Development of Fruit and Nut Ice cream using Tropical almond (Kottamba) as a substitute for Cashew nut

By

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Declaration

The work described in this thesis carried out by me at the Ceylon Cold Stores Ltd, Rannala, Kaduwela and at the Faculty of Applied Sciences, under the supervision of Mr. D.A.M. Arsekularathna and Mrs. R.S. Sabaragamuwa. A report on this has not been submitted to any other degree.

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Affectionately Dedicated

To My

Parents, All of My Teachers

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Abstract

Terminalia catappa (kottamba) is a tropical tree. This is probably indigenous to Andamans and the neighboring islands. It is common along the coast in Sri Lanka and it is also cultivated in home gardens to yield edible fruits and shade. The ripen nuts are drupes coloured yellowish or reddish, ellipsoidal, distinctly compressed, with a porous, fibrous to fleshy pericarp and a hard endocarp, enclosing the edible seed. Ice cream is a frozen and flavoured food product containing milk as the main ingredient. Other ingredients that are included stabilizer, colour, flavour, sugars, fruits, nuts, candies, syrups and water.

The purpose of this study was to develop a fruit and nut ice cream using tropical almond (Kottamba) as a substitute for cashew nut for Ceylon Cold Stores (CCS) Ltd. Due to the high production cost of cashew nut, tropical almond could be incorporated as a substitute to reduce the cost of production of fruit and nut ice cream.

Tropical almond kernels are enclosed hard endocarp, therefore it is difficult to separate the kernels from the nut and the nut contains brown colour seed coating. So it is difficult to incorporate the directly nuts into the ice cream without removing the fibrous seed coating. Several experiments were conducted to remove the outer fibrous coating of the nut in order to impart more consumer attraction. Seeds were blanched in hot water and the seed coating was removed by rubbing. Then seeds were cut into small pieces (1 – 1 ½ cm) thickness and dried at 105 ^{0}C for 1hr until the desired texture was obtained.

A physicochemical assessment of nuts was also performed. According to the results of the proximate analysis, the moisture percentage was 3.6 – 5.2%, the ash percentage was 3.73%, the protein percentage was 9.63% and total fat percentage was 34.06%. Colour, texture, flavour, taste and microbiological parameters (TCC, Yeast and moulds count and Coliform count) were evaluated in fresh nuts, nuts stored at room temperature (28 ± 3 ^{0}C) for 4 days and nuts stored under refrigerator conditions (4 ± 2 ^{0}C) and this experiment was repeated for processed (roasted) nuts, once in a two weeks for 11/2 months. The micro biological examination was conducted according to SLSI standards and also the 3M Petri film technology was used for enumerations.

Optimum nut content was formulated according to internal CCS standards of fruit and nut ice cream and four types of fruit and nut ice creams were made using the different formulations. The best formulated mixture was chosen by carrying out a consumer sensory evaluation and the data were statistically analyzed. After reviewing the results of the sensory analysis, a final formula for the ice cream was re-formulated. The best fruit and nut combination was tropical almond 30.0g: plums 30.0g: ash pumpkin 40.0g.

Colour, texture, flavour, taste and microbiological parameters were evaluated in the final product and there was no organoleptic and microbiological change during period of a storage life of 11/2 month thus rendering the product suitable for marketing.

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Abbreviations

DE	Dextrose equivalents
HFCS	High Fructose Corn Syrup
GRAS	Generally Recognized as Safe
W/V	Weight by Volume
V/V	Volume by Volume
N	Normality
Conc	Concentration
HCl	Hydro Choric acid
L	Liter
ml	Milliliter
^{0}C	Celsius
TCC	Total Colony Count
Kg	Kilo grams
g.	Grams
hr.	Hours
mm	Millimeter
Rs.	Rupees
CCS	Ceylon Cold Stores
ICMSF	International Commission on Microbiological Specifications for Foods
Et al.	And other
HTST	High Temperature Short Time

CHAPTER 01

Introduction

1.1 Introduction

Ice cream is a frozen and flavoured food product containing milk as the main ingredient. This includes whole milk, skimmed milk, cream, frozen cream, condensed milk products and milk solids (Bhandari, 2001).

Other ingredients that are included sugars, stabilizers, flavouring matters and water. Fruits, nuts, candies and syrups are optionally added into ice cream for flavour enrichment. Since ice cream is deficient in proteins, vitamins and mineral salts, it cannot be used as a sole item of food (Arbuckle, and Marshall, 1996).

In ice cream manufacturing first the ingredients are weighted and blended together to produce the "ice cream mix". The mixer is pasteurized and homogenized to form the fat emulsion. There after the mixer is drawn into a flavour tank where liquid flavours, fruit puree, nut and colours were added. The ice cream was packaged and was placed into blast freezer at – 30 ^{0}C to – 40 ^{0}C.

The purpose of this study is to develop a fruit and nut ice cream by using tropical almond (Kottamba) as a substitute of cashew nut. Due to the high production cost of cashew nut, tropical almond (*Terminalia catappa* / Kottamba) is incorporated as a substitute to reduce the cost of production of fruit and nut ice cream and also this experiment was done to development of new product using tropical almond kernels.

Terminalia catappa is a tropical tree. Terminalia catappa (Kottamba) is probably indigenous to Andamans and the neighboring islands. It is common along the coast in Sri Lanka. The seeds contain a fixed oil with olein, palmtin and stearin (Jayaweera, 1981).

The slender racemes are drupes yellowish or reddish, ellipsoidal, distinctly compressed, with a porous, fibrous to fleshy pericarp and a hard endocarp, enclosing the edible seed. The seeds are available in during June-July and to a small extent at other times in the year (Jayaweera, 1981).

1.2 Overall Objective

Studying the potential of replacing tropical almond as a substitute for cashew nut in fruit and nut ice cream.

1.2.1 Specific Objectives

1. Determination of optimum amount of tropical almond to be added into the 11 fruit and nut ice cream.
2. Development of most suitable method to remove the outer fibrous coat of almond.
3. Evaluation of sensory appeal to determine the best product.
4. Shelf life evaluation of fresh and roasted tropical almond nuts.
5. Shelf life evaluation of final product (Ice cream).
6. Comparing cost of production of fruit and nut ice cream with cashew nut and tropical almond.
7. Identification of availability of tropical almond in Sri Lanka for commercial production of almond nuts for ice cream.

CHAPTER 02

Review of Literature

2.1 Ice cream

Ice cream is a frozen and flavoured dairy food product containing milk as the main ingredient. The ingredients includes whole milk, skimmed milk, cream, frozen cream, condensed milk products, milk solids and sugar, dextrose, corn syrup in dry or liquid form, water or other optional ingredients with or without eggs or egg products. Harmless flavouring, colouring and stabilizing or emulsifying agents are added in small quantities (Bhandari, 2001).

2.2 History of Ice Cream

In probable that the Chinese some 3000 years ago were the first to mix snow and fruit juices together to form a dessert, and the Romans may also have used snow to "ice" drinks during summer. Marco Polo is credited with bringing a recipe back from Peking to Venice in 1292, which included frozen milk, and was probably the original sherbet ice (Robinson, 1981).

Ice cream probably came to the US with the early English colonists. In 1851, the first wholesale ice cream industry in the US was established in Baltimore, Maryland, by Jacob Fussell (Bhandari, 2001).

The development of condensed and dry milk, the introduction of the pasteurizer and homogenizer, improved freezers and other preserving equipments accompanied a slow growth in the industry only after 1900. The ice cream soda was introduced in 1879, and ice cream cone and Eskimo Pie were introduced in 1904 and 1921, respectively (Bhandari, 2001).

2.3 Basic Ingredients of Ice Cream and Functions

The selection of good ingredients is the most important factor in the successful manufacture of ice cream. A clean, fresh, creamy flavour in ice cream is obtained by using products which have been carefully produced and handled (Bhandari, 2001).

Ice cream has the following composition:

- greater than 10% **milk fat** by legal definition, and usually between 10% and as high as 16% fat in some premium ice creams
- 9 to 12% **milk solids-not-fat:** this component, also known as the serum solids, contains the proteins (caseins and whey proteins) and carbohydrates (lactose) found in milk
- 12 to 16% **sweeteners**: usually a combination of sucrose and glucose-based corn syrup sweeteners

- 0.2 to 0.5% **stabilizers** and **emulsifiers**
- 55% to 64% water which comes from the milk or other ingredients

These percentages are by weight, either in the mix or in the frozen ice cream. Remember, however, that when frozen, about one half of the volume of ice cream is air (overrun), so by volume in ice cream, these numbers can be reduced by approximately one-half, depending on the actual air content. However, since air does not contribute weight, we usually talk about the composition of ice cream on a weight basis. All ice cream flavours, with the possible exception of chocolate, are made from a basic white mix (Goff, 1995).

2.3.1 Milk fat (or "Butterfat") / Fat

Milk fat or fat in general, including that from non dairy sources, is important to ice cream for the following reasons:

- increases the richness of flavour in ice cream
- produces a characteristic smooth texture by lubricating the palate
- helps to give body to the ice cream, due to its role in fat destabilization
- aids in good melting properties, also due to its role in fat destabilization
- aids in lubricating the freezer barrel during manufacturing (Non-fat mixes are extremely hard on the freezing equipment)

The limitations of excessive use of butterfat in a mix include:

- cost
- hindered whipping ability
- decreased consumption due to excessive richness
- high caloric value

The best source of butterfat in ice cream for high quality flavour and convenience is fresh sweet cream from fresh sweet milk. Other sources include butter or anhydrous milk fat.

During freezing of ice cream, the fat emulsion which exists in the mix will partially destabilize or churn as a result of the air incorporation, ice crystallization and high shear forces of the blades. This partial churning is necessary to set up the structure and texture in ice cream, which is very similar to the structure in whipped cream. Emulsifiers help to promote this destabilization process (Arbuckle and Marshall, 1996).

Five factors of great interest in selection of fat source are,

- The crystal structure of the fat
- The rate at which the fat crystallizes during dynamic temperature conditions
- The temperature-dependent melting profile of the fat
- Especially at chilled and freezer temperatures

- The content of high melting triglycerides (which can produce a waxy, greasy mouth feel) and the flavor and purity of the oil.

Crystallization of fat occurs in three steps: under cooling to induce nucleation, heterogeneous or homogeneous nucleation (or both), and crystal propagation. In bulk fat, nucleation is predominantly heterogeneous, with crystals themselves acting as nucleating agents for further crystallization, and under cooling is usually minimal. However, in an emulsion, each droplet must crystallize independently of the next. For heterogeneous nucleation to predominate there must be a nucleating agent available in every droplet, which is often not the case. Thus in emulsions, homogeneous nucleation and extensive under cooling may be common. Blends of oils are often used in ice cream manufacture, selected to take into account physical characteristics, flavor, availability, stability during storage and cost. Hydrogenation is often necessary to achieve the appropriate melting characteristics. Palm kernel oil, coconut oil, palm oil and fractions thereof, plus their hydrogenated counterparts, can all be used (Goff, 1995).

2.3.2 Milk Solids-not-fat

The serum solids or milk solids-not-fat (MSNF) contain the lactose, caseins, whey proteins, minerals, and ash content of the product from which they were derived. They are an important ingredient for the following beneficial reasons:

- improve the texture of ice cream, due to the protein functionality
- help to give body and chew resistance to the finished product
- are capable of allowing a higher overrun without the characteristic snowy or flaky textures associated with high overrun, due also to the protein functionality
- may be a cheap source of total solids, especially whey powder

The limitations on their use include off flavours which may arise from some of the products, and an excess of lactose which can lead to the defect of sandiness prevalent when the lactose crystallizes out of solution. Excessive concentrations of lactose in the serum phase may also lower the freezing point of the finished product to an unacceptable level.

The best sources of serum solids for high quality products are:

- concentrated skimmed milk
- spray process low heat skim milk powder

Other sources of serum solids include: sweetened condensed whole or skimmed milk, frozen condensed skimmed milk, buttermilk powder or condensed buttermilk, condensed whole milk, or dried or condensed whey. Superheated condensed skimmed milk, in which high viscosity is promoted, is sometimes used as a stabilizing agent but does, then, also contribute to serum solids.

It has recently become common practice to replace the use of skim milk powder or condensed skim with a variety of milk powder replaces, which are blends of whey protein concentrates, caseinates, and whey powders.

The proteins, which make up approximately 4% of the mix, contribute much to the development of structure in ice cream including

- emulsification properties in the mix
- whipping properties in the ice cream
- water holding capacity leading to enhanced viscosity and reduced iciness

(Arbuckle and Marshall, 1996).

2.3.2.1 Lactose Crystallization

1. A decrease in temperature favours rapid crystallization in so far as it increases the super saturation.
2. A decrease in temperature favours slow crystallization insofar as it increases the viscosity, reduces the kinetic energy of the particles, and decreases the rate of transformation from beta to alpha lactose.

Supersaturated state can exist, however, due to extreme viscosity, and it is likely that much of the lactose in ice cream is non-crystalline. Stabilizers help to hold lactose in supersaturated state due to viscosity enhancement. Fruits, nuts, candy - add crystal centers and may enhance lactose crystallization. Nuts pull out moisture from ice cream immediately surrounding the nut thus concentrating the mix.

Citrate and phosphate ions decrease tendency for fat coalescence (Sodium citrate, Di Sodium Phosphate). They prevent churning in soft ice cream for example, producing a wetter product. These salts decrease the degree of protein aggregation. Calcium and magnesium ions have the opposite effect, promote partial coalescence. Calcium sulfate, for example, results in a drier ice cream. Calcium and Magnesium increase the degree of protein aggregation. Salts may also influence electrostatic interactions. Fat globules carry a small net negative charge, these ions could increase or decrease that charge as they were attracted to or repelled from surface (Goff, 1995).

2.3.3 Sugar and Sweeteners

A sweet ice cream is usually desired by the consumer. As a result, sweetening agents are added to ice cream mix at a rate of usually 12 - 16% by weight. Sweeteners improve the texture and palatability of the ice cream, enhance flavors, and are usually the cheapest source of total solids.

In addition, the sugars, including the lactose from the milk components, contribute to a depressed freezing point so that the ice cream has some unfrozen water associated with it at very low temperatures typical of their serving temperatures, -15° to -18° C. Without this unfrozen water, the ice cream would be too hard to scoop.

Sucrose is the main sweetener used because it imparts excellent flavour. Sucrose is a disaccharide made up of glucose (dextrose, cerelose), and fructose (levulose). Sucrose is dextrorotatory - meaning it rotates a plane of polarized light to the right, + 66.5°. With hydrolyzed sucrose the plane of polarization is to the left, "inverted" -20°. An acid, plus water, plus heat treatment, at concentrations above 10%, yields invert sugar and increases the sweetness.

It has become common in the industry to substitute all or a portion of the sucrose content with sweeteners derived from corn syrup. This sweetener is reported to contribute a firmer and chewier body to the ice cream, is an economical source of solids, and improves the shelf life of the finished product. Corn syrup in either its liquid or dry form is available in varying dextrose equivalents (DE). The DE is a measure of the reducing sugar content of the syrup calculated as dextrose and expressed as a percentage of the total dry weight. An enzymatic hydrolysis and isomerization procedure can convert glucose to fructose, a sweeter carbohydrate, in corn syrups thus producing a blend (high fructose corn syrup, HFCS), which can be used to a much greater extent in sucrose replacement (Goff, 1995).

2.3.4 Stabilizer and Emulsifiers

The stabilizers are a group of compounds, usually polysaccharide food gums that are responsible for adding viscosity to the mix and the unfrozen phase of the ice cream. Without the stabilizers, the ice cream would become coarse and icy very quickly due to the migration of free water and the growth of existing ice crystals.

The primary purpose of using stabilizers in ice cream are to produced smoothness in body and texture, retard or reduce ice crystal growth during storage, provide uniformity of product and increase resistance to melting.

An emulsifier is a substance that produces a stable suspension of two liquids that do not mix naturally. The main function of an emulsifier in the manufacture of ice cream is to produce a dry, stiff and smooth product.

Excellent ice cream can be made and considerable amounts are made, without the use of added stabilizer or emulsifier (Arbuckle and Marshall, 1996).

The functions of stabilizers in ice cream are:

- In the mix: To stabilize the emulsion to prevent creaming of fat and, in the case of carrageenan, to prevent serum separation due to incompatibility of the other polysaccharides with milk proteins, also to aid in suspension of liquid flavours.
- In the ice cream at draw from the scraped surface freezer: To stabilize the air bubbles and to hold the flavourings, e.g., ripple sauces, in dispersion.
- In the ice cream during storage: To prevent lactose crystal growth and retard or reduce ice crystal growth during storage, also to prevent shrinkage from collapse of the air bubbles and to prevent moisture migration into the package (in the case of paperboard) and sublimation from the surface.
- In the ice cream at the time of consumption: To provide some body and mouth feel without being gummy, and to promote good flavour release.

