Study on product development of Maize (*Zea mays*)

By

De Alwis T.P.G.T.N.

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Department of Food Science & Technology
Faculty of Applied Sciences
Sabaragamuwa University of Sri Lanka
Buttala.
91100

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DECLARATION

The work describe in this thesis was carried out by me at the Food Research Unit, Department of Agriculture, Gannoruwa, Peradeniya and Department of Food Science & Technology, Faculty of Applied Sciences, Sabaragamuwa University of Sri Lanka, under the supervision of Dr. K. H. Sarananda and Dr. K. B. Palipane. The report on this has not been submitted to another university for another degree.

De Alwis T. P. G. T. N.

15. 11. 2007

Date

Certified by:

External Supervisor,

Dr. K. H. Sarananda
Head
Food Research Unit
Gannoruwa
Peradeniya

Signature

15. 11. 2007

Date

Internal Supervisors,

Dr. K. B. Palipane
Head
Department of Food Science & Technology
Faculty of Applied Sciences
Sabaragamuwa University of Sri Lanka
Buttala.

Signature

04 – 12 – 2007

Date

The Head of the Department,

Dr. K. B. Palipane
Head
Department of Food Science & Technology
Faculty of Applied Sciences
Sabaragamuwa University of Sri Lanka
Buttala.

Signature

04 – 12 – 2007

Date

Head/Dept. of Food Sciences & Technology
Faculty of Applied Sciences
Sabaragamuwa University of Sri Lanka
BUTTALA

AFFECTIONATELY DEDICATED TO ALL MY

TEACHERS INCLUDING

MY PARENTS

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Abstract

Maize (*Zea mays*) is an important cereal grain in the world, providing nutrients for humans and animals. Because maize can be considered as a good source of carbohydrates and provides significant amount of protein as well. Therefore, it has a great value with regard to human nutrition and economical to use as a functional food in the food industry. However, a large quantity of maize is wasted due to inappropriate post harvest handling and less usage in industrial applications. Therefore, the economic value of maize needs to be improved using the knowledge of modern food technology. So far no proper method has been introduced to enhance industrial usage of maize in Sri Lanka through product development. Therefore there is a major challenge facing at present is how to reduce the wastage of the harvest.

The major objective of this project was to develop a value added product from maize in order to increase its industrial usage. In this study, corn pudding was formulated using green corn cobs and for the value addition and improvement of palatability, natural fruit juices and herb extracts were mixed. That product did not contain artificial colorings, flavours or preservatives and therefore, it can be considered as a natural product.

Sensory evaluation was carried out to determine the best maturity stage of maize and to determine the best fortification. After developing the corn pudding which has best palatability characteristics, proximate analysis was carried out to determine the composition of the product. Shelf life evaluation of corn pudding was based on the microbial analysis (Total Plate Count and Yeast and Mould Test) and chemical changes (P^H, Total Soluble Solids and Titrable Acidity) of the product during storage at $(4\text{-}5)^0C$ for two weeks.

Sensory evaluation of the product showed that the organoleptic characteristics were preferable when corn pudding was prepared using immature corn cobs with the fortification of pineapple juice. According to the results of proximate analysis, the best sample contains 70.42% moisture, 1.325% total fat, 0.115% free fat and 3.85% protein. Total Plate Count and Yeast and Mould Count showed that the product was almost free from micro organisms. In addition, no considerable variation in P^H, Total Soluble Solids and Titrable Acidity during the storage time. Therefore, the results of shelf life evaluation revealed that the product is acceptable for two weeks.

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LIST OF ABREVIATIONS

et al.	And others
FAO	Food and Agriculture Organization
g	Gram
H_2O	Water
HCl	Hydro Chloric Acid
KJ	Kilo Jule
mg	Mili gram
ml	Mili liter
N	Nitrogen
NaOH	Sodium Hydroxide
No	Number
TSS	Total Soluble Solids
WHO	World Health Organization
^0C	Degree of Celsius
%	Percentage
%DV	Percent Daily Values

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Chapter 01

Introduction

1.1 Background:

Maize botanically known as *Zea mays* is cultivated in many districts in Sri Lanka, mainly under rainfed conditions. It is considered primarily a dry zone crop and is one of the main crops cultivated in the highlands. It is cultivated as a monocrop as well as a mixed crop in both settled highlands and in the shifting type of agriculture practiced in highlands, called chena (Ranaweera *et al.*, 1988).

The period between planting and harvesting for maize depend upon the variety. In general the crop is physiologically mature 7-8 weeks after flowering, at that time the kernel contains 35-40 percent of moisture and has the maximum content of dry matter. This is the time when the crop should be harvested in order to avoid unnecessary losses in the field. But most varieties of corn require 100 to 140 days from seeding to full ripeness of the kernels though some kinds will ripen in as little as 80 days (Maizegenome.org, 2004). Loses may occur when maize crop is harvested at various stages beyond maturity.

Maize is still cultivated in Sri Lanka at a low level of technology, with seeds of local or mixed varieties, and minimum or zero inputs. Two major constraints identified for the expansion of the crop acreage are the lack of marketing facilities and fair prices (Ranaweera *et al.*, 1988).

Maize is the most important cereal grain in the world, providing nutrients for humans and animals and serving as a basic raw material for the production of starch, oil and protein, alcoholic beverages & food sweeteners. Sri Lanka produces approximately 35,000 t of Maize annually. But it is consumed mostly by rural people in both the cob and flour forms. So high amount of Maize is wasted due to post harvest losses (Accessed: http://www.agridept.gov.lk/)

The chemical composition of maize is characterized by high content of starch, relatively important protein content & relatively low lipid content.

Maize cannot be considered only as a source of energy, as they provide significant amounts of protein as well. Therefore the germ of maize is potentially a copious source of protein for human use. It can be used in the form of protein preparations (protein concentrates), as well as for protein enrichment or protein substitution in different food products. So the demand for protein supplements to increase the nutritional value of cereals can be increased from maize germ.

According to the composition and nutritive value of maize, it has a great value with regard to human nutrition and economical to use as functional food in food industry. Nutritive values of green cobs after harvesting rapidly deteriorate. If those are not refrigerated, quality deterioration is accelerated. If maize is processed at the green cob stage utilization can be increased by reducing post harvest losses. Therefore, it is important to improve the economic value of maize through product development using the knowledge of modern food technology.

Therefore, the main objective of this project is to study on product development of Maize. In order to achieve the main objective of the product, below mentioned specific objectives are taken into consideration.

1.2 Overall Objective:

- Study on product development of maize to introduce value added maize based food products.

1.3 Specific Objectives:

- Production of maize pudding.
- Selection of suitable maturity stage of maize for the production of maize pudding.
- Fortification of most appropriate herb and fruit to increase the nutritive value and flavor of the maize pudding.
- Sensory evaluation of the maize pudding.
- Shelf life evaluation of the maize pudding.

Chapter 02
Review of literature

2.1 Maize (Corn) - (*Zea mays*)

2.1.1 Introduction

2.1.1.1 The maize plant

Maize, the American Indian word for corn, means literally "that which sustains life". It is one of the most important cereal grains in the world, providing nutrients for humans and animals and serving as a basic raw material for the production of starch, oil and protein (FAO, 1992).

The maize plant may be defined as a metabolic system whose end product is mainly starch deposited in specialized organs, the maize kernels.

Botanically, maize (Zea mays) belongs to the grass family (Gramineae) and is a tall annual plant with an extensive fibrous root system. It is a cross pollinating species, with the female (ear) and male (tassel) flowers in separate places on the plant. The grain develops in the ears, or cobs, often one on each stalk. The kernels are often white or yellow in colour, although black, red and mixtures of colours are also found (FAO, 1992).

The development of the plant may be divided into two physiological stages. In the first or the vegetative stage, different tissues develop and differentiate until the flower structures appear. The vegetative stage is made up of two cycles. In the first cycle the first leaves are formed and development is upward. Dry matter production in this cycle is slow. It ends with the tissue differentiation of the reproductive organs. In the second cycle the leaves and reproductive organs develop (FAO, 1992).

The second stage, also known as the reproductive stage, begins with the fertilization of the female structures, which will develop into ears and grains. The initial phase of this stage is characterized by an increase in the weight of leaves and other flower parts. During the second phase, the weight of the kernels rapidly increases (Tanaka and Yamaguchi, 1972).

2.1.1.2 Morphology of corn

Corn is a tall, robust, monoecious annual, with overlapping sheaths and broad, conspicuously distichous blades; staminate spikelets in long spike like racemes, these numerous, forming large spreading terminal panicles, (tassels); pistillate inflorescence in the axils of the leaves, the spikelets in 8-16 (30) rows, on a thickened, almost woody axis (cob), the whole enclosed in numerous large foliaceous bracts or spathes, the long styles (silk) protruding from the summit as a mass of silky threads; grains at maturity greatly exceeding the glumes (Hitchcock and Chase, 1951).

2.1.1.3 Taxonomy of corn

Zea is a genus of the family Gramineae (Poaceae), commonly known as the grass family. The genus consists of some four species: *Zea mays*, cultivated corn and teosinte; *Zea diploperennis Iltis et al.*, diploperennial teosinte; *Zea luxurians* (Durieu et Asch.) Bird; and *Zea perennis* (Hitchc.) Reeves et Mangelsd., perennial teosinte. Various of the species have been assigned to the segregate genus Euchlaena, which is not currently recognized, or have been divided into numerous small species within the genus Zea (Terrell *et al.*, 1986).

Kingdom	:Plantae
Division	:Magnoliophyta
Class	:Liliopsida
Order	:Poales
Family	Gramineae
Genus	:*Zea*
Species:	:*Z. mays*

2.1.1.4 Structure of the maize kernel

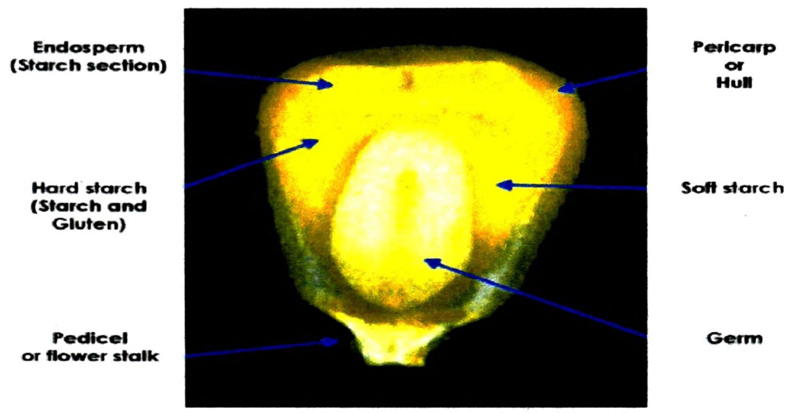


Figure 2.1 The maize kernel and their parts (Source: maize.agron.iastate.edu)

Figure 2.1 shows that, the kernel parts indicated include: Pericarp or hull (thin covering which enclose the kernel), Endosperm (starch section of the kernel both soft and hard starch, Germ (embryo). The hardness of the starch in the kernel is associated to gluten. The average caloric content of the whole meal from maize is 3,578 Calories per kilogram.

