THE EFFECT OF CHEESE POWDER IN THE FUNCTIONAL PROPERTIES OF CROISSANT PASTRY

A THESIS PRESENTED IN PARTIAL FULFILMENT
OF THE REQUIREMENTS OF THE DEGREE OF
MASTER OF TECHNOLOGY IN
FOOD TECHNOLOGY
AT MASSEY UNIVERSITY

SALAH A. JOUDI

1993

ABSTRACT

The increasing use of cheese powder as an ingredient used by food manufactures can be related to the changing consumer needs, identifying new consumer preferences, marketing and obtaining an acceptable capital return.

Cheese powder have been used in bakery products to improve their functional properties and impart flavour. Therefore, the development of cheese flavoured croissants was chosen to increase the utilization of cheese powder in the formulation croissant pastry. For this reason, the New Zealand Dairy Board (NZDB) predicted a brighter future for this type of dairy ingredient because of its dual acceptability of providing important functional characteristics and its cost advantage over other dairy products.

The addition of cheese powder to croissant pastry resulted in affecting the dough's physical properties and baking characteristics; i.e, increasing the dough elongational viscosity, decreasing the farinograph absorption values, decreasing the specific volume of baked croissants, and croissant firmness results indicating significant differences as a function of time for storage.

Cheese croissants containing ten percent level of cheddar-20 cheese powder was found to be the only one to have statistically significant differences in most of the attributes compared to CP1 and CP2 cheese powder when used in the formulation. Ten percent level of cheddar-20 cheese powder received the highest score and preferred by 77.8% of the panellists. Therefore, the ten percent of cheddar-20 cheese powder level was chosen for further development including the determination of the new cheese powder mixing method with its time-temperature relationship and evaluation of the market trial.

The new cheese powder mixing method (3% cheese powder mixed with dry ingredients, and 7% used to produce cheese paste) during which the paste was applied over the laminated dough and the cheese powder combined with the dry ingredients improved the cheese croissant quality characteristics when compared to the other mixing method (total 10% cheese powder mixed with other dry ingredients).

The baking time-temperature relationship of the new cheese powder mixing method was twenty seven minutes at 275°F which gave the best quality characteristics for high volume, a golden brown crust colour and flaky texture. This method received the highest scores and the most acceptable cheese croissant by the panellists.

The market evaluation results indicated that 87% of potential consumers preferred the cheese croissants. The total sales potential indicated to be approximately 2.000 tonnes/annum of finished product with a population of ten percent of the market share. The estimated net present value over five year product life was $3,206,000.

ACKNOWLEDGEMENTS

I am honoured in this opportunity to acknowledge the following people to whom I am most grateful and who have helped me so much in this study. With their help and support they have given me the strength and encouragement to take another step forward in the complection of this thesis.

I would like to thank Dr. Carmen Fernandez who had supervised me throught to the end of this research. She gave me guidelines, encouragement and confidence within myself to get this thesis finished.

I would also like to thank Dr. Osvaldo Campanella, throughtout this study. He has helped me extremely throughout the difficulties of the thesis, and kept patient with me to the end

A special thanks to Mrs Namalie Jayasinha of the New Zealand Dairy Board in Wellington for sponsoring this research.

Special thanks to the brothers Dr. Khaire Jordaan, Dr. Abdullah Abdullah, and Dr. Hussian for their interest and guidelines.

However, this thesis could not had been possible without the help of my wife,
Mrs Melwyn Joudi, who had helped me in the preparation of typing this thesis. Her devoted support, guideness and encouragement stood by me throughout the finished preparation of this thesis.

And if all the trees on earth were pens and the ocean (were ink), with seven oceans behind it to add to its (supply), yet would not the words of Allah be exhausted (in the writing):for Allah is Exalted in powerfull of Wisdom.

(The Holly Qur'an 31:27) Luqman

TABLE OF CONTENTS

CONTENTS **PAGE NUMBER**

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

CHAPTER ONE

INTRODUCTION

New Zealand is one of the biggest countries in the production and export of dairy products. About 85% to 90% of the total New Zealand dairy commodity production is exported (International Dairy Federation, 1992). Thus, the production of milk and milk products plays a key role in the New Zealand economy. The increasing demand for dairy products and ingredients by local and international food markets has encouraged the New Zealand Dairy Board to focus on applied research, development and services. These activities are being aimed at the development of new products and technical processes to ensure cost-effective production (Shaw, 1985).

Cheese powders have shown a wide variety of benefits and uses in the food industry. In 1991 the New Zealand natural cheese production was 128.000 tonnes (International Dairy Federation, 1992). New Zealand dairy companies have predicted that cheese powder market potential will increase in the next ten years because of the beneficial effect of cheese powder on the physical and chemical properties of many food products. The use of cheese powder as an ingredient in many products enhances their flavour, nutritional content, and functional properties (Alaco, 1992). Thus, major research in the development of new food products using cheese powder along with market studies have identified several market opportunities (Shaw, 1985). An example of this would be research and development on utilisation of cheese powder as a major ingredient in bakery products specifically croissant pastry.

Croissant pastry was chosen in this study because New Zealand croissant sales totalled $7.6 million in 1986 (Alaco, 1988). Alaco predicts that both croissants and Danish pastries will become more popular in New Zealand and Australia and the New Zealand Dairy Board could increase its present industrial demand by considerable amounts through the utilization of cheese powder in the formulation of croissants.
Both cheese and cheese powder exert a positive influence on important properties of baked products such as specific volume, water absorption, texture, flavour, crust appearance and freshness.

Furthermore, cheese products serve both as protein supplements since cheese powder contains 25% or more protein and increase the nutritional value of baked products by the introduction of calcium, phosphorous, thiamin and riboflavin. It is recognised that there is limited basic information on the mechanisms of protein interactions in baking products.

Thus, this study is attempted as a complementary applied research and development project which extends previous work on the development of cheese flavoured croissants carried out by the author.

CHAPTER TWO

LITERATURE REVIEW

2.1 CHEESE POWDER AND OTHER DAIRY PRODUCTS USED IN THE BAKING INDUSTRY AND THEIR EFFECTS

There is very limited research work on the application of cheese powder used in baked products. The existing reviews and articles have been written about cheese as a milk derivative product and as an ingredient itself used in baked products, as revealed by these references. Alaco (1992) reported the development of specific cheese powder applications in baked goods regarding flavour, browning colour, dough viscosity and binding water. Some reports mention the application of cheese proteins, classified as milk protein derivatives, in bakery products. These proteins were used for their functional properties (Mann, 1980; Parkinson, 1984; Sanderson, 1985; Cocup and Sanderson, 1987). Craig and Colmey (1971) described the importance of cheese manufacturing as a major source of commercialised dairy product proteins and predict that the utilization of cheese products will be very important in the area of structure and functional properties in baked goods. Mertens (1969) reviewed the availability of applied cheese powder in baked products, its convenience for incorporation into doughs and the importance of volatile flavours during baking. However, despite the importance of cheese proteins in baking products more information is needed on the effects of dairy ingredients when used in bakery products. The baking industry has commonly used milk (fresh, powdered, and condensed), butter, cream, and cheese as ingredients in bread, cakes, biscuits, and pastries (Cocup and Sanderson, 1987; Alaco, 1990). Non fat dry milk (NFM) is used frequently in bread making affecting both the handling characteristics of the dough and the physical and sensory qualities of the baked loaf (Cobb, 1976). The milk proteins contribute to the absorption of water by the dough and the development of crumb structure by complementing with wheat proteins to strengthen the bread dough. This effect becomes more apparent when flours of reduced protein (low percentage of flour protein) are used (Craig and Colmey 1971). Milk supplies fat and protein, which are used in bakery products for their functional performance in the appearance, texture and flavour (Mertens, 1969; Cobb, 1976; and Alaco, 1985, 1986).

Dairy industries have been developing speciality dried milks, casein, and whey products used by the food industry for protein functionality (de la Gueriviere, 1981). The development of plasticized butter sheets used in croissants, Danish pastry and puff pastry has shown more satisfactory functionality when compared with that of an hydrogenated pastry margarine (Schaap, 1981; Cocup and Sanderson, 1987; and Alaco, 1991, 1992). Butter is used to lubricate ingredient mixtures during processing and to encapsulate protein, moisture or air at various stages during and after manufacture of a product (Cocup and Sanderson, 1987). It has also been used to improve flavour of food products (Schaap, 1981; and Alaco, 1989).

Guy (1971) indicated that lactose in nonfat dry milk and cheese whey solids depressed both the bread loaf volume and carbon dioxide production of doughs made from hard red spring wheat and hard red winter wheat flours. Abhayaratra (1978) studied the performance in bread of whey protein concentrate (WPC) prepared from whey at different degrees of denaturation. It was concluded that the three principal factors responsible for the poor performance of WPC in bread were:

- High levels of undenatured protein.
- High levels of ionic phosphate and the action of ionic calcium in conjunction with phosphate.
- The action of ionic calcium in conjunction with high levels of undenatured protein.

Zadow and Hardham (1981) found that the whey protein source, the composition of individual components, the presence of lipids and the ionic calcium and phosphate, along with processing variables, affect the properties of breads when WPC was used as one of the ingredients in its manufacture.

It has been well established that milk solids influence dough absorption, mixing requirements, fermentation rate, amount of oxidation agent requirement of flour, baking times and temperatures and physical properties of the finish product (Pyler, 1990).
All dried milk products contribute to the dough water absorption capacity, the level usually being dependent on the quality, type and state of the protein present, and the application (Sanchez, 1981; Cocup and Sanderson, 1987).

Coppock (1967) and Kamat et al. (1973) indicated that the replacement of egg by milk protein such as WPC gives similar functionality in the flatness of sponge cake formulation. Perhaps the greatest advantage of milk solids in bread and commercial baked products is the improved sensory tasting besides a higher nutritional value. Jack and Haynes (1951) studied the acceptability of milk bread versus water bread and reported that the incorporation of 25% nonfat dry milk showed excellent eating quality. This finding led to the production of speciality high protein loaves and other types of dietary baked goods (Mertens, 1969).

Guy (1971) and Cocup and Sanderson (1987) suggested that the role of cheese protein should be further studied to elucidate the effects of dairy ingredients in baking products.

2.2 CLASSIFICATION AND STRUCTURE OF CASEIN PROTEIN IN CHEESE

The casein and whey proteins are main components of cheese. The cheese casein protein is defined as the milk casein protein. Casein contains approximately 80% of the milk proteins and is mainly composed of α, β and κ-casein (Craig and Colmey, 1971). Only α and β casein are precipitated by calcium (Rose, 1969) and κ-casein, which exhibits both hydrophobic and hydrophillic characteristics, acts as a protective colloid to keep the casein micelles from aggregation (Fox, 1989).

Casein structure exists as a colloidal dispersion of particles known as casein micelles which is a roughly spherical aggregate of casein proteins and organic compounds mainly colloidal calcium phosphate (Ruettimann and Ladisch, 1987).

Casein milk structures have been determined by Slattery (1976) and Whitney, (1976). They are strongly amphoteric having highly negatively charged regions separated from strongly hydrophobic regions. Uniform distribution of proline along the polypeptide chain yields a random coil with little helical structure (Kinsella, 1985). This region has far fewer residues with non-polar side chains than expected for a random arrangement (Fox, 1989).

The functional properties associated with the casein protein in bakery products are mainly related to high water absorption and interaction with wheat gluten protein, flavour, nutrition, browning colour and buffering action (Modler, 1985; Hugunin, 1984; and Kinsella, 1985).

2.2.1 PHYSICO-CHEMICAL CHARACTERISTICS OF CASEIN PROTEIN

The casein micelle system is complex and is still not completely understood. The majority of research studies have been carried out on the understanding of the interactions between components that make up the micelle, the forces that give its stability and the forces important in the interactions with other proteins (Kinsella, 1985). Therefore, it is important to know the intermolecular forces of casein protein.

2.2.2 INTERMOLECULAR FORCES OF CASEIN PROTEIN

Casein contains both covalent and non-covalent forces between the polypeptide chains, as reported by numerous authors for the past decades (Janine, 1984; Schulz, 1979 and Pace, 1975) Non-covalent forces stabilize the native conformation of proteins and influence their functional behaviour.

Non-covalent forces are presented in table 2.1 and can be classified as:

1 - Van der Waal's interactions (dispersion forces)

2 - Ionic (disulphate and electrostatic interactions)

3 - Hydrogen bonds

4 - Hydrophobic interactions

TABLE 2.1

NON-COVALENT FORCES BETWEEN POLYPEPTIDE CHAINS OF CASEIN PROTEIN

TYPE OF BONDS	EXAMPLE	BINDING ENERGY kJ/Mole
Van der Waal's	-C-H......H-C-	- 0.126
Ionic	$-C-OO^{-}$........H_3N^{+} C = O.......O =C-	- 21.0 + 1.26
Hydrogen bond	\\ O-H.......O- -N-H......O-	- 16.8
Hydrophobic forces	Side chain of phenaline	- 12.6

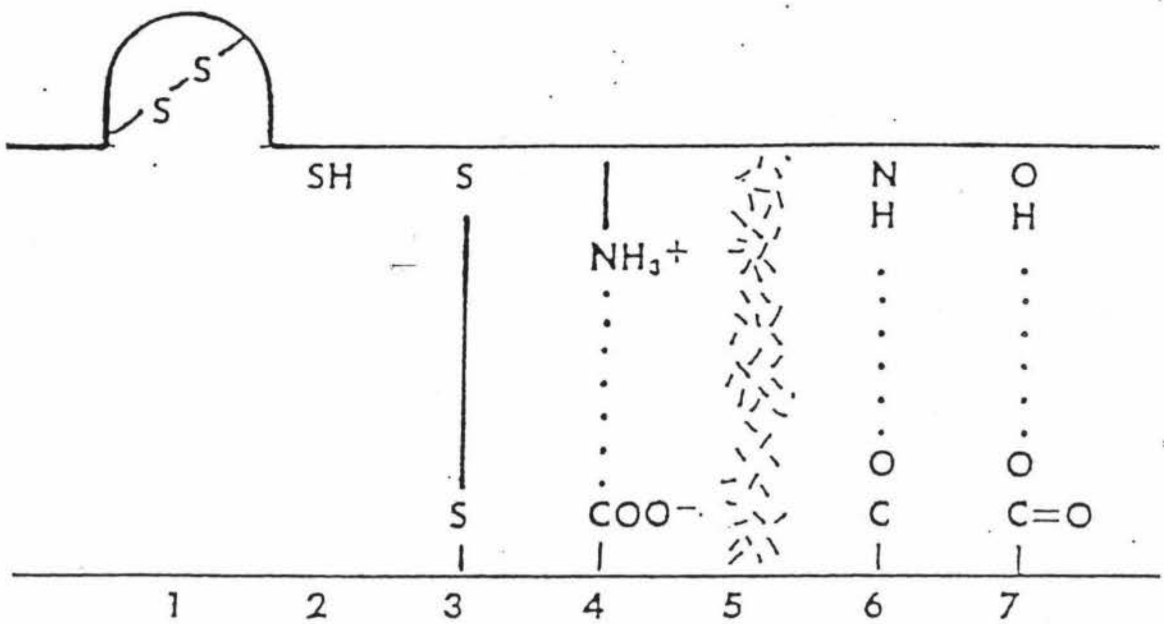
Creighton (1984).

According to Fox (1989) proteins display a wide spectrum of properties because the diversity of amino acid combinations influence protein structure and conformation, and the arrangement of amino acid determines different modes of protein folding.

Covalent disulphide bonds are important in maintaining the structural integrity of many extracellular proteins (Kinsella, 1982, 1984 and Schulz, 1979). Both non-covalent and covalent bonds are shown in figure 2.1

FIGURE 2.1

SCHEMATIC DIAGRAM OF COVALENT AND NON-COVALENT BONDS WITHIN AND BETWEEN PEPTIDE CHAINS



Chains - Solid lines = covalent bonds, dotted lines = non covalent bonds

1 - intramolecular disulphide bond

2 - free sulphydryl group

3 - intermolecular disulphide bond

4 - ionic bond

5 - Van der waal's bond between polypeptide chains

6 - inter peptide H-bond

7 - side chain H-bond

2.3 DOUGH FORMATION

When mixing flour and water a dough is formed (Pomeranz, 1985).
The physico-chemical basis of dough formation and structure has been extensively studied by Wall (1964); Holmes (1966); Ewart (1968); Krull (1969); Kasarda (1970); Ewart (1972 abc); Bietz et al. (1973); and Bushuk (1974).

The unique dough forming properties of wheat gluten are due to the thiol-disulphide bonds and the large degree of hydrophobic association which occurs between gluten proteins in the hydrated state.

The S-S cross-link contributes to the dough firmness by linking together the same chain or another chain of the polypeptide (Pomeranz, 1985). Covalent bonds are important in dough structure because they are strong and affect the rheological properties of dough.

2.3.1 RHEOLOGICAL PROPERTIES OF DOUGH AND BAKED DOUGH

2.3.1.1 VISCO-ELASTIC BEHAVIOUR OF DOUGH

The physical properties of dough derive primarily from an interaction of two states of matter, namely liquid and solid. Accordingly, dough exhibits plasticity that combines the attributes of both fluids and solids, elasticity that is primarily a property of solids, and viscosity or viscous flow that is a characteristic of liquids (Bushuk, 1985).
Solids maintain a more or less permanent shape and they can be deformed by the application of a force. Because of their elastic nature the deformation, if it does not exceed a certain limit it will disappear once the applied force is removed (Bushuk, 1985). Therefore, when dough is stretched, it will retract in part to its original shape if the deformation is small after the deforming force is removed.

If small deformation forces are applied to the dough, the dough will behave as a solid, but when the dough is subjected to large deformation it will flow behaving as a liquid. Dough is a visco-elastic material and its rheological behaviour has been described by Bloksma, 1981; Bushuk, 1985 and Weipert, 1990. Bushuk (1985) attributed the visco-elastic behaviour of dough to the protein helical configurations that act like "coiled springs" and are responsible for its elastic behaviour.

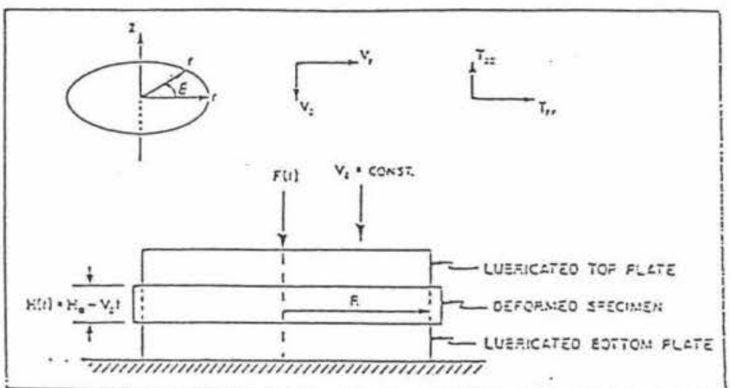
The coiled spring behaviour is expressed by Hooke's Law. The systems that obey this law are called Hookean and those that do not are non-Hookean. Non-Hookean bodies show either linear or non linear behaviour, depending on the applied deformation force (Weipert, 1990).

The rheological properties of dough are critical when it undergoes through physical transformations during the various stages of baking. Therefore, the great amount of research done with empirical tests relating to their worth is just to provide information about dough's behaviour in specific circumstances.
Wehrli (1969) indicated the importance of the bonds between the protein chains. They possess a variable degree of strength and energy associated with or required to break these bonds. However, dough including cheese proteins, shows reduced strength because during its extension some of the gluten covalent and non-covalent bonds break, almost causing permanent deformation or flow, while others remain intact and maintain the rigid structure of the dough (Mechan, 1973). Bohlin and Carlson (1980) investigated the dynamic visco-elastic properties of wheat dough as a function of mixing time. They also suggested a successful empirical test to correlate the physical quality of dough with a technical test for baking. Pyler (1983), and MacRitchie (1984) have presented important results on the role of gluten proteins in bread making. Bushuk, (1985) mentioned that during dough mixing and development the mechanical deformation is presumed to be larger than the proofing step or oven procedure. Fundamental measurements of dough rheology have recently been reviewed by Bloksma (1985); Hibbered and Parker (1975).

The application of basic rheometry measurement to dough rheology by using rheometers describes the flow properties of a dough and provides information about visco-elastic properties of that dough undergoing testing (Gerth, 1980; Muschelknautz and Heckenbach, 1980). According to Campanella et al. (1987), elongational flow with the geometry shown in Figure 2.2 can be used to evaluate the elongational viscosity of dough.

FIGURE 2.2

SCHEMATIC VIEW OF TEST ARRAY TO DETERMINE ELONGATIONAL VISCOSITY OF DOUGH AND THE SYSTEM'S CYLINDRICAL CO-ORDINATES



$$\varepsilon_T = \frac{Vz}{Ho - Vz(t)} \quad (1)$$

$$\mu_b = \frac{2F(t)\,(Ho - Vz(t))}{TR^2.Vz} \quad (2)$$

Where ε_T = is the momentary strain rate.

V = is the constant crosshead speed.

Vt = is the constant crosshead speed at time t.

Ho = is the initial height of the undeformed specimen.

μ_b = is the elongational viscosity

R = is the plate radius.

F(t) = is the momentary compression force.

t = is the time.

2.3.1.2 DETERMINATION OF TEXTURAL CHARACTERISTICS OF BAKED PRODUCTS

Texture is one of the most important attributes when measuring the food quality of food products. Several definitions have been proposed for texture. Matz (1972) reported that texture attribute has a relationship with the appearance, the feel to the touch, the softness and the mouthfeel. In general, it is recognised that all these attributes contribute to the concept of texture in its broad sense.

Food scientists are increasingly concerned in relating food texture to basic physical properties, standardizing methods and instruments, and relating physical properties to the results obtained by sensory evaluation (Kamel, 1986).

The sensorial characteristics of many textural attributes of materials measured by humans is based at least to some extent on a "deformation test" that involves soft tissues. Notable examples are squeezing foods between the fingers or between the tongue and the mouth roof which provides a strong effect on the magnitude and the character of the mechanical stimulus to which the sensory system responds (Campanella et al., 1987). The measurement of mechanical properties of foods covers all the basic aspects of rheology, which is the branch of physics dealing with force and deformation, their relationships, and their interrelationships with time.

Freshness is one of the primary factors consumers use to assess the quality of bread and other baked products and thus textural properties of the bread crumb and crust have been studied extensively with major emphasis on the rate of freshness and staling (Baker, 1986 and Walker, 1987). According to Kamel (1986) two approaches have been used to indicate the bread crumb firmness. The first approach is based on the compression of bread crumb with a constant force and to measure the change of deformation, and the second approach involves penetration tests (Bradley, 1950; Bechtel, 1953; Maleki, 1980; and Chen, 1982). The Baker Compressimeter is the only standard AACC method (74-10) to determine bread staleness (AACC, 1970).

The disadvantage of the Baker Compressimeter and various penetrometers is that the results obtained by both instruments are a single force reading which is not convertible to more fundamental rheological parameters (Szczeniak, 1963). The advantage of using the Instron Universal Testing Machine for both compression and penetration is that compression and penetration rates are well controlled and measured and thus force-time relationships can be directly converted to either force-deformation curves or stress-strain at constant reproducible deformation rates (Voisey, 1971).

2.4 MANUFACTURE OF PLAIN CROISSANTS

2.4.1 CHARACTERISTICS OF THE PLAIN CROISSANT DOUGH

Croissants should be light and flaky and have a moderately open grain and layered texture achieved by a well-developed dough which is yeast-raised and quite rich in egg and fat content (New Zealand Dairy Board, 1990).

Croissants are made from a rolled-in dough similar to that of a Danish pastry. Danish pastry is a dough leavened by yeast with fat rolled in and contains a much higher level of sugar, shortening, emulsifier and yeast than bread dough (Stauffer, 1990). However, bakeries may not give croissant dough as many rolls and folds as Danish pastry. This procedure depends on the type of fat, amount of fat, and make-up handling of the dough (Matz, 1989). A moderately strong flour (protein content of about 12.5%) is used to support the fat and to provide extensibility during the roll-in sheeting process of the make-up of the croissants (Sultan, 1986).
More detailed recipes and processes of croissant making are reported by many authors (Matz, 1972; Barrows, 1975 and Sultan, 1986). The dough can be formulated depending upon the processing system and it should be taken into account whether the croissants are made from fresh daily proofing and baking, or frozen storage before baking (New Zealand Dairy Board, 1990).

Different formulations and processing techniques result in various croissant types ranging from breads to puff pastry types due to the volume and texture attributes (New Zealand Dairy Board, 1990).

2.4.2 RAW MATERIALS OF PLAIN CROISSANTS AND THEIR FUNCTIONALITY

Croissants are basically made from wheat flour, fat and water aerated by yeast when mixed into a dough. Salt is added to the bakery product to control yeast fermentation (Matz, 1989). Wheat flour consists of protein, starch, lipid, vitamins and minerals. It is the major ingredient in croissants and its functionality is critical (Sultan, 1986 and Street, 1991).

* WHEAT PROTEINS

Street, (1991) and MacRitchie (1984), classified wheat proteins into four groups, two groups soluble and two groups insoluble proteins.

1) Soluble proteins: the two water soluble proteins, albumins (15%) and globulins (7.5%), play an important role in baking product.
2) Insoluble proteins: two insoluble classes are gliadin (32.5%) and glutenin (45.0%) which form gluten.