Limitations on their use include:

- production of undesirable melting characteristics, due to too high viscosity
- excessive mix viscosity prior to freezing
- contribution to a heavy or chewy body

(Goff, 1995).

The stabilizers in use today include:

Locust Bean Gum:

Soluble fiber of plant material derived from the endosperm of beans of exotic trees grown mostly in Africa.

Guar Gum:

From the endosperm of the bean of the guar bush, a member of the legume family grown in India for centuries and now grown to a limited extent in Texas.

Carboxymethyl cellulose (CMC):

Derived from the bulky components, or pulp cellulose, of plant material, and chemically derivative to make it water soluble.

Xanthan gum:

Produced in culture broth media by the microorganism *Xanthaomonas campestris* as an exopolysaccharide, used to a lesser extent.

Sodium alginate:

An extract of seaweed, brown kelp, also used to a lesser extent.

Carrageenan:

An extract of Irish moss or other red algae, originally harvested from the coast of Ireland, near the village of Carragheen but now most frequently obtained from Chile and the Philippines.

Each of the stabilizers has its own characteristics and often, two or more of these stabilizers are used in combination to lend synergistic properties to each other and improve their overall effectiveness. Guar, for example, is more soluble than locust bean gum at cold temperatures, thus it finds more application in HTST pasteurization systems. Carrageenan is not used by itself but rather is used as a secondary colloid to prevent the wheying off of mix which is usually promoted by one of the other stabilizers (Goff, 1995).

2.3.4.1 Emulsifiers

The emulsifiers are a group of compounds in ice cream which aid in developing the appropriate fat structure and air distribution necessary for the smooth eating and good meltdown characteristics desired in ice cream. Since each molecule of an emulsifier contains a hydrophilic portion and a lypophilic portion, they reside at the interface between fat and water. As a result they act to reduce the interfacial tension or the force which exists between the two phases of the emulsion. The emulsifiers actually promote a destabilization of the fat emulsion which leads to a smooth, dry product with good meltdown properties (Robinson, 1981).

The original ice cream emulsifier was egg yolk, which was used in most of the original recipes. Today, two emulsifiers predominate most ice cream formulations:

Mono- and **di-glycerides:**

Derived from the partial hydrolysis of fats or oils of animal or vegetable origin

Polysorbate 80:

A sorbitan ester consisting of a glucose alcohol (sorbitol) molecule bound to a fatty acid, oleic acid, with oxyethylene groups added for further water solubility

Other possible sources of emulsifiers include buttermilk, and glycerol esters. All of these compounds are either fats or carbohydrates, important components in most of the foods we eat and need. Together, the stabilizers and emulsifiers make up less than one half percent by weight of our ice cream (Goff, 1995).

2.4 Optional Ingredients

2.4.1 Flavours

The palatability of frozen deserts is largely influenced by flavour. Most ice cream is flavoured by the addition of natural or synthetic flavours. Among the flavouring substances that are commonly used in frozen deserts are vanilla, cocoa, chocolate and coffee, fruits and fruit extracts, nuts, spices and sugars (Robinson, 1981).

Flavour substance (both natural and synthetic) are available mainly in mixtures. Information occurring in the literature about food-flavouring materials is limited, as there is a great degree of secrecy in flavouring technology. The natural flavourings are:

(i) fruit flavours
(ii) citrus fruit
(iii) tropical fruit flavours
(iv) natural flavours from botanicals
(v) spices
(vi) coca and chocolate
(vii) coffee
(viii) natural flavourings from vanilla beans
(ix) nuts

The synthetic flavourings include aromatic chemicals and imitation flavours. Liqueur flavourings consisting of alcohol, whiskey and other distilled beverages, fruit liqueurs, fruit brandy distillate and brandy flavour essence are also included (Bhandari, 2001).

2.4.2 Colours

Ice cream should have a delicate, attractive colour which suggest or is readily associated with the flavour. Only colours certified by U.S. FDA should be used. Fruit ice cream need to be coloured because about 15% fruit, the maximum commonly used, produces only a slight effect on colour.

Most colours are of chemical origin, weak alkaline solutions. Most ice cream makers purchase the desired colours in liquid or paste form (Arbuckle and Marshall, 1996).

2.4.3 Fruit and Nuts

Fruit and/or nuts or toffee pieces may be fed into the ice cream as it extrudes from the continuous freezer by special proportioning machines, and ripple ice cream is produced in a very similar manner by injecting heavy fruit syrup (Robinson, 1981).

Nutmeats and nut extracts are quite extensively used as flavourings in ice cream. Pecans, walnuts, almonds, pistachios filberts and peanuts are among the most popular. Nutmeats should be sound and clean and free from rancid flavours. Some nuts such as almonds,

filberts and pistachios should be blanched to remove their dark outer skin (Arbuckle and Marshall, 1996).

2.5 Sri Lanka Standard of Ice Cream

2.5.1 Definition

Ice cream: A frozen sweetened product made a heat treated mix consisting of edible fat and milk solids with or without other ingredients and permitted additives. The product is intended for storage, sale and consumption in the frozen state.

2.5.1 Categories

2.5.1.1 Simple ice cream

A sweetened product made from a mix consisting of edible fat and milk solids with colour, flavour, emulsifier and stabilizer.

2.5.1.2 Complex ice cream

Simple ice cream with any one or more of the optional ingredients, fruit and fruit products and / or nuts.

2.5.1.3 Novelties

Single serve packs of either simple or complex ice cream with an outer edible coating such as chocolates, nuts, biscuits etc (SLS 223: 1989).

2.5.2 Ingredients

All ingredients used in the preparation of ice cream shall be clean and sound and fit for human consumption. Perishable ingredients not in immediate use shall be stored hygienically under refrigeration.

2.5.2.1 Basic ingredients

Fat:	Edible fats and oil
	Cream
	Butter conforming to SLS 279
Milk solids:	Milk/Skim milk conforming to SLS 181
	Dried milk/dried skim milk conforming to SLS 731
	Condensed milk conforming to SLS 179
Sugar:	conforming to SLS 191
	Artificial sweetening agents shall not be used.
Water:	conforming to SLS 614

2.5.2.2 Optional ingredients

Table 2.1 Optional ingredients

Ingredient	Condition
Fruits and fruit products:	Mature fruits and fruit products free from pith, seeds, skin and core may be used. Fresh, frozen, dried or canned fruits or fruit syrups may also be added.
Nuts:	free from damages, rancidity, moulds, insect and rodent infections.
Food ingredients:	intended to impart flavour, taste or texture. E.g. cocoa, chocolate, coffee, ginger, honey, treacle etc.
Salt:	conforming to SLS 79
Eggs:	fresh or pasteurized egg products (SLS 223: 1989).

Source (SLS 223: 1989).

2.5.3 Additives

Table 2.2 Additives

Additives	Condition
Colouring matter:	permitted natural or artificial colouring matter not exceeding 200 mg/kg in the final products.
Emulsifiers and stabilizers:	not exceeding 10 g/kg singly or in combination.
Modified starches and thickening agents:	not exceeding 10 g/kg singly or in combination.
Flavouring agents:	natural or artificial (SLS 223: 1989).

Source (SLS 223: 1989).

2.5.4 Requirements

2.5.4.1 General requirement

Ice cream shall be manufactured, packed, stored and distributed under the hygienic conditions. Ice cream shall be stored at a temperature below -18 ^{0}C. Product other than frozen deserts shall not be stored together with ice cream.

2.5.4.2 Pasteurization requirement

Milk ingredients used in the ice cream shall be pasteurized or subjected to an equivalent heat treatment. No ingredients other than fruit, fruit pulp, fruit juice, nuts, colouring matter and flavouring agents shall be added after heat treatment.

Heat treatment: Ice cream mixture shall be subjected to any of the heat treatments given below;

a) 66 ^{0}C for at least 30 minutes.
b) 71 ^{0}C for at least 10 minutes.
c) 79 ^{0}C for at least 15 seconds.
d) 149 ^{0}C for at least 2 seconds.

Note: After heat treatment, the temperature of the mixture shall be reduced to 7 ^{0}C or below within 90 minutes. The mixture shall be kept at that temperature until the freezing process begins (SLS 223: 1989).

2.5.4.3 Finished product requirement

- Ice cream shall have a pleasant odour and flavour. It shall be smooth in texture and of uniform consistency.
- Ice cream shall be free from contamination or any objectionable matter. It shall also be free from ice crystals, lactose crystals or butter granules.
- Ice cream shall comply with the requirements specified in table 2.1

Table 2.3 – Requirements for ice cream

Sl.	Characteristic	Requirement
i)	Total solids, per cent by mass, min	32
ii)	Fat, per cent by mass, min	08
iii)	Sucrose, per cent by mass, min	10
iv)	Milk solid non fat, per cent by mass, min	08
v)	Acidity as lactic acid, per cent by mass, min *	0.25
vi)	Mass in grams, per liter, min	475

* min: minimum

* This limit is not applicable to complex ice cream (Source SLS: 223: 1989).

Table 2.4 Microbiological limits

Sl.	Test organism			Limit per gram	
		n	c	m	M
i)	Aerobic plate count	5	2	$5 * 10^4$	$2.5* 10^5$
ii)	Coliform	5	2	$1 * 10^2$	$1 * 10^3$
iii)	*Salmonella*	10	0	0	-

(Source SLS: 223: 1989).

Where,

n is the number of sample units to be tested;

c is the maximum allowable number of sample units yielding values between m &M

m is the limit under which a count is acceptable for any sample unit; and

M is the above which a count is unacceptable for any sample unit.

2.5.5 Packaging

Ice cream may be wrapped / packed in a material which is impermeable and non absorbent. It shall not impart any off flavour/odour and shall not contaminate the product. If the wrapper is printed, the print dye shall not penetrate to the product (SLS 223: 1989).

2.5.6 Marking

Each wrapper / container shall be marked or labeled legibly and indelibly with the following;

a) Name of the product with proper prefixes

e.g. "fruit and nut ice cream"

b) Brand name / trade mark, if any;

c) Net content, in milliliters or in grams;

d) Name and address of the manufacturer and / or distributor,

e) Batch or code number;

f) Date of expiry and List of ingredients in descending order of proportion (SLS 223: 1989).

2.6 Ice Cream Manufacturing Process

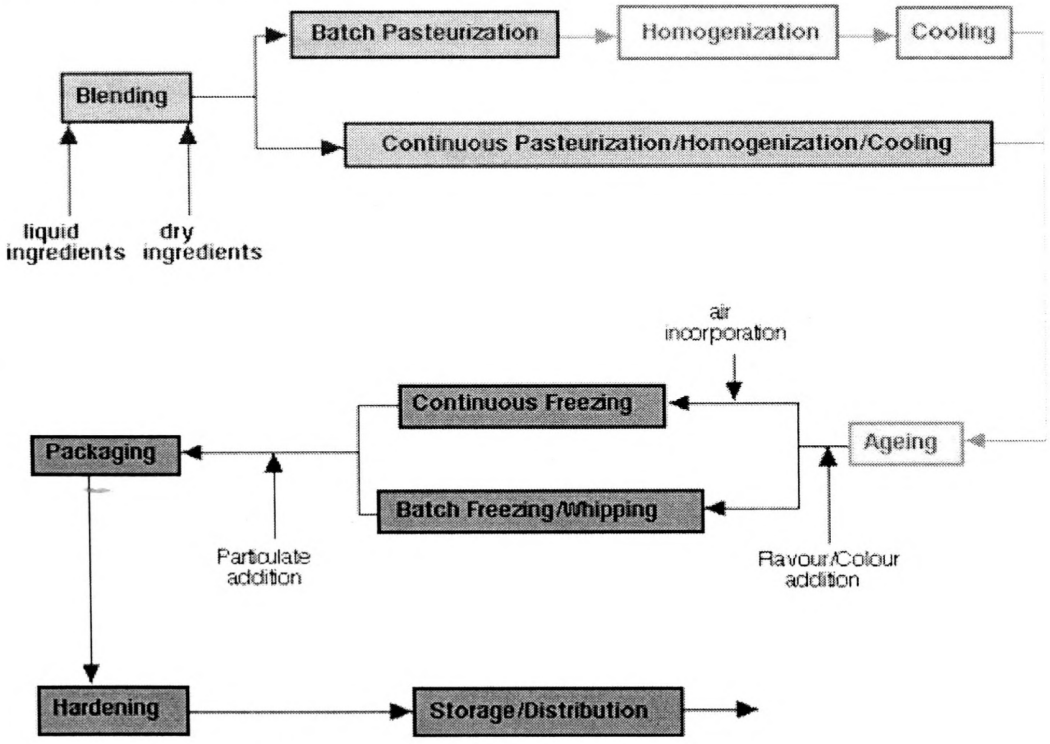


Fig. 2.1- Ice Cream Manufacturing Process

2.6.1 Blending of the mix ingredients

First the ingredients are selected based on the desired formulation and the calculation of the recipe from the formulation and the ingredients chosen, and then the ingredients are weighed and blended together to produce what is known as the "ice cream mix". Blending requires rapid agitation to incorporate powders, and often high speed blenders are used Arbuckle and Marshall, 1996).

2.6.2 Pasteurization

The mix is then pasteurized. Pasteurization is the biological control point in the system, designed for the destruction of pathogenic bacteria. In addition to this very important function, pasteurization also reduces the number of spoilage organisms such as psychrotrophs, and helps to hydrate some of the components (proteins, stabilizers). Both batch pasteurizers and continuous (HTST) methods are used Arbuckle and Marshall, 1996).

2.6.3 Homogenization

The mix is also homogenized which forms the fat emulsion by breaking down or reducing the size of the fat globules found in milk or cream to less than 1 μ m. Two stage homogenization is usually preferred for ice cream mix. Clumping or clustering of the fat is reduced thereby producing a thinner, more rapidly whipped mix. Melt-down is also improved. Homogenization provides the following functions in ice cream manufacture:

- Reduces size of fat globules
- Increases surface area
- Forms membrane
- Makes possible use of butter, frozen cream, etc.

By helping to form the fat structure, it also has the following indirect effects:

- makes a smoother ice cream
- gives a greater apparent richness and palatability
- better air stability
- increases resistance to melting

Homogenization of the mix should take place at the pasteurizing temperature. The high temperature produces more efficient breaking up of the fat globules at any given pressure and also reduces fat clumping and the tendency to thick, heavy bodied mixes (Goff, 1995).

2.6.4 Aging the mix

The mix is then aged for at least four hours and usually overnight. This allows time for the fat to cool down and crystallize, and for the proteins and polysaccharides to fully hydrate. Aging provides the following functions:

- Improves whipping qualities of mix and body and texture of ice cream.

It does so by:

- providing time for fat crystallization, so the fat can partially coalesce;
- allowing time for full protein and stabilizer hydration and a resulting slight viscosity increase;
- allowing time for membrane rearrangement and protein/emulsifier interaction, as emulsifiers displace proteins from the fat globule surface, which allows for a reduction in stabilization of the fat globules and enhanced partial coalescence.

Aging is performed in insulated or refrigerated storage tanks, silos, etc. Mix temperature should be maintained as low as possible without freezing, at or below 5 ^{0}C.

2.6.5 Air incorporation

Volume of ice cream obtained in excess of the volume of the mix. It is usually expressed as "per cent overrun". Mathematically, it is expressed as

$$\% \text{ Overrun} = \frac{\text{Volume ice cream - Volume of mix}}{\text{Volume of mix}} \times 100$$

2.6.6 The Freezing Process

Freezing the mix is one of the most important operations in making ice cream for upon it depend the quality palatability and yield of the finished product.

Freezing consist of tow parts,

1) The mix is frozen quickly while being agitated to incorporate air and to limit the size of ice crystals formed.
2) The partially frozen product is hardened without agitation in a special low temperature environment designed to remove heat rapidly (Arbuckle and Marshall, 1996).

2.6.8 Hardening

When ice cream is drawn from a freezer and placed in containers, it is of a semi-solid consistency and is not stiff enough to hold its shape. Therefore, the freezing process is continued in containers without agitation until the temperature reaches -18 ^{0}C (^{0}F) or lower, preferably -25 ^{0}C to 30 ^{0}C. Quick hardening is desirable because the formation of large ice crystals takes place with slow hardening.

2.7 Food Value of Ice Cream

The food value of ice cream depends to a large extent on its composition, and since it is purchased by volume, the weight of a unit, such as the quarter or gallon, must be considered. If the composition and weight of a quart of ice cream are known, the caloric value can be readily computed. Standards vary in different states; the fat requirement for plain ice cream ranging from 8 to 14 percent and the total solids may run from 28 to 38 percent.

There fore an ice cream testing 8 % fat and 28 % total solids would have only two-thirds the energy value of one testing 14 % fat and 38 % total solids. The caloric value per quart of these ice creams may be computed as follows; assume both samples to weigh the same an average weight of 1.2 pounds per quart.

