DEVELOPMENT OF FROZEN YOGHURT WITH FLAKED CEREAL

BY

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DECLARATION

The work described in this thesis carried out by me at the Newdale Dairies (Pvt.) Ltd. 100, Delgoda Road, Biyagama under the supervision of Mr. N.S. Pathirana and Mr. Jagath Wanshapala. A report on this has not been submitted to another university for another degree.

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Affectionately Dedicated

To

My beloved Parents

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Abstract

Frozen yoghurt with flaked cereal is a new approach of dairy product to the dynamic market. Frozen yoghurt is a fermented dairy product, which tastes much like ice – cream. Flaked cereal is added to the frozen yoghurt to enhance the consumer acceptability. The special features of frozen yoghurt are its high nutritive value with all the benefits of fermentation. Because of its added value of low fat and low calories, it is a fantastic product for health conscious people looking for a healthy treat.

Frozen yoghurt was prepared by mixing both ice – cream base mix and plain yoghurt together. Mixing amount of plain yoghurt with ice – cream base mix affected to the organoleptic properties of the final product. The aim of this project was to identify the level of plain yoghurt to be mixed in the manufacture of frozen yoghurt and to maintain the crispiness of flaked cereal within the product. Some treatments were applied to find the desirable level of plain yoghurt. A sensory evaluation was carried out to determine the preference of above treatments and to determine the acceptability of texture of flaked cereal. Physiochemical tests such as fat, total solids, milk solid non – fat, titrable acidity, pH and brix value determination were carried out to measure the composition of the product. Coliform counting and Yeast & Mould counting were done as microbiological tests to determine the shelf life of the product.

Based on the results, it concluded that the frozen yoghurt with 40% plain yoghurt is the most preferable product. It contains desirable acidity level and the product is creamier in taste. The physiochemical tests indicate that there is 3.5% of fat, 33.27% of total solids and 11.20% of milk solid non – fat in the frozen yoghurt. Also the results indicate the desirable pH value of frozen yoghurt is 4.85 and the acidity is 0.29%. The texture of the added flaked cereal was not accepted by the sensory panel. Because of the moisture absorption, crispiness of the flaked cereal could not be maintained in the frozen yoghurt.

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CHAPTER 1

1. Introduction.

Milk is an important food and milk and milk products gain demand because of its nutritional and organoleptic properties. Milk contains almost all the nutrients such as carbohydrates, fat, protein, vitamins and minerals. However, milk can be spoiled readily due to microbial activity. Because of this, people try to preserve it by converting milk to milk products. There are various types of milk products as fluid milk products, fermented milk products, concentrated milk products and frozen milk products. And also there is a combination of these product types like fermented fluid milk products, frozen concentrated milk products and fermented frozen milk products.

Various dairy products are intentionally frozen as a means of preservation. Intentional freezing is practiced in the manufacture of ice – cream, sherbet and other dairy confections for the purpose of creating a food product to be consumed in the frozen state. Ice – cream is a frozen dairy product loaded with saturated fat and calories. High saturated fat and calories may cause coronary diseases. Nowadays consumers prefer desserts or snacks with low fat and low calorie content.

Development of fermented frozen milk product may provide a solution to overcome this situation. Frozen yoghurt is a fermented frozen milk product, which tastes much like ice – cream and actually tastes like real yoghurt with an acid tang. Frozen yoghurt is produced by mixing the plain yoghurt and ice – cream base mix, which are prepared separately according to the standard methods. Mixing amount of plain yoghurt with ice – cream base mix affects to the organoleptic properties of the final product. Plain yoghurt is the most demanded and popular fermented milk product. Two microorganisms, *Streptococcus thermopiles* and *Lactobacillus bulgaricus*, growing together symbiotically are responsible for the lactic acid fermentation and yoghurt flavour.

Frozen yoghurt contains real, natural, beneficial yoghurt cultures namely Acidophilus and Bifidobacteria, which are probiotic and said to aid digestion. Because of low fat and low calories, frozen yoghurt is a good product for health conscious people who are looking for a healthy treat. Frozen yoghurt can be consumed in frozen state like ice – cream and as a dessert it can be served in cups, cones or a bowl. Frozen yoghurt could be divided into soft and hard frozen types based on the nature of ice crystals in the product. The mix intended for soft serve frozen yoghurt is differs somewhat from that of the hard frozen type.

Frozen yoghurt can be prepared by adding many flavours such as vanilla, chocolate, strawberry, pineapple and orange. Apart from the flavours, toppings such as nut crunch, honey and flaked foods can be added to enhance the consumer acceptability. Flaked cereals tend to absorb moisture from the product and become soggy. Because of this, the texture of flaked cereal should be maintained within the product.

Objectives:

To find out the optimum level of plain yoghurt that could be added for frozen yoghurt.

To find out a suitable method to maintain the crispiness of flaked cereal after adding in to the frozen yoghurt.

CHAPTER 2

2. Review of Literature

2.1. Milk.

Milk is the most important food product for the mammal and has always been the first food of the new born. Milk is as ancient as mankind itself, as it is the substance created to the mammalian infant. (Walstra *et al.*, 1999)

2.1.1. Cow's milk.

Cow's milk is the source of nutrients and immunological protection for the young cow. It contains not less than 8 1/4 % of milk solid non-fat and not less than 3 1/4 % of milk fat. (Webb *et al.*, 1987)

2.1.2. Milk composition.

Milk is the liquid food secreted by mammary gland for the nourishment of the newly born, containing water, fat, proteins, lactose and minerals. The nutritional value of milk is very high. The composition of milk is shown in the table 2.1.

Table 2.1: The composition of milk (per 100g fresh milk)

Component	Value
Protein (g)	3.2
Fat (g)	3.7
Carbohydrates (g)	4.6
Energy (kcal)	66

Source: Agriculture and Agri – food Canada (1997)

2.1.2.1. Milk Protein.

Milk proteins are broadly classified into two groups, casein and whey proteins. Caseins accounts for approximately 80% of total protein and rest 20% are represented by whey proteins. Caseins are basically storage protein and whey proteins are functional proteins. (Clarence, 1993)

2.1.2.2. Milk Fat.

Milk fat consists chiefly of triglycerides of fatty acids. The mixture of mixed triglycerides, which makes up 98 to 99% of milk fat, is peculiar to milk; though quite bland in taste, it imparts smoothness and palatability to fat containing dairy products. The remaining 1 to 2% of milk fat is composed of phopholipids, sterols, carotenoids, the fat-soluble vitamins A, D, E and K, and some traces of free fatty acids. (Webb *et al.*, 1987)

2.1.2.3. Lactose.

Lactose is a characteristic carbohydrate of milk. The lactose in normal cow's milk generally ranges from 4.4 to 5.2%, averaging 4.8% anhydrous lactose. Lactose is a disaccharide that yields α - D – glucose and β - D – galactose on hydrolysis. (Webb *et al.*, 1987)

2.1.2.4. Minerals.

The mineral content of milk is an analytical value indicating the amount of non-combustible matter in milk. In normal milk the value remains rather constant at about 0.7%. (Webb *et al.*, 1987)

2.1.2.5. Minor components of milk.

In addition to the major constituents, milk contains a number of constituents, which are of minor importance, particularly with regard to the proportion in which they occur in milk. The minor components of milk are phospholipids, cholesterol, pigments, enzymes of milk, vitamins, gases and non-protein nitrogenous substances. (Webb *et al.*, 1987)

2.2. Frozen Milk Products.

Various dairy products are intentionally frozen as a means of preservation. Intentional freezing is practiced in the manufacture of ice - cream, sherbet and other dairy confections for the purpose of a creating a food product to be consumed in the frozen state. (Webb *et al.*, 1987)

2.2.1. Ice - cream.

Ice - cream is a palatable, nutritious and healthful food. Ice – cream probably evolve from the iced beverages and water ices in Europe during medieval times and the ice – cream industry developed mainly in the United States. In recent years, the ice – cream production has increased rapidly in many countries of the world. (Singh *et al.*, 1997)

2.2.2. Definition of ice – cream.

Ice – cream is a frozen dessert, which is made by freezing a pasteurized mix with agitation, which incorporates air and ensures uniformity of consistency. The mix consists of a combination of milk products, sweetening materials, water, stabilizer and other optional ingredients with the exception of air and flavouring material. (Singh *et al.*, 1997)

2.2.3. Composition of ice – cream.

The composition of ice – cream is usually expressed as percentage of its constituents. The composition of ice – cream varies in different markets and in different locations and the percentage of fat varies more than any other constituents. Proximate composition of ice – cream is shown in the table 2.2.

