* | 21.3 ± 1.25 |
| 11/01/99 | Propolis-2 | 7.76* | 21.6 ± 1.00 |
| 15/01/99 | Propolis-3 | 7.53* | 21.2 ± 0.63 |
| 22/01/99 | Propolis-4 | 7.68* | 21.5 ± 1.05 |

* Total solids of extract

*5.4.1.2 Moulding Starch*

The moisture and temperature of the moulding starch have a significant effect on the quality of the finished product. If the starch is too wet, it will accumulate on the mould board thereby causing a poor print. Starch also absorbs on the surface of the candy upon deposition if it is too cold. This will give an opaque product with a gritty feeling on the outside rather than a smooth piece. On the other hand, if the starch is too hot or too dry, it will dry the surface of the centre too rapidly and have a leathery skin. To overcome these problems the moulding starch temperature is recommended between 50-55$^0$ C and moisture content between 5%-7%.

The complete sets of measured results of raw materials, showing antibacterial properties and moisture content of moulding starch are given in the Appendix 5.3 (page 227).

### *5.4.2 Pre-Mix and Slurry*

*5.4.2.1 Formulation Accuracy*

The scales were checked periodically for accuracy by verifying the weight with standard weights. All the lot numbers of ingredients was recorded on batch records. The dry ingredients were pre-mixed properly and visually inspected for lumps at cooking stage.

*5.4.2.2 Solids Content*

The percent solids in the slurry were measured using the refractometer on pre-mix, cooked slurry. In the finished product using a refractometer was not possible as the product was coloured so it was tested by moisture dish method.

*5.4.2.3 Degree of Cook*

The degree of cook was checked microscopically using a 100X microscopic magnification. The undercooked starch has the appearance of many swollen and fragmented granules

while properly cooked product will have a sandy background matrix of disintegrated starch, with very few fragmented granules. A count of 6-12 per field is indicative of proper cook (O' Mara, 1994). The method for testing degree of cook and solids content is explained in Section 4.3.2.

The complete sets of measured results of pre-mix and slurry, showing total solids and degree of cook are given in the Appendix 5.4 (page 228).

### *5.4.3 Jellybean Centres*

#### *5.4.3.1 Texture Profile Analysis*

Texture profile analysis (TPA) was done using a TAXT-2, a texture-measuring instrument. The measuring system measures the changes in force to compress a sample and is recorded using the software. A special pattern was selected for this experiment rather than jellybean samples. The force applied on the jellybean sample was not uniform and the results obtained were erratic. Therefore, for this test, wine gums were used as a pattern to print into a starch filled tray. The dimensions of the wine gums were 20 mm (top diameter) × 12 mm (bottom diameter) and 15 mm (height). The slurry was deposited into the wine gum shaped printed moulds and dried in the hot room. The product was removed from the starch at moisture of 12-14%, and cooled overnight. The gel sample was placed on the platform and a test cell known as plunger applied the force to the sample. A number of textural parameters can be quantified from the force/time curve. The method for testing the texture of the product is explained in Section 4.3.3.1.

The diameter of the plunger was 38mm and speed of compression was 10 cm/sec. A two-bite compression was applied to the sample. The product was compressed by 50% before the compression force was removed. A number of textural parameters can be quantified from force/time curve. The complete sets of measured results of jellybean centres, showing TPA is given in the Appendix 5.2 (page 225).

#### *5.4.3.2 Zones of Inhibition*

The jellybean centres were tested for their antibacterial properties by using agar diffusion method. The testing was done by the qualitative analysis and further validation was not possible due to time constrains. Validation by turbidity method takes about 16-18 hours per sample. 31 jellybean centres would have taken large research time and test material. But it was planned to test most preferred sample and commercially produced samples by this method. The method used is explained in Section 4.3.3.4. The coefficient of estimated quadratic models for zones of inhibition is given in the Appendix 5.5 (page 230).

#### *5.4.3.3 Sugar Content*

The formulation was checked for sugar content. It is necessary to check dextrose equivalent or reducing sugar to determine if inversion is occurring in any formulation. The variation in reducing sugar level would have given variation in textural characteristics. The sugar and reducing sugars were calculated by the method explained in Section 4.3.3.3. The complete sets of measured results of jellybean centres, showing degree of cook, colour, and sugar contents are given in the Appendix 5.4 (page 228).

## 5.5 Results: Effect of Ingredients and Process Conditions on the Jellybean Characteristics

Thirty-one samples were analysed and the data was interpreted using the software package Echip. The data from the trial was fitted to a quadratic model for the parameters of gumminess, chewiness, hardness, colour, antibacterial properties and consumer acceptability. Raw data for the 31 prototypes are tabulated in Appendix 5.1 (page 223), while the complete texture profile analysis and the coefficients of the quadratic model are shown in Appendices 5.2 (page 225) and 5.5 (page 230) respectively.

### *5.5.1 Textural Properties*

The texture of the product can be characterised into five primary and three secondary parameters. The primary parameters are adhesiveness, cohesiveness hardness, springiness, and viscosity. The secondary parameters are brittleness, chewiness, and gumminess, and are composed of two or more primary parameters (Szczesniak, 1963; Szczesniak, 1975). The adhesiveness is the force required overcoming the attractive forces between the product and the mouth. The other four primary parameters are related to forces of attraction between the food particles, thus oppose disintegration. Cohesiveness is the extent to which a material can be deformed before it ruptures.

A model or equation can predict these attributes. The equation summarises the relationship between the independent variables under the researcher's control like starch and gelatin, and the attribute measurements like gumminess and hardness. The equation is typically a quadratic function (Moskowitz, 1995) written as follows:

$$\text{Attribute} = k_o + k_1(A) + k_2(A^2) + k_3(B) + k_4(B^2) + k_3(C) + k_4(C^2) + k_5(A.B) + k_6(A.C)$$
$$k_7(B.C) \ldots\ldots\ldots\ldots$$

Where

$k_o$ = Constant

$k_1, k_2 \ldots$ = Coefficients

A, B, C = Ingredients or Processing conditions

#### *5.5.1.1 Gumminess*

The gumminess of the sample is the denseness that persists when chewing to disintegrate a semi-sold food to a state ready for swallowing (Civille and Szczesniak, 1973). This refers to a product of low degree of hardness and a higher degree of cohesiveness.

Table 5.3 shows the variables that significantly affected (P<0.05) the gumminess of jellybeans as well as the coefficients of the quadratic model.

**Table 5.3: Equation Coefficients and Variables that Significantly Affected the Gumminess of Jellybean Centres**

| Gumminess | Coefficients | P-value | Variables |
|---|---|---|---|
| | 4.08 | | CONSTANT |
| | 17.36 | 0.0000 | Starch |
| | 8.18 | 0.0006 | Gelatine |
| | -0.01 | 0.0145 | Time |
| | 0.61 | 0.0546 | Starch * Cooling Temperature |
| | -561.33 | 0.0022 | Starch * Starch |

Gumminess = 4.08+17.36 (starch level)+8.18 (gelatin)-0.01(Holding time)+0.61 (Starch x Cooling temp) -561.33(Starch)(Starch)

As indicated in Table 5.3 the gumminess of the sample was significantly affected by the starch, gelatine and holding time of the slurry at $95^0$ C. Starch and gelatine were positively correlated with gumminess, while holding time was negatively correlated. Although the cooling temperature did not affect the gumminess, the combination of this with starch had a significant influence on the gumminess. The quadratic variables for starch (starch*starch) and the interaction between starch and gelatine also influenced the gumminess of the product.

The quantity of starch had a positive effect on gumminess of the product (17.36) but when starch quantity was large (-561.33), a drop in gumminess was observed. The drop in gumminess at higher concentration of starch may be due to the inability of the atmospheric cooking to properly gelatinize the starch. The slurry was quite thick, and less free water in the slurry would have made it difficult to gelatinize the starch molecules. The degree of cook has a profound effect on the gel strength. If starch is under cooked, the strength of the gel will be less. Moderately undercooking the starch produces a soft and starchy tasting candy. Slight undercooking leaves the starch less utilised and will be reflected during texture measurements (O'Mara, 1994).

The gumminess of the product was dependent upon the cooling temperature at which gelatine and antibacterial components were added. The higher the cooling temperature the more gummy the product. The starch used in the formulation was modified starch, which is compatible with continuous high temperature operations, but was also recommended for open kettle process. At the same time, the recommended temperature of starch cooking was less, which was realised when the slurry was tested for degree of cook. By holding the product at higher cooling temperature it is possible that few more starch granules had gelatinised giving a better functionality to the starch.

Figure 5.1 shows that the behaviour of the response gumminess is interdependent upon starch and cooling temperature.

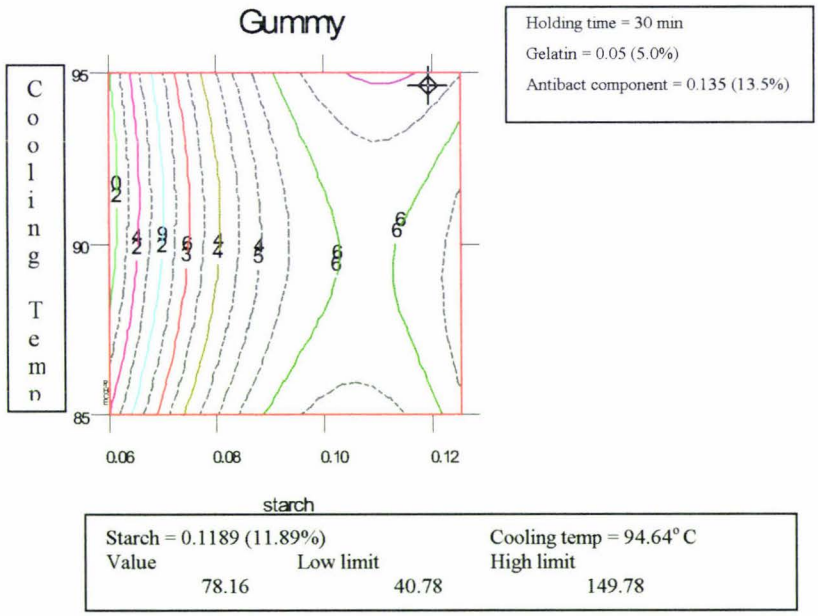



**Figure 5.1: Contour Plot for Gumminess Showing Interaction between %Starch in the formulation and Cooling Temperature °C**

The behaviour of the gumminess response, due to the changes in cooling temperature depends upon the level of starch. For low starch values, gumminess increases at a lower rate with increase in cooling temperature. For high starch values, gumminess increases

with increasing filling temperature to about 95° C or at around 85° C, all other temperature reduces the gumminess.

The quantity and ratio of the blend of gelatin and starch affect chewiness (Poppe, 1995; Carr, 1996). In the sweetener system chosen for experiments, the blend of starch and gelatin, and the processing temperature influenced the gumminess of the product and is in agreement with work reported by Poppe (1995).

### *5.5.1.2 Chewiness*

Chewiness is the energy required for masticating a food to a state ready for swallowing. This is composed of hardness, cohesiveness, and springiness (Civille and Szczesniak, 1973). The starch provides soft to firm, and chewy product, while gelatine provides elastic to firm gel (Carr *et al.*, 1995). Table 5.4 shows the variables that significantly affected ($P<0.05$) the chewiness of jellybeans as well as the coefficients of the quadratic model. As indicated in Table 5.4 the chewiness of the sample was significantly affected by the starch and gelatine. Both starch and gelatine were positively correlated with chewiness. It was found that different texture and firmness characteristics could be obtained by varying the gelatine content. The more gelatine in the formulation the chewier the product.

**Table 5.4: Equation Coefficients and Variables that Significantly Affected the Chewiness of Jellybean Centres**

| Chewiness | Coefficients | P-value | Variables |
|---|---|---|---|
| | 3.25 | | CONSTANT |
| | 16.27 | 0.0012 | Starch |
| | 10.05 | 0.0475 | Gelatin |

Chewiness = 3.25 + 16.27 (starch level) + 10.05 (gelatine)

R Squared = 0.842, P = 0.0567, Adj. R Squared = 0.526

Figure 5.2 shows variables having significant effect on the chewiness of the product. Figure 5.2 shows that the behaviour of response chewiness, was significantly affected by change in starch and gelatine levels. For low starch values, the chewiness increases with an

increase in gelatine at a lower rate. At higher starch values, the increasing gelatine increases chewiness. Therefore, the increase in chewiness is independent of the interaction of these two stabilisers and gelatin has more effect on chewiness of the product at higher starch values.

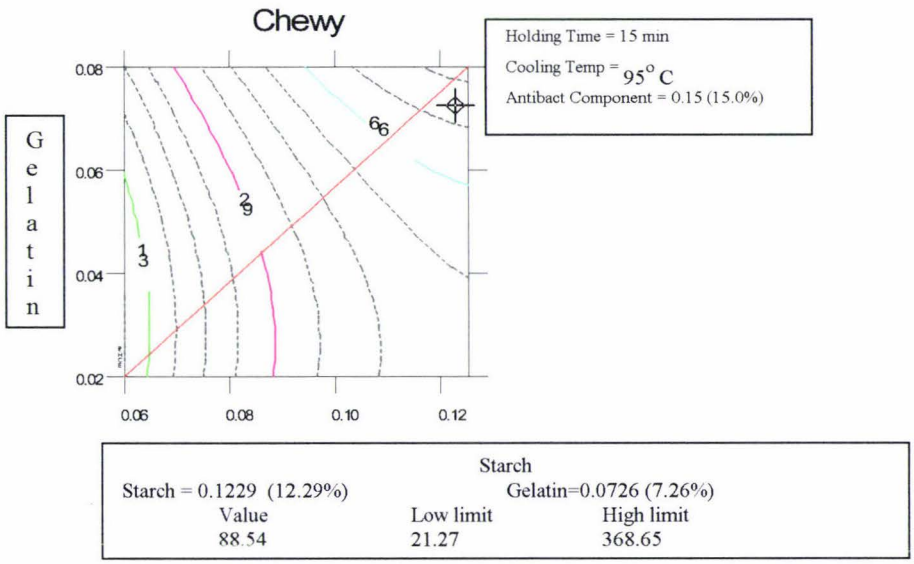



**Figure 5.2: Effect of Starch and Gelatine on the Chewiness**

The results seemed to be in agreement with the findings of the other researchers. For the same firmness in the finished product, the high bloom gelatine gives a less chewy texture. Yet the products with low bloom gelatine have a tough rubbery texture products. Gelatine and modified starch give chewy texture (Carr *et al.*, 1995).

### *5.5.1.3 Hardness*

Hardness is the forced required to attain a given deformation (Civille and Szczesniak, 1973). In the present research, total solids, bloom of gelatine and sugar to glucose ratio was same in all the formulation so, level of gelatine increased the firmness of the product. This is very much evident from the results available.

Table 5.5 shows the variables that significantly affected ($P<0.05$) the hardness of jellybeans, as well as the coefficients of the quadratic model. As indicated in Table 5.5 the hardness of the sample was significantly affected by the starch, gelatine and holding time of the slurry at $95^0$ C. Starch and gelatine were positively correlated with hardness, while holding time was negatively correlated. Although the cooling temperature did not affect the hardness, the combination of this with starch had a significant influence on the hardness. The quadratic variables for starch (starch*starch) and the interaction between starch and gelatine, holding time and cooling temperature at which gelatine and antibacterial properties were added to the gel also influenced the hardness of the product.

**Table 5.5: Equation Coefficients and Variables that Significantly Affected the Hardness of Jellybean Centres**

| Hardness | Coefficients | P-value | Variables |
|---|---|---|---|
| | 4.99 | | CONSTANT |
| | 17.25 | 0.0000 | Starch |
| | 9.37 | 0.0000 | Gelatine |
| | -183.16 | 0.0007 | Starch * Gelatine |
| | 0.18 | 0.0534 | Gelatine * Time |
| | 0.00 | 0.0344 | Time * Cooling temp. |
| | -238.43 | 0.0581 | Starch * Starch |

Hardness = 4.99 + 17.25 (starch level) + 9.37 (gelatin) - 183.16 (Starch)(Gelatine) + 0.18 (Gelatine x Holding time) - 238.43(Starch)(Starch)

Figure 5.3 shows the effect of starch and gelatine on hardness of the sample. At low starch level, gelatine has less effect on the hardness of the product, while at high starch level, increasing gelatine increases the hardness. In contrast, if the starch level is increased beyond about 11 % and level of gelatin is kept 8% the hardness starts decreasing. The hardness of the sample is related to the degree of gelatinization of starch. Beyond 11% starch level, gelatinization has not completely occurred in the samples thereby giving a slightly soft product. Gelatinization needs an excess water environment. Under a limited water environment, the swelling forces are much less significant and complete gelatinization will not occur at the usual gelatinization temperature range.

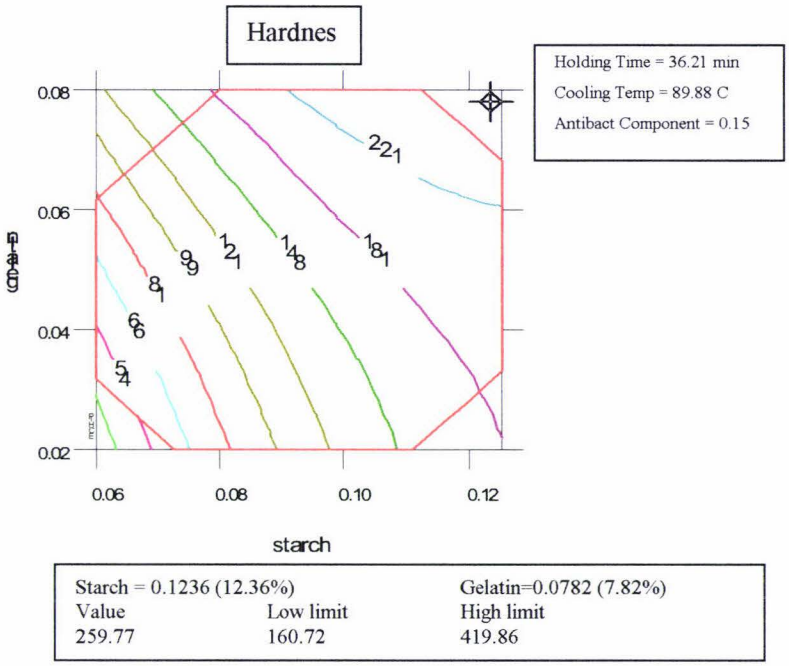



**Figure 5.3: Contour Plot for Hardness**

As the temperature increases and with the presence of limited moisture, the starch molecules become progressively more mobile. At first, this mobile condition will enhance the replacement of inter chain hydrogen bonds by water molecules, thus the polymers absorb more moisture. This absorption results in the growth and perfection of some crystalline regions, which will make inhibition of water more difficult and will raise the gelatinization range (Lai and Kokini, 1991).

Starch had shown a positive effect on hardness and negative effect when combined with gelatine. Likewise, it was found that soft to hard body can be achieved by varying the amount of starch (Carr *et al.*, 1995). Similarly, undesirable age toughening of gelatine is tempered by the presence of starch (Moore, 1996; Lees 1997).

However, large quantities of starch can form a thick solution as amount of water available in the formulation was same and granules of starch have to fight for the water. Therefore, gelatinisation of starch becomes as an energy intensive process and leaving more chance of undercooked starch. Moderately undercooked starch results in a soft and starchy tasting candy (O'Mara, 1994).

Finished product firmness is generally increased by an increase in gelatine bloom, usage level, and total solids (Poppe, 1995; Carr *et al.*, 1995). As a function of sugar/corn syrup ratio varies from 70/30 to 50/50, a 20/80 ratio gives softer products (Poppe, 1995). In the present formulation the ratio of sugar to corn syrup was 27/73.

Different firmness characteristics can be obtained by varying the gelatine content. Gelatine can be combined with other stabilisers to create texture variation. But polymers of glucose present in corn syrup and maltodextrin can delay the gelation of gelatine and so give slightly softer and less clear gel in confectionery (Poppe, 1995). Since maltodextrin was used as a bulking agent in the formulation and it varied among different formulations. Therefore, bulking agent was deleted from the formulation at the commercial run. Similarly, presence of acid has a positive effect on gelation; products containing 1% acid are harder than products without acid. In the formulation, 0.2% of acid was used to help gelation.

Similar graphs were obtained for the interactive terms of cooling temperature and gelatine, and are shown in Appendix 5.6 (page 231).

#### *5.5.1.4 Zones of Inhibition*

The antibacterial activity was measured in term of zones of inhibition as reported in Section 4.3.3.4.

Table 5.6 shows the variables that significantly affected ($P<0.05$) the zones of inhibition, as well as the coefficients of the quadratic model. As indicated in Table 5.6 the zones of inhibition of the sample were significantly affected by quantity of antibacterial agent and cooling temperature of gel. The interaction between cooling temperature and antibacterial component also significantly influenced the zones of inhibition.

**Table 5.6: Equation Coefficients and Variables that Significantly Affected the Zones of Inhibition of Jellybeans Centres**

| Zones of inhibition | Coefficients | P-value | Variables |
|---|---|---|---|
| | 2.91 | | CONSTANT |
| | -0.01 | 0.0000 | Cooling temp. |
| | 4.02 | 0.0000 | Antibacterial agent |
| | -0.25 | 0.0064 | Cooling temp. * Antibacterial |

Zones of inhibition = 2.91 -0.01 Cooling temp + 4.02 (Antibacterial agent) - 0.25 (Cooling temp)(Antibacterial agent).

The antibacterial properties of the jellybeans were affected by the cooling temperature of the product at which antibacterial component is added. During the processing of jellybean syrup, the product was cooled to different temperatures in order to know the temperature at which maximum activity was retained. $H_2O_2$ (White & Subers, 1963), and other volatile (Toth *et al.*, 1987) and partially volatile components (Russell, 1983) gets liberated from honey above 65°C (Roth *et al.*, 1986). The rest of the antibacterial activity was found to be stable at different time and temperature combinations up to 95°C (Molan and Russell, 1988). Similarly, the activity due to the presence of propolis constituents would reduce at higher temperatures due to the presence of volatile components. The antibacterial activity was directly related with the concentration of honey and quantity of propolis extract in product. Since antibacterial activity of honey related to $H_2O_2$ would have been liberated at all the working temperatures of the product, the coefficients are small. At the same time, activity of propolis is more heat stable.

The antibacterial properties of the jellybeans increased with the increase in the quantity of antibacterial component. This result was expected as in other studies the honey with higher concentration gave bigger zones of inhibition and lower concentration gave small area of inhibition (Molan & Russell, 1988; Somal *et al.*, 1994). The antibacterial activity of propolis against *S. aureus* had minimum inhibitory concentration of 10mg/ml and minimum bactericidal concentration of 120mg/ml. So at higher concentration of antibacterial component in the product, the zones of inhibition will be bigger.

The effect of cooling temperature and concentration of antibacterial component on the antibacterial properties of the finished product is shown in the Figure 5.4.

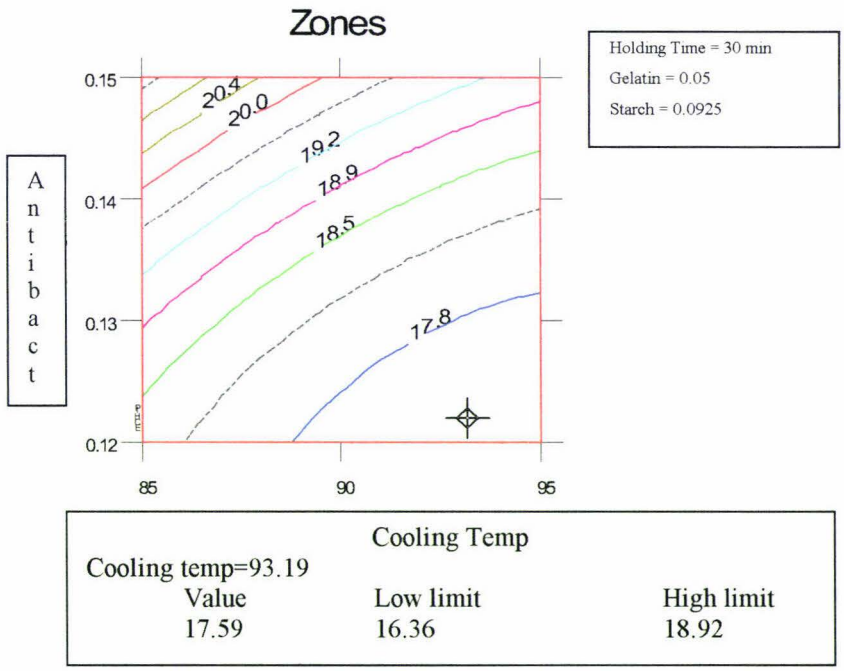



**Figure 5.4: Contour Plot for Zones of Inhibition**

At low cooling temperature, the antibacterial component has maximum activity, while at higher temperatures increasing antibacterial component has less effect on the zones on inhibition. The reduced antibacterial activity observed when temperature and level of

antibacterial component are increased can be explained by the reaction between the higher temperature and antibacterial components. When honey was heated to 82° C and in boiling water for 2 hours a reduction in antibacterial activity was observed (Roth *et al.*, 1986).

#### *5.5.1.5 Colour Measurements*

The colour measurements were obtained using a Minolta chromameter CR-200 as values of L*, a*, b* and ΔE*. Three replicates were taken for each samples. The methods to determine the colour are described in Section 4.3. There was no significant colour difference (ΔE) in the jellybeans centres produced under different formulations and under different processing conditions. The products had a yellowish colour with slight reddishness due to the presence of honey and flavonoids of propolis. The results were expected, since colour (E-102) was added in equal amount in all the formulations. Furthermore, propolis and honey added in the formulation did not vary more than 3% in the gel syrup. The results of the colour measurements are shown in Appendix 5.4 (page 228).

## 5.6 Conclusions

For low starch levels, gumminess increases at a low rate with increase in gelatine. For high starch levels, gumminess increases with increasing gelatine but after peaking at 11% starch level, further increase in starch reduces the gumminess. At the same time, the gumminess of the product was cooling temperature insensitive at low concentration of starch. But when starch level in the formulation was high, the increase in cooling temperature increased the gumminess.

For low starch levels, the chewiness increases with increase in gelatine at lower pace. At higher starch values, the increasing gelatine increases chewiness to a greater extent. Therefore, the increase in chewiness is independent of the interaction of these two stabilisers and gelatine has more effect on chewiness of the product than the starch.

Likewise, it was found that soft to hard body can be achieved by varying the amount of starch. Similarly, undesirable age toughening of gelatine is tempered by the presence of starch.

The zones of inhibition were significantly affected by quantity of antibacterial agent and cooling temperature of gel. The zones were bigger at higher concentration of antibacterial component in the product and at the lower temperature of addition. At higher temperatures a loss in activity was observed due to the loss of volatile and peroxide activity of honey and propolis. At the same time, the antibacterial activity was found to be stable at different time and temperature combinations up to 95°C. But around 90°C, the slurry starts thickening up due the presence of starch and give tailing on deposition.

The quadratic model explained the proportion of variance for the response of zones of inhibition, gumminess, hardness and chewiness. The product found to be significantly different in performance should be shown both, the consumer and the trained panel to know the most preferred product and their attributes. Based on findings of this research a product could be designed that would meet the expectations of the consumers and is cost effective at the same time.

# Chapter 6

# Preference Mapping

## 6.1 Introduction

The optimization of all aspects of the product is the main goal of the product development process. Sensory evaluation with a trained panel is used to determine whether or not the optimum product has been developed but it alone cannot produce the ideal product for an individual or market segmentation. It cannot determine consumer acceptance but provides information to describe differences between the food products. Market research provides qualitative data to understand the perceived association or relationship between the objects. A combination of both trained panels and consumer panels will provide both a description of sample differences and also a possibility for interpretation of these differences with regard to consumer perception. Preference mapping (Schiffman *et al.*, 1981; Macfie and Thomson, 1983; Jones *et al.*, 1989; Schlich, 1995) is one optimization technique that has been developed to fulfil these objectives.

Preference mapping allows the identification of each individual and their relative preferences for, or relationship, to a particular set of stimuli (MacFie & Thomson, 1988). Preference mapping may be divided into two categories, internal analysis (MDPREF) and external analysis (PREFMAP). Internal analysis is the only choice for data sets that consist exclusively of consumer preference data. But the information obtained from the internal map of consumers and products can be related to sensory profiling (McEwan, 1996). External analysis allows consumer data to be mapped on a multidimensional space derived from sensory profiling (e.g., perceptions of texture, sweetness, colour). This is similar to internal mapping but relate two types of information in the opposite order (Caroll, 1980; Schiffman *et al.*, 1981). Preference mapping technique allows for the identification of groups of consumers with different preference and consumption patterns. The individual

preferences can be commercially exploited by designing the product that can cater to the needs of target market.

The specific objectives of the study were:

- To study how the results from both internal and external preference mapping differ and also to look at the feasibility of using such a complex method for product optimization.
- To determine which characteristics of a product are important in the product preference.
- To derive market segmentation for the jellybeans. To conduct the identification of consumer groups with different preference patterns by visual inspection of plots.

## 6.2 Experimental

### *6.2.1 Selection of Samples for Trained Panel and Consumer Panel*

In the experimental design, a total of 31 samples were prepared. This consisted of 26 different trials and 5 replicates of the first five treatments. It was possible to reduce the number of experiments by reducing the variables but that could have reduced the chances of finding an optimum formulation. For a sensory evaluation test this number was considered large due to time and money constraints. Furthermore, from a consumer point of view, using a small number of samples is important to prevent fatigue and unreliability of data (Jones *et al.*, 1989). In a similar study conducted by Helgesen *et al.* (1997) a subset of 6 samples was selected from a set of 14 commercially available dry fermented lamb sausages.

For the purpose of screening, the formulations were analyzed by hierarchical cluster analysis using Euclidean distances. The analysis was performed on the hydrocolloids level, and response variables hardness and gumminess. As described in Chapter 5, these response variables were found to correlate well with the product and process variables. This method assigns samples that are close in multivariate space to the same cluster. In this way it can

identify groups of formulations, which are homogeneous in their performance. Eight clusters were formed and are shown by a dendrogram in Appendix 6.1 (page 235).

The screening of product formulations is shown in Appendix 6.1 (page 235). Finally 8 product formulations different in sensory performance, low in product cost and product cooling temperature of more than $90^0$ C were selected and labeled as A- H.

The products chosen for consumer and trained panel testing are shown in Table 6.1.

**Table 6.1: The Formulation of the Prototypes Tested in Consumer and Trained Panel**

| Ingredients | Product Code | Trial Code | Formulation | | | | | | | Process | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Starch (%) | Gelatin (%) | Antibacterial (%) | Sucrose (%) | Corn Syrup (%) | Malto-Dextrin (%) | Water (%) | Holding Time (min) | Cooling Temp. ($^{\circ}$C) |
| Formulation 3 | A | 20 | 9.25 | 5.0 | 12.0 | 18 | 40 | 4.15 | 11.2 | 15 | 95 |
| Formulation 12 | B | 18 | 9.25 | 8.0 | 13.5 | 18 | 40 | 0.4 | 11.2 | 45 | 95 |
| Formulation 9 | C | 11 | 6.0 | 8.0 | 12.0 | 18 | 40 | 1.4 | 11.2 | 15 | 90 |
| Formulation 8 | D | 2 | 12.5 | 2.0 | 12.0 | 18 | 40 | 3.9 | 11.2 | 15 | 95 |
| Formulation 1 | E | 13 | 6.0 | 2.0 | 12.0 | 18 | 40 | 10.5 | 11.2 | 45 | 95 |
| Formulation 14 | F | 19 | 12.5 | 8.0 | 12.0 | 18 | 37.9 | - | 11.2 | 30 | 95 |
| Formulation 13 | G | 10 | 6.0 | 5.0 | 13.5 | 18 | 40 | 5.9 | 11.2 | 15 | 95 |
| Formulation 15 | H | 25 | 12.5 | 5.0 | 12.0 | 18 | 40 | 0.9 | 11.2 | 45 | 95 |

### *6.2.2 Consumer Testing*

#### *6.2.2.1 Consumer Selection*

Prior to recruiting consumers, the target consumer was defined. This was according to the product usage, that is a person who consumed jellybeans at least once a month. Prescreening questionnaires with the demographic and product usage questions were distributed to more than 110 students and employees of Massey University. 60 consumers were defined as part of the target market and were invited to participate. 53 completed the test.

### *6.2.2.2 Testing of Consumer Preference*

The 53 consumers, all regular eaters of jellybeans, comprised 29 females and 24 males with 23 aged between 21 and 30, and 20 aged between 31 and 40 years. The consumers were divided into 9 groups with 5-8 participants who attended the test at different times in the University library lounge. Prior to testing all consumers were given the same information about purpose of the study and other practical matters related to the taste session. The 8 jellybean samples all assessed by a trained panel, were coded with 3-digit random numbers and served one at a time.

The consumers tasted the samples once in a randomized order given by the questionnaire. The tasting was done in two sessions, morning and the afternoon. In each session all panelists tasted 4 samples kept at room temperature in the plastic cups. Tap water was provided to rinse between the samples. The design was balanced for order and carry over effect. Each taste evaluation session lasted for about 15 minutes. The consumers marked their preferences on a 9-point hedonic scale, with "Dislike extremely" recorded as 1 and "Like extremely" recorded as 9. The consumers registered their opinion of overall liking, liking of texture, flavor, sweetness, and combined flavor.

### *6.2.2.3 Questionnaire for Consumer Testing*

Ideas for statements and answers for the multiple-choice questions were collected from the work of Schutz *et al.* (1988), along with individual interviews with five of the prospective panelists on believability and preference of jellybeans. Panelists completed an 11-page questionnaire in two sessions. A copy of the questionnaire is attached in Appendix 6.2 (page 237).

### *6.2.3 Trained Panel*

#### *6.2.3.1* Panel Selection and Training

9 panelists comprising students and staff of Massey University, who had some previous training in sensory evaluation, participated in a month long training program comprising 20 sessions. In the first session, the different samples made in the laboratory were used to develop a list of descriptive words to characterize the texture. A list of attributes was generated which in each panelist's opinion fully described the texture of the jellybeans. The profile and appropriate explanation for each attribute are listed in Table 6.2.

**Table 6.2: Fixed Choice Profile Developed for Use on Jellybeans with their Definition**

| Attribute | Definition |
|---|---|
| Springiness | Place sample on the molar teeth and compress partially; remove force and evaluate the degree and rate with which sample returns to its original size. |
| Cohesiveness | Degree, to which a substance is compressed between the teeth before it breaks, cracks or crumbles. |
| Hardness | Force required biting through the sample. |
| Denseness | Compactness of cross section of sample after biting through with molars. |
| Chewiness | Number of chews @ 1 chew/sec before the product is swallowed. |
| Adhesiveness | Amount of product adhering to teeth after mastication. |

Panelists also provided anchors for the ends of a 15-cm continuous unstructured line scale on which ratings of each attribute were recorded. These preliminary sessions were necessary for the panelists to set up their profiles and reach a consensus on the list of attributes. In the subsequent sessions, they used their final profiles to determine the differences between the samples. A 3-digit code was used to identify samples at each taste.

#### *6.2.3.1 Panel Testing of Jellybean Attributes*

The panelists assessed 8 samples, in-groups of four, with a total of 3 evaluations were made for each sample by a balanced incomplete block design (Cochran & Cox, 1957). The design was balanced for order and carry over effects (MacFie *et al.*, 1989). The attributes

were scored on a 15-cm line scale and were converted into millimeters for data analysis. Each panelist had to attend two testing sessions to complete the full range of samples on each day. The interval between two sets of samples was kept to an hour. Six testing sessions were required to collect the data from 9 trained panelists. Tap water was supplied to cleanse the palate between tastes. Sensory booths were in an air-conditioned room having air extraction and artificial daylight lighting.

### *6.2.4 Statistical Analysis*

5 types of analysis were completed on the data. Firstly, the sensory data for trained panel for each attribute was submitted to analysis of variance (random effect model) with panelists and samples as main effects. The panelists were treated as random variables and samples as fixed variables. The panelists were calibrated and their performance was checked by ANOVA before the evaluation of the final samples. Sensory data were averaged over judges, replicates, and sessions. Secondly, non-parametric test (Spinnler *et al.*, 1996) of rank interaction was used to examine whether the ranks of samples within a panelist varied between panelists.

Both internal (MDPREF) and external (PREFMAP) analysis was conducted on the data. MDPREF is a PCA on correlation matrix comprising of products (samples) and consumers (variables). PREFMAP is conducted by first using Principal Component Analysis (PCA) on the sensory data (Figure 6.1), and then by relating each of the consumers to this PCA space by regression analysis (Schlich, 1995). Graphic output of consumer preferences was made. The consumers for external preference mapping as well as for the internal analysis are usually represented as points on the map.

In this study, the preferences of the population were found to be complex and as number of consumers was not very large therefore, non-metric version of PCA (Caroll, 1972) was used. It involves calculating for each consumer the best monotonic transformation (Kruskal, 1964) of preference data in order to maximize the variation explained by first

few principal components. For monotonic transformation of data, the PRINQUAL procedure in SAS version 6.10 (SAS Institute Inc., USA) was used. The iteration history of this transformation is shown in Appendix 6.5 (page 257). The proportion of variance explained by first three factors is increased from an initial 0.63 to 0.80.

Lastly, the preferences were also analyzed by hierarchical cluster analysis. The method assigns samples that are close in multivariate space to the same cluster. In this way it can identify groups of consumers, which are homogeneous in their preferences for the eight samples. The consumer groups were compared to demographic data for consumers. This was done by simple tabulation and by a homogeneity test, which is an approximate Chi-square test for similarity among the groups. PCA was carried out using SAS and the cluster analysis and Chi-square were performed by Minitab version 12.

## 6.3 Results

The results of the liking of jellybean centers is shown in Appendix 6.4 (page 255).

### *6.3.1 Sensory Profiling*

#### *6.3.1.1 Performance and Agreement among Panelists*

Analysis of variance and the non-parametric rank interaction test indicated a good agreement between the panelists, for all the product attributes as shown in Appendix 6.8 (page 260). The panelist product interaction test was never significant ($p > 0.05$), indicating a difference in using the scale, which did not affect the ranking order of the 8 samples. These results indicate that the mean scores of each variety given by the 9 panelists for each descriptor could be considered satisfactory estimate of the sensory profiles of the varieties. They were, therefore, used in PCA.

### 6.3.2 *External Preference Mapping*

#### *6.3.2.1 Sensory Profile data*

The first step for this method was to perform PCA on the sensory data. The results of the sensory profile are plotted relative to the first and second principal sensory axis in Figure 6.1. The results are plotted as triplicates, except where points overlap, and are shown joined together.

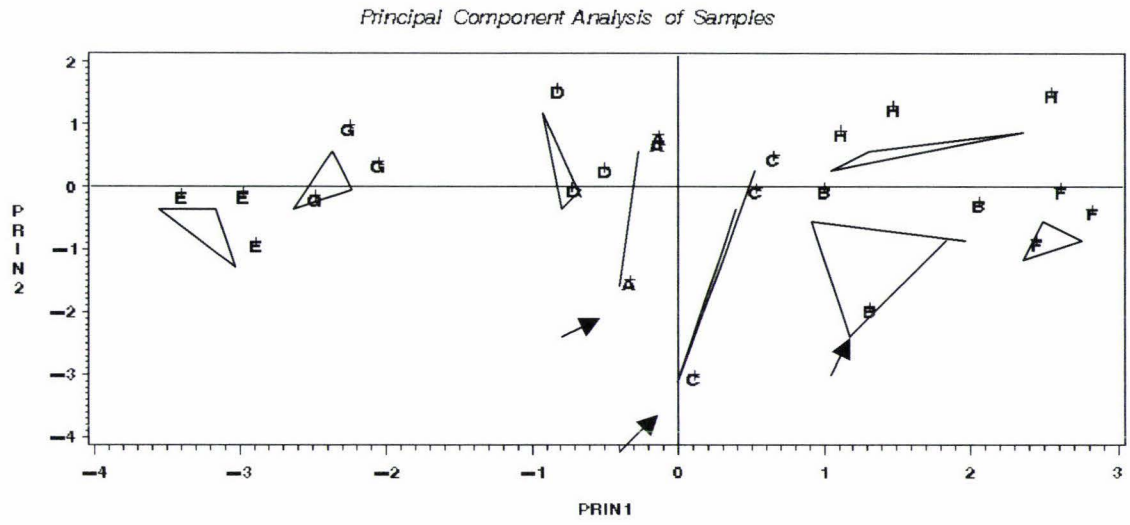



**Figure 6.1: Plot Obtained for 8 Jellybean Types (A-H) Relative to the First Two Components. The Three Replicates are Joined Together.**

The results are plotted as triplicates, except where points overlap, and are shown joined together. There is an excellent discrimination between all the 8 samples but sample A, B, and C have large variation within. To know the cause of variation, a new plot was made with replicates for each of the sample as shown in Figure 6.2.

It was found that discrepancy occurred with the products, which were assessed on Day 2, the panelists were not consistent in their assessment. Therefore, Day 2 data was considered outlier and the sensory data of Day 1 and 3 was averaged across the panelists and used for

PREFMAP and MDPREF. In a similar study Hough *et al.* (1997) used only duplicate measurements of powdered chocolate samples.

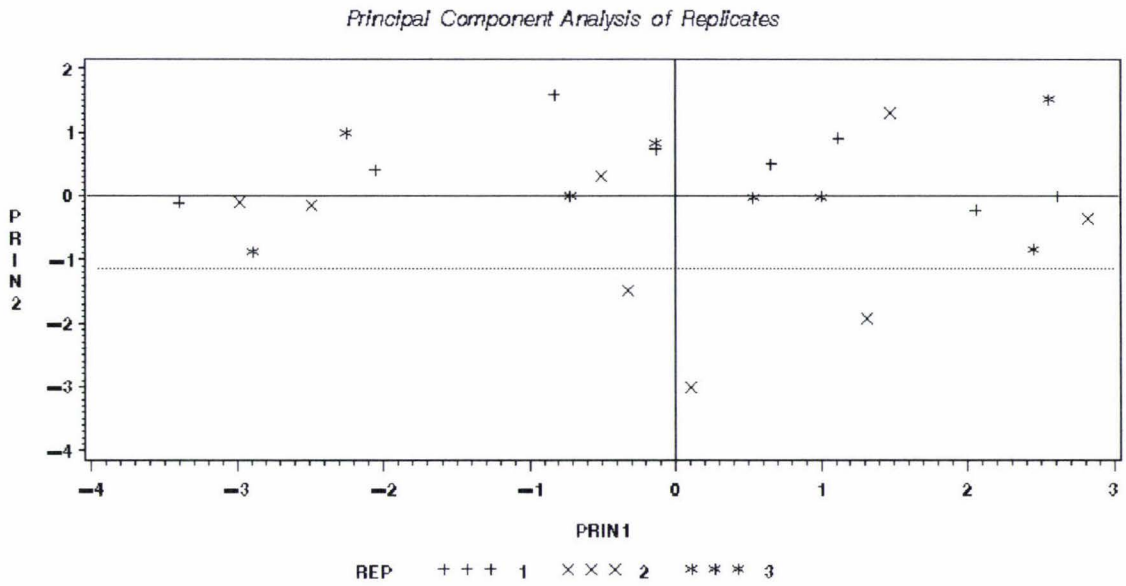



**Figure 6.2: Plot of Replicates of Products (A-H) for Three Sessions held on Day 1 (+), Day 2 (x) and Day 3 (*).**

The PREFMAP model used was the vector model. A PCA on the correlation matrix showed that the first three components accounted for 62.2%, 19.1% and 12.7% of the variance respectively. First three components thus together accounted for 94% of the variance. Although the third PC has an eigen-value of less than 1 (0.76) it explains 12.7% of total variation, it was also considered. The remaining PC's did not contribute much to explaining the total variations therefore were not considered. The dimensionality of the data was therefore, reduced to three from six dimensions. The scree plot displaying eigen values of the PCs is shown in Appendix 6.6 (page 258).

Interpretation of the first PC was done by examining the corresponding eigenvectors (principal component coefficients) listed in Table 6.3. It is clear from the 'component

coefficients' that the 1st PC can be regarded as a new dimension that was highly influenced by springiness, hardness, denseness, and chewiness. However, it may be inferred that it can be a contrast between adhesiveness and other textural attributes. Hence, considering the larger coefficients, only the 1st PC would indicate a product having moderate to high springiness, hardness, denseness, and chewiness but low level of adhesiveness. The 2nd PC, which accounted for 19.1% of the variation, is largely influenced by cohesiveness and to a lesser extent by adhesiveness.

**Table 6.3: Coefficients of Each Attribute for the First Three Components**

| Attributes | Principal 1 | Principal 2 | Principal 3 |
|---|---|---|---|
| Springiness | 0.45 | 0.08 | -0.29 |
| Cohesiveness | -0.017 | 0.88 | -0.37 |
| Hardness | 0.48 | -0.02 | 0.31 |
| Denseness | 0.47 | 0.18 | 0.09 |
| Chewiness | 0.46 | 0.10 | 0.40 |
| Adhesiveness | -0.35 | 0.41 | 0.71 |

The products such as A and D that are more cohesive would show a large value for 2nd PC, while products C and H will show low positive values for this PC. The position of the sample space relative to the attribute positions allowed a direct comparison of the samples in term of these attributes. By looking at Figure 6.3 the predominant attributes of the various samples (Table 6.1) can be ascertained. Sample A was considered to have cohesive and adhesive attributes, while springiness and denseness distinguished C and H from the other samples.

Other samples such as B and F, which contained largest amount of thickening agents (Table 6.1) were considered as hard and chewy in texture. The sample E, which contained lowest amount of thickening agents was characterized as soft, non-elastic, non-sticky and less chewy. Inter-sample comparison indicated that sample D was more adhesive than B

and F, which in turn had a hard and chewy texture. Information regarding the sensory attributes of the eight products can thus be derived from Figure 6.3 by comparing the relative position of the attributes and the samples. Hence, results indicate that hardness and chewiness were strongly influenced by starch and gelatin contents.

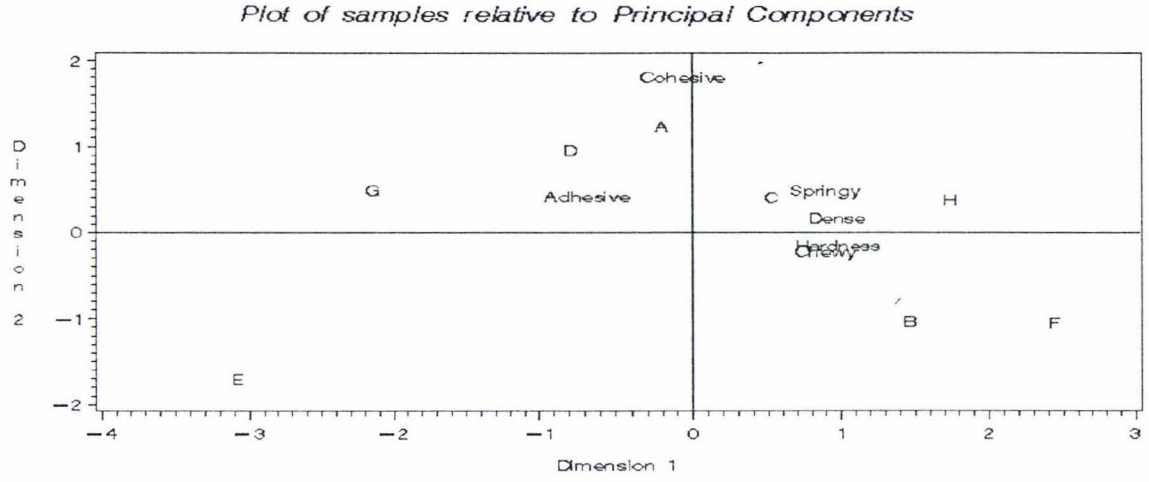



**Figure 6.3: Plot of Product and Correlation of Six Sensory Attributes to the First Two Components**

### *6.3.3 Summary Statistics of Consumer Data*

Appendix 6.4 (page 255) shows the overall liking response for the 53 consumers. The means of the consumer scores are plotted in Figure 6.4, where it can be seen that samples A and C were considered to be more acceptable, were rated highly for overall flavor and texture respectively. Furthermore, these samples were well rated for all the three attributes. The texture of samples A and C was liked more than the other samples, while texture of sample E was least liked. Sample C, which was rated highest for the overall liking characteristic, was rated highest for the overall flavour as well. This implies that overall flavour may be a slightly stronger driving force in influencing the consumer preferences than texture.