(1) 8% fat × 9 cal	= 72 cal per 100 grams
20% solids non fat × 4 cal	= 80 cal per 100 grams
Total	= 152 cal per 100 grams

Total in 1.2 lb or 544g = 152 × 5.44 or 826 cal per quart.
(152 × 5.44 = 826.88 cal)

(1) 14% fat × 9 cal	= 126 cal per 100 grams
24% solids non fat × 4 cal	= 96 cal per 100 grams
Total	= 222 cal per 100 grams

Total in 1.2 lb or 544g = 222 × 5.44 or 1208 cal per quart.
(222 × 5.44 = 1207.68 cal)

Acid from its energy value, ice cream is a valuable source of high quality proteins, which are complete and more readily assimilated than some other proteins. Calcium and phosphorus are present in generous quantities. Since ice cream is high in fat, it is an excellent source of vitamin A, and contains a fair amount of D and E, all three being fat soluble, it also is a good source of vitamin B1 and provides some vitamin C. ice cream is very palatable and highly digestible. It is not only an ideal and nutrition's food for people in good health, but also for invalids and convalescents. The fat fact that it is usually included in the diets of patients indicates that it has special merits as a food (Artherton and Newlander, 2003).

Table 2.5 - Summery of Food Nutrients in Dairy Products and Human Requirements (Average)

Nutritional factor	Daily requirements of adults	Nutrients in 1 quart of milk	Nutrients in 1 quart of ice cream	Nutrients in 1 pound of cheese	Nutrients in 1 pound of butter
Protein (g)	70	34	22	110	2.7
Calories	3000	675	1000	1860	3300
Calcium (mg)	800	1150	625	8300	91
Phosphorus (mg)	1320	907	500	2250	73
Iron (mg)	12	0.9	0.5	4	0
Vitamin A (IU)	5000	1560	2650	6350	15000
Vitamin B1 (mg)	1.5	0.4	0.2	0.1	Trace
Vitamin C (mg)	75	10	5	0	0
Vitamin D (IU) (child)	400	40	100	150	450
VitaminG (mg)	1.8	1.7	1.0	0.9	0.05
Niacin (mg)	20	1.0	0.5	Trace	0.4

(Source: Artherton and Newlander, 2003)

2.8 Defects of Ice Cream and Quality

Quality is an important variable in establishing price, so it is necessary to understand the causes and the remedies of defects in quality. Defects result from faults in flavour, body, texture, melting characteristics, colour, package, microbial content and / or composition. The ideal product should possess a typical, fresh, clean, pleasant and delicate flavour, have a close, smooth texture; possess moderate resistance of body, melt slowly into a liquid with the appearance of original mix; have a natural colour; have any particulates, ripples, or other inclusions evenly and liberally distributed; and have a low bacterial count (Arbuckle and Marshall, 1996).

2.11.1 Ice cream Mix and Frozen Dairy Products

Ice cream mix can be prepared in the same manner as cream. Frozen ice cream should be allowed to soften at room temperature in a blender for about two minutes. Ice cream containing fruits, nuts, etc; should be softened and then mixed up to 7 minutes in a high-speed blender until homogeneous (Artherton and Newlander, 2003).

2.12 Definition of Nut

Nuts are dry, one-seeded fruit which do not dehisce at maturity, and are usually enclosed by a rigid outer casing or shell. Most nuts grow on large shrubs or trees and known as "tree nuts" (ICMSF, 2000).

2.12.1 Handling and Storage of Nuts

In confectionary industry, nuts are practically always purchased with the shell removed, and before inclusion in a product may be blanched to remove the outer skin of the kernel, then roasted, and sometimes chopped or ground (Minifie, 1997).

2.12.2 Harvesting

With the exception of peanuts, most of the important nits are tree crops, and when growing the nuts are enveloped in a flesh or husk dries and perishes and usually becomes detached when the "fruit" falls from the tree, leaving the nut in its shell. This has to dried and the original practice was to expose to the sun on trays, covering at night or during rain, but much drying is now done artificially.

The quality of the nut kernel is largely dependent on efficient and speedy drying after harvesting, especially if the nuts are washed to remove dirt and other foreign matter (Minifie, 1997).

2.12.3 Storage

Nuts are a seasonal crop, which means that some of the kernels must be kept for as long as possible. Cool storage is always to be preferred but many uses do not understand the additional need to control the relative humidity of the store and the moisture content of the nuts. Light is also detrimental to nuts and promotes oxidative rancidity in the oil in the outer layers. Many nuts are not even stored in cool conditions and infestation becomes a problem in the warmer months (Minifie, 1997).

2.12.4 Roasting

Roasting decrease the stability nuts and renders them prone to oxidative rancidity and thus it is necessary to used roasted nuts immediately in the product for which they are intended. They should not be stored unless under vacuum or inert gas (Minifie, 1997).

2.12.5 Blanching

Almonds are blanched wet and any nut blanched wet must be roasted or dried immediately or rapid deterioration will set in. wet nuts also discolour in the presence of iron (Minifie, 1997).

2.12.6 Moisture

High moisture contents will accelerate the deterioration of all nuts and if roasted nuts are allowed to pick up moisture, the effect is even worse. Under these conditions, they turn sour and ultimately rancid. The water activity (a_w) should b 0.3 to 0.4 (Minifie, 1997).

2.13 Taxonomy of Tropical almond

Table 2.6 *Terminalia catappa* scientific classification

Terminalia catappa Scientific classification	
Kingdom:	Plantae
Division:	Magnoliophyta
Class:	Magnoliopsida
Order:	Myrtales
Family:	Combretaceae
Genus:	*Terminalia*
Species:	***Terminalia catappa***
Binomial name *Terminalia catappa* L.	

Source: http://www.traditionaltree.org

2.13.1 Botanical name and Vernacular names

Botanical name: *Terminalia catappa*

Vernacular names:	Sinhala:	Kottang, Kottamba
	Tamil:	Amandi, Nattuvadumai, Pinga, Siruppinga
	Hindi:	Badami, Hindibadam, Janglibadam
	England:	Indian almond, Tropical almond

2.14 Plant Description

Plant out look

Tropical almond is a 30 to 55 foot–tall, deciduous tree which forms a symmetrical, upright silhouette in youth with horizontal branches reaching 35 feet in width (Fig. x). The branches are arranged in obvious tiers, giving the tree a pagoda-like shape. As the tree grows older, the crown spreads and flattens on the top to form a wide-spreading vase shape. The large, 12 inch-long and six-inch-wide, glossy green, leathery leaves change to beautiful shades of red, yellow, and purple before dropping. Due to their large size, these old leaves may be considered a nuisance to some people. The leaves are quickly replaced by new growth so the tree is bare for only a short period of time.

The inconspicuous, greenish-white, springtime blossoms appear in six-inch-long terminal clusters and are followed by the edible fruits. These drupes are 2.5 inches long and mature

from green to yellow or red. The outside husk is corky fiber with an inner thin green flesh. The inside holds the edible, almond-like kernel. The fruit is high in tannic acid and this could happen to stain. It also causes significant litter on the ground (Gilman and Watson, 1994).

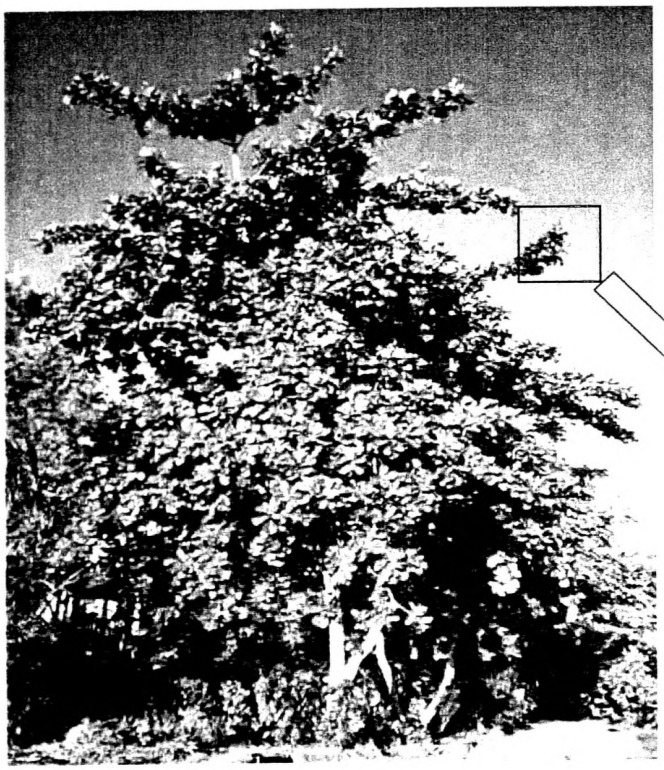


Fig: 2.1 Tropical almond plant

Fig: 2.2 Tropical almond unripe fruits

Fig: 2.4 Final product

Fig: 2.3 Tropical almond dried fruit

Fruit

Fruit shape:	elongated; oval
Fruit length:	5-7 cm long and 3-5.5 cm broad
Fruit covering:	dry or hard
Fruit colour:	tan, red, and yellow
Fruit characteristics:	does not attract wildlife; inconspicuous and not showy; fruit, twigs, or foliage cause significant litter (Edward et al., 1994).

2.15 Distribution

Probably indigenous to Andaman's and the neighboring islands. It is now grown widely in India, Burma, Ceylon, Malaya and Philippine Islands. It is common along the coast in Ceylon (Jayaweera, 1981).

2.16 Chemistry of Plant

2.16.1 Chemical Composition of Plant

The seeds contain a fixed oil with olein, palmitin and stearin. The bark contains tannin. The leaves and the flowers yield tannin and a sterol. The trunk of the tree exudes a gum while the bark yields a black dye (Jayaweera, 1981).

2.17 Food Uses

The nuts are edible, taste like almonds and are eaten, although the flesh is troublesome to separate from the hard stone. Unlike commercial almond, the Sea Almond can be eaten raw. Oil extracted from the dried nuts is edible and used in cooking (Lex and Evans, 2006).

2.18 Biological Health Activity

The leaves contain several flavonoids (like kamferol), several tannins (such as punicalagin or tercatin), saponines and phytosterols. Due to this chemical richness, the leaves (and also bark) are used in different traditional medicines for various purposes. It is also thought that the leaves contain against for prevention of cancers and antioxidant as well as anticlastogenic characteristics (Edward et al., 1994).

2.18.1 Traditional Medicinal Uses

Leaves, bark and fruits:	dysentery, (Southeast Asia) dressing of rheumatic joints (Indonesia, India).
Fruits and bark:	coughs (Samoa), asthma (Mexico).
Fruits:	leprosy, headaches (India).
Ripe fruits:	travel nausea (Mexico).

Leaves:	get rid of intestinal parasites (Philippines); treat eye problems, rheumatism, wounds (Samoa), stop bleeding during teeth extraction (Mexico), fallen leaves used to treat liver diseases (Taiwan), and young leaves for colic (South America).
Juice of leaves:	scabies, skin diseases, leprosy (India, Pakistan).
Bark:	throat and mouth problems, stomach upsets and diarrhea (Samoa), fever, dysentery (Brazil).

- Modern research has identified some properties which could be used to treat high blood pressure.
- The leaves contain agents for chemo-prevention of cancer and probably have anticarciogenic potential.
- They also have a anticlastogenic effect (a process which causes breaks in chromosomes) due to their antioxidant properties.
- The kernel of tropical almond has shown aphrodisiac activity; it can probably be used in treatment of some forms of sexual inadequacies (premature ejaculation).
- Ethanol extract of the leaves shown potential in the treatment of sickle cell disorders

(Lex and Evans, 2006).

2.19 Taxonomy of Cashew nut

Family: ANACARDIACEAE

2.19.1 Botanical name and Vernacular names

Botanical name: *Anacardium occidentale*

Vernacular names:

Sinhala:	*Kaju*
Tamil:	*Andima, Kallarma, Kottaimundiri, Saram, Palamundiri*
English:	Cashew Nut

2.20 Plant Description

A medium sized tree crooked trunk and teeter, glabrous branches (Jayaweera, 1981).

Fruit: Nut-reniform 2.5 cm long on a swollen, fleshy, yellow or red pedicel, pericarp cellular, full of acrid oil, seed reniform, ascending, exalbuminous, testa membranous, cotyledons semi lunar with a milky taste (Jayaweera, 1981).

2.21 Distribution

The Cashew nut is a native of Tropical America from Mexico to Peru, Brazil and West Indies. It was introduced to India in the 16th century. In Sri Lanka it is commonly found in village gardens and waste lands along the sandy western coast of the Island and in the dry zone (Jayaweera, 1981).

2.22 Edible parts

Edible parts of cashew nut are kernel of the seed and fruit apple. The small kidney shaped, grey or brown nut, about "1 – 11/2" in long, at the extremity. The latter has an edible kernel, which when roasted has a very agreeable nutty taste and is much relished for dessert. It is in demand in Europe, for use in confectionary and dessert (Macmillan, 1979).

2.23 Food uses

Cashew is one of the best nuts in the world. Matured seed kernels are eaten fresh, fried or roasted. It is also added in to ice creams and fruit salads and used in the confectionery industry. Immature kernels are prepared as a curry (Jayaweera, 1981).

2.24 Nutritional and Therapeutic value

Table 2.7 Nutritional Value

Constituent	Amount
Moisture	40.00g
Energy	568 Kcal
Protein	18.40g
Fats	46.30g
Carbohydrates	28.70g
Calcium	28.00mg
Phosphorus	462.00mg
Iron	3.60mg
Carotene	5mcg
Thiamin, Riboflavin, Niacin	250mcg, 340mg, 2.4mg
Vitamin C	1 mg

(Source: Medicinal Plants (Indigenous and Exotic) Used in Ceylon. Part I).

2.24.1 Therapeutic value

The pericarp of the nut of this tree contains a toxic principle, cardol, anacardol, cardanol and anacardic acid. The kernels yield a fixed oil which contains linoleic, palmitic, stearic and lignoceric acids and sitosterin. A decoction of the bark of this tree is used as a remedy for diarrhea, syphitiric swellings of joints and for diabetes. The oil of the pericarp is useful as an

anaesthetic in leprosy and psoriasis. It is a powerful vesicant, vermicide and insecticide (Jayaweera, 1981).

2.25 Time to harvest

Fruit production begins 3-5 years after planning, depending on conditions and variety. The period from flowering to nut fall is 50-77 days. Flowers can see in November and January to March. The apple takes 2-3 months to ripen fully. Cashew apple may be preserved as Jam or Canned. Matured dried nut can be preserved in dry places (Jayaweera, 1981).

2.26 New Product Development

The definition of new product development and introduction of a product not previously manufactured by a company into the market place or the presentation of an old product in to a new product into a new market not previously explored by a company (Fuller, 1994).

2.27 Sensory Evaluation

Scientific disciplines used to evoke measure, analyze and interpret people's reaction to products based on the senses.

2.27.1 Sensory parameters

Flavor: A complex group of sensation comprising olfactory, taste, and other chemical sensation such as irritation or chemical heat.

Odor: The characteristic smell of a substance.

Taste: Specialized sense organs on the tongue and soft palate contain the receptor for our sense of taste.

Aroma: The fragrance or odor of a product as perceived by the nose from sniffing through the external nasals. In some cultures, aroma may also refer to retro nasal smell.

Color: Color is the perception that results from the detection of light after it has interacted with on object.

2.27.2 Sensory panel and panelist

Panel

A group of people that comprises a test population chosen for specific characteristic such as product usage, sensory quality or willingness to participate in repeated sensory test.

Panelist

Generally a participant in a sensory evaluation several related terms are commonly used "panelist" con notes a participant as a member of group that is often tested on more than one occasion (Lawles and Heyman, 1998).

2.27.3 Classification of Test Method

Table 2.8 Classification of test method in sensory evaluation

Class	Question of interest	Type of test	Panelist characteristic
Discrimination	Are products different in any way?	"Analytic"	Screened for sensory acuity, oriented to test method sometimes trained
Descriptive	How do products differ in specific sensory characteristics?	"Analytic"	Screened for sensory acuity and motivation, trained or highly trained.
Affective	How well are products liked or which products are preferred?	"Hedonic"	For product use, untrained.

(Source: Lawles and Heyman, 1998).

Hedonic Test

Hedonic test is used in the food industry to determine acceptance of food. The most common hedonic scale is the 9-point hedonic scale. This is also known as degree of liking scale (Lawles and Heyman, 1998).

2.28 Shelf life evaluation

Numerous changes take place in foods during processing and storage. It is well known that conditions used to process and store foods may adversely influence the quality attributes in foods.

During storage and distribution, foods are exposed to a wide range of environmental conditions. Environmental factors such as temperature, humidity, oxygen and light can trigger several reaction mechanisms that may lead to food degrading. Chemical, physical and microbiological changes are the leading causes of food deterioration.

Shelf life determination of the new product often requires storage for significant periods and includes samples from early development stages as well as initial production runs. Through the evaluation of stored samples, potential storage problems can be identified and either eliminated or controlled before the food goes into production (Man and Jones, 1997).