Table 2.2: Proximate Composition of ice – cream.

Constituents	Percent values	
	Range	Average
Fat	8 – 20	12
Milk solid non - fat	8 – 15	11
Sugar	13 – 20	15
Stabilizer	0 – 0.7	0.3
Total solids	36 - 43	38.3

Source: Singh *et al.*, (1997)

2.2.4. Ingredients for ice – cream.

The ingredients, which are commonly used in ice – cream, can be grouped into two categories, via (a) dairy products and (b) non - dairy products.

The dairy products group includes products like fluid milk, cream, condensed milk, non – fat dry milk, butter and butter oil. The non – dairy group comprises of sweeteners, stabilizers, emulsifiers, colour, flavour and water. These basic ingredients of mix serve important functional properties in ice – cream. (Singh *et al.*, 1997)

2.2.4.1. Milk and Milk products.

Milk and Milk products are the principal ingredients used in manufacturing ice – cream. They are the source of milk fat and milk solids non – fat and furnish approximately 60% of total solids of the ice – cream mix. (Clarence, 1993)

2.2.4.2. Milk Fat.

Milk fat is the most important component of ice – cream that affects quality. It contributes a characteristic richness and mellowness to the flavour of ice – cream. It imparts smoothness to the texture, which is difficult to obtain by any other means. Fat also contributes to the body and melting resistance of ice – cream. (Singh *et al.*, 1997)

2.2.4.3. Milk solids non – fat.

Milk solid non – fat are high in food value and relatively cheap. The non – fat milk solids, besides contributing to the flavour, body and texture are essential for the formation and maintenance of small, stable air cells. (Webb *et al.*, 1987)

Milk solid non – fat includes protein, milk sugar and mineral matter. The proteins help to make the ice – cream more compact and smooth. Milk sugar adds to the sweet taste largely produced by added sugar and minerals impart a slightly salty taste. (Singh *et al.*, 1997)

2.2.4.4. Sweeteners.

The sweetness of ice – cream is contributed by sucrose, corn sweeteners and to a slight degree by lactose. The most common sweeteners used in commercial ice – cream are cane and beat sugar. Corn sugar, corn syrup or maltose syrup and honey can be used to sweeten ice – cream or as substitutes for a portion of the common sugar required. (Clarence, 1993)

Sugars increase the viscosity and the total solids in the mix. This improves the body and the texture of ice – cream, provided the total solids content does not exceed 42%. Most ice – cream is now made with some type of corn sweeteners as a partial replacement for sucrose. Those products result from the hydrolysis of cornstarch by either an acid or an enzyme, or both. The degree of hydrolysis is expressed as the Dextrose Equivalent, or DE. Complete hydrolysis yields D – glucose, which has a DE of 92. High DE syrups are more economical sources of sweeteners than lower DE products because they are sweeter and less is required per lb of sucrose replacement. (Webb *et al.*, 1987)

2.2.4.5. Stabilizers.

The ice – cream stabilizers, locust bean gum, guar gum, carboxymethyl cellulose, sodium alginate, carrageenan and xanthan are a group of ingredients used commonly in ice – cream formulations. They are usually integrated with the emulsifiers in proprietary blends. The primary purposes of using stabilizers in ice – cream are to produce smoothness in body and texture retard to reduce ice and lactose crystals, growth during storage and to provide uniformity of product and resistance to melting. Additionally they stabilize the mix to prevent wheying off, produce stable foam with easy cut – off at the barrel freezer and slow down moisture migration from the product to the package or the air.

Stabilizers increase viscosity, have no effect on the freezing point and with a few exceptions, tend to limit the whipping ability. They prevent the development of coarse texture under temperature fluctuations in retail cabinets. (Singh *et al.*, 1997)

2.2.4.6. Emulsifiers.

Emulsifiers play an important role during freezing and aeration of the mix. Incorporation of emulsifiers in the mix improves and provides uniform whipping quality and produces drier ice – cream with a smoother body and texture. Monoglycerides, diglycerides or both are commonly used emulsifiers in the ice – cream. (Singh *et al.*, 1997)

2.2.4.7. Total solids.

Total solids increase the nutritive value and viscosity by reducing the water content in the mix. They improve the body and texture of ice – cream. Increase in total solids content decrease the amount of frozen water and permits a higher overrun. (Singh *et al.*, 1997)

2.2.4.8. Flavour/Colour.

Flavour and colour of ice – cream influence the consumer appeal. A good flavour enhances the acceptability while a matching colour improves the aesthetic appeal of the product. Vanilla, Chocolate, Fruit extract, nuts and caramel are commonly used flavours in ice – cream. (Singh *et al.*, 1997)

2.2.5. Ice – cream production process.

The basic production process of ice – cream is summarized in the fig. 2.1.

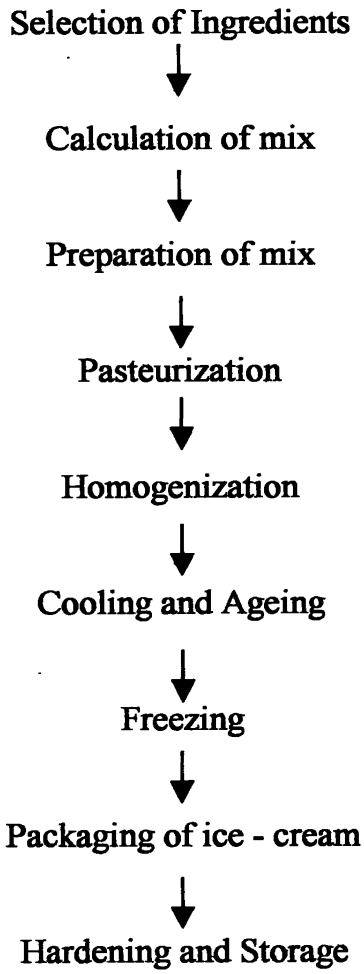

Fig. 2.1 Flow diagram for preparation of ice – cream

Source: Singh *et al.*, 1997

2.2.5.1 Selection of Ingredients.

The selection of ingredients for ice – cream depends on the availability, perishability of the ingredients, convenience in handling, effect on the flavour, body and texture of ice – cream, cost and equipment. It must be ensured that all the ingredients have been carefully produced and handled. (Singh *et al.*, 1997)

2.2.5.2. Calculation of mix.

The knowledge of calculation of ice – cream ingredients is important because the quality of ice – cream depends upon the right proportion of various ingredients. It also helps in properly balancing a mix, in establishing and maintaining uniform quality and in producing ice – cream that conforms to legal standards.

For calculation of a mix, information on the following points is required.

i. Composition of the mix to be made.
ii. Amount of mix in the batch to be made.
iii. Available materials, their contribution to quality characteristics of ice – cream and composition.
iv. Cost.

(Singh *et al.*, 1997)

2.2.5.3. Preparation of mix.

Ice – cream mix preparation is a multi – step process involving the blending and dispersing of a variety of liquid and solid ingredients into a homogenous fluid product that is pasteurized, homogenized and cooled. (Webb *et al.*, 1987)

2.2.5.4. Pasteurization of mix.

Proper pasteurization consists in rapidly heating the mix to a definite temperature, holding it at that temperature for a definite minimum period of time. More heat is required to effectively pasteurize ice – cream mix than milk because of its relatively high total solids content and greater viscosity. (Webb *et al.*, 1987)

Mix pasteurization may be accomplished by the batch method, high temperature – short time or other approved procedures. In high temperature – short time procedure, the practice is to pasteurize at 80 °C for not less than 25 seconds. (Singh *et al.*, 1997)

2.2.5.5. Homogenization of mix.

Ice – cream mix is homogenized to reduce the size of the fat globules and to create a high degree of fat dispersion. The main purpose of homogenization is to make a permanent and uniform suspension of the fat by reducing the size of the fat droplets to a very small diameter, preferably not more than two microns.