Gluten proteins do not dissolve in water, in spite of its high water binding capacity. This is due to the bonds between different molecules being so numerous that water molecules cannot invade the protein complex and separate them from each other (Pomeranz, 1988). Gluten's unique structural characteristics after conditioning include extension under pressure without rupturing, gas cell retention and coagulation when heated to maintain the structure build-up (Cocup and Sanderson, 1987).

* WHEAT STARCH

The major component of flour is starch at a level of 70% of its weight (Matz, 1989). The starch granule contains two kinds of molecules, amylose which is a lineal molecule, and amylopectin which exhibits a branched molecular structure (Pyler, 1990 and Pomeranz, 1988).

During gelatinisation, starch has a bulking effect by absorbing water which assists structural formulation during baking.

In the early years, Alsberg (1927) suggested that starch affects bread baking in terms of water absorption, dough consistency and viscosity. Starch is not usually considered a major factor influencing flour baking quality. However, Matz (1972) indicated the physical condition of the granules which may influence the mixing time, dough handling characteristics, and response to amyllytic enzymes. Starch also plays a key role in baking staling especially breads. Many studies about baking stalling have been made by Kim and D'Appolonia (1971); Kim (1977 a,b,c); Maleki (1980); and Kulp (1981).

* **WHEAT LIPIDS**

The wheat flour contains approximately one percent lipids (Morrison, 1978). Lipids of wheat have a definite effect on the baking quality of flour, but the exact mechanism by which this effect is exerted is not known. It is believed that lipids react with surfactants, proteins and starch during the baking process (Pomeranz, 1985).

2.4.3 ADDITIVES

An ideal croissant flour should be high in protein at a level between 10% to 14% with a high quality extensible gluten, no bran contamination and a bright colour (Sultan, 1986; and Matz, 1989). The flour quality is expressed by a variety of chemical and physical properties of doughs. Also, the end use to which a flour is to be put enters importantly into the evaluation of its quality (Pyler, 1990).

In fact, flours purchased by bakers for specific purposes, such as bread, pastry, cracker, or biscuit production, shows a wide quality variation within each group (Faridi and Finley, 1989). According to Finney (1978), the effect of the different dough ingredients on loaf volume and crumb in bread making can be used to differentiate between good and poor quality flours.

The functionality of flour in croissants depends on the gluten conditioning or development induced during dough making and laminating. This can be assisted by adding ingredients and additives such as oxidants, reducing agents, emulsifiers, sugar, skim milk powders, eggs, salt, butter, water and yeast, which are explained below.

* **Oxidants:**

Chemically, oxidants modify the gluten by oxidising the amino acid chain at the sulphydryl / disulphide interchange (Stauffer, 1990). This is due to the breaking of disulphate bonds S-S and exchange reactions to form a sulphydryl H-S group (Bloksma, 1968). Ascorbic acid (vitamin C) is used as an oxidant and may be used up to 150 ppm of flour weight of yeast dough (Chamberlain, 1979). Bromate is used about 20 ppm and gives the best volume of croissant (Doerry, 1986).

* **Reducing agents:**

Chemically reduce the gluten to make continuous processing easier. As reducing agents, L-cysteine, and amino acids may be used up to 30 ppm of the flour weight (Doerry, 1986).

* **Emulsifiers:**

They are hydrophillic-lipophilic systems, and their function as dough conditioners improves gluten's gas holding capacity, resulting in higher volume baked product. Emulsifiers like Glyceryl Mono Stearate (GMS) also complex gluten with starch to prevent retrogradation and to improve shelf-life by delaying moisture loss and staling (Knightly, 1973).

* **Sugar:**

According to Faridi (1991) the functional properties of residual sugars are used as sweetener, crust colorant, yeast food, developing flavour as well as increasing crust crispness and crumb tenderness (Matz, 1989).

* **Skimmed Milk Powders:**

Provides lactose, which is only sparingly fermentable by yeast, so it remains available to help in the Mallard reaction to provide a brown crust colour, water absorption and flavour (Pyler, 1990 and Matz, 1989).

* **Eggs:**

According to several researchers Street, (1991); Pyler, (1990) and Sultan, (1986) eggs are used to supplement inadequate flours with low protein quality, improve water absorption and assist gluten in providing structure. In croissants, egg is used to contribute a shiny golden-brown crust colour when it is glazed in the finished proofed croissant dough (Alaco, 1990).

* **Salt:**

Controls yeast activity, as reflected by a reduced gassing rate (Matz, 1989). Salt is also used due to its inhibitory action against spoilage microorganisms in the dough. The other function of salt is its strengthening and tightening effect on the gluten of dough, which may be due in part to its inhibitory effect on the occupation of bounded water as suggested by Bushuk and Hlynka (1964). Salt is added at the 1 to 1.5% of flour bases for its flavour and flavour enhancing properties (Strong, 1969).

* **Doughing-up butter:**

According to Matz (1972) and Sultan (1986) doughing-up butter reduces stress on the gluten network, reduces fragment during mixing, enhances flavour and keeps the quality of croissants by retaining moisture.

* **Water:**

Hydrates flour gluten provides a medium for blending the soluble ingredients (Pomeranz, 1985). The amount of water used depends on the flour, water absorption and dough processing techniques (Hoseney and Finney, 1974). Although dough has considerable buffering capacity by virtue of its protein content from flour, milk solids, etc, the use of excessively alkaline water may require the addition of acidifying agents, such as vinegar, lactic acid or mono calcium phosphate (Matz, 1972). If the alkaline water is enough to raise the dough's pH, deleterious effects on the yeast and enzymes might become noticeable (Haas, 1927).

* **Yeast:**

Freshly crumbed, chilled compressed yeast can be used. Burrows (1970) recognised four functions of yeast in bread and baked products:

1) To increase dough volume by evolution of carbon dioxide during fermentation of the available carbohydrates in the flour.
2) To develop structure and texture in the dough by the stretching of dough proteins (gluten) caused by the expanding gas bubbles.
3) To improve flavour and colour. The flavour components of the yeast activity during fermentation or baking are organic acids, alcohols, aldehydes, ketone and carbonyl products (Mangoffin, 1974). Protease action is also important as it releases peptone and amino acids which react with sugar during baking to produce desirable flavour and crust-browning.
4) To add (in a minor way) to the nutritive value of the bread and baked products.

* **Layering butter:**

Separates dough layers, enabling vertical expansion of the croissant during proof and baking. This creates a very high volume product with an open texture. The layering butter must have a high melting point which will be discussed in section 2.4.6.

2.4.4 THE FLAKINESS MECHANISM OF PLAIN CROISSANTS

According to Matz (1972); Hoseney (1988); and Faridi (1991) the volume of baked croissants achieved during baking can be attributed to the following reasons:

A) The baking characteristics of gluten dough

A piece of gluten dough expands enormously during baking to give a product with very light structure. Abels (1990) indicated the main factors that affect the volume of the puffed pastry and the amount of expansion which occurs depends on:

1) The strength of the gluten, higher protein content, and less starch.
2) The development of the gluten (low development).
3) The baking temperature.
4) Yeast and the production of carbon dioxide gas.

There are two keys in the making of good pastry dough as indicated by Sultan (1986):

1) Avoid gluten development as much as possible. This can be done by using lower water content and minimal manipulation of the dough.
2) Utilise the shortening so it performs two tenderising functions; isolating very small particles of starch and protein from each other, and isolating whole sheets of dough from each other.

B) The layered structure of the unbaked pastry

The importance of layers built into croissants during make-up is emphasised by the introduction of a layer of fat between layers of dough. The process to carry this out is through the rolling, folding and turning and is called rolling-in (Faridi, 1991 and Leung, 1984). In most bakery products gas retention is a property as important as gas production, because gas is responsible for volume increase in croissant pastry. The water vapour is produced from the water present in the dough (Abels, 1990).

Since the fat layers are more impervious to water vapour, they act as barriers against the water vapour formed by the underlying dough layer applying pressure (Cochran, 1981). In this way, the dough layers expand and separate, giving the texture required. During baking, eventually the fat melts and becomes absorbed by the dough layers causing them to cook individually and lift (Leung, 1984).

2.4.5 TYPES OF FATS USED IN CROISSANT PASTRIES

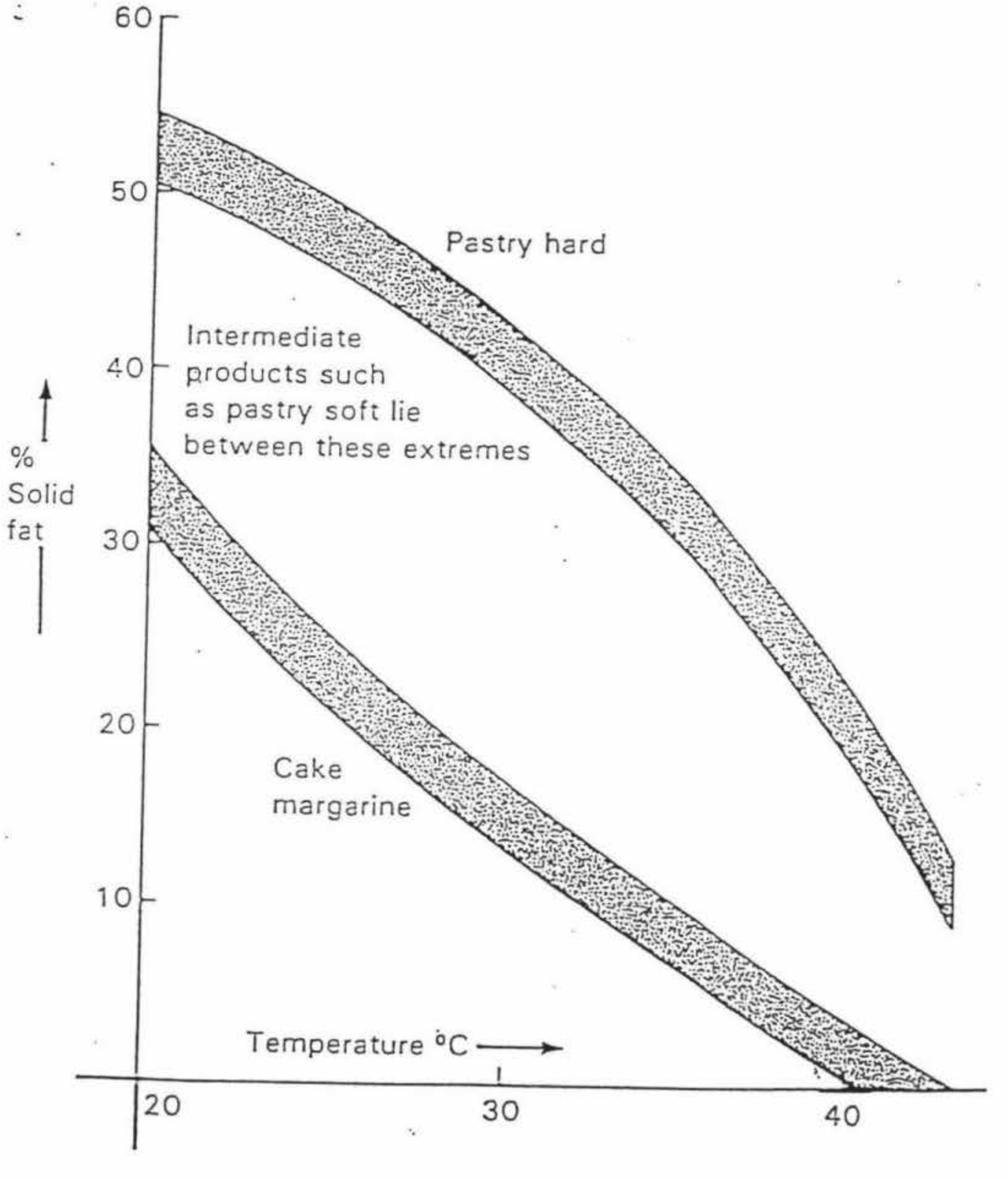
Two types of fat are used in the production of croissant pastry and these perform different roles. Fat which is added to the dough to modify the dough itself. Fat is also used as a layering medium to assist in the raising of the dough during baking. The total amount of fat in the recipe is fixed. It is possible to vary the relative amounts of dough and layering fats (N.Z.D.B, 1990; Alaco, 1990). In general, the higher the proportion of layering fats the more lift is obtained, and the higher proportion of dough fat, the less lift (the shorter gas retention) is obtained, affecting the eating quality and softness of the dough.

The requirements of both dough and layering fat amounts to obtain good eating quality and light flaky layer structures are 12.5 grams per 100 grams of flour and 50 grams per 100 grams of flour respectively (Abels, 1990).

The consistency of the layering fat is important if the structural integrity of the dough is to be maintained. The fat must be plastic but firm enough to maintain the structure (Faridi, 1991). For a fat to be plastic it must consist of both solid and liquid phases. It is the ratio of these two phases which determines its consistency (Bennion, 1972). Therefore, a fat of correct melting point must be selected in the formulation of the croissant dough. In addition to the correct fat melting point, the rolling-in procedure also affects the final quality of the pastry (Sultan, 1986). The measurement of total solid fat content against temperature also gives useful information. As shown in Figure 2.5, different pastry can be obtained using fat of different solid contents at different temperatures.

FIGURE 2.3

PERCENT OF SOLID FAT VERSUS DIFFERENT TEMPERATURE OF FAT USED IN PUFFED PASTRY FORMULATION AND ITS EFFECT ON TEXTURE



2.4.6 BASIC CROISSANT PASTRY RECIPES AND PROCEDURES

A basic formular for croissant dough provided by Sultan, 1986; Fraidi, 1991; and Street, 1991 is given below:

Ingredients	W/W of flour	Mixing procedure
yeast (variable)	5	dissolve the yeast in water and set aside.
water	10	
sugar (variable)	10	
salt	2.75	
NF Milk	6	blend these ingredients together to a smooth consistency.
Shortening	2	
Dough conditioner (SSL)	0.25-0.5	
Whole eggs	8	add eggs in two stages and blend in egg yolks (optional).
Water (cool) variable	32	add the water to the flour and mix.
Vanilla (optional)	1	
Flour (stronger)	100	shift and add the flour, stir in slightly and add the yeast solution. Develop the dough and remove from the machine into a rectangular shape and refrigerate for about 20-30 minutes, cover to prevent crustation. Roll in fat: one variety or a blend of several varieties.
Butter margarine	9.5	Blend the fats to a smooth consistency slightly firmer than the dough. Refrigerate if necessary.

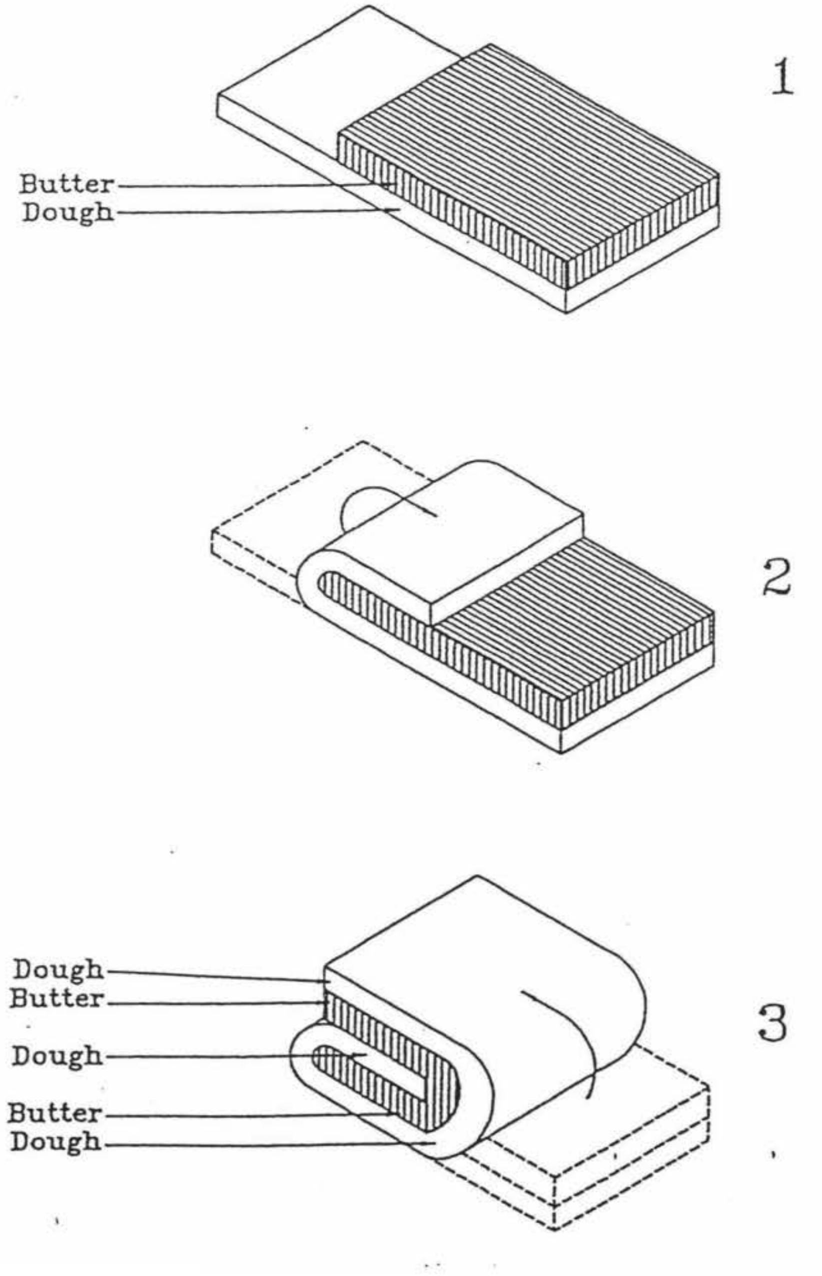
SSL = Sodium Stearoyl Lactylate

2.4.7 THE LAYERING OF CROISSANT PASTRY

The desired croissant texture, (light, flaky and open structure) will result from the turning process in which the dough and layering fat are rolled and folded (Faridi, 1991; Street, 1991). This forms a continuous and alternative layering of pastry, butter and dough (Cleven and Weber 1977).
The English method of croissant pastry making was described by France (1969) and Street (1991) and it is schematically shown in Figure 2.4 below.

FIGURE 2.4

THE ENGLISH THREE FOLD TURN (HALF TURN) METHOD



In this case, the pastry is rolled out into a rectangular shape, two-thirds of the dough is covered with roll-in fat and butter and then folded into three equal parts as shown in the previous diagram. The dough is rolled starting without fat position and turned over half of the covered part, then fold the remaining one-third dough on top (Hoseney 1985). Each half turn multiplies the number of dough layers by three, so that after two half turns, the number of dough layers is 3 x 3 = 9 layers. There is one more layer of dough than fat. Therefore, if **n** is the number of half turns given, the number of dough layers is $\mathbf{2(3^{n-1}) + 1}$. Table 2.4. indicates the number of dough layers up to five half turns and their corresponding dough layers and layers after calculation.

TABLE 2.2

NUMBERS OF LAYERS PER HALF TURN

(Abels 1990)

numbers of half turns	1	2	3	4	5
dough layers generally accepted	3	9	27	81	243
layers after recalculation	3	7	19	55	163

CHAPTER THREE

OBJECTIVES

3.1 INTRODUCTION

As it has been mentioned before, there is limited information concerning the mechanism of cheese powder interaction in food and especially in bakery products. Thus, this research is aimed to study the use of cheese powder as a major ingredient in bakery products, specifically its performance in specific functions and its affects on the flavour characteristics of the end product.

It is known that cheese powder plays an important role in bakery products by providing better functional properties that affect the manufacture of these products (Salsbury, 1988). These properties include the ability to form new network structure, absorbing and trapping water, crust and crumb colour, binding flavour compound and rheological properties of the product (Alaco, 1992).

Therefore, an understanding of the functional properties of cheese powder is necessary in order to overcome the difficulties of incorporating cheese powder in the croissant pastry.

Croissant pastry was chosen as a model example to research the functional properties of the cheese powder from the stage of dough to the finished baked croissant product.

The rationale for choosing croissants lies in the fact that the author carried out a product development project which developed cheese flavoured croissants. Thus, an understanding of cheese powder behaviour in the product is necessary. In addition, there is a high current demand and opportunities to develop new food products for the growing local population and for the international market.
Furthermore, the New Zealand Dairy Board (NZDB) could have an increased demand for at least one of its present industrial products through the utilisation of cheese powder in croissants (Joudi 1992).

The results of this study will constitute the base for the customers technical support that the NZDB could provide to its consumers. The value of this research and its findings are enhanced by the prediction that croissants will become more popular in New Zealand and Australia (Alaco, 1986).

3.2 STUDY OBJECTIVES

The overall objectives of the study are:

1. To investigate the functional properties of three types of cheese powder, namely CP1, CP2 and Cheddar-20 in croissant formulation by evaluating the dough and the finish baked product's physical properties and comparing them to the plain croissant.
2. To evaluate the performance of the above types of cheese powder in the cheese flavoured croissants, by using sensory evaluation.
3. To determine a suitable method for mixing and incorporating the cheese powder with other ingredients used in the croissant formulation and to obtain its baking time-temperature relationship.
4. To study the market forecast of the developed cheese croissant product and carry out on a economic evaluation of the product.

CHAPTER FOUR

MATERIALS AND METHODS

4.1 MATERIALS

* **CHEESE POWDERS** Supplied by the **NEW ZEALAND DAIRY BOARD, WELLINGTON.**

The cheese powders were natural, spray-dried New Zealand cheese. The CP_1 and CP_2 samples were natural cheese flavoured powder, with natural and tasty cheese flavour, whereas cheddar-20 cheese powder type was a sprayed dried powder flavoured with cheese concentrate.

* **ALACO PASTRY BUTTER SHEET** Supplied by the **ALACO FOOD INGREDIENT CO.**

The Alaco pastry butter sheets had a melting point of 37 $\pm$ 1°C. which had been plasticised and work toughened and produced in sheets designed specifically developed for laminated pastry products. Butter sheets were made from 100% milk fat by blending butter fat fractions and fresh cream, involving physical separation and blending processes.

* **FLOUR** Supplied by the **MANAWATU MILLS CO. PALMERSTON NORTH.**

A strong hard red winter wheat flour (beta flour) prepared specially for the manufacture of pastry products.

* **FRESH COMPRESSED YEAST** Supplied by the **QUALITY (HOME STYLE) CO. PALMERSTON NORTH.**

Commercial compressed baker's yeast was held at a 4°C temperature to lose the yeast activity during storage.

4.2 EXPERIMENTAL DESIGN

In order to improve the characteristics of the cheese croissant product it was decided to investigate the effects of varying levels of cheese powders and the interaction between cheese powder types, at various levels on the final product characteristics.

An experimental design was used to optimise both sensory response and physical properties of dough and baked croissant characteristics. Variables chosen and considered necessary for the optimisation of the above characteristics that needed to be assessed were the cheese powder type and cheese concentration.

The standard baking formulation for the plain croissant was indicated by Alaco Food Ingredient (N.Z.D.B., 1990) and is shown in table 4.1. This baking formulation was used as the basis for the manufacture of cheese flavoured croissants as shown in table 4.2. Therefore, adjustments were made to the water and substituting the skim milk powder and doughing up butter by cheese powder to standardise the formulation.

The baking procedure (figure 4.1) was started by placing all weighed ingredients except the Alaco butter sheets in the mixer (Bear Varimixer) and mixing for 10 minutes. Dough temperature was maintained under 16°C. Then the dough was covered with a polyethylene bag and chilled for 15 minutes. The dough was sheeted out into a square shape of 10mm thickness by gradual reduction through a pastry brake, with minimal flour dusting followed by placing Alaco butter sheets on the top of the dough.

The sheet was folded, using the three fold turn method as described in Figure 2.4, wrapped in polyethylene bag and chilled for 15 minutes. From the refrigerator, the dough was taken to the pastry brake and turned at an 90° angle to the previous sheeting direction and sheeted 10mm thick, folded three turns, wraped in a polyethylene bag and chilled for 15 minutes.