2.28.1 Sampling Methods of Cream

Highly viscous heavy cream may require sampling tubes of wider base (3/8 or ½ inch) than is needed for milk or cream of lesser viscosity. Proper mixing is of almost importance in preparing cream for sampling. Cream samples are not commonly combined into composites. Samples should be tested daily (Artherton and Newlander, 2003).

2.28.2 Plate count

The use of plate counts to estimate the number of bacteria in a food is based on the fact that living bacterial cells or clumps of cells will grow and increase in number in or on the surface of a suitable agar medium to give visible colonies that can be counted. The first stage in carrying out a traditional plate counts on a food involves producing a homogenate of a sample and a series of dilution.

A simple calculation can then be used to determine the number of colony forming units (CFU) in the original sample (Gabutt, 1997).

2.28.3 Yeas and Molds

The yeast and molds constitute a diverse group of microorganisms including more than 400,000 species. They grow readily on foods under tropical climatic conditions of 70 – 80% R.H. and temperature of 25 – 30 ^{0}C. They can grow in a wide pH range of 2-9 and buffer the foods to pH 4 to 6.5 to continue their growth. Some molds produce toxic and carcinogenic metabolites in foods (Samarajeewa, 1999).

2.28.4 *Escherichia coli*

Although *E-coli* are generally harmless part of the normal micro flora of the gut of humans and other warm blooded animals, a number of groups of *E-coli* are pathogenic for human and have been associated with food borne diseases (Gabutt, 1997).

2.28.5 The 3M Petri film

The use of Petrifilm ^{TM} (3M Centre, Building 275 – 4E – 01, st, Paul, MN 55144, 1000, USA) does away with the preparation of microbiological media in individual laboratories enabling rapid handling of samples. The diluted food product is transferred quantitatively to a dry culture medium coated in a 20 sq.cm film base. The test unit consists of there films overlaid on top of each other. The bottom film consists the growth medium, and over with middle cellophane like film coated with water soluble gelling agent. The upper film serves to protect the growing cultures during incubation. In using the Petri film the upper film is lifted and 1ml of the sample inoculated to the surface of the middle film. The film cover is replaced and the contents spreader with a plastic spreader. The gel solidifies within a minute

of addition of the diluted food sample containing the microorganisms. The test unit is incubated for growth of colonies and counting. The Petrifilm technique is applicable in estimating Total plate count, *E-coli* & Coliform and Yeast & molds (Samarajeewa, 1999).

2.28.6 *E-coli* / *Coliform* count plate

Petri film *E.coli* / coliform count (EC) plates contain violet red bile (VRB) nutrients, a cold-water soluble gelling agent, an indicator of glucuronidase activity, and an indicator that facilitate colony enumeration. Most *E-coli* (about 97%) produce beta-glucuronidase, which produces a blue precipitate, associated with the colony. The top film traps gas produced by the lactose fermenting coliforms and *E.coli* produce gas, indicated by blue to red –blue colonies associated with entrapped gas on the petrifilm EC plate.

3M"Petri film"*E.coli* /coliform count plates are designed to identify both *E.coli* and other coliforms. With one easy test, will have confirmed results in just 24 to 48 hours. If *E-coli* present in the sample there will be blue colony with gases on Petri film plates. Red and blue colonies with gases indicate that the coliforms present in the sample.

By eliminating the need for confirmation of presumtative colonies, will greatly increase lab efficiency and reduce overall costs. Petri film plates are simple-ready and provide the most cost-effective, convenient and reliable method for testing equipment, raw materials, food products and the manufacturing environment.

By using labor-saving Petri film plates, will have time to monitor critical control points more frequently the end results is better process control and higher quality product. 3M Petri film is AOAC INTERNATIONAL validated method (3M Petri film Technology).

CHAPTER 03

Material and Methodology

3.1 Raw material preparation

3.1.1 Material and Apparatus

Apparatus:	**Materials:**
Boiler	Water
Sieve	Tropical almonds (Kottamba)
Watch	

3.1.2 Methodology

Sun dried Tropical almond (kottamba) was taken and removed the outer hard cover without any damage to the kernel. Then tropical almonds were cleaned well and removed the outer husk (fibrous covering) in several methods.

1) Kernels were dried up to 105 ^{0}C for 30min and cooled up to room temperature then the husk was removed manually.
2) Kernels were dried up to 105 ^{0}C for 1 hr and cooled up to room temperature then the husk was removed manually.
3) Kernels were dried up to 105 ^{0}C for 11/2 hrs and cooled up to room temperature then the husk was removed manually.
4) Kernels were dried 105 ^{0}C for more than 2 hrs and cooled up to room temperature and husk was removed.

Then they were cut in to small pieces (1 – 11/2 cm) and packed.

5) Kernels were dipped in boiled water (blanched) for 1 minute and husk was removed.
6) Kernels were dipped in boiled water (blanched) for 2 minutes and husk was removed.
7) Kernels were dipped in boiled water (blanched) for 3 minutes and husk was removed.
8) Kernels were dipped in boiled water (blanched) for more than 3 minutes and husk was removed.

Dehusked kernels were taken and dried at 105 ^{0}C for 30 minutes and kernels were cut into small pieces (about 03 - 04mm). Then cut pieces of kernels were dried at 105 ^{0}C for about 1 hour.

The dehydrated nuts were roasted as follows

Table 3.1 Roasting time temperature combination of tropical almond

Temperature	Time (minutes)
130 ^{0}C	05
140 ^{0}C	05
150 ^{0}C	05
160 ^{0}C	05

Then roasted nuts were allowed to cold down to room temperature without adsorption of water and immediately packed in polythene.

3.1.3 Materials and Apparatus for preparation of mixed fruit ice cream

Apparatus:	**Materials:**
Table spoons	Vanilla flavored Ice cream
Ice cups (1L)	Fruit and nut mixture (Plump, ash Pumpkin and tropical almond)

3.1.4 Methodology for Formulation

Several frequently of tropical almond and fruits (plumps and ash pumpkin) formulae were obtained prior to the mixing with the ice cream for the study. After studying the available formulae, 4 different recipes were prepared based on personal judgments and specification with CCS (Ceylon Cold Stores) mixed fruit ice cream and proceeded with the development of the ice cream from each recipe. The fruit and nut mixture combination for one formula was about 10% (W/V) for 1L ice cream, according to above specification below formulated ratio were prepared.

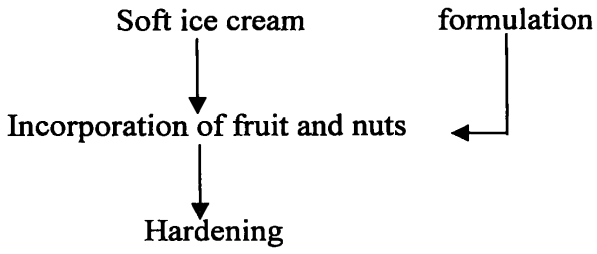
1) Tropical almond without fiber coat (10.0g): Plums (40.0g): Ash pumpkin (50.0g),
2) Tropical almond without fiber coat (20.0g): Plums (30.0g): Ash pumpkin (50.0g),
3) Tropical almond without fiber coat (30.0g): Plums (30.0g): Ash pumpkin (40.0g),
4) Tropical almond with fiber coat (30.0g): Plums (30.0g): Ash pumpkin (40.0g)

(W/V – weight per volume)

Then each fruit and nut formula was incorporated into a vanilla flavoured ice cream and tasted. The same procedure was repeated for the other formulae. Finally the three different formulae were taken and a sensory evaluation was carried out to find the best sample.

3.1.5 Methodology for incorporation of nuts

Soft Ice cream (before hardening) was taken and formulated fruit and nut mixtures were applied as layers with soft ice cream. They were kept in freezer –20 ^{0}C to – 30 ^{0}C temperature until become hardness for 3 to 4 hours.



3.2 Physicochemical Assessment

3.2.1 Determination of Moisture Content

Moisture content of foods varies greatly according to the food product. Water is a major constituent of most food products. Two methods were carried out to determination of moisture content.

1) Oven drying method
2) Distillation method (Dean and Stark distillation method)

3.2.2 Material and Apparatus for Oven drying method

- Tropical Almond (Kottamba)
- Moisture dishes with lids
- Oven
- Electric balance
- Desiccators

3.2.3 Methodology for oven drying

Well-washed and dried three cups with lids of moisture determination were taken and weighed accurately. 5.00 g of tropical almond (Kottamba) was weighed in to the moisture dish and kept in the oven at 105 ^{0}C for four hours. Then the porcelain dishes were put inside the desiccator to cool, and weight was taken. Then they were kept inside the oven at 105 ^{0}C for 30 min and cooled and weight was measured. This was repeated three times with 30 minutes period of time. The following calculation was used to determine the moisture content (Nielson, 1998).

$$\text{Moisture \% (wt/wt)} = \frac{\text{Wt } H_2O \text{ in sample}}{\text{Wt of wet sample}} \times 100$$

3.2.4 Materials and apparatus for Dean and Stark distillation method

Tropical Almond (Kottamba)	Dean and Stark apparatus
Electric balance	Pumic stones
Burner	Amyl Alcohol
Burette handles	Toluene
Measuring cylinder	Water

3.2.5 Methodology for Dean and Stark Distillation

Well-washed and dried Dean and Stark apparatus were fixed. A solution was prepared by mixing 75 ml of amyl alcohol and 150ml of toluene. 50 ml of the solution was taken out into a boiling flask together with the addition of some pumic stones. Then the solution mixture was boiled until graduated arm showing constant amount of water. Then 2.00ml of water was added to the solution mixture and boiled again until constant volume of water was obtained. 2.00g of tropical almond (Kottamba) sample was accurately weighed and added to the flask. Then boiling was continued until constant volume of water was obtained. Finally the % of moisture was calculated as follows (Nielson, 1998).

$$\text{Moisture content} = \frac{\left\{ \frac{2}{V_2} \times [(V_3) - (V_2 + V_1)] \right\}}{\text{Sample Weight}} \times 100\ \%$$

V_1 - Constant amount of water indicate before add sample

V_2 - Water was obtained after add water

2 - Sample was accurately weighted - 2.00 g

V_3 - Boiling was continued until constant volume of water was obtained

3.2.6 Materials and apparatus for Determination of Ash

Tropical Almond (Kottamba)	Muffle furnace (600 ^{0}C)
Electric Burner	porcelain dishes with lids
Electronic Balance	
Desiccator	

3.2.7 Methodology for Determination of Ash content

A small quantity of the sample (3.00 g) was weighed into a clean porcelain dish and burnt by using an electric burner to remove fumes. Then the dishes were placed in the muffle furnace and heated for about 600 ^{0}C for 6 hours. Then the dishes were removed and cooled in a dessicator until a constant weight was obtained. The ash content was calculated as follows (Nielson, 1998).

$$\text{Ash \%} = \frac{\text{Residual wt of sample}}{\text{Wt of wet sample}} \times 100\ \%$$

3.2.8 Material and apparatus for Determination of Total fat

Tropical Almond (Kottamba)	Electronic Balance
Hydrochloric acid	Desiccator
Ether	Ethanol
Majoinner flask	Beaker (100ml)

3.2.8 Methodology for determination Total fat

2.00g of the sample was placed in 50 ml beaker and 2 ml of 95% alcohol and 10 ml of HCl was added into the sample. HCl solution was prepared, adding 25 ml of Conc. HCl and 1 ml of distilled water and the mixture was mixed thoroughly. The mixture was placed in (70 ^{0}C to 80 ^{0}C) water bath and stirred for 30 – 50 minutes frequently and removed the beaker from the water bath and cooled in the atmosphere.

10 ml of Ethanol was added into and it was transferred into majoinner flask. Beaker was washed with 25 ml of ether in 3 portions and added it to the flask. The majoinner flask was shaken vigorously for about few minutes (1-2 minutes). Then 25 ml of Pet ether was added to it and shaken again. The flask was kept until the clear layer of pet ether and the upper layer was taken into clean previously weighed dried flash. Then the flash was dried in a water bath (90 ^{0}C) until the constant weight is obtained (Nielson, 1998).

Calculation

$$\text{Total fat \%} = \frac{\text{Weight of fat}}{\text{Weight of sample}} \times 100$$

3.2.10 Material and apparatus for Determination of crude protein

Tropical Almond (Kottamba)	Electronic Balance
2% Boric acid	Catalysts
Kjeldahl Unit	

3.2.11 Methodology for determination of protein

Sample preparation

5.00g of finely ground tropical almonds were taken into a 250 ml of Kjeldhal tube. 2.00g of catalyst mixture and 25 ml of conc. Sulphuric was added and revolved the tube gently to wash down any particle adhering to the walls of the tube and placed in the tube rack.

Sample digestion

The main electric supply was connected and set the temperature. The Kjeldhal unit was set the exhaust and turn on the aspirator. It was kept the digestion for sufficient time (1 hour or more) and switched off. The system was allowed to cool and 75 ml of distilled water added to the mixture adding along the wall of tube gently.

Dilution

100 ml of alkaline solution was taken into pipette and 25 ml of 4.0% Boric acid was measured into the receiver flask and few drops of bromocresol green were added. The liberate ammonia was escaped with steam through the condenser into the boric acid solution. The boric acid solution colour was changed from bluish purple to bluish green. Then it was titrating with standard hydrochloric acid until the blue colour was disappeared (Nielson, 1998) and (Ranganna, 2001).

Blank determination was carried out in the same way without the sample and protein content was calculated using the following expressions.

$$\text{Nitrogen \%} = \frac{(\text{Sample titrates} - \text{Blank titrates}) \times \text{N.of HCl} \times 14 \times 100}{\text{Wt. of Sample} \times 1000}$$

$$\text{Protein \%} = \text{Nitrogen} \times 6.25$$

3.2.12 Shelf life determination using visual inspection and organoleptic parameters

Colour, aroma, appearance, flavour and taste of roasted almond were checked visually inspection and organoleptically once in every two weeks for 2 months and microbiological evaluation also done.

3.3 Material and reagents for Microbiological tests

3.3.1 Media preparation

Nutrient agar

28g of sample was suspended in 1 liter of distilled water and it was boiled to dissolve completely. Then it was sterilized by autoclaving at 121^{0}C for 15 minutes.

Yeast Extract Agar

23g of sample was suspended in 1 liter of distilled water and boiled to dissolve completely. Then it was sterilized by autoclaving at 121^{0}C for 15 minutes.

Brilliant Green (2%) broth

40 g of sample was added in to 1 liter of distilled water and mixed well. It was put into a container and then Durham's tubes were put in to it. This whole unit was sterilized by autoclaving at 121^{0}C for 15 minutes.

Peptone water

15g of sample was added in to 1 liter of distilled water and mixed well and put in to containers. Then it was sterilized by autoclaving at 121^{0}C for 15 minutes.

3.3.2 Preparation of test sample for ice cream

- Unopened package was clean and disinfected with 70 % V/V alcohol.
- The container was kept until melt in aseptic environment.
- 50g of cream was placed in a wide mouth container with screw cap.
- Then the container was kept until melt in a water bath at 45 ± 1 ^{0}C for 15 minutes. Shake the container at intervals.

3.3.3 Preparation of test sample for raw material

- Clean and disinfect exterior of unopened package with 70 % V/V alcohol.
- The container was kept until melt in aseptic environment.
- 10g of well ground sample was placed in a wide mouth container with screw cap.
- Then 90ml of sterilized ringer solution was added to the sample container and closed and shaken thoroughly.
- Then mixture was kept few minutes and shaken again.

3.3.4 Preparation of the dilution for ice cream sample

First dilution

- 90 ml of sterilized ringer solution was taken into narrow mouth glass bottle.
- Thoroughly mix the melted sample and weighed 10 g using a pipette into a pre taken ringer solution.
- Then the mixture was mixed thoroughly.

Second dilution

- 1ml of first dilution sample was measured and added in to the 99 ml of ringer solution.
- The mixture was mixed thoroughly.

3.3.5 Raw material (roasted nut) *E-coli* and Coliform

Tropical Almond (Kottamba)	Brilliant Green (2%) broth (Oxoid)
Test tubes	Incubator
MPN table (See.App. I)	

3.3.6 Final product *E-coli* and Coliform

Ice cream	Incubator
MPN table	Petrifilm for test *E-coli* and Coliform

3.3.7 *E-coli* and Coliform testing using nine tubes method

- 10 ml of Brilliant green broth (2%) was aseptically introduced into 9 sterilized tubes (3 were large, 6 were small), which have Durham's tubes.
- Then they were sterilized 121 ^{0}C for 15 min.
- 10 ml of first dilution was also aseptically introduced in to 3 sterilized tubes separately.
- 1ml of second dilution was aseptically introduced in to 3 sterilized tubes separately.
- 1ml of third dilution was aseptically introduced in to 3 sterilized tubes separately.
- Then it was closed using cotton wool, and it was shaken thoroughly.
- After that tubes were placed in an incubator, in 36 ^{0}C for 48 hours.
- Then the results were recorded.
- If the test is positive for coli form, 1ml of Indol solution was added in to peptone tubes.