Homogenization is accomplished by forcing the mix through a small orifice under suitable conditions of temperature and pressure, using a positive displacement plunger pump to furnish the pressure. The mix is usually homogenized at temperatures ranging from 63 to77 °C (145 to170 °F) using a double stage homogenizer. A pressure of 2500 to 3000psi in the first stage and 500psi in the second stage is used for efficient homogenization of the mix. (Singh *et al.*, 1997)

2.2.5.6. Cooling and ageing of mix.

Cooling the mix below 5°C (40 °F) immediately after homogenization and before ageing is essential. If the mix is not cooled properly, it will become very viscous and the resultant Ice – cream will not melt down smoothly. Also cooling below 5 °C retards the growth of bacteria.

The mix after being homogenized and cooled is aged for a period of 4 to 24 hrs. Ageing refer to holding the ice – cream mix at low temperature before freezing. It improves the body and texture of ice – cream. In addition, ageing helps to improve the whipping capacity of the mix and confers melting resistance to ice – cream. (Singh *et al.*, 1997)

2.2.5.7. Freezing of mix.

Freezing the mix is one of the most important operations in ice – cream making as it controls the quality, palatability and yield of the finished product. The function of the ice – cream freezer is two fold. The ice – cream mix is partially frozen and at the same time air is incorporated or whipped into the mass. The expansion or increase in volume of mix as it is frozen is technically referred to as "overrun".

The result of a proper amount of well distributed air, coupled with small ice crystals, is a fine grained palatable product. Ice – cream of low overrun tends to be dense and soggy; if the overrun in ice – cream ranges from 40 to100%. (Webb *et al.*, 1987)

2.2.5.8. Packaging of ice – cream.

Ice – cream from the freezer is drawn in containers, which give it the desired shape and size for convenient handling during the hardening and marketing processes. The packages used for ice – cream should provide it protection against contamination, attractive appeal, ease of handling, opening and enclosure, and ease of disposal. Protection against moisture loss and temperature fluctuation is also desirable. Retail ice – cream is packaged in cups, sticks or bars. Cups may be of paper or cardboard treated with wax or polythene wax. Polystyrene cups are also widely being used. (Singh *et al.*, 1997)

2.2.5.9. Hardening and storage of ice – cream.

The packaged ice – cream should immediately be shifted to the hardening room as it has a semi – fluid consistency and is not stiff enough to hold its shape. Therefore the freezing process is continued without agitation until the temperature of the ice – cream reaches – 18°C or lower, preferably –26°C. It is desirable to get quick-freezing or quick hardening since slow hardening favours large ice crystals and coarseness. (Singh *et al.*, 1997)

2.2.6. Nutritional value of ice – cream.

Although ice – cream is known as a frozen dessert, it is a healthy and nutritious food. It provides all nutrients such as carbohydrates, protein, fat, minerals and vitamins. The nutritional value depends on the composition of the different ingredients. Composition of plain ice – cream is shown in the table 2.3.

Table 2.3: Composition of plain ice –cream

Constituents	Percent value
Water	61.7
Food energy	96.7
Protein	4.1
Fat	12.7
Total Carbohydrate	20.7

Source: Robert (1988)

2.3. Fermented milk products.

Fermented milk is characterized by the accumulation of microbial metabolic products. General requirement for fermented milk production is the conversion of lactose into lactic acid, which has a preservative effect on milk. The low pH of cultured milk inhibits the growth of putrefactive bacteria and other detrimental organisms, there by prolonging the shelf life of the product. Nutritional foods among fermented milk products include cheese, yoghurt, curd, precipitated or isolated milk protein. (Laval, 1995)

2.3.1. Yoghurt.

Yoghurt is a fermented fluid milk product obtains from coagulation of milk by the growth of organisms of *Lactobacillus bulgaricus* and *Streptococcus thermopiles*.

Yoghurt is a semi – solid fermented milk product that originated centuries ago in Bulgaria. It's popularity has grown and is now consumed in most parts of the world. Although the consistency, flavour and aroma may vary from one region to another, the basic ingredients and manufacturing are essentially consistent. (Silva, 1991)

2.3.2. Types of yoghurt.

Yoghurt is broadly categorized into two types according to the method of production viz. set yoghurt and stirred yoghurt. Yoghurt is typically classified as follows,

a. Set yoghurt - Incubated and cooled in the package

b. Stirred yoghurt - Incubated in tanks and cooled before packing

c. Drinking yoghurt - Similar to stirred type, but the coagulum is "break down" to a liquid before being packed

d. Frozen type - Incubated in tanks, concentrated and cooled before being packed

e. Concentrated type - Incubated in tanks, concentrated and cooled before being packed

Major categories of set yoghurt are:

a. Full - fat

b. Low - fat

c. Non - fat

The above categories can be further divided as follows according to the flavours, additives and other methods used.

a. Plain yoghurt
b. Sweetened or flavored yoghurt
c. Fruit yoghurt
d. Salad yoghurt

(Laval, 1995)

2.3.3. Standards for yoghurt.

Full – fat yoghurt should contain not less than 3% milk fat, not less than 5% milk solid non - fat and the titrable acidity as lactic acid 0.8 – 1.25%. (Silva, 1991)

The composition of yoghurt is shown in the table 2.4.

Table 2.4: Composition of yoghurt

Constituents	Percent value
Fat	0.5 – 3.0 %
Lactose	3 – 4.5 %
Milk solid non – fat (MSNF)	11 – 13 %
Stabilizer	0.3 – 0.5 %

Source: Laval (1995)

2.3.4. Ingredieants for yoghurt

2.3.4.1. Milk.

Although milk of various animals has been used for yoghurt production in various parts of the world, most of the industrialized yoghurt production uses cow's milk. Whole milk, partially skimmed milk, skim milk or cream may be used. In order to ensure the development of the yoghurt culture the following criteria for the raw milk must be met:

Low bacteria count.

Free from antibiotics, sanitizing chemicals, mastitis milk, colostrums, and rancid milk.

No contamination by bacteriophages. (Walstra *et al.*, 1999)

2.3.4.2. Other ingredients.

Other dairy products	: Concentrated skim milk, Non fat dry milk, Whey and Lactose
Sweeteners	: Glucose or Sucrose, High – intensity sweeteners
Stabilizers	: Gelatin, Carboxymethyl cellulose, Locust bean gum, Alginates, Carrageenan, Whey protein concentrates.
Flavours	: Vanilla, Strawberry, chocolate

(Walstra *et al.*, 1999)

2.3.4.3. Starter culture.

The starter culture for most yoghurt production is a symbiotic blend of *Streptococcus thermopiles* and *Lactobacillus bulgaricus*. Although they can grow independently the rate of acid production is much higher when used together than either of the two organisms grown individually. *Streptococcus thermopile* grows faster and produces both acid and carbon dioxide. The format and carbon dioxide produced stimulates *Lactobacillus bulgaricus* growth. On the other hand, the proteolytic activity of *Lactobacillus bulgaricus* produces stimulatory peptides and amino acids for use by *Streptococcus thermopiles*.

These microorganisms are ultimately responsible for the mixture coagulates during fermentation due to the drop in pH.

The Streptococci are responsible for the initial pH drop of the yoghurt mix to approximately 5.0. The lactobacilli are responsible for a further decrease to pH 4.0.

The following fermentation products contribute to flavour,

Lactic acid
Acetaldehyde
Acetic acid
Diacetyl

(Goff and Hill, 1993)

2.3.5. Yoghurt manufacturing method.

The milk is clarified and separated into cream and skim milk, then standardized to achieve the desired fat content. The various ingredients are then blended together in a mix tank equipped with a powder funnel and an agitation system. The mixture is then pasteurized using a continuous plate heat exchanger for 30 min at 85°C or 10 min at 95°C. These heat treatments, which are much more severe than fluid milk pasteurization, are necessary to achieve the following.

Produce a relatively sterile and conclusive environment for the starter culture.

Denature and coagulate whey proteins to enhance the viscosity and texture.