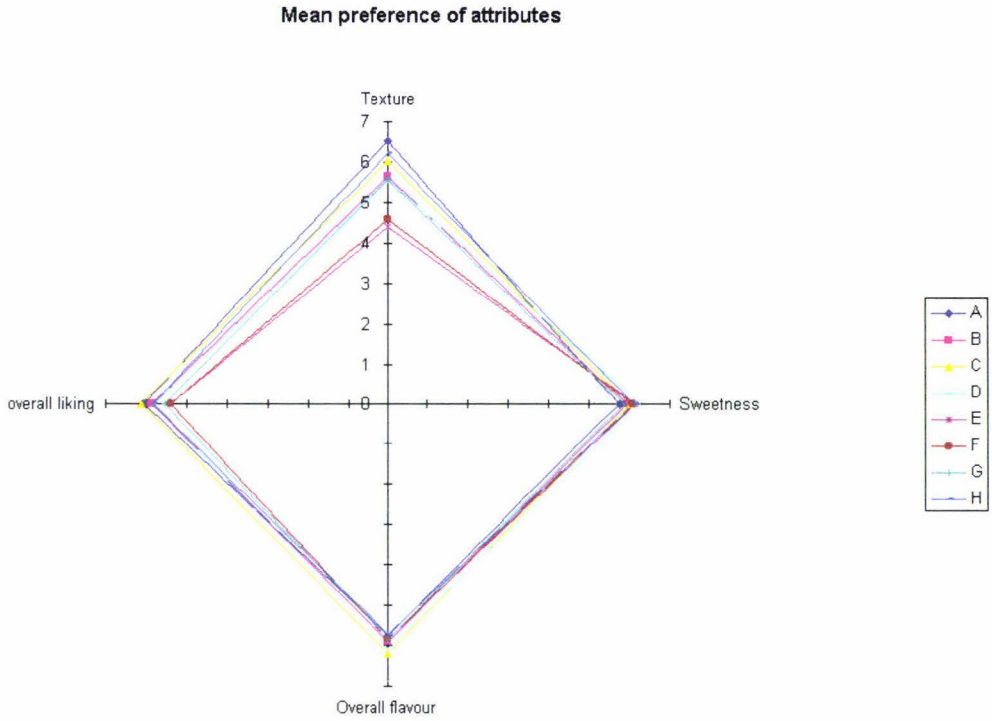



**Figure 6.4: Means of ratings scored by Consumers for Sweetness, Overall Flavour, Texture and Overall Liking**

The PREFMAP obtained by relating the sensory profile data and consumer data is plotted in Figure 6.5. The number and density of the consumer preference vector, indicate a higher preference in the upper right quadrant, indicating sample C and H as the most preferred samples. The density of the consumers decreased towards the lower left quadrant indicating G and D as the least preferred sample. It further shows by comparison with Figure 6.3 that C and H were preferred because they were less sticky.

Sample A is positioned very close to first quadrant and liking of the sample by consumers is not very clear. The majority of the respondents liked sample C over any other sample.

Findings of the results presented in Figure 6.4 are based on all consumers tested, with no reference to how well they fit into a linear model for sensory data.

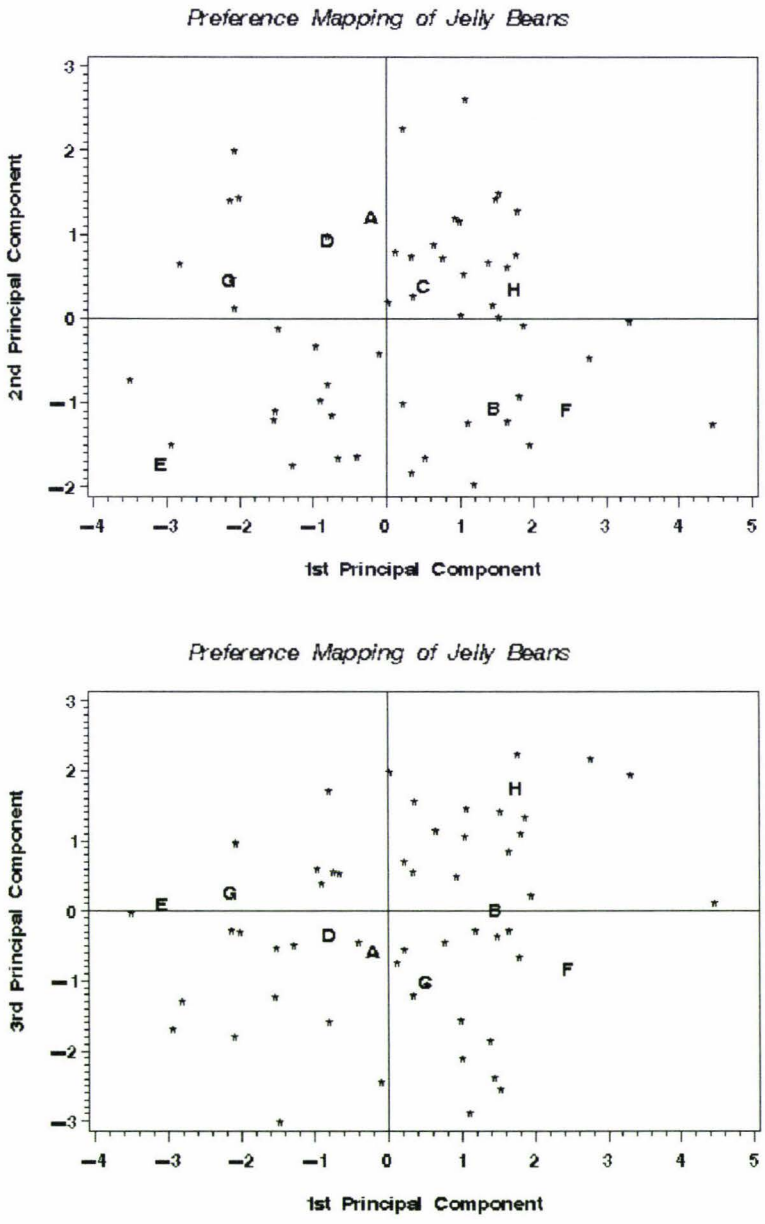



**Figure 6.5: External Preference Mapping of Jellybeans: (A) PC-1 and PC-2; (B) PC-1 and PC-3. Symbols: (*) Consumers; (A-H) Samples.**

An additional preference analysis (Figure 6.6) was performed for those consumers only who could be significantly ($p<0.05$) described by first two principal components. Thirty-two percent of consumers could satisfy this condition. As can be seen, the plot shows consumer regression is different from what has been seen before, when all the consumer data was analyzed. Now sample E is no longer preferred and sample A has joined sample C and H as most preferred sample. All the three samples are low in antibacterial components and moderate in gums level. In fact, the most preferred product is A, which is indicated by the number and density of the consumer preference vectors. The consumers with shorter vectors (distance of the consumer from the vertex) are contributing less information to the sample map than those with longer vectors. Therefore consumers with large vectors show a marked difference in preference for samples around them.

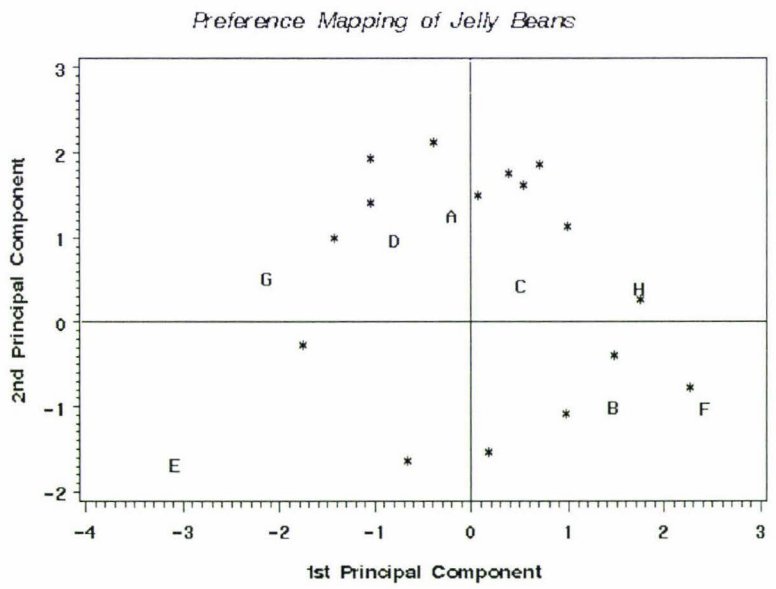



**Figure 6.6: External Preference Mapping of Jellybeans Samples, Described by a Linear Model in the First Two Components ($p < 0.05$)**

### 6.3.4 *Internal Preference Mapping – MDPREF*

The resulting plot for first two components is shown in Figure 6.7.

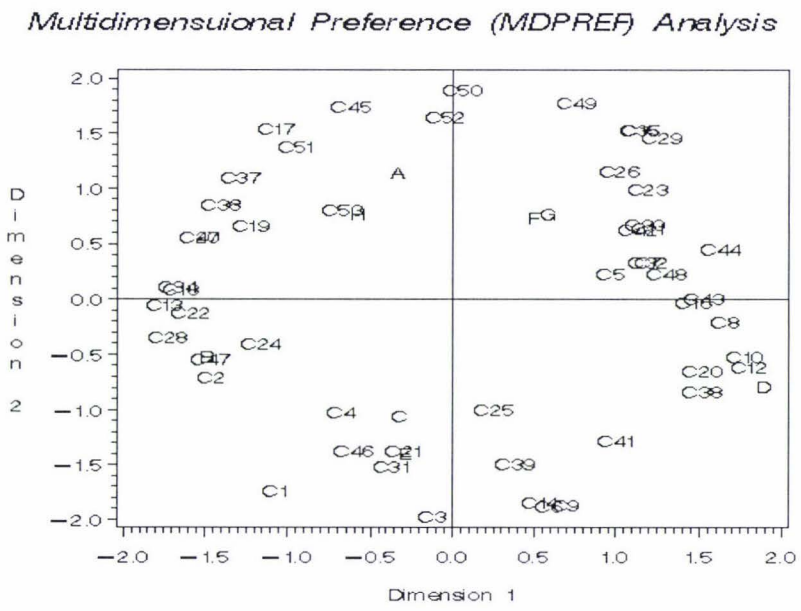



**Figure 6.7: MDPREF of Jellybean Data Derived from Consumer Vector. Symbols: (C1-C53) Consumers; (A-H) Samples by PC-1 & PC- 2**

Figure 6.7 shows the sample as letters and the consumers as the direction of increasing preference. The PCA of the preference scores showed that 60.9% of the variation in the preferences were explained by the first two components. Adding a third component to this proportion increased the explained variance to about 80.25%. The length of vector indicates how much information an individual consumer is contributing to the preference map. Consumers with shorter preference vectors (C25, etc.) are contributing less information to the sample map than those with longer vector (C50, etc.). It is clear from the above plot that some consumers are contributing less information than others are because they did not show a marked difference for those samples, which dominate a particular PC. The largest group of consumers falls into the upper right quadrant in Figure 6.7. Since the

most preferred samples from the analysis of the averages above, namely sample A and C are not lying in these quadrant which clearly indicates that rest of the samples seem to be preferred by some of the subjects. It appears that the direction of preference is towards products F and G. However, based on this information, preference for a particular product cannot be determined. Consumer have preferences for other product samples as well, and number of consumers in the second largest quardent is short by 2 consumers. Therefore, consumer did not have clear preferences for a single sample. But it seems to be segmentation of the consumer in loading plots. The MDPREF of clusters based on overall liking will help in selecting a product which is highly acceptable to most of the consumers.

As may be seen, PREFMAP score plots in Figure 6.5 (PC-1 and PC-2) are entirely different from the identical score plots for MDPREF (PC-1 and PC-2). The difference in score plots is quite natural, the sensory profile (PREFMAP) is based on only the texture data of the product, while MDPREF on the overall liking. The consumers while assessing the overall liking of the product might have given equal or more emphasis to other product attributes like flavour, sweetness, and apperance. Hence, the difference in weighting is quite natural as texture is only one of the important attributes of jellybeans.

### *6.3.5 Cluster Analysis*

#### *6.3.5.1 Segmentation by Similarity of Preference*

Since results of internal and external analysis were not consistent, and in order to reach a consensus, cluster analysis was performed on the data. Hierarchical Cluster Analysis was conducted on the centered consumer data of 8x53 matrix. Inspection of the dendrogram indicated that four clusters were sufficient to classify consumers. In Figure 6.8 the score plot from the internal preference mapping is shown with positions of consumer preference vectors within each of the four subgroups labeled with different symbols. It is clear that the four subgroups define different regions in the loading plot.

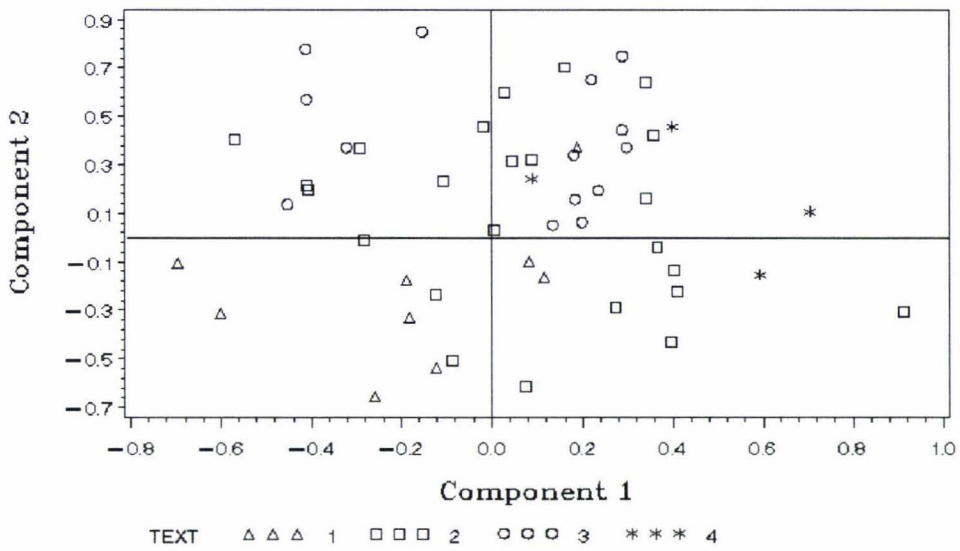



**Figure 6.8: Consumer Preference Vectors for each of the Subgroup Labeled with Different Symbols. Symbols: $A_1$ (Δ), $A_2$ (□), $A_3$ (o), $A_4$ (ς)**

The mean scores of the eight products by the total group and by cluster of consumers are presented in Table 6.4. For each cluster it is possible to find a most liked and least liked product, and for most of the clusters these products are different.

**Table 6.4: Mean Scores of the Jellybeans by Cluster of Consumers**

| Cluster | N[1] | F[2] | A[3] | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|---|---|---|
| A1 | 9 | 5.87 | $3.4^{bc}$ | $5.6^{a}$ | $5.8^{a}$ | $5.4^{ab}$ | $5.9^{a}$ | $3.3^{bc}$ | $3.7^{b}$ | $3.7^{b}$ |
| A2 | 25 | 1.01 | $6.8^{b}$ | $6.9^{b}$ | $7.0^{b}$ | $6.5^{b}$ | $6.4^{b}$ | $6.4^{b}$ | $6.7^{b}$ | $6.8^{b}$ |
| A3 | 14 | 6.74 | $6.8^{a}$ | $3.9^{d}$ | $4.8^{bc}$ | $6.0^{ab}$ | $4.4^{c}$ | $5.9^{ab}$ | $5.4^{bc}$ | $5.4^{bc}$ |
| A4 | 5 | 13.54 | $5.2^{ab}$ | $6.4^{a}$ | $5.8^{a}$ | $2.6^{c}$ | $2.6^{c}$ | $2.6^{c}$ | $3.6^{b}$ | $6.6^{a}$ |
| Total | 53 | 1.48 | $6.1^{a}$ | $5.9^{a}$ | $6.1^{a}$ | $5.8^{a}$ | $5.4^{a}$ | $5.4^{a}$ | $5.6^{a}$ | $5.9^{a}$ |

[1]N= number of consumers in the cluster, [2]F: Fisher ratio test, [3]Product mean scores: two products having the same letter are not significantly different (Fisher, 5%).

The product effect (F) is more pronounced in clusters A1, A3, and A4 than in the whole panel. For cluster A1, the differences in preference between the samples are significant ($p< 0.05$). However, the acceptability of all the samples in this cluster was low (Average liking score<6) thereby indicating poor acceptance of all the samples. Therefore, this cluster was not considered for further interpretation. For cluster A2, there was no significant difference in preference for the jellybeans. The analysis of cluster A2 indicated that 47% of the sample of panelists did not show a marked difference in preference for these jellybeans. However, the level of acceptability of all the products is high in this cluster (Average liking score >6), and will prefer any of the products.

Cluster A3 and A4 indicated that the differences in liking between the samples are significant. Therefore sample A that was liked by the second biggest cluster (A3) was selected for further development.

## 6.4 Conclusion

### *6.4.1 Trained Panel*

The vocabulary developed by the author along with the trained panel was helpful in summarizing the product by a few components. The plot of the first two components in Figure 6.3 demonstrates the discrimination between the products. Axis 1 in this figure appears to contrast between a product that are hard in texture and product sticking to teeth. Axis 2 in this figure appears to contrast between cohesive and hard product and third axis contrasts between cohesive and adhesive products. The comparison of the plot of products showed that there is large separation of products H and E.

### *6.4.2 Preference Mapping*

Preference mapping is one of the methods for product optimization. It was used to identify the most acceptable formulation and how to refine the product further. Two methods were used for preference mapping. The first method of external analysis (PREFMAP) was based

on relating the individual preferences scores to the PCA analysis of the sensory data and other method of internal analysis (MDPREF) was based on generating preference space using PCA on the preference data. The structure of MDPREF and PREFMAP was quite different and no consensus was reached about the preference of the individual product. PREFMAP of consumers who were significantly described by the first two principal indicated that sample A is the most preferred sample.

External preference mapping indicated that to improve the liking of sample E that has low liking by reformulation it towards the sensory properties of product A, which will require sample E to have less stickiness, more cohesive and improved hardness and chewiness as well. Another way of improvement could be to reformulate it towards the sensory properties of product H, which will require sample E to have less stickiness and more of hardness, chewiness and cohesiveness.

However, MDPREF indicated that global preference is towards samples F and G. Therefore from internal preference mapping no conclusive results were obtained which made its usage difficult for product development purposes.

The information derived from this study is in line with the other study conducted by using internal and external preference mapping, although maps are different. Unlike the findings of other researchers (Risvik *et al.*, 1996; Helgesen *et al.*, 1997) who had structure of internal preference map similar to external preference map on PC-1 while PC-2 was reversed. But it is quite possible that the range of attribute and product considered in this study is entirely different from these studies. This study comprised mainly of texture attributes, which may be only one of the key attributes for consumers' preferences, as they may like to consider flavor and taste equally important. So results are not surprising, that trained panel and consumer panel perceived the samples in different ways.

Since based on the results of PREFMAP and MDPREF a consensus was not reached to the further development of the product. So MDPREF was further analysed with subgrouping of the consumer preferences. The cluster analysis allowed consumer with no differences in liking to be identified. Consequently, the analysis of the remaining clusters was more relevant because of their higher discrimination.

### *6.4.3 Consumer Preference - Cluster Analysis*

In this plot consumer preferences were broadly categorised into four subgroups. They were well separated, indicating that the visual and mathematical clustering technique can be effectively used. Interpretation of the cluster showed that market existed for most of the product samples and hence most liked product should be selected for majority of the clusters having higher acceptance for one product. This would not have been possible by average method in which product having highest liking score would have gone in for further development.

Finally concerning the results of this survey, it was noticed that cluster A2, which comprises half the panel did not have marked differences in liking for the jellybeans. Therefore, a product, which is well liked by this group and at the same time also most liked by other large cluster A3, would be selected for further development. Hence product A, which was liked by cluster A2 and the most liked by cluster A3 was chosen for further development. This product would be carried forward to the commercial level production at the Cadbury's plant. The product A, is low in hardness, chewiness and denseness, and as these attributes were not liked by the consumers. This indicated that the attributes that are not liked by the consumer are already at their minimum level.

# CHAPTER 7

# Process Scale Up

## 7.1 Introduction

The bench top tests had shown that antibacterial properties of honey were sensitive to time and temperature combinations used in the process. Therefore, once the prototypes were ready, the process was scaled up to ensure that all manufacturing processes performed as required. This helped to identify and correct all the process and product problems before launching the product in the market place.

The performance of the product in the market place can be predicted by using central location tests and home use tests. These two consumer-testing methods required a large volume of product to be manufactured. The facilities available at Massey University were not large enough to make the product in such a large scale. The Cadbury Confectionery Limited, Auckland plant was contracted to obtain the desired volumes of output.

Product quality may deteriorate at any stage in the usual development sequence of bench top, pilot plant, and full-scale production due to change of equipment and process (Matz, 1994). The scale up of the product involved many problems, such as nature of the plant available, and compatibility of the plant with the bench top trials. It was important to learn about these before the actual tests were considered. The Product Development Manager at Cadbury's was of great help in identifying anticipated problems well in advance and formulating necessary precautions to counter them. The details of the process work done at Massey were communicated and any gaps in the development work were identified. The process layout along with the results and samples of the trial formulation were sent for appraisal. Once satisfied on all the aspects for scale up, a target date of 29 March 1999 was finalized as production trial date.

The major difference identified was the type of cooker used at Cadbury's Limited. They were using a continuous static cooker, unlike the open pan process used in bench top trials. Massey did not have suitable pilot plant facilities so it was not possible to study in detail the impact of any process change on the sensory attributes of the jellybeans. The major impact of this was likely to be the gelatinizing the starch under different temperatures. It may be thought that this change would not make much difference as both processes are used in the jellybean production and are recommended by material suppliers. Keeping this point in mind Ultra set-LT was used which is compatible with batch as well continuous process. Gelatin in the formulation was also found to be compatible with the continuous process. It was further believed that small-expected changes in the product due to scale up had to be accepted.

The aim of the study was to make a product at commercial level and study the presence of the antibacterial properties in the finished product. Specific objectives of the study were:

- To investigate the presence of antibacterial properties in a commercially produced finished product.
- Suitability of the product formulation on the processing operation at up scaled level.

## 7.2 Commercial Production

In order to compare the antibacterial performance of commercial and bench top formulation, the formulation, which was largely accepted in the consumer study, was used in this study.

This formulation was pre-tested for consumer acceptance (Chapter 6) and was found to be most acceptable among the samples. At the same time, this formulation was found to have potent antibacterial properties. The formulation used for scaled up production is described in Table 7.1. The complete process showing the various stages of jellybean processing is shown in Figure 7.1.

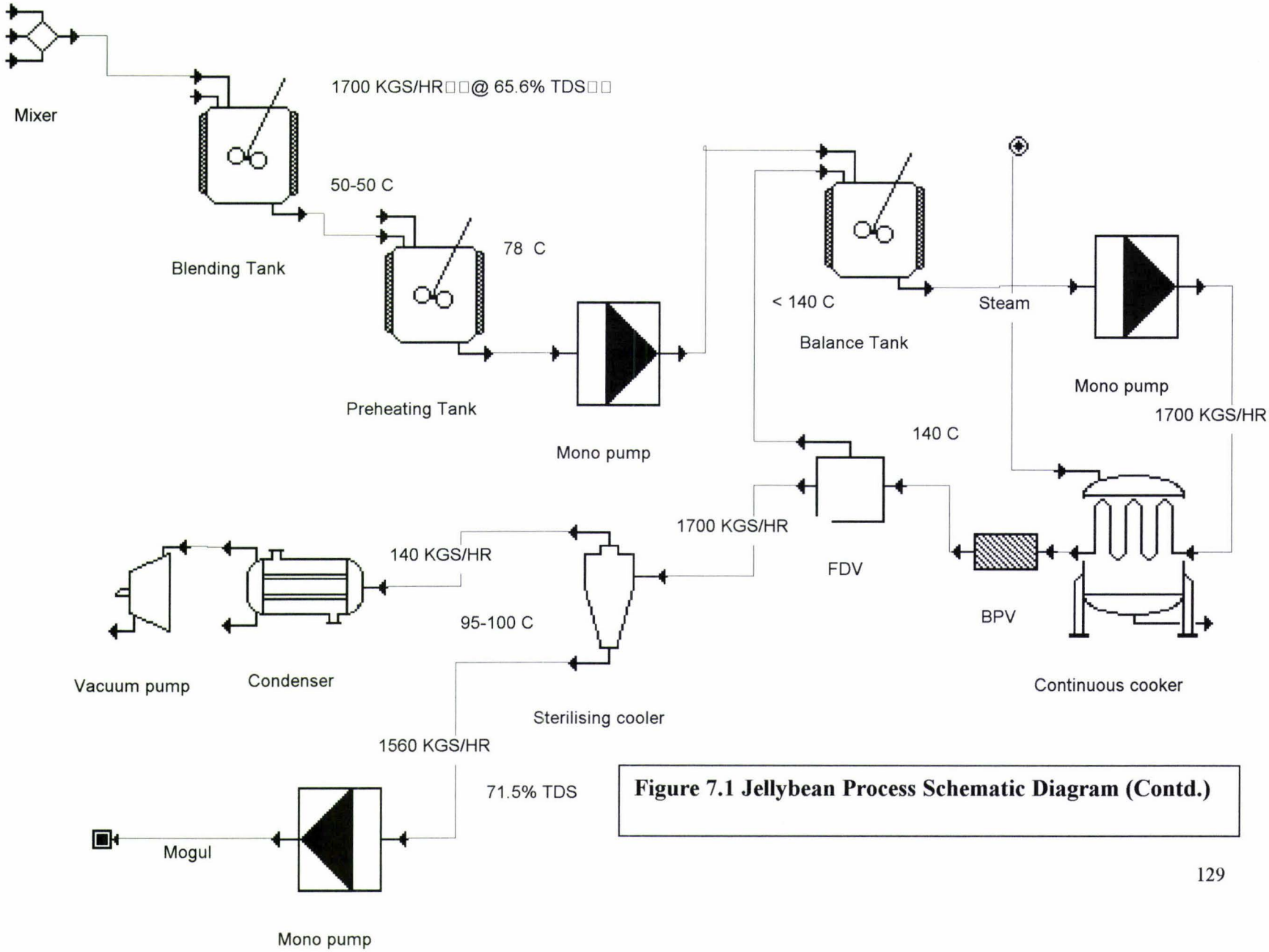



**Figure 7.1 Jellybean Process Schematic Diagram (Contd.)**

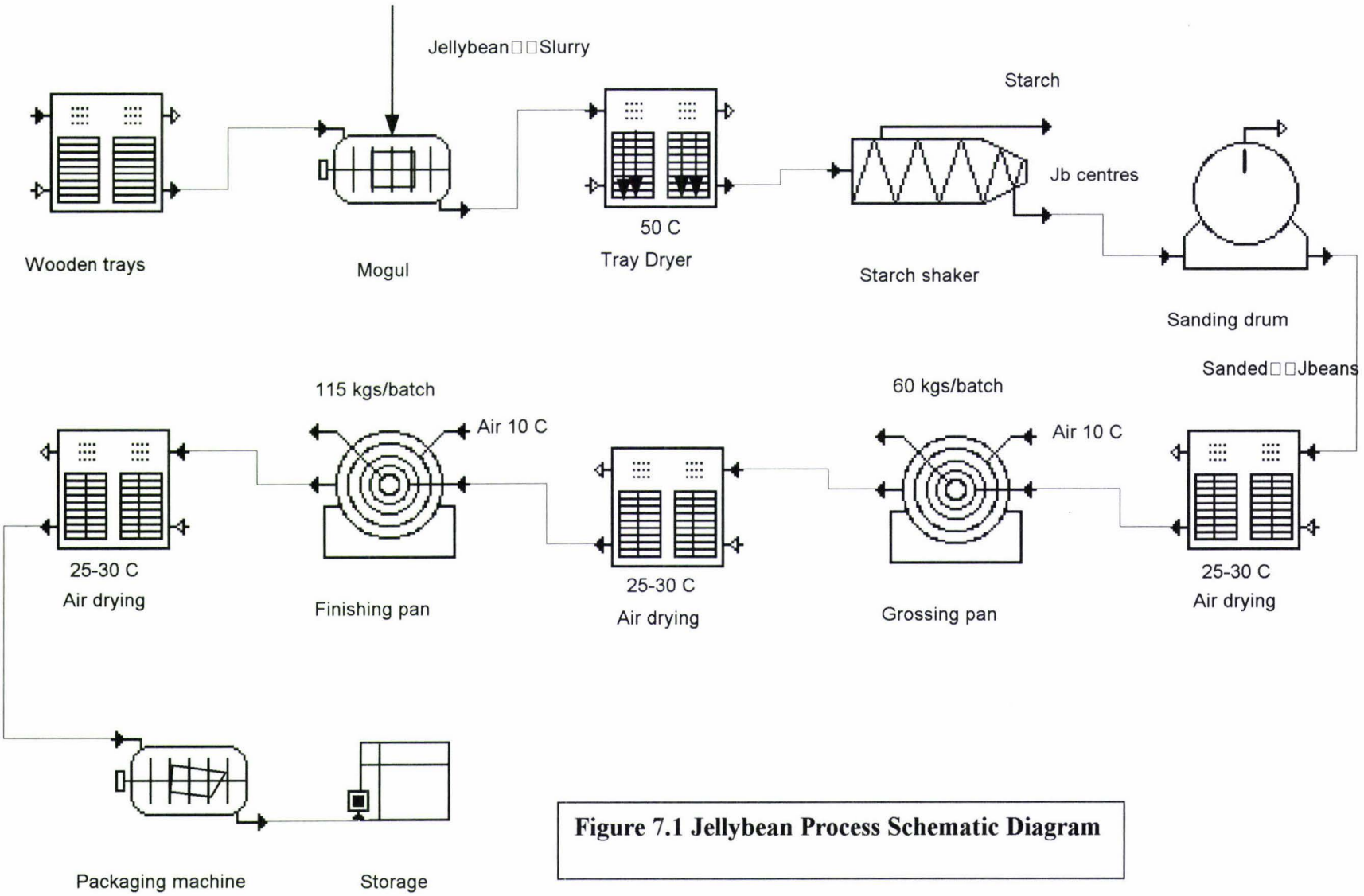



**Figure 7.1 Jellybean Process Schematic Diagram**

**Table 7.1: Ingredients for Formulation**

| Ingredients | Bench top | Commercial Formulation[c] | % DS[d] On dry matter Commercial | Plant[b] Formulation | % DS[d] On dry matter Plant |
|---|---|---|---|---|---|
| Starch | 9.2 | 9.2 | 11.0 | 8.0 | 11.0 |
| Gelatin | 5.0 | 5.0 | 6.3 | 4.4 | 6.3 |
| Honey[a] | 10.2 | 10.2 | 11.5 | 8.9 | 11.5 |
| Propolis extract[a] | 1.8 | 1.8 | - | 1.6 | - |
| Sucrose | 18.0 | 20.0 | 26.5 | 17.5 | 26.5 |
| Corn syrup | 40 | 42.0 | 44.5 | 36.7 | 44.5 |
| Citric acid | 0.2 | 0.2 | 0.25 | 0.2 | 0.3 |
| Lemon Flavour[a] | 0.1 | 0.1 | - | 0.1 | - |
| Maltodextrin | 4.8 | 0.0 | - | 0.0 | - |
| Water | 10.7 | 11.5 | | 22.4 | - |
| Total | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Water of evaporation | 52.0 | - | | - | |
| TDS | | 75.5 | | 66.0 | |

a = Added after cooling down to 95° C. Qty. of propolis required at 66%TDS in plant formulation = 1.8/75.5x66= 1.6kg.
b = batch size = 340 kgs. Based on in-going weight of the ingredients. In the plant the solids are increased from 66% to 69-71% due to vacuum cooling as indicated in Table 7.2.
c = Bulker taken out of the formulation and replaced with sucrose and corn syrup as decided at design stage. Refer Table 5.1.
d = % DS = % Dissolved Solids. On the basis of % DS both the commercial formulation and plant formulation are same. Difference is slightly more evaporation loads in the curing room in case of plant formulation.

The costing of finished product is shown in Appendix 7.1 (page 264) and this was $5.68 per kg of the finished product.

## 7.3 Experimental Conditions

### *7.3.1 Cooking Method*

In this study a Terbraak static cooker was used. The slurry was continuously processed at 135-140° C and was continuously cooled to 95-97° C. Figure 7.2 shows the Terbraak Static Cooker used in the manufacture of jellybeans. Static cooking is performed under pressure which offers several advantages like fast and complete gelatinisation of starch and reduction in cooking time from several minutes to seconds, processing variables are automatically controlled, efficient steam utilization, and less equipment and space required. All of which result in lower production costs as well as higher production rates.

In this method the preheated slurry passes at a high velocity through a tube coiled in a steam chamber. There are no internal scrappers.

The water of formulation was heated in a jacketed steam vessel at $80^0$ C and dry ingredients comprising of starch, sucrose and corn syrup were blended with the help of high-speed stirrer. Then presoaked gelatin was added into it.

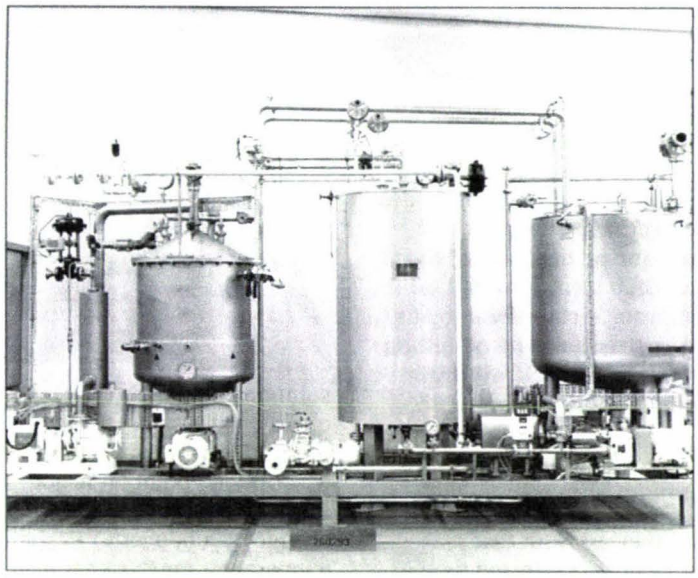


**Figure 7.2: Terbraak Static Cooker used in the Manufacturing of Jellybeans**

The premix solids were checked with a refractometer and were found to be around 65%, which was well within the designed limits. The product was cooked to 135-$140^0$ C to get proper gelatinisation of starch. In the Terbraak process, when the product is rapidly cooled under vacuum from $135^0$ C to $95^0$ C, the moisture boils off and leaves more solids in the slurry. A vacuum of 100 mm of water column was kept in the cooler to get the discharge product temperature of $95^0$ C. At the same time, the 65% solids slurry that was fed to the

cooker was discharged at 71% dissolved solids. Table 7.2 shows the Terbraak process control sheet for the trial.

**Table 7.2: Terbraak Process Control Sheet of the Trial**

| Process parameters | Recommended | 1430 hrs | 1440 hrs | 1445hrs |
|---|---|---|---|---|
| Preheating | 80°C | 78°C | 78°C | 78°C |
| Premix solids % | 63-65 % | 66 % | 66 % | 66 % |
| Cooking temp. | 135-140 | 136 | 140 | 140 |
| Back pressure | 2.8 bar | 2.8 bar | 2.9 bar | 3.0 bar |
| Vacuum | 100 mm | 100 | 120 | 120 |
| Temperature cooling | 95°C | 95°C | 95°C | 95°C |
| Syrup total solids | 71% | 68% | 69% | 71% |

### *7.3.2 Jelly Forming Method*

After cooking of jellybean syrup the forming of beans was done by depositing. The deposition was carried out using a starch mogul. The hot starch at 90-95°C is filled into the trays continuously and fed to the mogul. The mogul operation prints a pattern of moulds into a starch filled tray using a mould board as pattern. Each tray is then conveyed automatically under a hopper containing the hot cooked candy. The depositor then deposits the jellybeans through a series of pistons and nozzles into the printed moulds. The filled board is then stacked and manually conveyed to the drying rooms at 50° C.

### *7.3.3 Moulding Starch and Starch Conditions*

The moulding starch contained mineral oil with maximum limit of 0.3% (Cooley, 1993). The temperature and moisture of moulding starch has a significant effect on the quality of the finished jelly product. The moisture of starch was kept between 5% to 7%. If the starch is too wet or too cold it will soak into the surface of the candy upon deposition. If the starch is too dry or too hot, the surface of the jellybeans dry too rapidly and have a leathery skin (Cooley, 1993). The product was dried for at 50° C for 38 hours. Once the product has been dried to the proper solids level, the product is shaken out of the starch and is finished with sanding.

### *7.3.4 Product Finishing*

To sand the jellybean centers, the product passes through a steamer and then into a sanding drum. In the pre-steamer the pieces must not be touching each other. But at the same time they must be exposed to enough steam from the top and bottom to effectively wet off all of the surface starch. In the drum, the product is tumbled with castor sugar. After finishing the product, it was dried at 30°C for overnight.

### *7.3.5 Soft Panning of Centres*

In the panning process the dry sugars were glued to the center with the help of panning Syrup-A. The formulation of syrup-A and the details of the preparation used for soft panning are shown in Appendix 7.2 (page 265). Colour and flavour are added into the coating syrup for addition into the product. These centers were sugar sanded to perform four functions. The first is that the sugar prevents the centers sticking together in intermediate storage and the second is that this rough sugar surface acts as a primer coat and is necessary for the proper adhesion of the coating in the early stages (Lynch, 1987). Thirdly, the sugar crystals prevent doubling during the first wetting and the fourth function is that the sanding of the sugar is a quick and efficient way of building up the weight on to the centers thereby saving panning time (Lynch, 1987; Bianco, 1993).

### *7.3.6 Panning Process*

The pan was loaded with 60 kgs of jellybean centers and subsequently switched on to rotate. Syrup A is made from corn syrup, was adjusted to 74% TDS and filled in a dipper up to 5.2 kgs. About 3.5 kgs of this quantity was added to the pan, and allowed to distribute evenly over the entire surface area of the centers. The dry sugar was added to the pan in an amount that uniformly covered the centers. As the product rolls, the dry sugars are softened and solubilised by the syrup, and causes the centers to sweat back appearing moist and sticky. At this stage another dry application of sugar was made. This process was continued until all available moisture was used, and the coating did not sweat back.

Then next syrup application of 1.7 kg of syrup is made. Castor sugar is added regularly and enough time is allowed to mix well between the scoops. This process was repeated till 10.4 kgs of syrup was consumed and about 38 kgs of castor sugar was used to gain about 100% weight over the centers weight. The formulation used for soft panning is shown in Table 7.3.

**Table 7.3: Ingredients Used in the Soft Panning Process**

| Ingredients | Quantity used per Batch |
|---|---|
| Sanded jellybean centers | 60.0 Kgs |
| Soft panning syrup A | 10.4 kgs |
| Soft panning syrup B | 1.8 kgs |
| Vanillin alcohol 4547 | 90 mls |
| Tartrazine 10% solution | 26 ml |
| Sugar castor | 38.0 kgs |
| Icing sugar | 7.5 kgs |
| Polishing wax | 16.5 grams |
| Citric acid | 120 ml |
| Lemon flavour | 75 ml |

Finally, a last syrup application is made of syrup B, and instead of castor sugar, icing sugar was used. Icing sugar was added one scoop at a time until product smooth and dry. Enough time is given between the scoops to allow the icing sugar to mix well between the scoops. A total of 7.5 kgs icing sugar was used in the batch.

The product was sieved to remove any double units formed during the panning process. The product is removed from the pan and placed in the shallow trays to allow coating to completely dry. The product is kept for drying for 24 hours before polishing it. The jellybeans were polished with a solution of beeswax and carnuba wax. The product was transferred to polishing pans. Polishing solution was added to the rolling product in a pan

and allowed to disperse uniformly over the entire surface area of centers without drying air. When completely dispersed, the cool dry air at 10-15° C and 50-55% RH is introduced. The product was rolled enough to just dry the polish. The gloss in the product was accomplished by charging with vanillin alcohol, and dried while starting and stopping the polishing pan number of times.

### *7.3.7 Testing of Jellybeans*

The commercial product was tested for moisture content, colour, antibacterial properties, and sucrose content. The methods for testing of the jellybeans are described in Section 4.3.3.4. It was not possible to measure the texture using TAXT-2 of the commercial sample because of the shape of the product. In the bench top tests, special moulds were prepared to make samples purely for instrumental measurements. This was not possible for commercial product as the flow of jellybean syrup was through pipelines and there was no provision to take samples to immediately fill in the moulds of special shape required for instrument. A t-test was used to find the differences between the samples produced with both commercial plant and the bench top trials.

## 7.4 Comparison Of Jellybeans Characteristics Produced With Commercial Plant And Bench Top

In the batch process the antibacterial components of the formulation was added at 95° C after cooling the jellybean mix from 108° C. The same procedure was followed in the commercial production run when the product was cooled down from 135° C to 95° C and antibacterial ingredients were added.

The suppliers tested the antibacterial properties of manuka honey used for the scaled up run, and a test report is attached in Appendix 7.3 (page 266). Similarly, the ethanol soluble ingredients of propolis were tested and were certified by Comvita. The ethanolic

component of propolis gives bad odour and taste to the product. The honey was used in the formulation as such, but propolis was further refined to get the water-soluble component for jellybeans. The water-soluble component was tested for its antibacterial properties by agar diffusion and spectro-photometry prior to addition into the jellybean syrup. Spectro-photometry is a rapid test for analyzing the flavonoids in the extract and was done at 292 nm.

The jellybeans were manufactured as described in the Section 7.3. The characteristic of the jellybeans produced in the commercial plant and under laboratory conditions is shown in Table 7.4. As indicated in Table 7.4, a t-value analysis shows non-significant difference of characteristics like moisture content, colour, and antibacterial properties. But the sugar level in the product was found to be significantly different.

**Table 7.4: The Jellybeans Characteristics Produced on Bench-Top and Commercial Run**

| Product | MC | SC | Colour | | | | ET | ZI |
|---|---|---|---|---|---|---|---|---|
| | (%) | (%) | $L^*$ | $a^*$ | $b^*$ | $\Delta E^*$ | (292 nm) | (mm) |
| Trial-20 | 13.44 | 41.2 | 49.6 | -5.06 | 33.44 | 3.77 | 0.596 | 17.9± (1.3) |
| | 13.55 | 41.6 | 49.63 | -4.82 | 33.64 | 3.79 | 0.600 | 17.3± (1.4) |
| | 13.77 | 41.4 | 49.10 | -4.88 | 34.07 | 3.55 | 0.601 | 17.4± (1.35) |
| Commercial product | 13.33 | 42.8 | 49.53 | -4.85 | 33.18 | 4.11 | 0.590 | 17.3± (1.15) |
| | 13.88 | 42.6 | 50.14 | -4.98 | 32.75 | 4.35 | 0.586 | 16.9± (1.35) |
| | 14.11 | 43.0 | 50.01 | -4.95 | 31.22 | 5.68 | 0.581 | 17.3± (1.4) |
| | 1.26[1)] | 7.00*[1)] | 1.58[1)] | -0.06[1)] | -1.71[1)] | 1.79[1)] | -3.29[1)] | -3.08[1)] |

[1)] t-test analysis

* $P < 0.05$

Note: MC = Moisture content
SC = Sugar content
ET = Extract of propolis used in the formulation diluted to $5 * 10^{-4}$
ZI = Zones of inhibition

All the pieces were uniform in shape and size, which was an improvement on the bench top trials. At the same time, the expertise of operators in running the soft pans was highly

commendable, which is purely a craft and contributed to the better appearance of the product.

The finished product was also tested for minimum inhibitory concentration (MIC) as shown in Figure 7.3. The extract from jellybeans was dissolved in 8% lysine and diluted with distilled water to achieve the stated strengths.

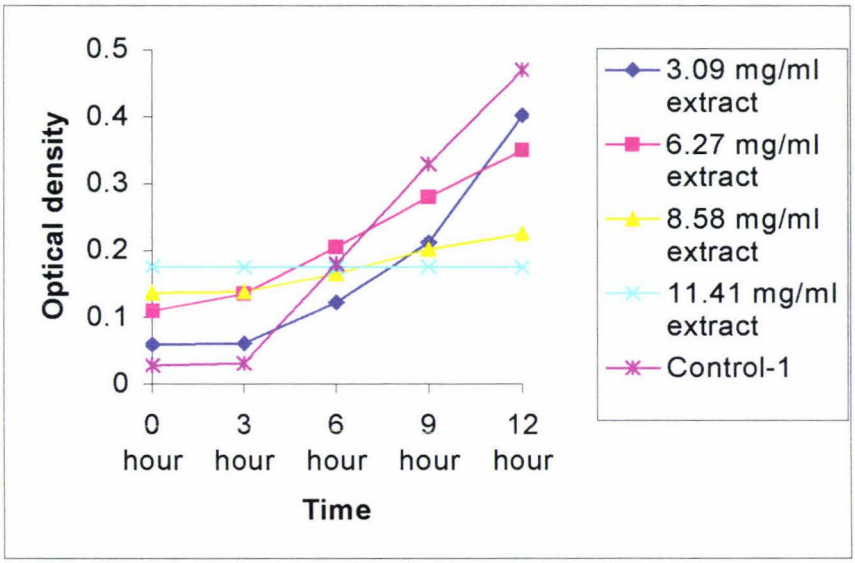



**Figure 7.3: Antibacterial Properties of Finished Product at Different Concentration of Extract in the Testing Medium by MIC**

The testing of the product showing the antibacterial properties of the finished is shown in Table 7.5. From the finished product (Commercial), four samples of 200 grams were randomly picked along with the sample without antibacterial properties (Control-1) and 2 ml of extract containing antibacterial properties was mixed with growth medium. A drop of bacterial suspension was added to each test tube. The turbidity of the sample was read at 0 hours and 12 hours at 520 nm. They were expressed in % inhibition compared to the absorbance of the control, which was taken as 0% inhibition.

**Table 7.5: Antibacterial Properties of the Developed Product Compared to Market Sample (Without Antibacterial Ingredients) by Turbidity Method**

| Sample | Concentration of extract | 0 - hour $E_1$ | 12 - hour $E_2$ | $\Delta E = E_2 - E_1$ | $\frac{(\Delta E_{control} - \Delta E) \times 100}{\Delta E_{control}}$ |
|---|---|---|---|---|---|
| Commercial - 1 | 3.09 mg/ml | 0.06 ± (0.004) | 0.405 ± (0.004) | 0.345 ± (0.004) | 21.6% ± (0.9) |
| Commercial - 2 | 6.27 mg/ml | 0.117 ± (0.006) | 0.362 ± (0.011) | 0.245 ± (0.007) | 44.3% ± (1.7) |
| Commercial - 3 | 8.58 mg/ml | 0.139 ± (0.003) | 0.23 ± (0.005) | 0.091 ± (0.005) | 79.3% ± (1.2) |
| Commercial - 4 | 11.41 mg/ml | 0.205 ± (0.043) | 0.201 ± (0.03) | -0.004 ± (0.028) | 100.9% ± (6.4) |
| Extract-1 | 10.4 mg/ml | 0.048 ± (0.01) | 0.048 ± (0.01) | 0.0 ± (0.002) | 100.0 ± (5.2) |
| Control - 1 | 0 mg/ml | 0.027 ± 0.001 | 0.467 ± 0.005 | 0.44 ± | 0% ± (4.1) |

The results have shown that there was a linear correlation between the concentration of the strength and antibacterial properties of the finished product. At 11.4 mg/ml of the extract, the inhibition properties of the product were 100%. The water-soluble derivative of extract (Extract-1) was lethal to bacteria at 10.4 mg/ml.

Finally the product antibacterial properties were also tested by the agar diffusion method following the procedure explained in Section 4.3.3.4. The results of the agar diffusion

method are shown in Table 7.4. Figure 7.4 shows the zones of inhibition exhibited by the darker circles and dots denote the growth of *Staphylococcus aureus*.

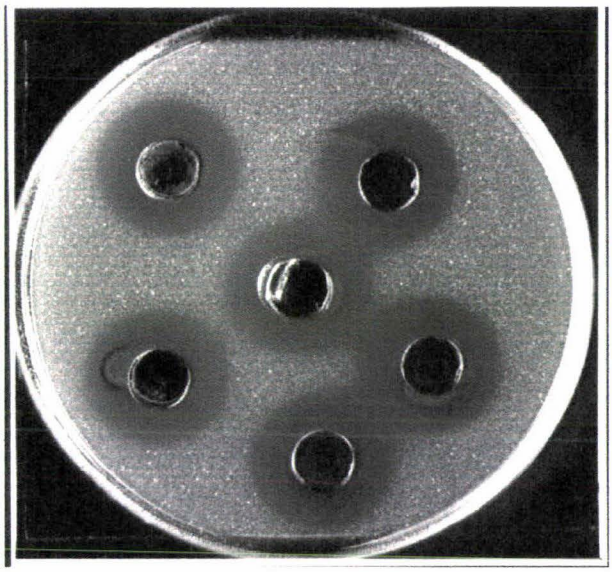


**Figure 7.4: The Antibacterial Properties of the Finished Product by Agar Diffusion Method**

## 7.5 Conclusions

The process details were communicated before hand to Cadbury's that made the equipment available for the commercial run. The compatibility of the formulation was ascertained before hand to the piece of equipment available. All these precautions helped in the successful execution of the trial.

The change in the process from open kettle evaporation to high temperature short time process has not adversely affected the acceptance of the jellybeans, as the starch used was

compatible with the continuous process as well as the batch process. Under both the conditions, the starch slurry has shown fully gelatinisation of the starch molecules and is in line with the recommendations of the ingredient suppliers and subsequent evaluation in the central location and home use test. The continuous process had better control over the process conditions as the equipment used was automatic and precise temperature controls through out the process were possible.

Similarly, the stoving temperature was increased from $40^0$ C to $50^0$ C. But increase in curing temperature did not alter the curing time and any adverse effect on the antibacterial properties. The curing room was not forced circulated unlike available at Massey University, higher curing temperature compensated for the lack of forced draft. Moisture testing under different conditions did not show any variation in the moisture content of the jellybean centers. Sosnowski (1983) made a bactericidal dry propolis powder by incubating the extract at $70^{\circ}$ C.

The most important aspect was the preservation of antibacterial properties of commercially produced jellybeans. The properties were intact as the product cooling temperatures were easily controlled to desired level through the controlling devices, and the ingredients having antibacterial properties were added at desired temperature of $95^0$ C. This reduced any adverse effect of the process on the antibacterial properties of product. As is indicated by the results, the change of the process did not make any adverse impact on the antibacterial properties of the finished product.

The ingredient cost for the developed product worked to be $ 5.68/kg. This compares quite well with retail price of jellybeans made by Cadbury's Pascall (without antibacterial properties) at $ 8.70/kg. This allows a margin for overheads, production cost, advertisement cost and profit margin. A current manufacturer of similar product will find it very easy to put these costs to evaluate the commercial viability of the developed product.