3.3.8 *E-coli* and Coliform testing using petrifilm

- 70 % of alcohol solution was sprayed on to microbiology testing table and clean it well.
- The petrifilm plate was placed on table surface.
- 1ml of first diluted sample was placed on to center of bottom film, with pipette perpendicular to petrifilm plate.
- Top film was rolled down carefully to avoid entrapping air bubbles.
- Spreader was placed on top film over inoculums.
- Gently spreader was applied pressure on distribute inoculums over circular area before gel is formed (do not twist or slide the spreader).
- Spreader was left. Wait a minimum of one minute for gel for solidify.
- Plates were incubated at 35 ± 1^{0}C, for 72 hours with clear side up in stacks of no more than 20.

3.3.9 Raw material (roasted nut) Yeast and mold

Tropical Almond (Kottamba)	Yeast extract agar (Oxoid)
Antibiotic solution	Petri dishes

3.3.10 Final product Yeast and mold

Ice cream	Ptrifilm for test Yeast and Mold

3.3.11 Pore plate techniques for yeast and moulds

- Sterilized yeast extract mixture was kept until cooled 45 ^{0}C.
- 100 ml of sterilized yeast extract was taken and 2 ml of antibiotic was mixed.
- 1ml of dilution sample was aseptically introduced into sterilize plate and approximately 10 – 15 ml of yeast extract agar with antibiotic was poured.
- Then the lid was closed and shaken gently for even distribution of media in Petri dish.
- It was kept in few minutes at a room temperature for solidifying the yeast extract agar.
- The solidified plates were placed upside down in the sterilized plate in 25 ^{0}C (room temperature) for 72 hours.
- Colonies appearing in the media were counted by using the colony counter and the results were recorded.
- This procedure was repeated for second dilution sample and also without dilution.

3.3.12 Methodology for Yeast and Mold testing using Petri film

- 70 % of alcohol solution was sprayed on to microbiology testing table and clean it well.
- The Petri film plate was placed on table surface.
- 1ml of first diluted sample was placed on to center of bottom film, with pipette perpendicular to Petri film plate.
- Top film was rolled down carefully to avoid entrapping air bubbles.
- Spreader was placed on top film over inoculums.
- Gently spreader was applied pressure on distribute inoculums over circular area before gel is formed (do not twist or slide the spreader).
- Spreader was left. Wait a minimum of one minute for gel for solidify.
- Plates were incubated with clear side up in stacks of no more than 20 at 25 ^{0}C (room temperature) for 72 hours.

3.3.13 Raw material (roasted nut) Aerobic plate count

Tropical Almond (Kottamba) Nutrient agar (Oxoid)

Petri dishes

3.3.14 Final product Aerobic plate count

Ice cream Petri film for APC

3.3.15 Methodology for Total Plate Count

- 1ml of dilution sample was measured by using sterilized pipette and introduced in to aseptically sterilized plate.
- Then approximately 10 – 15 ml of nutrient agar was poured, the temperature of agar was 45 ^{0}C.
- Then immediately lid was closed and shaken gently for even distribution of media in a plate. After that plates were kept few minutes to become solidified nutrient agar.
- After solidified plates were kept upside down in the incubator and temperature was set 30 ^{0}C and incubated for 48 hours.
- Colonies appearing in the media were counted by using the colony counter and results were recorded.
- This procedure was repeated for second dilution sample and also without dilution.

3.3.16 Methodology for Total Plate Count (TPC) testing using Petri film

- 70 % of alcohol solution was sprayed on to microbiology testing table and clean it well.
- The TPC Petri film plate was placed on table surface.
- 1ml of first diluted sample was placed on to center of bottom film, with pipette perpendicular to Petri film plate.
- Top film was rolled down carefully to avoid entrapping air bubbles.
- Spreader was placed on top film over inoculums.
- Gently spreader was applied pressure on distribute inoculums over circular area before gel is formed (do not twist or slide the spreader).
- Spreader was left. Wait a minimum of one minute for gel for solidify.
- Plates were incubated with clear side up in stacks of no more than 20 at 30 ^{0}C for 48hours.

3.4 Sensory evaluation to select the most suitable formulation of fruit and nut content

3.4.1 Material and Apparatus

Sensory Evaluation Ballet Paper (See.App.II)

Coded sample	Biscuits
Serviettes	Glass of potable water

3.4.2 Methodology for Sensory Evaluation

Randomly selected untrained sensory panelists sensed the three prepared samples. The panelists were instructed to evaluate the taste, texture of nuts, appearance and overall acceptability of the four different formulated samples. The samples were coded as follows,

Sample (1)	235 (A)
Sample (2)	354 (B)
Sample (3)	426 (C)
Sample (4)	378 (D)

They were given standard ballot papers to rank the attributes. The 9 - point hedonic scale was used to evaluate the degree of likeness for a particular sensory attribute. The collected data were analyzed statistically by computer aided MINITAB Statistical Analysis package. Data were analyzed to determined normality and One Way ANOVA Test was performed on the data at 5 % level of significance.

3.5 Reformulation

After doing sensory evaluation most suitable fruit and nut mixture ratio was selected and early formulation was reformulated. The almond flavour was incorporated to the tropical almond and mixed with an ice cream.

3.6 Cost of production

Cost of production was calculated as follows.

One person can prepare 3 kg of tropical almond nut per day.

One-person day payment Rs.300.00

Addition of cost transport, collection, storage, electricity etc. Rs.200.00

Total cost of Rs.500.00

Cost of production of 1kg of roasted cashew nut Rs.900.00

Cost of production of 1kg of tropical almond assigns Rs.500.00

3.5 Reformulation

After doing sensory evaluation most suitable fruit and nut mixture ratio was selected and early formulation was reformulated. The almond flavour was incorporated to the tropical almond and mixed with an ice cream.

3.6 Cost of production

Cost of production was calculated as follows.

One person can prepare 3 kg of tropical almond nut per day.

One-person day payment Rs.300.00

Addition of cost transport, collection, storage, electricity etc. Rs.200.00

Total cost of Rs.500.00

Cost of production of 1kg of roasted cashew nut Rs.900.00

Cost of production of 1kg of tropical almond assigns Rs.500.00

CHAPTER 04

Results and Discussion

4.1 Raw Material Preparation

When the kernels were dried at 105 ^{0}C, the fibrous coat was not removed well and also efficiency was very low. The blanched kernels fibrous coat was removed efficiently than earlier method. So that to remove the fibrous coat blanching method was selected.

4.2 Physicochemical Assessment Results

The results obtained from the physicochemical analysis of the raw material were shown in Table 4.1.

Table 4.1 Physicochemical assessment results

Parameter analyzed	Content
Moisture (Oven drying)	3.6 – 5.2%
Moisture (Dean & Stark)	3.1 – 4.3%
Ash	3.73%
Total fat	34.06%
Protein	9.63%

According to the results obtained in the physicochemical analysis, of the tropical almond (roasted) nuts moisture percentage was 3.6 – 5.2% and ash percentage was 3.73% and total fats percentage was 34.06% protein percentage was 9.63%. According to moisture % of dehydrated nut, most suitable drying time temperature combination was obtained at 105 ^{0}C for 1 hour. Best roasting time temperature was 140 ^{0}C for 05 minutes.

4.3 Shelf life Evaluation of Tropical almond Nuts

Shelf life evaluation, were mainly considered visual inspections and organoleptic characteristic in roasted nuts and microbiological activity in roasted nut and final product (fruit and nut ice cream). There were no any changes of visual inspections and organoleptic characteristics, storage period of 2 months in roasted almond nuts. According to SLSI standard for nuts there were no microbial contaminations.

4.3.1 Organoleptical Evaluation of Fresh Nuts (without dehydrate)

Preparation Date: 20.04.2006 (fresh nut)

Variety: fresh nut

Storage condition: Under normal environment

The results obtained from the visually inspection and Organoleptical evaluations of the fresh (without dehydrated) tropical almond nuts were shown in Table 4.2.

Table 4.2 Organoleptic evaluation and visual inspection results

Testing parameters	Date 28.04.2006	Date 06.05.2006
Colour	Not change	change
Flavour	Not change	change
Aroma	Not change	change
Taste	Not change	change
Appearance	Not change	change
Texture	Not change	Not change

4.3.2 Microbiological Evaluation

The results obtained from the Microbiological evaluation of fresh Tropical almond nuts were shown in Table 4.3.

Table 4.3 Microbiological evaluation results

Microbiology	Dilution factor (1 = original sample, 2 = 1/10)							
Test dates								
	1	2	1	2	1	2	1	2
TPC	07	Nil	43	09	-	-	-	-
Yeast & Mould	03	Nil	16	01	-	-	-	-

(-) Not tested

According to the results of visual inspection and organoleptic parameters, colour, flavour, aroma, taste and appearance were changed after 14 days storage period and it can be shown microbial growth on the kernels. According to microbiological examination yeast and mould, TCC colonies were examined. There were rancid flavours existing, due to the rancidity of kernels aroma and taste were changed. It was seen green color formation on kernels.

4.3.3 Organoleptic Evaluation and Visually inspection of Roasted Tropical almond Nut without coat removing

Preparation Date: 20.04.2006 (Drying T 105^{0}C for 1 hr)

Storage condition: Under refrigerator conditions

The results obtained from the visually inspection and Organoleptical Evaluation of the roasted tropical almond nuts were shown in Table 4.4.

Table 4.4 Organoleptic evaluation and visual inspection results

Testing parameters	Date 08.05.2006	Date 22.05.2006	Date 13.06.2006	Date 03.07.2006
Colour	Not change	Not change	Not change	Not change
Flavour	Not change	Not change	Not change	Not change
Aroma	Not change	Not change	Not change	Not change
Taste	Not change	Not change	Not change	Not change
Appearance	Not change	Not change	Not change	Not change
Texture	Not change	Not change	Not change	Not change

Organoleptic, visual parameters and microbiological characteristics of the roasted almonds were remained unchanged during the period of a storage life of 1 1/2 months.

4.3.4 Microbiological Evaluation

The results obtained from the Microbiological evaluation of fresh Tropical almond nuts were shown in Table 4.5.

Table 4.5 Microbiological evaluation results

Microbiology	Dilution factor (1 = original sample, 2 = 1/10)							
Test dates	08.05.2006		13.06.2006		03.07.2006			
	1	2	1	2	1	2	1	2
TPC	Nil	Nil	Nil	Nil	12	Nil	-	-
Yeast & Mould	Nil	Nil	Nil	Nil	Nil	Nil	-	-

According to microbiological examination yeast and mould, TCC colonies were not examined and there was no visual inspection and organoleptical characteristics changed. The presence of shells provides a very strong protective barrier against infection by both fungi and bacteria. Under refrigeration condition and low moisture conditions (3.5%) microbes can't be performed. So the nut can be stored under refrigeration condition for 2 ½ months without any changes of colour, flavour, texture, appearance, aroma and taste.

4.3.5 Organoleptic Evaluation and Visual inspection of Roasted peel removed Tropical almond Nut

Preparation Date: 20.04.2006 (Drying T 105^{0}C for 1 hr)

Test dates (Under refrigerator conditions)

The results obtained from the Oganoleptical Evaluation and visual inspection of the roasted Tropical almond nuts were shown in Table 4.6.

Table 4.6 Organoleptic evaluation and visual inspection results

Testing parameters	Date 03.05.2006	Date 17.05.2006	Date 13.06.2006	Date 03.07.2006
Colour	Not change	Not change	Not change	Not change
Flavour	Not change	Not change	Not change	Not change
Aroma	Not change	Not change	Not change	Not change
Taste	Not change	Not change	Not change	Not change
Appearance	Not change	Not change	Not change	Not change
Texture	Not change	Not change	Not change	Not change

Organoleptic, visual parameters and microbiological characteristics of the roasted almonds were remained unchanged during the period of a storage life of 1 1/2 months.

4.3.6 Microbiological Evaluation

The results obtained from the Microbiological evaluation of roasted Tropical almond nuts were shown in Table 4.7.

Table 4.7 Microbiological evaluation results

Microbiology	Dilution factor (1 = original sample, 2 = 1/10)							
Test dates	03.05.2006		13.06.2006		03.07.2006			
	1	2	1	2	1	2	1	2
TPC	Nil	Nil	03	Nil	85	Nil	-	-
Yeast & Mould	Nil	Nil	Nil	Nil	Nil	Nil	-	-

According to microbiological examination yeast and mould, TCC colonies were not examined and there were no any changed in organoleptical and visual parameters. Naturally almond presence of shells provides a very strong protective barrier against infection by both fungi and bacteria. Under refrigeration condition and low moisture conditions (3.5%) microbes can't be performed. So the nut can be stored under refrigeration condition at least 2 ½ months without any changes of colour, flavour, texture, appearance, aroma and taste.

4.4 Sensory Evaluation

As sensory evaluation was carried out using same human subject serving both the four samples at the same time, data generated were independent one upon other. In fact One Way ANOVA test was used to analyze the sensory attributes and following are the outcomes.

4.4.1 Normality Test

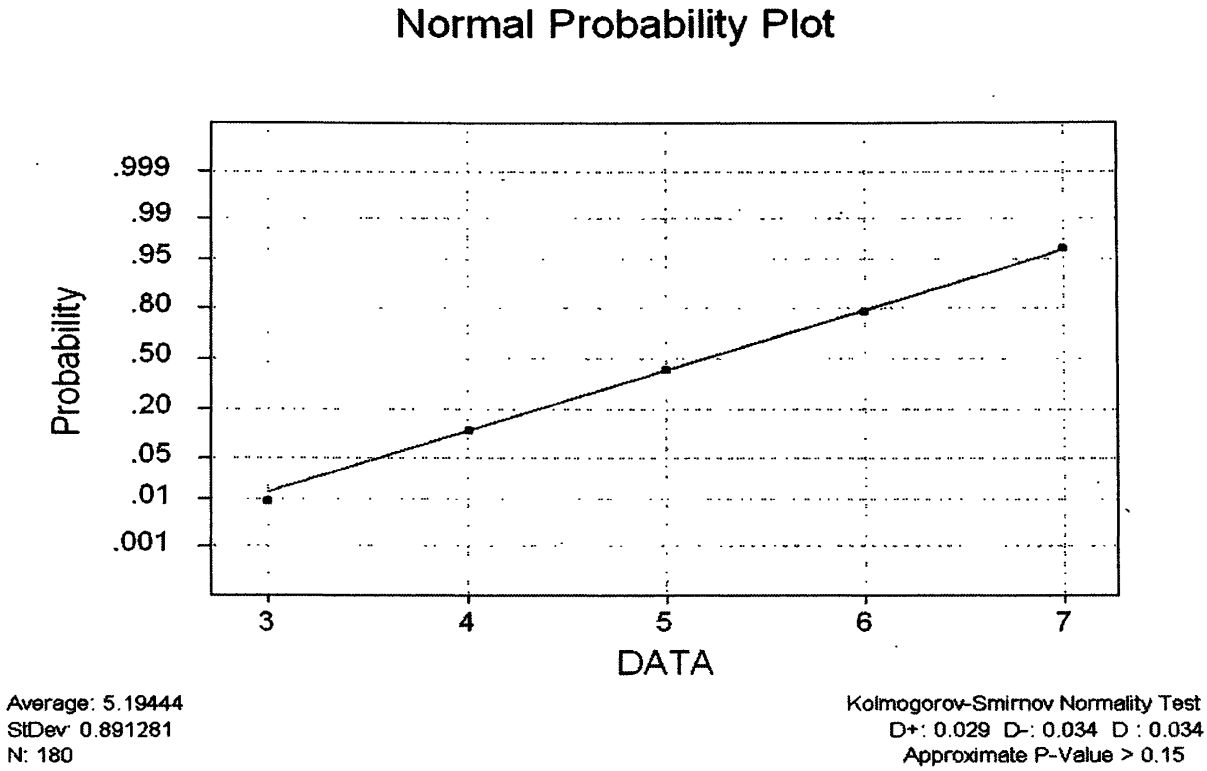


Fig: Normality test for Sample 235 (A)