The mix is then homogenized using high pressure of 2000 – 2500psi. Besides thoroughly mixing the stabilizers and other ingredients, homogenization also prevents creaming and wheying off during incubation and storage. Stability, consistency and body are enhanced by homogenization. Once the homogenized mix has cooled to an optimum growth temperature, the yoghurt starter culture is added. (Herbts, 1995)

A ratio of 1:1, *Streptococcus thermopiles* to *Lactobacillus bulgaricus*, inoculation is added to the jacketed fermentation tank. A temperature of 43°C is maintained for 4-6 hrs under quiescent conditions. This temperature is a compromise between the optimum for the two microorganisms. The titrable acidity is carefully monitored until the titrable acidity is 0.85 to 0.90%. At this time the jacket is replaced with cool water and agitation begins, both of which stop the fermentation. The coagulated product is cooled to 5-22°C depending on the product. The product is now cooled and stored at refrigeration temperature (5°C) to slow down the physical, chemical and microbiological degradation. (Goff and Hill, 1993)

2.3.5.1. Factors affecting the quality of yoghurt.

Numerous factors must be carefully controlled during the manufacturing process in order to produce a high – quality yoghurt with the required flavour, aroma, viscosity, consistency, appearance, freedom from whey separation and long shelf life. Factors are as follows.

Choice of milk
Milk standardization
Milk additives
De aeration
Homogenization
Heat treatment
Choice of culture
Culture preparation
Plant design

(Laval, 1995)

2.4. Frozen yoghurt.

Frozen yoghurt is a frozen dairy dessert, which is popular in U.S.A and other developed countries. It tastes much like ice – cream. This product is a combination of both yoghurt and ice – cream. Frozen yoghurt can be considered as a health food because it is lower in fat and calories than ice – cream.

Frozen yoghurt can be divided into soft – serve and hard frozen types. The mix intended for soft – serve yoghurt is differs somewhat from that of the hard frozen type. Frozen yoghurt can be prepared by adding many flavours such as vanilla, chocolate, orange, pineapple and strawberry. Apart from the flavours, toppings such as nut crunch, honey and flaked foods can be added to enhance the consumer acceptability. (Mann, 1977)

The formula for the manufacture of frozen yoghurt is shown in the table 2.5.

Table 2.5: The formula for the manufacture of frozen yoghurt.

Ingredients	Hard frozen	Soft frozen
Fat (milk)	6%	4%
Sugar	12 – 15%	11 – 14%
MSNF(Milk Solid Non Fat)	12%	10 – 11 %
Stabilizer and Emulsifier	0.85%	0.85%
Water	66%	71%

Source: Silva (1991)

2.4.1. Hard frozen yoghurt.

Hard frozen yoghurt, which is whipped with nitrogen, can be kept in cold storage for 2 – 3 months without any adverse effects on its flavour or texture. As in the case of conventional ice – cream, the yoghurt is pre frozen and whipped in a continuous atmosphere to avoid oxidation problems during subsequent storage. The frozen yoghurt leaves the freezer, which is somewhat lower than the temperature of conventional ice – cream. After freezing, the frozen yoghurt is packed into cones or cups or family size packs in the same way as conventional ice – cream. The packs then go into a hardening tunnel. Distribution requires an unbroken cold chain right up to instant of consumption. (Mann, 1977)

2.4.2. Soft - serve frozen yoghurt.

The term " Soft – serve" is often used to describe fast food, carry out ice – cream or frozen yoghurt served in a cone or cup. More accurately soft – serve is a method of dispensing. Soft – serve gives a much smoother texture, which makes it easier to suck through a straw. This definition expands the terms to include frozen custard, sherbet, sorbet, as well as regular and reduced or non fat ice – cream and frozen yoghurt.

Soft – serve frozen yoghurt is most frequently concern as a light meal, a dessert or a snack. Specialized soft – serve machines add air to a dairy mix and dispense it at temperature between 18F and 21F. The mix for soft – serve yoghurt is packed directly into disposable packages such as conventional milk packs or bag in box. These are then distributed direct to the sales outlets. The economic aspect of soft frozen yoghurt appears to be favourable. (Nicole, 1997)

2.5. Flaked cereal.

Flaked cereal may be divided into two sub categories: flakes made from whole grain or part of whole grains and flakes made from finer materials which must be extruded or agglomerated to produce normal sized break fast cereal flakes. The best example of a flaked cereal made from parts of whole grain is corn flakes. (Fast, 1987)

2.5.1. Corn flakes.

The basic grain raw material used for corn flakes is a product derived from the dry milling of regular field corn. Extruded flakes are flakes, which may be larger in size than what can be, obtain by using whole grains of wheat for instance. The flavour materials would be sugar, salt and malt. In most cases, however an artificial colour will be added to give the finished flake an appetizing golden brown colour.

Corn flakes are available in coarse, medium and fine granulations. These very thin and light corn flakes are milled from yellow corn grits, with no additives. Use to agglomerate with flavouring and colours, then dry to give crunchy, light bits and topping. Also use as an ingredient in candy bars to give a lighter crunchier center core prior to chocolate enrobing. (Fast, 1987)

The major constituents of corn flakes are shown in the table 2.6.

Table 2.6: The major constituents of corn flakes.

Constituents	Amounts per serving
Calories	100
Calories from fat	0
Total fat (g)	0
Protein (g)	2
Total Carbohydrate (g)	24
Sodium (mg)	200
Potassium (mg)	25

Source: Kellogg's (2003)

CHAPTER 3

3. Materials and Methodology.

The research was conducted at the laboratory of the Newdale Dairies (PVT) Limited, 100, Delgoda Road, Biyagama, Sri Lanka.

3.1. Materials.

Frozen yoghurt with flaked cereal was produced by using below mentioned materials.

Whole milk (3.5% fat)

Skimmed milk powder

Sugar

Glucose syrup, DE 42, 75% TS

Dextrose

Butter

Stabilizer (Cremodan SE 30)

Culture (Yoghurt culture, Joghurt V1)

Corn flakes

Water

Vanilla flavour

3.1.1. Apparatus.

Beakers

Spoons

Electric Balance

Blender

Water bath

Lab scale homogenizer

Electric Beater

Pipettes

Incubator

Plastic cups/lids

3.2. Determination of acceptable texture of flaked cereal.

3.2.1. Sugarcoated flaked cereal.

Corn flakes, which were used as a flaked cereal was coated with sugar by dipping them into the boiled sugar solution, which showed 10° brix value.

3.3. Determination of acceptable percent level of plain yoghurt in frozen yoghurt production.

3.3.1. Preparation of frozen yoghurt with flaked cereal.

First the ice – cream base mix and plain yoghurt were prepared separately. Then both of the samples were mixed together percent wisely.

3.3.1.1. Preparation of ice – cream base mix.

The flow diagram for the procedure of preparation of ice – cream base mix is shown in the fig. 3.1.

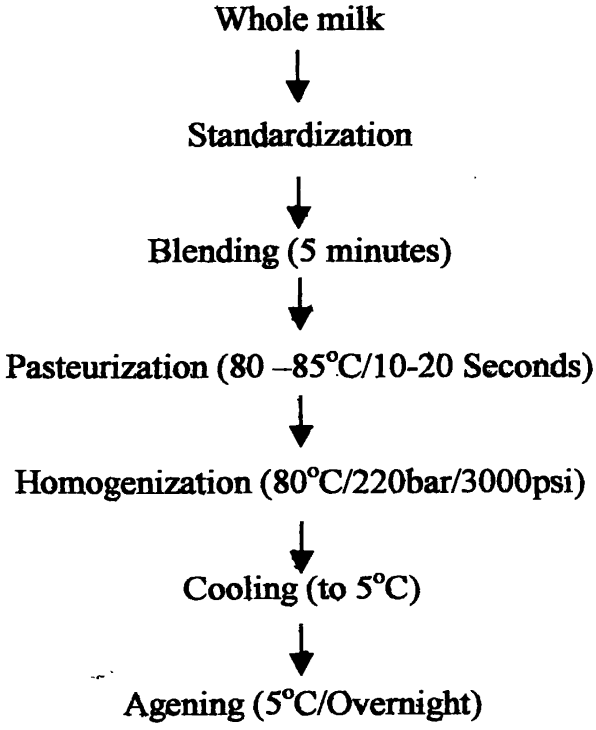

Fig 3.1: Flow diagram for preparation of ice – cream base mix.