Maize kernels develop through accumulation of the products of photosynthesis, root absorption and metabolism of the maize plant on the female inflorescence called the ear. This structure may hold from 300 to 1 000 single kernels depending on the number of rows, diameter and length of the cob. Kernel weight may be quite variable, ranging from about 19 to 40 g per 100 kernels. During harvest the ears of maize are removed from the maize plant either by hand or mechanically. The husks covering the ear are first stripped off, and then the kernels are separated by hand or, more often, by machine.

The weight distribution of the different parts of the maize kernel is shown in Table 2.1. The endosperm, the largest portion of the kernel represents about (80-85) percent of the weight of the grain, while the germ averages 11 percent and the pericarp 5 percent. The remainder is the tip cap, a conical structure that together with the pedicel attaches the kernel to the ear of maize (FAO, 1992).

Table 2.1 Weight distribution of main parts of the kernel

Structure	Percent weight distribution
Pericarp	5-6
Aleurone	2-3
Endosperm	80-85
Germ	10-12

(Source: Landry and Moureaux, 1980)

2.1.1.5 Types of maize

There are a number of grain types, distinguished by differences in the chemical compounds deposited or stored in the kernel. Grain corn is classified commercially into four main types: Dent corn, Flint corn, Flour or soft corn and Waxy corn (Emily Gatch, 2005).

2.1.1.5.1 Dent corn

When fully ripe, has a pronounced depression or dent at the crown of the kernels. The kernels contain a hard form of starch at the sides and a soft type in the center. This latter starch shrinks as the kernel ripens resulting in the terminal depression. Dent varieties vary in kernel shape from long and narrow to wide and shallow.

2.1.1.5.2 Flint corn

It has the hard starch layer entirely surrounding the outer part of the kernel. Consequently, on drying the kernel shrinks uniformly and does not develop a depressed area.

2.1.1.5.3 Flour or soft corn

These kernels contain almost entirely soft starch, with only a very thin layer of hard starch. This type is little grown commercially.

2.1.1.5.4 Waxy corn

It is so-called because the endosperm when cut or broken is wax-like in appearance. The starch consists almost entirely of amylopectin, while in ordinary corn the starch is near 30 percent amylose and the remaining 70 percent is amylopectin. Waxy corn is largely used industrially although it is also suitable for food or feed.

Special crops grown primarily for food include sweet corn and popcorn.

2.1.1.5.5 Pop corn

Popcorn is characterized by a very high proportion of hard starch. Under heat the moisture in the starch grains expands rapidly resulting in an explosive rupture of the epidermis and the starch grains. Increase in volume after "popping" is 15 to 35 fold, depending on variety.

2.1.1.5.6 Sweet corn

Sweet corn differs from field corn in that a large proportion of the carbohydrates of the kernel are present as dissolved or dispersed glucose polymers of fairly low molecular weight rather than as starch granules. As a consequence, the kernels of sweet corn retain their tender & succulent texture, & their sweet taste, for a long period of time during their development (Emily Gatch, 2005).

2.1.1.6 Origin of maize

The cultivation of maize or Indian corn most probably originated in Central America, particularly in Mexico. The oldest maize, about 7 000 years old, was found by archaeologists in Teotihuacan, a valley near Puebla in Mexico.

At the end of the fifteenth century, after the discovery of the American continent by Christopher Columbus, maize was introduced into Europe through Spain. It then spread through the warmer climates of the Mediterranean and later to northern Europe. Mangelsdorf and Reeves (1939) have shown that maize is grown in every suitable agricultural region of the world and that a crop of maize is being harvested somewhere around the globe every month of the year. Maize grows from latitude 58° in Canada and the former Union of Soviet Socialist Republics to latitude 40° in the Southern Hemisphere. Maize crops are harvested in regions below sea-level in the Caspian Plain and at altitudes of more than 4 000 m in the Peruvian Andes.

All maize is classified as *Zea mays*. Furthermore, evidence from botany, genetics and cytology has pointed to a common origin for every existing type of maize. Most researchers believe that maize developed from teosinte, Euchlaena mexicana Schrod, an annual crop that is possibly its closest relative. Others, however, believe that maize originated in wild maize that is now extinct. The closeness of teosinte to maize is suggested by the fact that both have ten chromosomes and are homologous or partially homologous (FAO, 1992).

2.1.1.7 World production of maize

World maize production increased from 1979-1981 to 1987. The land area planted with maize increased from 105 million ha in 1961 to about 127 million ha in 1987. The developing countries have more area given to maize cultivation than developed countries, but yield in the latter is about four times higher. Since 1961, yields per ha in the United States, for example, have increased significantly, while yields in Mexico, Guatemala and Nigeria (selected as countries where maize intake by the human population is high, particularly in the first two) have increased only slightly (FAO, 1992).

2.1.1.8 Maize cultivation and production in Sri Lanka

Maize is cultivated in many districts in sri Lanka, mainly under rainfed conditions. Maize is traditionally cultivated during the maha season throughout Sri Lanka, except in the southwest. coastal districts (Matara, Galle, Kalutara, Colombo and Gampaha) and Kegalle district in the mid country. The extent of cultivation is relatively small in the northern districts of Jaffna, Vavunia, Mullaitivu and Mannar.The major maize producing districts are Anuradhapura, Ampara, Badulla, Moneragala, Matale and Baticaloa. The cultivation in these districts accounts for over 80% of the land planted to maize in Sri Lanka. Sri Lanka produces approximately 35,000 t of maize annually (Ranaweera *et al.*,1988).

2.1.1.9 Uses of maize

Maize has three possible uses: as food, as feed for livestock and as raw material for industry.

As a food, the whole grain, either mature or immature, may be used; or the maize may be processed by dry milling techniques to give a relatively large number of intermediary products, such as maize grits of different particle size, maize meal, maize flour and flaking grits. These materials in turn have a great number of applications in a large variety of foods. Maize grown in subsistence agriculture continues to be used as a basic food crop. In developed countries more than 60 percent of the production is used in compounded feeds for poultry, pigs and ruminant animals. In recent years, even in developing countries in which maize is a staple food, more of it has been used as an animal feed ingredient. "High moisture" maize has been paid much attention recently as an animal feed because of its lower cost and its capacity to improve efficiency in feed conversion. The by-products of dry milling include the germ and the seed-coat. The former is used as a source of edible oil of high quality. The seed-coat or pericarp is used mainly as a feed (Earll *et al.*, 1988; Burge and Duensing, 1989).Wet milling is a process applicable mainly in the industrial use of maize, although the alkaline cooking process used in manufacturing tortillas (the thin, flat bread of Mexico and other Central American countries) is also a wet milling operation that removes only the pericarp (Bressani, 1990). Wet milling yields maize starch and by-products such as maize gluten, used as a feed ingredient. The maize germ processed to produce oil gives as a by-product maize germ meal, used as an animal feedstuff. Some attempts have been made to use these by-products for humans in food mixes and formulations.

Finally, maize plant residues also have important uses, including animal feeds as well as a number of chemicals produced from the cobs, such as furfural and xylose. These residues are also important as soil conditioners (FAO, 1992).

2.1.1.10 Medicinal uses of maize

A decoction of the leaves and roots is used in the treatment of strangury, dysuria and gravel. The corn silks are cholagogue, demulcent, diuretic, lithontripic, mildly stimulant and vasodilator. They also act to reduce blood sugar levels and so are used in the treatment of diabetes mellitus as well as cystitis, gonorrhoea, gout etc. The seed is diuretic and a mild stimulant. It is a good emollient poultice for ulcers, swellings and rheumatic pains, and is widely used in the treatment of cancer, tumours and warts. It contains the cell-proliferant and wound-healing substance allantoin, which is widely used in herbal medicine (especially from the herb comfrey, Symphytum officinale) to speed the healing process.The plant is said to have anticancer properties and is experimentally hypoglycaemic and hypotensive (Rich Morris, 2004).

2.1.2 Chemical composition and nutritional value of maize

Chemical composition after processing for consumption is an important aspect of nutritive value. It is affected by the physical structure of the kernel, by genetic and environmental factors, by processing and by other links in the food chain.

There are important differences in the chemical composition of the main parts of the maize kernel. The seed-coat or pericarp is characterized by a high crude fibre content of about 87 percent, which is constituted mainly of hemicellulose (67 percent), cellulose (23 percent) and lignin (0.1 percent) (Burge and Duensing, 1989). On the other hand, the endosperm contains a high level of starch (87.6 percent) and protein levels of about 8 percent. Crude fat content in the endosperm is relatively low. Finally, the germ is characterized by a high crude fat content, averaging about 33 percent. The germ also contains a relatively high level of protein (18.4 percent) and minerals (FAO, 1992).

Table 2.2 Proximate chemical composition of main parts of maize kernels (%)

Chemical component	Pericarp	Endosperm	Germ
Protein	3.7	8.0	18 4
Ether extract	1.0	0.8	33.2
Crude fibre	86.7	2.7	8.8
Ash	0.8	0.3	10.5
Starch	7.3	87.6	8.3
Sugar	0.34	0.62	10.8

(Source: Watson, 1987)

Crude fibre in the kernel comes mainly from the seed-coat. The weight distribution among parts of the maize kernel and their particular chemical composition and nutritive value are of great importance when maize is processed for consumption. Germ oil provides relatively high levels of fatty acids (Bressani et al., 1990; Weber, 1987).

Germ proteins nevertheless contribute a relatively high amount of certain amino acids, although not enough to provide a higher quality of protein in the whole kernel. The germ provides some lysine and tryptophan, the two limiting essential amino acids in maize protein. Endosperm proteins are low in lysine and tryptophan, as is the whole grain protein (See Table 6, in which the FAO/ WHO essential amino acid pattern is also shown).

Table 2.3 Essential amino acid content of germ protein and endosperm protein

Amino acid	Endosperm[a]		Germ[b]		FAD/WHO pattern
	mg %	mg/g N	mg %	mg/g N	
Tryptophan	48	38	144	62	60
Threonine	315	249	622	268	250
Isoleucine	365	289	578	249	250
Leucine	1 024	810	1 030	444	440
Lysine	228	180	791	341	340
Total sulphur amino acids	249	197	362	156	220
Phenylaianine	359	284	483	208	380
Tyrosine	483	382	343	148	380
Valine	403	319	789	340	310

[a]1.16 percent N, [b]2.32 percent N (Source: Orr and Watt, 1957)

2.1.2.1 Gross chemical composition

Table 2.4 Gross chemical composition of different types of maize (%)

Maize type	Moisture	Ash	Protein	Crude fibre	Ether extract	Carbohydrate
Salpor	12.2	1.2	5.8	0.8	4.1	75.9
Crystalline	10.5	1.7	10.3	2.2	5.0	70.3
Floury	9.6	1.7	10.7	2.2	5.4	70.4
Starchy	11.2	2.9	9.1	1.8	2 2	72 8
Sweet	9 5	1 5	12.9	2.9	3.9	69.3
Pop	10.4	1.7	13.7	2.5	5.7	66.0
Black	12.3	1.2	5.2	1.0	4.4	75.9

Source: Cortez and Wild-Altamirano, 1972

2.1.2.1.1 Starch

The major chemical component of the maize kernel is starch, which provides up to 72 to 73 percent of the kernel weight. Other carbohydrates are simple sugars present as glucose, sucrose and fructose in amounts that vary from 1 to 3 percent of the kernel. The starch in maize is made up of two glucose polymers: amylose, an essentially linear molecule, and amylopectin, a branched form. The composition of maize starch is genetically controlled. In common maize, with either the dent or flint type of endosperm, amylose makes up 25 to 30 percent of the starch and amylopectin makes up 70 to 75 percent. Waxy maize contains a starch that is 100 percent amylopectin. An endosperm mutant called amylose-extender (ae) induces an increase in the amylose proportion of the starch to 50 percent and higher. Other genes, alone or in combination, may also modify the amylose-to-amylopectin ratio in maize starch (Boyer and Shannon, 1987).