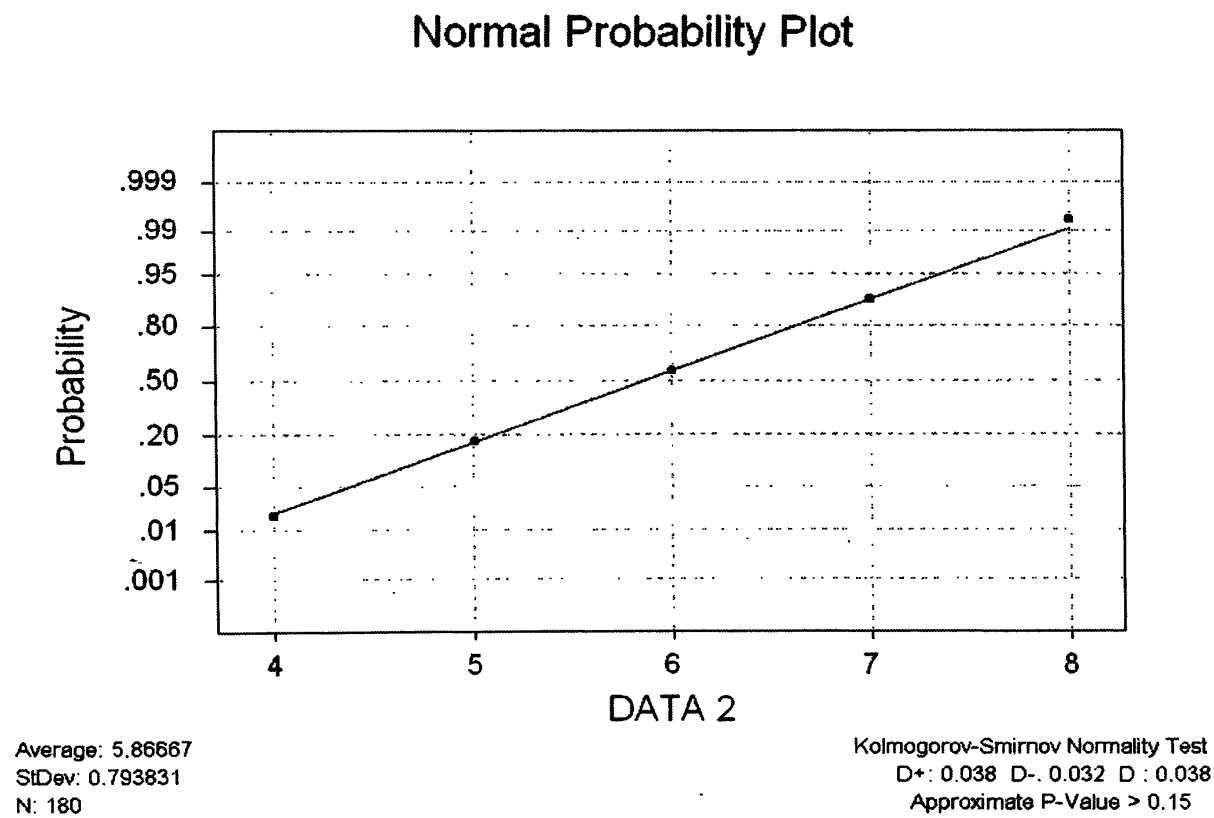


Fig: Normality test for Sample 354 (B)

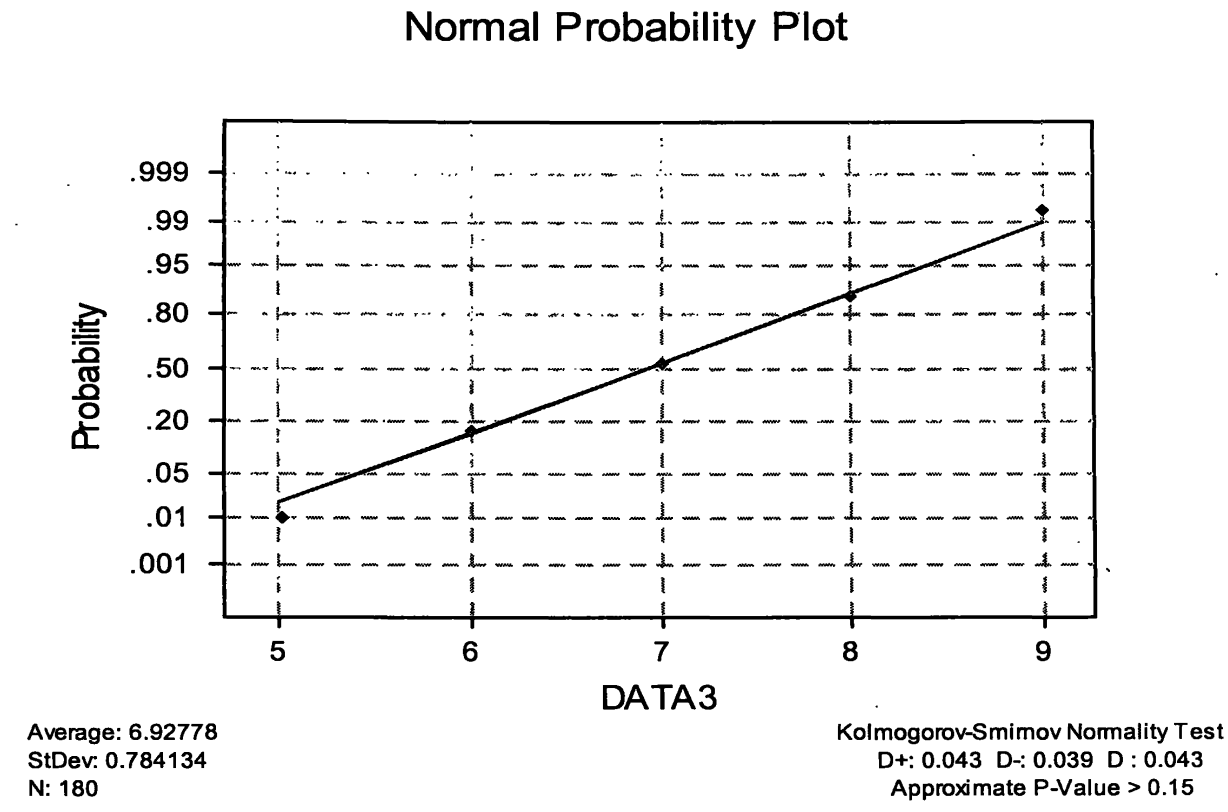


Fig: Normality test for Sample 426 (C)

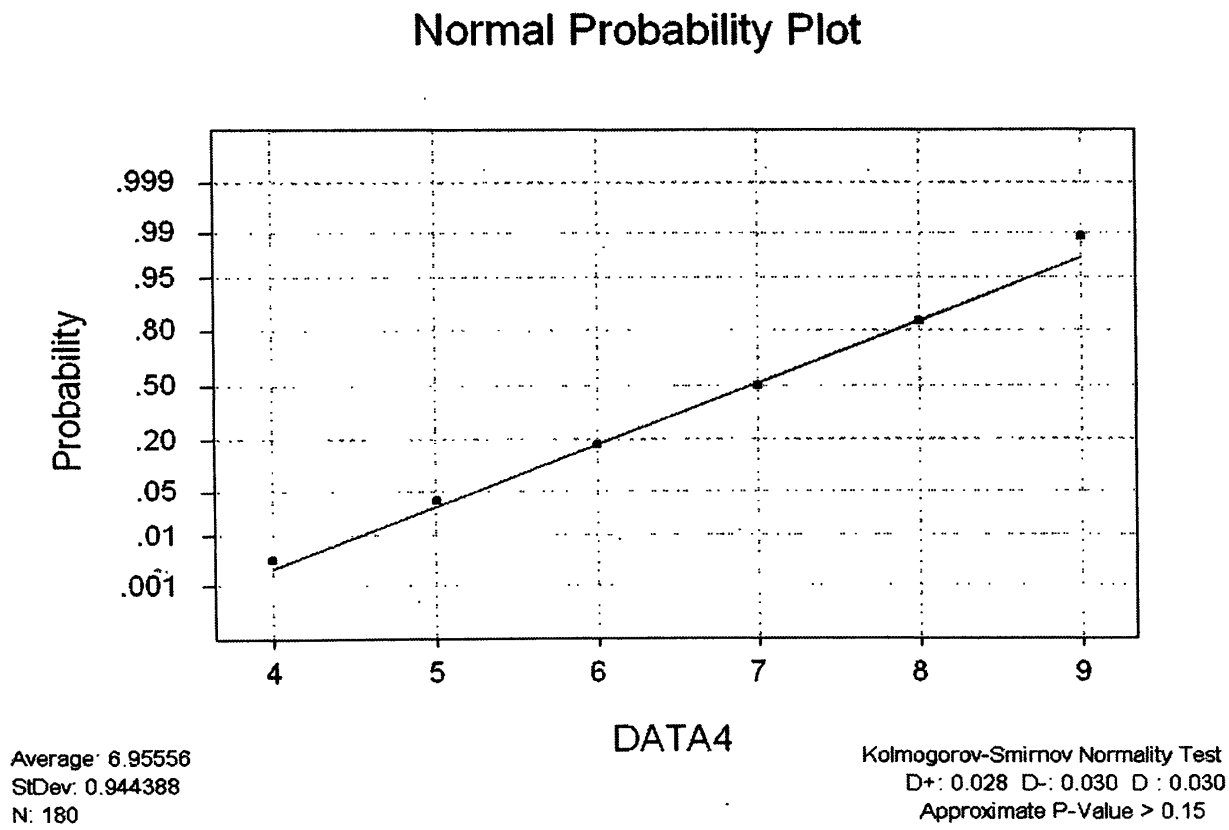


Fig: Normality test for Sample 378 (D)

The sensory evaluation were conducted to determine most appropriate nut content, taste of nut, flavour of nut, texture of nut, appearance and overall acceptability. The results analyzed were given below. According to the analyzed data of the sensory evaluation, the levels of preference for each sensory attribute in all 4 samples were identified (See.App.III).

4.4.2 Determination of Taste of Nut

Normality test's p-value indicates that, at 5% levels less than 0.150; there is evidence that the data follow a normal distribution. (See. App. V).

P (α) = table value P^1 = calculated value

Table 4.8 Results of the nut taste with fruit and nut ice cream.

Sample code	Number of sample	Mean	Normality P value
(A) 235	30	4.9000	0.150
(B) 354	30	5.6667	
(C) 426	30	6.7000	
(D) 378	30	7.2000	

According to analyzed data there is a significant difference between the samples, since probability value $p^1 = 0.000$ of the test is less than the minimum probability value p (α) = 0.05. According to the data, sample 378 (D) gained the highest mean value for taste of nut. So the sample number 4 (378) can be considered as the best when considering the taste of nut (See. App. IV). To explore the differences among the means, examine the multiple comparison results. Best spiciness was selected as 4^{th} sample (sample code 378) by Hsu's MCB (Multiple Comparisons with the Best) (See. App. VI).

4.4.3 Determination of Optimum Nut Content

Normality test's p-value indicates that, at 5% levels less than 0.150; there is evidence that the data follow a normal distribution. (See. App. V).

P (α) = table value P^1 = calculated value

Table 4.9 Results of the optimum nut content in fruit and nut ice cream.

Sample code	Number of sample	Mean	Normality P value
(A) 235	30	4.4667	0.150
(B) 354	30	3.3667	
(C) 426	30	6.6000	
(D) 378	30	6.6333	

According to analyzed data there is a significant difference between the samples, since probability value $p^1 = 0.000$ of the test is less than the minimum probability value p (α) = 0.05. According to the data, sample 378 (D) gained the highest mean value with for optimum nut content. So the sample number 378 (D) can be considered as the best when considering the optimum nut content (See. App. IV). To explore the differences among the means, examine the multiple comparison results. Best spiciness was selected as 4th sample (sample code 378) by Hsu's MCB (Multiple Comparisons with the Best) (See. App. VI).

4.4.4 Determination of Appearance of Ice cream

Normality test's p-value indicates that, at 5% levels less than 0.150; there is evidence that the data follow a normal distribution. (See. App. V).

P (α) = table value P^1 = calculated value

Table 4.10 Results of the appearance of fruit and nut ice cream.

Sample code	Number of sample	Mean	Normality P value
(A) 235	30	5.9667	0.150
(B) 354	30	6.2333	
(C) 426	30	6.9667	
(D) 378	30	5.9333	

According to analyzed data there is a significant difference between the samples, since probability value $p^1 = 0.000$ of the test is less than the minimum probability value p (α) = 0.05. According to the data, sample 426 (C) gained the highest mean value for appearance of ice cream. So the sample numbers 426 (C) can be considered as the best when considering the appearance of ice cream (See. App. IV). To explore the differences among the means, examine the multiple comparison results. Best spiciness was selected as 3rd sample (sample code 426) by Hsu's MCB (Multiple Comparisons with the Best) (See. App. VI).

4.4.5 Determination of Flavour of Nut

Normality test's p-value indicates that, at 5% levels less than 0.150; there is evidence that the data follow a normal distribution. (See. App. V).

P (α) = table value P^1 = calculated value

Table 4.11 Results of the Flavour of nut in fruit and nut ice cream.

Sample code	Number of sample	Mean	Normality P value
(A) 235	30	4.8667	0.150
(B) 354	30	5.6667	
(C) 426	30	6.9333	
(D) 378	30	7.1333	

According to analyzed data there is no a significant difference between the samples, since probability value $p^1 = 0.000$ of the test is less than the minimum probability value p (α) = 0.05. According to the data, sample 378 (D) gained the highest mean value for flavour of nut in an ice cream. So the sample numbers 378 (D) can be considered as the best when considering the flavour of nut in an ice cream (See. App. IV). To explore the differences among the means, examine the multiple comparison results. Best spiciness was selected as 4th sample (sample code 378) by Hsu's MCB (Multiple Comparisons with the Best) (See. App. VI).

4.4.6 Determination of Texture of Nuts

Normality test's p-value indicates that, at 5% levels less than 0.150; there is evidence that the data follow a normal distribution. (See. App. V).

P (α) = table value P^1 = calculated value

Table 4.12 Results of the optimum nut content in fruit and nut ice cream.

Sample code	Number of sample	Mean	Normality P value
(A) 235	30	5.8333	0.150
(B) 354	30	6.3000	
(C) 426	30	7.2667	
(D) 378	30	7.6000	

According to analyzed data there is a significant difference between the samples, since probability value $p^1 = 0.000$ of the test is less than the minimum probability value p (α) = 0.05. According to the data, sample 378 (D) gained the highest mean value for texture of nut in an ice cream. So the sample numbers 378 (D) can be considered as the best when considering the texture of nut in ice cream (See. App. IV). To explore the differences among the means, examine the multiple comparison results. Best spiciness was selected as 4th sample (sample code 378) by Hsu's MCB (Multiple Comparisons with the Best) (See. App. VI).

4.4.7 Determination of Overall Acceptability of Ice cream

Normality test's p-value indicates that, at 5% levels less than 0.150; there is evidence that the data follow a normal distribution. (See. App. V).

P (α) = table value P^1 = calculated value

Table 4.13 Results of the Overall acceptability of fruit and nut ice cream.

Sample code	Number of sample	Mean	Normality P value
(A) 235	30	5.1667	0.150
(B) 354	30	5.9667	
(C) 426	30	7.1000	
(D) 378	30	7.2333	

According to analyzed data there is a significant difference between the samples, since probability value $p^1 = 0.000$ of the test is less than the minimum probability value p (α) = 0.05. According to the data, sample number 378 (D) gained the highest mean value for overall acceptability of an ice cream. So the sample number 378 (D) can be considered as the best when considering the overall acceptability of an ice cream (See. App. IV). To explore the differences among the means, examine the multiple comparison results. Best spiciness was selected as 4^{th} sample (sample code 378) by Hsu's MCB (Multiple Comparisons with the Best) (See. App. VI).

The sensory results were reveled that, the sample code 426 (C) and 378 (D) were the best samples for optimum nut content and overall acceptability. Both samples have same fruit and nut formulae except nut preparation procedure. Sample number 378 nuts had outer fibrous coat, sample number 426 had not outer fibrous coat. According to sensory results texture, flavour and taste of nuts were best in sample code 378 (D). When removing of outer layer of nut the flavour of nuts were decreased. The sample number 378 the fibrous layer of nut was not removed. When consider the appearance of nuts sample number 426 (D) was the best one. Therefore to increase the flavour strength almond flavour was added to the tropical almond. The best formulae were as follows,

Sample number 426 (C): tropical almond outer coat removed 30.0g: plums 30.0g: ash pumpkin 40.0g,

Sample number 378 (D): tropical almond outer coat not removed 30.0g: plums 30.0g: ash pumpkin 40.0g.

4.6 Shelf life evaluation for final product

Table 4.14 Final product microbiological results

Microbiology	Dilution factor (1 = 1/10, 2 = 1/100)				**SLSI** Standard
Test dates	15.06.2006		20.07.2006		
Dilutions	1	2	1	2	
TPC	19	6	23	7	**5×10^4**
Yeast & Mould	Nil	Nil	Nil	Nil	**Not define**
E-coli and Coliform	Nil	Nil	Nil	Nil	**1×10^2**

According to the microbiological results few TPC colonies were examined but this is in the limit of SLSI standard. There is no any colony count in Yeast and Mold, *E-coli* and Coliform. Under SLSI standard *E-coli* and Coliform should be free. Nut in the fruit and nut ice cream was not any flavour, colour, taste, appearance and textural changes occurred during storage period of 11/2 month.