TABLE 4.1

STANDARD FORMULATION OF PLAIN CROISSANT AS INDICATED BY ALACO FOOD INGREDIENT (N.Z.D.B)

INGREDIENTS	W/W % BASES	100% FLOUR WEIGHT BASES
High protein flour	42.100	100
Dried vital wheat gluten	1.700	4
Sugar	3.800	9
Skimmed milk powder	2.100	5
Salt	0.530	1.25
Doughing up butter	3.800	9
Fresh compressed yeast	2.740	6.5
Oxidants	0.005	0.013
Water (4°)	22.130	52.5
Alaco sheets (laminating)	21.100	50
TOTAL	100.000	237.263

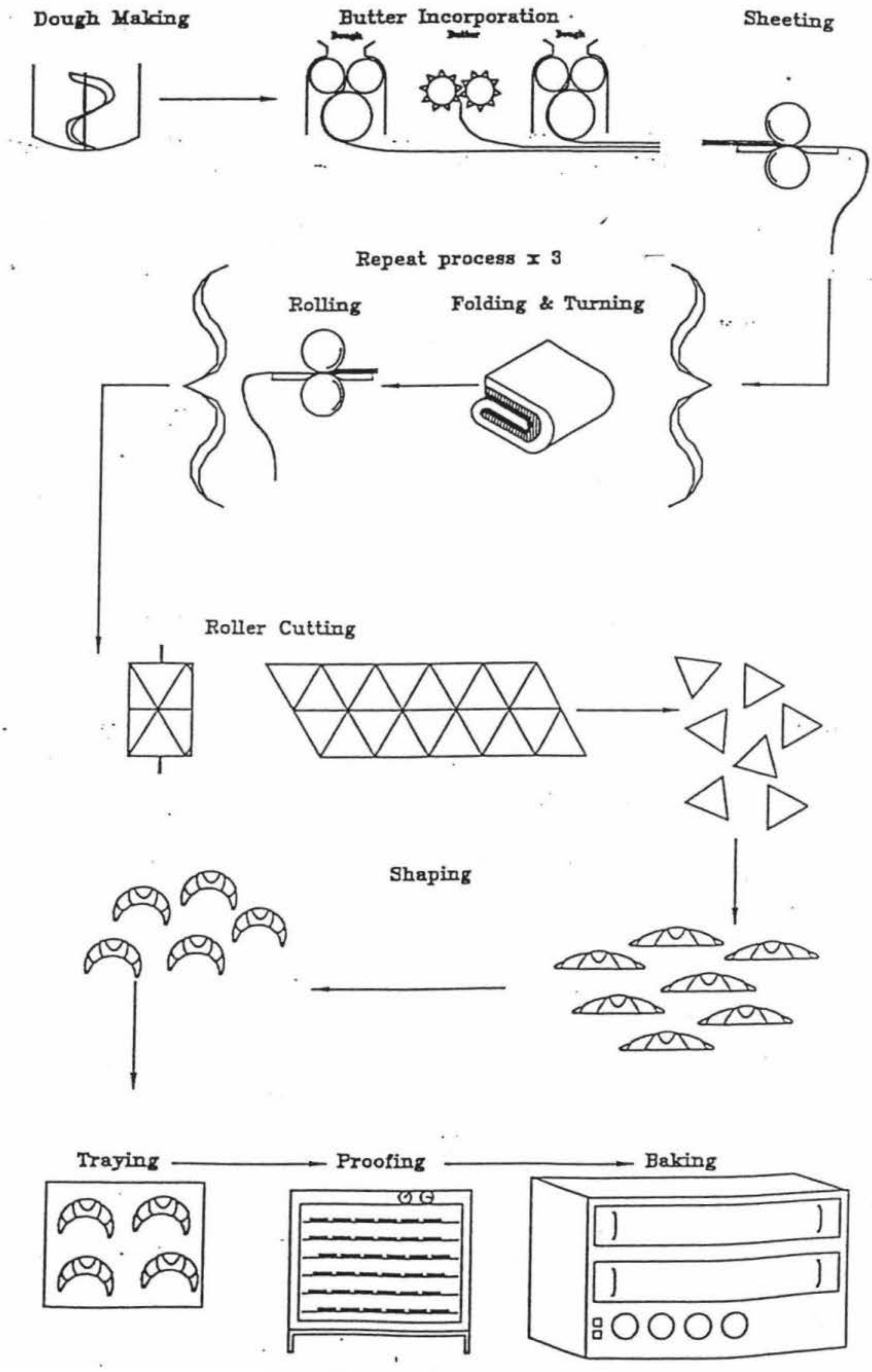
TABLE 4.2

FORMULATION USED FOR PRODUCING CHEESE CROISSANTS WITHIN THREE LEVELS

INGREDIENTS	10% W/W CP	15% W/W CP	20% W/W CP
High protein flour	42.000	41.000	40.0
Dried vital wheat gluten	1.500	1.500	1.5
Sugar	3.000	3.000	3.0
Cheese powder	10.000	15.000	20.0
Salt	0.500	0.500	0.5
Fresh compressed yeast	2.400	2.400	2.4
Oxidants	0.005	0.005	0.005
Water (4°)	22.500	20.000	17.5
Alaco sheets (laminating)	18.000	16.500	15.0
TOTAL	100.00	100.00	100.00

FIGURE 4.1

FLOW CHART PROCEDURE FOR THE BAKING CHEESE CROISSANT



The folding and turning procedure was repeated to build up 27 layers of dough-butter. The folded dough was turned 90 degrees and sheeted by a pastry brake reduction between 3mm-5mm thickness. The sheeted dough was transferred to a work bench and cut into triangle shapes with a kitchen knife.

The triangle dough pieces were rolled up, beginning at a straight edge and finished at the point, curled into a crescent shape with the point extending out at least 10mm from the middle of the crescent. The curled croissant was placed onto greased baking trays and into a proofing cabinet for 90 minutes at 30°C and 85% relative humidity. The proofed curled croissant was baked at 125°C for 25 minutes.

Initial experiments were carried out on three types of cheese flavoured croissants to find the best level of cheese powder percentage. After several pre-trials, it was found that the suitable level of cheese powder which could give acceptable flavour and texture to the croissant was to be 15% W/W% of cheese powder from CP_1, CP_2 and Cheddar-20. Thus, cheese powder contents of 10%, 15% and 20% were used for the experimental design. A randomised complete factorial design for all baking schedules was used to study a total of twelve blends and each sample was prepared in triplicate. This is presented in table 4.3.

TABLE 4.3

EXPERIMENTAL DESIGN OF THE DIFFERENT CHEESE POWDER LEVELS

CHEESE TYPE	CP1 %	CP2 %	CHEDDAR 20 %
Control	0	0	0
Low Level	10	10	10
Medium Level	15	15	15
High Level	20	20	20

4.3 METHODS OF ANALYSIS

4.3.1 CHEMICAL METHODS

4.3.1.1 PROTEIN CONTENT

The protein content of cheese powder types was measured by the Kjeldahl method using a Kjeltec 1026 system distillation unit.

The sample (0.5g) was weighed accurately and placed into the digestion tube. Two kjeltabs 3.55 (containing 3.5g K_2SO_4 and 0.0035g Se) and 12 ml concentrate H_2SO_4 were added. Digestion was then carried out using a digestion system 1007 at 420°C for 30-45 minutes. After cooling, the solution was diluted with 75 ml distilled water. Distillation was then applied using a distillation unit programmed to use 2 ml alkali with 0.2 minute delay time and 3.6 minutes steaming time.

The liberated NH_3 was collected in 25 ml 4% boric acid solution. When the distillation was completed, the sample was titrated against 0.1 M HCl to a pink end point. The calculation of hitrogen percentage was 1 ml of 0.1 M Hcl and was defined as being equivalent to 1.4 mg N and a multiplication factor of 6.25 was used to calculate crude protein content.

4.3.1.2 FAT CONTENT

The fat content of cheese powders used was determined using the official method of the Association of Official Analytical Chemists (Section 18.044) (AOAC, 1984). The sample (2 g) was weighed into a Mojonnier flask and mixed with 10 ml warm (40°C) distilled water until no solid particles remained, followed by adding 2 ml ammonia solution.

The mixture was heated in a water bath at 60°C for five minutes with occasional stirring. After cooling the contents of the flask, two drops of phenolphthalein solution were added followed by the addition of 10 ml ethanol and then 25 ml diethylether. The Mojonnier flask was then shaken vigorously. Twenty five mls of petroleum ether were added and the flask was vigorously shaken. The Mojonnier flask was centrifuged at 600 rpm for three minutes and the ether-fat fraction was then separated as much as possible. To optimise the fat extraction a second extraction step was repeated and the two extraction volumes were collected together into a 250 ml round-bottomed flask which had been weighed. The ether-fat fraction was dried using a two step process. Most of the organic solvent was removed using a rotary evaporator at 45°C and then the sample was completely dried by heating in an oven at 100 $\pm$ 2°C for 90 minutes.

4.3.1.3 MOISTURE CONTENT

The moisture content of cheese powder types was determined by using the American Association of Cereal Chemists (AACC) method 44-19 (1970). Therefore, 2 g $\pm$ 1 mg samples in aluminium dishes were dried in an air oven at 100 $\pm$ 2°C for approximately three hours.

Moisture content was determined by weight difference before and after sample drying.

4.3.1.4 ASH CONTENT

The ash content of cheese powder types was determined by using the AACC method 08-11 (1970). Two gram samples contained in silica dishes were burned in a furnace at 600°C for approximately 16 hours.

4.3.2 PHYSICAL METHODS

4.3.2.1 pH MEASUREMENTS

pH was determined using an Orion pH-meter model 720. The method was used according to the AACC standard procedure by inserting the electrodes of the pH-meter directly into the dough.
The pH of the crust was determined using the following method:

1) Fifteen grams of cut small pieces of fresh crust were placed into a small beaker in water.
2) The flash was agitated until an even suspension free from crust lumps was obtained. Thus, the suspension was allowed to stand at 25°C for 30 minutes and then agitated continuously.
3) Supernatant liquid was decanted into electrode vessel and immediately the pH was determined by using a potentiometer and electrodes which have been calibrated against known buffer solutions.

4.3.2.2 VOLUME MEASUREMENTS

The volume is the space occupied by the croissant. There is generally an ideal relationship between dough weight and volume expressed to give a desirable texture. The volume expressed in cubic centimetres is usually determined by the rape seed displacement method. The croissant is placed in a container of known volume in which small rapeseed are added until the container is full. The volume of rapeseed displaced by the croissant is calculated. This concept of volume also includes the factor of croissant shape, i.e. the length, width and height should all be in a pleasing relationship.

4.3.2.3 WEIGHT MEASUREMENTS

The weight of the dough and baked croissant were measured by using a weighting scale.

<u>4.3.2.4</u> <u>SPECIFIC VOLUME MEASUREMENTS</u>

From the determination of the volume and weight of the croissant the specific gravity of the croissant was calculated. The specific volume was calculated as 1/specific gravity.

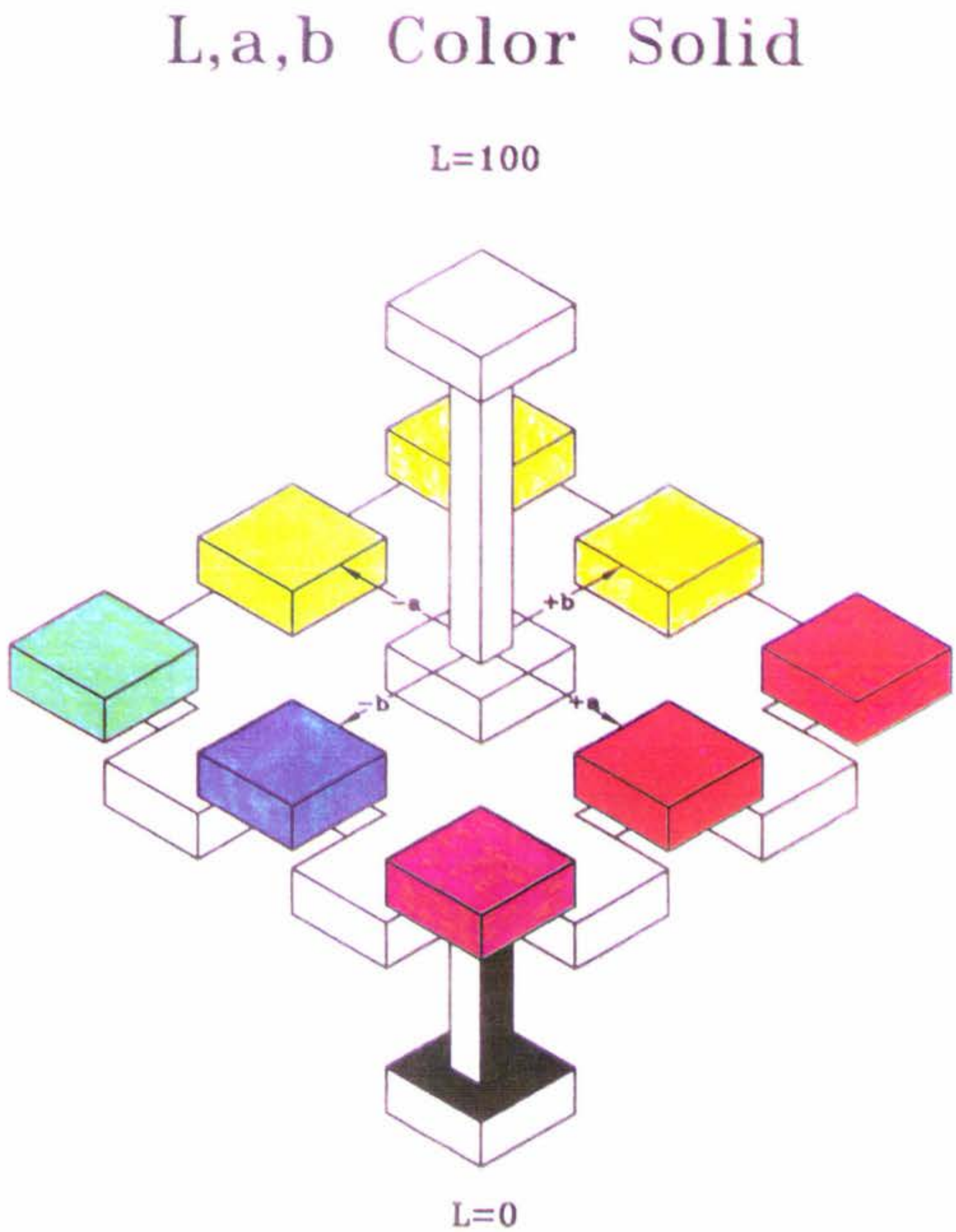
<u>4.3.2.5</u> <u>COLOUR MEASUREMENTS</u>

Hunter Colour reading 'L', 'a' and 'b' values were determined using a Hunterlab Colour Quest Spectrophotometer Model CQ1200K with version 2.33 software (Hunter Associates Laboratory, Inc. Reston, Virginia USA) and calibrated with white and gray standard tiles supplied by the manufacturer.
For the dough samples, 10 g were placed in a metal container. Colour of the inside crumb was determined by placing a whole crumb, after cutting the baked croissant in the middle, was placed also in the sample container while the crust colour of a whole baked croissant was placed in the sample container.

For the dough and crumb (inside) samples colour only the 'L' values were measured but for the crust samples colour the 'L', 'a' and 'b' values were measured. The Hunter 'L' value is the lightness function, L = 100 is a perfect white sample, whereas L = 0 is a black sample. The 'a' value is a red-green function, and the colour scale measurement is +a = red, a = 0 (grey) and -a = green. The 'b' is a yellow-blue function and the colour scale measurement is +b = yellow, b = 0 (grey) and -b = blue. These values are indicated in Figure 4.2.

FIGURE 4.2

A DIAGRAMMATIC REPRESENTATION OF THE HUNTER COLOUR SPACE OF THE L, a, AND b COLOUR SOLIDS



4.3.2.6 FARINOGRAPH MEASUREMENTS

A Farinograph shown schematically in figure 4.3 is an instrument used to measure the dough quality characteristics and to record the power that is needed to mix a dough at constant speed or the resistance to mixing. The changes in the nature of the dough are recorded over a period of time. The evaluation is derived from a typical Farinograph curve called a Farinogram which includes dough development, stability, mixing tolerance index, degree of softening parameters as shown in figure 4.4.

Besides the Farinogram measurements one additional important piece of information obtained from this instrument is water absorption capacity. This value gives the amount of water that can be added to flour so that the dough has a fixed consistency and can be expressed as an absorption percentage.

The Farinograph curve is used to determine the following:

1) Water Absorption Capacity, (WAC) is a percentage of total dough mixture
2) dough development time, in minutes
3) stability time, in minutes
4) mixing tolerance index time, in minutes
5) degree of softening in Farinograph Units (F.U).

The calculation of WAC is obtained from the following equation (AACC, 1970 method 54-21).

$$\text{Absorption \%} = \frac{x + y - 300}{300}$$

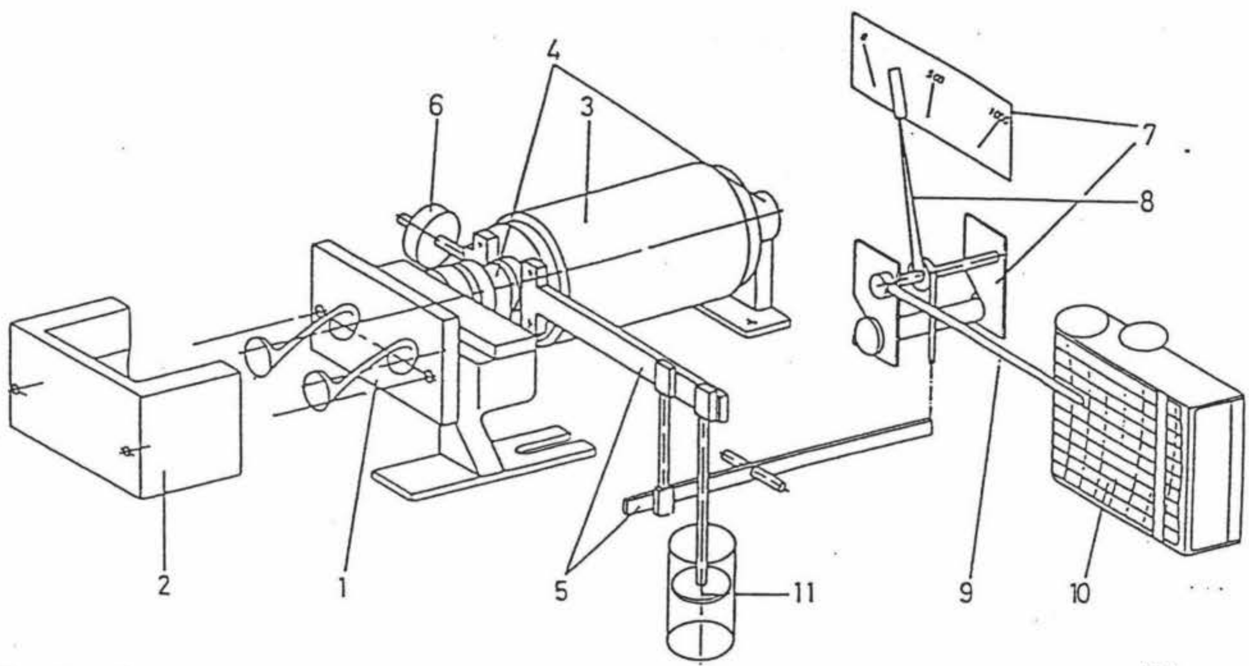
Where x = ml of water added.

y = gram of flour used.

300 = gram constant of the machine capacity.

FIGURE 4.3

DIAGRAM SHOWING THE PRINCIPLE OF THE BRABRENDER FARINOGRAPH

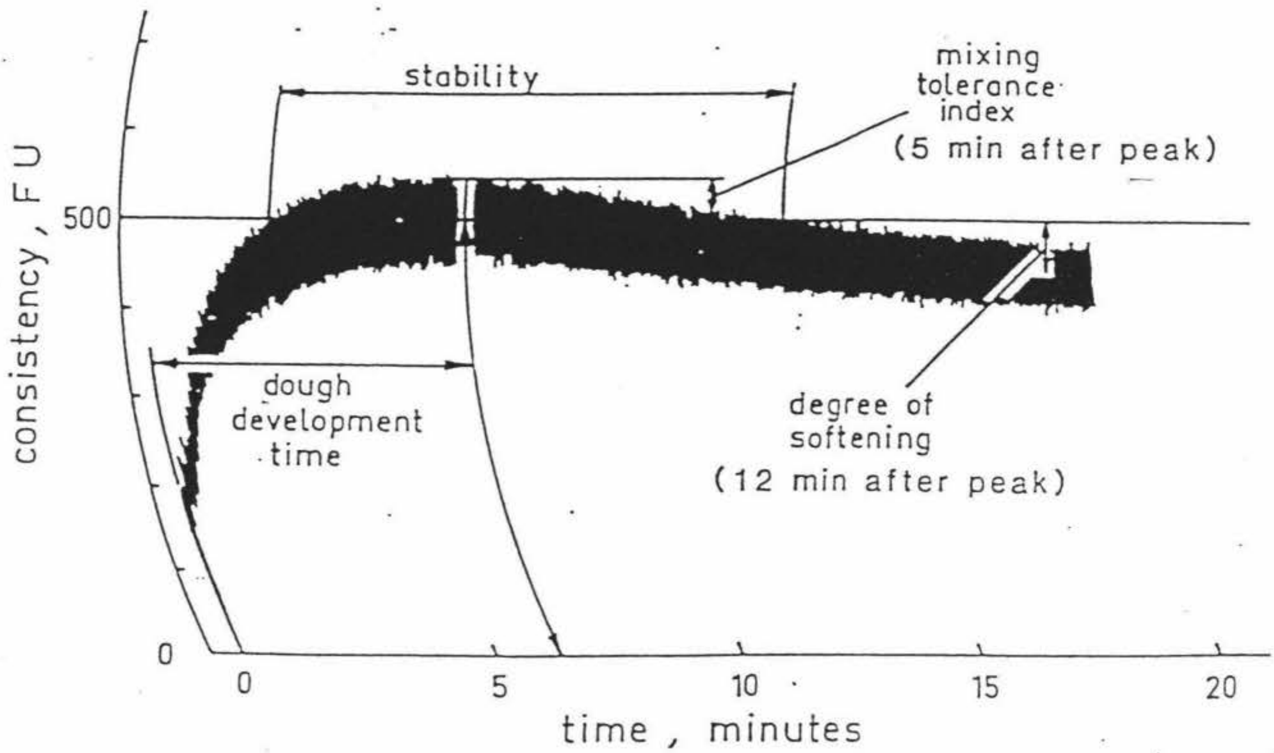


1 = Back wall of mixer with mixing blades
2 = reminder of mixer
3 = housing of motor and gears
4 = ball race bearings
5 = levers
6 = counterweight
7 = scale head and scale
8 = pointer
9 = pen arm
10 = recorder
11 = dashpot damper
12 = biuret

(reproduced from Pomeranz, 1988)

FIGURE 4.4

REPRESENTATIVE FARINOGRAM SHOWING SOME COMMONLY MEASURED INDEXES



A consistency of 500 farinograph units (F.U) corresponds to a power of 68 and 81 W per kilogram of dough in mixer for 300 g of flour (Pomeranz, 1988).

The strength and stability of the dough studied were measured using a Farinograph machine Model PL-2H at 30°C using the 300 g constant flour weight. The mixer rotated at 90 rpm (AACC, 1970 method 54-21).

The process was started by placing 300 g of dry flour in the mixer. The instrument was started and water added rapidly from a funnel biuret.

The torque on the driving shaft of the mixing blades causes proportional rotation of the dynamometer (3-7 in figure 4.3) which is transmitted to a pointer and then a recorder. The mixer wall is hollow and water circulates through it to control temperature at 30°C.

The optimum Water Absorption Capacity (WAC) of the flour was measured by centring the curve on the 500 Farinograph Unit (F.U.) line as shown in Figure 4.4. The blend of flour and cheese powder involved the following measurements:

1) 270 g of flour and 30 g of cheese powder were mixed to obtain a level of 10% of cheese powder.
2) 255 g of flour and 45 g of cheese powder were mixed to obtain a 15% level of cheese powder.
3) 240 g of flour and 60 g of cheese powder were mixed to obtain a 20% level of cheese powder.

4.3.2.7 ELONGATIONAL VISCOSITY MEASUREMENTS

Elongational viscosity of the dough was measured using the Instron Universal Testing Machine Model 4502. The dough samples were placed between two parallel plates. The base plate (148 mm diameter) made from stainless steel and the plunger plate (51.7 mm diameter) made from plastic (Acetal). Both plates were lubricated with sunflower oil. The compression tests were performed under standard testing conditions:

* cross-head speed = 50 mm/min
* specimen shape = cylindrical
* specimen height = 20 mm
* specimen diameter = 45 mm
* compression depth = 6 mm
* temperature of the compression test = ambient (18°C)

4.3.2.8 TEXTURE MEASUREMENTS

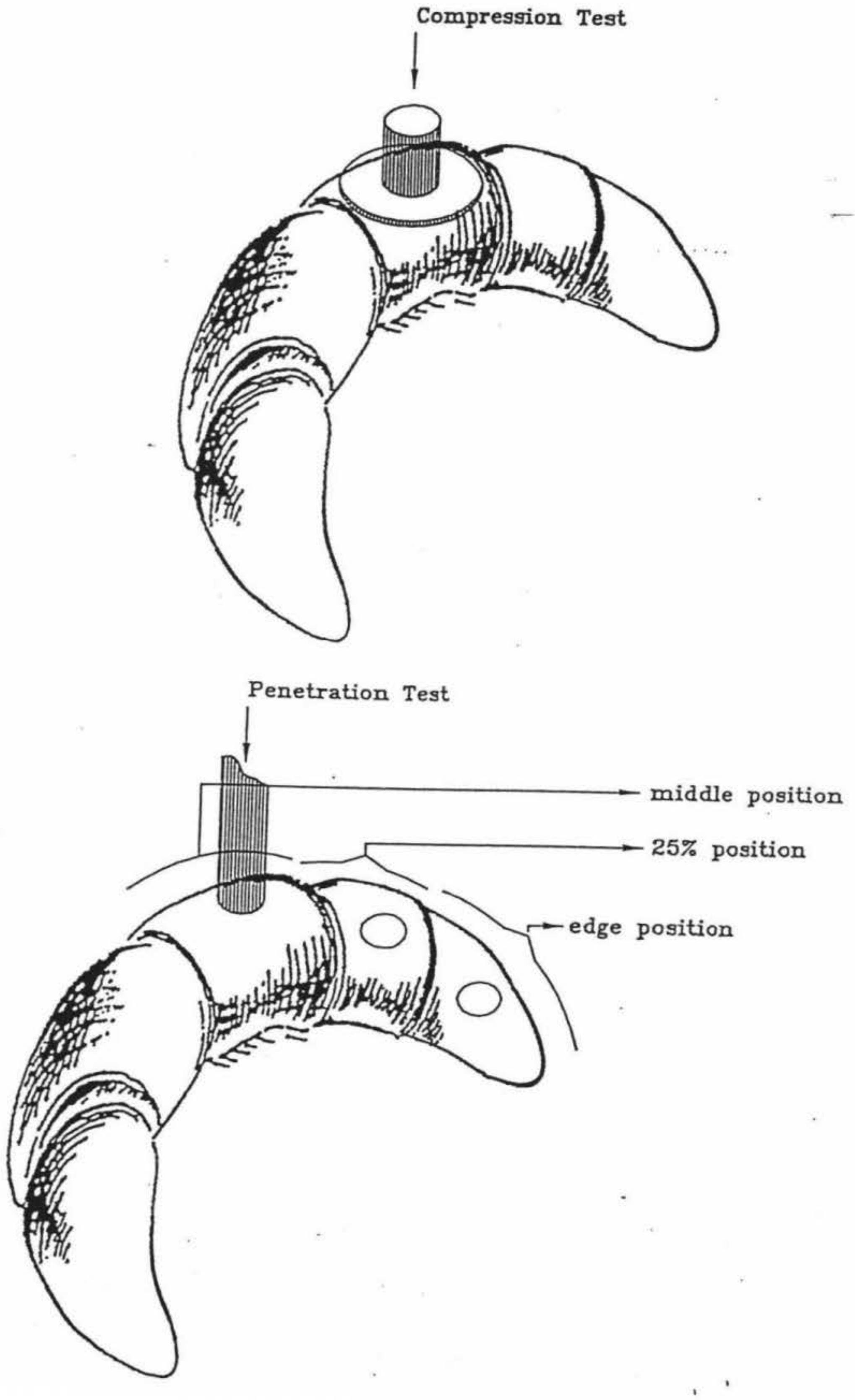
The evaluation of the texture assessment was performed using the Instron Universal Testing machine for both compression and penetration tests. For the compression test (samples of whole baked cheese croissant were placed between two parallel plates). The penetration test was conducted at three different positions, middle, 25%, and edge, as shown in figure 4.5.