2.1.2.1.2 Protein

After starch, the next largest chemical component of the kernel is protein. Protein content varies in common varieties from about 8 to 11 percent of the kernel weight. Most of it is found in the endosperm. The protein in maize kernels has been studied extensively. It is made up of at least five different fractions, according to Landry and Moureaux (1970, 1982). In their scheme, albumins, globulins and non-protein nitrogen amount to about 18 percent of total nitrogen, in a distribution of 7 percent, 5 percent and 6 percent, respectively (Patterson et al., 1980).

2.1.2.1.3 Oil and fatty acids

The oil content of the maize kernel comes mainly from the germ. Oil content is genetically controlled, with values ranging from 3 to 18 percent. Maize oil has a low level of saturated fatty acids, i.e. on average 11 percent palmitic and 2 percent stearic acid. On the other hand, it contains relatively high levels of polyunsaturated fatty acids, mainly linoleic acid with an average value of about 24 percent. Only very small amounts of linoleic and arachidonic acids have been reported. Furthermore, maize oil is relatively stable since it contains only small amounts of linoleic acid (0.7 percent) and high levels of natural antioxidants. Maize oil is highly regarded because of its fatty acid distribution, mainly oleic and linoleic acids (FAO, 1992).

2.1.2.1.4 Dietary fibre

After carbohydrates, proteins and fats, dietary fibre is the chemical component found in the greatest amounts. The complex carbohydrate content of the maize kernel comes from the pericarp and the tip cap, although it is also provided by the endosperm cell walls and to a smaller extent the germ cell walls.

2.1.2.1.5 Other carbohydrates

When mature, the maize kernel contains carbohydrates other than starch in small amounts. Total sugars in the kernel range between I and 3 percent, with sucrose, the major component, found mostly in the germ. Higher levels of monosaccharides, disaccharides and trisaccharides are present in maturing kernels. At 12 days after pollination the sugar content is relatively high, while starch is low. As the kernel matures, the sugars decline and starch increases.

Sucrose concentration at 15 to 18 days after pollination is between 4 and 8 percent of kernel dry weight. These relatively high levels of reducing sugar and sucrose are possibly the reason why immature common maize and, even more, sweet maize are so well liked by people (FAO, 1992).

2.1.2.1.6 Minerals

The concentration of ash in the maize kernel is about 1.3 percent, only slightly lower than the crude fibre content. Environmental factors probably influence the mineral content. The germ is relatively rich in minerals, with an average value of 11 percent as compared with less than 1 percent in the endosperm. The germ provides about 78 percent of the whole kernel minerals. The most abundant mineral is phosphorus, found as phytate of potassium and magnesium. All of the phosphorus is found in the embryo, with values in common maize of about 0.90 percent and about 0.92 percent in opaque-2 maize. As with most cereal grains, maize is low in calcium content and also low in trace minerals.

2.1.2.1.7 Fat soluble vitamins

The maize kernel contains two fat-soluble vitamins: provitamin A, or carotenoids, and vitamin E. Carotenoids are found mainly in yellow maize, in amounts that may be genetically controlled, while white maize has little or no carotenoid content. Most of the carotenoids are found in the hard endosperm of the kernel and only small amounts in the germ. The betacarotene content is an important source of vitamin A, but unfortunately yellow maize is not consumed by humans as much as white maize. Squibb, Bressani and Scrimshaw (1957) found beta-carotene to be about 22 percent of total carotenoids (6.4 to 11.3 μg per gram) in three yellow maize samples. Cryptoxanthin accounted for 51 percent of total carotenoids. Vitamin A activity varied from 1.5 to 2.6 μg per gram. The carotenoids in yellow maize are susceptible to destruction after storage. Watson (1962) reported values of 4.8 mg per kg in maize at harvest, which decreased to 1.0 mg per kg after 36 months of storage. The same loss took place with xanthophylls.

The other fat-soluble vitamin is vitamin E, which is subject to some genetic control, is found mainly in the germ. The source of vitamin E is four tocopherols, of which alpha-tocopherol is the most biologically active.

2.1.2.1.8 Water soluble vitamins

Water-soluble vitamins are found mainly in the aleurone layer of the maize kernel, followed by the germ and endosperm. This distribution is important in processing. Variable amounts of thiamine and riboflavin have been reported. The content is affected by the environment and cultural practices rather than by genetic make-up. The water-soluble vitamin nicotinic acid has attracted much research because of its association with niacin deficiency or pellagra, which is prevalent in populations consuming high amounts of maize (Christianson et al., 1968). As with other vitamins, niacin content varies among varieties, with average values of about 20 μg per gram. The association of maize intake and pellagra is a result of the low levels of niacin in the grain, although experimental evidence has shown that amino acid imbalances, such as the ratio of leucine to isoleucine, and the availability of tryptophan are also important (Gopalan and Rao, 1975; Patterson *et al.*, 1980).

Maize has no vitamin B12, and the mature kernel contains only small amounts of ascorbic acid, if any. Yen, Jensen and Baker (1976) reported a content of about 2.69 mg per kg of available pyridoxine. Other vitamins such as choline, folic acid and pantothenic acid are found in very low concentrations.

2.1.2.2 Changes in chemical composition and nutritive value during grain development

In many countries, immature maize is often used as a food, either cooked whole as corn on the cob or ground to remove the seed-coat, with the pulp used to make thick gruels or foods like tamalitos. The changes in chemical composition that take place upon maturation are important. All relevant studies have shown a decrease in nitrogen, crude fibre and ash on a dry-weight basis and an increase in starch and ether extract (e.g. Ingle, Bietz and Hageman, 1965). The alcohol-soluble proteins increase rapidly as the kernel matures, while acid- and alkali-soluble proteins decrease. During this biochemical process arginine, isoleucine, leucine and phenylalanine (expressed as mg per g N) increase, while lysine methionine and tryptophan decrease with maturation. Gómez-Brenes, Elías and Bressani (1968) further showed a decrease in protein quality (expressed as protein efficiency ratio). Thus, immature maize should be promoted during weaning or for infant nutrition.

2.1.2.3 Nutritional value of maize

The importance of cereal grains to the nutrition of millions of people around the world is widely recognized. Because they make up such a large part of diets in developing countries, cereal grains cannot be considered only as a source of energy, as they provide significant amounts of protein as well. It is also recognized that cereal grains have a low protein concentration and that protein quality is limited by deficiencies in some essential amino acids, mainly lysine. Maize contains an excess of certain essential amino acids that influence the efficiency of protein utilization (FAO, 1992).

2.1.2.4 Approaches to improving the nutritive value of maize

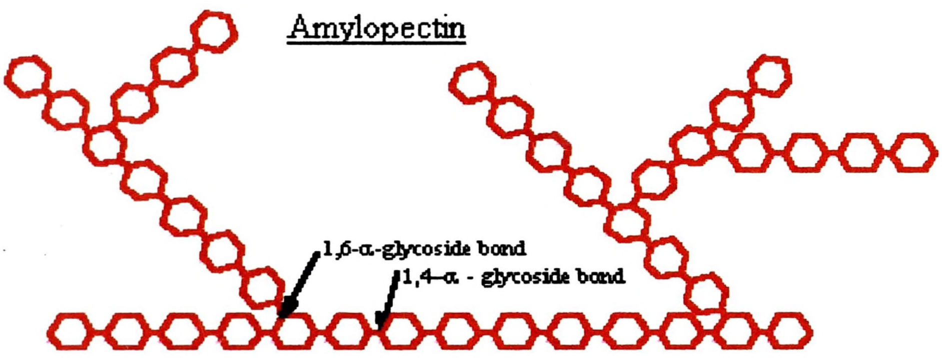
Because of the great importance of maize as a basic staple food for large population groups, particularly in developing countries, and its low nutritional value, mainly with respect to protein, many efforts have been made to improve the biological utilization of the nutrients it contains. Three approaches have been tried: genetic manipulation, processing and fortification (FAO, 1992).

2.1.3 Corn processing

Kernels of maize contain naturally occurring starch. It is an important constituent in Maize. It plays an obvious role in achieving the desired viscosity in such products as corn starch pudding.

Starch is a polymer of glucose in which monosaccharide units are linked together by the 1, 4'-*a*-glycoside bonds. Starch is composed of two polymers - amylose and amylopectin.

Amylopectin is the branched chained glucose polymer containing both alpha - 1, 4-linear and alpha - 1, 6-branched linkages. This branched bushy polymer with branches 20 to 30 glucose residues long, contributes primarily to the viscosity of a prepared food. This was contrasted to the gelling contribution of the alpha - 1, 4 linked linear polymer - amylose. Amylose is approximately one-fourth the size of amylopectin. Amylopectin is soluble in cold water and amylose is insoluble in cold water. Amylose accounts for 80% of the starch. Amylopectin is occurring approximately every 35 glucose units (Mbata *et al*., 2006).



Upon heating under hydrolyzing conditions, amylose and amylopectin polymers start to deploymerize. This depolymerization is called gelatinization. Starch gelatinization is a more complex process. Undamaged starch granules are insoluble in cold water. They will in fact swell slightly but their structure is maintained. When the temperature of the water is increased, the starch molecules begin to vibrate, breaking the intermolecular bonds and allowing water to penetrate and bind. The point where there is a complete loss of crystalinity is the gelatinization point. This occurs over a narrow range of temperatures termed the gelatinization temperature. Since the water becomes increasingly bound, the water acidity drops and the viscosity increases. Amylose plays an important role during the initial stages of corn starch gelatinization. Because the linear shape of the amylose molecules allow to the formation of three dimensional networks easily.

When naturally occurring starch undergoes gelatinization, it tends to form a colloidal suspension in water that gels upon cooling. Starch that is partially or fully gelatinized is useful in corn processing (McCarthy *et al.*, 2001).

2.2 Pineapple (*Ananas sativus*)

2.2.1 Nutritional value of pineapple fruit

The Pineapple has great nutritive value. It is the most essential foodstuff in "The Dries Cancer Diet". It contains carbohydrates, proteins, fats, vitamins, minerals, fiber, enzymes and water. It also has calcium, phosphorous, iron, magnesium, potassium and sodium, chlorine, sulphur and manganese; pineapples are an excellent source of vitamin C and have vitamin A, B1 and B2. That is good for the digestive system and helps in maintaining ideal weight and balanced nutrition. It has minimal fat and sodium with no-cholesterol. Pineapple is high in fiber. It is delicious, healthy and nutritious. (Access: http: //www.fruitarian.com)

2.2.2 Medicinal Properties of pineapple fruit

Pineapple contains micro-nutrients that experts believe protects against cancer and this micro-nutrients also break up blood clots and is beneficial to the heart. The ripe pineapple has diuretic properties. Pineapple juices also kill intestinal worms. It also relieves intestinal disorders and soothes the bile. Pineapple juice contains chemicals that stimulates the kidneys and aids in removing toxic elements in the body (Herbal medicine, 2007).