# Chapter 8

# Central Location Test of Commercially Produced Jellybeans

## 8.1 Aim of Central Location Test

The aim of the study was to measure product acceptability of the antibacterial jellybeans. The objectives of the study were to:

- Evaluate the product by the target consumers by itself - Uninformed score.
- Evaluate product performance to determine parity or improve response for the product over the market sample.
- Evaluate the effect of product information on the acceptability of product - Informed score.
- Determine the consumer belief in the antibacterial properties of the finished product.
- Ascertain the consumer purchase intention of the developed product.

## 8.2 Materials and Methods

### *8.2.1 Selection of Consumers*

Prior to recruiting consumers for the consumer panel, the target consumer was defined. This was based on the product usage. The subjects had to consume jellybeans more than once a month to be selected. The subjects were recruited from outside of the student cafeteria as well as library lounge of Massey University, Palmerston North, New Zealand. Once prescreening of 110 consumers was complete, 53 individuals were defined as target consumers and were invited to participate. The panelists were not paid for their participation, but they were given a chocolate bar as a gift at the end of the study.

### *8.2.2 Products*

Two samples of jellybeans, one the product developed with honey and propolis, and another without honey or propolis and therefore not having any antibacterial properties were considered for the study. The sample not having antibacterial properties is a variant of the standard product currently marketed by Cadburys Confectionery Limited and was used as a competitor product in this study. The samples given to the panelists are shown in Figure 8.1.

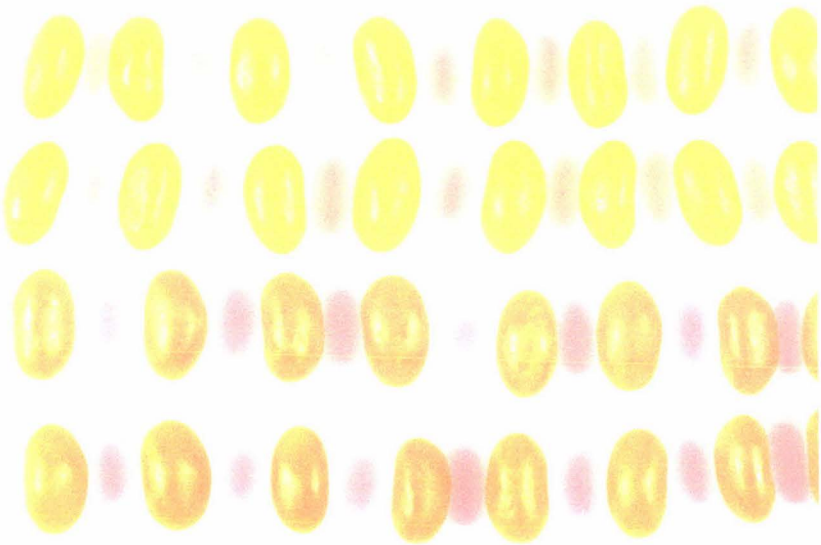


**Figure 8.1: Samples of Jellybeans Used in the Study**
**Top: Market Product;**
**Bottom: Product Developed with Honey and Propolis**

### *8.2.3 Consumer Testing*

The group consisted of 51 subjects, 23 women and 28 men. 12 of them ranged in the age of less than 20, 21 aged between 21 and 30, and 18 aged between 31 and 40 years (Table 8.1). All testing sessions were conducted in the library lounge of Massey University, Turitea

Campus. Each consumer had to attend two testing sessions to complete the full range of samples. The interval between two sets of samples was kept to at least an hour. Twelve testing sessions were required to collect the data from 51 panelists. In each testing session, 8-12 consumers completed the task.

**Table 8.1: Age and Gender Characteristics of the Panelists**

| Gender/Age group | Number of panelists | % of panelists |
|---|---|---|
| Male | 28 | 55 |
| Female | 23 | 45 |
| Under 20 years | 12 | 23.5 |
| 21-30 years | 21 | 41.2 |
| 31-40 years | 18 | 35.3 |
| 41-50 years | 0 | 0 |
| Above 50 years | 0 | 0 |

Prior to the test, all consumers were given the same information on the purpose of the study and other practical matters related to the taste session. The three jellybeans samples, were coded with 3-digit random numbers and served in a sequential monadic design balanced for order effect and carry over effect.

In the first session, they tasted the commercial sample and the nutraceutical jellybeans. The panelists were not informed (uninformed score) about the antibacterial properties of the samples. Samples presented to the panelists were randomized. Each participant was given samples at room temperature in the plastic cups and tap water was provided to rinse between the samples. Each taste evaluation session lasted for 15 minutes. In the first session panelists tasted the commercial sample and the nutraceutical jellybeans (uninformed score). In the second session, they were given details about the antibacterial properties of the product (informed score) prior to tasting and their views were recorded.

### *8.2.4 Questionnaire Design*

Ideas for statements and answer categories in the questionnaire were collected from the work of Crawford (1991) and Dolan (1993). Individual interviews and testing of the questionnaire was carried out with five of the prospective panelists. The questions were classified as primary criterion, comprehension, and diagnostic questions. The questionnaire contained a total of twelve pages to be completed in the two sessions. The questionnaire presented in the first session was divided into two parts. Each questionnaire consisted of overall liking questions, followed by liking of appearance, colour, sweetness, hardness, and overall flavour. The consumers marked their preferences on a 9-point hedonic scale, with "Dislike extremely" recorded as 1 and "Like extremely" recorded as 9. The questionnaire presented in the second session contained same questions about the nutraceutical product. Additionally, seven close-ended questions regarding usage of the non-confectionery products, throat products, buying intention and perception of the product in general were asked. Except for throat and health product usage all other questions were answered by a multiple choice, 5-point category scale. The throat and health product usage questions were presented as multiple-choice questions. The last page of the questionnaire recorded information on the claims about the product. The copy of the questionnaire used in the central location test is shown in Appendix 8.3 (page 270).

### *8.2.5 Data Processing and Analysis of Results*

Two incomplete questionnaires were discarded prior to data analysis leaving 51 questionnaires. Data was analyzed statistically using T-test and ANOVA two-way test, and carried on with a Tukey's honestly significant difference test. The data from the multiple-choice questions was then analyzed using a chi-square ($\chi^2$) test with Minitab 12. The responses from the open-ended questions were summarized and used for better explanation of the results. The summary of the results is shown in Appendix 8.4 (page 279).

## 8.3 Evaluation of Jellybeans by Consumers

The results of the consumer acceptability of antibacterial jellybeans having manuka honey and propolis, with no information about the presence of these ingredients in the product, are shown in Table 8.2. For the flavour acceptability, 82% of the respondents liked the overall flavour of the jellybeans. For the hardness acceptability, most of the panelists (84.3%) liked the hardness of the sample. For sweetness acceptability, 64.6% of the respondents liked the sweetness of the jellybean samples. On the other hand, 29.5% of the panelists disliked it moderately.

In overall acceptability, most of the respondents (90.2%) indicated that they liked the product sample. 4% of the respondents found that they 'neither liked or disliked' the sample. About 6% of the respondents disliked the jellybean sample.

**Table 8.2: The Consumer Acceptability of Nutraceutical Jellybeans (Uninformed Scores)**

| Like/Dislike Scale | Overall Liking % panelists | Appearance % panelists | Colour % panelists | Hardness % panelists | Flavour % panelists | Sweetness % panelists |
|---|---|---|---|---|---|---|
| Dislike extremely | 2 | 11.8 | 2 | 0 | 4 | 2 |
| Dislike moderately | 3.9 | 3.9 | 9.8 | 15.7 | 11.7 | 27.5 |
| Neither like nor dislike | 3.9 | 2 | 3.9 | 0 | 2 | 5.9 |
| Like moderately | 76.5 | 58.8 | 60.8 | 53 | 56.8 | 31.3 |
| Like extremely | 13.7 | 7.8 | 23.5 | 31.3 | 25.5 | 33.3 |

Table 8.3 shows the means for the each of the attributes considered. The table illustrates that the mean score for the developed product was within the range of 6 and 7, i.e. between the 'like slightly and like moderately'. The panelists who scored lower on the scale pointed out that they did not like the slightly bitter aftertaste of the product. On the other hand, the panelists who scored on the upper end of the scale liked the lasting flavour, and the texture

of the product. At the same time, they were not averse to the slightly medicinal taste of the product.

**Table 8.3: The Mean Acceptability of Jellybeans and Degree of Association of Attributes with Overall Liking**

| Acceptability | Mean | Covariance coefficients |
|---|---|---|
| Overall liking | 6.6 | - |
| Appearance | 6.2 | 0.4812 |
| Colour | 6.5 | -0.0055 |
| Hardness | 6.5 | 0.2655 |
| Overall Flavour | 6.1 | **1.6361**[1] |
| Sweetness | 6.1 | **1.2121**[1] |

Equation: Overall liking = A + B * (Attribute liking)
[1] Variables highly correlated with overall liking

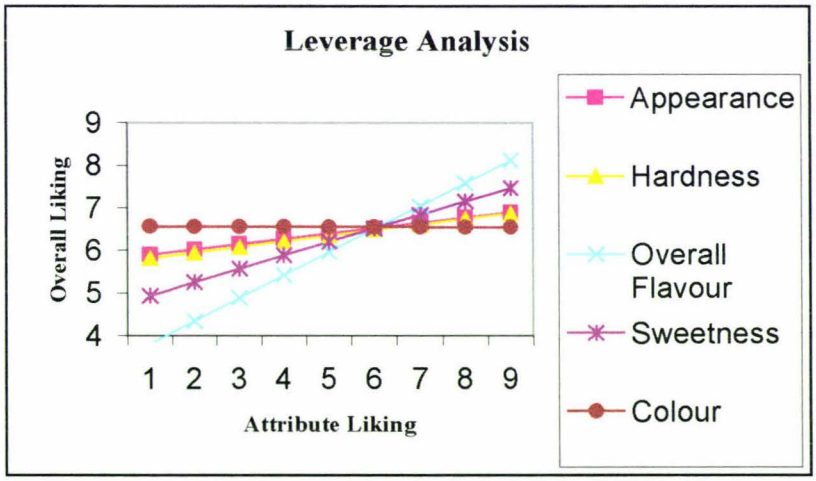



**Figure 8.2: Relationship between Change in Attribute Liking and Corresponding Change in Overall Liking of Jellybeans**
1=Dislike Extremely; 9=Like Extremely

Data from Figure 8.2 implies that the consumers have paid different amount of attention to sensory inputs when they judged the overall liking of jellybeans. The relationship between

attribute liking and overall liking is always a straight line. The higher the slope the more important is attribute in deriving the overall liking of the product. As can be seen, overall flavour and the sweetness of the sample drive the overall liking. The liking of overall flavour is the most critical of the attributes.

## 8.4 Comparison with Lemon Flavoured Jellybeans (Competitors Product)

The results of the consumer acceptability of jellybeans are shown in Table 8.4. In overall acceptability, most of the respondents (90.2%) indicated that they liked the product sample. 8% of the respondents found that they 'neither liked or disliked' the sample. About 2% of the respondents 'moderately disliked' the jellybean samples.

**Table 8.4: The Consumer Acceptability of the Commercial Jellybean**

| Like/Dislike Scale | Overall Liking% panelists | Appearance % panelists | Colour % panelists | Hardness % panelists | Flavour % panelists | Sweetness % panelists |
|---|---|---|---|---|---|---|
| Dislike extremely | 0 | 0 | 0 | 0 | 3.9 | 0 |
| Dislike moderately | 2.0 | 0 | 3.9 | 9.8 | 0.0 | 2.0 |
| Neither like nor dislike | 7.8 | 7.8 | 0.0 | 0.0 | 2.0 | 2.0 |
| Like moderately | 72.6 | 68.6 | 47.1 | 58.8 | 41.2 | 54.8 |
| Like extremely | 17.6 | 23.6 | 49.0 | 31.4 | 52.9 | 41.2 |

For the flavour acceptability, about 94% of the respondents liked the flavour of the jellybeans. About 4% of the respondents disliked the flavour of the jellybeans. For the hardness acceptability, most of the panelists (90.2%) liked the hardness of the sample compared to only 9.8% who disliked it moderately. For sweetness acceptability, 96% of the respondents liked the sweetness of the jellybean samples. On the other hand 2% of the panelists disliked it moderately. For appearance acceptability, 92.2% of the respondents liked the appearance of the jellybeans compared to about 8% 'neither like or dislike' the samples.

Table 8.5 shows the mean for the each of the attributes considered. The table illustrates that the mean score for the commercial product was within the range of 6 and 7, i.e. between the 'like slightly and like moderately'. The panelists who scored lower on the scale pointed out that, product was too sweet and sticky. On the other hand, the panelists who scored on the upper end of the scale liked the flavour, taste, and colour of the product. The bold values indicate importance of the attributes in driving the overall liking.

**Table 8.5: The Mean Acceptability of Commercial Jellybeans and Degree of Association of Attributes with Overall Liking**

| Acceptability | Mean | Slope | Covariance coefficients |
|---|---|---|---|
| Overall liking | 6.9 | - | - |
| Appearance | 6.9 | 0.091 | 0.0721 |
| Colour | 7.3 | **0.284**[2] | **0.3953**[1] |
| Hardness | 6.9 | 0.143 | 0.2541 |
| Overall Flavour | 7.4 | **0.197**[2] | **0.3792**[1] |
| Sweetness | 7.2 | **0.348**[2] | **0.5615**[1] |

Equation: Overall liking = A + B * (Attribute Liking)
[1] Attributes highly correlated with overall liking
[2] Attributes influencing overall liking

A covariance analysis of different attributes was carried out in relation to overall liking, and the coefficients of covariance matrix are shown in Table 8.5.

As can be seen from the results in Table 8.5, sweetness, colour, and lemon flavour of the sample drives the overall liking. The liking of sweetness was the most critical of the attributes. A small change in sweetness corresponded to a relatively larger change in overall liking. The overall liking of both the samples was compared and an average value with statistical analysis is shown in Table 8.6. By looking at the mean values of overall liking, the commercial product has a slightly better overall liking than new product but t-test showed that differences are not significant ($p>0.05$).

**Table 8.6: Comparison of Overall Liking of Nutraceutical and Lemon Flavoured Jellybeans**

| Samples of Jellybeans | Mean | St. Dev | T-value | P-value |
|---|---|---|---|---|
| Nutraceutical | 6.55 | 1.3 | -1.59 | 0.11 |
| Lemon Flavoured | 6.90 | 0.9 | | |

On the other hand, t-test of the attributes indicated (Table 8.7) that there were differences in liking of overall flavour, colour, appearance, and sweetness. But differences in individual attribute were not strong enough to rate lemon flavoured jellybeans as a better overall liked product.

**Table 8.7: The Comparison of Different Product Attributes**

| Acceptability | Nutraceutical (Mean) | Lemon Flavoured (Mean) | T-value | P-value |
|---|---|---|---|---|
| Appearance | 6.18 | 6.92 | -2.46 | 0.016 |
| Colour | 6.51 | 7.35 | -3.19 | 0.002 |
| Hardness | 6.50 | 6.94 | -1.65 | 0.100 |
| Overall Flavour | 6.08 | 7.39 | -4.21 | 0.001 |
| Sweetness | 6.08 | 7.2 | -3.48 | 0.008 |

The slightly dark colour of the product due to propolis and honey may have affected the liking of the new product. The commercial product had a colourless base and was ideal for colour coating in the soft panning process. An effort to reduce the colour of the propolis was made by extracting the antibacterial properties in an aqueous base rather than an ethanol base, so only further research in the extraction process can improve the colour and subsequent appearance of the products. The colour of the product can be improved by manufacturing only flavours, which need dark complementary colours such as blue and black coloured jellybeans flavoured with fruit and aniseed. Similarly, the addition of propolis imparts a typical medicinal to the product and improvement is not possible with

the available research. But an effort was made to mask this by flavouring the jellybean center with lemon flavour, resulting into longer lemon flavour release. This is unlike market sample, which is flavoured on the outer casing only and therefore, looses its flavour as soon as coating of the jellybean is consumed.

In the soft panning process, the engrossing of sugar on the jellybean's center in both the samples used for consumer testing was identical with 100% increase in weight. But the new product, because of the presence of propolis had a slightly bitter aftertaste, which could not be overcome by sugar coating.

While the new product is well accepted when tested on its own, there may need to be an improvement of sweetness and colour to compete well with other confectionery products. To further understand consumer acceptability, the informed score of the antibacterial product was also taken to detect any change in acceptability after disclosing the additional benefits of the product.

## 8.5 Effect of Product Information on the Acceptability of the Nutraceutical Product

In this study the consumers were informed about the type of product they were going to taste and scores obtained from this study are taken as 'informed scores' for each product attributes. The results of the consumer acceptability of jellybeans are shown in Table 8.8.

In overall acceptability, most of the respondents (98%) indicated that they liked the product sample. About 2% of the respondents 'moderately disliked' the jellybean samples. For the flavour acceptability, about 90% of the respondents liked the blended flavour of the jellybeans due the presence of flavouring ingredients like propolis, honey, and lemon flavour. About 4% of the respondents disliked the flavour of the jellybeans. For the

hardness acceptability, most of the panelists (84%) liked the hardness of the sample compared to only 2% who disliked it moderately.

**Table 8.8: The Consumer Acceptability of Jellybeans (Informed Scores)**

| Like/Dislike Scale | Overall Liking % panelists | Appear-ance % panelists | Colour % panelists | Hardness % panelists | Honey flavour % panelists | Lemon flavour % panelists | Sweet-Ness % panelists | Flavour blend % panelists |
|---|---|---|---|---|---|---|---|---|
| Dislike extremely | 0 | 0 | 0 | 0 | 0 | 0 | 5.9 | 3.9 |
| Dislike moderately | 2.0 | 5.9 | 0 | 2.0 | 2.0 | 3.9 | 5.9 | 5.9 |
| Neither like nor dislike | 0.0 | 2.0 | 0 | 13.7 | 23.5 | 9.9 | 3.9 | 0.0 |
| Like moderately | 68.6 | 66.7 | 60.8 | 54.9 | 49.0 | 33.3 | 62.7 | 74.5 |
| Like extremely | 29.4 | 25.5 | 39.2 | 29.4 | 25.5 | 52.9 | 21.6 | 15.7 |

For sweetness acceptability, 84% of the respondents liked the sweetness of the jellybean samples. On the other hand, 3.9% of the panelists disliked it moderately.

Table 8.9 shows the mean for the each of the attributes. The table illustrates that the mean score for the developed product was within the range of 6 and 7, i.e. between the 'like slightly and like moderately'. The panelists who scored lower on the scale pointed out that they did not like the after taste of honey and propolis, which was lingering on their tongue. On the other hand, the panelists who scored on the upper end of the scale liked the colour and honey flavour of the product very much, and were not concerned about the slightly medicinal taste of the product.

To understand the relationship between the change in attribute liking and corresponding change in overall liking a leverage analysis was performed. A covariance analysis of different attributes was carried out in relation to overall liking, and the coefficients of covariance matrix are shown in Table 8.9.

**Table 8.9: The Mean Acceptability of Nutraceutical Jellybeans (Informed Score) and Degree of Association of Attributes with Overall Liking**

| Acceptability | Mean | Slope | Covariance coefficients |
|---|---|---|---|
| Overall liking | 6.90 | - | - |
| Appearance | 6.8 | 0.217 | 0.3584 |
| Colour | 7.2 | **0.507**[2] | **0.5956**[1] |
| Hardness | 6.8 | 0.375 | 0.5403 |
| Honey flavour | 6.3 | **0.473**[2] | **0.6714**[1] |
| Lemon flavour | 7.3 | **0.346**[2] | **0.5655**[1] |
| Sweetness | 6.5 | 0.162 | 0.4749 |
| Blend of flavours | 6.5 | 0.169 | 0.3329 |

Equation: Overall liking = A + B * (Attribute liking)
[1] Attributes highly correlated with overall liking
[2] Attributes influencing overall liking

Colour, honey flavour, lemon flavour, and hardness of the sample drive the overall liking of the nutraceutical product. The liking of colour and honey flavour are the most important attributes. A small change in colour and honey flavour corresponds to a relatively large change in overall liking.

## 8.6 Comparison of Informed and Uninformed Score of New Product with Commercial Product

From Table 8.10, where all the products are compared, it seems that consumer has traded off few of the less important attributes with the functional properties of the jellybeans. The overall liking of the product has improved and has become comparable with the market sample, as the mean score for both of the products was found to be not significantly different. The attributes, which they have traded off, are colour and appearance of the product. These tradeoffs were enough for the consumer to give high ratings to the nutraceutical product. This implies that the product is good enough to withstand the competition, provided claims are sufficiently substantiated.

## Table 8.10: Comparison of Attributes Score of Informed and Uninformed New Product with Commercial Product

| Acceptability | Nutraceutical[1] Uninformed (Mean) | Lemon[1] Flavoured (Mean) | Nutraceutical[1] Informed (Mean) | F-value | P-value |
|---|---|---|---|---|---|
| Overall Liking | $6.55^{a}$ | $6.90^{a}$ | $6.90^{a}$ | 2.00 | 0.14 |
| Appearance | $6.18^{a}$ | $6.92^{b}$ | $6.78^{ab}$ | 4.85 | 0.01 |
| Colour | $6.5^{a}$ | $7.35^{b}$ | $7.16^{b}$ | 6.86 | 0.002 |
| Hardness | $6.49^{a}$ | $6.94^{a}$ | $6.80^{a}$ | 1.56 | 0.216 |
| Overall Flavour | $6.08^{a}$ | $7.39^{b}$ | $6.53^{a}$ | 10.56 | 0.001 |
| Sweetness | $6.08^{a}$ | $7.2^{b}$ | $6.55^{a}$ | 8.12 | 0.001 |

[1] Means in a row with the same letter are not significantly different ($p<0.05$)
[2] All scores input on a 9-point hedonic scale where 1 = dislike extremely, 9 = like extremely

There was a significant difference between the nutraceutical and the lemon-flavoured product for attributes namely, sweetness and flavour. Lemon-flavoured product does not contain any one of the specialty ingredients like honey and propolis. These ingredients intervene with the sweetness and lemon flavour, and leave a slightly medicinal feeling on the tongue, thereby reducing the liking of nutraceutical product.

Mean values of overall liking indicate that, the informed score of the product is marginally better than uninformed score but analysis of variance showed that differences were not significant ($p>0.05$). This is further supported (Figure 8.3 A) by the diagonal line, which is marked as an equal liking line, and is heavily crowded by the panelists who have little difference in liking.

The only attribute, which was found to be statistically different in liking ($p<0.05$), was colour (Figure 8.3 B). After knowing about the antibacterial properties of the product the consumers were ready to trade the attribute colour in assurance of getting the extra benefits as given to them in the claim statement.

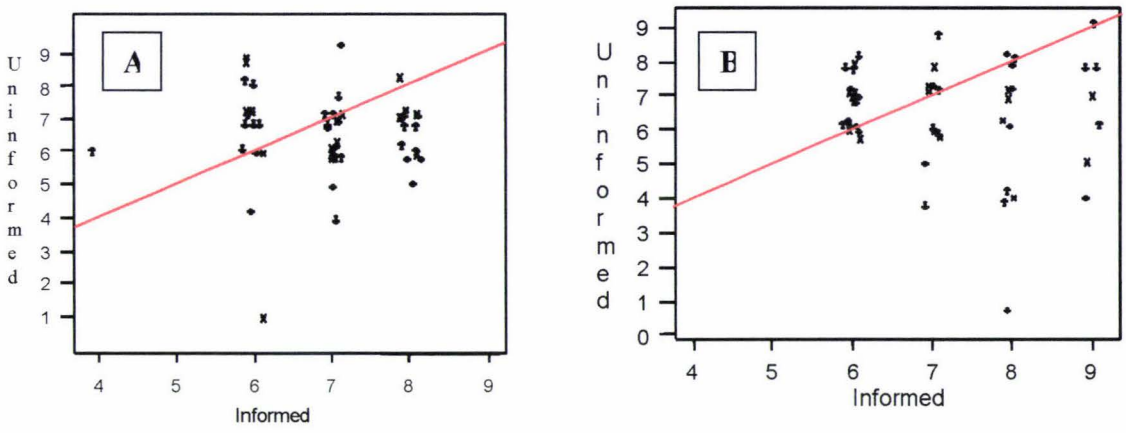



**Figure 8.3: Comparison of Uninformed score (developed product) with Informed Score (developed product). (A) Overall liking; (B) Colour**

After disclosing the identity of the product, the overall liking and liking of most of the attributes improved, which is indicated by the identical scores for overall liking.

The slight bitter taste of the product due to the presence of propolis was commented on unfavorably by the consumers. Further improvements are needed to give high ratings to overall flavour and sweetness. The improvements in these two attributes will certainly help in getting better consumer overall liking and edge over the competitor.

## 8.7 Perception of the Product

The majority of the respondents (45%) saw the manuka honey jellybean, as a confectionery product having additional benefits like antibacterial properties, while about 41% of the respondents decided it was a confectionery product. In comparison to previous work done by Sofat (1998), the order of the preference is same but in that study a larger majority

(73%) of people believed the product to be 'a confectionery product with additional benefits'. The perception of the jellybeans by various panelists is shown in Table 8.11.

**Table 8.11: Perceived Effectiveness of Jellybeans**

| Product type | Number of panelists | % of panelists |
|---|---|---|
| Medical product | 0 | 0 |
| Preventive product taken in danger period | 6 | 11.8 |
| Preventive product taken around the year | 1 | 2.0 |
| Confectionery with benefits | 23 | 45.1 |
| Confectionery product | 21 | 41.2 |

## 8.8 Usage of Throat Products

When the respondents were asked to indicate their consumption of similar products which consumers were familiar with, most of the panelists (76%) identified the throat lozenges as their most consumed commercial product. Only 27% of the respondents have used the honey and propolis lozenges before. 16% of the respondents used the propolis spray before. This showed that around 25% of the people in the study had used propolis-based products for throat complaints and around 75% used lozenge products. None of the respondents had used propolis oral fresh. The relative category usage of throat products is shown in Table 8.12.

**Table 8.12: The Usage of Throat Products by the Panelists**

| Product type | % of panelists [1] |
|---|---|
| Honey and propolis lozenges | 27.4 |
| Propolis tincture | 7.8 |
| Propolis oral fresh | 0 |
| Propolis-throat spray | 15.7 |
| Pollen and honey spread | 3.9 |
| Throat lozenges | 76.5 |

[1] Panelists could tick as many products as they liked.

## 8.9 Usage of Health Products

Table 8.13 shows the reasons for using the health products. The results indicated that the most important attribute to 63% of consumers was to keep the immune system healthy thereby helping to prevent and treat illness and disease.

**Table 8.13: Usage of Health Products**

| Health attributes | % of panelists [1] |
|---|---|
| Source of nutrition | 43.1 |
| Source of instant energy | 23.5 |
| Healthy at different life cycles | 23.5 |
| Immune system healthy | 62.8 |
| Life extension (others) | 11.8 |

[1] Panelists could tick as many products as they liked.

The retention of nutrition seems to be on back of the consumer's mind. 43% of the consumers thought that the other important reason for the consumption of health foods were the basic nutritive value they impart. On the other hand, 23% of the consumers wanted instant energy and the concept of self-health maintenance at different life cycles. Living longer and better was on the mind of about 12% respondents. These were the main reasons, which significantly influenced the consumption of health foods.

## 8.10 Buying Intention of the New Product

About 61% of the respondents indicated that they would buy the new product, if available in the market ($p<0.0001$). About 28% of the respondents 'might or might not buy' the product and only 4% of the respondents would probably not buy the product if it were available in the market. Table 8.14 shows the consumer intention for buying the new product.

**Table 8.14: Buying Intention of the Nutraceutical Product**

| Buying intention | Number of panelists | % of panelists |
|---|---|---|
| Definitely buy | 4 | 7.8 |
| Probably buy | 31 | 60.8 |
| Might or might not buy | 14 | 27.4 |
| Probably not buy | 2 | 3.9 |
| Definitely not buy | 0 | 0 |

$\chi^2 = 64.39$; df = 4; p = 0.0001

The consumer acceptance of the nutraceutical product is at par with the commercial sample as the mean liking score for both of the products is identical. 60% of consumers would probably buy the product and, only 4% of the respondent thought of not buying the product, this shows that the consumer response was positive and it could indicate a potential success for the new product, provided perceived claims are met and the product can be successfully manufactured.

A correlation analysis of buying intention and overall liking of the product was carried out, which showed that these two attributes are not highly correlated. It seems that a relatively high acceptance score is not enough alone to convert acceptance into buying intention.

However, at this stage it may be difficult to forecast the market potential of the product because of the small sample size and consumer inability to verify the claims. To assess the market potential of this product a larger sample size and long term consumption plan will help to get the true consumer opinion.

## 8.11. Believability of Claims

Table 8.15 shows that the consumers' attitude towards the claims after eating the nutraceutical product.

**Table 8.15: Believability of Claims**

| Product Claims | Respondents | % Respondents |
|---|---|---|
| Definitely believable | 9 | 17.7 |
| Probably believable | 29 | 58.9 |
| Might/might not | 11 | 21.6 |
| Probably not believable | 2 | 3.9 |
| Definitely not believable | 0 | 0.0 |

$\chi^2 = 51.65$; df = 4; p = 0.0001

Consumers were asked to answer this question after carefully reading the claims statement and tasting the samples given to them. 18% of the respondents definitely believed the claims about the antibacterial properties of the product. 59% probably would believe the claims ($p<0.0001$). While 22% of the respondents 'might or might not' believe the claims.

The statistical analysis showed that there was positive correlation ($R^2 = 0.731$) between buying intention and believability of the claims. This showed that product claims are an important factor for consumers to indicate their intention of buying the new product. Any change in attitude towards the functionality of the product would affect the buying intention among the respondents. This showed that, for these consumers, functional properties of the product were far more important in determining the buying intention towards the nutraceutical product than the overall liking.

In other words, the overall liking of the product was fairly optimized as the mean product informed score is identical to the market leader in the similar product range, so it need not to be further improved to better the buying intention.

Most of the panelists (59%) 'probably' would believe the claims while, only 18% 'definitely' believed it. There still exist a possibility to educate the panelists who have not made up their mind (23%) to believe the claims. The long-term usage of the product will help them in making up their mind and they may come out with more precise answer.

## 8.12 Conclusion

The consumer testing of the product has indicated that the idea of developing nutraceutical product that consisted of the addition of propolis and manuka honey as antibacterial agents was highly acceptable among the panelists. The panelists accepted the idea of these two ingredients in the confectionery product as they felt it could increase the product's nutritional value, particularly by keeping the immune system healthy thereby helping to prevent and treat ailments. Moreover, this concept affected their purchase intention; as the believability of a new product having antibacterial properties was highly correlated with the buying intention.

Since this product is regarded as a confectionery product with additional benefits, the product has to satisfy the consumer who is looking at only sensory properties as well as the consumers who is looking for additional benefits like nutraceutical properties. Although, the developed confectionery has similar preference to the commercial sample of the market leader, attributes like sweetness can be further improved. The new product could be positioned as a substitute to the jellybeans, which they are already consuming and could be a serious contender for the market currently dominated by lozenges and other throat products, which have a medicinal image.

The developed product has an overall liking comparable to the lemon-flavoured jellybeans available in the market. But in order to improve its potential success rate, the acceptability of the developed product could be improved further by slightly improving the flavour of the core and toning down the bitterness of the product. The product has acquired a typical aftertaste due to the flavonoids in the propolis. A better balance between sweet and bitter taste may be tried for the core of the product to help overcome this problem. The overall sweetness of the product can still be reduced by reducing thickness of the outer shell formed with the help of different grades of sugar in the soft panning process. Therefore, it

could be considered worthwhile producing the product on a commercial scale, once the desired improvements were made and successfully tested with consumers.

The overall liking of the developed product indicated that the 'informed score' of the product was marginally better than 'uninformed score'. But analysis of variance indicated that difference is not significant. The lack of significant change in score indicated that the product could easily stand out as a confectionery without any functional claims. In other words the sensory attributes of the product has been reasonably fine tuned to meet the consumer requirements.

The developed product was different from the jellybeans available in the market in terms of its nutritional image, main ingredients, and consistent flavour release in the product. The product presently available in the market is flavoured on the outer casing only, which gives first sharp flavour and then looses it as soon as coating of the jellybeans is consumed. But this new product has flavour in the core as well, due to the presence of honey propolis and lemon flavour. A home use test of the product will now be conducted in order to reassess the believability of the new product, which has the single largest affect on the buying intention and hence future market share of this product.

# Chapter 9

# Home Use Test

The consumers tested commercially produced nutraceutical jellybean samples to measure product liking. The consumer's liking can be measured in a central location test (CLT) and home use test (HUT). The results from the central location test indicated that there was strong correlation between the buying intention and believability of the antibacterial properties of new product. But about 25% of the respondents were not sure about belief in the functionality of the product and because they had to base their attitude on information provided by the author and they did not have any other source to confirm or deny this information. So a home use test was performed to overcome the drawbacks of central location test and to measure the long-term responsiveness to a product.

## 9.1 Aim of Home Use Test

The aim of the study was to measure product acceptability of the antibacterial jellybeans. The objectives of the study were to:

- Evaluate the product by the target consumers after extended use.
- Evaluate the effect of repeated consumption on liking ratings.
- Determine the consumer belief in the antibacterial properties of the finished product after repeated consumption.
- Determine the consumer purchase intention of the developed product after extended usage.

## 9.2 Materials and Methods

### *9.2.1 Selection of Consumers*

Prior to recruiting consumers for the consumer panel, the target consumer was defined. This was according to the product usage, and subjects had to consume jellybeans more

than once a month to be selected. Two groups of consumers were recruited, one from a small town and other from a metropolitan city. The consumers from the small town tended to have lower than University education, and other group had higher University degrees and was employed with Massey University. Outs of the prescreened consumers, about 65 were defined as target consumers and were invited to participate. With passage of time 17 panelists dropped out of the study and finally 48 panelists completed the 5 questionnaire required. The panelists were compensated for their participation by shopping vouchers or a $ 20 donation to an organisation of their choice.

### *9.2.2 Products*

Jellybean samples produced commercially in Cadbury's Confectionery Limited, were used in this study. The samples were from the same production batch that was used for the CLT. The samples are lemon flavoured containing honey and propolis.

### *9.2.3 Consumer Testing*

The final group comprised 48 subjects: women and men. They ranged in the age from less than 20 to more than 50 years; with 12 aged between 31 and 40, and 20 aged more than 50 years (Table 9.1).

**Table 9.1: The Panel Demographics**

| Gender/Age Group | Number of panellists | % of panellists |
|---|---|---|
| Male | 22 | 45.8 |
| Female | 26 | 54.2 |
| Under 20 years | 4 | 8.3 |
| 21-30 years | 3 | 6.2 |
| 31-40 years | 12 | 25.0 |
| 41-50 years | 9 | 18.8 |
| Above 50 years | 20 | 41.7 |

The consumers received the questionnaire and jellybeans packet at home but after the 1st packet they were required to go down to a central location to procure the product to simulate the actual usage conditions. During the study, about 23% of the subjects stopped returning the questionnaires (the number of subjects dropped from 65 to 50). Two of the subjects did not answer correctly to the questionnaire and these questionnaires were removed. About 15% of the respondents dropped after first two weeks of study and rest of the subjects dropped gradually during rest of the study. This percentage was not very high considering the long duration of the study.

Prior to testing, all consumers were given the same information on the purpose of the study. The jellybean packages were labeled with ingredient information. The product samples delivered to the panelists are shown in Figure 9.1.

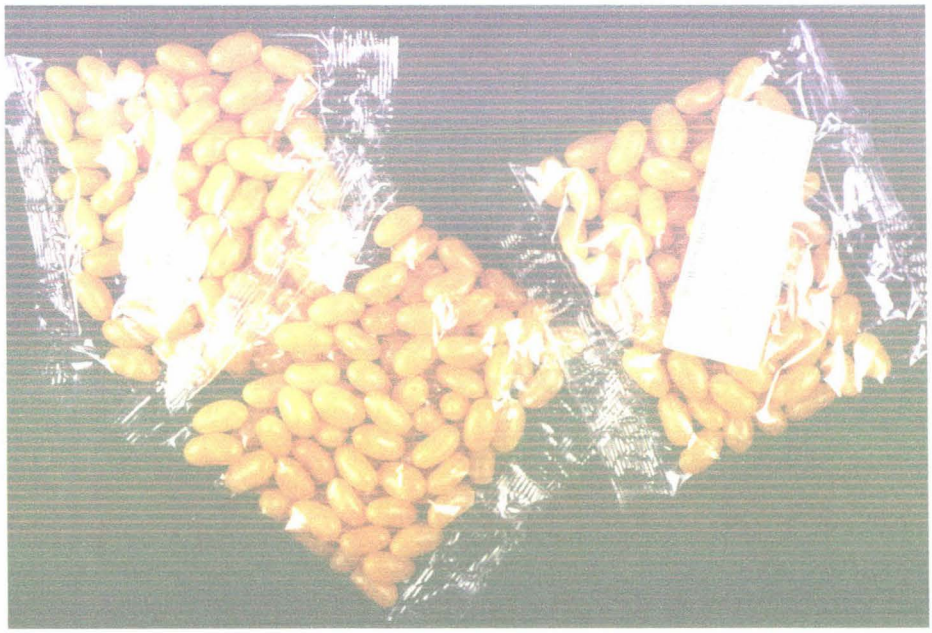


**Figure 9.1: Samples Delivered to the Panelists**

The measurements were made during the first product delivery and responses were gathered as week-0. Afterwards, for eight weeks, the subjects rated liking every two weeks after consuming the product for this period. The flow diagram showing the experimental process is shown in Figure 9.2. The subjects were not constrained to use any specific quantity; they were at liberty to eat as much as they wanted. The product package weight was equal to 200 grams and they had to finish the product before they could go and procure from the central location. The consumers marked their preferences on a 9-point hedonic scale, with "Dislike extremely" recorded as 1 and "Like extremely" recorded as 9. The consumers recorded of their opinion of overall liking, texture, flavor, sweetness, and combined flavor.

### *9.2.4 Questionnaire Design*

The questions used in the survey can be classified as primary criterion, comprehension, and diagnostic questions. During the study period of 8 weeks, the panelists were asked to complete 5 questionnaires. The first questionnaire contained a total of nine pages to be completed in the two sessions, in the first session the panelists were told not to eat the product. Part-1 recorded the believability and effectiveness of the product, based on the information contained in the concept statement. After completing Part-I of the questionnaire they were told to eat the product. Part-2 recorded the overall liking of the product and Part-3 recorded about the important characteristics of the product. Part-4 recorded the sales appeal and Part-5 recorded the personal details of the panelists.

The rest of the questionnaire consisted of the nine close-ended questions regarding perception of the product in general, preference of the new product over the competitors, complaints to be cured, and usage of the honey and propolis based products. Except for complaints to be cured, throat and health product usage all other questions was answered by a multiple choice, 5-point category scale. For these two questions they had multiple choices.

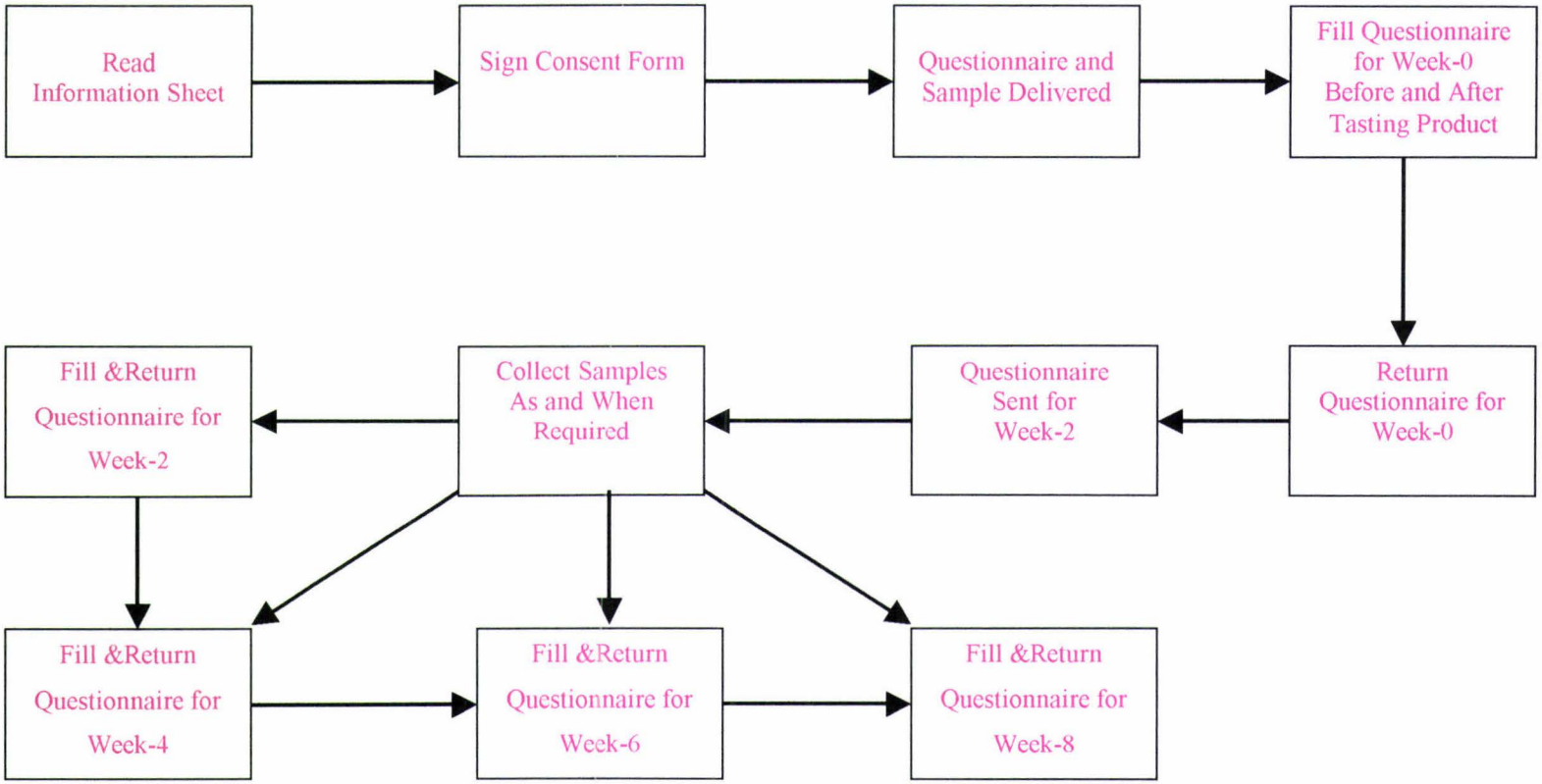



**Figure 9.2: Flow Diagram Showing the Experimental Process**

In the second questionnaire similar information was recorded, along with the consumption pattern of the jellybeans, buying intention, and ability of the jellybeans to cure the ailments. In the third questionnaire overall liking of the new product, consumption pattern, and effectiveness of the jellybeans were recorded. Identical questions were asked in the fourth questionnaire. Fifth questionnaire was filled at the end of the 8 weeks study. Part 1 recorded the overall liking of the product and Part 2 recorded about the important characteristics of the product. The rest of the questionnaire consisted of the nine close-ended questions regarding perception of the product in general, preference of the new product over the competitors, complaints to be cured, and consumption pattern. Except for complaints to be cured, all other questions were answered by a multiple choice, 5-point category scale. For this question they had a multiple choice. The copy of the questionnaires used in the home use test is shown in Appendix 9.4 (page 294).

### *9.2.5 Data Processing and Analysis of Results*

The data from the multiple-choice questions was analysed using a Chi-square ($\chi^2$) test on Minitab. The panelists' answers for the open-ended questions were summarised and used for better explanation of the results. The summary of the results is shown in Appendix 9.5 (page 315). The samples were tested using a 9-point hedonic scale and data obtained was analysed statistically using an ANOVA two-way test, and carried on with a Tukey's honestly significant difference test. The summary of the results is shown in Appendix 9.5 (page 315).

## 9.3 Consumer Acceptability of the Jellybeans

A 9-point hedonic acceptability scale was used to evaluate product's overall liking, colour, appearance, hardness, flavour, and sweetness. Table 9.2 shows the change in liking ratings of different attributes at different intervals.

The initial result from the Week-0, gave the immediate reaction of the consumer after eating the product. Some changes in liking over exposure could be observed for product attributes. But, only few differences were observed among the different attributes, and none of the attributes was significantly different over time ($p>0.05$).

**Table 9.2: Change of Liking Ratings for the Attributes over the Period**

| Exposure | Overall Liking | Appearance | Colour | Hardness | Overall Flavour | Sweetness |
|---|---|---|---|---|---|---|
| Week-0 | 7.6 | 7.0 | 6.7 | 7.2 | 7.9 | 7.1 |
| Week-2 | 7.5 | 7.1 | 6.9 | 7.5 | 7.7 | 6.8 |
| Week-8 | 7.4 | 7.1 | 6.9 | 7.3 | 7.7 | 6.7 |
| **Average** | **7.5** | **7.1** | **6.8** | **7.3** | **7.8** | **6.9** |

The slight decrease in ratings from first exposure to later exposures could be related to an overestimation of the first sample (Peryam & Pilgrim, 1957). It was apparent that the overall opinion results obtained in the immediate use test at Week-0 were replicated over four fortnightly sessions. Although, there was some variation over time for such product attributes as hardness, and sweetness, this variation did not impact overall product performance. Therefore in this test, the superior performance of the product with respect to appearance, flavour, and sweetness in Week-0 test was a valid indicator of the further product performance over the next four fortnights. There was no evidence from the results of this test that the initial high score for product declined over repeated exposure.

After consuming the product regularly and in large quantities for two months the consumers commented it too sugary, but this drop in liking for sweetness was not significant. Reduction in sweetness may improve success rate of the product in the market. But at the same time, they did not object to the typical aftertaste due to the presence of flavonoids, acquired from the propolis. It may be inferred that consumers had become accustomed to the flavour, thereby, not objecting to the aftertaste, unlike in CLT.

The overall liking curve for all the five product sessions were visually inspected, and four types of pattern were observed. Table 9.3 shows about 60% of the panelists with no change or fluctuation in the liking ratings. For all the sessions they consistently tested the product and graded the product with identical values. About 17 % of panelists fluctuated in their responses over the study period. No trend was evident about the liking from these panelists. But generally fluctuation in liking was higher before the fourth week. Similarly, the decreasing trend of liking had stopped after the fourth week and the panellists had given consistent ratings afterwards. It was again true in the case of increasing liking also, though the percentage of people falling into this category is quite small.

**Table 9.3: Change in Liking During the Home Use Study**

| Attribute | No Change in Liking (%) | Decreasing Liking (%) | Increasing Liking (%) | Fluctuation of Liking (%) |
|---|---|---|---|---|
| Overall liking | 60.4 | 18.8 | 4.2 | 16.7 |

This test was a closer representative of the real life situation. The consumption of product at any time did not reduce the acceptance of product, as the panelists were free to choose the quantity and the time of consumption. This also confirmed that the product's delivery of sensory performance was consistent over the study period.

## 9.4 Comparison of Product Acceptability of Central Location Test with Home Use Test

In this study the average score of the consumers for Home Use Test (HUT) was compared with the score for central location test (CLT). As shown in Figure 9.3, when the average ratings of HUT were compared with the CLT, it was found that overall liking rating were significantly different ($p<0.05$) between the two sets of data. ANOVA of the different attributes indicated that the panelists has significantly more liking ($p<0.05$) for the

attributes of hardness and flavour, which resulted in higher overall rating of the sample in HUT. The score in the immediate use test (Week-0), were also high (score 7.6) for overall acceptability of the product for the consumer participating in HUT. The results merely indicate that the consumers recruited for HUT found this product (average score 7.5) more acceptable than those recruited for the CLT (average score 6.9).

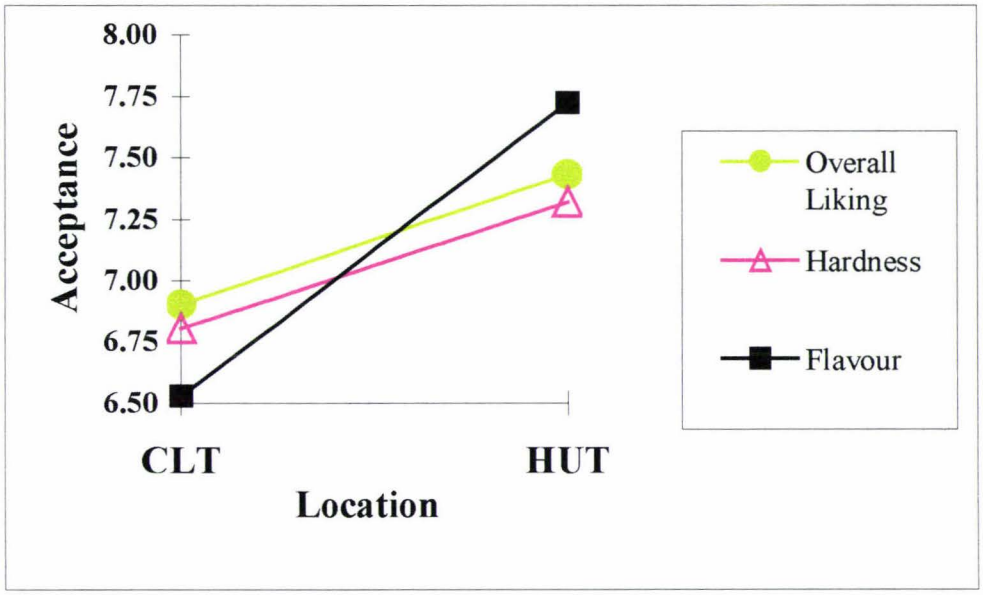



**Figure 9.3: Comparison of Product Characteristics between Two Methods**

Furthermore, majority of the consumers (60%) recruited for HUT were aged above 40 years, while in CLT none of the panelists was aged above 40 years. It seems that this group liked the developed product very much.