The compression plunger diameter was 51.13 mm and the penetration plunger diameter was 6.35 mm. The base plate (148 mm diameter) were used for both tests. The testing conditions were as follows:

* specimen height = 30 - 40 mm
* compression and penetration depth = 15 mm
* cross-head speed = 15 mm/min
* specimen shape = crescent
* position of the compression test = middle of the specimen
* position of the penetration test = 3 different positions
* temperature of the compression and penetration tests = ambient (18°C)

FIGURE 4.5

COMPRESSION AND PENETRATION TESTS OF CHEESE CROISSANT



4.4 SENSORY EVALUATION

Sensory evaluation was carried out for cheese croissant samples containing the three cheese powder types and levels of 10%, 15%, and 20% and evaluated against the control (plain) using multiple comparisons method (ASTM 1968).

Informal sensory evaluation was carried using eighteen panellists for consumer preference tests. Croissant samples were evaluated for crust and crumb colour, texture, odour, and taste including saltiness, bitterness and cheesiness attributes. Overall acceptability of the sample was measured on a horizontal scale from 0 - 10 points. Five points was the reference (R) assigned to the control croissant. The panellists were asked to compare each coded sample against R, and to decide whether it was better than, equal to, or inferior to the reference (Peterson and Johnson 1978).

A marking of ten points in the scale indicated much more than R, five points signified the same as R, and zero on the scale symbolised much less than R. A total of three randomly coded cheese croissant slices from each cheese powder type at the studied levels and the R sample were placed in succession before the panellists on a single-service white plate.

The sensory tests were conducted after one day of completing the baked croissants. Samples were served at ambient temperature. All the tests were conducted in three sessions, each session for one cheese powder type and its three levels. Comparisons between the three levels of one cheese powder type samples were determined. The tests were conducted in a well-lit and odour free environment, and at mid-afternoon time with specific instructions for the sample evaluation as shown in Appendix 1.

4.5 DATA ANALYSIS

All analyses were done in triplicate, and their average values were reported. Only the sensory characteristics tests were analysed using the Analysis of Variance (ANOVA) and the least significant differences procedures that were carried out by using the SAS Statistical package (SAS Institute Inc. 1987).

CHAPTER FIVE

RESULTS AND DISCUSSION

5.1 EVALUATION OF DOUGH RHEOLOGY

Table 5.1 shows the mean results of Farinograph absorption (% of water absorption capacity by flour and total peak time of Farinogram) and elongational viscosity of dough for the three cheese powder types at each percent cheese level. Table 5.1 also shows standard deviations in the Farinograph absorption and elongational viscosity.

5.1.1 EVALUATION OF THE FARINOGRAPH ABSORPTION

The Farinograph absorption data is displayed in table 5.1 showed that the dough containing cheese powder decreased the dough consistency (at 14% moisture basis of flour) when compared to the control and as shown in Figure 5.1. This was due to the high content of milk fat in the cheese powder types as indicated in table 5.2. Results indicated that the three cheese powder types did not show much differences among each other, however, there were significant differences with increasing cheese powder levels. The differences in the dough mixing properties were indicated by the shape of the Farinogram tests, (Figure 5.1) which were used to characterize flour blend properties. These differences are the dough mixing requirements and tolerance (physical dough properties), dough handling properties and water absorption capacity requirements of the flour blend.

TABLE 5.1

FARINOGRAPH ABSORPTION AND ELONGATIONAL VISCOSITY DATA OF THE CROISSANT DOUGH WITH DIFFERENT CHEESE POWDER LEVELS

CHEESE POWDER TYPE	LEVEL W/W %	FARINOGRAPH ABSORPTION		ELONGATIONAL VISCOSITY Pa.sec
		ABSORPTION %	PEAK TIME (min)	
CP1	10	49.96 + 1.05	7.0 - 8.0	29373.3 ± 4281.2
	15	41.53 + 0.75	6.5 - 7.5	38250.6 ± 5517.5
	20	34.33 + 1.53	6.0 - 7.0	47918.6 ± 6521.2
CP2	10	49.93 + 0.60	7.0 - 8.0	25922.3 ± 4228.8
	15	41.33 + 0.55	6.5 - 7.5	32741 ± 3762.8
	20	32.7 + 0.26	6.0 - 8.0	39605.6 ± 5927.4
CHEDDAR-20	10	46.06 + 1.10	9.0 - 10	32604.3 ± 1715.1
	15	41.43 + 0.77	7.0 - 8.0	38177 ± 10717.8
	20	36.0 + 1.0	6.0 - 7.0	45172 ± 1885.1
Control	0	67.5 + 0.5	13.0 - 14.0	22768.3 ± 1171.6

Elongational viscosity standard condition

- specimen height = 20 mm
- specimen diameter =45 mm
- plunger diameter = 51.7 mm
- compression depth = 6 mm
- crosshead speed = 50 mm/min
- specimen shape = cylindrical
- position of the compression test = at the middle of the specimen
- triplicate measurements for each sample

TABLE 5.2

TYPICAL COMPOSITION ANALYSIS OF THE THREE CHEESE POWDER TYPES, PASTRY BUTTER SHEETS AND FLOUR USED FOR CHEESE CROISSANT PRODUCTION

	CHEESE POWDER %			*P.BUTTER SHEETS %	FLOUR %
	CP1	CP2	CHED-20		
Protein	36.8	36.2	25.6	0.54	13.5
Milk Fat	50.0	50.0	30.0	80.0	Nil[1]
Moisture	3.5	3.7	3.8	14.0	13.0
Lactose	4.7	4.7	33.9	5.5	72.7[2]
Ash	5.0	5.5	6.7	Nil	0.8

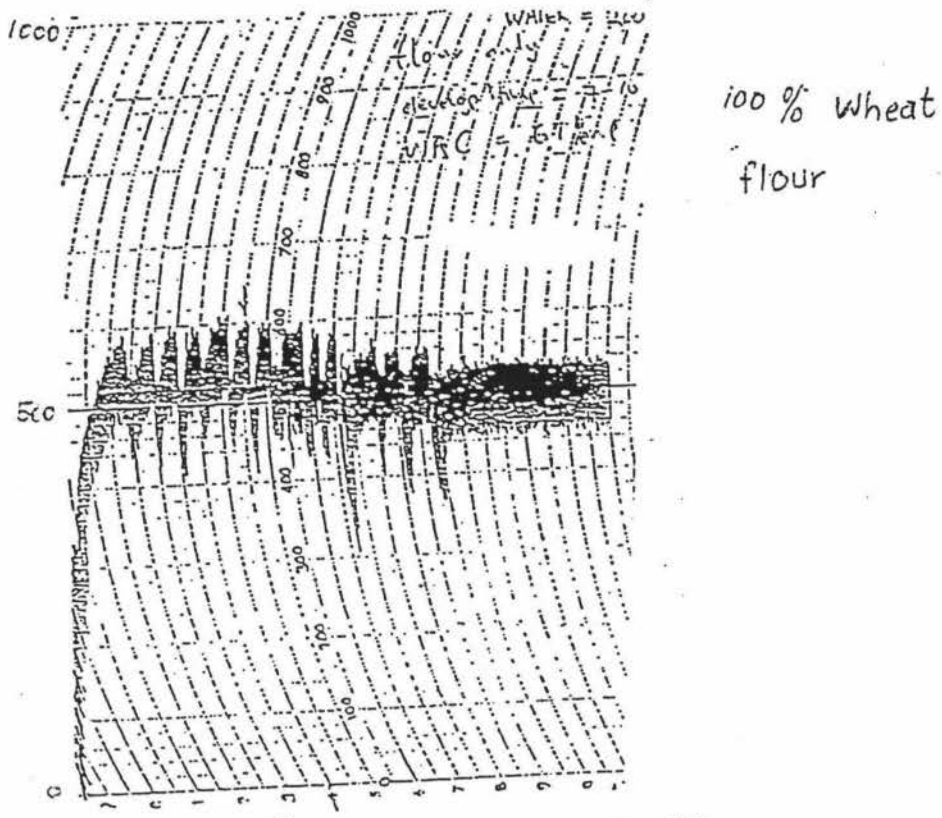
*P.Butter = Pastry Butter

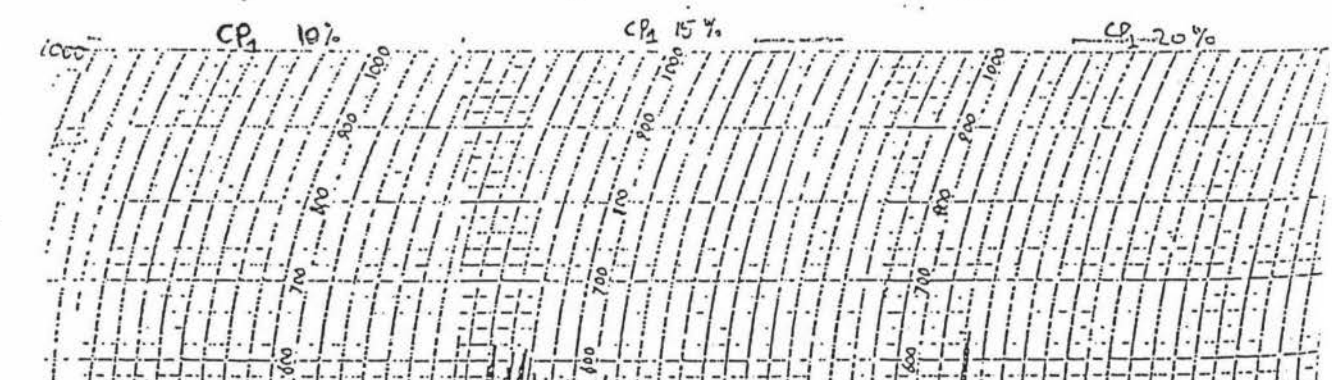
1 = As fat

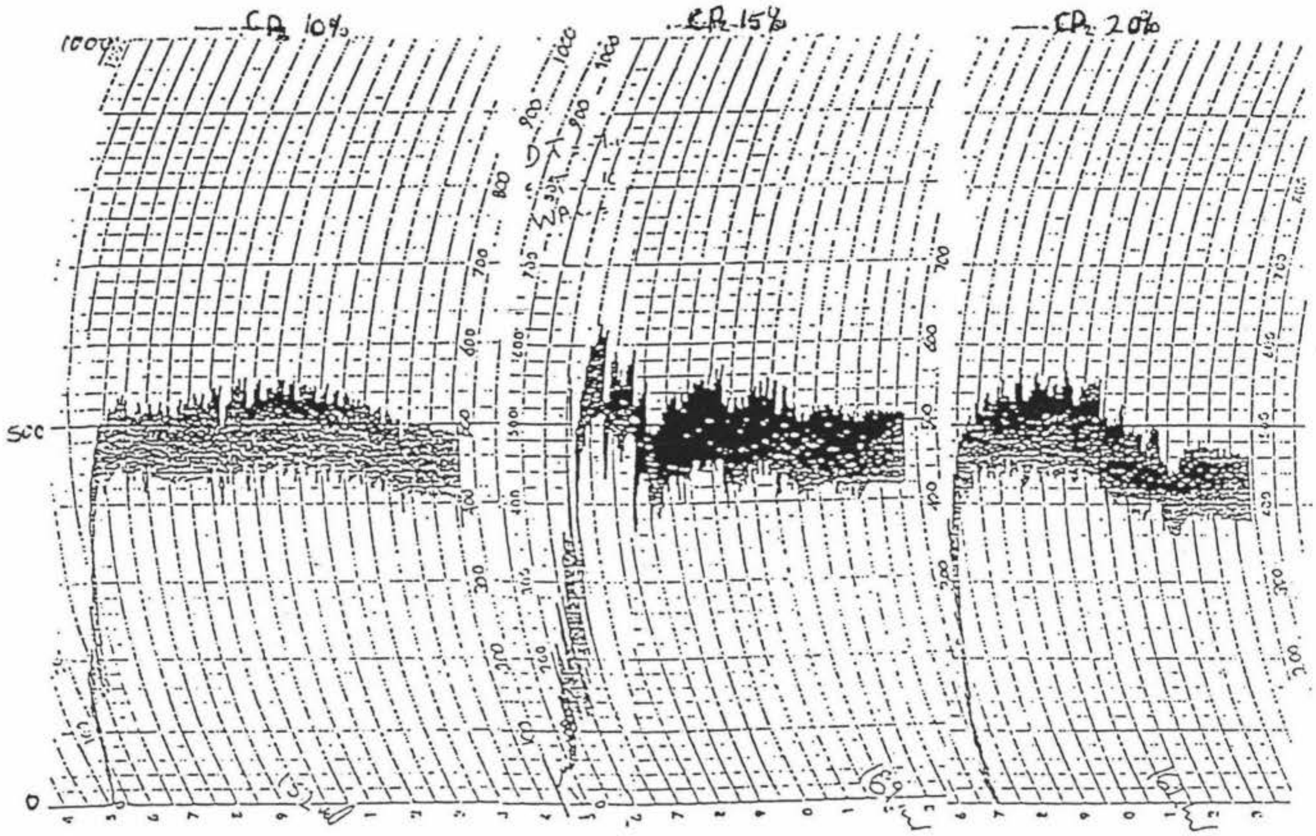
2 = As flour carbohydrates

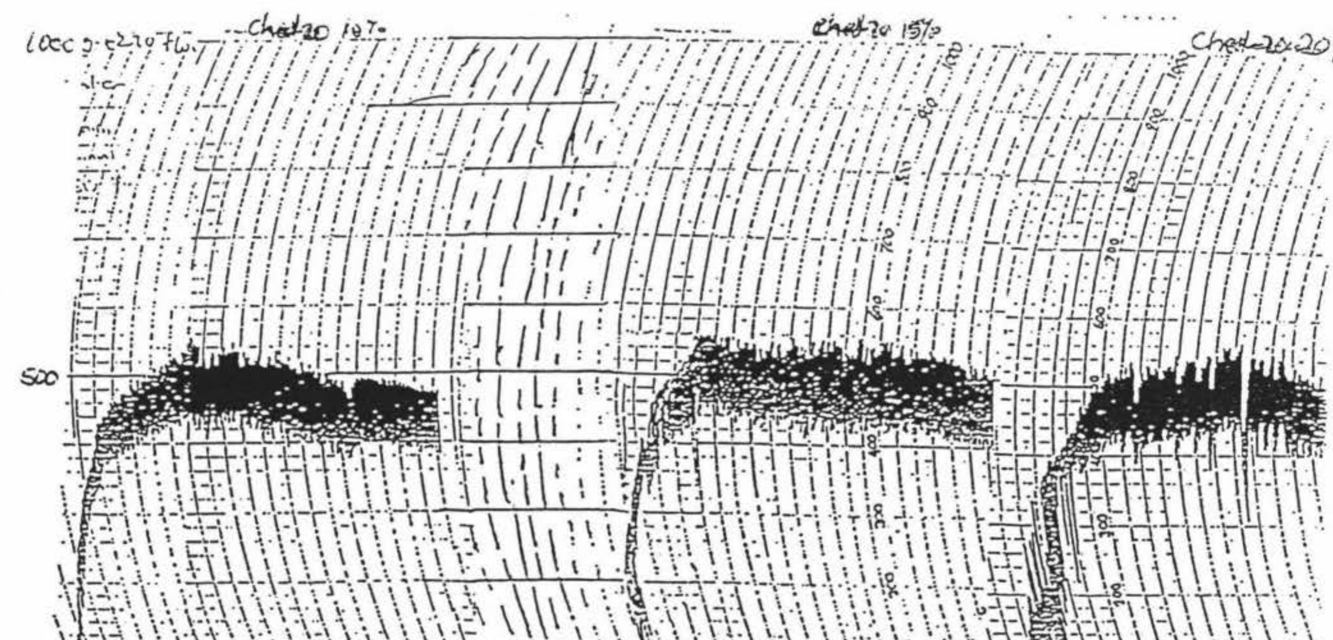
FIGURE 5.1

FARINOGRAMS CURVES OF THE CONTROL (100% wheat flour) AND FLOUR BLENDS OF THREE TYPES OF CHEESE POWDERS CP1, CP2 AND CHEDDAR-20 AT LEVELS OF 10%, 15% AND 20% RESPECTIVELY






CR 10%
CR 15%
CR 20%
1000
500
0


Chetzo 10%
Chetzo 15%
Chetzo 20%
500
0

* Dough mixing requirement and tolerance.

The quality and quantity of protein in the flour and the added cheese powder quantity affected the dough mixing requirement and tolerance. This was objectively determined by the Farinograph curves at an optimum water absorption capacity of flour. As the mixing proceeded, the water was absorbed and the dough progressively developed. The control dough (without cheese powder) showed 3-7 minutes longer peak times when compared to doughs with cheese powder. This was due to the effect of the cheese powder components fat, lactose, and mineral (ash), which enhance dough softening (Hermansson, 1974). However, dough mixing properties are dependent upon the flour protein content (gluten) (Bushuk and MacRitchie, 1988). A flour of high protein content has the action of improving the broadening of the dough mixing range and tolerance (Kunerth and D'Appolonia, 1985). The flour used to produce the croissant dough was classified as a strong flour containing approximately 13% protein. This provided the dough with the best mixing properties. Hence the variation in the dough mixing properties was a function of the addition of the cheese powder type.

All the cheese powders showed noticeable weakening of the dough mixing strength when compared with the control sample. This was exhibited by a decreasing developing time as shown in Figure 5.1 and the percentage of WAC for a high level blend of 20% as indicated in Table 5.1.

* The dough handling properties.

The physical dough properties measured on the Farinogram are generally good indicators of dough handling properties. The cheese powder disperses in the dough with increasing mixing requirements and tolerance (long mixing time and high amount of water), which means the cheese powdered containing dough was required to be mixed for more than three minutes before it reached the same mixing time of the control dough. But blending a strong flour (13% protein) with cheese powder produces a dough that has usually high physical strength and an undesirable lack of extensibility. This is shown in Figure 5.1.

* Water absorption capacity requirements of flour.

As the protein content of the flour increases, the water absorption capacity also increases. This is due to the hydration rate of the protein (Pyler, 1988). However, in the case of cheese powder addition the results show a lower water absorption capacity requirement and a shorter peak time when compared to the control dough. The extremely short development time of doughs with cheese powder indicates that hydration is taking place rapidly.

Application of a special process treatment, for example protein denaturation, low percentage of lactose, minerals and fat in the cheese powder results in a high quality baking product in terms of high WAC and mixing stability (Guy, 1971; and Zadow, 1984).

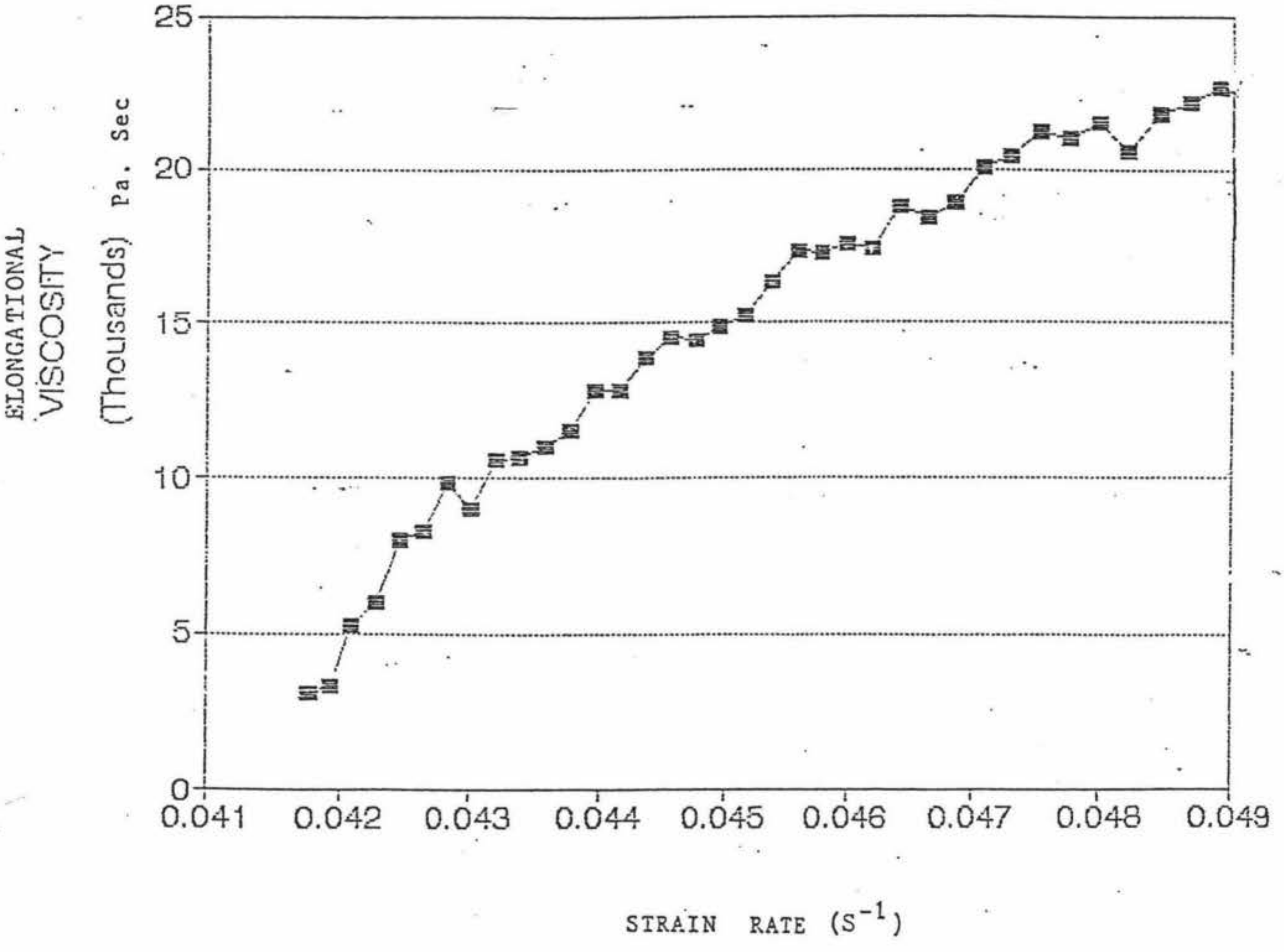
5.1.2 EVALUATION OF THE ELONGATIONAL VISCOSITY

The elongational viscosity is protein dependent and it is influenced by factors such as high solubility and swelling properties of protein (Hermansson 1973, 1975), salt and alkaline pH (Weipert, 1990), protein concentrate, and ionic strength (Fleming 1974). Elongational viscosities measured at the last point of the curve as shown in Figure 5.2, are shown in table 5.1. It can be noted that the elongational viscosity increased with increasing cheese powder content.

This can be attributed to two reasons. The first reason was related directly to analogous properties of gluten and casein. Combined gluten-casein contributed to a higher protein content dough providing a stronger visco-elastic behaviour more resistant to deformation. Therefore, elongational viscosity of dough depends on gluten-casein and their main proteins (gliadin and glutenin) and α, β, κ-casein respectively. The constituents contribute to the viscosity of gluten-casein when mixed with water (Bushuk et al, 1984; and Sherman, 1979). The casein protein molecular weight and structure, and the intermolecular forces between the polypeptide chains contribute to the visco-elastic properties of the dough.