3.3.1.2. Preparation of plain yoghurt.

The flow diagram for the procedure of preparation of plain yoghurt is shown in the fig. 3.2.

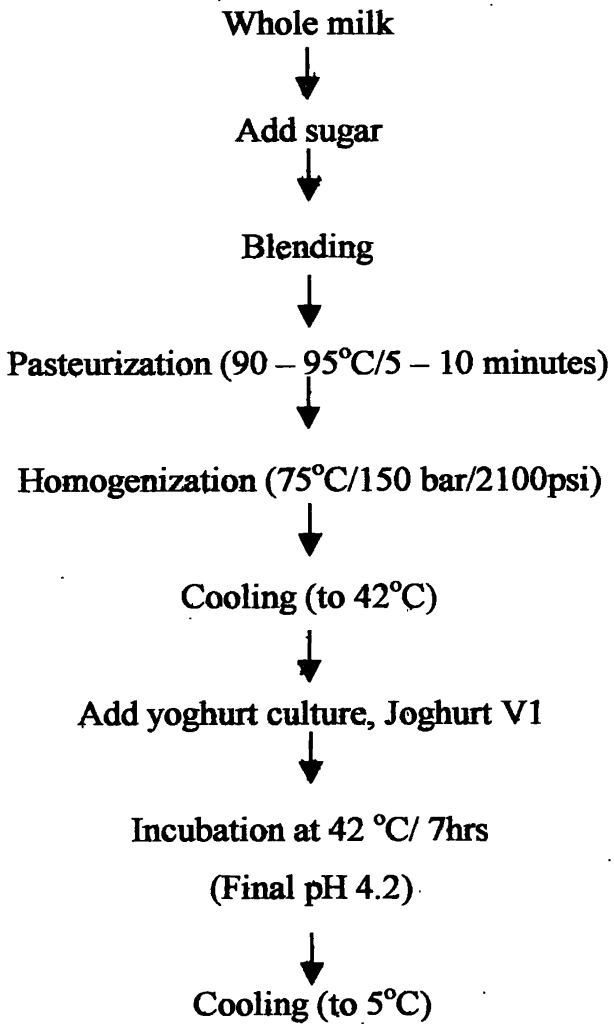

Fig 3.2: Flow diagram for preparation of plain yoghurt.

3.3.1.3. Production process of frozen yoghurt with flaked cereal.

The flow diagram for the procedure of preparation of frozen yoghurt with flaked cereal is shown in the fig. 3.3.

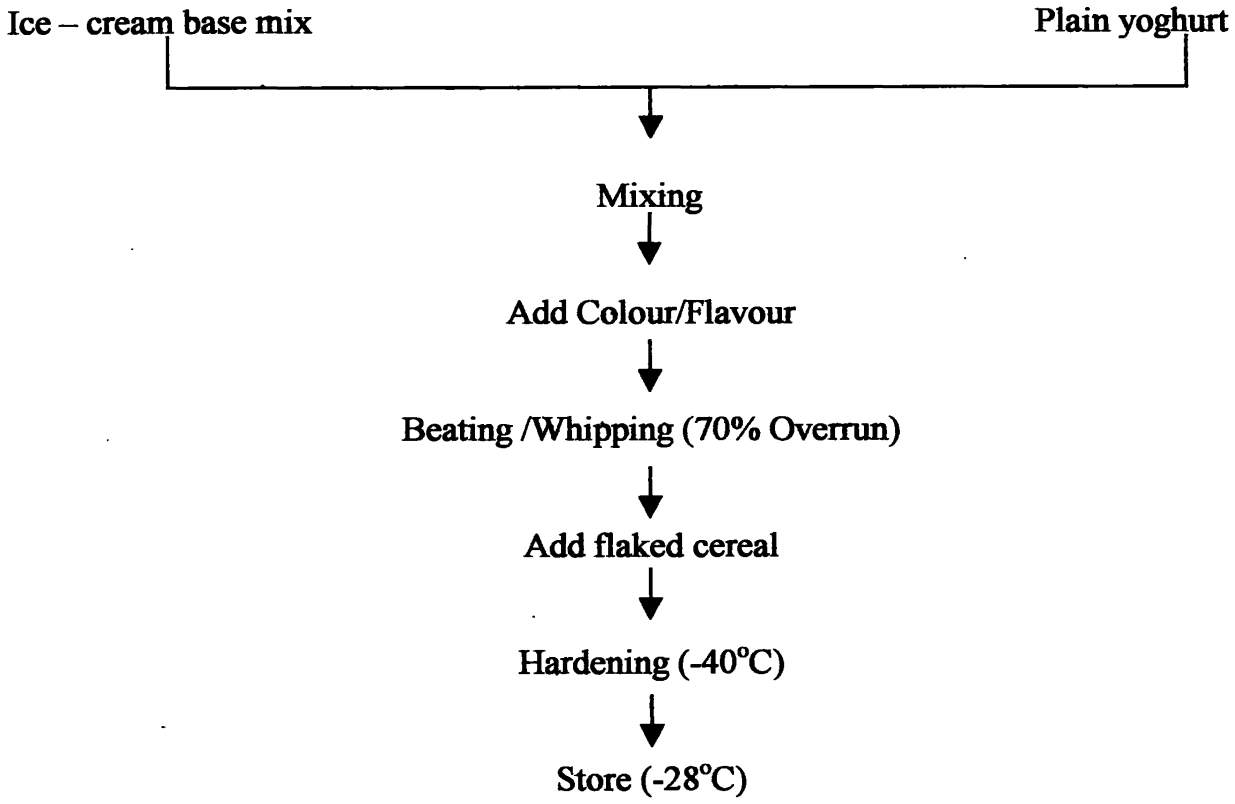

Fig 3.3: Flow diagram for preparation of frozen yoghurt with flaked cereal.

Frozen yoghurt was prepared by mixing plain yoghurt at the levels of 20, 40 and 60 percents with the ice – cream base mix. The treatment levels and their codes are given in the table 3.1.

Table 3.1: Treatment levels and their codes.

Treatment	Treatment code	Plain yoghurt %
1	493	20%
2	327	40%
3	535	60%

3.3.2. Sensory evaluation of the product.

Sensory evaluation was done for the three frozen yoghurt samples, which contain three different levels of plain yoghurt such as 20, 40 and 60 percent levels. Sensory evaluation was conducted by sensory panel at the laboratory of Newdale Dairies (PVT) Limited. Products were tested by 25 panel members. The product quality characteristics like appearance, flavour, colour, texture, mouth feel and overall acceptability were evaluated by using seven point hedonic scale. (Appendix I)

An acceptability of the texture of flaked cereal was also determined at the sensory evaluation.

3.3.3. Statistical analysis.

The results of the sensory evaluation was analyzed by using a non – parametric ' Friedman test' at he computer aided MINITAB statistical package. Friedman test was used due to that the observations were related in same way across the samples.

3.4. Physiochemical analysis of the product.

The selected sample from the sensory evaluation was analyzed for the composition of fat, total solids, milk solid non – fat, titrable acidity, pH and brix value by using standards methods.

3.4.1. Determination of Fat. (Standard Gerber method)

Frozen yoghurt sample was mixed thoroughly by using a teaspoon until it become into the liquid form. Then 10 ml of Gerber sulphuric was added into the Gerber tube and 10.94ml of sample was pipetted and added to it. 1 ml of amyl alcohol was added by using an automatic dispenser. Then the tube was closed with stopper. After mixing thoroughly the tube was subjected to centrifuge at 1100rpm for 5 minutes. Then the tube was kept in a water bath at 65°C for about 3 minutes. The reading was taken directly from the scale of the Gerber tube.

3.4.2. Determination of Total Solids.

Sartorius AG GOTTINGEN MA-30 – 000X3 moisture analyzer was used to detect total solids in final product. This moisture analyzer contain dryer and balance. The balance was zeroed and the drying cover was opened. Then the aluminum pan, which was covered with quarts sand, was mounted on the pan support. After tarring, 1.5g of sample were added on to the pan. The sample was evenly distributed on to pan by using a teaspoon. Then the dryer was closed and start key was pressed. When the dryer switched off automatically the result was indicated on the screen.