4.6.1 Microbiology tests

Testing of microbiological parameters for *E.coli*, Coliform, was used to both Petri film and tube method and to test yeast and mold and aerobic plate count both Petri film and SLS method was used. So Petri film method was greatly increase lab efficiency and reduced overall costs. Petri film plates are sample ready made and provide the most cost effective, convenient and reliable method for testing equipment, raw materials, food products and the manufacturing environment. This plates already pre prepared special microbial nutrient medias so it is wanted only inoculation and kept it for appropriate time and environment. It can be shown specific microorganism colonies with specific colour and their special characteristics e.g. *E-coli* gas formation.

4.7 Reformulation

According to the sensory evaluation most of panelist was recommended the flavour strength of nuts may lesser than the flavour contribution of cashew nut. Sensory panelists were recommended; the flavour of nut should be increased. So almond flavour was added to improve the flavour of nut and the nut was incorporated to ice cream. Finally almond flavoured ice cream was made.

4.8 Cost of production

Production cost of 1kg of roasted cashew nut Rs.900.00

Production cost of 1kg of tropical almond assign Rs.500.00

Production Cost of cashew nut for 1l of ice cream	Rs. =	900.00 / 50
		18.00
Production Cost of tropical almond for 1l of ice cream	Rs. =	500.00 / 33.33
		15.0015

The production cost of tropical almond nuts was less than production cost of cashew nut per 1l of ice cream at the movement but this is not exact value this may vary with availability of product, seasonal variation and country economy.

CHAPTER 5

Conclusion and Recommendation

5.1 Conclusion

- Blanching of nut was better to remove the fibrous coat in nuts.
- Best fruit and nut formulae for 1l Ice cream was,

  Tropical almond 30.0g: Plums 30.0g: Ash pumpkin 40.0g
- Flavour, taste and texture of nut was high in outer fiber coat contain nut than fiber coat removed one.
- Shelf life of Fresh nuts, store under normal environment (room temperature) condition for about 8 days and processed (roasted) nut can be stored under refrigeration condition for about 2 month without any change of colour, texture, taste, and appearance.
- Moisture content of processed (roasted) nut was around 3.6% - 5.2%, fat was 34.06%, protein was 9.63% and ash was 3.73%.
- Final product can safely be kept for 8 weeks without the changes either microbiological or organoleptic properties.
- Production cost of 1Kg of roasted nuts Rs.500.00 and nuts for 1L pack of ice cream Rs.15.0015.

5.2 Recommendation

- The outer fibrous coat removing process should be improved.
- As an innovative new product it is recommended to develop an almond flavoured ice cream (instead of vanilla flavour) with almond nuts incorporated.
- Availability of tropical almond in Sri Lanka to assess the feasibility of using tropical almond nuts in commercial ice cream production.

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URL: http://www.3M.com/microbiology.html

Appendix (I)

MPN TABLE

Number of positive tubes for the three dilution factors retained			MPN	Confidence limits 99%		95%	
0	0	0	0.3				
0	1	0	0.3	0.1	2.3	0.1	1.7
1	0	0	0.4	0.1	2.8	0.1	2.1
1	0	1	0.7	0.1	3.5	0.2	2.7
0	1	1	0.7	0.1	3.6	0.2	2.8
1	2	0	1.1	0.2	4.4	0.4	3.5
2	0	0	0.9	0.1	5.0	0.2	3.8
2	0	1	1.4	0.3	6.2	0.5	4.8
2	1	0	1.5	0.3	6.5	0.5	5.0
2	1	1	2.0	0.5	7.7	0.8	6.1
2	2	0	2.1	0.5	0.8	0.8	6.3
3	0	0	2.3	0.4	17.7	0.7	12.9
3	0	1	4	1	25	1	18
3	1	0	4	1	29	2	21
3	1	1	7	2	37	2	28
3	2	0	9	2	52	3	39
3	2	1	15	3	66	5	51
3	2	2	21	5	82	8	64
3	3	0	20	10	190	10	140
3	3	1	50	10	320	20	240
3	3	1	110	20	640	30	480
3	3	3	>110				

Results not shown in the table cannot be used; such results may be expected in only 5 per cent of cases.

SLS 516: Part 3: 1982

Appendix (II)

THE SENSORY BALLOT SHEET

Name: ..... Date: .....

Product Description: .....

You have given four different fruit and nut ice creams were prepared by using different combination of nut content. You are kindly requested to assess each ice cream sample presented, with reference to under mentioned sensory attributes according to your preference considering the following scale.

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

Sample code	Taste of nut	Colour of nut	Appearance of nut	Flavour of nut	Texture of nut	Overall acceptability
374						
426						
354						
235						

Comments:

.....

.....

.....

.....

Instructions

Please rinse your mouth with water before starting.
You may rinse again at any time during the test if you need to.
Please taste the four samples in the order presented, from left to right.
Check degree of liking and use appropriate scale to best describe your feeling.
You may re-taste the samples once you have tried all of them.
If you have any questions, please ask the server now.
Please return your sensory evaluation form to the server.

Thank you for your participation

Appendix (III)

Sensory evaluation results

Sample 235

Result of the sensory attributes with reference to the scales of ballot paper

Numb	Nut taste	Nut content	Appearance	Nut flavour	Texture of nut	Overall acceptability
1	6	5	7	5	7	6
2	5	4	6	5	7	5
3	4	6	6	4	6	5
4	4	5	6	4	6	5
5	4	4	6	4	6	5
6	4	3	6	4	6	4
7	5	4	6	5	6	5
8	4	5	6	5	7	6
9	5	6	7	5	6	6
10	5	4	6	6	6	5
11	5	4	6	5	6	6
12	5	5	6	5	6	5
13	5	3	6	6	5	6
14	6	5	7	6	6	5
15	5	5	7	6	5	6
16	5	4	6	5	5	5
17	4	4	5	4	6	4
18	5	4	5	5	5	5
19	5	3	6	5	6	5
20	4	4	6	5	5	5
21	4	4	5	4	5	4
22	4	4	5	5	4	4
23	4	5	5	4	6	5
24	5	4	5	5	5	5
25	6	5	5	5	4	5
26	5	5	6	5	6	5
27	6	5	6	5	6	6
28	6	5	6	5	7	6
29	6	5	7	4	7	5
30	6	5	7	5	7	6

Sample 354

Result of the sensory attributes with reference to the scales of ballot paper

Numb.	Nut taste	Nut content	Appearance	Nut flavour	Texture of nut	Overall acceptability
1	6	6	7	5	6	6
2	5	6	7	6	7	6
3	5	6	6	5	6	6
4	5	5	6	5	7	6
5	5	6	6	5	7	5
6	4	6	5	6	6	5
7	6	5	6	5	7	6
8	6	6	6	6	7	7
9	6	6	8	5	7	6
10	6	5	7	6	7	6
11	6	5	7	6	6	7
12	6	6	6	6	7	6
13	6	4	6	7	6	6
14	6	6	7	7	6	6
15	5	6	7	7	6	7
16	5	5	7	6	6	6
17	6	5	6	5	6	5
18	6	4	5	5	6	5
19	5	4	6	5	7	6
20	5	5	6	6	5	6
21	5	4	5	5	5	5
22	4	5	5	6	5	5
23	5	5	6	5	6	6
24	6	5	5	6	6	6
25	7	6	5	6	5	6
26	6	6	7	6	7	6
27	6	6	6	5	6	6
28	7	6	6	6	7	7
29	7	5	7	5	7	6
30	7	6	8	6	7	7

Sample 426

Result of the sensory attributes with reference to the scales of ballot paper

Numb.	Nut taste	Nut content	Appearance	Nut flavour	Texture of nut	Overall acceptability
1	7	6	7	6	7	7
2	6	7	7	7	8	7
3	6	8	7	7	7	7
4	7	7	7	8	8	8
5	6	7	7	6	7	6
6	6	7	6	8	9	7
7	7	6	7	7	7	7
8	8	8	8	8	8	8
9	7	6	8	6	7	8
10	8	6	8	6	8	8
11	7	6	8	8	7	7
12	6	7	7	8	7	7
13	7	6	7	7	8	8
14	7	7	8	8	7	7
15	6	7	8	7	7	8
16	6	7	7	7	6	7
17	6	6	6	7	7	6
18	6	6	6	6	6	6
19	6	6	7	6	7	7
20	6	6	6	7	6	6
21	5	6	5	6	7	6
22	5	6	6	7	6	7
23	7	6	7	7	7	7
24	7	6	6	8	8	7
25	8	7	7	7	9	7
26	7	8	7	7	7	7
27	7	7	6	6	8	7
28	8	7	7	7	7	8
29	8	6	8	6	8	7
30	8	7	8	7	7	8

Sample 378

Result of the sensory attributes with reference to the scales of ballot paper

Numb.	Nut taste	Nut content	Appearance	Nut flavour	Texture of nut	Overall acceptability
1	8	6	8	7	7	7
2	7	7	8	7	8	8
3	7	7	6	8	8	8
4	8	8	6	6	7	7
5	7	7	6	7	8	7
6	7	9	6	6	7	8
7	7	6	6	7	9	7
8	6	6	6	8	8	6
9	7	6	7	6	7	7
10	8	6	7	7	8	8
11	8	7	7	9	7	8
12	7	7	6	7	8	8
13	7	6	6	8	7	8
14	7	6	7	6	8	8
15	7	6	7	6	7	8
16	7	7	7	8	8	8
17	7	7	6	7	8	7
18	8	6	5	8	7	7
19	7	7	5	7	8	6
20	6	6	5	8	7	7
21	5	6	4	7	7	6
22	6	6	5	8	7	7
23	8	6	5	6	8	6
24	7	6	5	7	7	7
25	8	8	5	8	9	8
26	7	7	5	7	7	6
27	8	7	5	7	8	7
28	8	7	5	6	8	8
29	8	6	6	7	7	7
30	8	7	6	8	8	7

Appendix IV

One-way ANOVA: Nut taste_1 versus sample

```
Analysis of Variance for Nut tast
Source     DF        SS        MS        F        P
FACTOR      3    95.900    31.967    49.80    0.000
Error     116    74.467     0.642
Total     119   170.367

                                    Individual 95% CIs For Mean
                                    Based on Pooled StDev
Level       N      Mean     StDev  ---+---------+---------+---------+---
1          30    4.9000    0.7589   (--*---)
2          30    5.6667    0.8023            (---*--)
3          30    6.7000    0.8769                      (---*--)
4          30    7.2000    0.7611                            (---*---)
                                    ---+---------+---------+---------+---
Pooled StDev =    0.8012             4.80      5.60      6.40      7.20
```

One-way ANOVA: Nut content_1 versus sample

```
Analysis of Variance for Nut cont
Source     DF        SS        MS        F        P
FACTOR      3    98.867    32.956    61.07    0.000
Error     116    62.600     0.540
Total     119   161.467

                                    Individual 95% CIs For Mean
                                    Based on Pooled StDev
Level       N      Mean     StDev  --------+---------+---------+--------
1          30    4.4667    0.7761   (--*--)
2          30    5.3667    0.7184            (--*--)
3          30    6.6000    0.6747                      (---*--)
4          30    6.6333    0.7649                       (--*--)
                                    --------+---------+---------+--------
Pooled StDev =    0.7346                 4.80      5.60      6.40
```

One-way ANOVA: Appearance_1 versus sample

```
Analysis of Variance for Appearan
Source     DF        SS        MS        F        P
FACTOR      3    20.758     6.919     9.89    0.000
Error     116    81.167     0.700
Total     119   101.925

                                    Individual 95% CIs For Mean
                                    Based on Pooled StDev
Level       N      Mean     StDev  --------+---------+---------+--------
1          30    5.9667    0.6687   (-----*-----)
2          30    6.2333    0.8584         (-----*-----)
3          30    6.9667    0.8087                   (-----*-----)
4          30    5.9333    0.9803   (-----*-----)
                                    --------+---------+---------+--------
Pooled StDev =    0.8365                 6.00      6.50      7.00
```

One-way ANOVA: Nut flavour_1 versus sample

```
Analysis of Variance for Nut flav
Source     DF        SS        MS        F        P
FACTOR      3   103.833    34.611    67.51    0.000
Error     116    59.467     0.513
Total     119   163.300

                                  Individual 95% CIs For Mean
                                  Based on Pooled StDev
Level       N      Mean     StDev  ---+---------+---------+---------+---
1          30    4.8667    0.6288   (--*--)
2          30    5.6667    0.6609            (--*--)
3          30    6.9333    0.7397                      (---*--)
4          30    7.1333    0.8193                         (--*--)
                                  ---+---------+---------+---------+---
Pooled StDev =   0.7160             4.80      5.60      6.40      7.20
```

One-way ANOVA: Texture of nut_1 versus sample

```
Analysis of Variance for Texture
Source     DF        SS        MS        F        P
FACTOR      3    60.967    20.322    37.10    0.000
Error     116    63.533     0.548
Total     119   124.500

                                  Individual 95% CIs For Mean
                                  Based on Pooled StDev
Level       N      Mean     StDev  -+---------+---------+---------+-----
1          30    5.8333    0.8339   (--*---)
2          30    6.3000    0.7022         (---*---)
3          30    7.2667    0.7849                   (---*---)
4          30    7.6000    0.6215                        (---*--)
                                  -+---------+---------+---------+-----
Pooled StDev =   0.7401           5.60      6.30      7.00      7.70
```

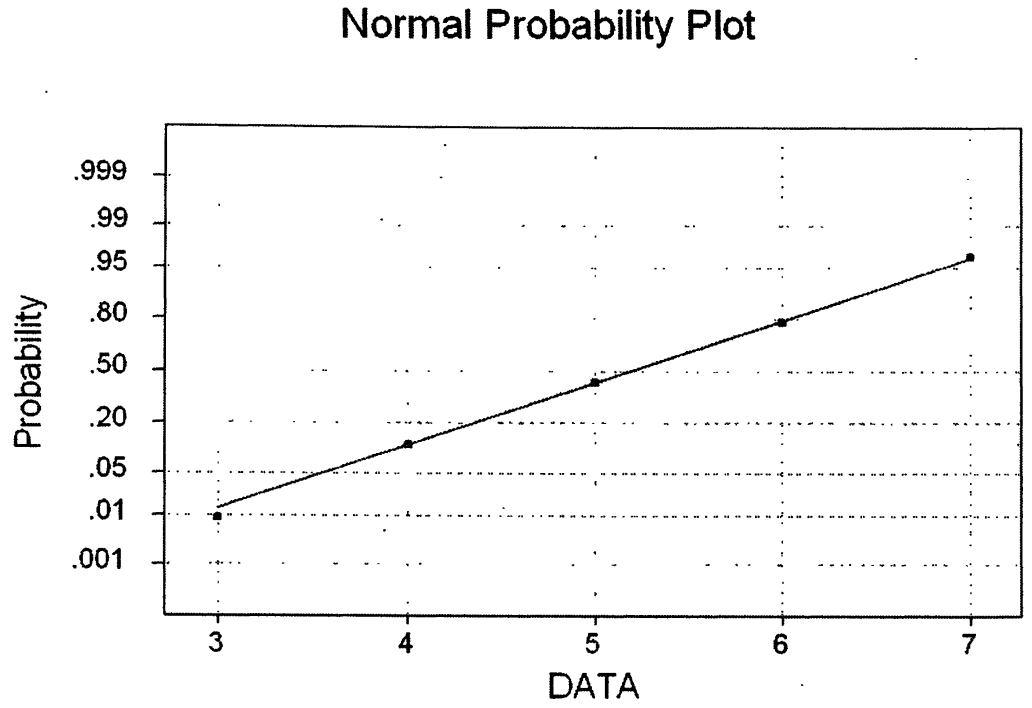
One-way ANOVA: Overall acceptability_1 versus sample

```
Analysis of Variance for Overall
Source     DF        SS        MS        F        P
FACTOR      3    86.667    28.889    65.45    0.000
Error     116    51.200     0.441
Total     119   137.867

                                  Individual 95% CIs For Mean
                                  Based on Pooled StDev
Level       N      Mean     StDev  ----------+---------+---------+------
1          30    5.1667    0.6477  (---*--)
2          30    5.9667    0.6149            (--*---)
3          30    7.1000    0.6618                      (--*---)
4          30    7.2333    0.7279                        (--*---)
                                  ----------+---------+---------+------
Pooled StDev =   0.6644                    5.60      6.30      7.00
```