FIGURE 5.2

ELONGATIONAL VISCOSITY (μ_b) OF THE CHEESE CROISSANT DOUGH MEASURED AT A STRAIN RATE OF 0.049 $^1/_s$



The gluten proteins, glutenin molecules, can differ in several ways: molecular weight and structure, and polypeptide composition which contribute to the visco-elastic properties of gluten and dough (Ewart 1985). In addition, the intermolecular interaction between gluten-casein protein provides the dough with high physical strength and lack of extensibility which needs more compression force to deform. Furthermore, the intermolecular interaction with non-protein flour-cheese powder constituents, especially lipid, starch, milk fat and lactose, leads to the formation of various aggregates (films, fibrils and micelles) which also contribute to rheological properties of dough.
The second reason was due to less WAC, which leads to an increase in the amount of solids in the dough by less flour-cheese powder component (starch and protein) hydration with water.

5.2 EVALUATION OF BAKED DOUGH RHEOLOGY

Table 5.3 shows the mean of the triplicate determinations and standard deviation of specific volume of baked croissants, indicating that the specific volume of baked croissants decreased by increasing the level of all cheese powder types. This effect has been already observed with other dairy powders which cause marked reduction of the loaf volume, high weight, and immature characteristics in bread (Abhayaratna, 1978-79 and Zadow, 1984).

5.2.1 EVALUATION OF COMPRESSION TEST

The compression test was measured at 10 mm of displacement as shown in Figure 5.3. The compression test at different storage times of various cheese powder levels is shown in table 5.3. Results indicate that there was no significant differences among the three cheese powders showing variation data between samples containing cheese powder. However, there is a significant effect of storage time on the compression force.

The firmness of baked products stored for different periods of time at room temperature increases with storage time. This is mainly due to firmness of the crumb as it ages (Baker, 1987ab; Kamel 1987; Walker, 1987 and Short, 1971).

The firmness of croissants should also increase by increasing the levels of cheese powder. However, this trend was not observed. The reason for this was due to the fact that the croissants were hand made and baked at different times.

The specific volume of the baked croissants also seems to play a key role in the compression and penetration tests for the baked croissants. Croissants with high specific volumes provide a flaky, light texture which affects mouth-feel attributes during eating and when the croissant is compressed between the roof of the mouth and the tongue. This flaky texture generally results in low compression force volume ratios.

The results of the compression tests showed a large spread of data due to the variation of the specific volume and the size of the baked croissants. In order to reduce the variability, the measurements of the ratio between compression force and specific volume were considered. These ratios are presented in table 5.4. They increase by increasing the storage time in most cases. This is due to loss of moisture during the storage period. The baked croissants were kept in the cabinet at ambient temperature and were not sealed in polyethylene bags to prevent loss of moisture and preserve freshness.

5.2.2 EVALUATION OF PENETRATION TEST

The penetration tests were performed in three positions, in the middle, a quarter of the distance across the croissant, and on the edge of the croissant. Penetration was measured at the peak of the force against displacement curve as shown in Figure 5.4. Tables 5.5.A and B. shows the specific volume and penetration tests of baked croissants at different storage times with varying cheese powder types and levels.

The penetration force and specific volume ratios are presented in tables 5.6A, B, and C for the middle position, 25% across, and edge position respectively and the data were spread again as it happened with the compression test as shown in table 5.4.

* The variability in the results are likely due to the same factors which influenced the variability of the compression results.

TABLE 5.3

SPECIFIC VOLUME AND COMPRESSION TEST OF BAKED CROISSANTS AT DIFFERENT STORAGE TIMES

CHEESE TYPES AND LEVEL	SPECIFIC VOLUME cm^3/g	1 DAY STORAGE OF COMPRESSION KN	SPECIFIC VOLUME cm^3/g	4 DAY STORAGE OF COMPRESSION KN	SPECIFIC VOLUME cm^3/g	7 DAY STORAGE OF COMPRESSION KN
CP1						
10%	3.19 ± 0.59	14.18 ± 5.2	3.41 ± 0.98	25.59 ± 5.62	3.59 ± 0.98	44.95 ± 13.21
15%	3.69 ± 0.42	19.95 ± 10.73	2.99 ± 1.02	34.49 ± 5.37	2.81 ± 0.59	57.93 ± 22.2
20%	3.01 ± 0.78	56.19 ± 34.86	2.27 ± 0.433	49.95 ± 54.08	3.40 ± 0.82	77.63 ± 56.19
CP2						
10%	2.38 ± 0.82	15.78 ± 4.03	3.77 ± 0.36	26.75 ± 7.2	4.29 ± 0.28	72.82 ± 26.15
15%	3.08 ± 0.19	23.00 ± 2.55	2.73 ± 0.31	31.04 ± 8.87	2.65 ± 0.75	62.11 ± 13.13
20%	3.67 ± 0.45	25.41 ± 4.33	2.18 ± 0.46	41.03 ± 21.11	2.54 ± 1.18	41.60 ± 25.93
CHEDDAR-20						
10%	4.03 ± 0.39	28.45 ± 14.85	3.08 ± 0.33	34.42 ± 5.0	4.81 ± 0.21	59.47 ± 12.84
15%	2.82 ± 0.17	27.95 ± 5.22	3.32 ± 0.44	56.97 ± 16.49	4.26 ± 0.5	36.86 ± 15.03
20%	3.66 ± 0.37	14.92 ± 1.62	4.01 ± 0.13	16.19 ± 2.45	3.87 ± 0.15	29.19 ± 2.54
CONTROL	5.85 ± 0.21	13.92 ± 5.04	14.23 ± 3.12	14.23 ± 3.12	6.27 ± 0.66	18.29 ± 2.38

FIGURE 5.3

COMPRESSION TEST OF BAKED CHEESE CROISSANTS

MEASURED AT 10 mm OF DISPLACEMENT

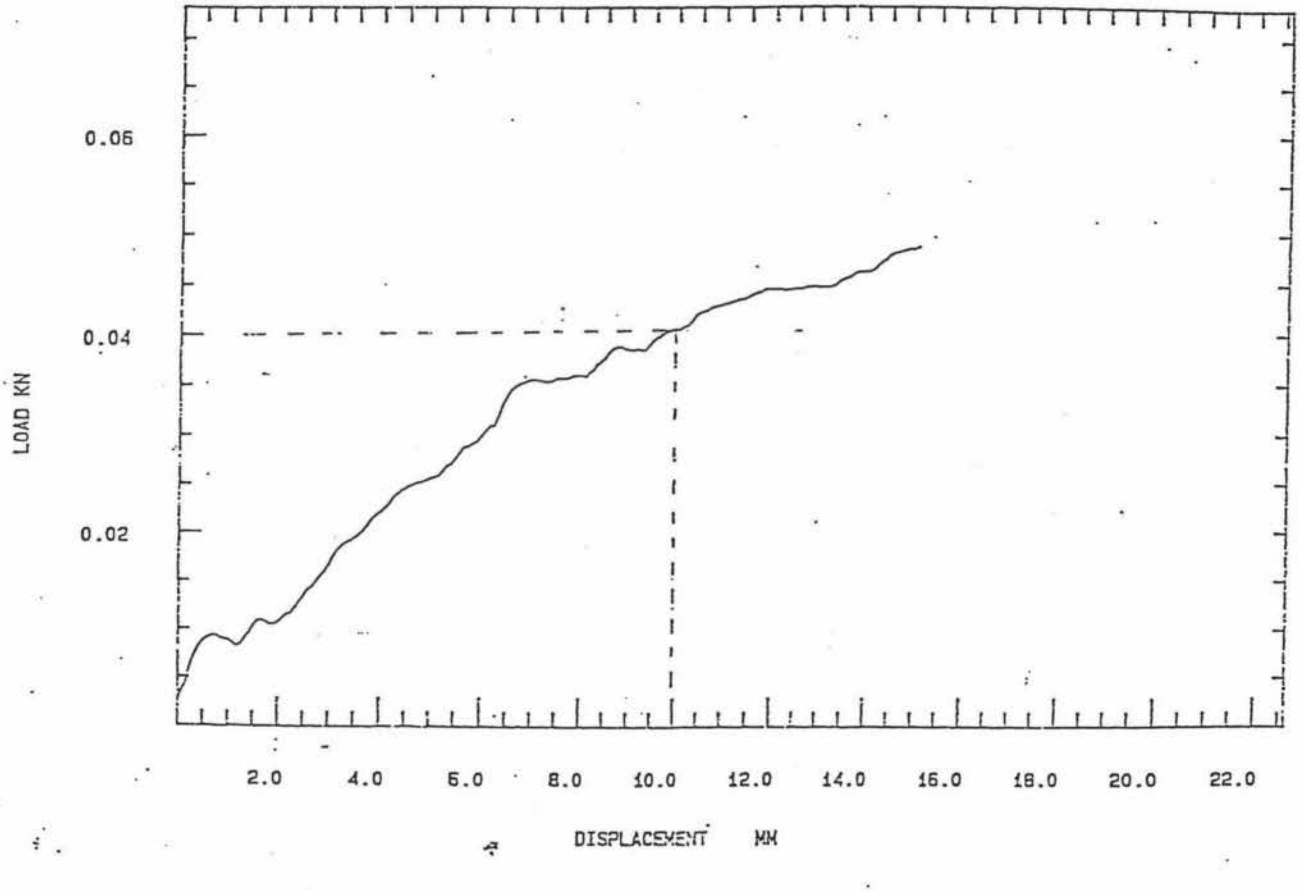


TABLE 5.4

COMPRESSION FORCE / SPECIFIC VOLUME RATIO IN BAKED CROISSANT CONTAINING CHEESE POWDER AT DIFFERENT LEVELS

CHEESE POWDER TYPE	LEVEL W/W %	1 DAY STORAGE N.g/ml	4 DAY STORAGE N.g/ml	7 DAY STORAGE N.g/ml
CP1	10	4.37	7.50	13.6
	15	5.41	11.54	13.72
	20	16.67	22.004	22.83
CP2	10	6.63	7.10	16.97
	15	7.47	11.37	23.44
	20	6.89	18.82	16.38
CHEDDAR-20	10	7.06	11.14	16.38
	15	9.91	14.21	8.65
	20	4.08	4.04	7.543
Control	0	2.38	2.41	7.54

* Compression tests were measured at the (10 mm) of displacement

- specimen height = 30-40 mm
- plunger diameter = 51.7 mm
- compression depth = 15 mm
- crosshead speed = 50 mm/min
- specimen shape = crescent
- position of the compression test at the middle of the specimen
- triplicate measurements for each sample

FIGURE 5.4

PENETRATION TESTS OF BAKED CHEESE CROISSANTS MEASURED AT THE PEAK INFLECTION POINT OF THREE POSITIONS, MIDDLE, 25% ACROSS AND EDGE RESPECTIVELY

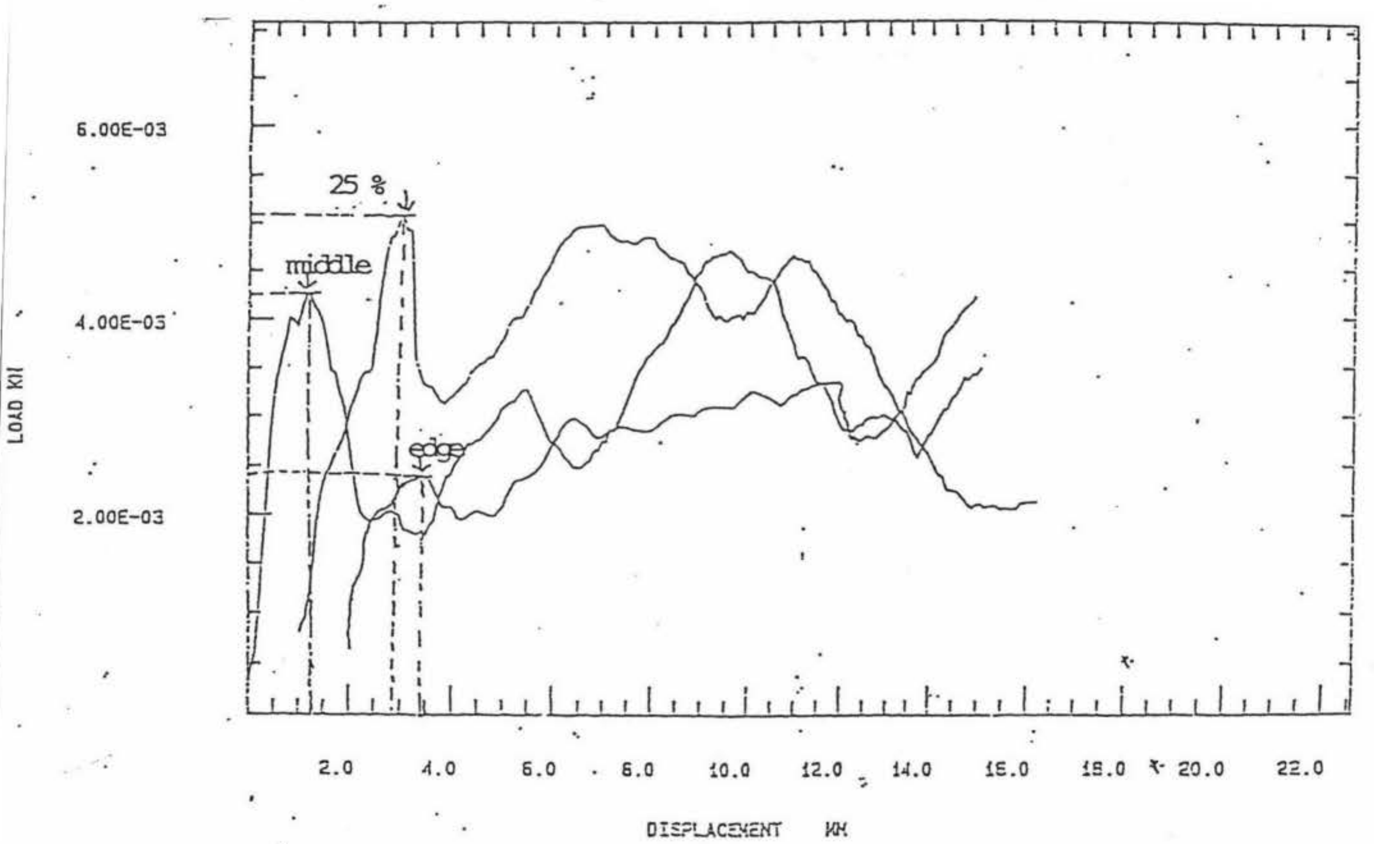


TABLE 5.5.A

SPECIFIC VOLUME MEASUREMENTS FOR PENETRATION TEST OF BAKED CROISSANTS AT DIFFERENT STORAGE TIMES WITH VARYING CHEESE POWDER TYPES AND LEVELS

CHEESE POWDER TYPE	LEVEL %	1 DAY STORAGE cm^3/g	4 DAY STORAGE cm^3/g	7 DAY STORAGE cm^3/g
CP1	10	3.35 ± 0.4	3.58 ± 0.43	3.63 ± 0.4
	15	3.52 ± 0.45	3.59 ± 0.32	3.315 ± 0.67
	20	2.43 ± 0.32	2.22 ± 0.37	2.81 ± 0.36
CP2	10	3.82 ± 0.2	3.50 ± 0.07	3.52 ± 0.136
	15	2.87 ± 0.2	3.28 ± 0.46	2.38 ± 0.52
	20	3.06 ± 0.33	3.32 ± 0.33	2.81 ± 0.36
CHEDDAR-20	10	3.13 ± 0.16	3.58 ± 0.13	4.64 ± 0.2
	15	2.75 ± 0.32	3.34 ± 0.54	4.28 ± 0.5
	20	3.42 ± 0.55	4.38 ± 0.68	3.94 ± 0.18
CONTROL	0	5.93 ± 0.38	5.62 ± 0.32	6.31 ± 0.86

TABLE 5.5.B

PENETRATION TEST OF BAKED CROISSANTS AT 3 DIFFERENT DISTANCES AND STORAGE TIME WITH DIFFERENT CHEESE POWDER LEVELS

CHEESE POWDER TYPE	LEVEL w/w%	MIDDLE POSITION			0.25 POSITION			EDGE POSITION		
		1 Day Storage KN	4 Day Storage KN	7 Day Storage KN	1 Day Storage KN	4 Day Storage KN	7 Day Storage KN	1 Day Storage KN	4 Day Storage KN	7 Day Storage KN
CP1	10	2.21 ± 0.83	4.17 ± 1.2	6.35 ± 34.0	3.62 ± 0.75	0.5 ± 0.26	6.62 ± 3.55	0.51 ± 0.41	2.7 ± 1.72	28.4 ± 36.1
	15	6.04 ± 1.21	3.97 ± 0.3	38.5 ± 36.07	3.58 ± 0.66	7.51 ± 2.62	6.13 ± 1.29	38.93 ± 20.8	8.30 ± 3.09	6.88 ± 1.2
	20	4.08 ± 1.56	9.22 ± 4.15	8.30 ± 2.82	4.19 ± 2.85	18.35 ± 1.24	11.82 ± 6.2	31.66 ± 3.17	22.23 ± 6.75	16.3 ± 9.2
CP2	10	22.2 ± 0.79	8.51 ± 4.19	7.38 ± 1.08	1.98 ± 1.0	3.69 ± 0.78	7.84 ± 4.7	4.98 ± 3.17	6.015 ± 4.7	7.51 ± 2.2
	15	9.01 ± 9.82	84.6 ± 25.77	9.01 ± 4.72	9.47 ± 10.1	65.45 ± 39.94	5.9 ± 3.12	37.1 ± 12.54	24.83 ± 21.93	7.3 ± 1.71
	20	3.39 ± 1.54	8.19 ± 2.53	7.79 ± 2.72	2.9 ± 1.42	42.94 ± 62.76	6.51 ± 2.06	9.6 ± 13.86	11.27 ± 5.025	16.5 ± 9.2
Cheddar -20	10	1.66 ± 0.87	12.45 ± 4.15	7.50 ± 2.91	21.7 ± 10.6	5.0 ± 0.42	6.66 ± 2.08	6.54 ± 0.94	13.76 ± 3.23	7.07 ± 5.0
	15	6.35 ± 2.33	5.91 ± 1.85	7.15 ± 3.56	4.5 ± 0.28	6.06 ± 1.86	6.91 ± 3.6	7.7 ± 2.26	8.30 ± 0.93	9.75 ± 4.0
	20	37.3 ± 19.4	5.016 ± 0.54	88.5 ± 30.73	21.1 ± 5.9	2.85 ± 0.38	85.69 ± 36.0	2.57 ± 0.52	4.25 ± 1.52	7.3 ± 2.9
Control		1.43 ± 0.84	3.75 ± 2.35	4.85 ± 1.12	1.60 ± 0.5	4.23 ± 1.42	4.35 ± 3.36	1.32 ± 0.3	2.85 ± 1.36	4.35 ± 3.3

*Penetration tests were measured at the inflection point.

Plunger diameter = 6.34 mm/min

Penetration depth = 15 mm/min

Crosshead speed = 50 mm/min

Triplicate measurements for each sample

TABLE 5.6.A

PENETRATION FORCE / SPECIFIC VOLUME RATIO IN BAKED CROISSANTS CONTAINING CHEESE POWDER AT DIFFERENT LEVELS

MIDDLE POSITION

CHEESE POWDER TYPE	LEVEL W/W %	1 DAY STORAGE N.g/ml	4 DAY STORAGE N.g/ml	7 DAY STORAGE N.g/ml
CP1	10	0.60	1.12	1.15
	15	1.68	1.03	1.92
	20	1.44	3.39	3.11
CP2	10	0.35	1.54	2.94
	15	0.98	2.21	3.78
	20	1.11	2.47	2.41
CHEDDAR-20	10	0.49	0.99	1.34
	15	1.56	1.30	1.67
	20	0.97	1.50	1.47
CONTROL	0	0.24	0.67	0.77

* Penetration tests were measured at the inflection point

- specimen height = 30-40 mm
- plunger diameter = 6.35 mm
- compression depth = 15 mm
- crosshead speed = 50 mm/min
- triplicate measurements for each sample

TABLE 5.6.B

PENETRATION FORCE / SPECIFIC VOLUME RATIO IN BAKED CROISSANTS CONTAINING CHEESE POWDER AT DIFFERENT LEVELS

25 % POSITION

CHEESE POWDER TYPE	LEVEL W/W %	1 DAY STORAGE N.g/ml	4 DAY STORAGE N.g/ml	7 DAY STORAGE N.g/ml
CP1	10	1.09	1.54	1.80
	15	1.02	1.43	1.95
	20	2.35	3.78	3.89
CP2	10	0.52	1.06	1.73
	15	0.91	2.49	2.48
	20	0.95	1.33	2.22
CHEDDAR-20	10	0.68	1.11	11.1
	15	1.77	1.45	1.60
	20	0.62	0.53	1.54
CONTROL	0	0.23	0.88	0.69

* Penetration tests were measured at the inflection point
- specimen height = 30-40 mm
- plunger diameter = 6.35 mm
- compression depth = 15 mm
- crosshead speed = 50 mm/min
- triplicate measurements for each sample

TABLE 5.6.C

PENETRATION FORCE / SPECIFIC VOLUME RATIO IN BAKED CROISSANTS CONTAINING CHEESE POWDER AT DIFFERENT LEVELS

EDGE POSITION

CHEESE POWDER TYPE	LEVEL W/W %	1 DAY STORAGE N.g/ml	4 DAY STORAGE N.g/ml	7 DAY STORAGE N.g/ml
CP1	10	1.32	1.90	2.20
	15	1.11	1.75	1.72
	20	3.15	3.25	3.32
CP2	10	0.48	0.73	3.56
	15	1.20	2.23	3.07
	20	1.37	2.95	3.89
CHEDDAR-20	10	0.86	1.13	1.51
	15	0.97	1.63	1.32
	20	0.75	0.53	0.78
CONTROL	0	0.22	0.51	0.69

* Penetration tests were measured at the infliction point

- specimen height = 30-40 mm
- plunger diameter = 6.35 mm
- compression depth = 15 mm
- crosshead speed = 50 mm/min
- Triplicate measurements for each sample

5.3 EVALUATION OF THE DOUGH, CRUMB (INSIDE) AND CRUST COLOUR

As shown in table 5.7, when the percent of cheese powder level is increased a significant decrease in the 'L' values of the dough, the inside (crumb) and the crust of croissants is observed when compared to the control samples. Since L measures the percentage of reflection, therefore from the results it can be concluded that samples containing cheese powder were darker than the control sample.

Increasing the cheese powder level in the crossants, significantly increases the 'a' and 'b' values of croissant crust as compared with the control. The increased values tend to increase their colour scale toward the direction of more redness-yellowness colour.

Furthermore, the addition of cheese powder provided the crust colour visually with more golden brown colour than the control. This is due to the reactions of sugars that are involved in the caramelization and the Maillard reactions between sugars and proteins (Shelton, 1985). The main sugar sources in croissants are commercial sugar and lactose from the cheese powder. During baking at high temperature, sugar is converted by reduction to coloured substances. This process is known as caramelization.

The other reaction occurring is the Maillard reaction between sugars and protein and is very important for crust browning. It requires sugar and amine (from protein) and generally occurs at lower temperatures. The crust browning of both reactions produces different flavours and odours (Shelton, 1985).

In conclusion, it can be said that the effect of adding cheese powder in the making of cheese croissants results in a dark golden brown crust and does the equivalent job of producing a good colour crust as skim nonfat milk powder and an egg glaze do in the croissant formulation.

TABLE 5.7

EFFECT OF DIFFERENT CHEESE TYPE LEVELS ON COLOUR OF DOUGHS AND BAKED CROISSANTS (INSIDE AND CRUST) MADE WITH CHEESE POWDER

CHEESE TYPE	LEVEL W/W %	DOUGH COLOUR 'L'	BAKED PRODUCT			
			INSIDE 'L'	CRUST 'L'	CRUST 'a'	CRUST 'b'
CP1	10	73.08 ± 0.87	67.00 ± 0.95	56.86 ± 7.05	11.86 ± 1.8	23.98 ± 0.77
	15	72.52 ± 0.9	64.73 ± 0.2	52.53 ± 2.0	14.14 ± 1.99	24.52 ± 0.66
	20	71.45 ± 0.91	63.28 ± 1.04	50.96 ± 2.5	19.13 ± 0.99	25.58 ± 0.66
CP2	10	72.00 ± 1.03	65.70 ± 0.8	51.63 ± 1.56	12.00 ± 1.4	22.10 ± 0.98
	15	69.02 ± 0.81	59.19 ± 0.88	46.38 ± 2.01	13.42 ± 0.8	22.52 ± 0.89
	20	64.79 ± 1.07	54.84 ± 2.16	45.76 ± 0.25	15.32 ± 0.6	25.70 ± 0.66
CHEDDAR-20	10	72.34 ± 1.26	70.56 ± 0.90	54.74 ± 1.95	11.87 ± 1.36	21.13 ± 1.40
	15	71.23 ± 0.87	66.13 ± 0.85	49.92 ± 1.74	12.57 ± 1.07	22.46 ± 0.98
	20	71.22 ± 1.34	65.95 ± 0.97	44.15 ± 1.8	13.34 ± 1.42	24.50 ± 0.69
CONTROL	0	72.80 ± 0.98	74.22 ± 0.63	60.92 ± 1.76	11.85 ± 1.75	22.29 ± 1.04

* Colour measures the (L) values only which is measuring the % of reflection

* Triplicate measurements were taken for each sample

5.4 EVALUATION OF pH ON THE DOUGH AND BAKING DOUGH

An increase in acidity with cheese powder level was the observed trend. However, there was no significant statistical differences for the dough and baked product as presented in table 5.8. The pH measurement was taken after mixing the ingredients together to make the dough. As the pH decreases, doughs become less extensible due to salt linkages and electrostatic repulsive forces decrease the interaction between protein molecules. In addition, conformational changes in the gluten-casein proteins which occur when the pH is lowered, may decrease their ability to aggregate and ordinarily increase the elongational viscosity of the dough (Pyler, 1988). The decrease of pH could also be attributed to the fermentation process because lactose is changed into lactic acid by bacteria. This affects the product quality in terms of depression of croissant volume (Zadow, 1981 and Holmes, 1987) and cheese powder modifies the pH of the croissant pastry (Mathason, 1978).