Pineapple contains a mixture of enzymes called bromelain. There is significant evidence pointing to the anti-inflammatory benefits of bromelain.Bromelain blocks the production of kinins that form when there is inflammation. This blocking property of Bromelain in pineapple helps reduce swelling brought about by arthritis, gout, sore throat and acute sinusitis. To help reduce inflammation, eat pineapple in between meals. This also helps accelerate the healing of wounds due to injury or surgery. If eaten during or after meals, the enzymes will be utilized for digesting food. Pineapple is an excellent cerebral toner. It combats loss of memory, sadness and melancholy. Pineapple is efficient in the treatment of arterioscleroses and anaemia (Herbal medicine, 2007).

Pineapple contains a proteolytic enzyme bromelain, which digests food by breaking down protein. Some have claimed that pineapple has benefits for some intestinal disorders while others claim that it helps to induce childbirth when a baby is overdue. These enzymes can be hazardous to someone suffering from certain protein deficiencies or disorders, such as Ehlers-Danlos syndrome.It can also be used to enhance digestion. Despite these benefits, fresh pineapple may cause irritation of the tip of the tongue in some cases (Herbal medicine, 2007).

2.2.3 Chemical composition of pineapple

Nutrients per serving for pineapple, raw, all varieties

Amounts per 1 cup, diced (155g)

Table 2.5 Protein content of pineapple

Protein and Amino Acids		
Amounts Per Selected Serving	Amounts per 1 cup, diced (155g)	%DV
Protein	**0.8g**	**2%**
Tryptophan	7.8mg	
Threonine	29.4mg	
Isoleucine	29.4mg	
Leucine	37.2mg	
Lysine	40.3mg	
Methionine	18.6mg	
Cystine	21.7mg	
Phenylalanine	32.6mg	
Tyrosine	29.4mg	
Valine	37.2mg	
Arginine	29.4mg	
Histidine	15.5mg	
Alanine	51.2mg	
Aspartic acid	188mg	
Glutamic acid	122mg	
Glycine	37.2mg	
Proline	26.4mg	
Serine	54.3mg	
Hydroxyproline	~	

Table 2.6 Carbohydrate content of pineapple

Carbohydrates		
Amounts Per Selected Serving	Amounts per 1 cup, diced (155g)	%DV
Total Carbohydrate	**19.6g**	**7%**
Dietary Fiber	2.2g	9%
Starch	0.0g	
Sugars	14.4g	
Sucrose	8480mg	
Glucose	2697mg	
Fructose	3177mg	
Lactose	0.0mmg	
Maltose	0.0mg	
Galactose	0.0mg	

Table 2.7 Calorie amount of pineapple

Food Energy		
Amounts Per Selected Serving	Amounts per 1 cup, diced (155g)	%DV
Calories	**74.4 (311 kJ)**	**4%**
Calories from Carbohydrate	70.0 (293 kJ)	
Calories from Fat	1.6 (6.7 kJ)	
Calories from Protein	2.8 (11.7 kJ)	
Calories from Alcohol	0.0 (0.0 kJ)	

Table 2.8 Mineral content of pineapple

Minerals		
Amounts Per Selected Serving	Amounts per 1 cup, diced (155g)	%DV
Calcium	20.2 mg	2%
Iron	0.4 mg	2%
Magnesium	18.6 mg	5%
Phosphorus	12.4 mg	1%
Potassium	178 mg	5%
Sodium	1.6 mg	0%
Zinc	0.2 mg	1%
Copper	0.2 mg	8%
Manganese	1.8 mg	91%
Selenium	0.2 mcg	0%
Fluoride	~	

Table 2.9 Fats and fatty acid content of pineapple

Fats and Fatty Acids		
Amounts Per Selected Serving	Amounts per 1 cup, diced (155g)	%DV
Total Fat	0.2g	0%
Saturated Fat	0.0g	0%
16:00	7.8mg	
17:00	~	
18:00	4.7mg	
Monounsaturated Fat	0.0g	
14:01	~	
15:01	~	
16:1 undifferentiated	1.6mg	
18:1 undifferentiated	20.2mg	
22:1 undifferentiated	0.0mg	
Polyunsaturated Fat	0.1g	
16:2 undifferentiated	~	
18:2 undifferentiated	37.2mg	
18:03	27.9mg	
Total trans fatty acids	~	
Total trans-monoenoic fatty acids	~	
Total trans-polyenoic fatty acids	~	
Total Omega-3 fatty acids	27.9mg	
Total Omega-6 fatty acids	37.2mg	

Table 2.10 Vitamin content of pineapple

Vitamins		
Amounts Per Selected Serving	Amounts per 1 cup, diced (155g)	%DV
Vitamin A	**86.8 IU**	**2%**
Retinol Activity Equivalent	4.7 mcg	
Beta Carotene	52.7 mcg	
Vitamin C	**56.1 mg**	**94%**
Vitamin D	~	
Vitamin E (Alpha Tocopherol)	**0.0 mg**	**0%**
Vitamin K	**1.1 mcg**	**1%**
Thiamin	**0.1 mg**	**8%**
Niacin	**0.8 mg**	**4%**
Vitamin B6	**0.2 mg**	**9%**
Folate	**23.2 mcg**	**6%**
Food Folate	23.2 mcg	
Dietary Folate Equivalents	23.2 mcg	
Vitamin B12	**0.0 mcg**	**0%**
Pantothenic Acid	**0.3 mg**	**3%**

Table 2.11 Sterol content of pineapple

Sterols		
Amounts Per Selected Serving	Amounts per 1 cup, diced (155g)	%DV
Phytosterols	9.3mg	

Table 2.12 Other ingredient content of Pineapple

Other		
Amounts Per Selected Serving	Amounts per 1 cup, diced (155g)	%DV
Alcohol	0.0g	
Water	134g	
Ash	0.4g	
Caffeine	0.0mg	
Theo bromine	0.0mg	

(Access:http://www.nutritiondata.com/facts-C00001-01c20WZ.html)

2.3 Iramusu (*Hemidesmus indicus*)

2.3.1 Medicinal importance

The plant enjoys a status as tonic, alterative, demulcent, diaphoretic, diuretic and blood purifier. It is employed in nutritional disorders, syphilis, chronic rheumatism, gravel and other urinary diseases and skin affections. It is administered in the form of powder, infusion or decoction as syrup. It is also a component of several medicinal preparations. Syrup prepared from the roots is used as a flavoring agent and in the preparation of a sherbet which have cooling properties (Deepak Acharya *et al., 2006)*

The roots are used as addition in main treatment of snakebite and scorpion sting. It improves the general health; plumpness, clearness, and strength, succeeding to emaciation, said to be useful in affections of the kidneys, scrofula, cutaneous diseases, thrush, rheumatism, scrofula, skin diseases, venereal disease, nephritic complaints, for sore mouths of children, syphilis, gonorrhea and appetite

According to Ayurveda, root is cooling, aphrodisiac, antipyretic, alexiteric, antidiarrhoeal, astringent to bowels and useful in treatment of fevers, foul body odour, asthma, bronchitis, blood disorders, leucorrhoea, dysentery, diarrhoea, thirst, burning sensation, piles, eye troubles, epileptic fits etc. Roots are useful in hemicrania, joint pains whereas stem is good in treatment of brain, lever and kidney related diseases. It is also useful in treatment of urinary discharges, uterine complaints, paralysis, cough, asthma etc. The natives use the roots internally in treatment of premature graying of hairs, jaundice, eye related diseases (Deepak Acharya *et al., 2006)*

The root is said to be good for gout, colds, fevers and catarrhal problems as well as for relieving flatulence, scrofula and ringworms. It is said to be promoting health and cure all kinds of diseases caused by vitiated blood. It is useful in venereal diseases, herpes, epilepsy, insanity, chronic nervous diseases, abdominal distention, intestinal gas, debility, impotence and turbid urine in Ayurvedic system. It also purifies the urino-genital tract, blood and helps cleanse the mind of negative emotions; therefore it is useful in many nervous disorders. It promotes health and vigor. Root decoction helps in skin diseases, syphilis, elephantiasis, loss of sensation, hemiplegia, loss of appetite, blood purification and for kidney and urinary disorders (herbsforever, 2005).

2.3.2 Chemical components

The flavanoid glycosides recognized in the flowers, were hyperoside, isoquercitin and rutin whereas in the leaves, only hyperoside and rutin were identified (Subramaniam & Nair, 1968). Tannins 2.5 % present in leaves; roots are reported to contain sitoserol (Chatterjee & Bhattacharya, 1955). A new ester identified as lupeol octacosanoate in addition to the known compounds viz., lupeol, (-amyrin, (-amyrin, lupeol acetate, (-amyrin acetate, and hexatriacontane (Pioneerherbs, 2005). Coumarins, triterpenoid saponins, essential oil, starch, tannic acid, triterpenoid saponins present (Globalherbal, 2005). A stearopten smilasperic acid is also obtained by distillation with water (Joseph *et al.,* 1918).

2.3.3 Pharmacology

The herb is mildly immuno-suppressant. The aqueous, alcoholic and steam distilled fractions of the crushed roots had no significant diuretic activity. The 50% ethanolic extract of the whole plant did not exhibit any effect on respiration, normal blood pressure and also on pressor response to adrenaline and depressor response to acetylalcholine and histamine in experimental animals. The extract also had no antispasmodic effect on guinea pig ileum. A saponin from the plant is found to have antiinflammatory activity against formalin induced edema (Pioneerherbs, 2005).

The antioxidant activity of methanolic extract of *H. indicus* root bark is evaluated in several *in vitro* and *ex vivo* models. Preliminary phytochemical analysis and TLC fingerprint profile of the extract was established to characterize the extract which showed antioxidant properties (Ravishankara *et al.,* 2002).

Modern studies have confirmed the antibacterial activity of the root extract and essential oil. Clinical trials have shown a benefit in ringworm infection and for malnutrition. The clinically used doses are considered safe and beneficial, but overdose can be toxic (kalyx, 2005). *Hemidesmus indicus* has been shown to have significant activity against immunotoxicity and other pharmacological and physiological disorders (Sultana *et al.*, 2003).

Chapter 03

Materials and Methodology

3.1 Preparation of corn slurry

Materials:

Corn pods (Immature)

Portable water

Equipments:

Knife

Cutting board

Cooker

Blender

Sieve (No 20)

Electrical balance

Measuring cylinders

Methodology:

The fresh corn cobs were peeled and boiled for (30-45) minutes. Then corn seeds were separated from corn cobs using a knife. Then 1000g of corn seeds were blended for (15-25) minutes with 2000ml of portable water (Corn: Water 1:2 ratio) and slurry was obtained. Then the slurry was drained out through No. 20 sieve.

3.2 Chemical analysis of fresh corn slurry

3.2.1 Analysis of Titrable Acidity (TA) of fresh corn slurry

Materials:

0.1M NaOH

1% phenolphthalein

Laboratory glassware

Methodology:

Known amount of fresh corn slurry was diluted with distilled water and two drops of 1% phenolphthalein indicator was added. Then it was titrated with standard sodium hydroxide solution (0.1M NaOH) until pink colour was obtained. Finally the end point was noted down.

Calculation:

$$\text{Acidity, percent by mass} = \frac{6.404*V*C}{M}$$

Where,

V=Volume, in ml, of standard sodium hydroxide required for the titration.
C=Concentration, in mol per liter, of the standard NaOH solution.
M=Mass, in g of the sample taken for test.