Appendix V

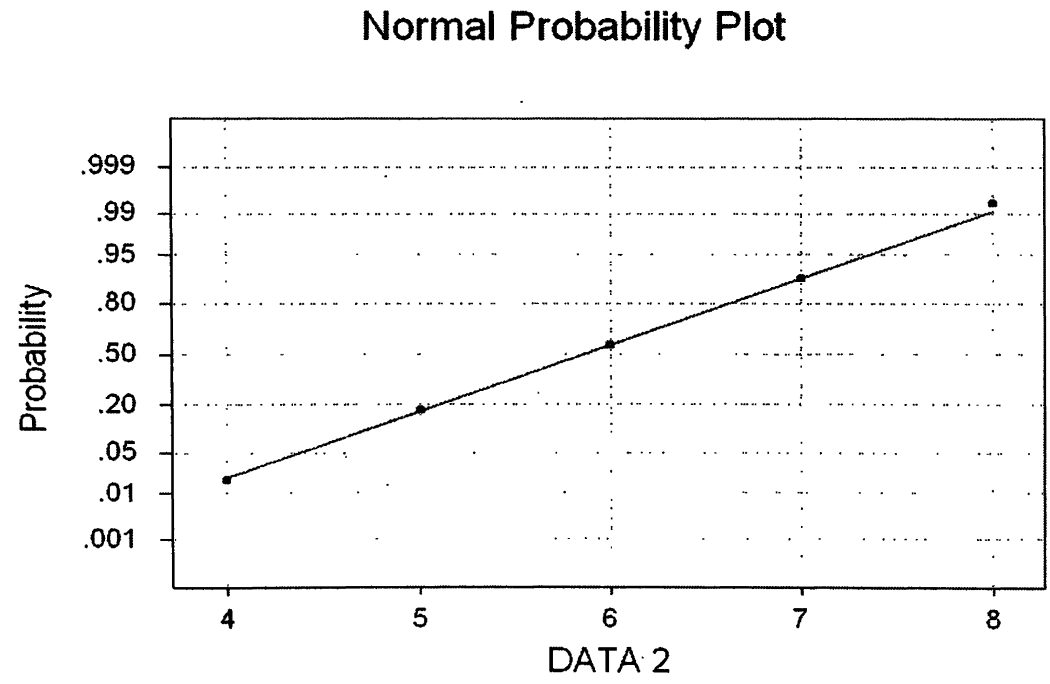
Sample 01 235 (A)



Average: 5.19444
StDev: 0.891281
N: 180

Kolmogorov-Smirnov Normality Test
D+: 0.029 D-: 0.034 D : 0.034
Approximate P-Value > 0.15

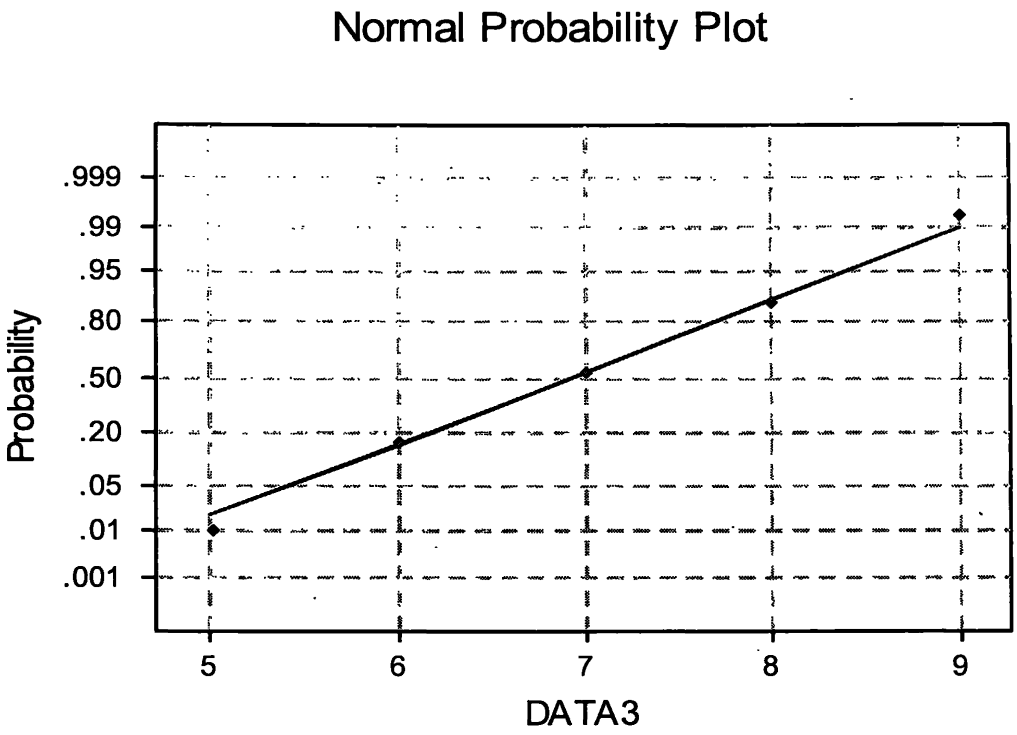
Sample 02 354 (B)



Average: 5.86667
StDev: 0.793831
N: 180

Kolmogorov-Smirnov Normality Test
D+: 0.038 D-: 0.032 D : 0.038
Approximate P-Value > 0.15

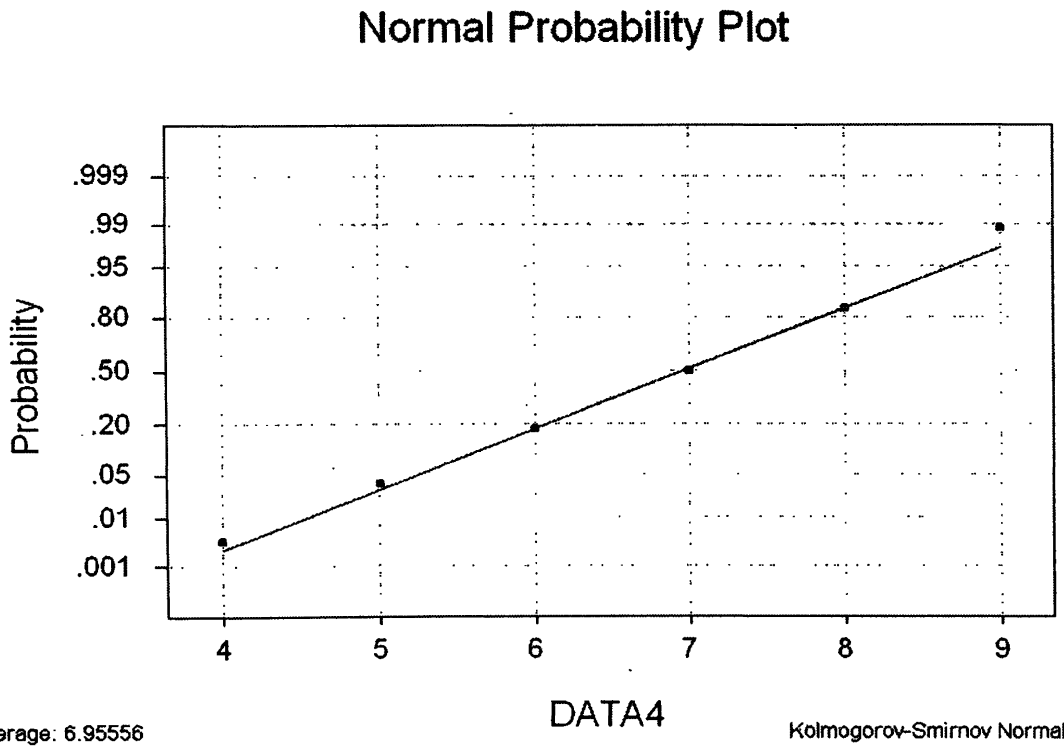
Sample 03 426 (C)



Average: 6.92778
StDev: 0.784134
N: 180

Kolmogorov-Smirnov Normality Test
D+: 0.043 D-: 0.039 D : 0.043
Approximate P-Value > 0.15

Sample 04 378 (D)



Average: 6.95556
StDev: 0 944388
N: 180

Kolmogorov-Smirnov Normality Test
D+: 0 028 D-: 0.030 D : 0.030
Approximate P-Value > 0.15

Appendix (VI)

One-way ANOVA: Nut taste_1 versus sample

```
Analysis of Variance for Nut tast
Source     DF        SS        MS        F        P
FACTOR      3    95.900    31.967    49.80    0.000
Error     116    74.467     0.642
Total     119   170.367

                                    Individual 95% CIs For Mean
                                    Based on Pooled StDev
Level       N      Mean     StDev  ---+---------+---------+---------+---
1          30    4.9000    0.7589   (--*---)
2          30    5.6667    0.8023            (---*--)
3          30    6.7000    0.8769                      (---*--)
4          30    7.2000    0.7611                            (---*---)
                                    ---+---------+---------+---------+---
Pooled StDev =    0.8012             4.80      5.60      6.40      7.20
```

H_0: There is sufficient evidence that all the means are equal

H_1: There is sufficient evidence that all the means are NOT equal

At 5% significant levels, P-value = 0.000

$\alpha > P$

H_0 - rejected

At 5% significant levels, there is sufficient evidence that all the means are NOT equal

```
Hsu's MCB (Multiple Comparisons with the Best)

    Family error rate = 0.0500

Critical value = 2.08

Intervals for level mean minus largest of other level means

Level        Lower    Center     Upper --------+---------+---------+---------
1          -2.7311   -2.3000    0.0000  (---*----------------------)
2          -1.9644   -1.5333    0.0000         (----*---------------)
3          -0.9311   -0.5000    0.0000                (---*----)
4           0.0000    0.5000    0.9311                      (----*---)
                                       --------+---------+---------+---------
                                           -2.0      -1.0       0.0
```

One-way ANOVA: Nut content_1 versus FACTOR

```
Analysis of Variance for Nut cont
Source     DF        SS        MS        F        P
FACTOR      3    98.867    32.956    61.07    0.000
Error     116    62.600     0.540
Total     119   161.467
```

```
                                        Individual 95% CIs For Mean
                                        Based on Pooled StDev
Level       N       Mean      StDev    --------+---------+---------+--------
1          30     4.4667     0.7761     (--*--)
2          30     5.3667     0.7184                (--*--)
3          30     6.6000     0.6747                               (---*--)
4          30     6.6333     0.7649                                (--*--)
                                       --------+---------+---------+--------
Pooled StDev =    0.7346                     4.80      5.60      6.40
```

H_0: There is sufficient evidence that all the means are equal

H_1: There is sufficient evidence that all the means are NOT equal

At 5% significant levels, P-value = 0.000

α > P

H_0 – rejected

At 5% significant levels, there is sufficient evidence that all the means are NOT equal

```
Hsu's MCB (Multiple Comparisons with the Best)

    Family error rate = 0.0500

Critical value = 2.08

Intervals for level mean minus largest of other level means

Level        Lower     Center      Upper  ---+---------+---------+---------+----
1          -2.5619    -2.1667     0.0000   (----*-------------------------)
2          -1.6619    -1.2667     0.0000             (----*---------------)
3          -0.4286    -0.0333     0.3619                          (----*----)
4          -0.3619     0.0333     0.4286                          (----*----)
                                          ---+---------+---------+---------+----
                                          -2.40     -1.60     -0.80     -0.00
```

One-way ANOVA: Appearance_1 versus FACTOR

```
Analysis of Variance for Appearan
Source     DF        SS        MS        F        P
FACTOR      3    20.758     6.919     9.89    0.000
Error     116    81.167     0.700
Total     119   101.925
                                        Individual 95% CIs For Mean
                                        Based on Pooled StDev
Level       N       Mean      StDev    --------+---------+---------+--------
1          30     5.9667     0.6687     (-----*-----)
2          30     6.2333     0.8584           (-----*-----)
3          30     6.9667     0.8087                          (-----*-----)
4          30     5.9333     0.9803     (-----*-----)
                                       --------+---------+---------+--------
Pooled StDev =    0.8365                     6.00      6.50      7.00
```

H_0: There is sufficient evidence that all the means are equal

H_1: There is sufficient evidence that all the means are NOT equal

At 5% significant levels, P-value = 0.000

α > P

H_0 - rejected

At 5% significant levels, there is sufficient evidence that all the means are NOT equal

Hsu's MCB (Multiple Comparisons with the Best)

Family error rate = 0.0500

Critical value = 2.08

Intervals for level mean minus largest of other level means

```
Level        Lower    Center     Upper ---------+---------+---------+--------
1          -1.4500   -1.0000    0.0000  (-----*----------)
2          -1.1834   -0.7333    0.0000     (-----*--------)
3           0.0000    0.7333    1.1834                   (--------*-----)
4          -1.4834   -1.0333    0.0000 (-----*------------)
                                        ---------+---------+---------+--------
                                              -0.80      0.00      0.80
```

One-way ANOVA: Nut flavour_1 versus FACTOR

```
Analysis of Variance for Nut flav
Source     DF        SS        MS        F        P
FACTOR      3   103.833    34.611    67.51    0.000
Error     116    59.467     0.513
Total     119   163.300
                                  Individual 95% CIs For Mean
                                  Based on Pooled StDev
Level       N      Mean     StDev ---+---------+---------+---------+---
1          30    4.8667    0.6288  (--*--)
2          30    5.6667    0.6609           (--*--)
3          30    6.9333    0.7397                    (---*--)
4          30    7.1333    0.8193                       (--*--)
                                  ---+---------+---------+---------+---
Pooled StDev =    0.7160           4.80      5.60      6.40      7.20
```

H_0: There is sufficient evidence that all the means are equal

H_1: There is sufficient evidence that all the means are NOT equal

At 5% significant levels, P-value = 0.000

$\alpha > P$

H_0 - rejected

At 5% significant levels, there is sufficient evidence that all the means are NOT equal

Hsu's MCB (Multiple Comparisons with the Best)

Family error rate = 0.0500

Critical value = 2.08

Intervals for level mean minus largest of other level means

Level	Lower	Center	Upper	----+----+----+----
1	-2.6519	-2.2667	0.0000	(---*----------)
2	-1.8519	-1.4667	0.0000	(---*----------)
3	-0.5852	-0.2000	0.1852	(---*---)
4	-0.1852	0.2000	0.5852	(---*---)
				----+----+----+----
				-2.0 -1.0 0.0 1.0

One-way ANOVA: Texture of nut_1 versus FACTOR

Analysis of Variance for Texture

Source	DF	SS	MS	F	P
FACTOR	3	60.967	20.322	37.10	0.000
Error	116	63.533	0.548		
Total	119	124.500			

Level	N	Mean	StDev	Individual 95% CIs For Mean Based on Pooled StDev
1	30	5.8333	0.8339	(--*---)
2	30	6.3000	0.7022	(---*---)
3	30	7.2667	0.7849	(---*---)
4	30	7.6000	0.6215	(---*--)
Pooled StDev =		0.7401		-+----+----+----+---- 5.60 6.30 7.00 7.70

H_0: There is sufficient evidence that all the means are equal

H_1: There is sufficient evidence that all the means are NOT equal

At 5% significant levels, P-value = 0.000

$\alpha > P$

H_0 - rejected

At 5% significant levels, there is sufficient evidence that all the means are NOT equal

Hsu's MCB (Multiple Comparisons with the Best)

Family error rate = 0.0500

Critical value = 2.08

Intervals for level mean minus largest of other level means

Level	Lower	Center	Upper	--------+---------+---------+---------
1	-2.1648	-1.7667	0.0000	(----*----------)
2	-1.6982	-1.3000	0.0000	(----*----------)
3	-0.7315	-0.3333	0.0648	(----*----)
4	-0.0648	0.3333	0.7315	(----*----)
				--------+---------+---------+---------
				-1.60 -0.80 -0.00

One-way ANOVA: Overall acceptability_1 versus sample

```
Analysis of Variance for Overall
Source     DF        SS        MS        F        P
FACTOR      3    86.667    28.889    65.45    0.000
Error     116    51.200     0.441
Total     119   137.867

Level       N      Mean     StDev
1          30    5.1667    0.6477
2          30    5.9667    0.6149
3          30    7.1000    0.6618
4          30    7.2333    0.7279

Individual 95% CIs For Mean
Based on Pooled StDev
----------+---------+---------+------
 (---*--)
              (--*---)
                            (--*---)
                              (--*---)
----------+---------+---------+------

         5.60      6.30      7.00

Pooled StDev =    0.6644
```

H_0: There is sufficient evidence that all the means are equal

H_1: There is sufficient evidence that all the means are NOT equal

At 5% significant levels, P-value = 0.000

$\alpha > P$

H_0 - rejected

At 5% significant levels, there is sufficient evidence that all the means are NOT equal

```
Hsu's MCB (Multiple Comparisons with the Best)

    Family error rate = 0.0500

Critical value = 2.08

Intervals for level mean minus largest of other level means

Level        Lower    Center     Upper -+---------+---------+---------+------
1          -2.4241   -2.0667    0.0000  (---*-------------------------)
2          -1.6241   -1.2667    0.0000            (---*--------------)
3          -0.4908   -0.1333    0.2241                          (---*----)
4          -0.2241    0.1333    0.4908                             (----*---)
                                      -+---------+---------+---------+------
                                    -2.40     -1.60     -0.80     -0.00
```

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