5.5 ANALYSIS OF THE SENSORY EVALUATION TRIAL

Statistical analysis of the sensory evaluation data was carried out using the SAS statistical package which includes Analysis of Variance (ANOVA) and General Linear Model (GLM) procedures. The programs (ANOVA and GLM) were both used to test the level differences in the baked cheese croissants related to the cheese powder types and levels. The variables studied were crust colour, crumb colour, texture, saltiness, bitterness, cheese taste, odour and acceptability and were tested against a control plain croissant. The sensory evaluation tests of the cheese croissants played an important part of the formulation trial as the sensory attributes were critical to determine the product acceptance (Cooper, 1981). The sensory evaluation results indicated that cheese croissants were more preferred than the control samples, showing a higher average mean of acceptability for the three levels (10%, 15% and 20%) of CP1, CP2 and Cheddar-20 (5.3, 5.1, and 5.1 respectively) than the control (5.0) as shown in tables 5.9.A, B and C. Panellists indicated the baked croissants were pleasant although the texture was not as flaky as the control and the crust was darker than the control.

TABLE 5.8

EFFECT OF DIFFERENT CHEESE TYPE LEVELS ON pH OF DOUGH AND BAKED CROISSANTS MADE WITH CHEESE POWDER

CHEESE TYPE	LEVEL W/W %	DOUGH pH	BAKED PRODUCT pH
CP1	10	5.66 ± 0.115	5.77 ± 0.057
	15	5.60 ± 0.1	5.63 ± 0.057
	20	5.56 ± 0.057	5.37 ± 0.057
CP2	10	5.77 ± 0.057	5.97 ± 0.057
	15	5.77 ± 0.057	5.77 ± 0.057
	20	5.63 ± 0.057	5.77 ± 0.057
CHEDDAR-20	10	5.90 ± 0.1	5.90 ± 0.1
	15	5.67 ± 0.057	5.87 ± 0.115
	20	5.53 ± 0.057	5.77 ± 0.057
CONTROL	0	5.9 ± 0.1	6.10 ± 0.1

- Triplicate measurements for each sample

5.5.1 EVALUATION OF CP1 AND CP2 CHEESE POWDER TYPES

The cheese croissants containing CP1 and CP2 cheese powders were found to be statistically non-significantly different in most of the attributes compared to the control, with the exception of the cheese taste (tables 5.9 A and B) as expected. While the panellists did not find any differences between the 10% and 15% levels of cheese type CP1, it was noticed that the 20% level had a stronger cheese taste than both 10% and 15% levels and was statistically significant (table 4.9A). The panellists considered that the 10% level of CP2 had less cheese taste than the 15% and 20% levels as expected (table 5.9B). The panellists indicated that the crust colour of the croissants containing CP1 and CP2 cheese powders was darker than the control. However, they indicated that the crumb colour (inside) of croissants containing CP1 was lighter than the control showing the lowest means of 4.3, 4.3 and 3.8 respectively of the CP1 levels. The panellists indicated that the crumb colour (inside) of croissants containing CP2 was darker than the control.

The texture results indicated that croissants containing CP1 and CP2 cheese powders were not flaky. This is shown by scores lower than the control (2.1, 2.5 and 2.3 respectively for the CP1 levels, and 3.4, 3.0 and 3.0 respectively for the CP2 levels). The panellists indicated that the croissants containing CP1 and CP2 cheese powders were higher in salt than the control, but they indicated that the croissants containing CP1 were lower in bitterness than the control, whereas croissants containing CP2 were higher in bitterness than the control. In general, the panellists indicated that the croissants containing CP1 and CP2 were higher in cheese odour than the control. These results were as expected.

The sensory attributes results indicated that the addition of CP1 and CP2 cheese powders affect the croissant characteristics and it may be considered that both cheese powders provide similar functional properties. This may be explained by the similarities of the cheese typical compositions.

TABLE 5.9.A

ANALYSIS OF VARIANCE OF THE SENSORY EVALUATION DATA[d] OF CHEESE CROISSANTS CONTAINING DIFFERENT LEVELS[e] OF CHEESE POWDER CP1 SCORED AGAINST THE CONTROL[f]

ATTRIBUTES	LEAST SQUARES MEANS Level 10	Level 15	Level 20	R^2 %	SIG
CRUST COLOUR[1]	5.9 ± 1.8	6.3 ± 2.0	5.3 ± 2.3	4.1	ns
CRUMB COLOUR[2]	4.3 ± 2.1	4.3 ± 2.3	3.8 ± 1.9	1.2	ns
TEXTURE[3]	2.1 ± 0.9	2.5 ± 1.2	2.3 ± 1.4	2.1	ns
SALTINESS[4]	5.2 ± 1.9	5.3 ± 1.0	5.3 ± 2.0	0.1	ns
BITTERNESS[5]	4.6 ± 2.2	4.6 ± 1.8	4.6 ± 2.2	0.1	ns
CHEESE TASTE[6]	6.3^a ± 1.7	6.7^a ± 1.4	8.0^b ± 1.4	20	***
ODOUR[7]	6.0 ± 2.1	6.0 ± 2.0	6.8 ± 1.9	5.2	ns
ACCEPTABILITY[8]	5.0 ± 2.2	6.0 ± 2.1	4.8 ± 2.3	5.4	ns

SIG Significant Difference.

ab Means in the same row with superscripts that do not contain a common letter differ significantly ($p < 0.05$).

ns not significant ; *** ($P < 0.001$)

d A horizontal scale of 1-10 was used.

e The statistical analysis was used to indicate the difference between the cheese levels.

f Control always scored 5 points on the horizontal scale.

1, 2 scale 0-10 where 0 = light and 10 = dark

3 scale 0-10 where 0 = closed not flaky and 10 = opened flaky

4, 5, 6, 7 scale 0-10 where 0 = weak and 10 = extreme

8 overall acceptability of the preferred sample and its level by the panellist

TABLE 5.9.B

ANALYSIS OF VARIANCE OF THE SENSORY EVALUATION DATA[d] OF CHEESE CROISSANTS CONTAINS DIFFERENT LEVELS[e] OF CHEESE POWDER CP2 SCORED AGAINST THE CONTROL[f]

ATTRIBUTES	LEAST SQUARES MEANS Level 10	Level 15	Level 20	R^2 %	SIG
CRUST COLOUR[1]	6.5 ± 1.3	7.2 ± 1.1	7.4 ± 1.3	9.4	ns
CRUMB COLOUR[2]	7.5 ± 0.8	7.3 ± 1.0	7.4 ± 0.6	1.0	ns
TEXTURE[3]	3.4 ± 1.2	3.0 ± 1.2	3.0 ± 1.3	2.5	ns
SALTNESS[4]	6.9 ± 1.3	7.0 ± 1.4	7.5 ± 0.9	7.5	ns
BITTERNESS[5]	6.5 ± 1.0	6.9 ± 1.4	6.8 ± 1.6	1.7	ns
CHEESE TASTE[6]	$7.5^a \pm 0.5$	$8.1^b \pm 0.8$	$8.3^b \pm 0.7$	22	***
ODOUR[7]	7.5 ± 0.9	8.1 ± 0.8	8.0 ± 1.2	7.3	ns
ACCEPTABILITY[8]	5.2 ± 2.5	5.4 ± 2.0	4.5 ± 2.0	3.1	ns

SIG Significant Difference

ab Means in the same row with superscripts that do not contain a common letter differ significantly ($p < 0.05$).

ns not significant ; *** ($P < 0.001$)

d A horizontal scale of 1-10 was used.

e The statistical analysis were used to indicate the difference between the cheese levels.

f Control always scored 5 points on the horizontal scale.

1, 2 scale 0-10 where 0 = light and 10 = dark

3 scale 0-10 where 0 = closed not flaky and 10 = opened flaky

4, 5, 6, 7 scale 0-10 where 0 = weak and 10 = extreme

8 overall acceptability of the preferred sample and its level by the panellist

5.5.2 EVALUATION OF CHEDDAR-20 CHEESE POWDER

The Cheddar-20 cheese croissant samples was significantly different in most of the attributes when compared to CP1 (Table 5.9.A) and CP2 (Table 5.9.B) croissant samples i.e. crust colour, crumb colour, texture, bitterness, cheese taste and the overall acceptability as presented in table 5.9.C. The panellists indicated that the crust and crumb (inside) colours were darker for cheddar-20 samples than the control.
This was due to the higher percentage of lactose (33.9% shown in Table 5.2), than CP1 and CP2 which highly influenced the browning reaction.
Panellists indicated that the crust colour of the croissant with a 15% cheese powder level was not significantly different from those containing the 10% and 20% cheese powder types, although the panellists did indicate that the crust colour of samples with the 10% cheese level of crust colour was significantly different from the 20% level. In addition, the panellists considered the crumb (inside) colour of both the 15% and 20% cheese powder levels samples to be the same, and both the 15% and 20% cheese level samples were significantly different from the 10% level.

The texture of the Cheddar-20 containing samples had a high statistical significant difference compared to the texture of the control sample. Cheddar-20 provided the croissants, particularly those containing 15% and 20% cheese powder, with a closed unflaky texture.
The panellists indicated that the attributes given at the three levels used were different from each other. This implies that increasing the cheese powder level adversely affects the flakiness texture and gives a flat croissant or lower volume croissant as compared to the control. Both 15% and 20% cheese powder levels had less acceptable texture (in terms of closed unflaky texture, compared to the control) indicated by the lower means of 2.5 and 1.4 respectively. Thus, the 10% level scored a better texture compared to the control texture as shown by the high mean of 5.9 compared with the control of 5.0 as shown in table 5.9.C.

TABLE 5.9.C

ANALYSIS OF VARIANCE OF THE SENSORY EVALUATION DATA[d] OF CHEESE CROISSANTS CONTAINING DIFFERENT LEVELS[e] OF CHEDDAR-20 CHEESE POWDER SCORED AGAINST THE CONTROL[f]

ATTRIBUTES	LEAST SQUARES MEANS Level 10	Level 15	Level 20	R^2 %	SIG
CRUST COLOUR[1]	$6.5^a \pm 1.2$	$5.1^{ab} \pm 2.5$	$4.8^b \pm 2.3$	11.4	*
CRUMB COLOUR[2]	$5.9^a \pm 0.9$	$6.9^b \pm 1.5$	$7.0^b \pm 1.8$	10.6	*
TEXTURE[3]	$5.9^a \pm 1.7$	$2.5^b \pm 0.9$	$1.4^c \pm 0.8$	74	***
SALTNESS[4]	5.6 ± 1.3	6.3 ± 1.8	6.3 ± 1.9	3.7	ns
BITTERNESS[5]	$4.4^a \pm 1.4$	$5.4^b \pm 1.7$	$5.6^b \pm 1.8$	9.8	*
CHEESE TASTE[6]	$4.6^a \pm 1.8$	$6.5^b \pm 1.5$	$7.1^b \pm 1.9$	27	***
ODOUR[7]	4.2 ± 2.1	4.6 ± 2.2	4.8 ± 2.4	1.7	ns
ACCEPTABILITY[8]	$6.9^a \pm 2.0$	$5.0^b \pm 1.9$	$3.4^c \pm 0.8$	45	***

SIG Significant Difference

abc Means in the same row with superscripts that do not contain a common letter differ significantly ($p < 0.05$).

*($P < 0.05$); *** ($P < 0.001$); ns not significant

d A horizontal scale of 1-10 was used.

e The statistical analysis was used to indicate the difference among the cheese levels.

f Control always scored 5 points in the horizontal scale.

1, 2 scale 0-10 where 0 = light and 10 = dark

3 scale 0-10 where 0 = closed not flaky and 10 = opened flaky

4, 5, 6, 7 scale 0-10 where 0 = weak and 10 = extreme

8 overall acceptability of the preferred sample and its level by the panellist

All the Cheddar-20 cheese croissant levels indicated a no significant differences in saltiness compared to the control, and panellists characterised them as being not salty. The panellists indicated that the bitterness of the 15% and 20% cheese levels was not significantly different to the control, but both 15% and 20% cheese levels were significantly different from the 10% cheese powder level samples.

As expected, cheese taste recorded a high statistically significant difference and panellists indicated that the 15% and 20% levels were not significantly different from each other but significantly different from the 10% cheese level sample.

The cheese odour was found to be no significantly different between the three levels and tended to be similar to the control. This is shown by the means of 4.2, 4.6 and 4.8 for 10%, 15% and 20% cheese power levels respectively.

The overall acceptability of the cheese croissants showed a highly statistical significant difference compared to the control. Panellists indicated that the acceptability between the three levels was different and both 15% and 20% cheese powder levels were found to be less acceptable than the control (means of 5.0 and 3.4 respectively).

The sample containing 10% cheese powder was found to be as more acceptable than the control and the other two cheese powder levels containing samples (15% and 20%), by a high mean of 6.9 as shown in table 5.9.C.

In summary, the cheese croissants containing 10% of Cheddar-20 cheese powder level received the highest acceptability of preferable score as shown in the preference data (last question in the Sensory Evaluation Questionnaire). The results indicated that 77.8% of the panellists preferred the 10% Cheddar-20 cheese level samples, and only 22.2% favoured the 15% cheese level samples as shown in table 5.10.

TABLE 5.10

CHEESE POWDER LEVELS ACCEPTABILITY BY 18 PANELLISTS

LEVELS	CP1 ACCEPTABILITY	CP2 ACCEPTABILITY	CHEDDAR-20 ACCEPTABILITY
10%	4 Panels (22.2 %)	8 Panels (44.4 %)	14 Panels (77.8 %)
15%	9 Panels (50.0 %)	7 Panels (38.9 %)	4 Panels (22.2 %)
20%	5 Panels (27.8 %)	3 Panels (16.7 %)	none (0%)

Panels = Panellists

5.6 CONCLUSIONS

The results clearly indicate that the use of cheese powder as an ingredient in croissant pastry affects the dough's physical properties and baking characteristics by increasing the dough elongational viscosity, decreasing the Farinograph absorption values and decreasing the specific volume of baked croissants.

Croissant texture was an important attribute in the evaluation of cheese croissant quality, due to its relationship to the sensorial characteristics and croissant shelf life.

Croissant firmness measurements showed significant variations as a function of storage time. However, both compression and penetration tests indicated that there were no significant differences among samples containing cheese powder. This was due to the variation of the specific volume and the size of baked croissant.

By using different levels of cheese powders the colour and pH measurements showed no significant differences. The results were compared for similarities with the control and showed a close shared relationship results.
Sensory evaluation results indicated that the cheese powder is a critical additional ingredient for the cheese flavour in croissant pastry and influences the overall acceptability of the product.

The sensory evaluation results indicated that the cheese croissants containing CP1 and CP2 cheese powders were not significantly different in most of the attributes, except the cheese taste when compared to the control. As expected, the incorporation of higher levels of cheese powder will provide a stronger cheese taste than the lower levels of cheese powder.

In addition to this, there were higher statistically significant differences in most of the attributes of the croissants containing Cheddar-20 cheese powder compared to croissants made with CP1 and CP2 cheese powders.

Croissants with a 10% level of Cheddar-20 cheese powder were found to have statistically significant differences in most attributes when compared to the control. These attributes were crumb (inside) and crust colours being slightly darker due to the effect of the browning reaction of the lactose content with the protein of the cheese powder which improved the colour in baked goods.

The 10% cheddar-20 cheese level samples showed the texture attribute to be flaky and open structure which was similar to the control. This was due to the low percentage of milk fat (30%) incorporated in the cheddar-20 cheese powder (Joudi, 1992). Also, both the flavour and the aroma of the baked croissant were considered desirable in this sample. The overall acceptability results showed to be the preferred level.

Therefore, for this study a 10% cheese powder level of cheddar-20 was chosen for further development involving economic evaluation and market trial research which will be described in chapter seven.

CHAPTER SIX

DETERMINATION OF THE CHEESE POWDER MIXING METHOD AND ITS TIME-TEMPERATURE RELATIONSHIP FOR BAKED CHEESE CROISSANTS

6.1 INTRODUCTION

The previous chapter outlined the criteria by which ten percent level of cheddar-20 cheese powder was chosen for further development.

The next stage in the development of cheese croissants was to determine a new method of mixing cheese powder with other dry ingredients and to improve its time-temperature relationship for baked cheese croissants.
The previous method of manufacturing cheese croissants was described in chapter four (section 4.2). Ten percent cheese powder was used as the main ingredient mixed together with other dry ingredients for the preparation of a cheese pastry dough.

The results of mixing cheese powder with other dry ingredients affected the dough's physical properties and baking characteristics in terms of low water absorption capacity (WAC), low mixing time and tolerance, yielding cheese croissants with a low volume, a high yield (weight), and dark crust colour, giving an undesirable pastry product. To overcome these problems it was necessary to look for the best quality in the finished baked product by evaluating the criteria of ingredient quality, proper dough maintenance and checking factors of manufacturing process.

Thus, to develop a better cheese croissant than the one previously described, with unique product attributes compared to a plain croissant, providing a high consumer acceptability, it was necessary to find a new method of mixing the cheese powder, and evaluating its optimum time-temperature relationship for baking the cheese croissant pastry.

6.2 OBJECTIVES

The experiment was designed to optimise the cheese powder mixing method and time-temperature relationship to bake cheese croissants in order to obtain the best quality cheese croissant characteristics in terms of high specific volume, open flaky texture, golden brown crust colour, and a high consumer acceptability.

6.3 METHODOLOGY

6.3.1 CHEESE POWDER MIXING METHOD

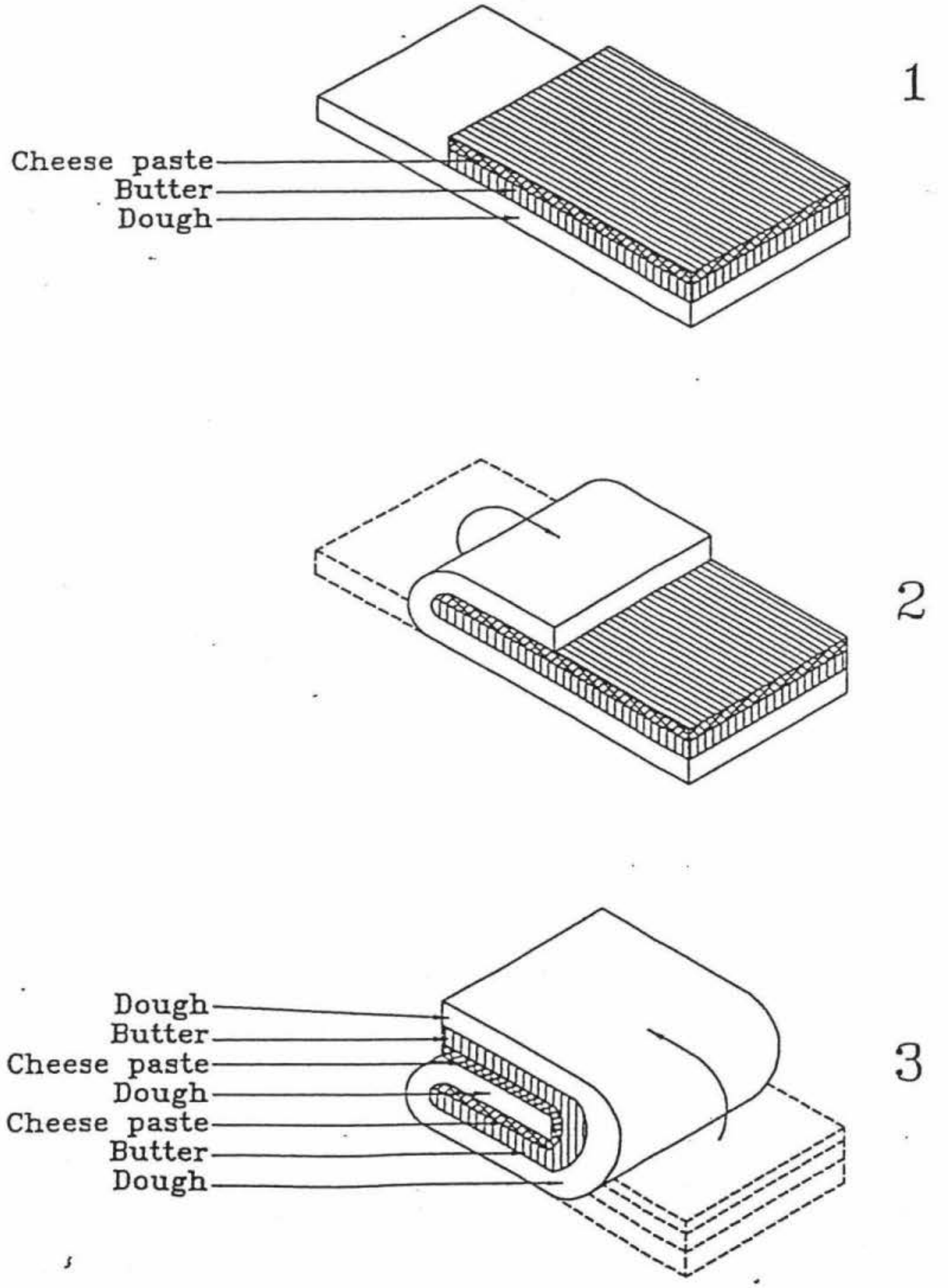
The total cheese powder amount was 10% w/w. The new method was performed by mixing cheese powder with water to make a cheese paste. The cheese paste was applied over the dough as a layer after lamination with pastry butter sheets. The procedure was carried out by turning and folding the dough as shown in Figure 6.1 and repeated up to three times. After this, in order to provide the pastry with a cheese taste, odour, and a golden brown crust colour, it was decided to blend a dry part (3-5%) of cheese powder (from the total 10%) with other dry ingredients.

To provide the best cheese croissant characteristics of a high specific volume, flakiness texture, golden crust colour, cheese taste, cheese odour and a high consumer acceptability, three trials were conducted to determine a suitable cheese powder amount to be mixed with the dry ingredients. The trials included mixing three, four and five percent of cheese powder with dry ingredients while laminating the dough with cheese paste. Seven, six and five percent of cheese paste layers were applied over the butter sheets. Therefore, the samples obtained with the new method of mixing cheese powder was 3% mixed with other dry ingredients and 7% of cheese paste applied over the dough during lamination compared with the previous method (10% cheese powder).

It was found that the best croissant characteristics were achieved by mixing three percent of cheese powder together with other dry ingredients followed by seven percent of reconstituted cheese paste applied over the dough after laminating with pastry butter sheets. Then, folding and turning dough procedure was carried out twice.

FIGURE 6.1

APPLICATION OF CHEESE POWDER PASTE AS A LAYER OVER THE PASTRY BUTTER AFTER LAMINATING THE DOUGH



The specific volume was determined using the rapeseeds displacement method, whereas the crust colour and croissant texture were determined by nine informal panellists using the total score method.

6.3.2 TIME-TEMPERATURE RELATIONSHIP

In order to determine the optimum time-temperature relationship for baking cheese croissants the different combinations indicated in table 6.1 were used.
Completed proofing cheese croissant doughs were place on greased oven trays. Oven trays were used containing the dough samples throughout the six trials. All the finished baked products underwent a scoring system method that was used against a plain croissant (R) containing specific instructions as shown in Appendix 2.
The cheese croissants were evaluated informally in terms of crust colour, crumb (inside) structure, texture flakiness, specific volume, and the overall acceptability by nine panellists members using a scoring system from a scale of 1 (poorer quality than R), 5 (same as R), and 10 (higher quality than R). In addition, the panellists were asked to indicate the best overall acceptable sample characteristics compared to the plain flavoured croissant.

TABLE 6.1

TIME TEMPERATURE RELATIONSHIP OF CHEESE CROISSANTS USING 3% CHEESE POWDER MIXED WITH DRY INGREDIENT AND 7% OF CHEESE PASTE LAMINATED OVER THE BUTTER SHEET

TIME (minutes)	TEMPERATURE (°F)
35	250
27	275
20	300
15	325
13	350
10	375

6.4 RESULTS AND DISCUSSION

6.4.1 EFFECT OF CHEESE POWDER MIXING METHOD

The new cheese powder mixing method (3% mixed with other ingredients and 7% of cheese paste applied over the dough lamination) showed an improvement in the cheese croissant quality characteristics when compared with the previous mixing method where the total cheese powder (10%) was mixed together with other dry ingredients.
The results (table 6.2) showed an increase in the croissant specific volume for the new method. The panellists did indicate that the crust colour produced by the new method was nearly the same by only 0.08 points when compared to the previous method, shown by the means of 6.39 and 6.47 respectively.

The panellists indicated that the texture was flakier than the previous method. The new method provided the same scores for the crumb (inside) structure as the plain croissant.