3.2.2 Analysis of Total Soluble Solids (TSS) content of fresh corn slurry

Equipments:

Refractometer

Methodology:

The glass lense of the hand refractometer (Reichert-Jung hand refractometer range 0-30^0) was washed well with distilled water and wiped out with cleaned tissue. Then 1g of corn slurry was added to the measured amount of water. Then the mixture was homogenized and filtered through the cloth into the prism of the refractometer. Then the refractometer was closed by lowering the fogged glass into the sample. Then the results (Brix value) were recorded.

Calculation:

$$\text{Total Soluble Solids} = \left\{\text{Refractometer Reading}\right\} * \left\{\text{Dilution factor}\right\}$$

3.2.3 Analysis of P^H value of fresh corn slurry

Equipments:

P^H meter

Methodology:

P^H value of the fresh corn slurry was measured using a P^H tester. (Jenway Model 3510 P^H tester). Firstly the P^H tester was calibrated with two buffer solutions (P^H=4 & P^H=7). Then the P^H value of the fresh corn slurry was measured by immersing the bulb of the P^H meter in the sample. The bulb of the P^H tester was washed with distilled water and cleaned using a tissue paper after and before taking measurements.

3.3 Procedure for the preparation of corn pudding

3.3.1 Preparation of corn slurry

The corn slurry was obtained according to the method described in 3.1.1

3.3.2 Preparation of pineapple juice

Well ripe pineapple were peeled and cut into small pieces. Then pineapple juice was obtained using blender and obtained juice was weighed.

3.3.3 Preparation of Iramusu herbal extracts

First "Maha Iramusu" roots were weighed and washed. Then root was cut into small pieces. Thereafter measured amount of water was added for it. Then it was boiled for 30 minutes. Finally required amount was measured.

3.3.4 Preparation of pineapple juice fortified corn pudding formula

Pre prepared corn slurry, pineapple juice, sugar and portable water was mixed according to the ratio (Corn slurry: Sugar: Pineapple juice: Water 1:1/5:1/5:1/2).Then above mixture was heated up to (80-85)^{0}C while stirring until it become gelatinized. It is better to add pineapple juice to the mixture before few minutes removing from the pan. Then product was poured into plastic cups and allowed to cool at room temperature. Finally the product was stored at (4-5)^{0}C refrigerator (Domestic fridge).

3.3.5 The developed recipe for pineapple juice fortified corn pudding

Corn slurry	1000g
Sugar	200g
Pineapple juice	200g
Portable water	500ml

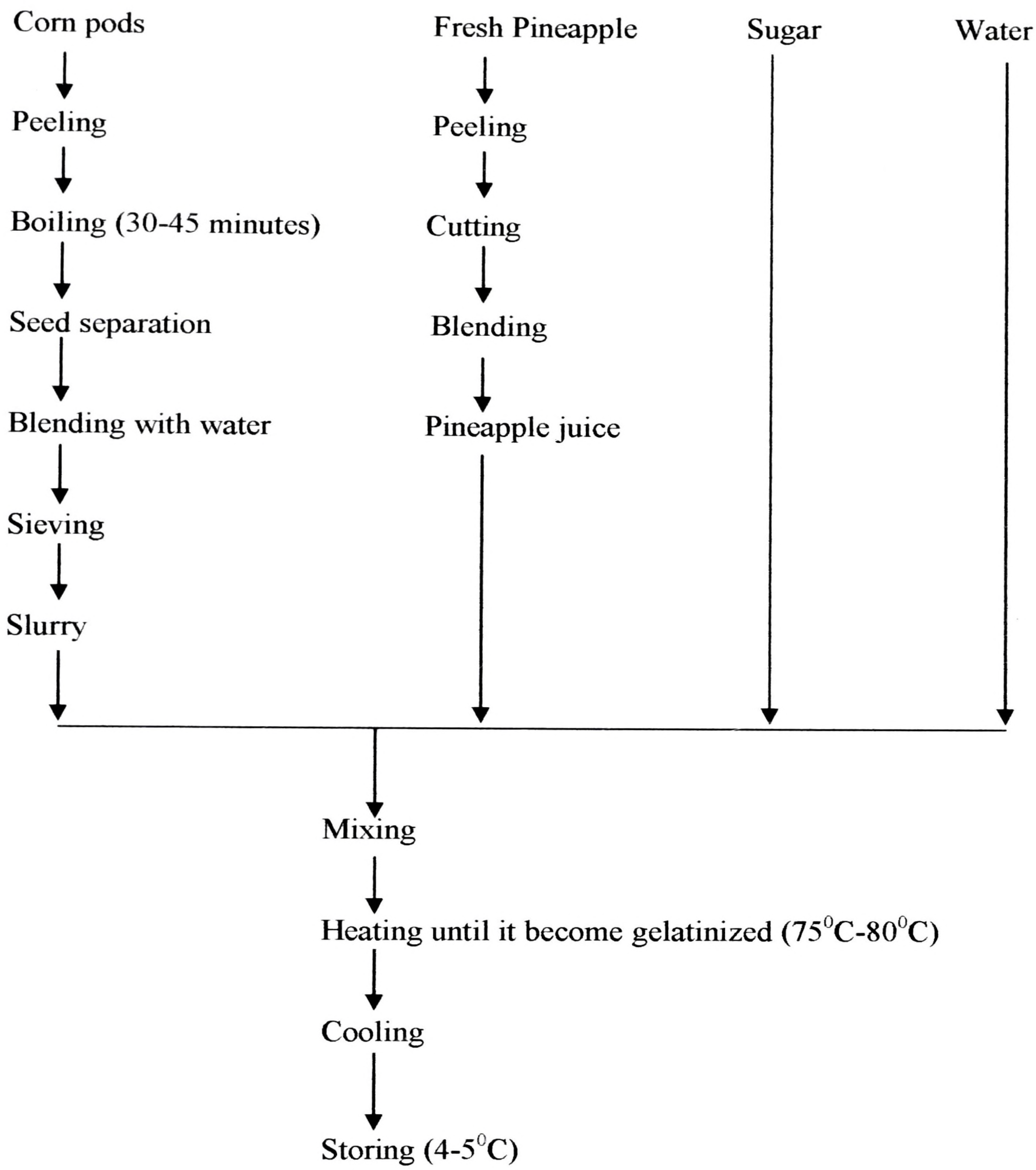


Figure 3.1 Processing flow diagram of the pineapple juice fortified corn pudding

Figure 3.2 Prepared pineapple juice fortified corn pudding

3.3.6 Preparation of Iramusu extract fortified corn pudding formula

Pre prepared Corn slurry, Iramusu extract, Sugar, portable water were mixed according to the ratio (Corn slurry: Sugar: Iramusu extract: Water 1:1/5:1/5:1/2) and 0.12% citric acid also added into it. Then above mixture was heated up to (80-85)^{0}C while stirring until it become gelatinized. Then the product was packed and cooled to room temperature. Finally the product was stored at (4-5)^{0}C refrigerator (Domestic fridge).

3.3.7 The developed recipe for Iramusu extract fortified Corn pudding

Corn slurry	1000g
Sugar	200g
Iramusu extract	200g
Portable water	500ml
Citric acid	1.2g

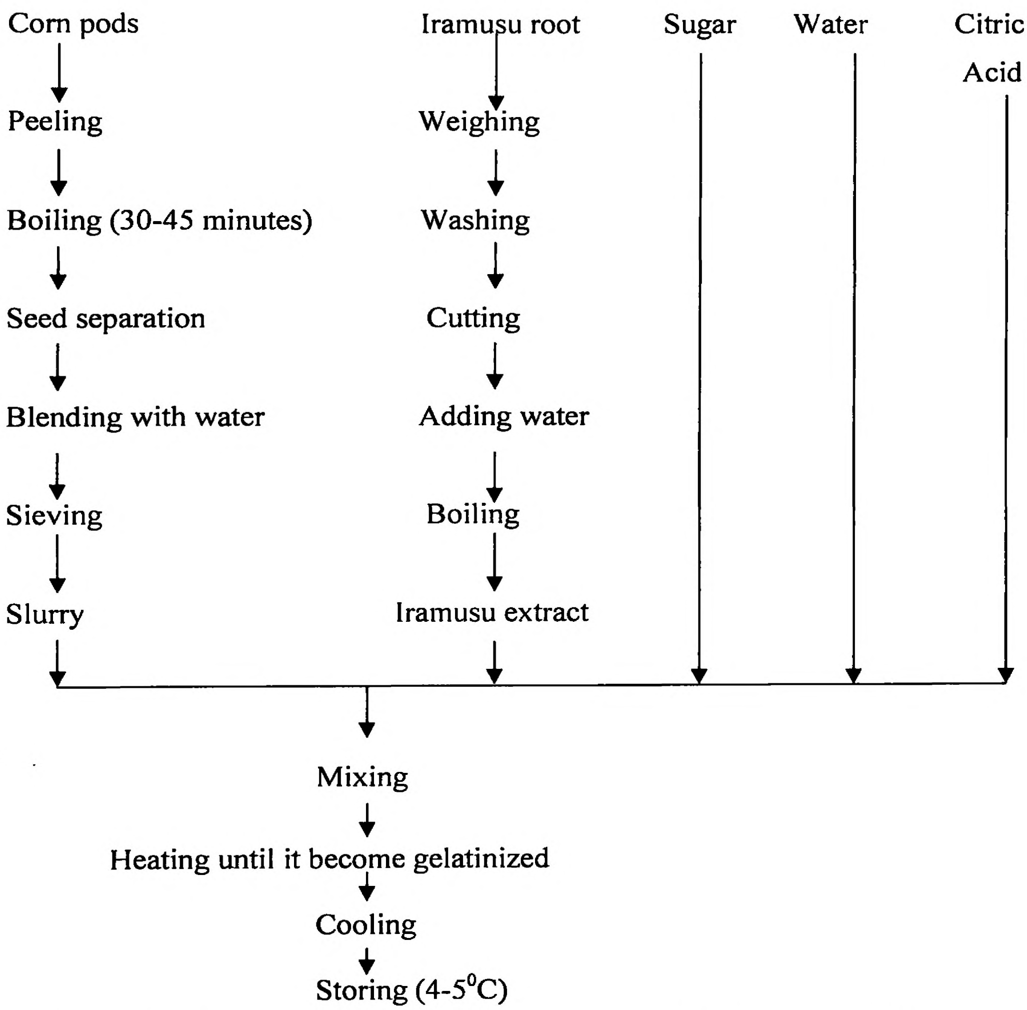


Figure 3.3 Processing flow diagram of the Iramusu extracts fortified corn pudding

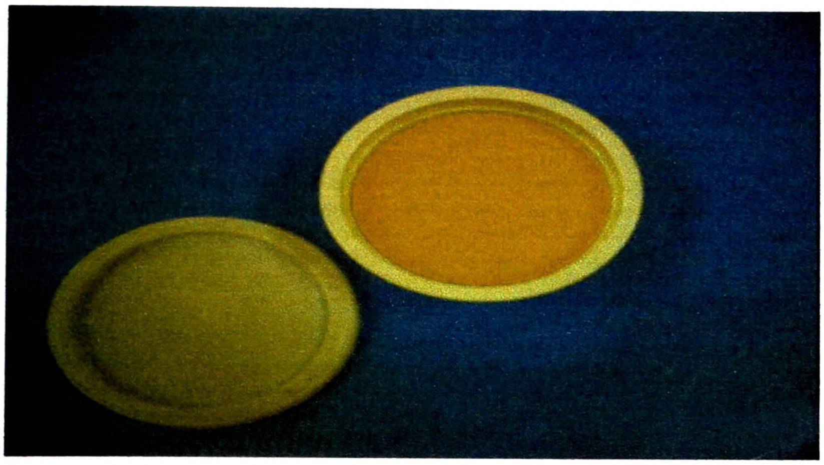


Figure 3.4 Prepared Iramusu extract fortified corn pudding

3.4 Sensory evaluation of the product

Three sensory evaluations were carried out for the products. The first sensory analysis was done for the determination of best maturity stage of Corn pods for the best production out of two samples prepared. The second sensory evaluation was carried out for the determination of suitable fortified fruit juice out of three fruits. The third sensory evaluation was carried out for the determination of best consumer preference for the fortification.