As shown in Figure 9.3, the consumer had liked the product more during HUT. They liked the overall flavour of the product and at the same time did not complain about any aftertaste or medicinal taste of the product, which had considerable effect on the product acceptance in CLT. The higher rating of the product was also helped by the hardness of the

sample, which panelists found to be appropriately optimized. The hardness of the product in CLT obtained a relatively low score, when panellists consumed a sample of 1 or two pieces during testing. But this is in agreement with research carried out with sweetened yoghurt (Lucas and Bellisle, 1988) where lower acceptability score were obtained following the evaluation of small samples than following consumption of large portions. These results are also in agreement with Shepherd *et al.* (1991) who found that panelists showed a preference for higher salt level in smaller samples than following consumption of large amount. The believability of the product also remained fairly similar between CLT and HUT.

## 9.5 Perception of the Product

At the start of the study the consumers were given a written product concept and asked to decide a product type then asked the same question after eating the product. The concept of new product was seen as a confectionery product that had additional benefits like antibacterial properties by 75% of the respondents, no significant change in the view was observed when the physical product was given to the panelists. The perception of the jellybeans by various panelists is shown in Table 9.4.

**Table 9.4: Perception of Concept and of Product at Week-0**

| Product type | Concept | | Product | |
|---|---|---|---|---|
| | Number of Panelists | % of panelists | Number of panelists | % of panelists |
| Medical product | 0 | 0 | 0 | 0 |
| Preventive product | 3 | 6.2 | 2 | 4.2 |
| Preventive all time | 6 | 12.1 | 7 | 14.6 |
| Confectionery with benefits | 36 | 75.0 | 36 | 75.0 |
| Confectionery product | 3 | 6.2 | 3 | 6.3 |

DF=3; p=0.964; $\chi^2$= 0.277

About 6% of the respondents rated the jellybeans as a purely confectionery product, while 94% of the respondents were able to rate it as a product associated with medicinal value. The results showed that the product concept was developed into a final product during the

product development process because the main aim of the project was to make a confectionery product having additional antibacterial properties.

The analysis of the results indicated that there was not a significant shift in opinion of the panelists between concept description and the finished product.

## 9.6 Buying Intention of the New Product

After two weeks of consumption of the new product, about 69% of the respondents indicated that they would buy the new product if available, in the market ($p<0.0001$). About 21% of the respondents 'might or might not buy' the product and 8% of the respondents 'probably not buy' the product if it was available in the market. Table 9.5 shows the consumer intention for buying the new product at different time intervals.

**Table 9.5: Change in Buying Intention of the Consumer with Time**

| Buying intention | Week-2 Number of Panelists (%) | Week-8 Number of Panelists (%) | CLT Number of Panelists (%) |
|---|---|---|---|
| Definitely buy | 15 (31.3) | 14 (29.2) | 4 (7.8) |
| Probably buy | 18 (37.5) | 17 (35.4) | 31 (60.8) |
| Might or might not buy | 10 (20.8) | 11 (22.9) | 11 (27.5) |
| Probably not buy | 4 (8.3) | 4 (8.3) | 2 (3.9) |
| Definitely not buy | 1 (2.1) | 2 (4.2) | 0 (0.0) |

$\chi^2 = 0.444$; df = 4; p = 0.979; $\chi_{CLT}^2 = 12.59$; df = 4; p = 0.003

When the consumers were asked the same question after completion of the study, about 65% of the respondents indicated that they would buy the new product, if available in the market. About 23% of the respondents 'might or might not buy' the product and 8% of the respondents 'probably not buy' the product if it was available in the market.

The buying intention results were not found to be statistically different. But when results were compared with CLT, the differences in buying intention were significant ($p=0.003$). About 30% of consumers in HUT opted definitely to buy the product as against only 8% in CLT. The consumer panel in CLT largely comprised of students with no panelists over 40

years of age. Conversely, in HUT the panel was largely comprised of a non-student population aged over 20 years. In addition, 85.5% of HUT population was over 30 and predominated by females. At the same time consumers in HUT have more acceptance than CLT. It seems that after consuming the product for quite some time a higher percentage of consumers opted for definitely buying the product. But this is in agreement with research carried out with nutraceutical products (Wrick, 1994; Childs 1997; Childs and Poryzees, 1998) where females and respondents aged 35 to 64 displayed a higher level of belief than those in the lower age groups.

A correlation analysis of buying intention and overall liking of the product was carried out, which showed that these two attributes are not highly correlated. It seems that high acceptance score is not enough alone to convert acceptance into buying intention.

The statistical analysis showed that the buying intention of consumer was predominantly affected by the believability of claims, replacement of existing jellybeans with new product, and extra price paid over the normal jellybeans available in the market. The variables affecting the consumer buying intention are shown below ($p<0.09$):

| Buying intention = 0.502 + 0.501 belief in claims + 0.361 replacement - 0.161 extra price over market price. |
|---|

The statistical analysis showed that there was positive correlation between buying intention and believability of the claims ($r = 0.76$), replacement of existing jellybeans ($r = 0.66$) and negative correlation ($r = -0.37$) with extra price over existing jellybeans. This showed that product claims as shown to consumers are the single most important factor for consumers to indicate their intention of buying the new product.

No correlation was obtained between the sensory properties and the buying intention of the product ($p = 0.135$). This showed that, for these consumers, functional properties of the

product were far important in determining the buying intention towards the nutraceutical product than the sensory attributes. In other words, the sensory attributes of the product were fairly optimized, as the mean product score is between 'like moderately' and 'like very much'.

## 9.7 Frequency of Buying

The frequency of buying pattern of the new product among the panelists is shown in Table 9.6.

**Table 9.6: Frequency of Buying Pattern of New Product**

| Buying Frequency | Number Of Panelists | % panelists |
|---|---|---|
| More than once a week | 0 | 0 |
| Once a week | 4 | 8.3 |
| Once fortnight | 7 | 14.6 |
| Once month | 14 | 29.2 |
| Less than once month | 23 | 47.9 |

52% of the consumers would buy the product more than or at least once a month. About 48% of the consumers would buy the new product less than once a month. This shows that the consumer response was positive and it could indicate a potential success of the new product.

## 9.8 Preference of the Product over Jellybeans Available in the Market

Table 9.7 shows the consumer preference over the existing product at different time intervals.

After immediate consumption of the new product about 27 % of the respondents indicated that they would 'definitely prefer' the new product to the existing jellybeans and about 38%

'probably prefer' the product if it available in the market. About 27% of the respondents 'might or might not prefer' this product to the existing product and 8% of the respondents would 'probably not prefer' the product if it was available in the market.

**Table 9.7: Change in Preference over Existing Jellybeans with Time**

| Preference Intention | Week-0 Number of Panelists (%) | Week-2 Number of Panelists (%) | Week-8 Number of Panelists (%) |
|---|---|---|---|
| Definitely prefer | **13 (27.1)** | 15 (31.2) | **21 (43.8)** |
| Probably prefer | **18 (37.5)** | 20 (41.7) | **10 (20.8)** |
| Might or might not prefer | **13 (27.1)** | 7 (14.6) | **9 (18.8)** |
| Probably not | **4 (8.3)** | 5 (10.4) | **5 (10.4)** |
| Definitely not | **0 (0)** | 1 (2.1) | **3 (6.2)** |

$\chi^2 = 8.00$; df = 4; p = 0.091

When consumers were asked about their preference after two weeks of consumption, about 31% of the respondents indicated that they would 'definitely prefer' the new product to the existing jellybeans and about 42% 'probably prefer' the product if it available in the market. About 15% of the respondents 'might or might not prefer' the product if it was available in the market.

The results were not found to be statistically different. But when results of immediate use test (Week-0) were compared with Week-8, the differences in preference were significant (p=0.003). About 44% of consumers in Week-8 opted 'definitely to prefer' the product as against only 27% in Week-0. It seems that after consuming the product for quite some time a higher percentage of consumers opted 'definitely preferred' the product as their taste buds became accustomed to the flavour of propolis and honey which are fairly uncommon flavour for most of the consumers.

## 9.9 Replacement of the Current Jellybeans with the New Product

Table 9.8 shows the consumer replacement of the existing product at different time intervals.

After immediate consumption of the new product about 60% of the respondents indicated that they would replace the existing jellybeans with the new product if it was available in the market. About 23% of the respondents 'might or might not replace' to the existing product and 17% of the respondents 'probably not replace' the product if it was available in the market.

**Table 9.8: Replacement of the Current Jellybeans with New Product**

| Replacement Intention | Week-0 Number of Panelists (%) | Week-2 Number of Panelists (%) | Week-8 Number of Panelists (%) |
|---|---|---|---|
| Definitely replace | 16 (33.3) | 14 (29.2) | 16 (33.3) |
| Probably replace | 13 (27.1) | 16 (33.3) | 14 (29.2) |
| Might or might not replace | 11 (22.9) | 9 (18.8) | 10 (20.8) |
| Probably not | 8 (16.7) | 5 (10.4) | 5 (10.4) |
| Definitely not | 0 (0) | 4 (8.3) | 3 (6.2) |

$\chi^2 = 5.41$; df = 4; p = 0.713

When consumers were asked the same question after two weeks of consumption, about 29% of the respondents indicated that they would 'definitely replace' the new product to the existing jellybeans and about 33% 'probably replace' the product if it was available in the market. Similar results were obtained after eight weeks of study.

The results from this study were not found to be statistically different. The results of this research show that immediate-use opinion regarding replacement of the current product with new product under HUT condition are valid predictors of the extended-use responses. About 8% of the respondents thought that it may replace the throat lozenges, while 12.5% of the respondents thought it may replace manuka honey as it might be convenient to use.

However, at this stage it may be difficult to forecast the market potential of the product because of the small sample size (48). To assess the market potential of this product a larger sample size comprising of 200-300 consumers representing the true population along with a long-term consumption plan will help to get the true consumer opinion.

## 9.10 Price of the New Product

The results of the recommended price by the consumers are shown in Table 9.9. Consumers were asked to recommend a suitable price for the new product. They were asked to consider in their evaluation the price of the currently available jellybeans as the reference price.

**Table 9.9: Recommended Price of the New Product Compared with the Current Product Available in the Market**

| Recommended Price per packet | Week-0 Number of Panelists (%) | Week-2 Number of Panelists (%) | Week-8 Number of Panelists (%) |
|---|---|---|---|
| <0.50 | 15 (31.3) | 11 (22.9) | 17 (35.4) |
| 0.50 | 16 (33.3) | 15 (31.3) | 13 (27.1) |
| 0.75 | 9 (18.8) | 10 (20.8) | 11 (22.9) |
| 1.00 | 8 (16.7) | 12 (25.0) | 7 (14.6) |
| 1.25 | 0(0.0) | 0(0.0) | 0(0.0) |
| 1.50 | 0 (0.0) | 0 (0.0) | 0 (0.0) |

$\chi^2 = 2.82$; df = 6; p = 0.831

As shown in Table 9.9, after immediate consumption of product about 31% of the consumers were willing to pay a slightly higher price (<0.50) than the same product they are currently purchasing. About 33% of the consumers would accept the product to be sold at a $0.50 higher price than that they currently buy. About 19% of the respondents would accept the product to be sold at a $0.75 higher price than that they currently buy.

When consumer was asked the same question after two weeks of consumption, about 23% of the respondents were willing to pay a slightly higher price (<0.50) than the same product they are currently purchasing. About 31% of the consumers would accept the product to be sold at a $ 0.50 higher price than that they currently buy. About 21% of the respondents would accept the product to be sold at a $ 0.75 higher price than that they currently buy. Similar results were obtained after eight weeks of study.

The results from this study were not found to be statistically different. The results of this research show that immediate-use opinion regarding price of the product are valid predictors of the extended-use responses.

## 9.11 Believability of Claims

Table 9.10 shows the consumer attitude towards the claims when written product concept and physical product was shown during the extended usage.

**Table 9.10: Believability of Claims**

| Product claims | Concept Respondents | Week-2 Respondents | Week-8 Respondents |
|---|---|---|---|
| Definitely believable | 23 (47.9) | 13 (27.1) | 13 (27.1) |
| Probably believable | 18 (37.5) | 16 (33.3) | 22 (45.8) |
| Might/might not | 5 (10.4) | 18 (37.5) | 8 (16.7) |
| Probably not | 2 (4.2) | 1 (2.1) | 5 (10.4) |
| Definitely not | 0 (0.0) | 0 (0.0) | 0 (0.0) |

DF =6; p-value = 0.008; $\chi^2 = 17.3$

Consumers were asked to answer this question after carefully reading the claims statement given to them. About 48% of the respondents definitely believed the claims made about the antibacterial properties of the product. About 38% probably would believe the claims. While 10% of the respondents 'might or might not' believe the claims.

After two weeks of consumption of this product, the panelists changed their views about the believability of the claims. A significant (p=0.008) change in the belief was observed. The most of the respondents had changed their view from 'definitely believable' to 'might or might not believable'. However, an improvement in the response was observed after eight weeks of study, indicating panelist changing their view from 'might/might not believable' to 'probably believable'. This change definitely points out that the panelists

must have found positive effect on their ailments and were ready to give credence to this product. This trend is further verified by the positive statements given by the panelists from time to time indicating either they did not suffer from these problems when the rest of the family members were infected or they really could get the relief by consuming this product.

When the results from this study were compared with the CLT, it was found that the perception was not statistically different from the CLT test.

### *9.11.1 Anecdotal Evidence*

When panelists were asked what they think the product cured them for, their reply varied. Some of the responses are quoted as under:

- A pleasant way to cure cold
- Not being a doctor; not proven with any one of the above, I don't know
- Claims have some credence
- I was disappointed in its effectiveness, against sore throat and cold
- And definitely no sinus, which I had for years. No signs while on jellybeans diet
- Enjoyed participating; my husband & I did find that more as the time went on. We had to hide each one's packets.
- Did not have any one of these during the study - may be helps prevent
- Probably did
- None

## 9.12 Eating Frequency of New Product

The eating frequency of the new product during the study is shown in Figure 9.4. The consumption was highest in the first week and then fell down considerably afterwards. The consumption was regularized in the next few weeks.

The results from this study were found to be statistically different ($p = 0.037$). The consumption of new product remained fairly consistent after initial decline. Only difference in consumption of Week-6 and Week-1 was observed by performing Tukey's honestly difference test (95% C.I.).

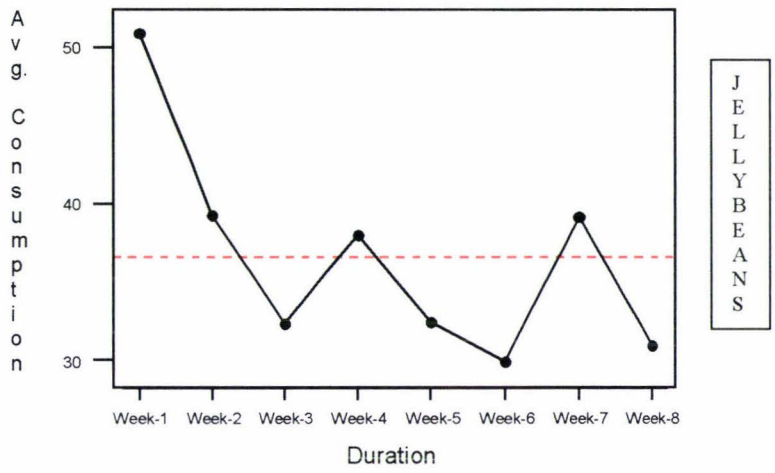



**Figure 9.4: Eating Frequency ( Average No. of Pieces) of New Product during the Study Period**

The results of this research show that immediate-use opinion regarding consumption of new product may not be a valid predictor as consumption of the product for a long period. In the first week the respondents have consumed novelty in good quantity, and after a while it became routine product to them. As a result, the average consumption declined due to irregularity in the consumption pattern rather than quantity of consumption.

## 9.13 Conclusions

The consumer testing of the product has indicated that the idea of developing nutraceutical product that consisted of addition of propolis and manuka honey as antibacterial agents was highly acceptable among the panelists. The panelists accepted the idea of these two ingredients in the confectionery product as they felt it could increase the products' nutritional value, particularly by keeping the immune system healthy, thereby, helping to prevent and treat ailments. They also believed that since the antibacterial agents are from natural sources, it is a safe alternative to the conventional medicines. The buying intention of new product was seen to be highly correlated with the believability of antibacterial properties and replacement of present product with the new product. On the other hand, they were price sensitive. Panelists also felt that propolis adversely affected the flavour as it gives slightly unpleasant aftertaste.

The developed product was different from the jellybeans available in the market in terms of its nutritional image, and consistent release of flavour until finished. The products available in the market have flavour in the sugar casing that tends to be lost after a while. 66 % of consumers liked this unique idea and they showed their preference over the currently available product. About 65% showed their willingness to replace the current product with the new product. The response of the consumer remained stable during the study; therefore, it is suggested that a new product can be launched as such, without making any further changes to it. The believability during the study was comparable to the CLT which further confirms the readiness of the product to face competition as this is the largest single factor influencing the buying intention and hence the future market share of this product.

Over a period of time the panelists have less acceptance for the sweetness of the product. To overcome this problem, the overall sweetness of the product can be reduced by decreasing thickness of the outer shell formed with the help of different grade of sugars in

the soft panning process. This will require working on the panning process without making any alterations to the core of the product. This will save plenty of time and money. Therefore, it could be considered worthwhile producing the product in a commercial scale, once the desired improvements were made and successfully tested with consumers.

The results of this study indicated that immediate-use response (Week-0; CLT) for the consumer acceptance could be used as valid predictor of the extended use responses. No statistical difference was observed in the overall liking of the product during the study. Although there was some variation over time for such product attributes as sweetness and overall flavour, this variation did not impact overall product performance. But during the study the product should not undergo changes, which could effect the functionality, sensory performance and product acceptance. The consistent score of the product could ensure that as expected the product could withstand the abuse of transportation, storage conditions in the house. The replicate testing at three weeks interval did not show any change in the product.

The results of this study (HUT) show that the responses collected in a controlled CLT are valid predictor of the extended use responses. It further confirms that there was no variation in the product as they continued to enjoy the uniform product during the study period. The CLT would have given only sensory response of the panelists and their gut feeling about the antibacterial properties rather than true time tested response. HUT was in a position to answer this question in a given time frame. At the same time, it further confirms the literature findings that the antibacterial activity of the propolis extract was found to be extraordinarily stable, with no reduction observed even after storage for 3-4 years at 0-4$^{o}$ C or at room temperature (Ghisalberti, 1979).

HUT gave the opportunity to conduct test for a longer duration to know the impact of the product on the immune system of the individuals and their feelings about effectiveness of the product after long period of consumption. This type of flexibility is not available in

CLT. The only improvement that is suggested is that instead of conducting the test for 8-weeks the duration of 4-5 weeks would have given the same result and hence saved plenty of time.

Finally, results from CLT and HUT reported good agreement for acceptability of the jellybeans samples. The HUT provided validity of results from CLT as liking of the product did not drop over time and with the repeated exposure of panelists to the product. The consumers liked the product consistently and their buying behaviour was also consistent over time which further augments the belief that consumer will like the product sufficiently and buy it repeatedly if it was made available in the market. From the study it may be inferred that the results from HUT and CLT were similar.

# Chapter 10

# Overall Discussion and Recommendations

## 10.1 Introduction

This research had two aims. First was the development of an acceptable nutraceutical jellybeans. Second was the evaluation of various product development techniques. The techniques used included market research, optimization, and testing of the developed product with the consumers. The project investigated the usage of various optimization techniques like response surface methodology, internal and external preference mapping. The developed product was evaluated under both CLT and HUT conditions. The change in opinion of consumer from concept to final product was investigated.

The developed product retained the antibacterial properties. These properties were extracted by a method developed during the study and they were finally tested by agar diffusion and turbidity tests.

## 10.2 Successful Development of Nutraceutical Jellybeans

Nutraceutical products contain ingredients, which help to prevent and treat illness and disease. This project dealt with the development of a nutraceutical confectionery product for the consumer market, using manuka honey and propolis as antibacterial agents. The acceptance and use of nutraceutical product depend mainly on two factors. First is the credibility of the claims made. The second factor is the development of convenient and tasty products.

The consumer liked the developed product, and the consumption pattern of the product was fairly constant during the study, which proves that consumer, will not stop eating, after eating it for a while.

Finally the developed product has all the product characteristics, which are important to consumers like credibility of the claims and, convenient and tasty product. Moreover, a product with large number of benefits has greater chances to succeed in the market place.

### *10.2.1 Successful Development of Testing Procedure for Antibacterial Properties*

Many New Zealanders understand the benefits and are using honey and propolis products. Claims for retention of antibacterial properties in these products are not made for lack of testing procedure. Therefore, a need for testing the antibacterial properties was visualised to make credibility to the consumer. The developed product was found to have antibacterial properties when extracted properties were tested by agar diffusion and turbidity testing.

Procedure for testing the antibacterial properties of the ingredients is based on removing interfering substances other than sugar, reduction of sugar and estimation of extracted antibacterial properties by standard agar diffusion and turbidity test. This method is enough accurate to give antibacterial components in a measurable quantity. This method can easily be used to test the antibacterial properties of similar confectionery products.

## 10.3 Suitability of Various Techniques for Product Development Process

### *10.3.1 Preference Mapping and Clustering by Preferences*

Preference mapping can be divided into two categories internal analysis (MDPREF) and external analysis (PREFMAP). MDPREF used consumer information and showed that direction of preference is towards two products and reasons for preference of these two products were not explained. PREFMAP mapping was able to identify one sample as the most preferred sample and reason for their preference. This technique was better than internal because you can see what characteristics to change to make product acceptable.

Inconsistency in the results between external and internal mapping could be explained by the fact that flavour was the main attribute in preference of jellybeans (Sofat, 1998) and in the current study only texture attributes were used by the trained panel. Moreover, it is quite possible that the samples shown to the consumer were quite similar in texture, and they must have liked most of the products. Therefore, a cluster analysis was performed to classify consumers based on individual preferences.

A cluster analysis on raw preference score was conducted to make products for the individual groups. Four subgroups were sufficient to classify consumers on the bi-plot of the first two components on MDPREF. For each subgroup it was possible to find a most liked and least liked product as differences between the samples were significant. This helped in identifying a most liked product for each subgroup. The results helped to illustrate the fact that consumers liking differ from individual to individual and products can be customised to meet the individual needs of the consumers. Sample A was liked by majority of the consumers and was considered for further development.

In brief, preference mapping is a complex, time consuming, and expensive technique but valuable data generated by consumer panel can also be used for segmentation of consumers. Segmentation by cluster analysis helped in developing a product that has an instant success with the consumer and manufacturer alike. A successful product was developed based on the analysis carried out by these techniques.

#### *10.3.1.1 Trained Panel*

Trained panel could identify the key attributes, and then accurately measure the change in product attributes for change in ingredient or process variables. The sensory data obtained was then used to relate to people's likes and dislikes through consumer panels.

Even though sensory evaluation is the most common way to determine the characteristics of the product it is time consuming and expensive. In this study panellists were trained to

perform the descriptive analysis of the product and they participated in a month long training program comprising 20 sessions. These characteristics were detected, described and the amount of each characteristic present in the samples was evaluated.

However, it remained important to the project for identifying sensory characteristics that are critical to acceptance of the product. The results indicated that 8 samples tested by the trained panel had large discrimination. Finally, results indicated that hardness and chewiness were strongly influenced by quantity of starch and gelatin in the formulation. The trained panel could accurately measure the change in product attributes for change in ingredient or process variables. Extensive training of the panelists, guidance of skilled supervisor, and use of reference materials gave reproducible, consensus profile data.

Finally, trained panel is a sensitive, analytical instrument for complete evaluation of the product. However, in this study consumer liking score was used in conjunction with sensory profile, which played an important role in the development of an acceptable product.

### *10.3.2 Feasibility of Central Location*

As CLT was conducted at Massey University, the majority of participants were either students or staff of the institute, which allowed limited information on account of age and socio-economic group. The consumer was also exposed to the product for a limited time so the effect of antibacterial properties on individuals well being was not ascertained.

Overall, CLT was found to be applicable for this development study, and enabled to screen more products than under home use test (HUT). However, CLT has the disadvantage of testing the products under artificial conditions and the limited number of questions that can be asked. The short time of exposure was of great concern to know the benefits of antibacterial properties to the consumers. Keeping in mind, the advantages and disadvantages of this test, it was decided to validate the findings by using HUT.

### *10.3.3 Home Use Test*

The HUT was used to assess product attributes, acceptance, and performance under actual user conditions. The test, therefore, provides information that may not be obtained in any other type of testing conditions. The evaluation of the product took 8 weeks.

In CLT the developed product was compared with the market sample. However, in HUT only developed product was tested to keep the test situation simple. Home testing gave more realistic environment conditions than CLT. It provided information about perception of performance and acceptance of the product under uncontrolled conditions of serving and evaluation.

In this study, the panelists mailed their response back this resulted in lower than desired response rate and also required considerable time to distribute samples and questionnaires, collect responses and time to implement the test. To overcome this problem, the respondents were pre-recruited and screened prior to the study and were compensated for their participation. Furthermore, apprising them of their role in the testing and importance of data being collected gained their commitment. At the same time, respondents were constantly reminded to send back the completed questionnaires.

When the average rating of the product was compared between CLT and HUT, it was found to be significantly different. But the results merely indicated that the product was more acceptable to consumers recruited for HUT than those recruited for CLT. Yet, believability during the study was comparable to CLT. Therefore, the buying intention of the consumers in both the studies was likely to be similar, as believability is the single largest factor influencing the buying intention.

Overall, HUT was found to be applicable for this development study as information on consumption pattern was also collected. Likewise, it has the highest degree of validity and provides an opportunity to measure performance and acceptance under normal use

conditions. As results provided by CLT on believability have less validation due to little exposure of the panelists to the product. Therefore, result of CLT had to be validated by HUT after extended exposure of the panelists to the product. Yet, it is a costlier and time-consuming technique than CLT. HUT was designed to validate the CLT so most of the demerits associated with the latter were reduced in this study. HUT was additionally helpful in ascertaining the shelf life of the product, as overall acceptability of the product did not decline during 8 weeks of study. Hence, no need for separate test to determine the shelf life of the product.

## 10.4 Recommendations for Further Study

The developed jellybeans were found worthwhile to be developed further on a commercial scale. The product can be commercially produced either using a batch process or static cooker depending upon the equipment availability. A product market test should be conducted before the product is launched on the market in order to test other factors such as brand name, packaging, and advertising, which affect consumer's buying decision apart from the sensory attributes. This will also establish the impact of competitor products on the consumer buying intention in the real shopping conditions and estimate the market size and share of the new product.

In this study the effect of process conditions in the commercial run could not be ascertained due to the non-availability of slurry sample at site for special moulds. The study found that there was a general trend between the product attributes particularly, texture and the process conditions. This correlation should be investigated further in order to know the effect of different process methods on the texture. This will help product developer to alter the ingredients and processing conditions in order to obtain the required texture.

The study showed that the confectionery process affected main functional ingredient starch, with reactions such as gelatinisation. However, the mechanism of these

transformations depends upon the specific slurry composition. In this study, microscopic examination of starch granule was studied for loss of birefringence crosses that measured a completeness of gelatinisation process. It is suggested that measurements by rheological studies, which can quantify degree of gelatinisation carried out, in order to understand about the process effects on the main raw material.

The method developed for testing the antibacterial properties of jellybeans is fairly accurate. This method generated the proof for the consumer to believe in the product claims. This aspect was very important for this product as during the surveys it was found that sales of the product are highly correlated with the believability score for antibacterial properties. Nevertheless, there is scope for further improvement. The fructose present in honey is more soluble than other sugars in ethyl alcohol and is retained along with the antibacterial properties. The reduction of fructose will give polyphenols largely free of sugars thereby giving accurate estimation of antibacterial properties. Fructose can be converted to insoluble glucose through isomerisation by base or enzymatic catalyst. But it must be seen that isomerisation does not bring any change to antibacterial properties.

In this study, looking at the length of the project it was not possible to train the panel for sensory profile of the jellybeans. Therefore, other important attributes like flavour intensity, colour intensity, bitterness, sweetness were largely ignored. It is suggested that preference mapping of the nutaceutical jellybeans be conducted by considering all the important attributes that explain the product. The sensory profiling of the product will help to discriminate the product on more than just texture attributes. A trained panel might be used instead of training it. Finally, internal and external preference mapping conducted to compare these two techniques. This will explain the 'why' different types of maps were obtained by these two techniques.

A cluster analysis on raw preference score was conducted to develop product for individual wants and needs. Since only 53 consumers were used as consumer panelists, the size of

cluster was not big enough to substantiate between the subgroups. It is felt that more than 100 consumers in the consumer panel would have made statistically meaningful clusters.

In this study, HUT lasted for 8 weeks and that consumed a lot of time of this study. The results indicated that it was possible to terminate the study after 4-5 weeks. This aspect can be verified by doing a similar study. If results of this study are validated then popularity of HUT will improve further.

## 10.5 Conclusions

The demand for functional food is increasing more rapidly in comparison to the overall food market. The market study indicated that a gap exists for a traditional confectionery product with added nutraceutical ingredients. For success of the product flavour, texture, antibacterial properties and price were found to be important attributes to the consumers.

It was observed during preliminary experiments that process conditions and the ingredient proportion affect the textural attributes of jellybeans. Echip enabled the usage of both processing conditions and ingredients variables in the experiment. The number of experiments required by RSM in the standard Echip design were less than the normal design and replicates of first 5 experiments measured standard error in the experiments to determine lack of fit. If lack of fit appears for any response it is inferred that the used model does not fit that response. Echip has provision to handle this problem, either by transformation of the given data or using a more complex model. The optimum conditions were achieved through graphs by finding the experimental region that will give desired value of the response. Because of these advantages, Echip's pre-calculated design was chosen for the study.

The zones of inhibition were significantly affected by quantity of antibacterial agent and cooling temperature of gel. The zones were directly related with concentration of antibacterial component in the product and inversely with temperature of addition. But

antibacterial activity was found to be stable up to 95° C. The method developed for testing the antibacterial properties of jellybeans is reasonably accurate. This method generated the much-needed proof for the consumer believability in the product claims. This aspect was very important as during the consumer survey it was found that sales of the product are highly correlated with the believability score for antibacterial properties.

For optimization of the product two methods were used. The structure of internal (MDPREF) and external preference map (PREFMAP) was quite different and no consensus was reached about the preference of the individual product. But PREFMAP was more informative by pin pointing why the consumer preferred a sample, and this information was missing in the MDPREF, which indicated only consumer preferences.

So MDPREF was further analysed with sub-grouping of the consumer preferences. The cluster analysis allowed consumer with no differences in liking to be identified. Consequently, the analysis of the remaining clusters was more relevant because of their higher discrimination. Finally, based on the liking of majority of panelists product A was selected for further development.

The prototypes were tested with the consumers to know their beliefs and attitude towards the developed product. The 53 consumers selected comprised 29 females and 24 males, all between 18 to 40 years of age. 41% of the consumers probably would believe the claims about the antibacterial properties of the product. Majority of the respondents (57%) saw jellybean, as a confectionery product having additional benefits like antibacterial properties.

The development of jellybean was done at the laboratory scale and has to be taken directly to the commercial plant, due to lack of pilot plant facilities at Massey University. The change in the process from open kettle evaporation to high temperature short time process has not affected the acceptance of the jellybeans, as the used starch was compatible with

both of these processes. The continuous process had better control over the process conditions as the equipment used was automatic and precise temperature controls through out the process were possible. Therefore this product was subsequently evaluated in the central location and home use test.

In this project, jellybeans with attributes acceptable to consumer were developed and were tested in the CLT. 66% of consumers liked the unique idea and they showed their clear preference over the currently available product. About 65% showed their willingness to replace the current product with the new product. The response of the consumer remained fairly stable during the extended study of HUT as well.

The results from CLT and HUT reported good agreement for acceptability of the jellybean samples. The results of this study also indicated that immediate-use response (Week-0; CLT) for the consumer acceptance could be used as valid predictor of the extended use response. HUT was able to provide additional information on liking of the product, which did not drop over time and repeated exposure of the panelists to the product. Therefore, if validation of the results is not required then CLT can give fairly accurate indication of the consumer acceptance and precious time can be saved.

It is suggested that a new product can be test marketed as such, without making any further changes to it. The new product could be positioned as a substitute to the jellybeans, which consumers are already consuming. It could also be a serious contender for the market currently dominated by lozenges and other throat products, which have medicinal image.

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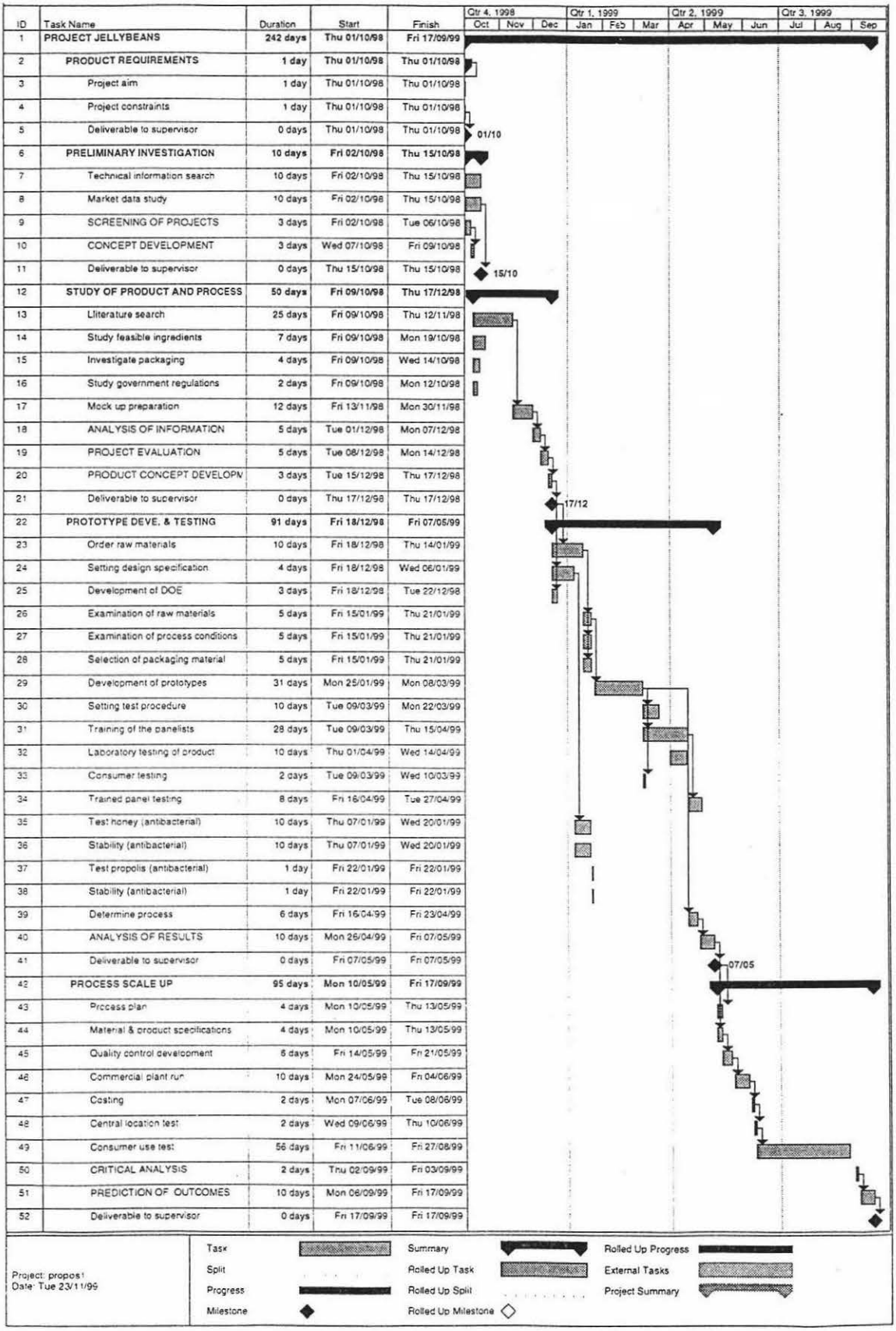
# Appendix 1.1: Gantt Chart of Jellybean Project



| ID | Task Name | Duration | Start | Finish |
|---|---|---|---|---|
| 1 | **PROJECT JELLYBEANS** | **242 days** | **Thu 01/10/98** | **Fri 17/09/99** |
| 2 | **PRODUCT REQUIREMENTS** | **1 day** | **Thu 01/10/98** | **Thu 01/10/98** |
| 3 | Project aim | 1 day | Thu 01/10/98 | Thu 01/10/98 |
| 4 | Project constraints | 1 day | Thu 01/10/98 | Thu 01/10/98 |
| 5 | Deliverable to supervisor | 0 days | Thu 01/10/98 | Thu 01/10/98 |
| 6 | **PRELIMINARY INVESTIGATION** | **10 days** | **Fri 02/10/98** | **Thu 15/10/98** |
| 7 | Technical information search | 10 days | Fri 02/10/98 | Thu 15/10/98 |
| 8 | Market data study | 10 days | Fri 02/10/98 | Thu 15/10/98 |
| 9 | SCREENING OF PROJECTS | 3 days | Fri 02/10/98 | Tue 06/10/98 |
| 10 | CONCEPT DEVELOPMENT | 3 days | Wed 07/10/98 | Fri 09/10/98 |
| 11 | Deliverable to supervisor | 0 days | Thu 15/10/98 | Thu 15/10/98 |
| 12 | **STUDY OF PRODUCT AND PROCESS** | **50 days** | **Fri 09/10/98** | **Thu 17/12/98** |
| 13 | Literature search | 25 days | Fri 09/10/98 | Thu 12/11/98 |
| 14 | Study feasible ingredients | 7 days | Fri 09/10/98 | Mon 19/10/98 |
| 15 | Investigate packaging | 4 days | Fri 09/10/98 | Wed 14/10/98 |
| 16 | Study government regulations | 2 days | Fri 09/10/98 | Mon 12/10/98 |
| 17 | Mock up preparation | 12 days | Fri 13/11/98 | Mon 30/11/98 |
| 18 | ANALYSIS OF INFORMATION | 5 days | Tue 01/12/98 | Mon 07/12/98 |
| 19 | PROJECT EVALUATION | 5 days | Tue 08/12/98 | Mon 14/12/98 |
| 20 | PRODUCT CONCEPT DEVELOPM | 3 days | Tue 15/12/98 | Thu 17/12/98 |
| 21 | Deliverable to supervisor | 0 days | Thu 17/12/98 | Thu 17/12/98 |
| 22 | **PROTOTYPE DEVE. & TESTING** | **91 days** | **Fri 18/12/98** | **Fri 07/05/99** |
| 23 | Order raw materials | 10 days | Fri 18/12/98 | Thu 14/01/99 |
| 24 | Setting design specification | 4 days | Fri 18/12/98 | Wed 06/01/99 |
| 25 | Development of DOE | 3 days | Fri 18/12/98 | Tue 22/12/98 |
| 26 | Examination of raw materials | 5 days | Fri 15/01/99 | Thu 21/01/99 |
| 27 | Examination of process conditions | 5 days | Fri 15/01/99 | Thu 21/01/99 |
| 28 | Selection of packaging material | 5 days | Fri 15/01/99 | Thu 21/01/99 |
| 29 | Development of prototypes | 31 days | Mon 25/01/99 | Mon 08/03/99 |
| 30 | Setting test procedure | 10 days | Tue 09/03/99 | Mon 22/03/99 |
| 31 | Training of the panelists | 28 days | Tue 09/03/99 | Thu 15/04/99 |
| 32 | Laboratory testing of product | 10 days | Thu 01/04/99 | Wed 14/04/99 |
| 33 | Consumer testing | 2 days | Tue 09/03/99 | Wed 10/03/99 |
| 34 | Trained panel testing | 8 days | Fri 16/04/99 | Tue 27/04/99 |
| 35 | Test honey (antibacterial) | 10 days | Thu 07/01/99 | Wed 20/01/99 |
| 36 | Stability (antibacterial) | 10 days | Thu 07/01/99 | Wed 20/01/99 |
| 37 | Test propolis (antibacterial) | 1 day | Fri 22/01/99 | Fri 22/01/99 |
| 38 | Stability (antibacterial) | 1 day | Fri 22/01/99 | Fri 22/01/99 |
| 39 | Determine process | 6 days | Fri 16/04/99 | Fri 23/04/99 |
| 40 | ANALYSIS OF RESULTS | 10 days | Mon 26/04/99 | Fri 07/05/99 |
| 41 | Deliverable to supervisor | 0 days | Fri 07/05/99 | Fri 07/05/99 |
| 42 | **PROCESS SCALE UP** | **95 days** | **Mon 10/05/99** | **Fri 17/09/99** |
| 43 | Process plan | 4 days | Mon 10/05/99 | Thu 13/05/99 |
| 44 | Material & product specifications | 4 days | Mon 10/05/99 | Thu 13/05/99 |
| 45 | Quality control development | 6 days | Fri 14/05/99 | Fri 21/05/99 |
| 46 | Commercial plant run | 10 days | Mon 24/05/99 | Fri 04/06/99 |
| 47 | Costing | 2 days | Mon 07/06/99 | Tue 08/06/99 |
| 48 | Central location test | 2 days | Wed 09/06/99 | Thu 10/06/99 |
| 49 | Consumer use test | 56 days | Fri 11/06/99 | Fri 27/08/99 |
| 50 | CRITICAL ANALYSIS | 2 days | Thu 02/09/99 | Fri 03/09/99 |
| 51 | PREDICTION OF OUTCOMES | 10 days | Mon 06/09/99 | Fri 17/09/99 |
| 52 | Deliverable to supervisor | 0 days | Fri 17/09/99 | Fri 17/09/99 |

## Appendix 3.1: Sugar Confectionery and Nutraceutical Products Available in Palmerston North

| Brand | Flavor | Packaging | Price ($) | Company |
|---|---|---|---|---|
| Honeygar Apple cider | Vinegar & honey | 750 ml | 8.45 | Comvita |
| Olde World Apple cider | Vinegar & honey | 1 litre | 15.00 | Olde World |
| Manuka honey | | 250; 500gms | 5.45, 8.45 | Comvita |
| Honey & Boysenberry spread | | 250gms | 4.80 | Comvita |
| Fortacold lozenges with propolis | original | 12/pkt | 4.00 | Comvita |
| | lemon & honey | | | |
| | cool mint | | | |
| Fotracold immune builder | propolis, enchinacea | 30/pkt | 13.45 | Comvita |
| Fotracold elixir | propolis, enchinacea | 200 ml | 9.45 | Comvita |
| Natural propolis toothpaste | teatree oil | 100 gms | 4.85 | Comvita |
| Natural propolis toothpaste | propolis with flouride | 110 gms | 5.75 | Comvita |
| Red seal propolis toothpaste | healthy gums | 100gms | 3.44 | Red seal natural health |
| Red seal propolis toothpaste | mint (flouride free) | 110 gms | 3.46 | Red seal natural health |
| UMF 10 manuka honey | | 375 gms | 18.45 | Comvita |
| Propolis tablets | | 100 tabs | 15.75 | Comvita |
| Propolis capsules | | 100 * 250mg | 19.00 | Comvita |
| Fortacold vitamin C bioactive | propolis | 40 tabs | 11.95 | Comvita |
| Royal Jelly | | 365 * 1000mg | 155.00 | Comvita |
| | | 180 * 1000mg | 77.10 | Comvita |
| Royal jelly and honey | | 250 gms | 12.6 | Comvita |
| Propolis candy with eucalyptus | | 52.5 gms | 4.25 | Natures Goodness |
| Hawaiian Pacific spiruline bar | spiruline, manuka honey | 50 gms | 1.75 | Good Health Products |
| Vicks Vapo Drops | butter and menthol | 12/pkt | 1.95 | Proctor and Gamble |
| Vicks Blue Extra strong | peppermint | 12/pkt | 1.95 | Proctor and Gamble |
| Vicks Throat drops | menthol | 18 * 2gms | 2.50 | Proctor and Gamble |
| | lemon | | | |
| Kurols mentholated lozenges | | 85 gms | 1.95 | Maycey's |
| Fisherman's friend lozenges | aniseed | 25 gms | 2.50 | Lofthouse's, England |
| | sorbitol | | | |
| | super strong mint | | | |
| | original extra strong | | | |
| Fisherman's friend lozenges | lemon | 45 gms | 5.95 | Lofthouse's England |
| Honey dream bar | oats, yoghurt | 80 gms | 2.95 | All Natural Bakery |
| Isomalt soft centred sugar free | choc mint | 60 gms | 3.50 | O Briens, Australia |
| | wild berry | | | |
| Strepsils | Anasthetic | 24/pkt | 6.95 | Boots Healthcare |
| | Honey and lemon | | | |
| | Vitamin C | | | |
| | Original | | | |
| | Menthol and Eucalyptus | | | |
| Pascall family packs | jet planes | 200 gms | 2.39 | Cadbury's |
| | wine gums | 200 gms | 2.35 | Cadbury's |
| | jaybees | 270 gms | 2.35 | Cadbury's |
| Strepsils sugar free lozenges | herbal lemon | 16/pkt | 6.50 | Boots Healthcare |

## Table 3.1 (contd.): Sugar Confectionery and Nutraceutical Products Available in Palmerston North

| Brand | Flavor | Packaging | Price ($) | Company |
|---|---|---|---|---|
| Strepsils cough lozenges | | 16/pkt | 6.95 | Boots Healthcare |
| Dequadin throat lozenges | | 24/pkt | 6.95 | Boots Healthcare |
| Duro Tuss lozenges | lemon<br>orange | 24/pkt | 8.95 | 3M Pharmaceuticals |
| Difflam cough lozenges | blackcurrant | 24/pkt | 9.95 | 3M Pharmaceuticals |
| Difflam cough lozenges sugar free | raspberry<br>eucalyptus and methnol | 16/pkt | 7,95 | 3M Pharmaceuticals |
| Lentacin cough discs | lemon<br>aniseed | 16/pkt | 5.95 | Marion Marrell Dow |
| Blackmore's lozenges | Enchina & Eucalyptus oil | 24/pkt | 8.95 | Blackmore's |
| Propolis echinacea & zinc lozenges | lemon | 15/pkt | 3.95 | Healtheir's |
| Royal Jelly capsules | | 30 * 500 mg | 10.50 | Healtheir's |
| Propolis and enchinacea tablets | | 30 tabs | 8.95 | Healtheir's |
| Bee pollen capsules | | 90 capsules | 12.95 | |
| Chuppa chups lollipops | variety mix<br>ice cream<br>bubble gum | 10/pkt, 5/pkt | 2.55, 1.35 | Chuppa chups, Spain |
| | fruity | 10/pkt | 2.49 | Chuppa chups, Spain |
| Chuppa chups lollipops | mega bag (assortment) | 24/pkt, 50/pkt | 4.95, 9.95 | |
| Chuppa chups lollipop (loose) | assortment | 1 | 0.25 | |
| Strock, Werther's Original candies | | 150 gms | 2.49 | Made in Germany |
| Layley's fruit bar | apricot coconut<br>apricot cashew<br>sunflower | 50 gms | 0.72 | Layley's health foods |
| Allen's Heards | malted barley sugars<br>fruit refreshers<br>plain | 130 gms | 2.00 | Nestle |
| Binka's natural jelly dinosaurs | Assorted flavours | 200 gms | 2.50 | Natural Confectionery |
| Binka's blinky bill | Assorted flavours | 200 gms | 2.50 | Natural Confectionery |
| Binka's natural snakes | Assorted flavours | 200 gms | 2.50 | Natural Confectionery |
| Lite & luscious chews | fabulous fruits<br>mints<br>creamy caramels | 70 gms | 2.90 | Ricci, Australia |
| Lite & luscious lemon drops | orange<br>blackcurrant<br>raspberry | 50 gms | 2.25 | Ricci, Australia |
| Pascall fruit burst jumbo | assortment | 200, 400 gms | 2.39, 4.50 | Cadbury's |
| | minties | 200, 400 gms | 2.39, 4.50 | Cadbury's |
| Pascall party pack | assortment | 200, 450 gms | 2.39, 4.50 | Cadbury's |
| Ojays | | 1000 gms | 9.90 | Foodtown, loose bins |
| Mint drops | | 1000 gms | 9.90 | Foodtown, loose bins |
| Locorice bullets | | 1000 gms | 9.90 | Foodtown, loose bins |
| Pascall Eskimo family pack | | 250 gms | 2.35 | Cadbury's |
| Pascall milk shakes | milk toffees | 200 gms | 2.20 | Cadbury's |