TABLE 6.2

EVALUATION RESULTS BETWEEN THE NEW METHOD OF MIXING CHEESE POWDER (3% OF CHEESE POWDER MIXED WITH OTHER DRY INGREDIENTS AND 7% OF CHEESE PASTE APPLIED OVER THE LAMINATED DOUGH) AND THE PREVIOUS MIXING METHOD (10% CHEESE POWDER MIXED TOTALLY DRY WITH OTHER INGREDIENTS)

ATTRIBUTES	PREVIOUS METHOD	NEW METHOD
SPECIFIC VOLUME[1]	4.53 $\pm$ 0.18 units cm^3/g	4.67 $\pm$ 0.18 units cm^3/g
CRUST COLOUR[2]	6.47 $\pm$ 1.18	6.39 $\pm$ 0.87
TEXTURE[3]	5.93 $\pm$ 1.71	6.78 $\pm$ 0.67
CRUMB (INSIDE) STRUCTURE[4]	5.0 $\pm$ 0.0	5.0 $\pm$ 0.0

1 = triplicate measurements

2, 3 and 4 = total scoring mean indicated by nine panellists

6.4.2 EFFECT OF THE TIME-TEMPERATURE RELATIONSHIP ON THE BAKED CHEESE CROISSANT

The reported score values for the six combinations of time-temperature are shown in table 6.3. Sample one received a total score of 61 points and was preferred by three panellists. The panellists expressed the opinion that sample one had a good soft texture, although the crust colour was not brown enough due to the low baking temperature. Sample one baking process lasted for 35 minutes at a temperature of 250°F.

Two panellists scored sample one less than the plain croissant, whereas six panellists scored sample one higher than the plain croissant. Only one panellist scored sample one the same as reference R.

Sample two was given the highest total score of 63 points for the best cheese croissant characteristics. Five panellists indicated that sample two was the best overall and more acceptable in terms of high volume, crust colour, a flaky texture and soft crumb structure. Eight panellists thought that sample two was better than reference R shown by the given high scores. Only one panellist scored sample two the same as reference R. Sample two baking process lasted for 27 minutes at a temperature of 275°F.

Sample three was given a total score of 54 points and was preferred by only one panellist as the best acceptable sample. The panellists showed it was unacceptable due to the cheese croissant characteristics of having a hard dark crust colour with a large volume. Five panellists scored sample three higher than the reference R, whereas three panellists indicated the same as reference R, and only one panellist scored sample three to be less acceptable than the plain croissant. Sample three was baked at 300°F for 20 minutes.

Samples four, five and six showed an unacceptable dark crust colour and texture as judged by the panellists, due to the high baking temperature and the short baking time (15 minutes at 325°F, 13 minutes at 350°F, and 10 minutes at 375°F respectively). Five panellists indicated that the cheese croissant for sample four gave higher scorings than that of reference R. Three panellists scored sample four the same as the plain croissant, whereas two panellists scored it less than reference R.

Four panellists scored both sample five and six higher than reference R, whereas four panellists scored both samples five and six less than reference R. Only one panellist scored both samples the same as reference R.

TABLE 6.3

TIME - TEMPERATURE RELATIONSHIP EVALUATION BY NINE PANELLISTS AS TOTAL SCORE FOR THE BEST CHEESE CROISSANTS CHARACTERISTICS

SAMPLE NUMBER	TIME min.	TEMP (°F)	PANELLISTS SCORING									TOTAL SCORE	*OVERAL ACPT.SAMP
			1	2	3	4	5	6	7	8	9		
1	35	250	8	7	8	5	6	4	9	4	7	61	3 panellists
2	27	275	6	8	6	6	8	8	5	8	8	63	5 panellists
3	20	300	4	5	5	6	7	5	7	7	6	54	1 panellists
4	15	325	5	3	4	8	5	5	7	7	6	50	none
5	13	350	5	1	2	7	7	4	6	4	6	42	none
6	10	375	3	2	3	5	6	4	6	7	6	42	none

*OVERALL ACPT.SAMP = OVERALL ACCEPTABILITY SAMPLE.

6.5 CONCLUSION

The new cheese powder mixing method (3% cheese powder mixed with dry ingredients and 7% cheese paste applied over the laminated dough) showed an improvement in cheese croissant quality characteristics compared to the other mixing method where the total 10% of cheese powder mixed with other dry ingredients.

The purpose of laminating the dough with seven percent of cheese paste was firstly to reduce the amount of cheese powder mixed with other dry ingredients since this adversely affected the dough's rheological properties. Secondly, to provide more moisture vapour during baking, providing the dough layers to be separated with the help of the pastry butter sheets. It could be said that the cheese paste function is giving an aid to the pastry butter sheets function. The main function of pastry butter sheets is to separate the layers of dough, allowing them to part as the trapped air expands with the help of moisture in the cheese croissant (Pomeranz, 1988).
However, the increased temperature during baking caused the water in the pastry butter sheets and the cheese paste to evaporate causing the butter oil and cheese to act as a barrier between the dough layers (Faridi, 1991). The water vapour, facing the oil barrier between the dough layers forces the dough layers up making an open texture.

The hot oil mixture of butter and cheese also helped the dough layers to cook quickly and was absorbed by the dough providing a crisp texture, and a mixed flavour of butter and cheese.
The baking time-temperature relationship of 27 minutes at 275°F gave the best quality characteristics, a higher volume, a golden brown crust colour and a flaky texture. This was shown by the high scores of acceptability by the panellists.

RECOMMENDATION

As an important recomendation, the New Zealand Dairy Board should produce frozen cheese paste pastry sheets, or to mix cheese powder together with pastry butter sheets. The second option should be chosen because of its simplicity to be used in its application during lamination process for cheese croissants (or any pastry).

In addition, the cheese paste must be plasticized i.e, to have a suitable consistency to enable it to become well sheeted during folding and rolling for the purpose of flakiness texture. It is recommended to incorporate the cheese powder with butter sheets to a ratio of 30/70% to produce the pastry cheese-butter sheets.

CHAPTER SEVEN

MARKET EVALUATION OF THE DEVELOPED PRODUCT

7.1 INTRODUCTION

One of the important issues in product development is to evaluate its costings in order to make stop / go decisions. The final costing and economics of the market evaluation were carried out in order to determine the production costs and feasibility of the project.

The company will require:

- a certain profit
- a return of the investment
- a time to recover the launch costs
- the development costs

Obviously, as the project proceeds, the evaluation will become more definite. More accurate predictions for future profits can be determined by estimating the economic evaluation of the project and its market potential (Earle, 1991).

7.2 OBJECTIVES

1 - To determine the consumer's attitude towards the cheese flavoured croissant's characteristics and acceptability.

2 - To determine the size of the market potential.

3 - To determine the price that consumers are prepared to pay and their decision to buy the product.

4 - To obtain market information for the final specification and reasons why the consumers liked or disliked the product.

7.3 METHODOLOGY

For the initial market research the technique employed was the market consumer survey.

7.3.1 SURVEY METHOD

The consumer survey was used to estimate the market evaluation for the developed cheese flavoured croissants. A mail survey was conducted in which a total of one hundred and fifty cheese flavoured croissants were packed in polyethylene bags and distributed together with a questionnaire form. Each bag contained two cheese flavoured croissants with heating instructions specified in the survey form and stated it was a Massey University, Food Technology project.
Eighty bags were distributed at Massey University to staff members and students, whereas seventy bags were distributed at PAK 'N' SAVE supermarket in Palmerston North to different household shoppers. The survey questionnaire form is presented in Appendix 3.

7.4 RESULTS AND CONCLUSION

Of the one hundred and fifty surveys distributed in Palmerston North, one hundred surveys were returned within two weeks and fifteen surveys were returned after one month. The survey analysis was based on one hundred answered questionnaires received. The survey were then analyzed by determining the frequency of all the responses for each question. The results are presented below by questions.

7.4.1 SOCIO-ECONOMIC CHARACTERISTICS OF THE RESPONDENTS

The income of fifty seven percent of the respondents was more than $30,000. Twenty percent of the respondents income ranged between $10,000-$20,000. Thirteen percent of the respondents income was between $20,000-$30,000, whereas 10% respondents income fell less than $10,000.

Thirty three percent of the respondents were between 36-50 years old. Thirty percent of respondents stated their age between 26-35. Twenty three percent of respondents indicated their age between 14-25 years, and 14% of respondents indicated to be older than 50. The majority of the respondents were females by 60% and males at 40%

INCOME	%	AGE (Year)	%	GENDER	%
$ < 10.000	10	14 - 25	23	FEMALE	60
$ 10-20.000	20	26 - 35	30	MALE	40
$ 20-30.000	13	36 - 50	33		
$ > 30.000	57	> than 50	14		

7.4.2 RESPONDEND PREFERENCE IN CRUST AND INSIDE COLOURS OF CHEESE FLAVOURED CROISSANT

Forty eight percent of the respondents thought that the colour of the crust was very appealing. Twenty four percent of the respondents indicated the colour was okay. Twenty one percent of the respondents thought that the colour appearance was slightly appealing and only 7% of the respondents indicated the colour appearance was slightly unappealing. The majority (77%) of the respondents indicated the inside colour of the crumb was just right. Fifteen percent of the respondents suggested the inside crumb colour was slightly light, and 8% claimed the inside crumb colour was slightly dark.

CRUST COLOUR	%	INSIDE COLOUR	%
Very appealing	48	Too dark	0
Slightly appealing	21	Slightly dark	8
Okay	24	Just right	77
Slightly unappealing	17	Slightly light	15
Very unappealing	0	Too light	0

7.4.3 RESPONSE TO ON TEXTURE OF CHEESE FLAVOURED CROISSANT

Fifty one percent of the respondents stated that the texture of the product was open and not flaky. Twenty nine percent of the respondents recommended that the texture was opened and flaky. The product texture was not open and not uniform as rated by 8% of the respondents. The product was rated as doughy and lumpy by 12% of the respondents.

TEXTURE	%
Open and flaky	29
Open and not flaky	51
Not open and not uniform	8
Doughy and lumpy	12
Closed and not uniform	0

7.4.4 RESPONSE TO ON TASTE AND AROMA OF CHEESE FLAVOURED CROISSANT

Fifty five percent of the respondents indicated that the cheese flavour was just right. As slightly too strong cheese flavour was suggested by 30% of the respondents. Seven percent of the respondents indicated too strong of a cheese flavour. Eight percent of the respondents thought that the cheese flavour was slightly weak. A majority of 72% respondents indicated that the saltiness taste was just right.

Seventeen percent of the respondents suggested that the product was slightly salty which is probably due to the cheese. Eleven percent of the respondents referred the product was not salty at all.

Thirty eight percent of the respondents indicated that the product bitterness was just right. Nineteen percent of the respondents suggested the product was slightly bitter, and 4% indicated the product was very bitter. Thirty nine percent of the respondents thought that it was not bitter.

Sixteen percent of the respondents indicated that the product's aroma was very cheesy, but the majority of the respondents, fifty two percent stated the cheese aroma was just right. Thirty two percent of the respondents claimed the cheese aroma was slightly cheesy.

	CHEESE FLAVOUR %	SALTNESS TASTE %	BITTER TASTE %	CHEESE AROMA %
Too strong	7	0	0	0
Slightly strong	30	0	4	16
Just right	55	72	38	52
Slightly weak	8	17	19	32
Too weak	0	11	39	0

7.4.5 RESPONSE TO ON PLEASANT TASTE OF CHEESE FLAVOURED CROISSANT

The majority of respondents 66% thought that the cheese flavoured croissant was pleasant. Very pleasant was indicated by 13% of the respondents. Twenty one percent of the respondents regarded the product as slightly unpleasant.

7.4.6 RESPONSE TO OVERALL ACCEPTABILIT OF CHEESE FLAVOURED CROISSANT

The overall acceptability indicated by 57% of the respondents was that they liked the cheese flavoured croissant moderately. Twenty eight percent of the respondents liked the product extremely. Nine percent of the replies stated neither likes nor dislikes of the product. Six percent of the respondents stated that they did not like the product.

PLEASANT TASTE	%	ACCEPTABILITY	%
Very pleasant	13	Like extremely	28
Pleasant	66	Like moderately	57
Slightly unpleasant	21	Neither liked or disliked	9
Very unpleasant	0	Disliked	6

7.4.7 RESPONSE TO PREFERENCES OF LOCATION TO BUY CHEESE FLAVOURED CROISSANT

The place most preferred by 58% of the respondents for purchasing the cheese flavoured croissants was the supermarket outlets. Twenty four percent of the respondents preferred bakery outlets for buying the cheese croissants. Seven percent, 5%, and 6% of respondents preferred to purchase the product at restaurants, hotels, delicatessens, and dairies respectively.

OUTLET LOCATION	%
Supermarket	58
Bakeries	24
Restaurants/Hotels	7
Delicatessens	5
Others	6

7.4.8 RESPONSE TO EXPECTED PRICE TO PAY

A majority of 64% would be willing to pay less than $2.00 for a package of two cheese flavoured croissants. Twenty nine percent decided they were willing to pay between $2.10 - $2.20, and 7% of the respondents suggested they would pay between $2.30 - $2.50.

PRICES OF TWO CROISSANTS	%
< than $2.00	64
$2.10 - $2.20	29
$2.30 - $2.50	7
> than $2.50	0

7.4.9 RESPONSE TO WILLINGNESS TO BUY THE PRODUCT

Forty four percent of the respondents stated they would buy the product if it were available. Eleven percent indicated they would not buy the product if it were available. Forty five percent of the respondents stated they might buy the product if it were available.

AVAILABILITY	%
Yes	44
No	11
Maybe	45

7.4.10 RESPONSE TO PREFERENCE ON PACKAGING SIZE

Forty eight percent of the respondents stated they preferred to buy a packet of four cheese flavoured croissants. Twenty percent of the respondents stated they would like to buy a packet of two cheese flavoured croissants, and twenty nine percent of them preferred six cheese croissants. Only three percent of the respondents preferred to buy a baker's dozen (13).

PACKAGING SIZE	%
A packet of 2	20
A packet of 4	48
Half a dozen 6	29
A baker's dozen 13	3

7.4.11 RESPONDENTS REASONS FOR BUYING THE CHEESE FLAVOURED CROISSANTS

A majority 57% remarked that the product was convenient. Thirty three percent of the respondents liked a change by trying something new. Ten percent of the respondents reasoned they would buy the product because of a suitable and low cost product.

REASONS FOR BUYING	%
Low cost product	10
Convenience	57
Others	33

7.4.12 THE RESPONDENTS RESPONSE TOWARDS THE PRODUCT USAGE

The cheese flavoured croissants were expected to be used as follows:
Snacks with fillings (24%); lunch sandwiches (29%); breakfast with jam and honey etc. (22%); dinner substitute bread (9%); special occasions - functions, parties etc. (16%)

PRODUCT USAGE	%
Snacks with fillings i.e cottage cheese	24
Lunch (sandwiches)	29
Breakfast	22
Dinner (substitute bread)	9
Special occasions (function or parties)	16

7.4.13 RESPONSE TOWARDS THE PRODUCT: OVERALL, LIKED OR DISLIKED

A total of eighty seven percent of the returned questionnaires stated that the respondents liked the product. A majority of 82% of the 1-3 persons who sampled the product liked it, whereas only five percent of 4-6 persons who sampled the product also liked it. Thirteen percent of the total respondents who sampled the product disliked it. Eight percent and five percent of the respondents of 1-3 persons and 4-6 persons respectively who sampled the product disliked it.

NO. OF PEOPLE	1 - 3	4 - 6	7 - 10
LIKED	82 %	5 %	0 %
DISLIKED	8 %	5 %	0 %

7.5 CALCULATION OF THE MARKET POTENTIAL

The market potential for the new product was based on the buying potential of respondents using the frequency of the product purchase from the consumer survey questionnaire form (question 12). The potential was calculated by corresponding weights of product purchased and conversions into a yearly total, as presented in table 7.1. A majority of 34% of the respondents stated they prefer to buy the product (two cheese croissants) once a month. Nineteen percent of the respondents indicated to buy the product once a week and fortnightly, whereas 13% of them indicated that they would prefer to buy the product twice a week. Only 2% of the respondents preferred to buy the product once a day. Thirteen percent of the respondents stated they would not buy the product due to the following reasons:

- the texture attribute was doughy after heating the product in the microwave.
- health reasons due to the respondent believe that the product was too high in fat.
- the product was not cheesy at all, or too cheesy as decided by them.

However, a total of 87% of the respondents indicated they would buy the product and liked it.

Assumptions:

Distribution system will cover 35% of New Zealand households.

Number of New Zealand households = 1078296

Potential households = 0.35 x 1078296 = 377403

Percent of survey buying the product = 87%

Total market potential =

$$\frac{\%\text{ of buying/year}}{100} \times \text{potential household} \times \frac{\text{total no. of respondents surveyed}}{100} \times 0.144\text{ Kg}$$

for example: Twice a week

$$= \frac{13}{100} \times 2 \times 52 \times 377{,}403 \times \frac{87}{100} \times 0.144$$

$$= 639{,}239.8$$

TABLE 7.1

CALCULATION OF TOTAL WEIGHT OF 144 g (2 CROISSANTS) PER PRODUCT PURCHASED PER YEAR

FREQUENCY OF PURCHASE	% BUYING	YEARLY TOTAL (Kg)
Once a day	2	345,151.7
Twice a week	13	639,239.8
Once a week	19	467,136.8
Fortnightly	19	233,568.4
Once a month	34	192,906.7
Total	87	1,878,003

- Calculation of sales potential.

If the total demand can be approximately 2,000 Tonnes/annum of finished product for ease of calculation.

7.6 PROJECT LIFE CYCLE

No one can accurately predict the life cycle of a new product, mainly because the product is unknown to the market. For this reason to estimate the market potential it was assumed that the life cycle would go through from development until the decline phases (product decreasing demand). It is assumed that for the product to go pass through the growth and maturity phases would taken five years.

7.7 CALCULATION OF SALES POTENTIAL

The predicted sales potential is less than the market potential for the following reasons:

* Not all respondents who indicated they would buy the product actually would in a supermarket place.
* It will take certain amount of time for the new product to become established on the market so immediate potential is less than the anticipated potential within three years time.
* The present competition from other products and potential products similar will decrease the market share gained.
* The price of $2.00 per two croissants could cause some potential consumers not to buy the product.

Therefore, the following market share and sales forecast is predicted based on the above asumptions in table 7.2.

TABLE 7.2

MARKET SHARE AND SALES FORECAST

YEAR	MARKET SHARE (%)	SALES POTENTIAL (Kg/annum)
1	15	300,000
2	20	400,000
3	30	600,000
4	18	360,000
5	10	200,000

7.8 PRICES

The product ought to be launched with the price that consumers are willing to pay for the cheese flavoured croissants chosen from the consumer survey.

Launch price = sum of fraction of respondents x mid point price

\$1.216 = 0.64 x \$1.90

\$0.624 = 0.29 x \$2.15

\$0.168 = 0.07 x \$2.40

\$2.01 per two cheese croissants

The consumers are willing to pay a retail price of \$2.00 for two cheese flavoured croissants and \$14 for 1 Kg of baked cheese flavoured croissants.

7.9 PRODUCTION COSTS

The production costs are presented as per packet basis of two cheese flavoured croissants. The production costs include the raw materials, labour, overheads, packaging and total production costs.

I) RAW MATERIALS COSTS

The raw material costs of the cheese croissants are given in table 7.3.

II) LABOUR AND OVERHEAD COSTS

Assume the costs of labour and overhead indicated by bakery / kilogram equal to \$1.00.

III) PACKAGING COSTS

Assume the sales of 1000 units of polyethylene bags to be \$10.00. Therefore the packaging (one bag) equals \$0.01. and packaging of 14 cheese flavoured croissants will need 7 bags costing at \$0.07.

TABLE 7.3

RAW MATERIAL COSTS

RAW MATERIALS	1 Kg of % W\W bases	$ PRICE
Flour	400	0.25
Gluten	150	0.44
Salt	5.0	0.002
Sugar	30.0	0.12
Softening	0.00	0.00
Yeast	2.00	0.044
Cheese Powder Cheddar-20	100.0	0.55
Butter Sheets	180.0	0.744
Total		$2.15

Each Kilogram makes 14 croissants weighting of 71.4 g each.

IV) TOTAL PRODUCTION

Total product costs are achieved by summing up all the raw material costs, packaging costs and labour and overhead costs to be:

Raw material/Kg = $2.15

Packaging/Kg = $0.07

Total $2.22

Labour and overheads/Kg = $1.00

Total approximately = $3.22 per Kg or per 14 croissants

Therefore, net sale price = production cost + profit

= $2.00/packet of two cheese croissants

Consumers are willing to pay a retail price of $14.00 per Kg.

Net Sale price = 14 x $2.00 /2

= $14 per Kg.

Profit = Net wholesale price - production costs

= $14.00 - $3.20

= $10.80 per Kg

7.10 GENERAL EXPENSES

Assume the following expenses:

1) **Development costs**

* expenses = $3,000
* work (technologist) = $15,000
* consumer survey = $2,000

2) Equipments and plant expenses

= $130,000

Total expenses = $150,000

7.11 NET PRESENT VALUE

The following table 7.4 shows the cash-flow analysis for the cheese flavoured croissant.

Net Present Value over five years project life = $3,206,000

TABLE 7.4

CASH-FLOW ANALYSIS AND NET PRESENT VALUE (x 1000)

YEAR	0	1	2	3	4	5
Market Share	-	15	20	30	18	10
Sales/Kg	-	300	400	600	360	200
Revenue	-	4200	5600	8400	5040	2800
Costs	-	645	860	1290	774	430
Profit before tax	-	3555	4740	7110	4266	2370
Capital Investment	150	-	-	-	-	-
Cash flow	-150	3555	4740	7110	4266	2370
Profit after Tax at 24%	-	853.2	1137.6	1706.4	1023.8	568.8
Discount factor 18%	1.000	08475	0.7180	0.6086	0.5160	0.4371
Present Value Profit	-150	723	817	1039	528	249

Net present Value = $3,356,000 - $150,000 = $3,206,000

7.12 DISCUSSION

Potential consumers indicated that they liked the cheese flavoured croissant extremely or moderately due to the cheese flavour, being very tasty, and a very good idea, and they enjoyed eating the cheese flavoured croissants as indicated by 87% of the market survey questionnaire respondents.

In summary the cheese croissant attributes shown to be acceptable by the consumers as the majority of the survey respondents (60% female and 40% male) indicated as following:

- the cheese flavour was just right (55%)
- the saltiness was just right (72%)
- the bitterness was weak (39%)
- the cheese aroma was just right (52%)
- a pleasant taste of cheese in the croissant (66%)

In addition, the majority of the potential consumers indicated the following:

- the location to buy the product should be the supermarket (58%)
- the price to pay should be less than $2.00 (64%)
- availability of the product should be sold in the supermarket (44%)
- the packaging size should be a packet of four croissants (48%)
- the product was chosen to be bought because of its convenience (57%)
- the product should be used for lunch sandwiches (29%)

Respondents stated their reasons for buying the product as following:

- tasty and nicely flavoured.
- a change to something new and different.
- to introduce the cheese croissants to their relatives, friends and visitors.
- gave an attractive appearance on the table.

Some potential consumers indicated that they disliked the product due to the texture attribute being doughy, lumpy, soggy (due to heating in the microwave), too cheesy, or not cheesy at all, and high in fat as indicated by a minority of 13% of the respondents. The respondents who indicated they neither liked or disliked the cheese flavoured croissant preferred a plain flavoured flakier croissant and lighter cheese flavour.

The total demand of sales potential was indicated at approximately 2.000 tonnes/annum of the finished product being equivalent to 10% of the market. The market share would increase if there were less competition from other products. The estimated time for product establishment on the market would be within the third year of the production sales. The estimated net present value over a five year product life was $3,206,000.

APPENDIX 1.

SENSORY TEST FOR THE CHEESE CROISSANT CHARACTERISTICS

NAME: ____________ **DATE:** __________

INSTRUCTIONS

You have been given a croissant sample reference R (R is without cheese flavour) with three other cheese flavoured coded samples. Taste R first and leave enough to evaluate the next three samples (i.e. do not eat it all).

Please evaluate the croissant characteristics for each samples in relation to the reference R by giving a score point of each characteristics that best reveals to you.

Your sample numbers are: 139, 287, 352 and R.
Please rinse your mouth thoroughly with water before tasting each sample.

CHARACTERISTICS

CRUST COLOUR

0	5	10
I	I	I
I	I	I
Light	R	Dark

PLEASE COMMENT: ________________________________

CRUMB COLOUR

0	5	10
Light	R	Dark

PLEASE COMMENT: ____________________

TEXTURE

0	5	10
Closed Not Flaky	R	Open Flaky

PLEASE COMMENT: ____________________

ODOUR

0	5	10
Weak	R	Strong

PLEASE COMMENT: ____________________

TASTE

*SALTINESS

0	5	10
Not Salty	R	Extremely Salty

PLEASE COMMENT: ____________________

*CHEESY

0	5	10
Not Cheesy	Without R	Extremely Cheesy

PLEASE COMMENT: ____________________

*BITTERNESS

0	5	10
Not Bitter	R	Very Bitter

PLEASE COMMENT: ____________________

OVERALL ACCEPTABILITY

Could you please tell me which of the samples you preferred and why ?

____

APPENDIX 2.

SCORING TEST FOR CHEESE CROISSANT CHARACTERISTICS

NAME: ______________ **DATE:** __________

INSTRUCTION

You have been given a croissant sample reference R (R is without cheese flavour) with six other cheese flavoured samples. These cheese croissants had been baked at different time periods and temperatures.

Please evaluate each sample individually accordingly to their characteristics of crust colour, crumb (inside) structure, flaky texture and the croissant volume by giving a total score points (1 - 10) for all characteristics that best reveals to you against reference R.

Indicate also your choice of the overall acceptability sample that you think is the best in the space provided.