3.4.3. Determination of Milk Solid Non – Fat.

10g of prepared sample were weighed into porcelain dish and 1ml of phenolphthalein solution was added to it. Then the sample was titrated with 0.1N Sodium hydroxide until a faint pink colour was observed. The titration was done in a porcelain dish because it was help to detect the colour change easily and accurately. After that 3ml of Formaldehyde solution was added and mixed with glass rod. Then the mix was titrated with 0.1N Sodium hydroxide using phenolphthalein indicator. The burette reading was taken as a V_1 value. Then blank titration was done by titrating 3.0ml of Formaldehyde with 0.1N Sodium hydroxide solution.

MSNF % (by mass) = $5.67 (V_1 - V_2)$

V_1 – Volume of Sodium hydroxide in second titration

V_2 – Volume of Sodium hydroxide in blank titration (Appendix V)

3.4.4. Determination of Titrable Acidity.

Frozen yoghurt was mixed thoroughly by using a teaspoon until it become into the liquid form. Then 9ml of the sample was taken into a white porcelain dish and 3 drops of 1.5% phenolphthalein solution was added to it by using the dropper bottle. Then the sample was titrated with 0.1N Sodium hydroxide until a permanent very pale pink colour was observed. The burette reading was taken and the result was expressed in terms of percentage. Titration was done in a porcelain dish to detect an accurate colour change.

Titrable acidity = V/10

V – Burette reading (Appendix V)

3.4.5. Determination of pH.

pH was determined by using a METTLER TOLEDO MP 220 pH meter, which equipped with a glass electrode. 25ml of sample was got into a glass beaker and it was allowed to stand 2 – 5 minutes at 20°C. pH probe was dipped into a sample and then pH meter display the reading.

3.4.6. Determination of Brix.

The brix value was determined by using ABBE Refractometer Type – 1T. Brix is specially designed for checking the sugar content like sucrose, lactose in the product.

3.5. Shelf Life Evaluation.

Shelf life was evaluated by storing the product under cold room condition (-28°C), measuring the acidity, pH, Coliform and Yeast & Mould count at 7 days intervals.

3.5.1. Acidity and pH development during storage.

Acidity and pH of the samples were checked at 7 days intervals during time at -28°C with two replicates for about 42 days. Data were analyzed by using MINITAB statistical package.

3.5.2. Microbiological analysis.

Frozen yoghurt with flaked cereal was analyzed for Coliform and Yeast & Mould, using standard methods.

3.5.2.1. Coliform counting by direct plating.

One gram of frozen yoghurt from each sample was transferred into sterile petri – dishes. 12 ml of Violet Red Bile Agar (VRBA) at 45°C was poured into each petri- dish followed by mixing the contents by rotating the closed petri – dishes. Then the agar was allowed to solidify at room temperature. This procedure was done under sterilized laminar flow cabinet. The plates were then incubated in an inverted position aerobically 30°C for 24 hours. The colonies were counted using a colony counter and results were expressed as a "Coliform", 'Colony Forming Unit' (C.F.U) per gram. Since it was susceptible that the product is free from Coliform, serial dilution was not done.

3.5.2.2. Yeast & Mould counting method.

According to the New Zealand standards three replicates of 3.33g of frozen yoghurt were transferred into 3 sterile petri – dishes. About 15ml of Potato Dextrose Agar (PDA) at 45°C was poured into each petri – dish followed by mixing the contents by rotating the closed petri – dishes. The agar was then allowed to solidify at room temperature. This procedure was done under sterilized laminar flow cabinet.

3.6. Acceptability of texture of flaked cereal.

An acceptability of texture of flaked cereal by panelists was analyzed by using a pie chart under the MINITAB statistical package.

CHAPTER 4

4. Results and Discussion.

4.1. Results of the product quality characteristics.

Following results were obtained after analyzing the data of sensory evaluation by using a non – parametric 'Friedman test'. The results of an effect of the treatment on product quality characterictics are shown in the table 4.1.

Table 4.1. The effect of the treatment on product quality characterictics.

Quality Characteristics	Sample No	Code No	Plain yoghurt %	Estimated median	Sum of rank
Appearance	1	493	20%	6.000	54.0
	2	327	40%	6.000	58.0
	3	535	60%	5.000	38.0
Flavour	1	493	20%	5.333	54.0
	2	327	40%	5.667	60.5
	3	535	60%	4.000	35.5
Colour	1	493	20%	6.000	50.5
	2	327	40%	6.333	59.0
	3	535	60%	5.666	40.5
Texture	1	493	20%	5.666	53.5
	2	327	40%	6.333	65.0
	3	535	60%	5.000	31.5
Mouth Feel	1	493	20%	5.333	53.0
	2	327	40%	6.000	64.0
	3	535	60%	4.666	33.0
Texture of corn flakes	1	493	20%	5.000	52.5
	2	327	40%	5.000	51.0
	3	535	60%	5.000	46.5
Overall Acceptability	1	493	20%	5.667	54.5
	2	327	40%	6.333	65.0
	3	535	60%	4.000	30.5

Statistically analyzed results help to determine the most appropriate percent level of plain yoghurt for the development of frozen yoghurt. Data from the sensory evaluation was analyzed at 0.05 level of significance. When the probability value of the test is less than the minimum probability value (0.05) the test is significant.

4.1.1. Appearance.

The test for appearance of the frozen yoghurt with flaked cereal resulted that at least one treatment level was significant among the three samples. The treatment code 327, which contains 40% plain yoghurt showed the highest sum of rank value with the highest estimated median for appearance. Therefore this sample comes under the category of 'Like' according to the seven point hedonic scale. (Appendix IV)

4.1.2. Flavour.

The test for flavour of the frozen yoghurt with flaked cereal resulted that at least one treatment level was significant among the three samples. The treatment code 327, which contains 40% plain yoghurt showed the highest sum of rank value with the highest estimated median for flavour. Therefore this sample comes under the category of 'Like' according to the seven point hedonic scale. (Appendix IV)

4.1.3. Colour.

The test for colour of the frozen yoghurt with flaked cereal resulted that at least one treatment level was significant among the three samples. The treatment code 327, which contains 40% plain yoghurt showed the highest sum of rank value with the highest estimated median for colour. Therefore this sample comes under the category of 'Like' according to the seven point hedonic scale. (Appendix IV)

4.1.4. Texture.

The test for texture of the frozen yoghurt with flaked cereal resulted that at least one treatment level was significant among the three samples. The treatment code 327, which contains 40% plain yoghurt showed the highest sum of rank value with the highest estimated median for texture. Therefore this sample comes under the category of ' Like' according to the seven point hedonic scale. (Appendix IV)

4.1.5. Mouth Feel.

The test for mouth feel of the frozen yoghurt with flaked cereal resulted that at least one treatment level was significant among the three samples. The treatment code 327, which contains 40% plain yoghurt showed the highest sum of rank value with the highest estimated median for mouth feel. Therefore this sample comes under the category of 'Like' according to the seven point hedonic scale. (Appendix IV)

4.1.6. Texture of corn flakes.

The test for texture of corn flakes in the frozen yoghurt with flaked cereal resulted that there is no significant difference between three samples. Therefore there is no effect on the texture of corn flakes from the treatment levels. An acceptability of the texture of flaked cereal by the members of sensory panel was evaluated. (Fig. 4.3)

4.1.7. Overall Acceptability.

The test for overall acceptability of the frozen yoghurt with flaked cereal resulted that at least one treatment was significant among the three samples. The treatment code 327, which contains 40% plain yoghurt showed the highest sum of rank value with the highest estimated median for overall acceptability. Therefore this sample comes under category of 'Like' according to the seven point hedonic scale. (Appendix IV)

According to the results of the organoleptic test, sample 327 selected as the best sample, which contain 40% of plain yoghurt. Chemical analysis, Microbial analysis and Shelf life evaluation were done to the selected product.

4.2. Proximate Composition.

Product with 40% plain yoghurt shows the following composition. The proximate composition of the selected frozen yoghurt sample is shown in the table 4.2

Table 4.2: Proximate composition of the product.