Thirty panelists attended to sensory evaluation and scoring test method was used for the sensory evaluation. The scoring test was conducted by giving a hedonic scale of "like or dislike". Dislike extremely to like extremely was numbered from 1 to 9 respectively (See appendix I, III and V) and given to the panel to state their scores in front of the code number given to each sample.

At first, 3 code numbers were selected for each three samples using random numbers (Wrote numbers, 0 to 9 and put it into box. Then numbers were selected at randomly) Then obtained following codes,

Code no. 410 for sample No. 1
Code no. 630 for sample No. 2
Code no. 724 for sample No. 3

Color, Appearance, Texture, Smell, Taste, and Overall acceptability of samples were tested at the sensory evaluation according to the above method. Results obtained from sensory evaluation for organoleptic properties were analyzed using statistical software, "Mini Tab 14".

3.5 Proximate analysis of the best product

The best sample selected from the sensory evaluation was analyzed for moisture, total solids, fat (Total fat and free fat) and protein as described follow.

3.5.1 Determination of moisture and total solids (Oven-Drying Method)

Apparatus:

Moisture dishes made of Aluminum
Oven maintained at $105\pm1^{0}C$
Analytical balance (Weighing up to 220.0000g, Accuracy .0001)
Desiccator

Methodology:

Pre-dried 3 aluminum dishes were weighted to the nearest 0.1 mg on an analytical balance. Then 3-5 g of pudding sample was weighted quickly into the each aluminum dishes and kept at $105\pm1^{0}C$ for 4 hours. Thereafter samples were cooled in a desiccator and total dry weight was determined. Again, samples were kept for an additional 30 minutes inside the oven and reweighed. This was repeated several times until constant weight was attained. Once the difference between the two consecutive readings after the additional drying period was less than 1 mg, it was recorded as the final reading (Kirk and Sawyer, 1991). Then total solids and moisture contents were recorded on weight percent basis.

Calculation:

$$\% \text{ Moisture (wt / wt)} = \frac{(M_1 - M_2)}{(M_1 - M_3)} * 100$$

$$\text{Total Solids} = (100\text{-Moisture})\ \%$$

Where,
M_1=Mass of the dish with the sample before drying.
M_2 = Mass of the dish with the sample after drying
M_3 = Mass of the empty dish

3.5.2 Determination of free fat (Soxhelt Extraction Method)

Materials:

Petroleum ether

Ether

Apparatus:

Soxhelt extraction apparatus

Thimble

Methodology:

Extraction thimble with the sample was set to the Soxhelt apparatus. Then 150 cm^3 of petroleum ether and 150 cm^3 of ether were added to the cleaned, dried, round bottom flask using a measuring cylinder. Thereafter the flask was connected to the soxhelt syphon and it was kept for five hours to condenser and reflux. (The heating rate should be kept low enough to prevent solvent escaping from the top of the condenser during refluxing). Then the solvent was distilled off and placed the flask and contents in an oven at 105^0C for two hours. Again, flask and contents were kept for an additional 30 minutes inside the oven and reweighed. This was repeated several times until constant weight was attained (Nielsen and Suzanne, 2002)

Calculation:

$$\text{\% free fat content of the sample} = \frac{(X-F) * 100}{W}$$

Where,

F = Weight of flask

X = Weight of the flask with fat

W =Weight of the sample

3.5.3 Determination of total fat

Materials:

Hydrochloric acid

Ether

Ethanol

Apparatus:

Majoinner flask
Beaker (100ml)

Methodology:

Two g of the defatted sample was placed in 50 ml beaker. Then 2ml of 95% ethanol and 10ml of HCL (which was prepared by adding 25ml of conc. HCL and 1.0 ml of water) was added to it. Then the content was mixed thoroughly. Thereafter the beaker was placed in (70^0C-80^0C) water bath and stirred for 30-50 minutes frequently. Then the beaker was removed from the water bath and cooled in the atmosphere. Then 10 ml of ethanol was added into it and the mixture was transferred into the separation funnel. The beaker was washed with 25ml of ether in three portion of washing and added it to the flask. Then the flask was stopped with a cork and shaked vigorously for about few minutes and 25 ml of pet ether was added and shaked again. Thereafter the flask was stand until clear layer of pet ether is appeared. Then the upper ether layer was taken into the clean previously weighed dried flask. Then flask and content was dried in a water bath (90^0C) until the constant weight is obtained (Nielsen and Suzanne, 2002)

Calculation:

$$\% \text{ Total fat content of the sample} = \frac{\text{Weight of fat} * 100}{\text{Weight of sample}}$$

3.5.4 Determination of crude protein (Micro Kjeldhal Method)

Materials:

0.02M HCl
Conc. H_2SO_4
40% NaOH
4% Boric acid
Catalyst mixture ($SeO_2/K_2SO_4/CuSO_4.5H_2O$)
Kjeldhal indicator (Methyl red - methylene blue mixture)
Diethyl ether

Apparatus:

Kjeldhal Digestion unit
Kjeldhal distillation unit
Analytical balance
Common laboratory glasswares

Methodology:

One g of defatted sample, 1g of catalyst mixture ($SeO_2/K_2SO_4/CuSO_4.5H_2O$) and 25ml of Conc. H_2SO_4 were added in to a Kjeldhal flask and placed in the micro Kjeldhal unit for 6 hours. After the digestion was completed, the flask was allowed to cool and the contents were transferred to a 100 ml volumetric flask using distilled water. Then distillation unit was set up. 15ml of 4% boric acid was taken into a titration flask and 3 drops of indicator was added to it. Steam generator was fixed to the mouth of the distillation unit while other end that emits the gas out, was dipped in the titration flask that contains boric acid. Then 25ml of the diluted sample was added in to the distillation unit. 40% NaOH was added when contents get started to boiling. Steaming was continued until violet blue colour turns olive green and finally trapped ammonia was determined by titrating it with 0.01N HCl using phenolphthalein as the indicator. The amount of acid consumed was recorded. Triplicates and one blank were run (Chang, 1998).

Calculation:

$$\text{Nitrogen \%} = \frac{(\text{Sample titre - Blank titre}) * N_{HCl} * 14 * V_D * 100}{\text{Aliquot of the digestion taken} * \text{Wt. of the sample} * 1000}$$

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

Where;

N_{HCl} = Normality of HCl

V_D = Volume made up of the digestion

Wt = Weight

3.6 Chemical analysis of the product

3.6.1 Analysis of Titrable Acidity (TA) of the best corn pudding

The Titrable Acidity was measured according to the method described in 3.2.1. This procedure was repeated three times for each sample and Titrable Acidity was measured daily during storage time for 15 days.

3.6.2 Analysis of Total Soluble Solids (TSS) content of the best corn pudding

The Total Soluble Solids (Brix value) were measured using a refractometer according to the method described in 3.2.2. This procedure was repeated three times for each sample and Total Soluble solids were measured daily during storage time 15 days.

3.6.3 Analysis of P^H value of the best corn pudding

The P^H value of the product was measured using a P^H meter according to the method described in 3.2.3. This procedure was repeated three times for each sample and P^H value of the product was measured daily during storage time for15 days.

3.7 Microbiological analysis of the best product

Total Plate Count (Aerobic Plate Count) and Yeast and Mould test was carried out as a microbiological analysis for the shelf life evaluation of the best product.

Culture media:

Nutrient Agar (NA)

Potato Dextrose Agar media (PDA)

Methodology:

3.7.1 Sterilization of glassware

Sterilization was done to destroy or remove all unwanted living organisms without damaging or altering the substances being sterilized.

All the glassware including Petri dishes, test tubes, pipettes were thoroughly washed & sterilized in an oven at 180^0C for one hour. After sterilization, the oven was allowed to cool slowly.

3.7.2 Media preparation

3.7.2.1 Total Plate Count Test

Twenty eight g of nutrient agar powder was added to one litre of distilled water. It is stirred in a magnetic stirrer to dissolve the contents. It was boiled with agitation to completely dissolve the ingredients. Then it was sterilized in an autoclave at 121^0C for (15-20) minutes at 15 PSI. The medium was cooled to 45^0C and poured into sterilized Petri dishes.

3.7.2.2 Yeast and Mould Count Test

Potato Dextrose Agar media was prepared by adding of 100ml of Potato extracts, 10g of dextrose and distilled water up to 1000ml. Media was sterilized as above.

3.7.3 Procedure

Lamina air flow and hands were sterilized chemically by using 70% ethyl alcohol. Then 1g of pudding sample was put into test tube and 9ml of sterilized distilled water was added into it by using pipette. Then mixture was shaked by the help of shaker.

After preparation of mother solutions following dilution series were prepared 10^{-1}, 10^{-2}, 10-3, and 10^{-4}. Two plates were prepared by using each dilution.

3.7.4 Preparation of plates

3.7.4.1 Total Plate Count Test

Initially 1ml of inoculum was added into petridishes in the lamina air flow environment. Then 20ml of Nutrient Agar (NA) was added into the petridish and it was shaked well to proper mixing. Then petridish was sealed by sticking the parafilm.

Each plate was prepared by using above procedure. All the plates was incubated at (30^0C-35^0C) for 48 hours. After 48 hours colonies were counted by the help of colony counter (Garbutt, 1997)

3.7.4.2 Yeast and Mould Count Test

Initially 1ml of inoculum was added into Petri dishes in the lamina air flow environment. Then 20ml of Potato Dextrose Agar (PDA) was added into the Petri dish and it was shaked well to proper mixing. Then Petri dish was sealed by sticking the parafilm.

Each plate was prepared by using above procedure. All the plates were incubated at 28^0C for 72 hours. After 48 hours colonies were counted by the help of colony counter.

Calculation:

$$N = \frac{\sum C}{(n_1+0.1n_2)\,d}$$

Where,

$\sum C$ = The sum of colonies counted on all plates

n_1 = The number of plates retained in the first dilution

n_2 = The number of plates retained in the second dilution

d = The dilution factor corresponding to the first dilution

3.8 Cost analysis of the product

The cost for one cup of Corn pudding with the addition of Pineapple juice was determined.