## Table 3.1 (contd.): Sugar Confectionery and Nutraceutical Products Available in Palmerston North

| Brand | Flavor | Packaging | Price ($) | Company |
|---|---|---|---|---|
| Munchers | | 1000 gms | 9.90 | Foodtown, loose bins |
| Giant jellybeans | | 1000 gms | 9.90 | Foodtown, loose bins |
| Blackberries & Raspberries | | 1000 gms | 9.90 | Foodtown, loose bins |
| Pascall family packs | fruit jubes | 200 gms | 2.39 | Cadbury's |
| | hard jubes | 200 gms | 2.39 | Cadbury's |
| | licorice (all sorts) | 220 gms | 2.35 | Cadbury's |
| Pascall giant mallows | | 190 gms | 2.35 | Cadbury's |
| Pascall mallows | | 180 gms | 2.35 | Cadbury's |
| Regina marshmallows | | 180, 400 gms | 2.40, 4.30 | Nestle |
| Mackintosh toffee deluxe | | 200 gms | 2.40 | Nestle |
| Odd fellows | mints | 200 gms | 2.40 | Nestle |
| | spearmints | | | |
| | kool mints | | | |
| Allen's party mix | | 250 gms | 2.39 | Nestle |
| Allen's monster mix | | 240 gms | 2.40 | Nestle |
| Allen's body bits | | 220 gms | 2.50 | Nestle |
| Allen's black knight | licorice (all sorts) | 200 gms | 2.40 | Nestle |
| Allen's sporties | soft chewy mints | 200 gms | 2.50 | Nestle |
| Allen's spacies | | 220 gms | 2.50 | Nestle |
| Allen's fantales | caramel | 180 gms | 2.40 | Nestle |
| Bols jellybeans | | 220 gms | 1.20 | Kmart, Australia |
| Bols jellybabies | | 200 gms | 1.20 | Kmart, Australia |
| Bols snakes | | 200 gms | 1.20 | Kmart, Australia |
| Bols party lollies | | 200 gms | 1.20 | Kmart, Australia |
| Bols bananas | | 200 gms | 1.20 | Kmart, Australia |
| Bols musk sticks | | 200 gms | 1.20 | Kmart, Australia |
| Bols polkadots | | 200 gms | 1.20 | Kmart, Australia |
| Bols peppermints | | 200 gms | 1.20 | Kmart, Australia |
| Emir's Turkish delight | Rose, lemon, mint | 300 gms | 3.49 | Cyprus made |
| Candy lanes | | 170 gms | 2.29 | Grocery Holdings, N.Z. |
| Beacon | liquorice allsorts | 1000 gms | 12.99 | South Africa |
| Yoghurt raisins | | 1000 gms | 12.50 | Foodtown, loose bins |
| Ice-creams | | 1000 gms | 9.90 | Foodtown, loose bins |
| Candy bananas | | 1000 gms | 9.90 | Foodtown, loose bins |
| Fizzies | | 1000 gms | 9.90 | Foodtown, loose bins |
| Sugared blackballs | | 1000 gms | 9.90 | Foodtown, loose bins |
| Fruit tangs | | 1000 gms | 9.90 | Foodtown, loose bins |
| Spearmint chews | | 1000 gms | 9.90 | Foodtown, loose bins |
| Super ojays | | 1000 gms | 9.90 | Foodtown, loose bins |
| Snow's grannies candies | buttered | 200 gms | 1.79 | Snow confectionery |
| Snow's party mix | | 220 gms | 1.79 | Snow confectionery |
| Snow's smart beans | | 350 gms | 3.00 | Snow confectionery |

## Table 3.1 (contd.): Sugar Confectionery and Nutraceutical Products Available in Palmerston North

| Brand | Flavor | Packaging | Price ($) | Company |
|---|---|---|---|---|
| Allen's fabulicious twists | raspberry | 200 gms | 2.02 | Nestle |
| Allen's fruitips fruit jellies | | 200 gms | 2.02 | Nestle |
| Allen's snakes alive | | 180 gms | 2.02 | Nestle |
| Strawberry/Cream | | 1000 gms | 9.90 | Foodtown, loose bins |
| Spearmint leaves | | 1000 gms | 9.90 | Foodtown, loose bins |
| Rainbow fresh | | 1000 gms | 9.90 | Foodtown, loose bins |
| Wine gums | | 1000 gms | 9.90 | Foodtown, loose bins |
| party mix | | 1000 gms | 9.90 | Foodtown, loose bins |
| False teeth | | 1000 gms | 9.90 | Foodtown, loose bins |
| Giant jubes | | 1000 gms | 9.90 | Foodtown, loose bins |
| Fruity jellies | | 1000 gms | 9.90 | Foodtown, loose bins |
| Irish moss | | 1000 gms | 9.90 | Foodtown, loose bins |
| Toasted marshmallows | | 1000 gms | 9.90 | Foodtown, loose bins |
| Orange fish | | 1000 gms | 9.90 | Foodtown, loose bins |
| Sparkles | | 1000 gms | 9.90 | Foodtown, loose bins |
| Comvita lozenges | | 1000 gms | 9.90 | Foodtown, loose bins |
| Russian fudge | | 1000 gms | 9.90 | Foodtown, loose bins |
| Cocunut ice | | 1000 gms | 9.90 | Foodtown, loose bins |
| Licorice delights | | 1000 gms | 9.90 | Foodtown, loose bins |
| Giant licorice allsorts | | 1000 gms | 9.90 | Foodtown, loose bins |
| Penguins | | 1000 gms | 9.90 | Foodtown, loose bins |
| Jet planes | | 1000 gms | 9.90 | Foodtown, loose bins |
| Marshmallows | | 1000 gms | 9.90 | Foodtown, loose bins |
| Fruit cocktails | | 1000 gms | 9.90 | Foodtown, loose bins |
| Milk shakes | | 1000 gms | 9.90 | Foodtown, loose bins |
| Milk bottles | | 1000 gms | 9.90 | Foodtown, loose bins |
| Mega gums | | 1000 gms | 9.90 | Foodtown, loose bins |
| Wiggles | | 1000 gms | 9.90 | Foodtown, loose bins |
| Fruit puffs | | 1000 gms | 9.90 | Foodtown, loose bins |
| Nut nougat | | 1000 gms | 9.90 | Foodtown, loose bins |
| Beeneez fruit logs | cherry<br>apricot<br>pineapple | 230 gms | 4.95 | Beeneez, Auckland |
| Cadbury's after dinner mints | mint | 200 gms | 3.75 | Cadbury's |
| Snow's Eclairs | butterscotch<br>hazelnuts<br>locorice<br>choclate | 200 gms | 1.79 | Snow confectionery |
| Wrigley's extra sugarfree gum | wild berry<br>spearmint | 15 gms | 0.70 | Wrigley's, Australia |
| Hubba Bubba | strawberry | 35 gms | 0.50 | Wrigley's, Australia |
| Snow's amazing fruit grubbs | | 10 * 20 gms pack | 1.79 | Snow confectionery |
| Snow's amazing fruit dudes | | 10 * 20 gms pack | 1.79 | Snow confectionery |
| Snow's jersey caramels | | 200 gms | 1.79 | Snow confectionery |

## Table 3.1 (contd.): Sugar Confectionery and Nutraceutical Products Available in Palmerston North

| Brand | Flavor | Packaging | Price ($) | Company |
|---|---|---|---|---|
| Allen's fruit salad & cream | | 200 gms | 2.02 | Nestle |
| Allen's lollipops | | 130 gms | 2.02 | Nestle |
| | | 265 gms | 3.95 | Nestle |
| Allen's pineapple chunks | pineapple | 145 gms | 2.02 | Nestle |
| Black knight 12 licorice rolls | | 360 gms | 3.95 | Nestle |
| V pops | | 120 gms | 1.99 | Mexican made |
| The original pineapple lumps | | 140 gms | 2.04 | Cadbury's |
| Pascall impereals | spearmints<br>mint | 200 gms | 2.04 | Cadbury's |
| Pascall tangy fruits | fruit flavored candy | 200 gms | 2.04 | Cadbury's |
| Pascall Y2k bugs | sour power | 200 gms | 2.04 | Cadbury's |
| Pascall space troopers | | 200 gms | 2.04 | Cadbury's |
| RJ's licorice jellybeans | licorice and aniseed | 200 gms | 1.99 | RJ's licorice |
| RJ's real fruit licorice jellybeans | apricot | 200 gms | 1.99 | RJ's licorice |
| RJ's logs | raspberry<br>new real fruit<br>herbal | 125 gms | 1.73 | RJ's licorice |
| RJ's logs pieces | herbal | 500 gms | 3.09 | RJ's licorice |
| RJ's licorice superbly soft | herbal | 400 gms | 4.36 | RJ's licorice |
| Airwaves chewing gum | menthol & eucalyptus | 35 gms (25 pellets) | 2.00 | Wrigley's, England |
| | | 14 gms (10 pellets) | 0.80 | Wrigley's, England |
| Wrigley's P.K. chewing gum | PK blue | 17 gms (10 pellets) | 0.50 | Wrigley's, Australia |
| | juicy fruit<br>arrowmint<br>plain | | | |
| Wrigley's chewing gum | juicy fruit<br>arrowmint | 85 gms | 1.90 | Wrigley's, Australia |
| Wrigley's Extra for kids | sugarfree | 40 gms | 1.90 | Wrigley's, Australia |
| Wrigley's sugarfree bubblegum | bubble gum | 40 gms | 1.90 | Wrigley's, Australia |
| Wrigley's pack sugarfree gum | spearmint<br>peppermint | 40 gms | 1.90 | Wrigley's, Australia |
| Wrigley's extra sugarfree gum | wild berry<br>spearmint | 45 gms | 1.90 | Wrigley's, Australia |
| Wrigley's extra sugarfree gum | spearmint<br>bubble gum<br>peppermint | 13.5 gms | 0.70 | Wrigley's, Australia |

## Appendix 4.1: Preliminary Production Trials

Several preliminary trials were carried out before the actual development experiments to identify the variables, which affect the product attributes. In the beginning no products were specifically developed for but range of variation that may be encountered in the production runs were ascertained. In the next stage of development trials, products were created in which all of the variables were held constant and one was systematically varied. In this phase of development study, several samples were developed to determine the effect of the change in the variable to the sensory characteristics of the product. The variables, which appeared to make difference to the sensory attribute of the product, were selected. The preliminary work was also aimed in developing analysis method aimed for antibacterial activity assessment. The other reason of these trials was to know the suitability of the ingredients for the available equipment in the product development laboratory and the commercial trial.

The ranges of process conditions were tried from the trials, relevant literature and the recommendation of the material suppliers. To achieve the functional properties of starch, the gelatinization of starch is very important. This was checked by looking at the starch molecules in a polarized light for birefringen crosses and under normal light for swelling of the starch granules. Any uncooked starch granule will give starchy taste and soft texture. The temperature of gelatin addition was important to conserve the setting power of gelatin it was found that above $100^{\circ}$ C, gelatin looses about 10% of its strength.

Jellybean is a panned confectionery in which centers are engrossed to increase the weight of the finished product. After loading the pan with fixed weight of jellybeans a repetitive step of cycles begins and continues till desired level of coating is achieved. The procedure involves the charging of syrup and different grades of sugar during the coating process. Once weight gain is achieved a last syrup application is made and small size of sugar is used for finishing (Lynch, 1987; Isganitis, 1993; Brisson, 1994).

The effect of temperature on the antibacterial properties of honey and propolis is shown in the Table A 4.1 and Table A4.2.

**Table A 4.1: Comparison of Antibacterial Properties of Honey at Different Temperatures**

| Time | Mean diameter (mm) of duplicate zones of inhibition | | | |
|---|---|---|---|---|
| | Honey diluted to 28.4% (v/v) | | | |
| | RT[a] | 75° C | 85° C | 95° C |
| 1.0 hour | 9.33 | 9.17 | 7.5 | NZ[b] |
| 2.0 hour | 9.17 | 9.33 | NZ[b] | NZ[b] |

[a] RT = Room temperature
[b] NZ = No distinct zone of inhibition observed

**Table A 4.2: Comparison of Antibacterial Properties of Propolis at Different Temperatures**

| Time | Mean diameter (mm) of duplicate zones of inhibition | | | |
|---|---|---|---|---|
| | Propolis total solids 2.4% (w/w) | | | |
| | RT[a] | 85° C | 90° C | 95° C |
| 1.0 hour | 11.45 | 11.42 | 11.29 | 9.91 |
| 2.0 hour | 11.37 | 11.35 | 10.45 | 9.75 |

[a] RT = Room temperature

The antibacterial properties of the honey were not found to be stable at 95° C of the present sample. The properties were found to be fairly stable at 75° C. But antibacterial properties found in propolis were found to be stable at various temperatures.

Stabilizer blends can be used in any combination to improve the texture, functional improvement, processing advantage and cost reduction. Numbers of formulation were prepared using the different level of raw materials, such as gelatin, starch, propolis extract, manuka honey and sugar. In the beginning only one or two ingredients were varied at a

time to understand their impact on the product. Eleven trials were conducted in order to demonstrate the range of variation that normally encountered during the production runs. In the second step range setting comprised the creation of different products in which all of the variables were held constant but one was changed systematically to a range suitable to that variable. The objective of the study was to determine whether or not the change in the single variable exerted effects on the sensory characteristics of the product. Those variables were selected, which appeared to make a difference when the variables were systematically changed. These variables included sweetener level, starch level, gelatin level, die size, the type source of antibacterial properties. Manuka honey was used as a source of antibacterial agents.

In the first trial, as the temperature of the gel was dropped to the cooling temperature it started thickening and failed to deposit in the starch moulds. For commercial operations this temperature might be very low to fill the product properly in the starch moulds. Though the starch level in the trial was not sufficient to get a firm body but its combination with gelatin would give better texture. So 6% starch in the formulation was fixed as the lower limit.

The increase of starch in the formulation helped improving the hardness of the product. The product was quite hard and there was no need to make the product still harder. So 12% of starch as chosen as the upper limit for starch. But increase in filling temperature did not help to deposit the product without tailing.

The presence of gelatin in the product improved the hardness of the starch gel. It was evident that a variety of textures can be obtained by manipulating the starch and gelatin combination. The product obtained with 10% gelatin was very hard and reduction in gelatin will definitely give an improved product. Finally it was decided to keep the upper limit for gelatin at 8%.

Further increase in temperature above 80° C improved the depositing of the gel. The temperature range for cooling the gel for addition of antibacterial component before deposition was raised to 85° C-95° C. The reducing sugars in all the formulations were kept above 30% of total dissolved solids in order to retard re-crystallisation of sugar in the formulation.

To analyze the properties of jellybean centers, methods were determined during the preliminary experiments. Most of the analysis procedures were standard methods. For texture measurements, TA-$XT_2$ machine was used. A special type of cylindrical mould was made to test the texture of the centers. In the preliminary trials only hardness was used as texture attribute and later in the study five more attributes were chosen.

For testing the antibacterial properties of confectionery no method exists, but by developing a procedure for extraction of antibacterial properties in the liquid medium standard procedure could be used. The details of this method are shown in section 4.3.3.4.

Once the desired moisture level was obtained after stoving the centers for 36-39 hours it was sanded with sugar and was ready for soft panning.

The pan was loaded with 600 gms of jellybean centers and started rolling. Syrup A (Table A 4.3) was adjusted to 74% TDS and filled in a cylinder up to 52 grams. About 2/3 of this quantity was added to the pan, and allowed to distribute evenly over the entire surface area of the centers. The dry sugar was added to the pan in an amount that uniformly covered the centers. As the product rolls, the dry sugars are softened by the syrup and solubilised, throwing off unneeded moisture. At this stage another dry application of sugar was made. This process was continued until all available moisture was used, and the coating did not sweat back. Then next syrup application of 1/3 of syrup was made. Caster sugar is added regularly and enough time is allowed to mix well between the scoops. This process was repeated till 104 gms of syrup was consumed and about 380 gms of caster sugar was used

and the required weight gain has been achieved. The formulations used for soft panning are shown in Table A 4.4.

**Table A 4.3: Formulation Soft Panning Syrup A**

| Glucose syrup | Gelatine A | Crystal gum | Sugar | Water | Comments |
|---|---|---|---|---|---|
| 45 | - | 5 | 33 | 17 | Thick syrup, cracks after long storage |
| 55 | - | - | 30 | 15 | Cracks after storage, grainy texture |
| 53 | | 2 | 30 | 15 | Cracks after storage, grainy texture |
| 93 | - | - | - | 11 | Hairline cracks |
| 93 | 3 | - | - | 11 | Smooth shiny body |

**Process conditions:**

Combine sugar, water, and gums and bring to boil. Add corn syrup.

For gelatin formulation

Add 0.07 kgs of hot water and 0.93 kgs of glucose. Mix 0.03 kgs of gelatine with 0.04 kgs of water. Heat glucose and water mix, until boils. Add gelatine solution.

Total solids = 74 ± 1%.

**Formulation soft panning syrup B**

Heat 1 kg of water with 1 kg of sugar until sugar is dissolved.

Total solids = 57± 1%.

**Citric acid solution**

Take 160 grams of water and mix 9.14 grams of citric acid. Mix until dissolved.

**Yellow colour**

10 % w/v solution of tartrazine. Put 1.8 ml of yellow colour with syrup A and 0.8 ml of colour with syrup B.

### Jellybean polishing

Polishing wax: Mix equal volume of carnuba wax, beeswax and mineral oil. Thick grease like paste is formed. Use 0.2 grams of polish, just enough to wet the palms and was applied on the entire batch of jellybeans.

**Table A 4.4: Final Formulation Used in the Soft Panning Process**

| Ingredients | Quantity used per batch |
|---|---|
| Sanded jellybean centers | 600 gms |
| Soft panning syrup A | 104 gms |
| Soft panning syrup B | 18 gms |
| Vanillin alcohol 4547 | 0.9 mls |
| Tartrazine 10% solution | 2.6 ml |
| Sugar caster | 380 gms |
| Icing sugar | 75 gms |
| Polishing wax | 1.65 gms |
| Citric acid @ 5.4% (w/w) | 1.2 ml |
| Lemon flavour | 0.75 ml |
| Consumption | 1142.2 |
| % Gain over original weight | 90.36 |

## Appendix 5.1: Experimental Conditions for the 31 Trials (Response Surface Methodology)

| Ingredients | Trial Code | Formulation (%) | | | | | | | Process | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Starch | Gelatin | Antibacterial | Sucrose | Corn Syrup | Maltodextrin | Water | Holding Time | Cooling Temp. |
| Formulation 1 | 1A | 6.0 | 2.0 | 12.0 | 18 | 40 | 10.5 | 11.2 | 15 | 85 |
| | 1B | 6.0 | 2.0 | 12.0 | 18 | 40 | 10.5 | 11.2 | 15 | 85 |
| | 13 | 6.0 | 2.0 | 12.0 | 18 | 40 | 10.5 | 11.2 | 45 | 95 |
| | 22 | 6.0 | 2.0 | 12.0 | 18 | 40 | 10.5 | 11.2 | 45 | 90 |
| Formulation 2 | 15 | 12.5 | 2.0 | 15.0 | 18 | 40 | 0.9 | 11.2 | 15 | 85 |
| | 6 | 12.5 | 2.0 | 15.0 | 18 | 40 | 0.9 | 11.2 | 45 | 95 |
| Formulation 3 | 20 | 9.25 | 5.0 | 12.0 | 18 | 40 | 4.15 | 11.2 | 15 | 95 |
| Formulation 4 | 5A | 12.5 | 8.0 | 15.0 | 18 | 34.9 | - | 11.2 | 15 | 95 |
| | 5B | 12.5 | 8.0 | 15.0 | 18 | 34.9 | - | 11.2 | 15 | 95 |
| | 9 | 12.5 | 8.0 | 15.0 | 18 | 34.9 | - | 11.2 | 45 | 85 |
| Formulation 5 | 12 | 6.0 | 5.0 | 15.0 | 18 | 40 | 4.4 | 11.2 | 45 | 90 |
| Formulation 6 | 4A | 6.0 | 2.0 | 15.0 | 18 | 40 | 7.4 | 11.2 | 45 | 85 |
| | 4B | 6.0 | 2.0 | 15.0 | 18 | 40 | 7.4 | 11.2 | 45 | 85 |
| | 16 | 6.0 | 2.0 | 15.0 | 18 | 40 | 7.4 | 11.2 | 15 | 95 |
| Formulation 7 | 26 | 6.0 | 2.0 | 13.5 | 18 | 40 | 8.9 | 11.2 | 45 | 95 |

a) Code A and B indicate replicates

## Appendix 5.1 (Contd.): Experimental Conditions for the 31 Trials (Based on Response Surface Methodology)

| Ingredients | Trial Code | Formulation (%) | | | | | | | Process | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Starch | Gelatin | Antibacterial | Sucrose | Corn Syrup | Maltodextrin | Water | Holding Time | Cooling Temp. |
| Formulation 8 | 2A | 12.5 | 2.0 | 12.0 | 18 | 40 | 3.9 | 11.2 | 15 | 95 |
| | 2B | 12.5 | 2.0 | 12.0 | 18 | 40 | 3.9 | 11.2 | 15 | 95 |
| | 8 | 12.5 | 2.0 | 12.0 | 18 | 40 | 3.9 | 11.2 | 45 | 85 |
| Formulation 9 | 23 | 6.0 | 8.0 | 12.0 | 18 | 40 | 1.4 | 11.2 | 30 | 85 |
| | 11 | 6.0 | 8.0 | 12.0 | 18 | 40 | 1.4 | 11.2 | 15 | 90 |
| | 17 | 6.0 | 8.0 | 12.0 | 18 | 40 | 1.4 | 11.2 | 45 | 85 |
| Formulation 10 | 3A | 6.0 | 8.0 | 15.0 | 18 | 40 | 4.2 | 11.2 | 15 | 85 |
| | 3B | 6.0 | 8.0 | 15.0 | 18 | 40 | 4.2 | 11.2 | 15 | 85 |
| | 14 | 6.0 | 8.0 | 15.0 | 18 | 40 | 4.2 | 11.2 | 30 | 95 |
| Formulation 11 | 24 | 9.25 | 8.0 | 15.0 | 18 | 38.2 | - | 11.2 | 45 | 90 |
| Formulation 12 | 18 | 9.25 | 8.0 | 13.5 | 18 | 40 | 0.4 | 11.2 | 45 | 95 |
| | 21 | 9.25 | 8.0 | 13.5 | 18 | 40 | 0.4 | 11.2 | 30 | 90 |
| Formulation 13 | 10 | 6.0 | 5.0 | 13.5 | 18 | 40 | 5.9 | 11.2 | 15 | 95 |
| Formulation 14 | 7 | 12.5 | 8.0 | 12.0 | 18 | 37.9 | - | 11.2 | 15 | 85 |
| | 19 | 12.5 | 8.0 | 12.0 | 18 | 37.9 | - | 11.2 | 30 | 95 |
| Formulation 15 | 25 | 12.5 | 5.0 | 12.0 | 18 | 40 | 0.9 | 11.2 | 45 | 95 |

a) Code A and B indicate replicates

## Appendix 5.2: Texture Profile Analysis of Jellybeans

| Test ID[A] | Force 1 | Force 2 | Force 3 | Area-FT 1:2 | Time-diff. 1:2 | Area-FT 1:3 | Area-FT 2:3 | Area-FT 3:4 | Time-diff. 4:5 | Area-FT 4:6 | Hardness | Fractur-ability | Cohesive-ness | Springiness | Gumminess | Chewiness |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | N | N | N s | s | N s | N s | N s | s | N s | F2 | F3 | A4:6:: A1:3 | T4:5:: T1:2 | F1 × Cohesiveness | Springiness × Gumminess |
| 1A | 65.5 | 65.6 | 0.5 | 95.9 | 5 | 106.6 | 13.5 | -3.8 | 6.3 | 50.2 | 65.6 | 0.5 | 0.5 | 1.3 | 30.9 | 39.0 |
| 1B | 65.5 | 69.8 | 0.5 | 95.9 | 5 | 106.6 | 13.5 | -3.8 | 6.3 | 50.2 | 69.8 | 0.5 | 0.5 | 1.3 | 30.9 | 39.0 |
| 2A | 193.0 | 216.5 | 0.4 | 596.9 | 6 | 711.1 | 122.8 | -0.2 | 3.8 | 315.2 | 216.5 | 0.4 | 0.4 | 0.6 | 85.5 | 53.6 |
| 2B | 209.8 | 227.0 | 0.4 | 673.9 | 6 | 801.6 | 137.1 | -0.1 | 3.6 | 349.6 | 227.0 | 0.4 | 0.4 | 0.6 | 91.5 | 54.9 |
| 3A | 123.35 | 114.2 | 0.4 | 674.5 | 6 | 802.2 | 136.2 | -0.1 | 3.8 | 346.8 | 114.2 | 0.4 | 0.4 | 0.6 | 49.3 | 31.2 |
| 3B | 116.2 | 110.2 | 0.4 | 672.1 | 6 | 799.8 | 135.8 | -0.1 | 3.8 | 347.6 | 110.2 | 0.4 | 0.4 | 0.6 | 50.4 | 33.3 |
| 4A | 38.8 | 44.4 | 0.5 | 107.3 | 6 | 114.6 | 9.1 | -0.4 | 2.9 | 49.6 | 44.4 | 0.5 | 0.4 | 0.5 | 16.8 | 8.2 |
| 4B | 25.2 | 28.5 | 0.4 | 63.1 | 6 | 70.2 | 8.2 | -0.3 | 3.0 | 34.7 | 28.5 | 0.4 | 0.5 | 0.5 | 12.4 | 6.2 |
| 5A | 196.6 | 206.7 | 215.3 | 373.5 | 6 | 746.8 | 168.5 | -0.7 | 4.5 | 426.8 | 206.7 | 0.4 | 1.0 | 0.7 | 112.06 | 84.0 |
| 5B | 219.1 | 238.6 | 0.4 | 565.8 | 6 | 717.9 | 161.6 | -0.7 | 4.4 | 388.3 | 238.6 | 0.4 | 0.5 | 0.7 | 118.5 | 87.7 |
| 6 | 167.0 | 183.1 | 0.4 | 280.5 | 5 | 341.3 | 68.2 | -5.1 | 3.8 | 154.5 | 183.1 | 0.4 | 0.5 | 0.8 | 75.6 | 56.8 |
| 7 | 225.2 | 222.6 | 0.4 | 255.1 | 5 | 305.5 | 61.2 | -3.8 | 3.3 | 142.8 | 222.6 | 0.4 | 0.5 | 1.0 | 112.6 | 112.8 |
| 8 | 133.8 | 146.5 | 0.4 | 252.1 | 5 | 306.5 | 60.3 | -3.7 | 3.3 | 142.2 | 146.5 | 0.4 | 0.5 | 0.7 | 62.0 | 40.7 |
| 9 | 190.0 | 211.6 | 0.3 | 287.6 | 6 | 361.4 | 78.7 | -0.3 | 4.8 | 108.4 | 211.6 | 0.3 | 0.3 | 0.8 | 57.0 | 52.8 |
| 10 | 41.9 | 47.5 | 0.3 | 129.8 | 6 | 142.9 | 15.0 | -0.3 | 3.3 | 62.3 | 47.5 | 0.3 | 0.4 | 0.5 | 18.3 | 10.0 |
| 11 | 107.6 | 112.2 | 0.4 | 208.5 | 6 | 362.6 | 42.5 | -0.3 | 3.3 | 109.4 | 112.2 | 0.3 | 0.3 | 1.0 | 32.5 | 32.3 |
| 12 | 59.8 | 61.2 | 0.4 | 209.4 | 6 | 802.2 | 43.5 | -0.3 | 4.0 | 320.8 | 61.2 | 0.4 | 0.4 | 0.7 | 23.9 | 15.8 |
| 13 | 31.5 | 37.0 | 0.4 | 208.8 | 6 | 692.5 | 168.0 | -5.3 | 6.0 | 373.5 | 37.0 | 0.4 | 0.5 | 1.0 | 17.0 | 17.0 |
| 14 | 101.7 | 114.0 | 0.4 | 113.9 | 5 | 124.5 | 13.1 | -5.1 | 2.8 | 39.9 | 114.0 | 0.4 | 0.3 | 0.6 | 32.5 | 18.0 |
| 15 | 210.0 | 213.2 | 0.4 | 85.4 | 6 | 151.5 | 8.8 | 0.0 | 4.2 | 42.6 | 213.2 | 0.4 | 0.3 | 0.7 | 59.0 | 41.3 |
| 16 | 30.0 | 34.0 | 0.4 | 184.8 | 4 | 219.1 | 38.9 | -0.5 | 2.7 | 113.8 | 34.0 | 0.4 | 0.5 | 0.7 | 15.6 | 10.4 |
| 17 | 116.5 | 120.8 | 0.4 | 241.4 | 5 | 300.0 | 64.1 | -3.6 | 7.5 | 149.2 | 120.8 | 0.4 | 0.5 | 1.5 | 57.9 | 86.7 |

a) Code A and B indicates replicates

## Appendix 5.2 (Contd.): Texture Profile Analysis of Jellybeans

| Test ID | Force 1 | Force 2 | Force 3 | Area-FT 1:2 | Time-diff. 1:2 | Area-FT 1:3 | Area-FT 2:3 | Area-FT 3:4 | Time-diff. 4:5 | Area-FT 4:6 | Hardness | Fracturability | Cohesiveness | Springiness | Gumminess | Chewiness |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | N | N | N s | s | N s | N s | N s | s | N s | F2 | F3 | A4:6:: A1;3 | T4:5:: T1:2 | F1 × Cohesiveness | Springiness × Gumminess |
| 20 | 149.4 | 164.6 | 0.4 | 156.3 | 6 | 183.2 | 29.7 | -1.7 | 3.9 | 99.1 | 164.6 | 0.4 | 0.5 | 0.6 | 80.8 | 52.3 |
| 21 | 211.5 | 216.9 | 0.2 | 501.3 | 6 | 591.5 | 97.7 | -0.3 | 3.9 | 205.1 | 216.9 | 0.2 | 0.3 | 0.7 | 73.3 | 47.9 |
| 22 | 24.8 | 28.7 | 0.3 | 402.6 | 6 | 481.8 | 85.9 | -0.8 | 3.8 | 241.2 | 28.7 | 0.3 | 0.5 | 0.6 | 12.4 | 7.9 |
| 23 | 95.7 | 106.6 | 0.4 | 422.1 | 6 | 504.7 | 89.7 | -0.7 | 3.8 | 250.1 | 106.6 | 0.4 | 0.5 | 0.6 | 47.4 | 30.0 |
| 24 | 193.1 | 210.2 | 0.4 | 74.5 | 6 | 233.0 | 43.2 | -0.3 | 3.6 | 116.6 | 210.2 | 0.4 | 0.5 | 0.6 | 96.6 | 58.0 |
| 25 | 196.2 | 211.5 | 0.3 | 287.6 | 6 | 398.5 | 78.7 | -0.3 | 4.3 | 108.4 | 211.5 | 0.3 | 0.3 | 0.7 | 53.4 | 38.0 |
| 26 | 38.8 | 44.4 | 0.5 | 107.3 | 5 | 114.6 | 9.1 | -0.4 | 6.9 | 49.6 | 44.4 | 0.5 | 0.4 | 1.4 | 16.8 | 23.2 |

## Appendix 5.3: Analysis of Raw Materials

Moisture Content of Moulding Starch

| Date | Tray No. | % Moisture |
|---|---|---|
| 04.01.99 | 1 | 5.42 ± 0.15 |
| 04.01.99 | 2 | 5.51± 0.04 |
| 04.01.99 | 3 | 5.44± 0.10 |
| 04.01.99 | 4 | 5.65 ± 0.05 |
| 18.01.99 | 1 | 6.42 ± 0.08 |
| 18.01.99 | 2 | 6.73 ± 0.05 |
| 18.01.99 | 3 | 6.69 ± 0.13 |
| 18.01.99 | 4 | 6.45 ± 0.04 |
| 05.02.99 | 1 | 5.48 ± 0.17 |
| 05.02.99 | 2 | 5.75 ± 0.08 |
| 05.02.99 | 3 | 5.57 ± 0.11 |
| 05.02.99 | 4 | 5.69 ± 0.07 |
| 20.02.99 | 1 | 6.65 ± 0.08 |
| 20.02.99 | 2 | 6.75 ± 0.04 |
| 20.02.99 | 3 | 6.86 ± 0.11 |
| 20.02.99 | 4 | 6.65 ± 0.05 |
| 09.03.99 | 1 | 6.14 ± 0.14 |
| 09.03.99 | 2 | 6.48 ± 0.07 |
| 09.03.99 | 3 | 5.95 ± 0.08 |
| 09.03.99 | 4 | 5.87 ± 0.06 |

Note: When moisture of starch was more than 6.5% it was put in oven at 65-70° C for 4-5 hours to reduce to around 5%

## Appendix 5.4: The Physical Attributes of the Prototypes

| Ingredients | Trial Code | % Syrup solids | % Total solids | Degree of cook Fragments/field | % Total sugar | Colour | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | L* | a* | b* | ΔE* |
| Formulation 1 | 1A | 71.3 ± 0.2 | 86.8 ± 0.3 | 7-8 | 43.2 | 48.25 | -5.32 | 31.63 | 57.9 |
| | 1B | 71.8 ± 0.3 | 86.4 ± 0.4 | 7-8 | 42.3 | 49.10 | -5.65 | 32.38 | 59.1 |
| | 13 | 70.5 ± 0.2 | 87.1 ± 0.2 | 5-6 | 42.1 | 48.74 | -5.52 | 32.62 | 58.9 |
| | 22 | 72.0 ± 0.1 | 86.9 ± 0.3 | 5-6 | 43.5 | 48.23 | -5.36 | 33.16 | 58.8 |
| Formulation 2 | 15 | 71.7 ± 0.3 | 86.4 ± 0.2 | 14-15 | 43.5 | 40.42 | -3.55 | 25.16 | 47.7 |
| | 6 | 71.4 ± 0.2 | 87.2 ± 0.3 | 11-12 | 43.2 | 38.87 | -3.10 | 22.69 | 45.1 |
| Formulation 3 | 20 | 71.5 ± 0.2 | 87.3 ± 0.2 | 8-9 | 42.1 | 47.87 | -5.61 | 34.16 | 59.1 |
| Formulation 4 | 5A | 70.5 ± 0.4 | 86.5 ± 0.3 | 15-16 | 41.8 | 42.14 | -2.85 | 22.73 | 48.0 |
| | 5B | 71.8 ± 0.2 | 86.9 ± 0.2 | 15-16 | 41.6 | 41.58 | -3.05 | 23.31 | 47.8 |
| | 9 | 71.5 ± 0.1 | 86.1 ± 0.2 | 13-14 | 41.6 | 40.86 | -3.55 | 24.16 | 47.6 |
| Formulation 5 | 12 | 70.7 ± 0.2 | 87.4 ± 0.1 | 5-6 | 44.3 | 41.23 | -3.15 | 24.64 | 48.1 |
| Formulation 6 | 4A | 71.6 ± 0.2 | 88.0 ± 0.1 | 5-6 | 44.8 | 42.42 | -4.15 | 23.68 | 48.8 |
| | 4B | 71.5 ± 0.3 | 87.6 ± 0.3 | 5-6 | 44.6 | 40.25 | -3.87 | 22.25 | 46.2 |
| | 16 | 71.2 ± 0.2 | 88.4 ± 0.2 | 5-6 | 44.8 | 40.42 | -3.35 | 25.17 | 47.7 |
| Formulation 7 | 26 | 71.4 ± 0.1 | 86.4 ± 0.1 | 5-6 | 44.1 | 45.12 | -4.55 | 26.68 | 52.6 |

## Appendix 5.4 (Contd.): The Physical Attributes of the Prototypes

| Ingredients | Trial Code | % Syrup solids | Degree of Cook Fragments/field | % Total solids | % Total sugar | Colour | | | ΔE |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | L* | a* | b* | |
| Formulation 8 | 2A | 71.7 ± 0.2 | 16-17 | 87.4 ± 0.2 | 41.9 | 49.27 | -5.22 | 35.47 | 60.9 |
| | 2B | 70.5 ± 0.2 | 16-17 | 86.9 ± 0.2 | 42.1 | 48.87 | -5.16 | 37.16 | 61.6 |
| | 8 | 70.8 ± 0.2 | 13-14 | 87.8 ± 0.2 | 40.9 | 49.58 | -5.56 | 36.76 | 62.0 |
| Formulation 9 | 23 | 71.5 ± 0.2 | 5-6 | 86.9 ± 0.2 | 41.5 | 49.67 | -5.02 | 35.87 | 61.5 |
| | 11 | 71.3 ± 0.2 | 6-7 | 86.8 ± 0.2 | 40.6 | 48.17 | -5.06 | 36.14 | 60.4 |
| | 17 | 71.8 ± 0.2 | 5-6 | 87.7 ± 0.2 | 40.4 | 48.48 | -5.19 | 35.71 | 60.4 |
| Formulation 10 | 3A | 72.3 ± 0.2 | 7-8 | 88.0 ± 0.2 | 44.2 | 41.47 | -3.55 | 25.6 | 48.9 |
| | 3A | 71.5 ± 0.2 | 8-9 | 86.4 ± 0.2 | 44.2 | 42.25 | -3.55 | 25.6 | 49.5 |
| | 14 | 70.9 ± 0.2 | 6-7 | 87.3 ± 0.2 | 43.5 | 42.48 | -3.55 | 25.6 | 49.7 |
| Formulation 11 | 24 | 70.7 ± 0.2 | 8-9 | 86.9 ± 0.2 | 42.7 | 40.35 | -3.55 | 25.6 | 47.9<br>0.0 |
| Formulation 12 | 18 | 71.4 ± 0.2 | 8-9 | 87.6 ± 0.2 | 42.4 | 46.22 | -4.35 | 28.4 | 54.4 |
| | 21 | 71.8 ± 0.2 | 9-10 | 86.8 ± 0.2 | 41.5 | 46.76 | -4.51 | 27.9 | 54.6 |
| Formulation 13 | 10 | 71.2 ± 0.2 | 5-6 | 86.4 ± 0.2 | 43.3 | 49.53 | -5.72 | 36.18 | 61.6 |
| Formulation 14 | 7 | 71.4 ± 0.2 | 14-15 | 86.7 ± 0.2 | 40.5 | 47.88 | -5.32 | 36.77 | 60.6 |
| | 19 | 71.0 ± 0.2 | 13-14 | 86.8 ± 0.2 | 40.2 | 48.67 | -5.12 | 36.33 | 60.9 |
| Formulation 15 | 25 | 71.1 ± 0.2 | 13-14 | 86.6 ± 0.2 | 41.4 | 49.67 | -4.92 | 35.94 | 61.5 |

## Appendix 5.5: Coefficients of Estimated Quadratic Models for the Parameters of Zones of Inhibition, Gumminess, Hardness and Chewiness

| Variables | Coefficients | Zones | Gumminess | Hardness | Chewiness |
|---|---|---|---|---|---|
| CONSTANT | $\beta_0$ | 2.91 | 4.08 | 4.99 | 3.25 |
| Starch | $\beta_1$ | -0.24 | 17.36 | 17.25 | 16.27 |
| Gelatin | $\beta_2$ | 0.09 | 8.18 | 9.37 | 10.05 |
| Time | $\beta_3$ | 0.00 | -0.01 | -0.00 | -0.00 |
| Cold temperature | $\beta_4$ | -0.01 | -0.00 | -0.00 | -0.00 |
| Antibacterial agent | $\beta_5$ | 4.02 | -0.82 | -2.37 | -6.21 |
| Starch * Gelatin | $\beta_{12}$ | -10.17 | -97.50 | -183.16 | 39.46 |
| Starch * Time | $\beta_{13}$ | 0.01 | -0.07 | -0.04 | -0.15 |
| Starch * Cold temperature | $\beta_{14}$ | 0.00 | 0.61 | 0.36 | 0.94 |
| Starch * Antibacteria | $\beta_{15}$ | 18.95 | -39.37 | 70.73 | 111.34 |
| Gelatin * Time | $\beta_{23}$ | -0.00 | -0.04 | 0.18 | -0.06 |
| Gelatin * Cold temperature | $\beta_{24}$ | 0.05 | -0.27 | 0.11 | -0.15 |
| Gelatin * Antibacteria | $\beta_{25}$ | 2.00 | 165.69 | 119.08 | 41.74 |
| Time * Cold temperature | $\beta_{34}$ | -2.66e-005 | 0.00 | 0.00 | 0.00 |
| Time * Antibacteria | $\beta_{35}$ | 0.006 | 0.29 | 0.16 | 0.45 |
| Cold temp. * Antibacteria | $\beta_{45}$ | -0.25 | 0.93 | -0.02 | 1.43 |
| Starch * Starch | $\beta_{11}$ | 9.59 | -561.33 | -238.43 | -312.39 |
| Gelatin * Gelatin | $\beta_{22}$ | 7.26 | 86.42 | 68.09 | 232.09 |
| Time * Time | $\beta_{33}$ | 8.42e-005 | -0.00 | -0.00 | 0.00 |
| Coldtemp * Coldtemp | $\beta_{44}$ | 0.00 | 0.01 | -0.00 | 0.01 |
| Antibacteria * Antibacteria | $\beta_{55}$ | 100.56 | 710.55 | 134.41 | 652.17 |
| $R^2$ | | 0.973*** | 0.976*** | 0.983*** | 0.842 (P= 0.0567) |

Response $Y = \beta_0 + \beta_1$ (Starch) + $\beta_2$ (Gelatin) + $\beta_3$ (Time) + $\beta_4$ (Cold temperature) + $\beta_5$ (Antibacterial agent) $\beta_{12}$ (Starch * Gelatin) + $\beta_{13}$ (Starch * Time) + $\beta_{14}$ (Starch * Cold temperature) + $\beta_{15}$ (Starch * Antibacteria) + $\beta_{23}$ (Gelatin * Time) + $\beta_{24}$ (Gelatin * Cold temperature) + $\beta_{25}$ (Gelatin * Antibacteria) + $\beta_{34}$ (Time * Cold temperature) + $\beta_{35}$ (Time * Antibacteria) + $\beta_{45}$ (Cold temp. * Antibacteria) + $\beta_{11}$ (Starch$^2$) + $\beta_{22}$ (Gelatin$^2$) + $\beta_{33}$ (Time$^2$) + $\beta_{44}$ (Coldtemp$^2$) + $\beta_{55}$ (Antibacteria$^2$)

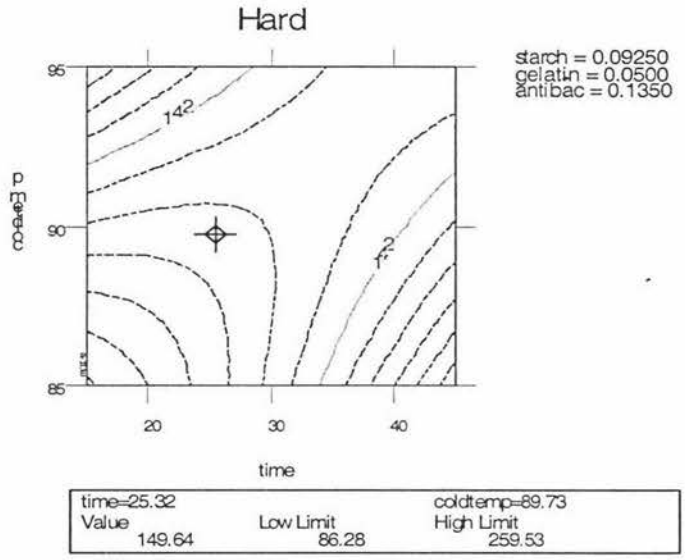
Where, Y = Zones of inhibition or Gumminess or Hardness or Chewiness

* ~ $0.05 < P \leq 0.1$

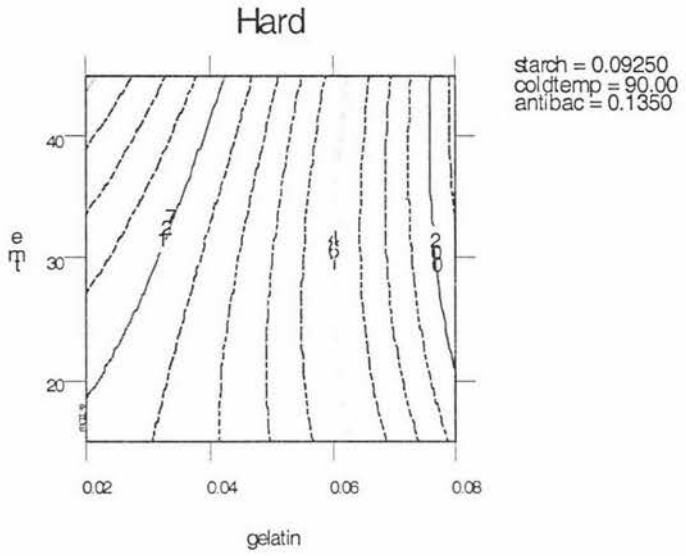
** ~ $0.01 < P \leq 0.05$

*** ~ $< P \leq 0.01$

## Appendix 5.6: Variables Affecting the Product Attributes

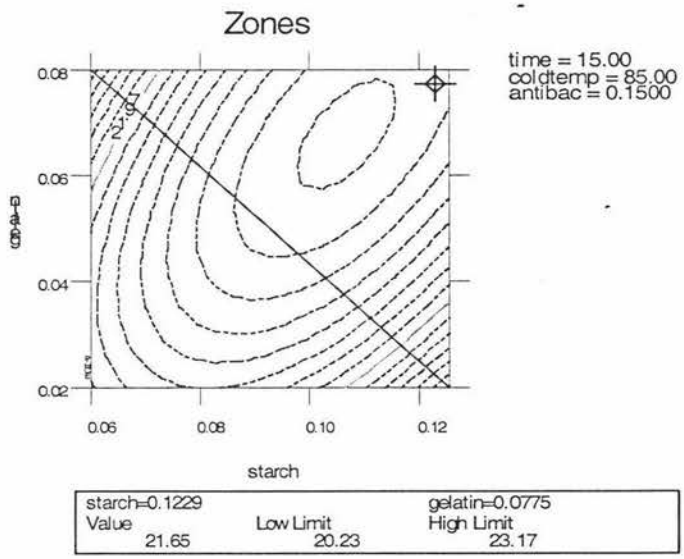



**Contour Plot for Hardness Showing Interaction between Holding Time and Cooling Temperature**




**Contour Plot for Hardness Showing Interaction between Gelatin and Holding Time**

# Appendix 5.6 (Contd.): Variables Affecting the Product Attributes




**Contour Plot for Zones of Inhibition Showing Interaction between Starch and Gelatine**

## Appendix 5.7: Cost of Jellybeans Centres for Each Formulation Based on Major Ingredients

| Ingredients | Product Code[10] | Starch (kg) | Gelatin (kg) | Antibacterial (kg) | Sugar (kg) | Corn syrup (kg) | Maltodextrin (kg) | Water (kg) | Total cost ($) | Total solids | Finshed product | Cost ($/kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Formulation 1 | 1A | 6 | 2 | 12 | 18 | 40 | 10.5 | 11.2 | 729.7 | 76.9 | 83.0 | 8.8 |
| | 1B | 6 | 2 | 12 | 18 | 40 | 10.5 | 11.2 | 729.7 | 76.9 | 83.0 | 8.8 |
| | 13 | 6 | 2 | 12 | 18 | 40 | 10.5 | 11.2 | 729.7 | 76.9 | 83.0 | 8.8 |
| | 22 | 6 | 2 | 12 | 18 | 40 | 10.5 | 11.2 | 729.7 | 76.9 | 83.0 | 8.8 |
| Formulation 2 | 15 | 12.5 | 2 | 15 | 18 | 40 | 0.9 | 11.2 | 898.7 | 76.0 | 82.1 | 11.0 |
| | 6 | 12.5 | 2 | 15 | 18 | 40 | 0.9 | 11.2 | 898.7 | 76.0 | 82.1 | 11.0 |
| Formulation 3 | 20 | 9.25 | 5 | 12 | 18 | 40 | 4.15 | 11.2 | 786.6 | 76.6 | 82.7 | 9.5 |
| Formulation 4 | 5A | 12.5 | 8 | 15 | 18 | 34.9 | 0 | 11.2 | 993.8 | 76.8 | 82.9 | 12.0 |
| | 5B | 12.5 | 8 | 15 | 18 | 34.9 | 0 | 11.2 | 993.8 | 76.8 | 82.9 | 12.0 |
| | 9 | 12.5 | 8 | 15 | 18 | 34.9 | 0 | 11.2 | 993.8 | 76.8 | 82.9 | 12.0 |
| Formulation 5 | 12 | 6 | 5 | 15 | 18 | 40 | 4.4 | 11.2 | 924.3 | 76.3 | 82.4 | 11.2 |
| Formulation 6 | 4A | 6 | 2 | 15 | 18 | 40 | 7.4 | 11.2 | 877.8 | 76.3 | 82.4 | 10.7 |
| | 4B | 6 | 2 | 15 | 18 | 40 | 7.4 | 11.2 | 877.8 | 76.3 | 82.4 | 10.7 |
| | 16 | 6 | 2 | 15 | 18 | 40 | 7.4 | 11.2 | 877.8 | 76.3 | 82.4 | 10.7 |
| Formulation 7 | 26 | 6 | 2 | 13.5 | 18 | 40 | 8.9 | 11.2 | 803.7 | 76.6 | 82.6 | 9.7 |

[10]Code A and B indicate replicates

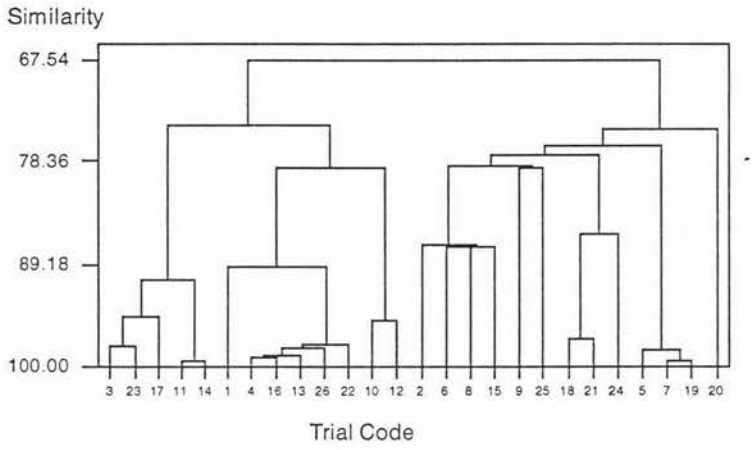
## Appendix 5.7(Contd.): Cost of Jellybeans Centres for Each Formulation Based on Major Ingredients

| Ingredients | Product code[10] | Starch (kg) | Gelatin (kg) | Antibacterial (kg) | Sugar (kg) | Corn syrup (kg) | Maltodextrin (kg) | Water (kg) | Total cost ($) | Total solids | Finshed product | Cost ($/kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Formulation 8 | 2A | 12.5 | 2 | 12 | 18 | 40 | 3.9 | 11.2 | 750.5 | 76.5 | 82.5 | 9.1 |
| | 2B | 12.5 | 2 | 12 | 18 | 40 | 3.9 | 11.2 | 750.5 | 76.5 | 82.5 | 9.1 |
| | 8 | 12.5 | 2 | 12 | 18 | 40 | 3.9 | 11.2 | 750.5 | 76.5 | 82.5 | 9.1 |
| Formulation 9 | 23 | 6 | 8 | 12 | 18 | 40 | 1.4 | 11.2 | 819.0 | 73.9 | 79.8 | 10.3 |
| | 11 | 6 | 8 | 12 | 18 | 40 | 1.4 | 11.2 | 819.0 | 73.9 | 79.8 | 10.3 |
| | 17 | 6 | 8 | 12 | 18 | 40 | 1.4 | 11.2 | 819.0 | 73.9 | 79.8 | 10.3 |
| Formulation 10 | 3A | 6 | 8 | 15 | 18 | 40 | 4.2 | 11.2 | 974.2 | 79.0 | 85.3 | 11.4 |
| | 3A | 6 | 8 | 15 | 18 | 40 | 4.2 | 11.2 | 974.2 | 79.0 | 85.3 | 11.4 |
| | 14 | 6 | 8 | 15 | 18 | 40 | 4.2 | 11.2 | 974.2 | 79.0 | 85.3 | 11.4 |
| Formulation 11 | 24 | 9.25 | 8 | 15 | 18 | 38.2 | 0 | 11.2 | 982.0 | 76.5 | 82.6 | 11.9 |
| Formulation 12 | 18 | 9.25 | 8 | 13.5 | 18 | 40 | 0.4 | 11.2 | 908.1 | 77.1 | 83.2 | 10.9 |
| | 21 | 9.25 | 8 | 13.5 | 18 | 40 | 0.4 | 11.2 | 908.1 | 77.1 | 83.2 | 10.9 |
| Formulation 13 | 10 | 6 | 5 | 13.5 | 18 | 40 | 5.9 | 11.2 | 850.2 | 76.6 | 82.6 | 10.3 |
| Formulation 14 | 7 | 12.5 | 8 | 12 | 18 | 37.9 | 0 | 11.2 | 844.4 | 76.8 | 82.9 | 10.2 |
| | 19 | 12.5 | 8 | 12 | 18 | 37.9 | 0 | 11.2 | 844.4 | 76.8 | 82.9 | 10.2 |
| Formulation 15 | 25 | 12.5 | 5 | 12 | 18 | 40 | 0.9 | 11.2 | 797.0 | 76.5 | 82.5 | 9.7 |

[10]Code A and B indicate replicates

## Appendix 6.1: Cluster Analysis of Different Product Formulations

Dendrogram for Nutraceutical Jellybean Formulation



## Appendix 6.1 (Contd.): Cluster Analysis of Different Product Formulations

| Trial Code | Hardness | Gumminess | Starch | Gelatin | Group ID | Cost ($) /100 kg | Screening similar samples by Cost | Similar Samples by Temp > 90 C | Product Code |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 67.7 | 30.9 | 6.0 | 2.0 | 2 | 729.7 | 2 | - | - |
| 2 | 221.7 | 88.5 | 12.5 | 2.0 | 4 | 750.5 | 4 | 4 | D |
| 3 | 112.2 | 49.9 | 6.0 | 8.0 | 1 | 974.2 | - | - | - |
| 4 | 36.4 | 14.6 | 6.0 | 2.0 | 2 | 877.8 | - | - | - |
| 5 | 222.6 | 115.3 | 12.5 | 8.0 | 7 | 993.8 | - | - | - |
| 6 | 183.1 | 75.6 | 12.5 | 2.0 | 4 | 898.7 | - | - | - |
| 7 | 222.6 | 112.6 | 12.5 | 8.0 | 7 | 844.4 | 7 | - | - |
| 8 | 146.5 | 62.0 | 12.5 | 2.0 | 4 | 750.5 | 4 | - | - |
| 9 | 211.6 | 57.0 | 12.5 | 8.0 | 5 | 993.8 | - | - | - |
| 10 | 47.5 | 18.3 | 6.0 | 5.0 | 3 | 850.2 | 3 | 3 | G |
| 11 | 112.2 | 32.5 | 6.0 | 8.0 | 1 | 819.0 | 1 | 1 | C |
| 12 | 61.2 | 23.9 | 6.0 | 5.0 | 3 | 924.3 | - | - | - |
| 13 | 37.0 | 17.0 | 6.0 | 2.0 | 2 | 729.7 | 2 | 2 | E |
| 14 | 114.0 | 32.5 | 6.0 | 8.0 | 1 | 974.2 | - | - | - |
| 15 | 213.2 | 59.0 | 12.5 | 2.0 | 4 | 898.7 | - | - | - |
| 16 | 34.0 | 15.6 | 6.0 | 2.0 | 2 | 877.8 | - | - | - |
| 17 | 120.8 | 57.9 | 6.0 | 8.0 | 1 | 819.0 | 1 | - | - |
| 18 | 210.2 | 69.3 | 9.25 | 8.0 | 6 | 908.1 | 6 | 6 | B |
| 19 | 220.6 | 112.6 | 12.5 | 8.0 | 7 | 844.4 | 7 | 7 | F |
| 20 | 164.6 | 80.8 | 9.25 | 5.0 | 8 | 786.6 | 8 | 8 | A |
| 21 | 216.9 | 73.3 | 9.25 | 8.0 | 6 | 908.1 | 6 | - | - |
| 22 | 28.7 | 12.4 | 6.0 | 2.0 | 2 | 729.7 | 2 | - | - |
| 23 | 106.6 | 47.4 | 6.0 | 8.0 | 1 | 819.0 | 1 | - | - |
| 24 | 210.2 | 96.6 | 9.25 | 8.0 | 6 | 982.0 | - | - | - |
| 25 | 211.6 | 53.4 | 12.5 | 5.0 | 5 | 797.0 | 5 | 5 | H |
| 26 | 44.4 | 16.8 | 6.0 | 2.0 | 2 | 803.7 | - | - | - |

**Appendix 6.2: Questionnaire for the Consumer panel**

## Nutraceutical Confectionery Product (Centres)

### Dear Panelists

I am a postgraduate student in The Institute of Food Nutrition and Human Health, Massey University; I am conducting a consumer test on a nutraceutical confectionery product. This product has derived the antibacterial properties from manuka honey and propolis. Both of these products have been shown to have potent antibacterial properties in laboratory tests. Studies have proved that honey and propolis have antibacterial properties against a wide spectrum of bacteria and fungus causing sore throat, stomach ulcers and dermatitis. The quantity of honey and propolis used in the product is sufficient to stop the growth of these bacteria. Moreover, the preliminary testing of the finished product has shown antibacterial properties against test organisms.