Fat (percent)	3.50
Total solids (percent)	33.27
MSNF (percent)	11.20
pH	4.85
Acidity (percent)	0.29
Brix	31°

4.3. Changes during the storage.

4.3.1. Physical changes during the storage at –28°C

There was no any discolouration, gas formation or mould growth observes in the frozen yoghurt after 42 days at –28°C

4.3.2. Acidity and pH changes during the storage at –28°C.

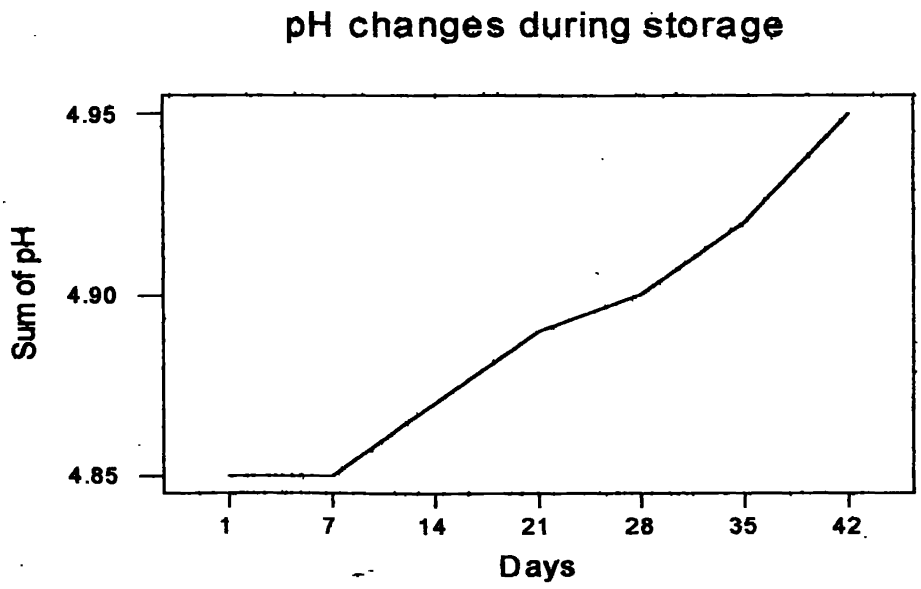

Fig. 4.1: pH changes during storage.

According to the figure 4.1 pH value of the product has increased from 4.85 to 4.95 during the storage at –28°C.

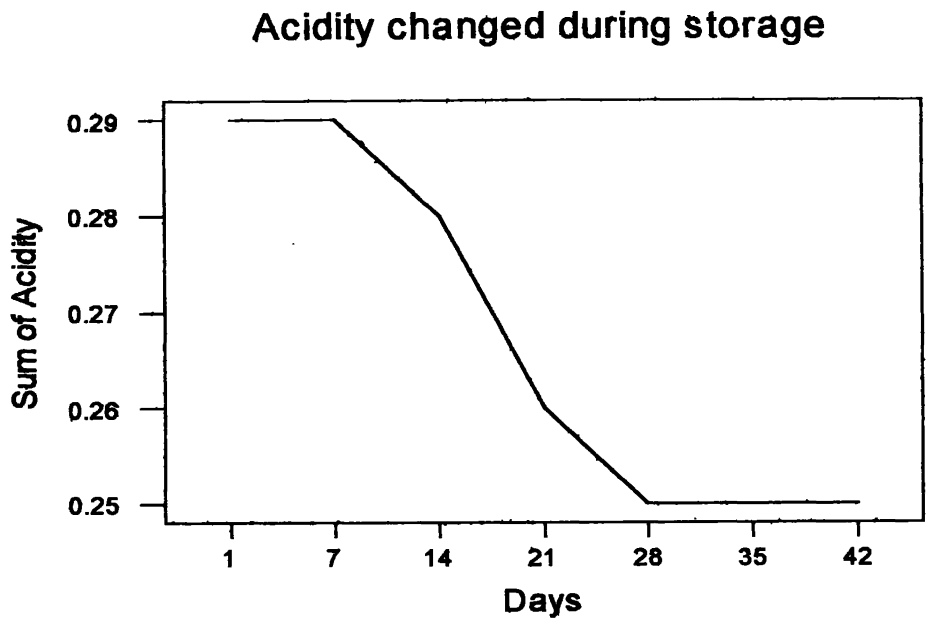

Fig. 4.2: Acidity changes during storage.

According to the figure 4.2 acidity level of the product has decreased from 0.29 to 0.25 during the storage at –28°C.

4.4. Microbial analysis.

4.4.1. Coliform, Yeast & Mould test.

All the values of microbial counts are within the standard limit for yoghurt specified by SLS 824: 1989. Coliform, yeast & mould counts of the product during the storage period are shown in the table 4.3.

Table 4.3: Coliform, Yeast & Mould counts

Days	Coliform	Yeast & Mould
7	No count	No count
14	No count	No count
21	No count	No count
28	No count	No count
35	No count	No count
42	No count	1/g

4.5. Acceptability of texture of flaked cereal.

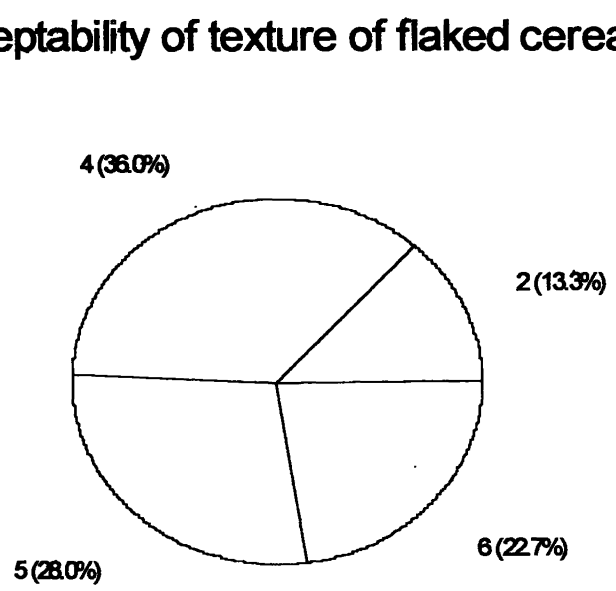

Fig 4.3: Acceptability of texture of flaked cereal

According to the figure 4.3 it can be seen that 13.3% of panelists dislike for texture of flaked cereal in the frozen yoghurt with flaked cereal. 36.0% of the panelists neither like nor dislike and 28.0%, like a little for texture of flaked cereal. There are only 22.7% of like for the texture of flaked cereal.

4.6. Discussion.

Frozen dairy desserts like ice – cream, Sherbet and other dairy confections are manufactured for the purpose of creating a food product to be consumed in the frozen state and also they are intentionally frozen as a means of preservation. Ice – cream is a high fat content food product. Approximately there are about 12% fat, 11% milk solid non – fat, 15% sugar and 38.3% total solids. In the ice – cream production, dairy products like fluid milk, cream, condensed milk, non – fat dry milk, butter and butter oil and the non-dairy products like sweeteners, stabilizers, emulsifiers, colours and flavours are used as basic ingredients.

Yoghurt is a nutritive food that consumed by people all over the world since very ancient times. It is a semi solid fermented milk product, which typically contains 3.9% protein, 3.4% of fat and 4.9% of carbohydrate. The fat content of the yoghurt is very low, when it is compared with the fat level of ice – cream. Due to the conversion of lactose into lactic acid or alcohol during the fermentation, yoghurt is a suitable food for use to the individuals who are suffering from lactose intolerance. (Silva, 1991)

Frozen yoghurt is a combination of two products, yoghurt and ice – cream. It tastes much like ice – cream and actually tastes like real yoghurt. The important of this product is its nutritive value as a fermented dairy product and it is a product with low fat content. In the manufacturing of frozen yoghurt ice – cream base mix and plain yoghurt were mixed together. The added level of plain yoghurt was responsible for the organoleptic properties of the final product. By adding different flavours and toppings, it can be increased the consumer acceptability of the frozen yoghurt.