Score points:

1 = poorer quality than R 5 = same as R 10 = higher quality than R

SAMPLE NO.	CRUST COLOUR	CRUMB STRUCT*	FLAKY TEXT*	VOL*	TOTAL SCORE POINTS
1					
2					
3					
4					
5					
6					

* STRUCT = STRUCTURE, TEXT = TEXTURE AND VOL = VOLUME

Overall acceptability sample numbers: 1____ 2____

3____ 4____

5____ 6____

APPENDIX 3.

MARKET TRIAL QUESTIONNAIRE FORM
DEPARTMENT OF FOOD TECHNOLOGY
MASSEY UNIVERSITY
PALMERSTON NORTH
CONSUMER SURVEY CHEESE FLAVOURED CROISSANT

Hello. With this form, you have been provided with a Free sample of a new "Cheese Flavoured Croissant" product, which had been developed at the Department of Food Technology, Massey University. Please complete the questionnaire form, then post it back in the FREE POST ENVELOPE PROVIDED (no stamp required), within the next 3 days. There is no right or wrong answers. Your honest opinion is imperative for further development, and your suggestions and ideas are welcomed. ALL ANSWERS WILL BE KEPT STRICTLY CONFIDENTIAL. Thank you for your help. Please follow any of the heating instructions for the Cheese Croissant:

Microwave: Place the cheese croissant in the microwave, set on high for 20 seconds. The croissant should be soft and warm. Take out and complete the questionnaire.

Oven: On bake, pre-heat oven temperature to 250°C, place the cheese croissant inside, and heat for 3 minutes. The croissant should be soft and warm. Take out and complete the questionnaire.

The Cheese Flavoured Croissant is specially designed for the New Zealand markets, and is to be sold as a baked package from supermarkets and bakeries.

Please tick the appropriate box. You may tick more than once.

PART ONE

1) **Is the Colour Appearance of the Cheese Croissant ?**

[ ] Very Appealing

[ ] Slightly Appealing

[ ] Okay

[ ] Slightly Unappealing

[ ] Very Unappealing

2) **Is the Texture of the Cheese Flavoured Croissant ?**

[ ] Opened and Flaky

[ ] Opened and Not Flaky

[ ] Not Opened and Not Uniformed

[ ] Doughy and Lumpy

[ ] Closed and Not Uniformed

3) **Is the Cheese Flavour ?**

[ ] Too Strong

[ ] Slightly Too Strong

[ ] Just Right

[ ] Slightly Frail

[ ] Too Weak

4) **Is the Saltness Taste of the product ?**

[ ] Too Salty

[ ] Very Salty

[ ] Just Right

[ ] Slightly Salty

[ ] Not Salty

5) **Is the Bitterness Taste of the product?**

[ ] Too Bitter

[ ] Very Bitter

[ ] Just Right

[ ] Slightly Bitter

[ ] Not Bitter

6) **Is the Aroma of the Cheese Croissant ?**

[ ] Too Cheesy

[ ] Very Cheesy

[ ] Just Right

[ ] Slightly Cheesy

[ ] Not Cheesy at all

7) Is the Inside Colour (the crumb) of the product ?

[ ] Too Dark

[ ] Slightly Dark

[ ] Just Right

[ ] Slightly light

[ ] Too light

8) How Pleasant or Unpleasant do you think the After-Taste of the product is ?

[ ] Very Pleasant

[ ] Pleasant

[ ] Slightly Unpleasant

[ ] Very Unpleasant

9) Please rank your ideal of the Overall Acceptability of the Cheese Flavoured Croissant ?

[ ] Like extremely

[ ] Like Moderately

[ ] Neither Liked or Disliked

[ ] Dislike

Please Comment:____________________

PART TWO

10) Which outlet would you prefer to buy this product ?

[ ] Supermarkets

[ ] Bakeries

[ ] Restaurants/Hotels

[ ] Delicatessens

[ ] Others please specify ____________________

11) What price would you pay for a package of Two Cheese Flavoured Croissants ?

[ ] Less than $2.00

[ ] $2.10 - $2.20

[ ] $2.30 - $2.50

[ ] More than $2.50

12) How often would you buy it ?

[ ] Once A Day

[ ] Twice A Week

[ ] Once A Week

[ ] Fortnightly

[ ] Once A Month

[ ] Never

13) Would you buy it, if it were available in the market ?

[ ] Yes

[ ] No

[ ] Maybe

14) What Size Packaging would you purchase your Cheese Flavoured Croissants

[ ] A Packet of 2

[ ] A Packet of 4

[ ] Half a Dozen (6)

[ ] A Baker's Dozen (13)

15) What would your main reasons be for buying the product ?

[ ] Low Cost Product

[ ] Convenience

[ ] Others please specify________________________

16) Would you most often use this product for ...

[ ] Snacks with fillings i.e. cottage cheese

[ ] Lunch (sandwiches)

[ ] Breakfast with jam and honey

[ ] Dinner (substitute bread)

[ ] Special Occasions (function, parties etc..)

PART THREE

Finally, I wold like to ask you a few questions about yourself. All questions will be treated as being **CONFIDENTIAL without mentioning names**.

17) Sex: Female [ ] Male [ ] Age [ ]

18) How many people have tried this product ? Please indicate whether they liked it or not?

No. of people	1 - 3	4 - 6	7 - 10
Liked			
Disliked			

19) Please specify the Total Income before Tax of your household

[ ] Less than $10.000

[ ] $10.000 - $20.000

[ ] $20.000 - $30.000

[ ] More than $30.000

THANK YOU

REFERENCES

AACC (1970). *American Association of cereal chemists.* Approved methods of the AACC, 7th ed. The Association, Saint Paul. Minnesota.

Abels (1990). A guide to pastry making in New Zealand. *The baker advisory service, Abels Co. Ltd.* Auckland, New Zealand.

Abhayaratna, N. M. (1978). The functional bread making properties of whey protein concentrates. *Chemistry in Australia 45:* 371.

Abhayaratna, N. M. (1979). The functional bread making properties of Whey Protein Concentrates Milk Protein. *News letter 1:* 14-15.

Alaco Food Ingredients (New Zealand Dairy Board Division), (1985). Milk proteins in bakery products. *Journal of Food Technology in New Zealand, November 20:* 18-19.

Alaco (1986). Pasta and milk protein *(Alaco Advisor).* A bulletin of Alaco Food Ingredients. June.

Alaco (1988). Pastry craze catches on *(Alaco Advisor).* A bulletin of Alaco Food Ingredients. October.

Alaco (1989). Fractionated Butter a hit at Barends *(Alaco Advisor).* A bulletin of Alaco Food Ingredients. September.

Alaco (1990). Specialty milk fats *(Alaco Food Ingredient).* A special bulletin of Alaco Food Ingredients.

Alaco (1991). The taste that works *(Alaco Advisor).* A bulletin of Alaco Food Ingredients. October.

Alaco (1992). Alaco's Butter Pastry Butter *(Alaco Advisor).* A bulletin of Alaco Food Ingredients. February.

Alsberg, C. L. (1927). Starch in flour. *Cereal Chemistry Journal l4:* 485-495.

AOAC (1984). "Official Methods of Analysis" 14th ed. *Association of Official Analytical Chemists*, Washington, D.C., USA.

ASTM (1968). Manual on Sensory Testing Methods. ASTM Special Technical Publication 434. *American Society for Testing materials*, Philadelphia., USA.

Baker, A. E., Dorry, W. T. and Kemp, K., (1986). Instron factors involved in measuring crumb firmness. Cereal Foods World 31: 193-195.

Baker, A. E. and Ponte, J. G. Jr. (1987)a. Compression of bread firmness measurements by four instruments. *Cereal Foods World 32:* 486-489.

Baker, A. E. and Ponte, J. G. Jr. (1987)b. Measurement of bread firmness with the Universal Testing Machine. Report of the AACC Technical Committee on bread firming measurement. *Cereal Foods World 32:* 491-493.

Barrows, A. B. (1975). Every day production of baked good. 2nd edit. Chp6. *Applied Science publishers Ltd.*

Bechtel, W. G., Meisner, D. F. and Bradly, W. B. (1953). The effect of the crust on the staling of bread. *Cereal Chemistry Journal 30:* 160.

Bennion, M. (1972). Fats as cooking media, shortening agents and components of pastry in food theory and applications. *John Wiley and sons, Inc., New York.*

Bietz, J.A., Hubner, F.R., and Wall, J.S. (1973). Glutenin the strength protein of flour. *Baker's Digest 47:* 26.

Bloksma,A. H. (1968). Effect of potassium iodate on creep and recovery and thiol and disulphide contents of wheat flour doughs. *Society of Chemical Industry (London) 27:* 135-166.

Bloksma, A. H. (1981). Effect of surface tension in the gas-dough interface on the rheological behaviour of dough. *Cereal Chemistry Journal 58:* 481.

Bloksma, A. H. (1985). The effect of temperature on dough viscosity, and its consequence for the control of dough temperature. *Journal of Food Engineering 4:* 205-227.

Bohlin, L. and Carlson, T.L. (1980). Dynamic visco-elastic properties of wheat flour dough, dependence on mixing time. *Cereal chemistry Journal 57:* 174-1770.

Bradley, W. B. and Thompson, J. B. (1950). The effect of crust on changes in crumbliness and compression in relation to staling. *Cereal Chemistry Journal 41:* 216.

Burrows, S. (1970). Baker's Yeast. In; *The yeasts, vol.3, p 349-419. Academic press, New York.*

Bushuk, W. and Hlynka, I. (1964). Water as a constituent of flour, and dough and bread. *Baker's Digest 38:43.*

Bushuk, W. (1974). Glutenin functions, properties and genetics. *Baker's Digest 48:* 14.

Bushuk, W., Bakes, F., McMaster, G. J. and Zawistowiska, U. (1984). Carbohydrate and lipid complexes with gliadin and glutenin. p 101-109 In: Gluten proteins: proceedings of the 2nd International workshop on gluten proteins. *TNO Wageningen, the Netherlands, May 1-3.*

Bushuk, W. (1985). Rheology theory and application to wheat flour doughs series of rheology of wheat products. p 1-26 Ed. *American Association of Cereal Chemists.* Publisher. Saint Paul, Minnesota, United States of America.

Bushuk, W. and Mac Ritchie, F. (1988). Wheat proteins: Aspects of structure that are related to bread making quality. p337-361 In: Protein quality and the effects of processing. *Marcel Dekker, New York.*

Campanella, O. H., Popplewell, L. M., Rosenau, J. R. and Peleg, M. (1987). Elongational viscosity measurements of melting American process cheese. *Journal of Food Science 52:* 1249-1251.

Chamberlain, N. and Colling T. H. (1979). The charley wood bread process; the role of oxygen and nitrogen. *Baker's Digest 53:* 18-24.

Chen, S.S. and Rasper, V.F. (1982). Functionality of Soy Protein in wheat flour, soy isolate doughs: its rheological properties and bread baking potential. *Canadian Institute of Food Science and Technology Journal 15:* 211.

Cleven, F. and Weber, L. (1977). A new method for the continuous production of puff pastry and Danish pastry dough's. *Baker's Digest 51:138.*

Cobb, S. G. (1976). Alternatives to nonfat dry milk. *Baker's Digest 52:* 14.

Cochran, W. M. and Baenerlen, R. J. (1981). Formulation, innovations and other developments in shortenings, margarine and oils. *Baker's Digest 55:* 16-18.

Cocup, R. O. and Sanderson, W. B. (1987). Functionality of dairy ingredients in bakery products. *Journal of Food Technology 41: 86-90.*

Cooper, H. R., (1981). Sensory evaluation of N.Z. commercial whole milk powder. A thesis presented in partial fulfilment of the requirements of the degree of Ph.D in Product Development at *Massey University, Palmerston North, New Zealand.*

Coppock, J. B. (1967). The place of eggs in the food industry. *Journal of Food Manufacture 42:* 33.

Craig, T. W. and Colmey, J. C. (1971). Milk and milk products for use in bakery products. *Baker's Digest 45:* 36-39.

Creighton, T.E. (1984). Proteins: in structure and molecular properties. *W.H. Freeman, New York.*

de al Gueriviere, J. F. (1981). Bulletin of the *International Dairy Federation (IDF).* Bakery products subject 6b:May, 48-50.

Doerry, W. F. and Meloan, L. (1986). Croissant technology. Technical Bulletin. *American Institute of Baking 8(10)*: 1-9.

Earle, M. D. (1991). An introduction to food products, consumers, markets and marketing. In consumer marketing of food products. *Massey University, Food Technology Department, New Zealand.*

Ewart, J. A. (1968). A hypothesis for the structure and rheology of glutenin. *Journal of the Science of Food and Agriculture 19:* 617.

Ewart, J. A. (1972)a. Recent research and dough visco-elasticity. *Baker's Digest 46:* 22.

Ewart, J. A. (1972)b. Further studies on the SS bonds in cereal glutenin's. *Journal of the Science of Food and Agriculture 23:* 567

Ewart, J. A. (1972)c. A modified hypothesis for the structure and rheology of glutenins. *Journal of the Science of Food and Agriculture 23:* 687.

Ewart, J.A. (1985). Blocked thiol in glutenin and protein quality. *Journal of the Science of Food and Agriculture 36:101.*

Faridi, H. and Finley, J.W. (1989). Improved wheat for Baking Chemical Rubber Company. *Critical Reviews in Food Science and Nutrition. 28:175-209.*

Faridi, H. (1991). Soft wheat products, In: Handbook of Cereal Science and technology. chp17. *Marcel Dekker Inc. New York.*

Finney, K. F. (1978). Contribution of individual chemical constituents to the functional (bread making) properties of wheat. In cereals 78; Better Nutrition for the World's millions. *AACC, Saint Paul, Minnesota.*

Fleming, S. E., Sosulski, F. W., Kilara, A. and Humbert, E. S. (1974). Viscosity and water absorption characteristics of slurries of sunflower and soy bean flours concentrates and isolates. *Journal of Food Science 39:* 188.

Fox, P. F. (1989). Development in dairy chemistry (4): Functional milk proteins. *Elesvier Applied Science, London and New York.*

France, W. J. (1969). The students Technology of bread making and flour confectionary. Chp22, *Routledge and Kegan Paul Ltd. London.*

Gerth, C. H. (1980). Rheology, in Analysis and measurements. Uhlmanns Encyclopedia of technological chemistry, Vol.5 (German) *Chemie Weinheim: Beerfield Beach, FL and Basel, Switzerland.*

Guy, E. J., Vettel, H. E. and Pallancch, M. J. (1971). Effect of lactose in nonfat dry milk and cheese whey solids on sponge bread loaf volume and yeast activity. *Baker's Digest 45:34.*

Haas, L. W. (1927). Water in baking process. *American Sociologist of Bakery Engineers* 80-81.

Hermansson, A. M. (1973). Determination of functional properties of protein foods, in problems. Human Nutrition Porter. *Academic press, New York.*

Hermansson, A. M., Olsson, I. and Holmberg, B. (1974). Functional properties of products for foods - modification studies on rapeseed protein concentrates, *Lebensm, Wiss. U. Technology 7: 176.*

Hermansson, A. M. and Akesson, C. (1975). Functional properties of added proteins correlated with properties of meat systems: Effect of various parameters. *Journal of Food Science 40:* 595, 603, 611.

Hibbered, G. E. and Parker, N. S. (1975). Measurement of the fundamental rheological properties of wheat flour doughs. *Cereal Chemistry Journal 52.* (3II) Ir.

Holmes, J. T. (1966). Wheat flour proteins and their functional properties. *Baker's Digest 40:* 38.

Holmes, J. T. and Hoseney, R. C. (1987). Chemical leavening : effect of pH and certain ions on bread making properties. *Cereal Chemistry Journal 64:* 343-47.

Hoseney, R. C. and Finney, P. L. (1974). Mixing; a Contrary view. *Baker's Digest 48:* 22.

Hoseney, R. C., Drade, P. and Finley J. W. (1985). Soft wheat products. In: Wheat chemistry and technology chp7, 407-408. *AACC, Saint Paul, Minnesota.*

Hoseney, R. C., Drade, P. and Finley, J. W. (1988). Soft wheat products. In: Wheat Chemistry and Technology p407-456, *AACC, Saint Paul, Minnesota.*

Hugunin, A. G. (1984). Functionality of WPC's in processed cereal products. In: dairy products for the cereal processing industry. *AACC, Saint Paul, Minnesota.*

International Dairy Federation (IDF) Bulletin (1992). (274) page 11.

Jack, E. L. and Haynes, V. M. (1951). Consumer preference for bread containing different levels of nonfat dry milk solids. *Food Research 16:* 1-5.

Janine, J. (1984). Colloids and Surfaces. *Journal of Dairy Nutrition 10:* 1.

Joudi, S. A. (1992). Development of Cheese Flavoured Croissant. Thesis presented in partial fulfilment of the requirement Post Graduate study in Food Technology Department, *Massey University, New Zealand.*

Kamat, V. B., Lawrence, G. A., Hart, C. J. and Yoll, R. (1973). Contribution of egg yolk lipoproteins to cake structure. *Journal of the Science of Food and Agriculture 24:* 77.

Kamel, B.S. and Rasper, V.F. (1986). Comparison of precision penetrometer and baker compressimeter in testing bread crumb firmness. *Cereal Foods World 31:* 269.

Kamel, B.S. (1987). Bread Firmness measurement with emphasis on baker compressimeter. *Cereal Foods World 32:* 472 - 475.

Kasarda, D. (1970). Conformational structure of wheat proteins. *Baker's Digest 44:* 20.

Kim, S. K. and D'Appolonia, B. L. (1971). The role of wheat flour constituent in bread staling. *Baker's Digest 51:* 38,44,57.

Kim, S. K. (1977)a. Bread staling studies I. Effect of protein content on staling rate and bread crumb pasting properties. *Cereal Chemistry Journal 54:* 207-215.

Kim, S. K. (1977)b. Bread staling studies II. Effect of protein content and storage temperature on the role of starch. *Cereal Chemistry Journal 54:* 216-224.

Kim, S. K. (1977)c. Bread staling studies III. Effect of penetration on dough, bread and bread staling rate. *Cereal Chemistry Journal 54:* 225-229.

Kinsella, J. E. (1982). Food protein. p51-104, *Applied Science Publishers, London and New York.*

Kinsella, J. E. (1985). Milk proteins: physco-chemical and functional properties. *Chemical Rubber Company Critical Reviews in Food Science and Nutrition 21:* 197-262.

Knightly, W. H. (1973). The evaluation of softeners and conditioners used in baked foods. *Baker's Digest 47:* 64.

Kulp, K., and Ponte, J. G. (1981). Staling of white pan bread: Fundamental causes. *Chemical Rubber Company Critical Reviews in Food Science and Nutrition 15:* 1-48.

Kunerth, W. H. and D'Appolania, B. L. (1985). Use of the mixograph and Farinograph in wheat quality evaluation. In rheology of wheat products. H. Faridi the editor, *AACC. The Publisher Saint Paul, Minnesota.*

Krull, L.H. and Wall, J.S. (1969). Relationship of amino acid composition and wheat protein properties. *Baker's Digest 43:* 30.

Leung, H. K., Matlock, J. P., Meyer, R. S. and Morad, M. M. (1984). Storage stability of a puff pastry dough with reduced water activity. *Journal of Food Science 49:* 1405-1409.

Mac Ritchie, F. (1984). Studies of the methodology for fraction and reconstitution of wheat flours. *Journal of Cereal Science 3:* 221-230.

Mangoffin, C. D. and Hoseney, A. C. (1974). A review of fermentation. *Baker's Digest 45:* 22,26-27.

Maleki, M., Hoseney, R. C. and Mattern, P. J. (1980). Effects of loaf volume, moisture content, and protein quality on the softness and staling rate of bread. *Cereal Chemistry Journal 57:* 138-140.

Mann, E. J. (1980). Use of dairy ingredients in bakery products. *Dairy Industries International 45*:33-39.

Mathason, I. J. (1978). pH and T.T.H determinations for fermentation control. *Bakers Digest 52:* 10.

Matz, S. A. (1972). Bakery Technology and Engineering. Chp11, *AVI publishing Company. Westport, Connecticut, USA.*

Matz, S. A. (1989). Technology of the materials of baking. *AVI publishing Company. Westport, Connecticut, USA.*

Mechan, D. K. (1973). Wheat and flour proteins. *Baker's Digest 47:* 24.

Mertens, M.H., (1969). Functions of dairy ingredients in baking. *Baker's Digest 43:* 57-60.

Modler, H. W. (1985). Functional properties of non-fat dairy ingredients. A review modification of products containing casein. *Journal of Dairy Science 68:* 2195-206

Morrison, W.R. (1978). Wheat lipid composition. *Cereal chemistry Journal 55:* 548-558

Muschel Khautz, E. and Heckenbach, M. (1980). Rheological measurements in chemical practice, vol.2, (in German) *Springer: Berlin.*

New Zealand Dairy Board Bulletin (NZDB), (1990). Butter Croissants: A Technical guide to manufacture. *Technical bulletin No. T105.*

Pace, C. N. (1975). The stability of globular proteins. *Chemistry Rubber Company Critical Reviews in Biochemistry 3:* 1-43.

Parkinson, C. J. (1984). Uses for dairy ingredient in baked products. *Journal of the Society of Dairy Technology 37:* 125-7.

Peterson, M. and Johnson, A.H. (1978). Encyclopedia of Food Science, *The AVI Publishing Company Inc. WestPort, Connecticut.*

Pomeranz, Y. (1985). Wheat flour lipids - what they can and cannot do in bread. *Cereal Food World 30:* 443-446.

Pomeranz, Y. (1988). Wheat Chemistry and Technology. Vol.II p167. *AACC Monograph Series.*

Pyler, E. T. (1983). Flour proteins role in baking performance. *Baker's Digest 57*: 24-33.

Pyler, E. T. (1988). Functions of salt in dough: In Baking Science and Technology , vol.1, p581-584, *Sosland the publishing Company. 9000W, 67th Street, Merriam, Kansas 66202.*

Pyler, E. T. (1990). Baking Science and Technology, vol 1. *Siebel Publishing Company. Chicago II.*

Rose, D. (1969). A proposed model of micelle structure in bovine milk. *Dairy Science Abstract 31:* 171.

Ruettimann, K. W. and Ladisch, M. R. (1987). Casein micelles structure, properties and enzymatic coagulation, enzyme microbiology. *Technology 9:*

Salsbury, N. (1988). Fermented Milk Products as Food Ingredients. *Journal of Dairy Industries International 54:* 40-43.

Sanchez, H., Bachetta, R. and Castelao, E. (1981). Protein forti-faction of French-type bread with whey protein concentrate. *Bulletin of the International Dairy Federation (IDF). Bakery products subject 6a:* May p51.

Sanderson, W. B. (1985). Dairy ingredients for the food industry, Cakes, Cookies and biscuits. *International Dairy Federation Newsletter 1.*

SAS. Institute Inc. (1987). SAS User's Guide: Statistics version, 6th ed. *SAS Institute Inc., Gary, N.C.*

Schaap, J. E. (1981). Application of fractionated milkfat as shortening in flour confectionery products. *Bulletin of the International Dairy Federation (IDF). Bakery products subject 6b: May* p51.

Schulz, G. E. and Schirmer, R. H. (1979). Principles of protein structure. *Springer-Verlas. New York and Heidelberg.*

Shaw, M. (1985). Research and Development in the Cheese Industry. Journal of *Dairy Industries International 50:* 18-23.

Shelton, D. R. and D'Appolonia, B. L. (1985). Carbohydrate function in the baking process. *Cereal Foods World 30*: 437-442.

Sherman, P. (1979). Food Texture and Rheology. *Academic press Inc. London.*

Short, A. L. and Roberts, E. A. (1971). Pattern of firmness within a bread loaf. *Journal of the Science of Food and Agriculture 22:* 470.

Slattery, C. W. (1976). Casein micelle structure; An examination of models. *Journal of Dairy Science 59:* 1547.

Stauffer, C. E. (1990). Functional additives for bakery food. *An AVI Book published by Van Nostrand Reinhold, New York.*

Street, C. A. (1991). Flour Confectionery Manufacture. *Blackie, VCH Publishing Inc., New York.*

Strong, L. R (1969). The function properties of salt in bakery products. *Baker's Digest 43*: 55-57.

Sultan, W. J. (1986). Practical Baking, *AVI Publishing Company. Westport, Connecticut, USA.*

Szczeniak, A. S. (1963). Classification of textural characteristics. *Journal of Food Science 28:* 385.

Voisey, P. W. (1971). Modernization of textural characteristics. *Journal of Food Science 28:* 385.

Wall, J. S. (1964). Cereal proteins. In proteins and their reactions. p315. *AVI Publishing Company, Westport, Connecticut, USA.*

Walker, C. E., West, D. I., Pierce, M. M. and Buck, J. S. (1987). Cake Firmness measurement by the Universal Testing Machine. *Cereal Foods World 32:* (7)477.

Wehrli, H. P. and Pomeranz, Y. (1969). The role of chemical bonds in dough. *Baker's Digest 43:* 12

Weipert, D. (1990). The benefits of basic rheometry in studying dough rheology. *Cereal Chemistry Journal 67:* 311.

Whitney, R. M., Brunner, D. R., Ebner, K. E., Farrell, H. H., Jr, Josephson, R. V., Morr, C. V. and Swainsgood, H. E. (1976). Nomenclature of proteins of cow's milk. *Journal of Dairy Science 59:* 795.

Zadow, J. G. and Hardham, J. F. (1981). Studies on the use of WPC's in bread. *The Australian Journal of Dairy Technology 36: 60-63.*

Zadow, J. G. and Hardham, J. F. (1984). Measurement of the effect of WPC's on fermenting dough by the instron tester. *The Australian Journal of Dairy Technology 36:*56-59.