Ms. Carol Pound and Ms. Lisa Duizer are jointly supervising this project. For any queries, please feel free to contact them at 350-4399 in the normal working hours.

I would like to know what you think about the honey-propolis confectionery. If you would like to help me with my study, please turn the page and follow the instructions.

You are required to taste 4 products in the first session and four samples in second session. It is most important that you taste **ALL 8 SAMPLES**. After tasting the second set of samples you will be given a $ 10.00 gift voucher to compensate for your time and efforts.

Thank you for your help.

**Dinesh Sofat**

**Postgraduate student**

**SESSION-1.**

**PART-I. Overall liking**

INSTRUCTIONS:

1. PLEASE RINSE YOUR MOUTH WITH PLAIN WATER BEFORE TASTING.
2. EVALUATE THE PRODUCTS BY LOOKING AT AND TASTING THEM.

**Overall liking**

Consider all characteristics and indicate your overall opinion by giving a score to each sample that reflects your liking of the product.

1 = Dislike extremely, 2 = Dislike very much, 3 = Dislike moderately, 4 = Dislike slightly
5 = Neither like or dislike, 6 = Like slightly, 7 = Like moderately, 8 = Like very much,
9 = Like extremely

Using the scale above, mark your **overall liking** for each sample in the space besides the appropriate sample numbers.

| Sample no. | Overall Liking |
|---|---|
| 614 | |
| 189 | |
| 326 | |
| 911 | |

- Comments: Please indicate WHAT in particular you Liked or Disliked about these products? (USE WORDS NOT SENTENCES.)

| Sample no. | Liked | Disliked |
|---|---|---|
| 614 | | |
| 189 | | |
| 326 | | |
| 911 | | |

**PART-II. PRODUCT CHARACTERISTICS**

**TEXTURE**

1. Using the 1-9 scale as shown on page-1, indicate how much you **like the texture** of the sample?

| Sample no. | Liking of the Texture |
|---|---|
| 614 | |
| 189 | |
| 326 | |
| 911 | |

## FLAVOUR

1. Using the 1-9 scale as shown on the previous page, indicate how much you **like the Sweetness** of the sample?

| Sample no. | Liking of the sweetness |
|---|---|
| 614 | |
| 189 | |
| 326 | |
| 911 | |

2. What is your opinion of the **sweetness**?

| Sample | Not sweet enough | | Just Right | | Too sweet |
|---|---|---|---|---|---|
| 614 | ❒ | ❒ | ❒ | ❒ | ❒ |
| 189 | ❒ | ❒ | ❒ | ❒ | ❒ |
| 326 | ❒ | ❒ | ❒ | ❒ | ❒ |
| 911 | ❒ | ❒ | ❒ | ❒ | ❒ |

3. Using the 1-9 scale as shown on page-1, Overall, how do you feel about the **overall flavour** of the product?

| Sample no. | Liking of the overall flavour | Comments |
|---|---|---|
| 614 | | |
| 189 | | |
| 326 | | |
| 911 | | |

SESSION-1. ENDS

## Appendix 6.2 (Contd.): Questionnaire for the Consumer panel

### Nutraceutical Confectionery Product (Centres)

**Dear Panelists**

Thanks for returning to complete the other 4 samples. Just to refresh your memory:
I am a postgraduate student in The Institute of Food Nutrition and Human Health, Massey University; I am conducting a consumer test on a nutraceutical confectionery product. This product has derived the antibacterial properties from manuka honey and propolis. Both of these products have been shown to have potent antibacterial properties in laboratory tests. Studies have proved that honey and propolis have antibacterial properties against a wide spectrum of bacteria and fungus causing sore throat, stomach ulcers and dermatitis. The quantity of honey and propolis used in the product is sufficient to stop the growth of these bacteria. Moreover, the preliminary testing of the finished product has shown antibacterial properties against test organisms.

Ms. Carol Pound and Ms. Lisa Duizer are jointly supervising this project. For any queries, please feel free to contact them at 350-4399 in the normal working hours.

After you have completed the survey form you will receive your $ 10.00 voucher.

Thank you for your help.

**Dinesh Sofat**

**Postgraduate student**

SESSION-1I.

**PART-I. Overall liking**

INSTRUCTIONS:

1. PLEASE RINSE YOUR MOUTH WITH PLAIN WATER BEFORE TASTING.
2. EVALUATE THE PRODUCTS BY LOOKING AT AND TASTING THEM.

**Overall liking**

Consider all characteristics and indicate your overall opinion by giving a score to each sample that reflects your liking of the product.

1 = Dislike extremely, 2 = Dislike very much, 3 = Dislike moderately, 4 = Dislike slightly
5 = Neither like or dislike, 6 = Like slightly, 7 = Like moderately, 8 = Like very much,
9 = Like extremely

Using the scale above, mark your **overall liking** for each sample in the space besides the appropriate sample numbers.

| Sample no. | Overall Liking |
|---|---|
| 416 | |
| 918 | |
| 632 | |
| 191 | |

- Comments: Please indicate WHAT in particular you Liked or Disliked about these products? (USE WORDS NOT SENTENCES.)

| Sample no. | Liked | Disliked |
|---|---|---|
| 416 | | |
| 918 | | |
| 632 | | |
| 191 | | |

**PART-II. PRODUCT CHARACTERISTICS**

**TEXTURE**

1. Using the 1-9 scale as shown on page-1, indicate how much you **like the texture** of the sample?

| Sample no. | Liking of the Texture |
|---|---|
| 416 | |
| 918 | |
| 632 | |
| 191 | |

FLAVOUR

1. Using the 1-9 scale as shown on the previous page, indicate how much you **like the Sweetness** of the sample?

| Sample no. | Liking of the sweetness |
|---|---|
| 416 | |
| 918 | |
| 632 | |
| 191 | |

2. What is your opinion of the **sweetness**?

| Sample | Not sweet enough | | Just Right | | Too sweet |
|---|---|---|---|---|---|
| 416 | ❑ | ❑ | ❑ | ❑ | ❑ |
| 918 | ❑ | ❑ | ❑ | ❑ | ❑ |
| 632 | ❑ | ❑ | ❑ | ❑ | ❑ |
| 191 | ❑ | ❑ | ❑ | ❑ | ❑ |

3. Using the 1-9 scale as shown on page-1, Overall, how do you feel about the **overall flavour** of the product?

| Sample no. | Liking of the overall flavour | Comments |
|---|---|---|
| 416 | | |
| 918 | | |
| 632 | | |
| 191 | | |

## PART-III. CONFECTIONERY PRODUCT IN GENERAL

The following questions are about the perception of the product. Please tick your choices (√).

1. Do you think the CONFECTIONERY PRODUCT will effectively stop bacterial growth?

   ❒ It would definitely work
   ❒ It would probably work
   ❒ It might or might not work
   ❒ It would probably not work
   ❒ It would definitely not work

2. Do you see this product as:

   ❒ A medical product taken when need be
   ❒ A preventive product taken in danger period only
   ❒ A preventive product taken all the time
   ❒ A confectionery product with added benefits
   ❒ A confectionery product

3. The CONFECTIONERY PRODUCT may have antibacterial properties and will likely to cost $ 2.50/100 gram. Please indicate your opinion about the price, considering market price of the regular confectionery product $ 1.50/ 100 gram?

| Too Low | | Just Right | | Too High |
|---|---|---|---|---|
| ❒ | ❒ | ❒ | ❒ | ❒ |

4. If the cost of the CONFECTIONERY PRODUCT $ 2.50/100 gram, how likely are you to buy it?

- ❒ Definitely buy
- ❒ Probably buy
- ❒ Might or might not buy
- ❒ Probably not buy
- ❒ Definitely not buy

5. If the price of the CONFECTIONERY PRODUCT were $ 2.50/100gram, how often do you think you would eat the CONFECTIONERY PRODUCT that may have antibacterial properties?

- ❒ More than once a week
- ❒ Once a week
- ❒ Once a fortnight
- ❒ Once a month
- ❒ Less than once a month

**PART IV.**

The following questions are about you. Everything written in this survey is confidential. The questions are purely asked to indicate the type of consumer who has been surveyed. Please tick your choices (√ ).

Personal details

1. Gender
   - ❒ Male
   - ❒ Female

   Age group
   - ❒ Under 20 years
   - ❒ 21-30 years
   - ❒ 31-40 years
   - ❒ 41-50 years
   - ❒ Above 50 years

2. How often do you eat non-chocolate confectionery products?

- ❒ More than once a week
- ❒ Once a week
- ❒ Once a fortnight
- ❒ Once a month
- ❒ Less than once a month

3. Do you use lozenges/throat products for sore throat?

   ❒ Yes
   ❒ No

4. Do you use mints for bad breath?

   ❒ Yes
   ❒ No

5. Please indicate if you have taken the services of a doctor during the last 12 months for complaints of common cold/bad breath/sore throat/stomach ulcer/other mouth and stomach problems.

   ❒ Yes
   ❒ No

**Please check that you have answered all the questions. Thank you very much for your time and assistance.**

## Appendix 6.3: Questionnaire Used for Training the Panelists

### Day-2.

Objective: To train panelists on hardness, chewiness and springiness

Tests:

Hardness Definition:
Place the sample between molars and bite down evenly, evaluating force required to compress between molars.

Tests:

1) ranking of three references for hardness
   Edam cheese (BRAND) (softest)
   Olives (BRAND)
   Peanuts (hardest)

2) ranking of three jellybeans for hardness
   list the 3 jellybean formulations

3) ranking of jellybeans on 15cm line labelled soft-hard

Springiness

Chewiness

### Day 3:

Repeat rating test #2 from day 2

Trained for adhesiveness

**Hardness**

Ranking test for hardness of reference samples

| Rank the products in the coded cups in ascending order of hardness. |
|---|

| | Code |
|---|---|
| **Soft** | _____ |
| | _____ |
| **Hard** | _____ |

**Ranking test for hardness of jellybean**

| Rank the jellybeans in the coded cups in ascending order of hardness. |
|---|

| | **Code** |
|---|---|
| **Soft** | _____ |
| | _____ |
| **Hard** | _____ |

Rating test for intensities

| Rate the products in the coded cups for intensity of hardness using the line scale for each. |
|---|

| Code |
|---|

_____

_____

_____

Rate the jellybeans in the coded cups for intensity of hardness using the line scale for each.

Code

_____

_____

_____

**Chewiness**

**Number of chews @ 1 chew/sec before the product is swallowed.**

Ranking test for chewiness of reference samples

Rank the products in the coded cups in ascending order of chewiness.

**Code**

Tender _____

_____

Tough _____

**Ranking test for chewiness of jellybean**

Rank the jellybeans in the coded cups in ascending order of chewiness.

**Code**

Tender _____

_____

Tough _____

Rating test for intensities

Rate the products in the coded cups for intensity of chewiness using the line scale for each.

Code

Rate the jellybeans in the coded cups for intensity of chewiness using the line scale for each.

Code

Rate the jellybeans in the coded cups for intensity of springiness using the line scale for each.

Code

Day-3 Name: Date:

**Adhesiveness to teeth**

**Amount of product adhering to teeth after mastication.**

Ranking test for Adhesiveness of reference samples

Rank the products in the coded cups in ascending order of Adhesiveness.

**Code**

**Less adhesive** _____

_____

**More adhesive** _____

**Ranking test for adhesiveness of jellybean**

Rank the jellybeans in the coded cups in ascending order of adhesiveness.

**Code**

**Less adhesive** _____

_____

**More adhesive** _____

Rating test for intensities

Rate the products in the coded cups for intensity of adhesiveness to teeth using the line scale for each.

Code

_____

_____

_____

Rate the jellybeans in the coded cups for intensity of adhesiveness to teeth using the line scale for each.

Code

_____

_____

_____

**Denseness**

Compactness of cross section of sample after biting through with molars

Rank the products in the coded cups in ascending order of denseness.

**Code**

**Airy** _____

_____

**Compact/Dense** _____

**Ranking test for denseness of jellybean**

Rank the jellybeans in the coded cups in ascending order of denseness.

**Code**

**Airy** _____

_____

**Dense/compact** _____

Rating test for intensities

Rate the products in the coded cups for intensity of denseness using the line scale for each.

Code

Rate the jellybeans in the coded cups for intensity of denseness using the line scale for each.

Code

Rate the jellybeans in the coded cups for intensity using the line scale for each.

Code

Day-4 Name: Date:

**Cohesiveness**

**Amount of deformation to the material before rupture when biting completely through sample with molars.**

## Ranking test for cohesiveness of reference samples

Rank the products in the coded cups in ascending order of cohesiveness.

**Code**

**Less cohesive** _____

_____

**More cohesive** _____

### Ranking test for cohesiveness of jellybean

Rank the jellybeans in the coded cups in ascending order of cohesiveness.

**Code**

**Less cohesive** _____

_____

_____

**More cohesive**

## Rating test for intensities

Rate the reference products in the coded cups for intensity of cohesiveness using the line scale for each.

Code

None cohesive ----------→ Very cohesive

_____

_____

_____

Rate the jellybeans in the coded cups for intensity of cohesiveness using the line scale for each.

Code

**None cohesive** ----------→ **Very cohesive**

Rate the jellybeans in the coded cups for intensity using the line scale for each.

Sample no.

Springiness

Not springy ----------→ Very springy

0 9.0 15.0

Cream cheese Marshmallows Gelatin dessert

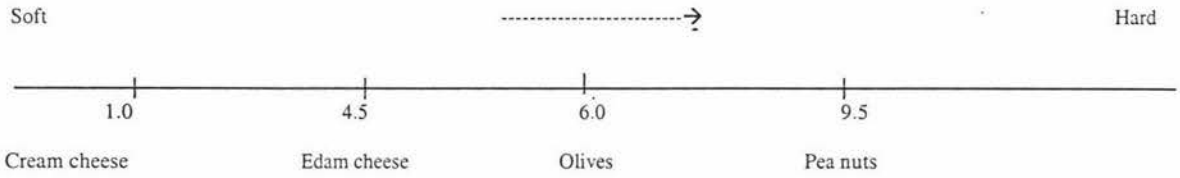
Cohesiveness

None cohesive ----------→ Very cohesive

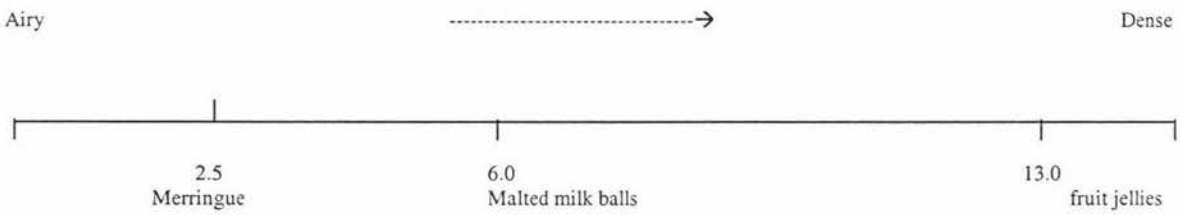
1.0 10.0 15.0

Corn muffin Raisins Chewing gum

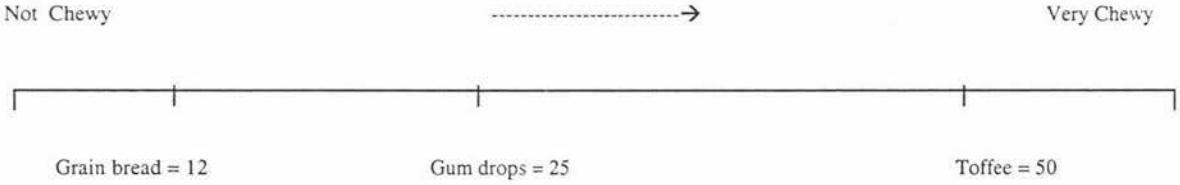
Hardness



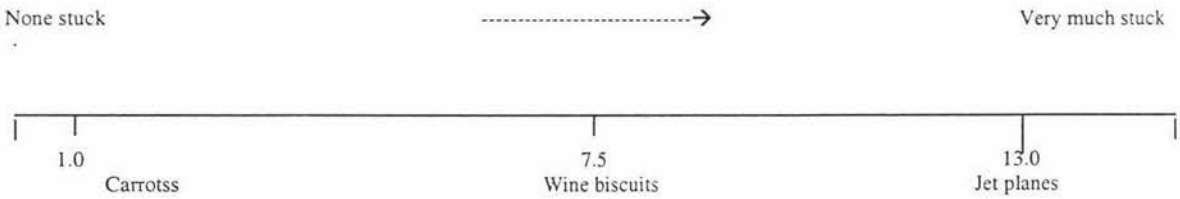

Denseness




Chewiness




Adhesiveness



## Appendix 6.4: Overall Liking of the Nutraceutical Jellybeans Centres

| Panelist | Samples 614 (A) | 189 (H) | 326 (G) | 911 (E) | 416 (B) | 918 (C) | 632 (D) | 191 (F) |
|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 2 | 2 | 7 | 5 | 4 | 6 |
| 2 | 4 | 6 | 7 | 4 | 8 | 7 | 5 | 6 |
| 3 | 4 | 4 | 3 | 4 | 5 | 7 | 5 | 5 |
| 4 | 8 | 7 | 6 | 4 | 8 | 7 | 8 | 8 |
| 5 | 8 | 7 | 6 | 6 | 7 | 7 | 8 | 6 |
| 6 | 3 | 3 | 6 | 1 | 6 | 7 | 7 | 8 |
| 7 | 7 | 7 | 5 | 3 | 2 | 5 | 6 | 6 |
| 8 | 6 | 7 | 8 | 7 | 6 | 7 | 8 | 7 |
| 9 | 4 | 3 | 6 | 5 | 6 | 8 | 8 | 9 |
| 10 | 4 | 4 | 5 | 7 | 3 | 7 | 8 | 2 |
| 11 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 6 |
| 12 | 7 | 4 | 5 | 6 | 4 | 6 | 8 | 6 |
| 13 | 4 | 8 | 3 | 4 | 8 | 7 | 3 | 4 |
| 14 | 3 | 5 | 3 | 3 | 5 | 6 | 6 | 6 |
| 15 | 7 | 7 | 7 | 7 | 6 | 6 | 8 | 6 |
| 16 | 6 | 4 | 6 | 7 | 6 | 4 | 7 | 4 |
| 17 | 7 | 7 | 7 | 7 | 7 | 6 | 5 | 6 |
| 18 | 6 | 4 | 3 | 1 | 5 | 6 | 1 | 3 |
| 19 | 6 | 7 | 5 | 8 | 8 | 7 | 5 | 5 |
| 20 | 4 | 5 | 5 | 4 | 6 | 4 | 7 | 3 |
| 21 | 8 | 4 | 5 | 3 | 7 | 8 | 7 | 6 |
| 22 | 7 | 6 | 6 | 4 | 7 | 8 | 5 | 6 |
| 23 | 6 | 5 | 6 | 6 | 4 | 6 | 6 | 3 |
| 24 | 8 | 6 | 6 | 7 | 8 | 6 | 6 | 8 |
| 25 | 3 | 9 | 6 | 8 | 6 | 7 | 6 | 9 |
| 26 | 7 | 5 | 6 | 5 | 3 | 6 | 6 | 4 |
| 27 | 6 | 8 | 7 | 8 | 7 | 8 | 4 | 7 |
| 28 | 7 | 7 | 4 | 5 | 7 | 8 | 4 | 6 |
| 29 | 6 | 5 | 6 | 7 | 4 | 4 | 6 | 4 |
| 30 | 7 | 5 | 8 | 4 | 4 | 5 | 6 | 4 |
| 31 | 3 | 3 | 2 | 4 | 3 | 5 | 2 | 7 |
| 32 | 7 | 8 | 7 | 8 | 6 | 8 | 7 | 7 |
| 33 | 6 | 7 | 4 | 2 | 6 | 5 | 3 | 2 |
| 34 | 7 | 6 | 5 | 6 | 7 | 6 | 5 | 6 |
| 35 | 7 | 8 | 4 | 4 | 3 | 3 | 6 | 3 |
| 36 | 6 | 7 | 4 | 2 | 6 | 5 | 3 | 2 |
| 37 | 4 | 7 | 4 | 4 | 7 | 6 | 3 | 2 |

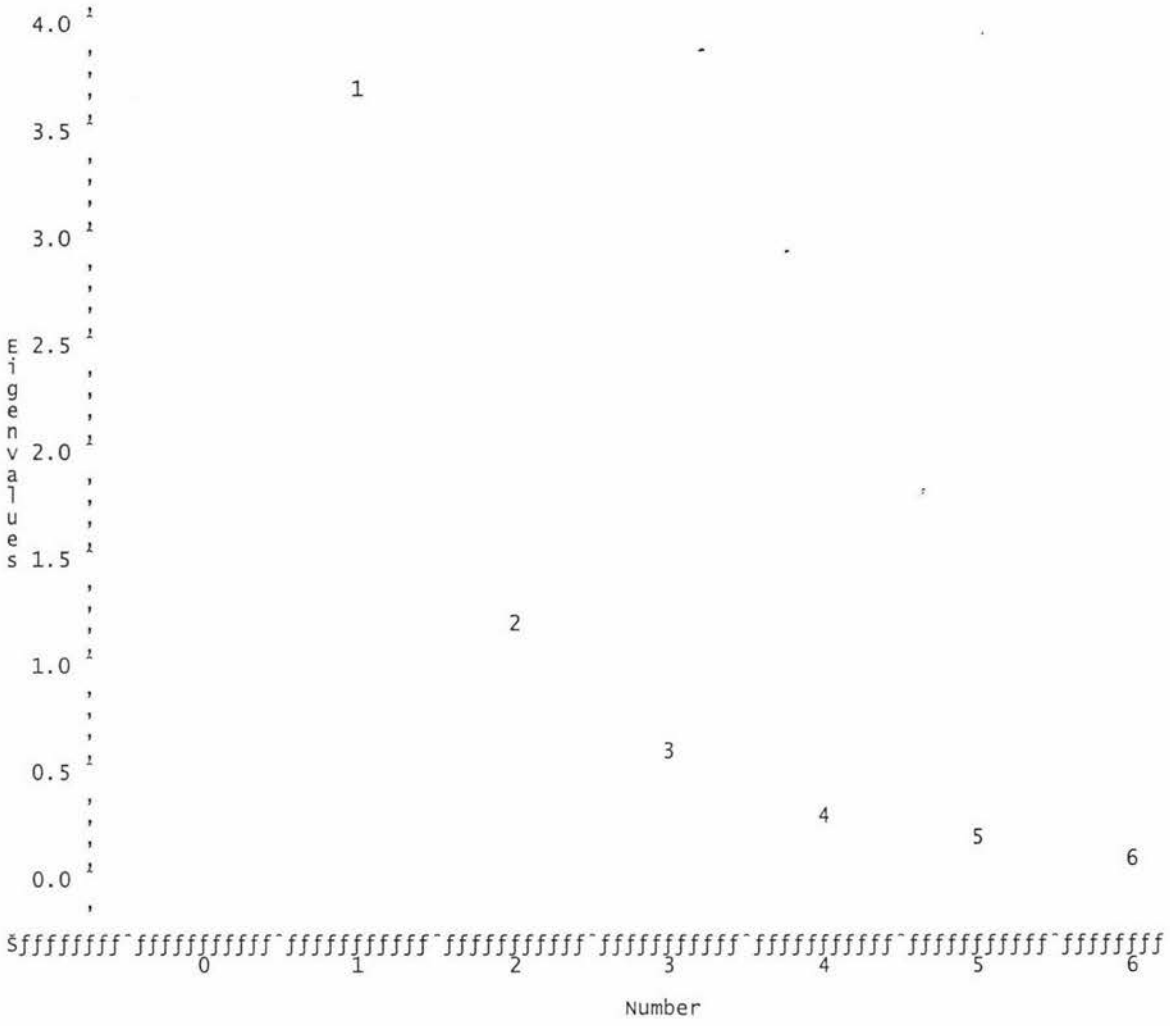
## Appendix 6.4 (Contd.): Overall Liking of the Nutraceutical Jellybeans Centres

| | Samples | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Panelist | 614 (A) | 189 (H) | 326 (G) | 911 (E) | 416 (B) | 918 (C) | 632 (D) | 191 (F) |
| 38 | 7 | 8 | 7 | 8 | 7 | 8 | 9 | 8 |
| 39 | 3 | 3 | 4 | 4 | 7 | 6 | 6 | 4 |
| 40 | 7 | 7 | 8 | 8 | 8 | 9 | 5 | 7 |
| 41 | 6 | 6 | 8 | 6 | 4 | 8 | 8 | 7 |
| 42 | 7 | 2 | 2 | 6 | 5 | 4 | 6 | 4 |
| 43 | 7 | 5 | 8 | 7 | 7 | 7 | 8 | 5 |
| 44 | 8 | 8 | 9 | 9 | 8 | 7 | 9 | 6 |
| 45 | 8 | 7 | 8 | 7 | 7 | 6 | 6 | 6 |
| 45 | 5 | 4 | 2 | 3 | 5 | 4 | 4 | 6 |
| 47 | 6 | 7 | 6 | 3 | 8 | 7 | 6 | 5 |
| 48 | 7 | 5 | 5 | 6 | 4 | 5 | 7 | 7 |
| 49 | 8 | 7 | 6 | 8 | 3 | 4 | 5 | 4 |
| 50 | 8 | 7 | 6 | 6 | 5 | 5 | 3 | 5 |
| 51 | 8 | 7 | 5 | 6 | 5 | 4 | 4 | 6 |
| 52 | 8 | 8 | 8 | 6 | 7 | 6 | 6 | 4 |
| 53 | 7 | 5 | 8 | 6 | 7 | 6 | 5 | 6 |
| Mean | 6.06 | 5.85 | 5.55 | 5.32 | 5.87 | 6.13 | 5.75 | 5.43 |
| SD | 1.68 | 1.70 | 1.80 | 2.02 | 1.63 | 1.37 | 1.82 | 1.78 |

## Appendix 6.5: PRINQUAL MTV Iteration History

| Iteration Number | Average Change | Maximum Change | Proportion of Variance | Variance Change | Iteration Number | Average Change | Maximum Change | Proportion of Variance | Variance Change |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.22542 | 1.13403 | 0.63429 | 0 | 38 | 0.00275 | 0.02902 | 0.7999 | 0.00006 |
| 2 | 0.06825 | 0.4371 | 0.75782 | 0.12353 | 39 | 0.00256 | 0.02734 | 0.79995 | 0.00005 |
| 3 | 0.03817 | 0.30325 | 0.77339 | 0.01557 | 40 | 0.00241 | 0.02578 | 0.8 | 0.00005 |
| 4 | 0.02674 | 0.1565 | 0.77906 | 0.00567 | 41 | 0.00229 | 0.03398 | 0.80004 | 0.00004 |
| 5 | 0.02342 | 0.21078 | 0.7826 | 0.00353 | 42 | 0.00222 | 0.04611 | 0.80008 | 0.00004 |
| 6 | 0.02384 | 0.17545 | 0.78564 | 0.00304 | 43 | 0.0022 | 0.06196 | 0.80012 | 0.00004 |
| 7 | 0.01951 | 0.19506 | 0.78899 | 0.00336 | 44 | 0.00224 | 0.08265 | 0.80017 | 0.00005 |
| 8 | 0.01793 | 0.28453 | 0.79104 | 0.00205 | 45 | 0.00235 | 0.10938 | 0.80024 | 0.00007 |
| 9 | 0.01511 | 0.33607 | 0.79343 | 0.00239 | 46 | 0.00248 | 0.14309 | 0.80034 | 0.0001 |
| 10 | 0.01276 | 0.3295 | 0.79492 | 0.00149 | 47 | 0.0027 | 0.18355 | 0.80048 | 0.00015 |
| 11 | 0.01031 | 0.21133 | 0.79602 | 0.0011 | 48 | 0.00299 | 0.22812 | 0.8007 | 0.00022 |
| 12 | 0.00779 | 0.08446 | 0.79673 | 0.00071 | 49 | 0.00325 | 0.27007 | 0.80102 | 0.00032 |
| 13 | 0.00585 | 0.05666 | 0.79705 | 0.00033 | 50 | 0.00347 | 0.29867 | 0.80145 | 0.00043 |
| 14 | 0.00515 | 0.05306 | 0.79724 | 0.00018 | 51 | 0.00308 | 0.20424 | 0.80196 | 0.00052 |
| 15 | 0.00465 | 0.05 | 0.79739 | 0.00015 | 52 | 0.00235 | 0.0655 | 0.80234 | 0.00038 |
| 16 | 0.00425 | 0.0514 | 0.79751 | 0.00013 | 53 | 0.00201 | 0.03004 | 0.80239 | 0.00004 |
| 17 | 0.00389 | 0.05181 | 0.79762 | 0.0001 | 54 | 0.00177 | 0.02815 | 0.80241 | 0.00003 |
| 18 | 0.00377 | 0.0514 | 0.79771 | 0.00009 | 55 | 0.00161 | 0.02626 | 0.80243 | 0.00002 |
| 19 | 0.0037 | 0.0506 | 0.7978 | 0.00009 | 56 | 0.00147 | 0.02441 | 0.80245 | 0.00002 |
| 20 | 0.00367 | 0.04964 | 0.79789 | 0.00009 | 57 | 0.00136 | 0.0226 | 0.80246 | 0.00002 |
| 21 | 0.0037 | 0.05468 | 0.79798 | 0.00009 | 58 | 0.00126 | 0.01758 | 0.80248 | 0.00001 |
| 22 | 0.00379 | 0.05943 | 0.79808 | 0.0001 | 59 | 0.00109 | 0.01401 | 0.80249 | 0.00001 |
| 23 | 0.0039 | 0.06361 | 0.79819 | 0.00011 | 60 | 0.001 | 0.01337 | 0.8025 | 0.00001 |
| 24 | 0.00406 | 0.0681 | 0.79831 | 0.00012 | | | | | |
| 25 | 0.00427 | 0.07588 | 0.79844 | 0.00013 | | | | | |
| 26 | 0.0045 | 0.08364 | 0.79859 | 0.00015 | | | | | |
| 27 | 0.00453 | 0.07201 | 0.79876 | 0.00017 | | NOTE: Algorithm converged. | | | |
| 28 | 0.00432 | 0.07027 | 0.7989 | 0.00014 | | | | | |
| 29 | 0.00417 | 0.06803 | 0.79902 | 0.00013 | | | | | |
| 30 | 0.00406 | 0.06461 | 0.79915 | 0.00012 | | | | | |
| 31 | 0.00395 | 0.06017 | 0.79926 | 0.00012 | | | | | |
| 32 | 0.00385 | 0.05504 | 0.79938 | 0.00011 | | | | | |
| 33 | 0.00374 | 0.04954 | 0.79949 | 0.00011 | | | | | |
| 34 | 0.00362 | 0.04394 | 0.79959 | 0.0001 | | | | | |
| 35 | 0.00347 | 0.03848 | 0.79968 | 0.00009 | | | | | |
| 36 | 0.00323 | 0.03334 | 0.79976 | 0.00008 | | | | | |
| 37 | 0.00298 | 0.03076 | 0.79984 | 0.00007 | | | | | |

## Appendix 6.6: Scree Plot of Eigenvalues



## Appendix 6.7: Analysis of Variance and Tukey's Honestly Significant Comparison Test for Overall Liking

### Analysis of variance

| Source of Variation | SS | DF | MS | F | P-value |
|---|---|---|---|---|---|
| Samples | 31.21 | 7 | 4.46 | 1.48 | 0.172 |
| Error | 1251.28 | 416 | 3.01 | | |
| Total | 1282.49 | 423 | | | |

**Tukey's honestly significant comparison test**

| Product code | 614 | 189 | 326 | 911 | 416 | 918 | 632 | 191 |
|---|---|---|---|---|---|---|---|---|
| Total | 321 | 310 | 294 | 282 | 311 | 325 | 305 | 288 |
| Means | 6.06[a] | 5.85[a] | 5.55[a] | 5.32[a] | 5.87[a] | 6.13[a] | 5.75[a] | 5.43[a] |

**Appendix 6.8: Analysis of Variance and non-parametric rank interaction**

## Test for Springiness

### Analysis of variance

| Source of Variation | SS | DF | MS | F | P-value |
|---|---|---|---|---|---|
| Samples | 63986.06 | 7 | 9140.87 | 656.35 | 0.000 |
| Panelist | 867.27 | 8 | 108.41 | 7.78 | 0.000 |
| Samples* Panelist | 779.9 | 56 | 13.93 | 0.32 | 1.000 |
| Error | 6187.74 | 144 | 42.97 | | |
| Total | 71820.96 | 215 | | | |

### Kruskal-Wallis

| Sample | Median | Ave Rank | DF | Z | H | P-value |
|---|---|---|---|---|---|---|
| A | 5.0 | 122.0 | 7 | 1.20 | 215 | 0.000 (Adj. Rank) |
| B | 3.0 | 68.0 | | -3.6 | | |
| C | 6.0 | 149.0 | | 3.6 | | |
| D | 2.0 | 41.0 | | -6.0 | | |
| E | 8.0 | 203.0 | | 8.4 | | |
| F | 1.0 | 14.0 | | -8.4 | | |
| G | 7.0 | 176.0 | | 95.0 | | |
| H | 4.0 | 95.0 | | -1.2 | | |

## Test for Cohesiveness

### Analysis of variance

| Source of Variation | SS | DF | MS | F | P-value |
|---|---|---|---|---|---|
| Samples | 1025.8 | 7 | 146.54 | 19.24 | 0.000 |
| Panelist | 784.39 | 8 | 98.05 | 12.87 | 0.000 |
| Samples* Panelist | 426.54 | 56 | 7.62 | 0.24 | 1.000 |
| Error | 4610.63 | 144 | 32.02 | | |
| Total | 6847.36 | 215 | | | |

### Kruskal-Wallis

| Sample | Median | Ave Rank | DF | Z | H | P-value |
|---|---|---|---|---|---|---|
| A | 4.0 | 95.0 | 7 | -1.20 | 215 | 0.000 (Adj. Rank) |
| B | 8.0 | 203.0 | | 8.4 | | |
| C | 7.0 | 176.0 | | 6.0 | | |
| D | 2.0 | 41.0 | | -6.0 | | |
| E | 6.0 | 149.0 | | 3.6 | | |
| F | 5.0 | 122.0 | | 1.2 | | |
| G | 3.0 | 68.0 | | -3.6 | | |
| H | 1.0 | 14.0 | | -8.4 | | |

## Test for Hardness

### Analysis of variance

| Source of Variation | SS | DF | MS | F | P-value |
|---|---|---|---|---|---|
| Samples | 164402.6 | 7 | 23486.1 | 2072.92 | 0.000 |
| Panelist | 718.5 | 8 | 89.8 | 7.93 | 0.000 |
| Samples* Panelist | 634.5 | 56 | 11.3 | 0.18 | 1.000 |
| Error | 8942.6 | 144 | 62.1 | | |
| Total | 174698.1 | 215 | | | |

### Kruskal-Wallis

| Sample | Median | Ave Rank | DF | Z | H | P-value |
|---|---|---|---|---|---|---|
| A | 5.0 | 122.0 | 7 | 1.2 | 215 | 0.000 (Adj. Rank) |
| B | 2.0 | 41.0 | | -6.0 | | |
| C | 4.0 | 95.0 | | -1.2 | | |
| D | 6.0 | 149.0 | | 3.6 | | |
| E | 8.0 | 203.0 | | 8.4 | | |
| F | 3.0 | 68.0 | | -3.6 | | |
| G | 7.0 | 176.0 | | 6.0 | | |
| H | 1.0 | 14.0 | | -8.4 | | |

## Test for Denseness

### Analysis of variance

| Source of Variation | SS | DF | MS | F | P-value |
|---|---|---|---|---|---|
| Samples | 12219.26 | 7 | 1745.61 | 179.61 | 0.000 |
| Panelist | 569.54 | 8 | 71.19 | 7.33 | 0.000 |
| Samples* Panelist | 544.26 | 56 | 9.72 | 0.37 | 1.000 |
| Error | 3786.8 | 144 | 26.30 | | |
| Total | 17119.86 | 215 | | | |

### Kruskal-Wallis

| Sample | Median | Ave Rank | DF | Z | H | P-value |
|---|---|---|---|---|---|---|
| A | 6.0 | 149.0 | 7 | 3.6 | 215 | 0.000 (Adj. Rank) |
| B | 3.0 | 68.0 | | -3.6 | | |
| C | 4.0 | 95.0 | | -1.2 | | |
| D | 5.0 | 122.0 | | 1.2 | | |
| E | 8.0 | 203.0 | | 8.4 | | |
| F | 2.0 | 41.0 | | -6.0 | | |
| G | 7.0 | 176.0 | | 6.0 | | |
| H | 1.0 | 14.0 | | -8.4 | | |

## Test for Chewiness

### Analysis of variance

| Source of Variation | SS | DF | MS | F | P-value |
|---|---|---|---|---|---|
| Samples | 28746.14 | 7 | 3820.88 | 275.89 | 0.000 |
| Panelist | 2002.02 | 8 | 250.25 | 18.07 | 0.000 |
| Samples* Panelist | 775.56 | 56 | 13.85 | 0.32 | 1.000 |
| Error | 6325.27 | 144 | 43.93 | | |
| Total | 35848.99 | 215 | | | |

### Kruskal-Wallis

| Sample | Median | Ave Rank | DF | Z | H | P-value |
|---|---|---|---|---|---|---|
| A | 4.0 | 95.0 | 7 | -1.2 | 215 | 0.000 (Adj. Rank) |
| B | 3.0 | 68.0 | | -3.6 | | |
| C | 6.0 | 149.0 | | 3.6 | | |
| D | 5.0 | 122.0 | | 1.2 | | |
| E | 8.0 | 203.0 | | 8.4 | | |
| F | 1.0 | 14.0 | | -8.4 | | |
| G | 7.0 | 176.0 | | 6.0 | | |
| H | 2.0 | 41.0 | | -6.0 | | |

## Test for Adhesiveness

### Analysis of variance

| Source of Variation | SS | DF | MS | F | P-value |
|---|---|---|---|---|---|
| Samples | 28746.14 | 7 | 3820.88 | 275.89 | 0.000 |
| Panelist | 2002.02 | 8 | 250.25 | 18.07 | 0.000 |
| Samples* Panelist | 775.56 | 56 | 13.85 | 0.32 | 1.000 |
| Error | 6325.27 | 144 | 43.93 | | |
| Total | 35848.99 | 215 | | | |

## Kruskal-Wallis

| Sample | Median | Ave Rank | DF | Z | H | P-value |
|---|---|---|---|---|---|---|
| A | 5.0 | 122.0 | 7 | 1.2 | 215 | 0.000 (Adj. Rank) |
| B | 6.0 | 149.0 | | -3.6 | | |
| C | 7.0 | 176.0 | | 6.0 | | |
| D | 4.0 | 95.0 | | -1.2 | | |
| E | 3.0 | 68.0 | | -3.6 | | |
| F | 8.0 | 203.0 | | 8.4 | | |
| G | 1.0 | 14.0 | | -8.4 | | |
| H | 2.0 | 41.0 | | -6.0 | | |

## Appendix 7.1: Costing of Developed Jellybean

| Costing of Jellybean Centres | | | |
|---|---|---|---|
| **Ingredients** | **Quantity** | **Price/kg** | **Cost ($)** |
| Starch-Ultra set LT | 9.2 | 4.42 | 40.66 |
| Gelatin | 5 | 16.71 | 83.55 |
| Honey | 10.2 | 20 | 204.00 |
| Propolis extracta | 1.8 | 224 | 403.20 |
| Sucrose | 20 | 1 | 20.00 |
| Corn syrup | 42 | 0.8 | 33.60 |
| Citric acid | 0.2 | 4.44 | 0.89 |
| Lemon Essence D | 0.1 | 13.61 | 1.36 |
| Water | 11.5 | 0 | 0.00 |
| Consumption quantity | 100 | | |
| TDS% | 76.5 | | |
| Production Quantity | 82.6 | | |
| **Total cost** | | | **787.26** |
| **Costing of Jellybean Centres/Kg** | | | **9.53** |
| **Cost of Finished product** | | | |
| Sanded jellybean centers | 60 | 9.53 | 571.80 |
| Soft panning syrup A | 10.4 | 1.20 | 12.48 |
| Soft panning syrup B | 1.8 | 0.59 | 1.06 |
| Vanillin alcohol 4547 (L) | 0.09 | 10.11 | 0.91 |
| Tartrazine 10% solution (260 ml) | 0.026 | 33.75 | 0.88 |
| Sugar caster | 38 | 1.00 | 38.00 |
| Icing sugar | 7.5 | 1.27 | 9.53 |
| Polishing wax | 0.0165 | 30.38 | 0.50 |
| Citric acid soln. (120ml) | 0.007 | 4.44 | 0.03 |
| Lemon flavour (L) | 0.075 | 13.6 | 1.02 |
| Consumption quantity | 117.91 | | |
| Production Quantity | 112.02 | | |
| **Total cost** | | | **636.21** |
| **Cost of Finished product/kg** | | | **5.68** |

## Appendix 7.2: Soft Panning Preparations for Jellybean Centres

### Formulation soft panning syrup A

| Ingredients | Quantity |
|---|---|
| Hot water | 1.1 ltr. |
| Gelatine A grade 175-200 bloom | 0.3 Kg |
| Glucose syrup 43 DE | 9.3 kg |
| Yield | 10.4 kgs |

### Process conditions:

Add 0.7 kgs of hot water and 9.3 kgs of glucose. Mix 0.3 kgs of gelatine with 0.4 kgs of water. Heat glucose and water mix, until boils. Add gelatine solution.

Total solids = 74 ± 1%.

Required quantity for the batch = 10.4 kgs.

### Formulation soft panning syrup B

Heat 1 kg of water with 1 kg of sugar until sugar is dissolved.

Total solids = 57± 1%.

Required quantity for the batch = 1.7 kgs.

### Citric acid solution

Take 160 grams of water and mix 9.14 grams of citric acid. Mix until dissolved.

### Yellow colour

10 % w/v solution of tartrazine. Put 180 ml of yellow colour with syrup A and 80 ml of colour with syrup B.

### Jellybean polishing

Polishing wax: Mix equal volume of carnuba wax, beeswax and mineral oil. Thick grease like paste is formed. Use 16.5 grams of polish for the entire batch of jellybeans.

## Appendix 7.2: Certificate of Analysis (C.O.A) of Manuka Honey

**The University of Waikato** Department of Biological Sciences
Te Whare Wā nanga o Waikato *Honey Research Unit*

Private Bag 3105, Hamilton 2001, New Zealand
Fax (07) 838 4324, Telephone (07) 838 4466 Extn 8250

**Supplier Name:** Young Mee Yoon **Date:** 18 - 2 - 99

**Address:** Bee and Herbal

11 Carter Crescent

Cambridge

**Phone No:**

**Fax No:**

### ANTIBACTERIAL ACTIVITY TESTS ON HONEY SAMPLES

The following table shows the results of the activity testing on your honey samples. The activity is measured as the equivalent % phenol. Two types of activity are measured. The total activity is all the activity including that due to hydrogen peroxide. The honey is also treated with an enzyme to remove the hydrogen peroxide so that the non-peroxide activity may be tested.

| | |
|---|---|
| High Activity: | Above 15% |
| Medium Activity: | 10-15% |
| Low Activity: | Below 10% |
| Not detectable: | Below 4% |

| Date Received | Samples Details | Total Activity (% phenol) | Non-peroxide Activity (% phenol) |
|---|---|---|---|
| 17 - 2 - 99 | B206002 | 10.4 | 9.7 |
| | | | |
| | | | |
| | | | |
| | | | |

**Comments:**
This testing has been carried out for your information only and cannot be used for certification. Although we take great care in the testing of honey samples for antibacterial activity, we are a research lab and not an accredited testing laboratory.