Toppings like flaked cereals may provide crunchy texture and thereby increase the palatability. In the production of frozen yoghurt with flaked cereal, the problem was to maintain the crispiness of flaked cereal within the product. Flaked cereal was added to the frozen yoghurt immediately before it is transferred to the hardening room, where the temperature is around – 40°C.

Sensory evaluation was conducted to determine the acceptable percent level of plain yoghurt in the manufacturing frozen yoghurt and also to determine the acceptability of the existing texture of flaked cereal in the product of frozen yoghurt with flaked cereal. Data were analyzed by using a non-parametric ranking procedure with 'Friedman test'. Analysis of data obtained by sensory evaluation revealed that the mixing of 40% plain yoghurt to the ice – cream mix was the acceptable level. Low scores were obtained for the samples with 60% plain yoghurt and 20% plain yoghurt. The sample with 60% plain yoghurt was high acidic in flavour and sour in taste. The sample with 20% plain yoghurt was low acidic in flavour and it was very much like to the ice – cream taste.

Acidity of the frozen yoghurt is due to the natural acidity of the milk and partially due to acidity develops by bacterial flora. Shelf life of the selected product was evaluated by determining the acidity and pH development during the storage at –28°C. Acidity of the product was decreased from 0.29% to 0.25% and thereby pH value was increased from 4.85 to 4.95 during 42 days of storage period. The changing amount of acidity and pH value during the storage is not in significant level. Microbial analysis, direct plate counting of the product indicated that the product contain 1g of yeast and moulds up to the 42 days of storage. There was no any coliforms count for the developed product. This was within the standard microbial requirement for yoghurt and ice – cream. (Appendix II, III)

There was no difference occurred in appearance, flavour, colour and texture of the product throughout the storage life. End product analysis indicated that the product contains 3.5% fat, 11.20% milk solid non – fat, 33.27% total solid and 31° brix. Results of data obtained by sensory evaluation revealed that the only 22.7% like to the existing texture of flaked cereal in the frozen yoghurt. Among the others, 13.3% dislike to the texture and 28.0% like a little. Remaining 36.0% neither like nor dislike to the texture of flaked cereal. The texture of flaked cereal was not accepted by the majority of sensory panel. That was because the crispiness of the flaked cereal has become soggy due to the moisture absorption.

CHAPTER 5

5. Conclusion and Recommendations.

5.1. Conclusion.

According to the results obtained it can be concluded that the most acceptable percentage of plain yoghurt for incorporation on frozen yoghurt with flaked cereal is the 40% from the total weight.

The final product specification within prescribed standards with a fair storage life of 42 days or more at –28°C without any deterioration of quality parameters.

The texture of flaked cereal in the product was not acceptable by the majority of the panelists because the crispiness of the flaked cereal has become soggy due to the moisture absorption.

5.2. Recommendations for further studies.

1. A market research should be carried out for frozen yoghurt without flaked cereal to determine the consumer acceptability of the product.
2. Crispiness/Crunchiness of flaked cereal to be improved to retain its crispiness in a frozen food product.

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Appendix I

Sensory Evaluation of Frozen Yoghurt with flaked cereal.

Date .....
Name.....

* Please taste the given 3 samples of **Frozen Yoghurt with flaked cereal** and indicate your score against each sample code.
* The ratings for such samples are given in numeric values ranging from 7 (like very much) to 1 (Dislike very much) as given below.

Like very much 7
Like 6
Like a little 5
Neither like nor dislike 4
Dislike a little 3
Dislike 2
Dislike very much..... 1

Quality Character	Code Number		
	493	327	535
Appearanee			
Flavour			
Colour			
Texture			
Mouth Feel			
Texture of Flaked cereal			
Overall Acceptability			

Comments.....
.....
.....
.....

Thank you.

Appendix II

Standards for yoghurt.

The compositional standards and microbiological limits for yoghurt.

Table 1: Sri Lankan standards for yoghurt.

Character	Yoghurt	Low – fat yoghurt	Non – fat yoghurt
Fat (%) w/w	3 min	0.5 – 3.0	<0.5
MSNF (%) w/w	8 min	8 min	8 min
Titrable acidity (%)	0.8 – 1.25	0.8 – 1.25	0.8 – 1.25

min – minimum

Source: SLS. 824,1989

Table2: Microbiological limits for yoghurt.

Micro organisms	Limits
E – coli	Not more than 1 per gram
Yeast	Not more than 1000 per gram
Moulds	Not more than I per gram

Source: SLS.824, 1989

Appendix III

Standards for ice - cream.

The compositional standards and microbiological limits for ice – cream.

Table 1: Compositional (%) standards for ice – cream in Sri Lanka.

Characteristic	Requirement
Total Solid (%) by mass	32
Fat (%) by mass	08
Milk Solid Non-Fat (%) by mass	08
Acidity (%) by mass	0.25

Source: SLS.223, 1989

Table 2: Microbiological limits for ice – cream.

Micro organisms	Limits
Aerobic Plate Count	Not more than $2.5 * 10^5$ per gram
Coliforms	Not more than $1 * 10^3$ per gram

Source: SLS.223, 1989

Appendix IV

Friedman Test for determination of quality characteristic of the product.

Friedman test for Appearance by Code No blocked by Taster

S = 8.96 DF = 2 P = 0.011
S = 13.37 DF = 2 P = 0.001 (adjusted for ties)

Code No	N	Est. Median	Sum of Ranks
327	25	6.0000	58.0
493	25	6.0000	54.0
535	25	5.0000	38.0

Grand median = 5.6667

Friedman test for Flavour by Code No blocked by Taster

S = 13.46 DF = 2 P = 0.001
S = 15.47 DF = 2 P = 0.000 (adjusted for ties)

Code No	N	Est. Median	Sum of Ranks
327	25	5.667	60.5
493	25	5.333	54.0
535	25	4.000	35.5

Grand median = 5.000

Friedman test for Colour by Code No blocked by Taster

S = 6.86 DF = 2 P = 0.032
S = 11.83 DF = 2 P = 0.003 (adjusted for ties)

Code No	N	Est. Median	Sum of Ranks
327	25	6.3333	59.0
493	25	6.0000	50.5
535	25	5.6667	40.5

Grand median = 6.0000

Friedman test for Texture by Code No blocked by Taster

S = 23.18 DF = 2 P = 0.000
S = 29.34 DF = 2 P = 0.000 (adjusted for ties)

Code No	N	Est. Median	Sum of Ranks
327	25	6.3333	65.0
493	25	5.6667	53.5
535	25	5.0000	31.5

Grand median = 5.6667

Friedman test for Mouth Feel by Code No blocked by Taster

S = 19.76 DF = 2 P = 0.000
S = 23.25 DF = 2 P = 0.000 (adjusted for ties)

Code No	N	Est Median	Sum of Ranks
327	25	6.0000	64.0
493	25	5.3333	53.0
535	25	4.6667	33.0

Grand median = 5.3333

Friedman test for Texture/Corn flakes by Code No blocked by Taster

S = 0.78 DF = 2 P = 0.677
S = 3.55 DF = 2 P = 0.170 (adjusted for ties)

Code No	N	Est. Median	Sum of Ranks
327	25	5.0000	51.0
493	25	5.0000	52.5
535	25	5.0000	46.5

Grand median = 5.0000

Friedman test for Overall Acceptability by Code No blocked by Taster

S = 25.02 DF = 2 P = 0.000
S = 25.79 DF = 2 P = 0.000 (adjusted for ties)

Code No	N	Est. Median	Sum of Ranks
327	25	6.333	65.0
493	25	5.667	54.5
535	25	4.000	30.5

Grand median = 5.333

Appendix V

Analysis of Milk solid non -fat and Titrable acidity of the product.

Determination of Milk solid non - fat

Volume of Sodium hydroxide in second titration (V_1)	= 2.50 ml
Volume of Sodium hydroxide in blank titration (V_2)	= 0.22 ml
Milk solid non - fat (%) by mass	= 5.67 (V_1 - V_2)
	= 5.67 (2.20 – 0.22)
	= 11.20%

Determination of Titrable acidity

Burette reading/Volume of Sodium hydroxide (V)	= 2.90 ml
Titrable acidity (%)	= V/10
	= 2.90/10
	=0.29%

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