Ingredients	Rs. 3.50
Packaging	Rs. 2.50
Labour	Rs. 0.50
Electricity and gas	Rs. 1.00
Total cost	Rs. 7.50

Chapter 04

Results and Discussion

4.1 Preparation of semisolid corn based slurry

Starch is the reserve carbohydrate of maize plant and occurs as granules in the cells of corn seeds in plastids, separated from the cytoplasm (Mayer, 1960). When cells of boiled tender corn seeds were ground, the starch granules come out from ruptured cells and make a slurry. These starch granules are washed out with water from above slurry during the draining procedure. When washed out solution was heated, it formed a paste due to gelatinization. Generally gelatinization is a major change of starch on cooking. When starch granules were mixed with cold water, no apparent changes occurred at initially. But when the water was heated, the viscosity of the mixture increased due to gelatinization. Therefore no texturing agent was needed for the formation of texture.

The starch granules of Maize contain both amylose and amylopectin molecules. Amylose is believed to form gels more rapidly. Because the linier shape of amylose molecules are allows the formation of a three dimensional network easily.

But the ability of the natural starch to form paste differ considerably with the variety of starch, P^H of the solution, temperature and heating time, size of the granules.

4.2 Formation of colour in the product

The carotinoids are a group of yellow, orange and orange red fat soluble pigments widely distributed in nature. This carotene is a mixture of three isomers such as alpha, beta and gama carotene (Mayer, 1960).

How ever, the tender corn seeds contain number of carotenoids such as Zeaxanthin, Crypto zanthin, Xanthyphyll, Alpha carotene, Beta carotene, kapha carotene, Keo-cryptozanthin, Hydroxyl-alpha-carotene. These are affected to light yellow colour of the product given through corn base. The colour of the product can be changed due to the amount of carotene content of different varieties. Bright yellow colour is given from the variety due to the high amount of carotene (Mayer, 1960).

In addition, fully ripen pineapple is also a carotene rich crop. It also affects the colour of the product.

Tender corn seeds are not promoting browning reaction due to the absence of phenolic and polyphenolic compounds as its constituents.

4.3 Physico chemical properties of the fresh corn slurry

The Titrable Acidity (TA) of the corn slurry used for the preparation of corn pudding was 0.06404 %. This indicates that the initial acidity of the slurry is very low. (See Appendix I). The high P^H value of this sample may be responsible for the decreased in the Titrable Acidity. But Titrable Acidity is not a good predictor of P^H value of the sample. Titrable Acidity provides a simple estimate of the total acid content of a food. Therefore it is a better predictor of an acid's impact on flavor than P^H value.

The Total soluble Solids (TSS) content of the corn slurry used for the preparation of corn pudding was 03 (See Appendix I). This indicates that the initial Total Soluble Solids content of the corn slurry is very low due to low sugar content of maize cobs. Therefore it is necessary to add sugar amount to the product to increase fllavour and palatability of the product.

The P^H value of the corn slurry used for the preparation of corn pudding was 6.8 (See Appendix I). This indicates that the initial P^H value of the corn slurry is very high. Therefore there is a high possibility for microorganisms to grow. So it should be controlled at least up to 4.0 value of P^H to preserve this product. But this product does not contain any artificial preservatives. Fruit juices used to decrease the P^H value. Fruit juices can not be considered only as a P^H value controller. But also it provides smooth flavour to the product.

4.4 Suitable maturity stage of maize for product preparation

Sensory evaluation was carried out to determine the suitable maturity stage of corn pods among two samples of corn pudding prepared by using immature corn pods and mature corn pods with the fortification of pineapple juice for the preparation of corn pudding.

According to the P value ($P>0.05$) for appearance, texture, smell and taste, there was no evidence for a difference in these sensory aspects of corn pudding samples which were prepared by using mature corn pods and immature corn pods (See Table 4.1). But when referring to the mean value, the appearance, texture, smell and taste were best in pineapple juice fortified corn pudding samples which are prepared by using immature corn pods.

According to the P value ($P<0.05$) for colour and overall acceptability, there was significant difference in colour and overall acceptability of corn pudding samples which were prepared by using mature corn pods and immature corn pods. Therefore according to the mean value, the colour and overall acceptability were best in pineapple juice fortified corn pudding samples which were prepared by using immature corn pods.

There were some comments with the flavour of corn pudding prepared by using mature corn pods. As it showed a watery flavour some panelists rejected the corn pudding prepared by using mature corn pods. It may be affected the sugar amount of the maize kernel. Sugar content of immature maize was relatively high, while starch was low. As the kernel matures the sugar content declines and starch increases. But the sugar level decreases significantly with age (FAO, 1992).

Table 4.1 Sensory evaluation of corn pudding for suitable maturity stage of corn pods for product preparation

Sensory characteristic	Corn pudding prepared from mature corn pods		Corn pudding prepared from immature corn pods	
	Mean value	P value	Mean value	P value
Colour	7.76	0.032	8.267	0.032
Appearance	7.53	0.123	8.00	0.123
Texture	6.80	0.079	7.40	0.079
Smell	7.37	0.663	7.20	0.663
Taste	7.20	0.260	7.57	0.260
Overall Acceptability	7.27	0.008	8.00	0.008

4.5 Suitable fruit juice fortification for product preparation

Sensory evaluation was conducted to determine the suitable fruit fortification among the three samples of corn pudding with pineapple, mango and wood apple fruit juices.

When performing ANOVA for corn pudding samples which were prepared by using different fruit juices such as wood apple, pineapple and mango juices, the p-value (0.002) for colour, (0.047) for appearance and (0.019) for smell, indicates that there was sufficient evidence that not all the means for above characteristics were equal when alpha was set at 0.05 (Table 4.2). This implies that there was a statistically significant difference in colour, appearance and smell. Since pineapple juice fortified corn pudding showed the highest mean it could be considered as the best of these three.

When performing ANOVA for corn pudding samples for above three samples, the p-value (0.297) for texture, (0.393) for taste and (0.199) for overall acceptability, indicates that there was sufficient evidence that all the means for above characteristics are equal when alpha is set at 0.05. This implies that there was no statistically significant difference in texture, taste and overall acceptability. Therefore mean comparison was meaningless and sample code 630 which contain pineapple juice fortified corn pudding could be selected as the best one for texture, taste and overall acceptability out of these three.

Table 4.2 Sensory evaluation of corn pudding for suitable fruit juice fortification for product preparation

Sensory characteristic	Corn pudding prepared from wood apple juice		Corn pudding prepared from pine apple juice		Corn pudding prepared from mango juice	
	Mean value	P value	Mean value	P value	Mean value	P value
Colour	7.2667	0.002	8.1000	0.002	7.8000	0.002
Appearance	7.2333	0.047	7.8000	0.047	7.7667	0.047
Texture	7.4000	0.297	7.7000	0.297	7.3000	0.297
Smell	6.7670	0.019	7.467	0.019	7.367	0.019
Taste	7.2333	0.393	7.5000	0.393	7.4667	0.393
Overall Acceptability	7.0333	0.199	7.5000	0.199	7.2667	0.199

4.6 Suitable fortification for product preparation

According to the P value ($P<0.05$) for colour, appearance, texture, smell, taste and overall acceptability, there was a significant difference in these sensory aspects of corn pudding samples which was prepared by fortifying pineapple juice and Iramusu extract (Table 4.3). Therefore according to the mean value, the colour, appearance, texture, smell, taste and overall acceptability were best in pineapple juice fortified corn pudding compared to those in Iramusu extract fortified corn pudding.

Table 4.3 Sensory evaluation of corn pudding for suitable fortification for product preparation

Sensory characteristic	Corn pudding prepared from pine apple juice		Corn pudding prepared from iramusu extract	
	Mean value	P value	Mean value	P value
Colour	8.267	0.000	6.30	0.000
Appearance	8.00	0.000	6.23	0.000
Texture	7.40	0.013	6.37	0.013
Smell	7.833	0.000	6.800	0.000
Taste	7.57	0.001	5.97	0.001
Overall Acceptability	8.00	0.000	6.17	0.000

4.7 Proximate composition of the best product

Table 4.4 shows the proximate analysis of the corn pudding prepared by fortifying pineapple juice. It was found that corn pudding contains 70.42% of moisture, 29.58% of total solids, 1.33% of total fat, 0.12% of free fat and 3.85% of protein. The summation of moisture, total fat and protein are 75.66%. Thus the final product contains 24.34% of carbohydrates, fibre and ash. The summation of fibre and ash are very low amount in maize (<4%). The total carbohydrate amount can there be concluded as >20%. (The vitamins content and minerals content of tender Corn are less than 1%) So the vitamin and mineral content is a negligible factor for the calculation.

Although there are many different nutrients that are required in the human diet, the two most important are adequate intakes of energy and protein (FAO/WHO, 1993). The energy intake of a particular diet is normally calculated from the amount of carbohydrates (starch and sugar), protein, fat and oil. Therefore, corn pudding can be considered as good source of energy due to high carbohydrate content of maize and significant amount of protein as well.

Fat impart the taste of a food and the shelf life also governed by the fat present in the food commodity as fat responsible for rancidity. But corn pudding contains low amount of fat resulting long shelf life.

Table 4.4 Gross composition of corn pudding

Component	Percentage
Moisture	70.42 %
Total Solids	29.58 %
Total fat	1.325 %
Free fat	0.115 %
Protein	3.85 %

4.8 Physico chemical quality of the products

Changes in physico chemical quality of any food item as well as microbial analysis determine its safety, acceptability, shelf stability and its fitness for consumption. Three samples were stored in two weeks at (4-5)^{0}C and measured the P^H value, Titrable Acidity (TA) and Total Soluble Solids (TSS) daily. The results indicate that no noticeable changes in the P^H, Total Soluble Solids and Titrable Acidity within these two weeks of storage. The results revealed that product was acceptable for two weeks.

4.8.1 Titrable Acidity (TA) of the corn pudding

According to the table 4.5, Titrable Acidity for corn pudding which were prepared by using pineapple juice and mature corn pods have increased from 0.128 to 0.141 since first day to end of storage time. But there is an unexplainable increase in Titrable Acidity at third day and fourth day. It may be due to an experimental error. The P^H decrement of this sample may be responsible for the slight increased in the Titrable Acidity. That figure shows only 0.013 variations from first day to fifteenth day.

According to Table 4.5, Titrable Acidity for sample which were prepared by using pineapple juice and immature Corn pods have increased from 0.128 to 0.141 since first day to end of storage time. The P^H increment of this sample may be responsible for the slight increased in the Titrable Acidity. That figure shows only 0.013 variations from first day to fifteenth day.

According to the Table 4.5, Titrable Acidity for sample which were prepared by using Iramusu extract and immature Corn pods have increased from 0.128 to 0.154 since first day to end of storage time. The P^H decrement of this sample may be responsible for the slight increased in the Titrable Acidity. That figure shows only 0.026 variations from first day to fifteenth day.

Table 4.5 Titrable Acidity (TA) variation of corn pudding samples

Days	Titrable Acidity (TA)		
	Corn pudding prepared from pineapple juice and mature corn pods	Corn pudding prepared from pineapple juice and immature corn pods	Corn pudding prepared from iramusu extract and immature corn pods
1	0.128	0.128	0.128
2	0.128	0.128	0.128
3	0.154	0.128	0.128
4	0.154	0.128	0.136
5	0.136	0.136	0.136
6	0.136	0.136	0.136
7	0.136	0.141	0.136
8	0.136	0.141	0.141
9	0.136	0.141	0.141
10	0.141	0.141	0.141
12	0.141	0.141	0.141
12	0.141	0.141	0.154
13	0.141	0.141	0.154
14	0.141	0.141	0.154
15	0.141	0.141	0.154

4.8.2 Total Soluble Solids (TSS) content of the corn pudding

According to the Table 4.6, there is a constant Total Soluble Solid amount (10.0) for sample which was prepared by using pineapple juice and mature corn pods with in first three days and final eight days. This figure has shown an unexplainable increase in Total Soluble Solids at fourth day, sixth day and seventh day. That may be due to an experimental error. That figure shows no variation from first day to fifteenth day.