Yours faithfully
Kerry Allen

**Appendix 8.1: Information Sheet provided to the Panelists**

## Information Sheet for Consumer Panelists

You have been invited to take part in a sensory study being conducted by Dinesh Sofat, post graduate student in the Institute of Food Nutrition and Human Health, Massey University, under my supervision.

As a participant in this study, you will be given jellybeans to eat and in turn will be asked to indicate your liking of a variety of characteristics, overall liking of the product and opinions on product effectiveness. This will take approximately 15 to 20 minutes.

Please read this ingredient list carefully as it contains all of the ingredients that you will be consuming during the study, and a given product may or may not have all the ingredients. If you are allergic to anything contained on the list, please inform the researcher and your name will be removed from the list of study participants.

**INGREDIENTS: Maize syrup, Cane sugar, New Zealand Manuka honey, Starch, Gelatin, New Zealand bee propolis extract, Citric acid, Flavour, Colour (E-102), (may also contain bee pollen)**

You are free at any time during the course of the panel to withdraw without giving us a reason. In order to protect your privacy, you will be assigned a panellist number, which will be recorded, on the top of your questionnaires. This number, not your name, will be used in the analysis of the data.

The information collected in this study will be used to understand consumer behaviour in respect to these jellybeans. At the end of the study, you may request a copy of the results. No individual data will be presented only the means and standard deviations will be

available. All the data will input into a computer program using panellist numbers only. No names will be used. The data and the original questionnaire will be kept file.

Please bear in mind that the researchers take no responsibility for any injuries that may occur during the panel.

If you have any questions about this research, please contact Carol Pound at 350-4399 in the normal working hours or 376-6654 after hours.

**Carol Pound**
**Lecturer, Food Technology**
**Institute of Food, Nutrition and Human Health**
**Massey University**
**Private Bag 11-222**
**Palmerston North**
**Ph. (06) 350-4399**
**Fax (06) 350-5655**

**Appendix 8.2: The Consent Form Filled by the Prospective Panelists**

## Consent Form

I have read the information sheet.

My questions have been answered to my satisfaction, and I understand that I may ask further questions at any time.

I understand that I have the right to withdraw from the study, decline to answer any questions or consume the jellybeans without giving a reason.

I agree to provide information to the researchers on the understanding that my name will not be used without my permission. The information will be published in a master's thesis and used for publications arising from this research project.

I have read the ingredient list and, to my knowledge, I am not allergic to anything contained on the list.

I agree to participate in this study under the conditions set out in the information sheet.

Signed: .....

Name: .....

Date: .....

**Appendix 8.3: Questionnaire for the Central Location Test**

## Lemon Flavored Jellybeans

**Dear Panelists**

**Hi!**

I am a postgraduate student in The Institute of Food Nutrition and Human Health, Massey University. I am conducting a consumer test of delicious lemon flavored jellybeans. I would like to know what you think about these jellybeans.

Thanks for offering to help me with my study. If you have any questions, while completing the test, please do not hesitate to ask me.

Ms. Carol Pound and Ms. Lisa Duizer are jointly supervising this project. If you have any questions about this research, please contact Ms. Carol Pound at 350-4399 in the normal working hours or 376-6654 after hours.

Thank you for your help.

**Dinesh Sofat**

**(Postgraduate student)**

***Please turn the page and follow the instructions.***

**Code Number -** **Name -** **Date -**

PART-I OVERALL LIKING

INSTRUCTIONS:

1. PLEASE RINSE YOUR MOUTH WITH PLAIN WATER BEFORE TASTING.
2. EVALUATE THE PRODUCT BY LOOKING AT, SMELLING AND TASTING IT.

**Overall Liking**

Consider all characteristics and indicate your overall opinion by giving a score to the sample that reflects your liking of the product.

1. Using the scale as shown on the card, mark your **overall liking** for the sample in the space provided.

| Sample No. | Overall Liking |
|---|---|
| 196 | |

2. Please indicate WHAT in particular you **Liked** or **Disliked** about this product? (USE WORDS NOT SENTENCES.)

| Sample No. | Liked | Disliked |
|---|---|---|
| 196 | | |

PART-II PRODUCT CHARACTERISTICS

INSTRUCTIONS: PLEASE LOOK AT THE SAMPLE

APPEARANCE

1. Using the 1-9 scale as shown on the card, indicate how much you **like the appearance** of the sample?

| Sample No. | Liking of the Appearance |
|---|---|
| 196 | |

2. Using the 1-9 scale as shown on the card, indicate how much you **like the color** of the sample?

| Sample No. | Liking of the Color |
|---|---|
| 196 | |

INSTRUCTIONS: PLEASE TASTE THE SAMPLE

**TEXTURE**

1. Using the 1-9 scale as shown on the card, indicate how much you **like the hardness** of the sample?

| Sample No. | Liking of the Hardness |
|---|---|
| 196 | |

**FLAVOUR**

1. Using the 1-9 scale as shown on the card, indicate how much you **like the lemon flavour** of the sample?

| Sample No. | Liking of the Lemon Flavour |
|---|---|
| 196 | |

2. Using the 1-9 scale as shown on the card, indicate how much you **like the sweetness** of the sample?

| Sample No. | Liking of the Sweetness |
|---|---|
| 196 | |

**Please check that you have answered all the questions on this sample and then proceed to the next page.**

**PART-I OVERALL LIKING**

**INSTRUCTIONS:**

1. PLEASE RINSE YOUR MOUTH WITH PLAIN WATER BEFORE TASTING.
2. EVALUATE THE PRODUCT BY LOOKING AT, SMELLING AND TASTING IT.

**Overall Liking**

Consider all characteristics and indicate your overall opinion by giving a score to the sample that reflects your liking of the product.

1. Using the scale as shown on the card, mark your **overall liking** for the sample in the space provided.

| Sample No. | Overall Liking |
|---|---|
| 311 | |

2. Please indicate WHAT in particular you **Liked** or **Disliked** about this product? (USE WORDS NOT SENTENCES.)

| Sample No. | Liked | Disliked |
|---|---|---|
| 311 | | |

**PART-II PRODUCT CHARACTERISTICS**

**INSTRUCTIONS:** PLEASE LOOK AT THE SAMPLE

**APPEARANCE**

1. Using the 1-9 scale as shown on the card, indicate how much you **like the appearance** of the sample?

| Sample No. | Liking of the Appearance |
|---|---|
| 311 | |

2. Using the 1-9 scale as shown on the card, indicate how much you **like the color** of the sample?

| Sample No. | Liking of the Color |
|---|---|
| 311 | |

**INSTRUCTIONS:** PLEASE TASTE THE SAMPLE

**TEXTURE**

1. Using the scale as shown on the card, indicate how much you **like the hardness** of the sample?

| Sample No. | Liking of the Hardness |
|---|---|
| 311 | |

**FLAVOUR**

1. Using the 1-9 scale as shown on the card, indicate how much you **like the overall flavour** of the sample?

| Sample No. | Liking of the Overall Flavour |
|---|---|
| 311 | |

2. Using the 1-9 scale as shown on the card, indicate how much you **like the sweetness** of the sample?

| Sample No. | Liking of the Sweetness |
|---|---|
| 311 | |

**Please check that you have answered all the questions and ask for the next sample.**

## Nutraceutical Confectionery Product

The researchers at Waikato University have determined that manuka honey has potent antibacterial properties. A joint study conducted by Institute of Industrial Research and Development, and Waikato University has also proved that New Zealand propolis is rich in polyphenols, which were found to have antibacterial, antiviral, and antifungal properties against organisms causing sore throat, stomach ulcer and dermatitis. Because of the presence of so many beneficial effects manuka honey and propolis have found their way into many pharmaceutical and cosmetic products.

The jellybean product given to you has derived its antibacterial properties from manuka honey and propolis. The testing of the finished product has shown antibacterial properties in the laboratory tests.

For this test I would now like to know what you think about the honey-propolis jellybean.

Thank you for your help.

**Dinesh Sofat**

**(Postgraduate student)**

**Code Number -** **Name -** **Date -**

**PART-I OVERALL LIKING**

**INSTRUCTIONS:**

1. PLEASE RINSE YOUR MOUTH WITH PLAIN WATER BEFORE TASTING.

2. EVALUATE THE PRODUCT BY LOOKING AT, SMELLING, AND TASTING IT.

**Overall Liking**

Consider all characteristics and indicate your overall opinion by giving a score to the sample that reflects your liking of the product.

1. Using the scale as shown on the card, mark your **overall liking** for the sample in the space provided.

| Sample No. | Overall Liking |
|---|---|
| 369 | |

2. Please indicate WHAT in particular you **Liked** or **Disliked** about this product? (USE WORDS NOT SENTENCES.)

| Sample No. | Liked | Disliked |
|---|---|---|
| 369 | | |

**PART-II PRODUCT CHARACTERISTICS**

**INSTRUCTIONS:** PLEASE LOOK AT THE SAMPLE

**APPEARANCE**

1. Using the 1-9 scale as shown on the card, indicate how much you **like the appearance** of the sample?

| Sample No. | Liking of the Appearance |
|---|---|
| 369 | |

2. Using the 1-9 scale as shown on the card, indicate how much you **like the color** of the sample?

| Sample No. | Liking of the Color |
|---|---|
| 369 | |

**INSTRUCTIONS:** PLEASE TASTE THE SAMPLE

**TEXTURE**

1. Using the 1-9 scale as shown on the card, indicate how much you **like the hardness** of the sample?

| Sample No. | Liking of the Hardness |
|---|---|
| 369 | |

**FLAVOUR**

1. Using the 1-9 scale as shown on the card, indicate how much you **like the honey flavour** of the sample?

| Sample No. | Liking of the Honey Flavour |
|---|---|
| 369 | |

2. Using the 1-9 scale as shown on the card, indicate how much you **like the lemon flavour** of the sample?

| Sample No. | Liking of the Lemon Flavour |
|---|---|
| 369 | |

3. Using the 1-9 scale as shown on the card, indicate how much you **like the sweetness** of the sample?

| Sample No. | Liking of the Sweetness |
|---|---|
| 369 | |

4. Using the 1-9 scale as shown on the card, overall, how do you feel about the **blend of flavours** of the product?

| Sample No. | Liking of the Blend of Flavour | Comments |
|---|---|---|
| 369 | | |

**PART III**

The following questions are about you. Everything written in this survey is confidential. The questions are purely asked to indicate the type of consumer who has been surveyed. Please tick your choices (√).

**Personal Details**

1. Gender

   ❒ Male

   ❒ Female

   Age group

   ❒ Under 20 years

   ❒ 21-30 years

   ❒ 31-40 years

   ❒ 41-50 years

   ❒ Above 50 years

2. Do you see this product as:

   ❒ A medical product taken when need be

   ❒ A preventive product taken in danger period

   ❒ A preventive product taken all the time

   ❒ A confectionery product with added benefits

   ❒ A confectionery product

3. Do you use dietary supplements/health products?

   ❒ Yes

   ❒ No

4. Have you ever used any one of the following products during the last 6 months? (Tick as many as appropriate).

- ❒ Honey and propolis lozenges
- ❒ Honey nuggets
- ❒ Pollen and honey spread
- ❒ Muesli bar
- ❒ Healthy nut bar
- ❒ Propolis tincture
- ❒ Propolis oral fresh
- ❒ Propolis - throat spray

5. Why do you use health products? (Tick as many as appropriate).

- ❒ Source of nutrition
- ❒ Source of instant energy
- ❒ To keep healthy body at different life cycles
- ❒ To keep immune system healthy
- ❒ Other, please specify _____

6. Would you buy this product?

- ❒ Definitely buy
- ❒ Probably buy
- ❒ Might or might not buy
- ❒ Probably not buy
- ❒ Definitely not buy

7. Do you find the claims made about the product believable?

- ❒ Definitely believable
- ❒ Probably believable
- ❒ Might or might not believe
- ❒ Probably not believable
- ❒ Definitely not believable

**Please check that you have answered all the questions. Thank you very much for your time and assistance.**

## Appendix 8.4: Summary of Results for the Central Location Test

## PART-I AND PART-II

Overall liking & product characteristics of the nutraceutical jellybeans 'Uninformed score'

| Code[1)] | Panelists | Overall[2)] Liking | Appearance[2)] | Colour[2)] | Hardness[2)] | Overall Flavour[2)] | Sweetness[2)] |
|---|---|---|---|---|---|---|---|
| 311 | 1 | 6 | 5 | 6 | 4 | 7 | 7 |
| 311 | 2 | 6 | 7 | 6 | 7 | 6 | 8 |
| 311 | 3 | 6 | 8 | 8 | 7 | 6 | 6 |
| 311 | 4 | 6 | 7 | 7 | 7 | 5 | 4 |
| 311 | 5 | 7 | 6 | 6 | 7 | 7 | 5 |
| 311 | 6 | 7 | 2 | 4 | 8 | 6 | 6 |
| 311 | 7 | 7 | 2 | 4 | 8 | 6 | 6 |
| 311 | 8 | 7 | 8 | 8 | 6 | 8 | 8 |
| 311 | 9 | 5 | 3 | 5 | 6 | 3 | 3 |
| 311 | 10 | 6 | 6 | 7 | 4 | 6 | 4 |
| 311 | 11 | 6 | 6 | 6 | 4 | 6 | 4 |
| 311 | 12 | 8 | 7 | 6 | 8 | 8 | 8 |
| 311 | 13 | 4 | 2 | 1 | 7 | 4 | 7 |
| 311 | 14 | 1 | 9 | 9 | 9 | 1 | 1 |
| 311 | 15 | 4 | 6 | 7 | 6 | 2 | 4 |
| 311 | 16 | 7 | 7 | 7 | 8 | 8 | 8 |
| 311 | 17 | 7 | 6 | 6 | 6 | 6 | 7 |
| 311 | 18 | 9 | 9 | 9 | 9 | 9 | 9 |
| 311 | 19 | 6 | 7 | 7 | 6 | 6 | 7 |
| 311 | 20 | 6 | 8 | 8 | 8 | 6 | 6 |
| 311 | 21 | 6 | 7 | 7 | 8 | 6 | 6 |
| 311 | 22 | 7 | 6 | 6 | 6 | 8 | 8 |
| 311 | 23 | 7 | 2 | 4 | 6 | 3 | 3 |
| 311 | 24 | 7 | 8 | 7 | 4 | 6 | 4 |
| 311 | 25 | 6 | 6 | 8 | 6 | 6 | 8 |
| 311 | 26 | 8 | 7 | 6 | 8 | 7 | 8 |
| 311 | 27 | 7 | 6 | 7 | 6 | 8 | 7 |
| 311 | 28 | 7 | 7 | 7 | 8 | 6 | 7 |
| 311 | 29 | 7 | 6 | 6 | 7 | 6 | 5 |
| 311 | 30 | 9 | 9 | 7 | 8 | 8 | 7 |
| 311 | 31 | 7 | 8 | 8 | 6 | 8 | 8 |
| 311 | 32 | 5 | 3 | 5 | 6 | 3 | 3 |
| 311 | 33 | 6 | 6 | 7 | 4 | 6 | 4 |
| 311 | 34 | 6 | 6 | 6 | 4 | 6 | 4 |
| 311 | 35 | 8 | 7 | 6 | 8 | 8 | 8 |
| 311 | 36 | 6 | 7 | 7 | 8 | 6 | 6 |

[2)] 9 points hedonic scale, where; 1= Dislike extremely; 2 = Dislike very much; 3 = Dislike moderately; 4 = Dislike slightly; 5 = Neither like or dislike; 6 = Like slightly; 7 = Like moderately; 8 = Like very much; 9 = Like extremely.

## Appendix 8.4 (Contd.): Summary of Results for the Central Location Test PART-I AND PART-II

Overall liking and product characteristics of the nutraceutical jellybeans 'Uninformed score'

| Code | Panelists[2)] | Overall Liking[2)] | Appearance[2)] | Colour[2)] | Hardness[2)] | Overall Flavour[2)] | Sweetness[2)] |
|---|---|---|---|---|---|---|---|
| 311 | 37 | 7 | 6 | 6 | 6 | 8 | 8 |
| 311 | 38 | 7 | 2 | 4 | 6 | 3 | 3 |
| 311 | 39 | 7 | 8 | 7 | 4 | 6 | 4 |
| 311 | 40 | 6 | 6 | 8 | 6 | 6 | 8 |
| 311 | 41 | 6 | 6 | 8 | 6 | 6 | 8 |
| 311 | 42 | 8 | 7 | 6 | 8 | 7 | 8 |
| 311 | 43 | 7 | 6 | 7 | 6 | 8 | 7 |
| 311 | 44 | 7 | 7 | 7 | 8 | 6 | 7 |
| 311 | 45 | 7 | 6 | 6 | 7 | 6 | 5 |
| 311 | 46 | 9 | 9 | 7 | 8 | 8 | 7 |
| 311 | 47 | 7 | 8 | 8 | 6 | 8 | 8 |
| 311 | 48 | 7 | 2 | 4 | 6 | 3 | 3 |
| 311 | 49 | 7 | 8 | 7 | 4 | 6 | 4 |
| 311 | 50 | 6 | 6 | 8 | 6 | 6 | 8 |
| 311 | 51 | 6 | 6 | 8 | 6 | 6 | 8 |
| Means | | 6.549 | 6.176 | 6.509 | 6.490 | 6.078 | 6.078 |
| Median | | 7 | 6 | 7 | 6 | 6 | 7 |

[2)] 9 points hedonic scale, where: 1= Dislike extremely; 2 = Dislike very much; 3 = Dislike moderately; 4 = Dislike slightly; 5 = Neither like or dislike; 6 = Like slightly; 7 = Like moderately; 8 = Like very much; 9 = Like extremely.

## Appendix 8.4 (Contd.): Summary of Results for the Central Location Test

## PART-I AND PART-II

Overall liking and product characteristics of the 'Commercial Sample'

| Code | Panelists | Overall [2)] Preference | Appearance[2)] | Colour[2)] | Hardness[2)] | Lemon Flavour[2)] | Sweetness[2)] |
|---|---|---|---|---|---|---|---|
| 196 | 1 | 4 | 5 | 6 | 4 | 6 | 4 |
| 196 | 2 | 7 | 7 | 7 | 4 | 5 | 7 |
| 196 | 3 | 5 | 8 | 8 | 4 | 7 | 8 |
| 196 | 4 | 7 | 8 | 8 | 7 | 8 | 8 |
| 196 | 5 | 7 | 6 | 7 | 7 | 6 | 5 |
| 196 | 6 | 7 | 5 | 4 | 3 | 2 | 6 |
| 196 | 7 | 7 | 5 | 4 | 3 | 2 | 6 |
| 196 | 8 | 7 | 8 | 8 | 6 | 8 | 8 |
| 196 | 9 | 8 | 7 | 9 | 7 | 9 | 9 |
| 196 | 10 | 7 | 7 | 7 | 7 | 7 | 6 |
| 196 | 11 | 6 | 6 | 6 | 7 | 7 | 6 |
| 196 | 12 | 7 | 7 | 6 | 8 | 8 | 6 |
| 196 | 13 | 7 | 7 | 8 | 8 | 7 | 7 |
| 196 | 14 | 8 | 5 | 9 | 9 | 9 | 9 |
| 196 | 15 | 7 | 7 | 8 | 7 | 8 | 9 |
| 196 | 16 | 7 | 7 | 7 | 7 | 7 | 7 |
| 196 | 17 | 7 | 6 | 6 | 6 | 7 | 6 |
| 196 | 18 | 9 | 9 | 9 | 8 | 9 | 9 |
| 196 | 19 | 7 | 7 | 7 | 7 | 7 | 6 |
| 196 | 20 | 7 | 7 | 7 | 8 | 8 | 6 |
| 196 | 21 | 5 | 8 | 8 | 8 | 7 | 7 |
| 196 | 22 | 7 | 8 | 8 | 9 | 9 | 9 |
| 196 | 23 | 7 | 6 | 7 | 7 | 8 | 9 |
| 196 | 24 | 8 | 7 | 9 | 7 | 8 | 8 |
| 196 | 25 | 7 | 7 | 7 | 8 | 7 | 7 |
| 196 | 26 | 6 | 6 | 6 | 7 | 8 | 6 |
| 196 | 27 | 7 | 7 | 6 | 8 | 7 | 6 |
| 196 | 28 | 7 | 7 | 8 | 7 | 8 | 7 |
| 196 | 29 | 7 | 8 | 8 | 6 | 8 | 8 |
| 196 | 30 | 8 | 7 | 9 | 7 | 9 | 9 |
| 196 | 31 | 7 | 7 | 7 | 7 | 7 | 6 |
| 196 | 32 | 6 | 6 | 6 | 7 | 7 | 6 |
| 196 | 33 | 7 | 7 | 6 | 8 | 8 | 6 |
| 196 | 34 | 7 | 7 | 7 | 8 | 8 | 6 |
| 196 | 35 | 5 | 8 | 8 | 8 | 7 | 7 |
| 196 | 36 | 5 | 8 | 8 | 8 | 7 | 7 |
| 196 | 37 | 7 | 8 | 8 | 9 | 9 | 9 |

[2)] 9 points hedonic scale, where; 1= Dislike extremely; 2 = Dislike very much; 3 = Dislike moderately; 4 = Dislike slightly; 5 = Neither like or dislike; 6 = Like slightly; 7 = Like moderately; 8 = Like very much; 9 = Like extremely.

## Appendix 8.4 (Contd.): Summary of Results for the Central Location Test

## PART-I AND PART-II

Overall liking and product characteristics of the 'Commercial Sample'

| Code | Panelists[2)] | Overall[2)] liking | Appearance[2)] | Colour[2)] | Hardness[2)] | Lemon[2)] Flavour | Sweetness[2)] |
|---|---|---|---|---|---|---|---|
| 196 | 38 | 7 | 6 | 7 | 7 | 8 | 9 |
| 196 | 39 | 8 | 7 | 9 | 7 | 8 | 8 |
| 196 | 40 | 7 | 7 | 7 | 8 | 7 | 7 |
| 196 | 41 | 7 | 7 | 8 | 7 | 8 | 7 |
| 196 | 42 | 7 | 8 | 8 | 6 | 8 | 8 |
| 196 | 43 | 8 | 7 | 9 | 7 | 9 | 9 |
| 196 | 44 | 7 | 7 | 7 | 7 | 7 | 6 |
| 196 | 45 | 6 | 6 | 6 | 7 | 7 | 6 |
| 196 | 46 | 7 | 6 | 7 | 7 | 8 | 9 |
| 196 | 47 | 8 | 7 | 9 | 7 | 8 | 8 |
| 196 | 48 | 7 | 7 | 7 | 8 | 7 | 7 |
| 196 | 49 | 7 | 7 | 8 | 7 | 8 | 7 |
| 196 | 50 | 7 | 8 | 8 | 6 | 8 | 8 |
| 196 | 51 | 8 | 7 | 8 | 7 | 7 | 8 |
| Means | | 6.902 | 6.922 | 7.353 | 6.941 | 7.392 | 7.2 |
| Median | | 7 | 7 | 7 | 7 | 8 | 7 |

[2)] 9 points hedonic scale, where; 1= Dislike extremely; 2 = Dislike very much; 3 = Dislike moderately; 4 = Dislike slightly; 5 = Neither like or dislike; 6 = Like slightly; 7 = Like moderately; 8 = Like very much; 9 = Like extremely.

## Appendix 8.4 (Contd.): Summary of Results for the Central Location Test

## PART-I AND PART-II

Overall liking and product characteristics of the antibacterial jellybeans 'Informed Scores'

| Panelists | Overall[2)] Preference | Appearance[2)] | Colour[2)] | Hardness[2)] | Honey[2)] Flavour | Lemon[2)] Flavour | Sweetness[2)] | Blend Of[2)] Flavours |
|---|---|---|---|---|---|---|---|---|
| 1 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 |
| 2 | 6 | 5 | 6 | 3 | 5 | 7 | 3 | 7 |
| 3 | 4 | 7 | 6 | 6 | 5 | 4 | 7 | 4 |
| 4 | 7 | 8 | 8 | 7 | 4 | 3 | 4 | 4 |
| 5 | 8 | 6 | 7 | 7 | 7 | 6 | 4 | 4 |
| 6 | 8 | 9 | 9 | 9 | 9 | 8 | 2 | 9 |
| 7 | 8 | 6 | 8 | 7 | 6 | 8 | 7 | 6 |
| 8 | 7 | 8 | 8 | 7 | 8 | 8 | 9 | 7 |
| 9 | 7 | 4 | 7 | 6 | 8 | 8 | 5 | 7 |
| 10 | 7 | 7 | 7 | 7 | 7 | 7 | 7 | 7 |
| 11 | 7 | 7 | 6 | 8 | 6 | 8 | 7 | 7 |
| 12 | 8 | 7 | 7 | 7 | 8 | 9 | 7 | 9 |
| 13 | 7 | 4 | 8 | 8 | 6 | 7 | 8 | 6 |
| 14 | 6 | 9 | 9 | 9 | 5 | 9 | 2 | 2 |
| 15 | 6 | 7 | 6 | 7 | 5 | 7 | 8 | 6 |
| 16 | 7 | 8 | 8 | 8 | 8 | 7 | 7 | 8 |
| 17 | 6 | 6 | 6 | 6 | 6 | 5 | 6 | 6 |
| 18 | 6 | 6 | 7 | 5 | 5 | 7 | 6 | 7 |
| 19 | 7 | 7 | 6 | 8 | 6 | 8 | 7 | 7 |
| 20 | 8 | 9 | 9 | 7 | 6 | 8 | 7 | 6 |
| 21 | 8 | 6 | 8 | 7 | 8 | 8 | 9 | 7 |
| 22 | 7 | 8 | 8 | 6 | 8 | 8 | 5 | 7 |
| 23 | 7 | 4 | 7 | 7 | 7 | 7 | 7 | 7 |
| 24 | 6 | 7 | 6 | 7 | 5 | 9 | 7 | 9 |
| 25 | 7 | 8 | 8 | 8 | 8 | 7 | 8 | 6 |
| 26 | 6 | 6 | 6 | 6 | 6 | 9 | 2 | 2 |
| 27 | 6 | 6 | 7 | 5 | 5 | 7 | 8 | 6 |
| 28 | 7 | 7 | 6 | 8 | 6 | 7 | 7 | 8 |
| 29 | 6 | 6 | 6 | 6 | 6 | 5 | 6 | 6 |
| 30 | 6 | 6 | 7 | 5 | 5 | 7 | 6 | 7 |
| 31 | 7 | 7 | 6 | 8 | 6 | 8 | 7 | 7 |
| 32 | 8 | 9 | 9 | 7 | 6 | 8 | 7 | 6 |
| 33 | 8 | 6 | 8 | 7 | 8 | 8 | 9 | 7 |
| 34 | 6 | 6 | 6 | 6 | 6 | 5 | 6 | 6 |
| 35 | 6 | 6 | 7 | 5 | 5 | 7 | 6 | 7 |

[2)] 9 points hedonic scale, where; 1= Dislike extremely; 2 = Dislike very much; 3 = Dislike moderately; 4 = Dislike slightly; 5 = Neither like or dislike; 6 = Like slightly; 7 = Like moderately; 8 = Like very much; 9 = Like extremely.

## Appendix 8.4 (Contd.): Summary of Results for the Central Location Test

## PART-I AND PART-II

Overall liking and product characteristics of the commercial sample

| Panelists | Overall Liking | Appearance | Colour | Hardness | Honey Flavour | Lemon Flavour | Sweetness | Blend Of Flavours |
|---|---|---|---|---|---|---|---|---|
| 36 | 7 | 7 | 6 | 8 | 6 | 8 | 7 | 7 |
| 37 | 8 | 9 | 9 | 7 | 6 | 8 | 7 | 6 |
| 38 | 8 | 6 | 8 | 7 | 8 | 8 | 9 | 7 |
| 39 | 7 | 7 | 6 | 8 | 6 | 7 | 7 | 8 |
| 40 | 6 | 6 | 6 | 6 | 6 | 5 | 6 | 6 |
| 41 | 6 | 6 | 7 | 5 | 5 | 7 | 6 | 7 |
| 42 | 7 | 7 | 6 | 8 | 6 | 8 | 7 | 7 |
| 43 | 8 | 9 | 9 | 7 | 6 | 8 | 7 | 6 |
| 44 | 6 | 6 | 6 | 6 | 6 | 5 | 6 | 7 |
| 45 | 6 | 6 | 7 | 5 | 5 | 7 | 6 | 6 |
| 46 | 7 | 7 | 6 | 8 | 6 | 8 | 7 | 7 |
| 47 | 8 | 9 | 9 | 7 | 6 | 8 | 7 | 7 |
| 48 | 8 | 6 | 8 | 7 | 8 | 8 | 9 | 6 |
| 49 | 6 | 6 | 7 | 5 | 5 | 7 | 6 | 7 |
| 50 | 7 | 7 | 6 | 8 | 6 | 8 | 7 | 8 |
| 51 | 8 | 6 | 8 | 7 | 8 | 8 | 9 | 6 |
| Means | 6.902 | 6.784 | 7.157 | 6.804 | 6.314 | 7.255 | 6.549 | 6.529 |
| Median | 7 | 7 | 7 | 7 | 6 | 8 | 7 | 7 |

9 points hedonic scale, where: 1= Dislike extremely; 2 = Dislike very much; 3 = Dislike moderately; 4 = Dislike slightly; 5 = Neither like or dislike; 6 = Like slightly; 7 = Like moderately; 8 = Like very much; 9 = Like extremely.

## Appendix 8.5: Analysis of Variance and Tukey's Honestly Significant Comparison Test for Each Product Attribute

### Overall Liking

#### Analysis of Variance

| Source of Variation | SS | DF | MS | F | P-value |
|---|---|---|---|---|---|
| Panelists | 59.88 | 50 | 1.20 | 1.13 | 0.296 |
| Samples | 4.24 | 2 | 2.12 | 2.00 | 0.140 |
| Error | 105.76 | 100 | 1.06 | | |
| Total | 169.88 | 152 | | | |

#### Tukey's Honestly Significant Comparison Test

| Product code | 196 | 311 | 369 |
|---|---|---|---|
| Total | 352 | 334 | 352 |
| Means | 6.902[a] | 6.549[a] | 6.902[a] |

### Appearance

#### Analysis of Variance

| Source of Variation | SS | DF | MS | F | P-value |
|---|---|---|---|---|---|
| Panelists | 150.43 | 50 | 3.01 | 1.82 | 0.006 |
| Samples | 16.04 | 2 | 8.02 | 4.85 | 0.010 |
| Error | 165.29 | 100 | 1.65 | | |
| Total | 331.76 | 152 | | | |

#### Tukey's Honestly Significant Comparison Test

| Product code | 196 | 311 | 369 |
|---|---|---|---|
| Total | 353 | 315 | 346 |
| Means | 6.922[a] | 6.176[b] | 6.784[ab] |

### Colour

#### Analysis of Variance

| Source of Variation | SS | DF | MS | F | P-value |
|---|---|---|---|---|---|
| Panelists | 92.33 | 50 | 1.85 | 1.28 | 0.152 |
| Samples | 19.86 | 2 | 9.93 | 6.86 | 0.002 |
| Error | 144.81 | 100 | 1.45 | | |
| Total | 256.99 | 152 | | | |

## Appendix 8.5 (Contd.): Analysis of Variance and Tukey's Honestly Significant Comparison Test for Each Product Attribute

### Tukey's Honestly Significant Comparison Test

| Product code | 196 | 311 | 369 |
|---|---|---|---|
| Total | 375 | 332 | 365 |
| Means | 7.353[a] | 6.510[b] | 7.157[a] |

### Hardness

### Analysis of Variance

| Source of Variation | SS | DF | MS | F | P-value |
|---|---|---|---|---|---|
| Panelists | 86.39 | 50 | 1.73 | 0.99 | 0.512 |
| Samples | 5.45 | 2 | 2.73 | 1.56 | 0.216 |
| Error | 175.22 | 100 | 1.75 | | |
| Total | 267.06 | 152 | | | |

### Tukey's Honestly Significant Comparison Test

| Product code | 196 | 311 | 369 |
|---|---|---|---|
| Total | 354 | 331 | 347 |
| Means | 6.941[a] | 6.490[a] | 6.804[a] |

### Overall Flavour

### Analysis of Variance

| Source of Variation | SS | DF | MS | F | P-value |
|---|---|---|---|---|---|
| Panelists | 131.33 | 50 | 2.63 | 1.22 | 0.199 |
| Samples | 45.45 | 2 | 22.73 | 10.56 | 0.000 |
| Error | 215.22 | 100 | 2.15 | | |
| Total | 392.00 | 152 | | | |

### Tukey's Honestly Significant Comparison Test

| Product code | 196 | 311 | 369 |
|---|---|---|---|
| Total | 377 | 310 | 333 |
| Means | 7.392[a] | 6.078[b] | 6.529[b] |

## Appendix 8.5 (Contd.): Analysis of Variance and Tukey's Honestly Significant Comparison Test for Each Product Attribute

**Sweetness**

### Analysis of Variance

| Source of Variation | SS | DF | MS | F | P-value |
|---|---|---|---|---|---|
| Panelists | 156.33 | 50 | 3.13 | 1.12 | 0.306 |
| Samples | 45.19 | 2 | 22.59 | 8.12 | 0.001 |
| Error | 278.14 | 100 | 2.78 | | |
| Total | 479.66 | 152 | | | |

### Tukey's Honestly Significant Comparison Test

| Product code | 196 | 311 | 369 |
|---|---|---|---|
| Total | 377 | 310 | 334 |
| Means | 7.392[a] | 6.078[b] | 6.549[b] |

## PART III

### Personal Details

| Gender | Number | % |
|---|---|---|
| Male | 28 | 55 |
| Female | 23 | 45 |

| Age group | Number of panelists | % of panelists |
|---|---|---|
| Under 20 years | 12 | 23.5 |
| 21-30 years | 21 | 41.2 |
| 31-40 years | 18 | 35.3 |
| 41-50 years | 0 | 0 |
| Above 50 years | 0 | 0 |

What do you see this product as?

| Product type | Number of Panelists | % of panelists |
|---|---|---|
| Medical product | 0 | 0 |
| Preventive product | 6 | 11.8 |
| Preventive alltime | 1 | 2.0 |
| Confectionery with benefits | 23 | 45.1 |
| Confectionery product | 21 | 41.2 |

## Appendix 8.5 (Contd.): Analysis of Variance and Tukey's Honestly Significant Comparison Test for Each Product Attribute

Do you use dietary supplements/health products?

| Dietary supplements | Number of panelists | % of panelists |
|---|---|---|
| Yes | 28 | 55 |
| No | 23 | 45 |

Have you used any of the following products?

| Product type | Number of panelists | % of panelists [1)] |
|---|---|---|
| Honey and propolis lozenges | 14 | 27.45 |
| Propolis tincture | 4 | 7.84 |
| Propolis oral fresh | 0 | 0 |
| Propolis-throat spray | 8 | 15.7 |
| Pollen and honey spread | 2 | 3.92 |
| Throat lozenges | 39 | 76.47 |

[1)] Percentages were calculated from the total number of panelists in the each group (e.g. 27.45% = 14/51); Panelists could tick as many products as they liked.

Why do you use health products?

| Health attributes | Number of Panelists | % of panelists [1)] |
|---|---|---|
| Source of nutrition | 22 | 43.14 |
| Source of instant energy | 12 | 23.53 |
| Healthy body at different life cycles | 12 | 23.53 |
| Immune system healthy | 32 | 62.75 |
| Life extension (others) | 6 | 11.76 |

[1)] Percentages were calculated from the total number of panelists in the each group (e.g. 23.53% = 12/51); Panelists could tick as many products as they liked.

Would you buy this product?

| Buying intention | Number of Panelists | % of panelists |
|---|---|---|
| Definitely buy | 4 | 7.84 |
| Probably buy | 31 | 60.8 |
| Might or might not buy | 14 | 27.45 |
| Probably not buy | 2 | 3.91 |
| Definitely not buy | 0 | 0 |

$\chi^2 = 64.39$; df = 4; p = 0.0001

## Appendix 8.5 (Contd.): Analysis of Variance and Tukey's Honestly Significant Comparison Test for Each Product Attribute

Do you find the claims about the product believable?

| Product claims | Number of panelists | % of panelists |
|---|---|---|
| Definitely believable | 9 | 17.65 |
| Probably believable | 29 | 58.86 |
| Might/might not believable | 11 | 21.57 |
| Probably not believable | 2 | 3.92 |
| Definitely not believable | 0 | 0 |

$\chi^2 = 51.65$; df = 4; p = 0.0001

**Appendix 9.1: Information Sheet provided to the Consumer Panelists**

## Information Sheet for Consumer Panelists

You have been invited to take part in a sensory study being conducted by Dinesh Sofat, post graduate student in the Institute of Food Nutrition and Human Health, Massey University, under my supervision.

As a participant in this study, you will be given jellybeans to eat over an eight-week period. During this time you will be given 5 surveys asking you to indicate your liking of a variety of characteristics, overall liking of the product, consumption pattern and opinions on product effectiveness. This will take approximately 10 to 20 minutes of your time each fortnight.

Please read this ingredient list carefully as it contains the ingredients that you will be consuming during the study. If you are allergic to anything contained on the list, please inform the researcher and your name will be removed from the list of study participants.

**INGREDIENTS: Maize syrup, Cane sugar, New Zealand Manuka honey, Starch, Gelatin, New Zealand bee propolis extract, Citric acid, Flavour, Colour (E-102). (may also contain Bee Pollen)**

In order to protect your privacy, you will be assigned a panellist number, which will be recorded, on the top of your questionnaire. This number, not your name, will be used in the analysis of the data.

You are free at any time during the course of the panel to withdraw without giving us a reason. Please inform us so that we will not send you any more questionnaires to complete.

The information collected in this study will be used to understand consumer behaviour in respect to these jellybeans. At the end of the study, you may request a copy of the results. No individual data will be presented only the means and standard deviations will be available. All the data will input into a computer program using panellist numbers only. No names will be used. The data and the original questionnaire will be kept in a file.

Please bear in mind that the researchers take no responsibility for any injuries that may occur during the panel.

If you have any questions about this research, please contact Carol Pound at 350-4399 in the normal working hours or 376-6654 after hours.

**Carol Pound**
**Lecturer, Food Technology**
**Institute of Food, Nutrition and Human Health**
**Massey University**
**Private Bag 11-222**
**Palmerston North**
**Ph. (06) 350-4399**
**Fax (06) 350-5655**

## Appendix 9.2: Consent Form Filled by Prospective Consumer Panelists

I have read the information sheet.

My questions have been answered to my satisfaction, and I understand that I may ask further questions at any time.

I understand that I have the right to withdraw from the study, decline to answer any questions or consume the jellybeans at any time without giving a reason.

I agree to provide information to the researchers on the understanding that my name will not be used without my permission. The information will be published in a Masters thesis and used for publications arising from this research project. If the new product appears to be viable, the group results may also be used to promote the project as a commercial proposition.

I have read the ingredient list and, to my knowledge, I am not allergic to anything contained on the list.

I agree to participate in this study under the conditions set out in the information sheet.

Signed: .....

Name: .....

Date: .....

## Appendix 9.3: Forwarding Letter Sent to Consumer Panelists

**Dinesh Sofat**
362 Ruahine street
Palmerston North

**6 May, 1999**

**Ms. XXXX**
**48 Edward Street**
**Pahiatua**

**Dear XXXX**

Thank you very much for showing interest to participate in the consumer panel. Please read carefully the enclosed information and consent form. I hope, that you will be able to agree to the terms and conditions contained in the documents.

The completed consent form should be sent back to me by 19 May, 99 in a free post envelope provided. After receiving this form you will be given a packet of jellybeans, and I would like you to use this product for 8 weeks at your own pace. In turn you will be asked to fill in a questionnaire at the end of every two weeks.

I hope you will oblige me by participating in the consumer test.

Thanks for your consideration.

Regards,

**Dinesh Sofat**
**Post graduate student**
**I.F.N.H.H**
**Massey University**

**Appendix 9.4: Questionnaires Used in Home Use Test**

## Nutraceutical Confectionery Product

**Dear Panelists**

**Hi!**

I am a postgraduate student in The Institute of Food Nutrition and Human Health, Massey University. I am conducting a home use consumer test of nutraceutical jellybeans. This product has derived the antibacterial properties from manuka honey and propolis. Both of this produce has shown to have potent antibacterial properties against a wide spectrum of bacteria and fungus causing sore throat, stomach ulcers and dermatitis. The quantity of honey and propolis used in the product is sufficient to stop the growth of these bacteria. Moreover, the preliminary testing of the finished product has shown antibacterial properties against test organisms.

You are required to use this product for 8 weeks. You will be given as much product as you require and will be asked to fill in a questionnaire at the end of every two weeks and return in the free post envelope provided. At the end of the study, you would have had an opportunity to complete five questionnaires. After I receive all the questionnaires from you, you will be given a $ 20.0 gift voucher to compensate for your time and efforts.

Ms. Carol Pound and Ms. Lisa Duizer are jointly supervising this project. To obtain the replacement product, you may contact the undersigned or my supervisors at 350-4399 in the normal working hours.

I would like to know what you think honestly about the honey-propolis jellybeans. Please turn the page and follow the instructions.

Thank you for your help.

**Dinesh Sofat**

**(Postgraduate student)**

QUESTIONNAIRE-1 Period_____ Code _____

**PART-I Confectionery Product in General**

**The following questions are about the perception of the product. Please tick your choices after carefully reading the concept and claims (√). Please don't taste the product yet.**

The researchers at Waikato University have reconfirmed that manuka honey has potent antibacterial properties. In a joint study conducted by Institute of Industrial Research and Development, and Waikato University has also proved that New Zealand propolis is rich in polyphenols, which are found to have antibacterial, antiviral, and antifungal properties against organisms causing sore throat, stomach ulcer and dermatitis. Because of so many beneficial effects the list of uses is endless and has found its way into pharmaceutical and cosmetic products.

The jellybean product given to you has derived the antibacterial properties from manuka honey and propolis. The testing of the finished product has shown antibacterial properties in the laboratory tests.

1. Do you find the concept and claims about manuka honey and propolis believable?
   - ❒ Definitely believable
   - ❒ Probably believable
   - ❒ Might or might not believe
   - ❒ Probably not believable
   - ❒ Definitely not believable
2. Do you think these honey-propolis jellybeans will effectively stop bacterial growth?
   - ❒ Definitely stop
   - ❒ Probably stop
   - ❒ Might or might not stop
   - ❒ Probably not stop
   - ❒ Definitely not stop
3. Do you see some distinct benefits of this product over the ordinary jellybeans?
   - ❒ Yes
   - ❒ May or may not
   - ❒ No
4. Do you see this concept as:
   - ❒ A medical product taken when need be
   - ❒ A preventive product taken in danger period
   - ❒ A preventive product taken all the time
   - ❒ A confectionery product with added benefits
   - ❒ A confectionery product

**Please taste the product and answer the following questions:**

**PART-II Overall Liking**

**INSTRUCTIONS:**

1. PLEASE RINSE YOUR MOUTH WITH PLAIN WATER BEFORE TASTING.

2. EVALUATE THE PRODUCT- Visual, Odour, and Taste.

**Overall Liking**

Consider all characteristics and indicate your overall opinion by giving a score to the sample that reflects your liking of the product.

1 = Dislike extremely
2 = Dislike very much
3 = Dislike moderately
4 = Dislike slightly
5 = Neither like or dislike
6 = Like slightly
7 = Like moderately
8 = Like very much
9 = Like extremely

1. Using the scale above, mark your **overall liking** for the sample in the space provided.

| Sample No. | Overall Liking |
|---|---|
| 614 | |

- Comments: Please indicate WHAT in particular you Liked or Disliked about this product? (USE WORDS NOT SENTENCES.)

| Sample No. | Liked | Disliked |
|---|---|---|
| 614 | | |

**PART-III Product Characteristics**

**INSTRUCTIONS:** PLEASE LOOK AT THE SAMPLE

**Appearance**

1. Using the 1-9 scale as shown on page-4, indicate how much you **like the appearance** of the sample?

| Sample No. | Liking of the Appearance |
|---|---|
| 614 | |

2. Using the 1-9 scale as shown on page-4, indicate how much you **like the color** of the sample?

| Sample No. | Liking of the Color |
|---|---|
| 614 | |

**INSTRUCTIONS:** PLEASE TASTE THE SAMPLE

**Texture**

3. Please re-taste the sample as needed. Using the scale as shown on page-4, indicate how much you **like the hardness** of the sample?

| Sample No. | Liking of the Hardness |
|---|---|
| 614 | |

**Flavour**

4. Using the 1-9 scale as shown on page-4, indicate how much you **like the overall flavour** of the sample?

| Sample No. | Liking of the Overall Flavour |
|---|---|
| 614 | |

5. Using the 1-9 scale as shown on page-4, indicate how much you **like the sweetness** of the sample?

| Sample No. | Liking of the Sweetness |
|---|---|
| 614 | |

**PART-IV Sales Appeal**

1. Do you see this product as:
   - ❒ A medical product taken when need be
   - ❒ A preventive product taken in danger period
   - ❒ A preventive product taken all the time
   - ❒ A confectionery product with added benefits
   - ❒ A confectionery product

2. Do you prefer this product to the existing jellybeans available in the market?
   - ❒ Definitely prefer
   - ❒ Probably prefer
   - ❒ Might or might not prefer
   - ❒ Probably not prefer
   - ❒ Definitely not prefer

3. Would you replace your current jellybeans with this new jellybeans having antibacterial properties?
   - ❒ Definitely replace
   - ❒ Probably replace
   - ❒ Might or might not replace
   - ❒ Probably not replace
   - ❒ Definitely not replace

4. If an antibacterial jellybean were available, would you be willing to pay more?

   ❒ Yes

   ❒ May or may not

   ❒ No

5. If yes, how much would you be willing to pay extra per 100 grams, considering market price of the regular jellybeans $ 1.80/100 gram?

   ❒ < 0.50 ❒ 1.00

   ❒ 0.50 ❒ 1.25

   ❒ 0.75 ❒ 1.50

**PART-V Personal Details**

The following questions are about you. Everything written in this survey is confidential. The questions are purely asked to indicate the type of consumer who has been surveyed. Please tick your choices (√).

1. Gender

   ❒ Male

   ❒ Female

   Age group

   ❒ Under 20 years ❒ 41-50 years

   ❒ 21-30 years ❒ Above 50 years

   ❒ 31-40 years

2. What is your qualification?

   ❒ Still at school

   ❒ Less than High school/High school

   ❒ Trade qualification

   ❒ Polytechnic qualification

   ❒ Degree

   ❒ Post graduate Degree

   ❒ Other specify _____

3. What is your profession?

   _____

4. What complaints would you like this product to cure? (Tick as many as appropriate).

   ❒ Sore throat

   ❒ Common cold

   ❒ Bad breath

   ❒ Stomach ulcer

   ❒ Other mouth or stomach problems, please specify _____

5. Please indicate if you have visited any of the following during the last 12 months for the complaints mentioned in the Question-4?
   - ❒ General practitioner
   - ❒ Specialist
   - ❒ Naturopath
   - ❒ Homeopath
   - ❒ Other, please specify _____

6. Have you ever used any one of the following products during the last 6 months? (Tick as many as appropriate)
   - ❒ Honey and propolis lozenges
   - ❒ Propolis tincture
   - ❒ Propolis oral fresh
   - ❒ Propolis-throat spray
   - ❒ Pollen and honey spread
   - ❒ Throat lozenges

7. Why do you use honey based products/throat products?
   - ❒ Safe alternative to conventional medicines
   - ❒ Source of nutrition
   - ❒ To keep immune system healthy
   - ❒ To keep healthy body at different life cycles
   - ❒ Source of instant energy
   - ❒ Other, please specify _____

**Please check that you have answered all the questions. Please return in the freepost envelope. Thank you very much for your time and assistance.**

**Appendix 9.4 (Contd.): Questionnaires Used in Home Use Test**

## Nutraceutical Confectionery Product

**Dear Panelists**

**Hi!**

I hope that you are enjoying your jellybeans. Now it is time to fill in the 2nd questionnaire.

I would like to know what you think about the honey-propolis jellybeans, which you have consumed for the last 2 weeks. If you have stopped eating them, don't be afraid to say so when you reach the consumption question. To make my study valid, I need all the questionnaires to be returned.

Be honest, you won't hurt my feelings.

Thank you for your help.

**Dinesh Sofat**

**(Postgraduate student)**

**A reminder if you need any more jellybeans or have any questions you can contact one of the following people:**

| | | |
|---|---|---|
| **Pahiatua** | **Carol Pound** | **3766654 (for questions)** |
| **Pahiatua** | **Nations Footwear** | **(for more jellybeans)** |
| **Auckland** | **Lisa Duizer** | **4439364** |

**QUESTIONNAIRE-2** **Period** _____ **Code** _____

**PART-I Overall Liking**

Consider all characteristics and indicate your overall opinion by giving a score to the sample that reflects your liking of the product.

1 = Dislike extremely
2 = Dislike very much
3 = Dislike moderately
4 = Dislike slightly
5 = Neither like or dislike
6 = Like slightly
7 = Like moderately
8 = Like very much
9 = Like extremely

1. Using the scale above, mark your **overall liking** for each sample in the space besides the sample number.

| Sample No. | Overall Liking |
|---|---|
| 614 | |

- **Comments:** Please indicate WHAT in particular you Liked or Disliked about this product? (USE WORDS NOT SENTENCES)

| Sample No. | Liked | Disliked |
|---|---|---|
| 614 | | |

**PART-II Product Characteristics**

**Appearance**

1. Using the 1-9 scale as shown on page-2, indicate how much you **like the appearance** of the sample?

| Sample No. | Liking of the Appearance |
|---|---|
| 614 | |

2. Using the 1-9 scale as shown on page-2, indicate how much you **like the colour** of the sample?

| Sample No. | Liking of the Colour |
|---|---|
| 614 | |

**Texture**

3. Using the scale as shown on page-2, indicate how much you **like the hardness** of the sample?

| Sample No. | Liking of the Hardness |
|---|---|
| 614 | |

**Flavour**

4. Using the 1-9 scale as shown on page-2, indicate how much you **like the overall flavour** of the sample?

| Sample No. | Liking of the Overall Flavour |
|---|---|
| 614 | |

5. Using the 1-9 scale as shown on page-2, indicate how much you **like the sweetness** of the sample?

| Sample No. | Liking of the Sweetness |
|---|---|
| 614 | |

**PART-III Confectionery Product in General**

The following questions are about the perception of the product. Please tick your choices (√).

The researchers at Waikato University have determined that manuka honey has potent antibacterial properties. A joint study conducted by Institute of Industrial Research and Development, and Waikato University has also proved that New Zealand propolis is rich in polyphenols, which were found to have antibacterial, antiviral, and antifungal properties against organisms causing sore throat, stomach ulcer and dermatitis. Because of the presence of so many beneficial effects manuka honey and propolis have found their way into many pharmaceutical and cosmetic products.

1. Now that you have eaten the product for two weeks do you find the claims made about the product believable?

   ❒ Definitely believable
   ❒ Probably believable
   ❒ Might or might not believe
   ❒ Probably not believable
   ❒ Definitely not believable

2. Do you see some distinct benefits of this product over the ordinary jellybeans?

   ❒ Yes
   ❒ May or may not
   ❒ No

3. Do you prefer this product to the existing jellybeans available in the market?

   ❒ Definitely prefer
   ❒ Probably prefer
   ❒ Might or might not prefer
   ❒ Probably not prefer
   ❒ Definitely not prefer

**Comments:** _____

4. Would you replace normal jellybeans with this new jellybeans having antibacterial properties?

- ❒ Definitely replace
- ❒ Probably replace
- ❒ Might or might not replace
- ❒ Probably not replace
- ❒ Definitely not replace

**Comments:** _____

5. Would you buy this product?

- ❒ Definitely buy
- ❒ Probably buy
- ❒ Might or might not buy
- ❒ Probably not buy
- ❒ Definitely not buy

6. How frequently do you think would you buy this product?

- ❒ More than once a week
- ❒ Once a week
- ❒ Once a fortnight
- ❒ Once a month
- ❒ Less than once a month

7. If this antibacterial jellybean were available, would you be willing to pay more?

- ❒ Yes
- ❒ May or may not
- ❒ No

8. If yes, how much would you be willing to pay extra per 100 grams, considering market price of the regular jellybeans $ 1.80/100 gram?

- ❒ <0.50
- ❒ 0.50
- ❒ 1.25
- ❒ 1.00
- ❒ 0.75
- ❒ 1.50

9. Have you given any of the jellybeans to any one else?

- ❒ Yes, appox. How many _____.
- ❒ No

10. Have you collected any more jellybeans in the past two weeks?

- ❒ Yes, How many packets-----
- ❒ No

11. How many jellybeans do you have left?

    ❒ Specify _____

12. Describe your consumption pattern?

    Example: ½ a packet a week, or 3 jellybeans a day.

    ❒ 1st week _____

    ❒ 2nd week _____

13. Have you had anyone of the following problems over the last two weeks?

    ❒ Sore throat

    ❒ Common cold

    ❒ Bad breath

    ❒ Stomach ulcer

    ❒ Other mouth or stomach problems, please specify _____

14. What treatment have you given the complaint?

    _____

15. Do you think the product has helped you in anyway?

    ❒ Yes, please specify

    ❒ May or may not

    ❒ No

16 Have you eaten any other manuka honey or honey products in the past two weeks?

    ❒ Yes, specify _____

    ❒ No

**Please check that you have answered all the questions. Please return in the freepost envelope. Thank you very much for your time and assistance.**

**Appendix 9.4 (Contd): Questionnaires Used in Home Use Test**

## Nutraceutical Confectionery Product

**Dear Panelists**

**Hi!**

I hope that you are still enjoying your jellybeans. Now it is time to fill in questionnaire 3. There has been a very good response, so keep it up.

I would like to know what you think about the honey-propolis jellybeans after consuming them for 4 weeks. If you have stopped eating them, please say so. To make my study valid, I need all the questionnaires to be completed even you have stopped consumption during the two weeks in question.

Be honest.

Thank you for your help.

**Dinesh Sofat**

**(Postgraduate student)**

**QUESTIONNAIRE-3** **Period** _____ **Code** _____

**PART-I Overall Liking**

Consider all characteristics and indicate your overall opinion by giving a score to the sample that reflects your liking of the product.

1 = Dislike extremely
2 = Dislike very much
3 = Dislike moderately
4 = Dislike slightly
5 = Neither like or dislike
6 = Like slightly
7 = Like moderately
8 = Like very much
9 = Like extremely

2. Using the scale above, mark your **overall liking** for each sample in the space besides the sample number.

| Sample No. | Overall Liking |
|---|---|
| 614 | |

- **Comments:** Please indicate WHAT in particular you Liked or Disliked about this product? (USE WORDS NOT SENTENCES.)

| Sample No. | Liked | Disliked |
|---|---|---|
| 614 | | |

**PART-II Confectionery Product in General**

1. Have you given any of the jellybeans to someone else?
   - ❒ Yes, appox. How many _____
   - ❒ No
2. How many jellybeans do you have left?
   - ❒ Specify _____
3. Describe your consumption pattern?
   - ❒ 3rd week _____ ❒ 4th week _____
4. Have you had anyone of the following problems over the last two weeks?
   - ❒ Sore throat
   - ❒ Stomach ulcer
   - ❒ Common cold
   - ❒ Bad breath
   - ❒ Other mouth or stomach problems, please specify _____
5. What treatment have you given the complaint?

   _____
6. Did this product work?
   - ❒ Yes
   - ❒ No
   - ❒ May or may not

**Appendix 9.4 (Contd): Questionnaires Used in Home Use Test**

## Nutraceutical Confectionery Product

**Dear Panelists**

**Hi!**

Now it is time to fill in the 4th questionnaire. I hope that you are still eating the jellybeans and not finding it too much of a chore. To those of you that have sent in all your questionnaires, many thanks! If you have fallen behind, then please send in your questionnaires. Even if you have stopped eating the jellybeans I still need you to complete ALL the questions.

I would like to know what you think about the honey-propolis jellybeans after consuming them for 6 weeks. If you have stopped eating them, please say so. I won't be offended. The purpose of the study is to look at consumption patterns so what you are actually eating is really important to me.

Be honest.

Thank you for your help.

**Dinesh Sofat**

**(Postgraduate student)**

**QUESTIONNAIRE-4** **Period** _____ **Code** _____

**PART-I Overall Liking**

Consider all characteristics and indicate your overall opinion by giving a score to the sample that reflects your liking of the product.

1 = Dislike extremely
2 = Dislike very much
3 = Dislike moderately
4 = Dislike slightly
5 = Neither like or dislike
6 = Like slightly
7 = Like moderately
8 = Like very much
9 = Like extremely

1. Using the scale above, mark your **overall liking** for each sample in the space besides the sample number.

| Sample No. | Overall Liking |
|---|---|
| 614 | |

- **Comments:** Please indicate WHAT in particular you Liked or Disliked about this product? (USE WORDS NOT SENTENCES.)

| Sample No. | Liked | Disliked |
|---|---|---|
| 614 | | |

**PART-II Confectionery Product in General**

1. Have you given any of the jellybeans to some one else?
   - ❒ Yes, appox. How many _____
   - ❒ No
2. How many jellybeans do you have left?
   - ❒ Specify _____
3. Describe your consumption pattern?
   - ❒ 5th week _____
   - ❒ 6th week _____
4. Have you had anyone of the following problems over the last two weeks?
   - ❒ Sore throat
   - ❒ Common cold
   - ❒ Bad breath
   - ❒ Stomach ulcer
   - ❒ Other mouth or stomach problems, please specify _____
5. Have you felt any benefits from using this product?
   - ❒ Yes
   - ❒ May or may not
   - ❒ No

Describe any benefits you have experienced.

_____

_____

**Please check that you have answered all the questions. Please return in the freepost envelope. Thank you very much for your time and assistance.**

**Appendix 9.4 (Contd): Questionnaires Used in Home Use Test**

## Nutraceutical Confectionery Product

**Hi there Jellybean Munchers!**

Now its time to fill in the last questionnaire and you can stop eating jellybeans. I hope you are not "jellybeaned out"!

After I receive this questionnaire from you, you will be sent a $ 20.0 gift voucher or a $ 20.0 donation will be made to an organization of your choice, to compensate for you time and efforts.

As this is the last questionnaire I would like to really thank you for your contribution to my research. As you will have seen products don't just happen and good product developers are always interested in what consumers think. If you are interested in the results of the survey please complete the attached form and send it to my supervisor Carol Pound and she will send you a copy once analysis is complete.

In the next few months we are hoping to get a company buy the rights to manufacture the jellybeans. So keep a watch out for them on your shop shelves.

Regards,

**Dinesh Sofat**

**(Postgraduate student)**

**QUESTIONNAIRE-5** **Period** _____ **Code** _____

**PART-I Overall Liking**

**Overall liking**

Consider all characteristics and indicate your overall opinion by giving a score to the sample that reflects your liking of the product.

1 = Dislike extremely
2 = Dislike very much
3 = Dislike moderately
4 = Dislike slightly
5 = Neither like or dislike
6 = Like slightly
7 = Like moderately
8 = Like very much
9 = Like extremely

1. Using the scale above, mark your **overall liking** for the sample in the space provided.

| Sample No. | Overall Liking |
|---|---|
| 614 | |

- **Comments:** Please indicate WHAT in particular you Liked or Disliked about this product? (USE WORDS NOT SENTENCES.)

| Sample No. | Liked | Disliked |
|---|---|---|
| 614 | | |

**PART-II Product Characteristics**

Appearance

1. Using the 1-9 scale as shown on page-2, indicate how much you **like the appearance** of the sample?

| Sample No. | Liking of the Appearance |
|---|---|
| 614 | |

2. Using the 1-9 scale as shown on page-2, indicate how much you **like the color** of the sample?

| Sample No. | Liking of the Color |
|---|---|
| 614 | |

Texture

3. Using the scale as shown on page-2, indicate how much you **like the hardness** of the sample?

| Sample No. | Liking of the Hardness |
|---|---|
| 614 | |

**Flavour**

4. Using the 1-9 scale as shown on page-2, indicate how much you **like the overall flavour** of the sample?

| Sample No. | Liking of the Overall Flavour |
|---|---|
| 614 | |

5. Using the 1-9 scale as shown on page-2, indicate how much you **like the sweetness** of the sample?

| Sample No. | Liking of the Sweetness |
|---|---|
| 614 | |

Please make any general comments that may help us to improve the product characteristics.

---

**PART-III Sales Appeal**

The following questions are about the perception of the product. Please tick your choices after carefully reading the claims made about the product (√).

The researchers at Waikato University have determined that manuka honey has potent antibacterial properties. A joint study conducted by Institute of Industrial Research and Development, and Waikato University has also proved that New Zealand propolis is rich in polyphenols, which are found to have antibacterial, antiviral, and antifungal properties against organisms causing sore throat, stomach ulcer and dermatitis. Because of so many beneficial effects manuka honey and propolis have found their way into many pharmaceutical and cosmetic products.

The jellybean product given to you has derived the antibacterial properties from manuka honey and propolis. The testing of the finished product has shown antibacterial properties in the laboratory tests.

1. Do you find the claims made about the product believable?

   ❒ Definitely believable
   ❒ Probably believable
   ❒ Might or might not believe
   ❒ Probably not believable
   ❒ Definitely not believable

2. Do you see some distinct benefits of this product over the ordinary jellybeans?

   ❒ Yes
   ❒ May or may not
   ❒ No

Describe:

---

3. Do you prefer this product to the existing jellybeans available in the market?

- ❒ Definitely prefer
- ❒ Probably prefer
- ❒ Might or might not prefer
- ❒ Probably not prefer
- ❒ Definitely not prefer

4. Would you replace your current jellybeans with this new jellybeans having antibacterial properties?

- ❒ Definitely replace
- ❒ Probably replace
- ❒ Might or might not replace
- ❒ Probably not replace
- ❒ Definitely not replace

5. If not, what product do you see this product replacing?

- ❒ Throat lozenges
- ❒ Antibiotic tablets
- ❒ Manuka Honey
- ❒ Other _____

6. Would you buy this product?

- ❒ Definitely buy
- ❒ Probably buy
- ❒ Might or might not buy
- ❒ Probably not buy
- ❒ Definitely not buy

7. If an antibacterial jellybean were available, would you be willing to pay more?

- ❒ Yes
- ❒ May or may not
- ❒ No

8. If yes, how much would you be willing to pay extra per 100 grams, considering market price of the regular jellybeans $ 1.80/100 gram?

- ❒ <0.50
- ❒ 0.50
- ❒ 1.25
- ❒ 1.00
- ❒ 0.75
- ❒ 1.50

9. What complaints would you like this product to cure?

(Tick as many as appropriate).

- ❒ Sore throat
- ❒ Common cold
- ❒ Bad breath
- ❒ Stomach ulcer
- ❒ Other mouth or stomach problems, please specify _____

10. Have you collected any more jellybeans in the past two weeks?

- ❒ Yes, How many packets _____
- ❒ No

11. Have you given any of the jellybeans to some one else?

- ❒ Yes, appox. How many _____
- ❒ No

12. How many jellybeans do you have left?

- ❒ Specify _____

13. Describe your consumption pattern?

❒ 7th week _____ ❒ 8th week _____

14. Have you had anyone of the following problems over the last two weeks?

- ❒ Sore throat
- ❒ Common cold
- ❒ Bad breath
- ❒ Stomach ulcer
- ❒ Other mouth or stomach problems, please specify _____

15. Did this product give any relief?

- ❒ Yes
- ❒ May or may not
- ❒ No

**Voucher**

What voucher would you like:

- ❒ **Music**
- ❒ **Book**
- ❒ **Supermarket, specify** _____
- ❒ **Warehouse**
- ❒ **Donation to be made to:**
  - ❒ **Pahiatua Lions Club**
  - ❒ **Albany Massey Creche**
  - ❒ **Other specify** _____

## Appendix 9.5: Summary of Results for the Home Use Test-Week-0

### PART-I

Concept and claims believable

| Claims believability | Respondents | % Respondents |
|---|---|---|
| Definitely believable | 23 | 47.9 |
| Probably believable | 18 | 37.5 |
| Might or might not believe | 5 | 10.4 |
| Probably not believe | 2 | 4.2 |
| Definitely not believe | 0 | 0.0 |

Effectiveness of jellybeans

| Effectiveness to bacteria | Respondents | % Respondents |
|---|---|---|
| Definitely stop | 2 | 4.2 |
| Probably stop | 14 | 29.2 |
| Might or might not | 26 | 54.2 |
| Probably not | 5 | 10.4 |
| Definitely not | 1 | 2.0 |

Benefits of product over ordinary product

| Benefits over other | Respondents | % Respondents |
|---|---|---|
| Yes | 36 | 75 |
| May or may not | 11 | 22.9 |
| No | 1 | 2.1 |

Concept type

| Concept type | Respondents | % Respondents |
|---|---|---|
| Medical product | 0 | 0.0 |
| Preventive product | 3 | 6.2 |
| Preventive all time | 6 | 12.6 |
| Confectionery benefits | 36 | 75.0 |
| Confectionery product | 3 | 6.2 |

## Appendix 9.5 (Contd.): Summary of Results for the Home Use Test- Week-0

### PART-II AND PART-III

Overall liking and product characteristics of the antibacterial jellybeans

| Panelists | Overall[2)] Liking | Appearance[2)] | Colour[2)] | Hardness[2)] | Overall Flavour | Sweetness[2)] |
|---|---|---|---|---|---|---|
| A1 | 7 | 7 | 7 | 8 | 7 | 4 |
| A2 | 8 | 7 | 6 | 8 | 9 | 9 |
| A3 | 9 | 8 | 6 | 9 | 8 | 8 |
| A4 | 5 | 5 | 5 | 7 | 6 | 5 |
| A5 | 8 | 7 | 8 | 7 | 8 | 7 |
| A6 | 8 | 8 | 6 | 7 | 9 | 9 |
| A7 | 9 | 7 | 8 | 8 | 9 | 9 |
| A8 | 9 | 8 | 8 | 9 | 9 | 9 |
| A9 | 9 | 8 | 8 | 8 | 9 | 7 |
| A10 | 8 | 8 | 9 | 8 | 8 | 9 |
| A11 | 9 | 8 | 8 | 9 | 9 | 8 |
| A12 | 9 | 9 | 5 | 2 | 9 | 5 |
| A13 | 7 | 7 | 6 | 8 | 9 | 8 |
| A14 | 5 | 4 | 4 | 8 | 7 | 7 |
| A15 | 7 | 7 | 6 | 7 | 7 | 3 |
| A16 | 9 | 8 | 9 | 8 | 9 | 9 |
| A17 | 7 | 5 | 6 | 4 | 7 | 8 |
| A18 | 8 | 8 | 7 | 8 | 9 | 8 |
| A19 | 7 | 8 | 8 | 5 | 7 | 8 |
| A20 | 9 | 8 | 7 | 8 | 8 | 9 |
| A21 | 9 | 7 | 8 | 6 | 8 | 9 |
| A22 | 8 | 8 | 6 | 7 | 8 | 8 |
| A23 | 8 | 8 | 8 | 8 | 8 | 6 |
| A24 | 8 | 4 | 4 | 5 | 8 | 8 |
| A25 | 8 | 8 | 8 | 8 | 8 | 8 |
| A26 | 8 | 5 | 5 | 4 | 8 | 8 |
| A27 | 7 | 5 | 4 | 5 | 6 | 3 |
| A28 | 8 | 8 | 8 | 7 | 9 | 9 |
| A29 | 7 | 8 | 8 | 7 | 7 | 8 |
| A30 | 7 | 8 | 8 | 7 | 8 | 7 |
| A31 | 8 | 7 | 7 | 8 | 8 | 6 |
| A32 | 8 | 8 | 8 | 9 | 8 | 9 |
| A33 | 7 | 7 | 7 | 6 | 7 | 8 |
| A34 | 8 | 8 | 7 | 8 | 8 | 8 |
| A35 | 8 | 5 | 4 | 7 | 8 | 8 |

[2)] 9 points hedonic scale, where: 1= Dislike extremely; 2 = Dislike very much; 3 = Dislike moderately; 4 = Dislike slightly; 5 = Neither like or dislike; 6 = Like slightly; 7 = Like moderately; 8 = Like very much; 9 = Like extremely.

## Appendix 9.5 (Contd.): Summary of Results for the Home Use Test

### PART-II AND PART-III

Overall liking and product characteristics of the antibacterial jellybeans

| Panelists | Overall Liking | Appearance | Colour | Hardness | Overall Flavour | Sweetness |
|---|---|---|---|---|---|---|
| A36 | 8 | 8 | 8 | 9 | 8 | 7 |
| A37 | 8 | 7 | 7 | 6 | 7 | 7 |
| A38 | 8 | 7 | 7 | 8 | 8 | 8 |
| A39 | 4 | 7 | 6 | 7 | 7 | 4 |
| A40 | 8 | 8 | 8 | 8 | 8 | 8 |
| A41 | 7 | 8 | 5 | 8 | 8 | 4 |
| A42 | 8 | 7 | 7 | 9 | 8 | 8 |
| A43 | 7 | 7 | 7 | 6 | 6 | 7 |
| A44 | 8 | 5 | 3 | 8 | 8 | 7 |
| A45 | 7 | 6 | 4 | 5 | 7 | 4 |
| A46 | 7 | 7 | 8 | 8 | 7 | 7 |
| A47 | 3 | 8 | 8 | 6 | 8 | 1 |
| A48 | 8 | 3 | 5 | 7 | 8 | 8 |

9 points hedonic scale, where; 1= Dislike extremely; 2 = Dislike very much; 3 = Dislike moderately; 4 = Dislike slightly; 5 = Neither like or dislike; 6 = Like slightly; 7 = Like moderately; 8 = Like very much; 9 = Like extremely.

### PART-IV SALES APPEAL

Product type

| Product type | Respondents | % Respondents |
|---|---|---|
| Medical product | 0 | 0.0 |
| Preventive product | 2 | 4.2 |
| Preventive all time | 7 | 14.6 |
| Confectionery benefits | 36 | 75.0 |
| Confectionery product | 3 | 6.2 |

Product preference to the existing jellybeans

| Preference | Respondents | % Respondents |
|---|---|---|
| Definitely prefer | 13 | 27.1 |
| Probably prefer | 18 | 37.5 |
| Might or might not prefer | 13 | 27.1 |
| Probably not | 4 | 8.3 |
| Definitely not | 0 | 0.00 |

Replacement of current jellybeans with new jellybeans

| Replacement | Respondents | % Respondents |
|---|---|---|
| Definitely replace | 16 | 33.3 |
| Probably replace | 13 | 27.1 |
| Might or might not replace | 11 | 22.9 |
| Probably not | 8 | 16.7 |
| Definitely not | 0 | 0.00 |

Would you be paying more?

| Pay more | Respondents | % Respondents |
|---|---|---|
| Yes | 23 | 47.9 |
| May or may not | 16 | 33.3 |
| No | 9 | 18.8 |

Willing to pay extra

| Above market price | Respondents | % Respondents |
|---|---|---|
| < 0.50 | 15 | 31.3 |
| 0.50 | 16 | 33.3 |
| 0.75 | 9 | 18.8 |
| 1.00 | 8 | 16.6 |
| 1.25 | 0 | 0.0 |
| 1.50 | 0 | 0.0 |

PART-V PERSONAL DETAILS

Gender

| Gender | Respondents | % Respondents |
|---|---|---|
| Male | 22 | 45.8 |
| Female | 26 | 54.2 |

Age group

| Age | Respondents | % Respondents |
|---|---|---|
| Under 20 | 4 | 8.3 |
| 21-30 years | 3 | 6.2 |
| 31-40 years | 12 | 25.0 |
| 41-50 years | 9 | 18.8 |
| Above 50 years | 20 | 41.7 |

Qualification

| Qualification | Respondents | % Respondents |
|---|---|---|
| Still at school | 4 | 8.3 |
| High school | 5 | 10.4 |
| Trade | 9 | 18.8 |
| Polytechnic | 6 | 12.5 |
| Degree | 10 | 20.8 |
| Post graduate | 7 | 14.6 |
| Other | 7 | 14.6 |

What complaints would you like to cure?

| Complaints to cure | Respondents | % Respondents |
|---|---|---|
| Sore throat | 40 | 83.3 |
| Common cold | 34 | 70.8 |
| Bad breath | 17 | 35.4 |
| Stomach | 11 | 22.9 |
| Other problems | 9 | 18.7 |

Visit to the medical professionals

| Professionals | Respondents | % Respondents |
|---|---|---|
| General practitioner | 9 | 18.7 |
| Specialist | 0 | 0.0 |
| Naturopath | 1 | 2.1 |
| Homeopath | 0 | 0.0 |
| Others | 1 | 2.1 |
| None | 37 | 77.1 |

Usage of the honey products

| Usage | Respondents | % Respondents |
|---|---|---|
| Honey and propolis | 10 | 20.8 |
| Propolis tincture | 0 | 0.0 |
| Propolis oral fresh | 0 | 0.0 |
| Propolis throat spray | 0 | 0.0 |
| Pollen spread | 14 | 29.2 |
| Throat lozenges | 23 | 47.9 |

Why use honey based products?

| Honey basd products | Respondents | % Respondents |
|---|---|---|
| Safe | 14 | 29.2 |
| Source of nutrition | 11 | 22.9 |
| Immune system healthy | 18 | 37.5 |
| Healthy life cycle | 8 | 16.7 |
| Source of energy | 8 | 16.7 |
| Other | 11 | 22.9 |

## Appendix 9.5 (Contd.): Summary of Results for the Home Use Test- Week-2

### PART-I

Overall liking and product characteristics of the antibacterial jellybeans

| Panelists | Overall[2)] Liking | Appearance[2)] | Colour[2)] | Hardness[2)] | Overall Flavour | Sweetness[2)] |
|---|---|---|---|---|---|---|
| A1 | 7 | 8 | 7 | 5 | 7 | 4 |
| A2 | 8 | 8 | 8 | 8 | 8 | 8 |
| A3 | 6 | 8 | 6 | 8 | 8 | 7 |
| A4 | 3 | 5 | 5 | 5 | 3 | 3 |
| A5 | 8 | 7 | 8 | 8 | 8 | 8 |
| A6 | 8 | 7 | 5 | 8 | 8 | 9 |
| A7 | 9 | 8 | 8 | 9 | 8 | 9 |
| A8 | 8 | 9 | 9 | 9 | 9 | 9 |
| A9 | 9 | 8 | 8 | 7 | 9 | 7 |
| A10 | 8 | 9 | 9 | 8 | 8 | 9 |
| A11 | 9 | 9 | 9 | 9 | 9 | 9 |
| A12 | 8 | 5 | 9 | 8 | 9 | 8 |
| A13 | 9 | 8 | 7 | 8 | 9 | 8 |
| A14 | 7 | 8 | 7 | 7 | 8 | 7 |
| A15 | 6 | 7 | 7 | 6 | 7 | 3 |
| A16 | 8 | 8 | 9 | 8 | 8 | 9 |
| A17 | 7 | 6 | 5 | 8 | 7 | 8 |
| A18 | 8 | 8 | 8 | 9 | 8 | 9 |
| A19 | 8 | 8 | 8 | 8 | 8 | 8 |
| A20 | 8 | 8 | 8 | 9 | 8 | 4 |
| A21 | 9 | 8 | 7 | 9 | 9 | 9 |
| A22 | 7 | 7 | 3 | 8 | 6 | 8 |
| A23 | 8 | 8 | 8 | 8 | 8 | 7 |
| A24 | 8 | 5 | 4 | 5 | 8 | 8 |
| A25 | 8 | 8 | 8 | 8 | 8 | 8 |
| A26 | 8 | 7 | 7 | 9 | 9 | 8 |
| A27 | 7 | 8 | 6 | 9 | 7 | 4 |
| A28 | 7 | 8 | 7 | 7 | 8 | 4 |
| A29 | 7 | 8 | 8 | 7 | 7 | 7 |
| A30 | 6 | 7 | 7 | 7 | 6 | 4 |
| A31 | 7 | 7 | 8 | 6 | 7 | 4 |
| A32 | 8 | 8 | 8 | 8 | 8 | 9 |
| A33 | 8 | 7 | 6 | 8 | 8 | 8 |
| A34 | 8 | 7 | 7 | 8 | 8 | 7 |
| A35 | 8 | 8 | 8 | 8 | 8 | 8 |

[2)] 9 points hedonic scale, where: 1= Dislike extremely; 2 = Dislike very much; 3 = Dislike moderately; 4 = Dislike slightly; 5 = Neither like or dislike; 6 = Like slightly; 7 = Like moderately; 8 = Like very much; 9 = Like extremely.

## Appendix 9.5 (Contd.): Summary of Results for the Home Use Test- Week-2

### PART-II AND PART-III

Overall liking and product characteristics of the antibacterial jellybeans

| Panelists | Overall Liking | Appearance | Colour | Hardness | Overall Flavour | veetness |
|---|---|---|---|---|---|---|
| A36 | 8 | 8 | 8 | 8 | 8 | 7 |
| A37 | 6 | 7 | 7 | 6 | 4 | 6 |
| A38 | 8 | 7 | 6 | 7 | 8 | 8 |
| A39 | 8 | 7 | 7 | 8 | 8 | 8 |
| A40 | 8 | 3 | 3 | 7 | 8 | 4 |
| A41 | 7 | 5 | 6 | 7 | 8 | 7 |
| A42 | 7 | 7 | 7 | 7 | 8 | 6 |
| A43 | 8 | 8 | 8 | 8 | 9 | 4 |
| A44 | 4 | 5 | 5 | 5 | 4 | 3 |
| A45 | 7 | 7 | 7 | 7 | 7 | 6 |
| A46 | 7 | 5 | 4 | 7 | 7 | 3 |
| A47 | 8 | 4 | 8 | 8 | 8 | 8 |
| A48 | 8 | 7 | 4 | 7 | 8 | 8 |

9 points hedonic scale, where; 1= Dislike extremely; 2 = Dislike very much; 3 = Dislike moderately; 4 = Dislike slightly; 5 = Neither like or dislike; 6 = Like slightly; 7 = Like moderately; 8 = Like very much; 9 = Like extremely.

### PART-III

Claims about the product believability

| Claims believability | Respondents | % Respondents |
|---|---|---|
| Definitely believable | 13 | 27.1 |
| Probably believable | 16 | 33.1 |
| Might or might not believe | 18 | 37.5 |
| Probably not believe | 1 | 2.1 |
| Definitely not believe | 0 | 0.0 |

Benefits of product over ordinary product

| Benefits over other | Respondents | % Respondents |
|---|---|---|
| Yes | 33 | 68.8 |
| May or may not | 12 | 25.0 |
| No | 3 | 6.2 |

Product preference to the existing jellybeans

| Preference | Respondents | % Respondents |
|---|---|---|
| Definitely prefer | 15 | 31.2 |
| Probably prefer | 20 | 41.7 |
| Might or might not prefer | 7 | 14.6 |
| Probably not | 5 | 10.4 |
| Definitely not | 1 | 2.1 |

Replacement of current jellybeans with new jellybeans

| Replacement | Respondents | % Respondents |
|---|---|---|
| Definitely replace | 14 | 29.2 |
| Probably replace | 16 | 33.3 |
| Might or might not replace | 9 | 18.8 |
| Probably not | 5 | 10.4 |
| Definitely not | 4 | 8.3 |

Would you buy this product?

| Buying intention | Respondents | % Respondents |
|---|---|---|
| Definitely buy | 15 | 31.3 |
| Probably buy | 18 | 37.5 |
| Might or might not | 10 | 20.8 |
| Probably not | 4 | 8.3 |
| Definitely not | 1 | 2.1 |

How frequently would you buy this product?

| Buying frequency | Respondents | % Respondents |
|---|---|---|
| More than once a week | 0 | 0.0 |
| Once a week | 4 | 8.3 |
| Once fortnight | 7 | 14.6 |
| Once month | 14 | 29.2 |
| Less than month | 23 | 47.9 |

Would you be paying more?

| Pay more | Respondents | % Respondents |
|---|---|---|
| Yes | 23 | 47.9 |
| May or may not | 17 | 35.4 |
| No | 8 | 16.7 |

Willing to pay extra

| Above market price | Respondents | % Respondents |
|---|---|---|
| < 0.50 | 11 | 22.9 |
| 0.50 | 15 | 31.2 |
| 0.75 | 10 | 20.8 |
| 1.00 | 11 | 22.9 |
| 1.25 | 0 | 0.0 |
| 1.50 | 1 | 2.1 |

Had problems related to stomach and mouth

| Physical problems | Respondents | % Respondents |
|---|---|---|
| Sore throat | 7 | 14.6 |
| Common cold | 6 | 12.5 |
| Bad breath | 2 | 4.2 |
| Stomach ulcer | 0 | 0.00 |
| Other | 3 | 6.2 |
| Total | 18 | 37.5 |

Do you think the product helped?

| Workability of product | Respondents | % Respondents |
|---|---|---|
| Yes | 8 | 16.7 |
| May or May not | 33 | 68.8 |
| No | 7 | 14.6 |

Have you eaten other manuka honey products?

| Honey products | Respondents | % Respondents |
|---|---|---|
| Yes | 24 | 50 |
| No | 24 | 50 |

## Appendix 9.5 (Contd.): Summary of Results for the Home Use Test: Week-4 and Week-6

Had problems related to stomach and mouth

| Physical problems | Week-4 | | Week-6 | |
|---|---|---|---|---|
| | Respondents | % Respondents | Respondents | % Respondents |
| Sore throat | 9 | 18.8 | 11 | 22.9 |
| Common cold | 6 | 12.5 | 7 | 12.5 |
| Bad breath | 2 | 4.2 | 4 | 8.3 |
| Stomach ulcer | 0 | 0 | 0 | 0 |
| Other | 3 | 6.2 | 0 | 0 |

$\chi^2$ = 3.86; dF = 3; P-value = .28

Benefits of using this product

| Benefits | Week-4 | | Week-6 | |
|---|---|---|---|---|
| | Respondents | % Respondents | Respondents | % Respondents |
| Yes | 8 | 16.7 | 5 | 10.4 |
| May/may not | 29 | 60.4 | 36 | 75.0 |
| No | 11 | 22.9 | 7 | 14.6 |

**Appendix 9.5 (Contd.): Summary of Results for the Home Use Test- Week-4 and Week-6**

| Panelists | Overall[2)] Week-4 | Liking Week-6 | Panelists | Overall[2)] Week-4 | Liking Week-6 |
|---|---|---|---|---|---|
| A1 | 7 | 7 | A36 | 7 | 7 |
| A2 | 8 | 8 | A37 | 6 | 5 |
| A3 | 8 | 8 | A38 | 8 | 8 |
| A4 | 3 | 3 | A39 | 8 | 8 |
| A5 | 7 | 8 | A40 | 8 | 5 |
| A6 | 8 | 8 | A41 | 6 | 7 |
| A7 | 9 | 9 | A42 | 6 | 6 |
| A8 | 8 | 9 | A43 | 8 | 7 |
| A9 | 9 | 9 | A44 | 4 | 4 |
| A10 | 9 | 8 | A45 | 7 | 6 |
| A11 | 8 | 8 | A46 | 6 | 8 |
| A12 | 9 | 9 | A47 | 8 | 8 |
| A13 | 8 | 8 | A48 | 8 | 8 |
| A14 | 6 | 5 | | | |
| A15 | 6 | 7 | | | |
| A16 | 8 | 8 | | | |
| A17 | 7 | 7 | | | |
| A18 | 8 | 8 | | | |
| A19 | 8 | 8 | | | |
| A20 | 8 | 8 | | | |
| A21 | 9 | 9 | | | |
| A22 | 7 | 7 | | | |
| A23 | 7 | 7 | | | |
| A24 | 8 | 8 | | | |
| A25 | 8 | 8 | | | |
| A26 | 8 | 8 | | | |
| A27 | 7 | 7 | | | |
| A28 | 7 | 7 | | | |
| A29 | 6 | 5 | | | |
| A30 | 6 | 6 | | | |
| A31 | 7 | 7 | | | |
| A32 | 8 | 8 | | | |
| A33 | 8 | 8 | | | |
| A34 | 8 | 8 | | | |
| A35 | 8 | 8 | | | |

## Appendix 9.5 (Contd.): Summary of Results for the Home Use Test- Week-8

| Panelists | Overall[2)] Liking | Appearance[2)] | Colour[2)] | Hardness[2)] | Overall Flavour | Sweetness[2)] |
|---|---|---|---|---|---|---|
| A1 | 7 | 8 | 8 | 7 | 5 | 3 |
| A2 | 8 | 8 | 6 | 8 | 8 | 9 |
| A3 | 8 | 9 | 8 | 9 | 8 | 9 |
| A4 | 3 | 5 | 5 | 5 | 3 | 3 |
| A5 | 8 | 7 | 7 | 8 | 9 | 7 |
| A6 | 8 | 7 | 7 | 8 | 9 | 8 |
| A7 | 9 | 9 | 8 | 9 | 9 | 9 |
| A8 | 9 | 9 | 9 | 9 | 9 | 9 |
| A9 | 9 | 8 | 8 | 7 | 9 | 7 |
| A10 | 8 | 9 | 9 | 8 | 8 | 9 |
| A11 | 8 | 8 | 8 | 8 | 8 | 8 |
| A12 | 9 | 8 | 8 | 6 | 9 | 8 |
| A13 | 8 | 8 | 9 | 8 | 9 | 9 |
| A14 | 5 | 5 | 5 | 6 | 6 | 6 |
| A15 | 7 | 7 | 7 | 7 | 8 | 3 |
| A16 | 9 | 8 | 8 | 8 | 9 | 9 |
| A17 | 7 | 6 | 5 | 6 | 7 | 8 |
| A18 | 9 | 8 | 8 | 9 | 9 | 9 |
| A19 | 8 | 8 | 8 | 8 | 9 | 8 |
| A20 | 8 | 8 | 8 | 9 | 8 | 4 |
| A21 | 9 | 9 | 9 | 8 | 9 | 9 |
| A22 | 7 | 4 | 3 | 8 | 8 | 7 |
| A23 | 7 | 8 | 8 | 8 | 9 | 4 |
| A24 | 8 | 7 | 7 | 5 | 8 | 8 |
| A25 | 8 | 8 | 8 | 8 | 8 | 8 |
| A26 | 8 | 7 | 6 | 9 | 9 | 8 |
| A27 | 7 | 4 | 5 | 3 | 4 | 3 |
| A28 | 7 | 7 | 7 | 8 | 7 | 4 |
| A29 | 6 | 8 | 8 | 7 | 7 | 5 |
| A30 | 7 | 8 | 8 | 7 | 8 | 8 |
| A31 | 7 | 5 | 7 | 7 | 8 | 4 |
| A32 | 8 | 8 | 9 | 8 | 8 | 8 |
| A33 | 8 | 6 | 4 | 7 | 7 | 7 |
| A34 | 8 | 8 | 8 | 8 | 8 | 7 |
| A35 | 8 | 6 | 4 | 8 | 8 | 8 |

## Appendix 9.5 (Contd.): Summary of Results for the Home Use Test- Week-8

| Panelists | Overall Liking | Appearance | Colour | Hardness | Overall Flavour | Sweetness |
|---|---|---|---|---|---|---|
| A36 | 8 | 8 | 7 | 7 | 8 | 8 |
| A37 | 7 | 7 | 7 | 6 | 8 | 6 |
| A38 | 5 | 5 | 5 | 5 | 4 | 4 |
| A39 | 8 | 8 | 8 | 8 | 8 | 8 |
| A40 | 8 | 8 | 8 | 8 | 8 | 8 |
| A41 | 3 | 3 | 3 | 5 | 5 | 3 |
| A42 | 8 | 8 | 5 | 6 | 9 | 7 |
| A43 | 6 | 7 | 8 | 7 | 7 | 8 |
| A44 | 8 | 9 | 9 | 8 | 9 | 8 |
| A45 | 4 | 5 | 5 | 5 | 4 | 3 |
| A46 | 7 | 6 | 6 | 7 | 7 | 4 |
| A47 | 6 | 4 | 4 | 7 | 7 | 3 |
| A48 | 8 | 6 | 8 | 8 | 8 | 8 |

## PART-III

Claims about the product believability

| Claims believability | Respondents | % Respondents |
|---|---|---|
| Definitely believable | 13 | 27.1 |
| Probably believable | 22 | 45.8 |
| Might or might not believe | 8 | 16.7 |
| Probably not believe | 5 | 10.4 |
| Definitely not believe | 0 | 0.0 |

Benefits of product over ordinary product

| Benefits over other | Respondents | % Respondents |
|---|---|---|
| Yes | 29 | 60.4 |
| May or may not | 13 | 27.1 |
| No | 6 | 12.5 |

Product preference to the existing jellybeans

| Preference | Respondents | % Respondents |
|---|---|---|
| Definitely prefer | 21 | 43.8 |
| Probably prefer | 10 | 20.8 |
| Might or might not prefer | 9 | 18.8 |
| Probably not | 5 | 10.4 |
| Definitely not | 3 | 6.2 |

Replacement of current jellybeans with new jellybeans

| Replacement | Respondents | % Respondents |
|---|---|---|
| Definitely replace | 16 | 33.3 |
| Probably replace | 14 | 29.2 |
| Might or might not replace | 10 | 20.8 |
| Probably not | 5 | 10.4 |
| Definitely not | 3 | 6.3 |

What other product it can replace?

| Product name | Respondents | % Respondents |
|---|---|---|
| Throat lozenges | 8 | 16.6 |
| Antibiotic tablets | 2 | 4.2 |
| Manuka honey | 7 | 14.6 |
| Other | 2 | 4.2 |

Would you buy this product?

| Buying intention | Respondents | % Respondents |
|---|---|---|
| Definitely buy | 14 | 29.2 |
| Probably buy | 17 | 35.4 |
| Might or might not buy | 11 | 22.9 |
| Probably not | 4 | 8.3 |
| Definitely not | 2 | 4.2 |

Would you be paying more?

| Pay more | Respondents | % Respondents |
|---|---|---|
| Yes | 28 | 58.3 |
| May or may not | 12 | 25.0 |
| No | 8 | 16.7 |

Willing to pay extra

| Above market price | Respondents | % Respondents |
|---|---|---|
| < 0.50 | 17 | 35.4 |
| 0.50 | 13 | 27.1 |
| 0.75 | 11 | 22.9 |
| 1.00 | 7 | 14.6 |
| 1.25 | 0 | 0.0 |
| 1.50 | 0 | 0.0 |

What problems this product would cure?

| Physical problems | Respondents | % Respondents |
|---|---|---|
| Sore throat | 25 | 52.1 |
| Common cold | 18 | 37.5 |
| Bad breath | 13 | 27.1 |
| Stomach ulcer | 1 | 2.1 |
| Other | 3 | 6.2 |

Had any of these problems

| Physical problems | Respondents | % Respondents |
|---|---|---|
| Sore throat | 7 | 14.6 |
| Common cold | 6 | 12.5 |
| Bad breath | 2 | 4.2 |
| Stomach ulcer | 0 | 0.00 |
| Other | 3 | 6.2 |
| Total | 18 | 37.5 |

Did this product give relief?

| Workability of product | Respondents | % Respondents |
|---|---|---|
| Yes | 8 | 16.7 |
| May or May not | 33 | 68.8 |
| No | 7 | 14.6 |

Believability of claims under different methods

| Product claims | CLT | Concept | Week-2 | Week-8 |
|---|---|---|---|---|
| | | Respondents | Respondents | Respondents |
| Definitely believable | 9 (17.6) | 23 (47.9) | 13 (27.1) | 13 (27.1) |
| Probably believable | 29 (56.9) | 18 (37.5) | 16 (33.3) | 22 (45.8) |
| Might/might not | 11 (21.6) | 5 (10.4) | 18 (37.5) | 8 (16.7) |
| Probably not | 2 (3.9) | 2 (4.2) | 1 (2.1) | 5 (10.4) |
| Definitely not | 0 (0.0) | 0 (0.0) | 0 (0.0) | 0 (0.0) |

DF = 9; p-value = 0.004; $\chi^2 = 24.43$

## Appendix 9.6: Analysis of Variance and Tukey's Honestly Significant Different Test for Each Product Attribute

### Overall Liking

#### Analysis of Variance

| Source of variation | SS | df | MS | F | P-value |
|---|---|---|---|---|---|
| Panelists | 288.133 | 47 | 6.130 | 12.24 | 0.000 |
| Exposure | 2.642 | 4 | 0.660 | 1.32 | 0.265 |
| Error | 94.158 | 188 | 0.501 | | |
| Total | 384.933 | 239 | | | |

#### Tukey's Honestly Significant Difference Test

| Exposure | Week-0 | Week-2 | Week-4 | Week-6 | Week-8 |
|---|---|---|---|---|---|
| Means | 7.60[a] | 7.50[a] | 7.37[a] | 7.31[a] | 7.37[a] |

### Colour

#### Analysis Of Variance

| Source of variation | SS | Df | MS | F | P-value |
|---|---|---|---|---|---|
| Panelists | 249.33 | 47 | 5.30 | 4.62 | 0.000 |
| Exposure | 2.18 | 2 | 1.09 | 0.95 | 0.390 |
| Error | 107.82 | 94 | 1.15 | | |
| Total | 359.33 | 143 | | | |

#### Tukey's Honestly Significant Difference Test

| Exposure | Week-0 | Week-2 | Week-8 |
|---|---|---|---|
| Means | 6.70[a] | 6.90[a] | 6.90[a] |

## Appearance

### Analysis of Variance

| Source of variation | SS | df | MS | F | P-value |
|---|---|---|---|---|---|
| Panelists | 170.33 | 47 | 3.62 | 3.15 | 0.000 |
| Exposure | 0.38 | 2 | 0.19 | 0.16 | 0.850 |
| Error | 108.29 | 94 | 1.15 | | |
| Total | 279.00 | 143 | | | |

### Tukey's Honestly Significant Difference Test

| Exposure | Week-0 | Week-2 | Week-8 |
|---|---|---|---|
| Means | 7.0[a] | 7.1[a] | 7.1[a] |

## Hardness

### Analysis of Variance

| Source of variation | SS | df | MS | F | P-value |
|---|---|---|---|---|---|
| Panelists | 132.64 | 47 | 2.82 | 2.35 | 0.000 |
| Exposure | 3.93 | 2 | 1.97 | 1.64 | 0.200 |
| Error | 112.74 | 94 | 1.20 | | |
| Total | 249.31 | 143 | | | |

### Tukey's Honestly Significant Difference Test

| Exposure | Week-0 | Week-2 | Week-8 |
|---|---|---|---|
| Means | 7.2[a] | 7.5[a] | 7.3[a] |

## Overall Flavour

### Analysis of Variance

| Source of variation | SS | df | MS | F | P-value |
|---|---|---|---|---|---|
| Panelists | 159.556 | 47 | 3.395 | 5.35 | 0.000 |
| Exposure | 1.681 | 2 | 0.840 | 1.32 | 0.271 |
| Error | 59.653 | 94 | 0.635 | | |
| Total | 220.889 | 143 | | | |

**Tukey's Honestly Significant Difference Test**

| Exposure | Week-0 | Week-2 | Week-8 |
|---|---|---|---|
| Means | 7.9[a] | 7.7[a] | 7.7[a] |

## Sweetness

**Analysis of Variance**

| Source of variation | SS | df | MS | F | P-value |
|---|---|---|---|---|---|
| Panelists | 472.42 | 47 | 10.05 | 8.71 | 0.000 |
| Exposure | 4.87 | 2 | 2.44 | 2.11 | 0.127 |
| Error | 108.46 | 94 | 1.15 | | |
| Total | 585.75 | 143 | | | |

**Tukey's Honestly Significant Difference Test**

| Exposure | Week-0 | Week-2 | Week-8 |
|---|---|---|---|
| Means | 7.1[a] | 6.8[a] | 6.7[a] |

## Overall Liking

**Analysis of Variance**

| Source of variation | SS | df | MS | F | P-value |
|---|---|---|---|---|---|
| Location | 11.88 | 1 | 11.88 | 8.07 | 0.005 |
| Error | 425.44 | 289 | 1.47 | | |
| Total | 437.32 | 290 | | | |

**Tukey's Honestly Significant Difference Test**

| Location | CLT | HUT |
|---|---|---|
| Means | 6.902[a] | 7.433[b] |

## Appearance

### Analysis of Variance

| Source of variation | SS | df | MS | F | P-value |
|---|---|---|---|---|---|
| Location | 3.37 | 1 | 3.37 | 1.80 | 0.182 |
| Error | 361.63 | 193 | 1.87 | | |
| Total | 364.99 | 194 | | | |

### Tukey's Honestly Significant Difference Test

| Location | CLT | HUT |
|---|---|---|
| Means | 6.784 [a] | 7.083 [b] |

## Colour

### Analysis of Variance

| Source of variation | SS | df | MS | F | P-value |
|---|---|---|---|---|---|
| Location | 3.77 | 1 | 3.77 | 1.74 | 0.188 |
| Error | 418.07 | 193 | 2.17 | | |
| Total | 421.85 | 194 | | | |

### Tukey's Honestly Significant Difference Test

| Location | CLT | HUT |
|---|---|---|
| Means | 7.157[a] | 6.840[b] |

## Hardness

### Analysis of Variance

| Source of variation | SS | df | MS | F | P-value |
|---|---|---|---|---|---|
| Location | 10.01 | 1 | 10.01 | 6.01 | 0.015 |
| Error | 321.34 | 193 | 1.66 | | |
| Total | 331.35 | 194 | | | |

### Tukey's Honestly Significant Difference Test

| Location | CLT | HUT |
|---|---|---|
| Means | 6.804[a] | 7.319[b] |

## Flavour

### Analysis of Variance

| Source of variation | SS | df | MS | F | P-value |
|---|---|---|---|---|---|
| Location | 53.58 | 1 | 53.58 | 32.36 | 0.000 |
| Error | 319.59 | 193 | 1.66 | | |
| Total | 373.18 | 194 | | | |

### Tukey's Honestly Significant Difference Test

| Location | CLT | HUT |
|---|---|---|
| Means | 6.529[a] | 7.722[b] |

## Sweetness

### Analysis of Variance

| Source of variation | SS | df | MS | F | P-value |
|---|---|---|---|---|---|
| Location | 4.00 | 1 | 4.00 | 1.05 | 0.306 |
| Error | 732.38 | 193 | 3.79 | | |
| Total | 736.38 | 194 | | | |

### Tukey's Honestly Significant Difference Test

| Location | CLT | HUT |
|---|---|---|
| Means | 6.549[a] | 6.875[b] |

## Eating Pattern

### Analysis of Variance

| Source of variation | SS | df | MS | F | P-value |
|---|---|---|---|---|---|
| Weeks | 15940 | 7 | 2277 | 2.16 | 0.037 |
| Error | 397184 | 376 | 1056 | | |
| Total | 413124 | 383 | | | |

### Tukey's Honestly Significant Difference Test

| Location | Week-1 | Week-2 | Week-3 | Week-4 | Week-5 | Week-6 | Week-7 | Week-8 |
|---|---|---|---|---|---|---|---|---|
| Means | 50.83[a] | 39.21[abc] | 32.27[bc] | 37.94[abc] | 32.42[bc] | 29.83[bc] | 39.17[abc] | 30.92[bc] |