According to the Table 4.6, there is a constant Total Soluble Solid amount (10.0) for sample which was prepared by using pineapple juice and immature corn pods with in first five days and last five days and seventh, eighth days. But this figure also has shown an unexplainable increase in Total Soluble Solids at sixth day, ninth day and tenth day. That may also be due to an experimental error. That figure shows no variation from first day to fifteenth day.

According to the Table 4.6, there is a constant Total Soluble Solid amount (10.2) for sample which was prepared by using iramusu extract and immature corn pods with in first three days. The Total Soluble Solid amount increased from eighth day and thereafter it is constant till the end of storage period. But this figure has shown an unexplainable decrease in Total Soluble Solids at fourth day and fifth day. That may also be due to an experimental error. That figure shows only 0.1 variations from first day to fifteenth day.

Table 4.6 Total Soluble Solids (TSS) variation of corn pudding samples

Days	Total Soluble Solids (TSS)		
	Corn pudding prepared from pineapple juice and mature corn pods	Corn pudding prepared from pineapple juice and immature corn pods	Corn pudding prepared from iramusu extract and immature corn pods
1	10.0	10.0	10.2
2	10.0	10.0	10.2
3	10.0	10.0	10.2
4	10.1	10.0	10.1
5	10.0	10.0	10.1
6	10.1	10.1	10.2
7	10.1	10.0	10.2
8	10.0	10.0	10.3
9	10.0	10.1	10.3
10	10.0	10.1	10.3
12	10.0	10.0	10.3
12	10.0	10.0	10.3
13	10.0	10.0	10.3
14	10.0	10.0	10.3
15	10.0	10.0	10.3

4.8.3 P^H value of the corn pudding

According to Table 4.7, there is a constant P^H (4.1) for sample which was prepared by using pineapple juice and mature corn pods from first day to fourth day. The P^H decreased from 4.1 to 4.0 in the fifth day and thereafter it is constant till the end of storage period. The figure shows only 0.1 variations from first day to fifteenth day.

According to the Table 4.7, there is a constant P^H (4.1) for sample which was prepared by using pineapple juice and immature corn pods from first day to tenth day. The P^H decreased from 4.1 to 4.0 in the eleventh day and thereafter it is constant till the end of storage period. That figure also shows only 0.1 variations from first day to fifteenth day.

According to the Table 4.7, there is a constant P^H (4.2) for sample which was prepared by using iramusu extract and immature corn pods from first day to third day. The P^H decreased from 4.2 to 4.1 in the fourth day and thereafter it is constant till the twelfth day. Then it decreased from 4.1 to 4.0 in the thirteenth day and thereafter it is constant till end of storage period. That figure shows only 0.2 variations from first day to fifteenth day.

Table 4.7 P^H value variation of corn pudding samples

Days	P^H value		
	Corn pudding prepared from pineapple juice and mature corn pods	Corn pudding prepared from pineapple juice and immature corn pods	Corn pudding prepared from iramusu extract and immature corn pods
1	4.1	4.1	4.2
2	4.1	4.1	4.2
3	4.1	4.1	4.2
4	4.1	4.1	4.1
5	4.0	4.1	4.1
6	4.0	4.1	4.1
7	4.0	4.1	4.1
8	4.0	4.1	4.1
9	4.0	4.1	4.1
10	4.0	4.1	4.1
12	4.0	4.0	4.1
12	4.0	4.0	4.1
13	4.0	4.0	4.0
14	4.0	4.0	4.0
15	4.0	4.0	4.0

4.9 Microbiological analysis of the best product

Shelf life evaluation of the best corn pudding was based on the microbiological analysis as well as chemical changes (P^H value, Total Soluble Solids (TSS) and Titrable Acidity (TA)) of the product during two weeks storage period at (4-5)^{0}C.

Therefore after two weeks storage period at (4-5)^{0}C, microbial evaluation (Total Plate Count and Yeast and Mould Test) was done to determine the microbial quality of the product.

After 48 hours incubation, there were no colonies appeared in the Petri dishes for Total Plate Count and Yeast and Mould count of the product.

The results of microbiological analysis revealed that product was acceptable for two weeks. But it does not contain any artificial colourings, flavours or preservatives. Shelf life of this product was increased due to low temperature (4-5)^{0}C storage and low P^H of the product. P^H value of the product was reduced due to fortification of fruit juice.

4.10 Cost of the product

The cost for one cup of this product is Rs.7.50.

Chapter 05

Conclusion and Further studies

5.1. Conclusion

Corn pudding can successfully be produced from maize without adding any artificial colorings, flavours or preservatives. Therefore, this product can be considered as a new natural product which has a high nutritive value.

The product contains 70.42% moisture, 1.325% total fat, 0.115% free fat and 3.85% protein. Results of microbial analysis indicated that there was no micro organism in any plate for Total Plate Count Method and Yeast and Mould Test and there was no considerable variation of P^H, Total Soluble Solids (TSS) and Titrable Acidity (TA) during the storage period of two weeks. Therefore, the results of shelf life evaluation reveal that the product is acceptable for two weeks.

Taking into consideration the acceptability, nutritive value, storage stability and cost effectiveness, it can be concluded that the corn pudding fulfilling the market requirements. Hence, the demand for this product can be increased within short time.

5.2. Suggestions for further studies

Carbohydrates, ash and fibre content of the final product should be analyzed. Vitamin content specially beta carotene also should be analyzed.

The product can be fortified by protein to increase the nutritive value of the product due to deficiencies in some essential amino acids of maize protein.

The product can be study on nutritional losses during processing and storage.

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APPENDIX I

Physico chemical properties of the fresh corn slurry

Titrable Acidity (TA) of the fresh Corn slurry

Volume of standard sodium hydroxide required for the titration = 0.5ml

Concentration, in mol per liter, of the standard NaOH solution = 0.1mol/l

Mass of the sample taken for test = 05g

$$\text{Acidity, percent by mass} = \frac{6.404 * 0.5\text{ml} * 0.1\text{mol/l}}{05\text{g}}$$

= 0.06404%

Total Soluble Solids (TSS) content of the Corn slurry

Refractometer reading = 1.5

Dilution factor = 02

Total Soluble Solids = 1.5 * 2

= 03

P^H value of the fresh Corn slurry

PH meter reading = 6.8

PH value = 6.8

APPENDIX II

Sensory evaluation of corn pudding samples

Name: ....

Instructions:

1. You have been given two types of Corn pudding samples, in random order.

2. Please assess the characters of the samples given below in the given order using the following scale.

3. At the beginning and in between samples wash your mouth with water.

4. Don't compare the samples.

Character	Code No	
	410	630
Colour		
Appearance		
Texture		
Smell		
Taste		
Overall Acceptability		

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

Comments: ....
....
....

Thank you!

APPENDIX III

Ranks of each parameter in sensory evaluation

Consumer Number	Colour		Appearance		Texture		Smell		Taste		Overall Acceptability	
	410	630	410	630	410	630	410	630	410	630	410	630
1	9	9	9	9	8	9	9	9	8	8	8	9
2	7	8	8	9	8	9	8	8	7	8	7	8
3	6	7	6	7	4	5	2	6	4	6	4	6
4	7	9	7	8	6	8	9	8	8	9	8	9
5	8	9	8	9	7	8	7	9	8	9	8	9
6	8	9	7	9	7	8	7	9	6	8	6	9
7	8	8	8	8	7	7	8	8	8	9	8	9
8	8	9	7	6	5	5	8	8	9	8	9	8
9	8	8	8	8	5	4	7	7	6	6	7	7
10	8	8	8	7	8	7	8	9	7	8	7	8
11	8	9	8	9	6	7	9	8	8	7	8	7
12	9	9	8	8	7	7	6	6	8	9	8	9
13	9	8	6	7	7	8	9	6	7	4	7	6
14	9	9	9	9	7	8	8	8	9	8	8	9
15	6	7	6	7	7	7	7	6	5	5	6	8
16	7	6	7	6	6	7	6	5	6	7	6	7
17	7	8	7	8	7	7	7	7	7	6	7	8
18	5	5	5	4	5	5	5	5	6	5	6	5
19	8	9	7	8	5	9	9	6	7	9	7	9
20	5	9	5	9	7	7	7	6	6	7	7	8
21	9	9	9	9	5	5	7	6	9	8	9	8
22	7	8	7	8	7	8	8	7	7	8	7	8
23	8	9	9	9	8	8	8	9	8	9	8	9
24	7	8	8	8	8	9	6	3	7	8	7	8
25	9	9	9	9	8	9	9	9	8	9	8	9
26	9	9	9	9	7	8	7	7	8	8	7	8
27	8	9	8	9	8	9	8	9	7	8	7	8
28	7	8	7	8	8	8	7	8	7	8	8	9
29	8	8	8	8	7	8	7	7	7	8	7	8
30	8	8	8	8	9	8	8	7	8	7	8	7

410-Pineapple juice fortified corn pudding prepared by using mature corn pods

630-Pineapple juice fortified corn pudding prepared by using immature corn pods

APPENDIX IV

Sensory evaluation of corn pudding samples

Name: ....

Instructions:

1. You have been given three types of Corn pudding samples, in random order.

2. Please assess the characters of the samples given below in the given order using the following scale.

3. At the beginning and in between samples wash your mouth with water.

4. Don't compare the samples.

Character	Code No		
	630	815	102
Colour			
Appearance			
Texture			
Smell			
Taste			
Overall Acceptability			

9- Like extremely
8- Like very much
7- Like moderately
6- Like slightly
5- Neither like nor dislike

4- Dislike slightly
3- Dislike moderately
2- Dislike very much
1- Dislike extremely

Comments: ....
....
....

Thank You!

APPENDIX V

Ranks of each parameter in sensory evaluation

Consumer Number	Colour			appearance			Texture			Smell			Taste			Overall Acceptability		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
1	9	9	9	9	9	9	9	9	9	9	8	8	9	8	8	9	8	8
2	9	8	8	9	8	8	8	8	8	8	9	8	8	8	8	9	8	7
3	8	7	7	8	7	7	8	8	6	9	8	8	8	7	7	8	7	7
4	9	9	9	9	9	9	8	9	8	8	9	8	7	8	7	7	8	6
5	8	7	7	8	7	7	8	8	8	8	7	6	8	7	7	8	7	7
6	8	7	8	8	7	8	9	7	9	8	8	7	7	8	9	8	8	9
7	8	7	7	8	7	7	8	7	9	8	8	7	8	7	8	7	7	9
8	6	7	5	6	7	5	8	8	8	7	7	6	8	8	7	8	7	7
9	8	7	6	7	7	6	7	6	7	6	5	5	8	7	8	8	7	6
10	9	8	8	9	8	8	7	8	5	6	8	7	9	8	7	9	8	8
11	9	8	7	9	8	7	7	6	6	8	7	9	8	6	7	7	6	5
12	8	8	7	8	8	7	8	7	6	8	9	9	8	7	6	8	7	7
13	8	8	9	8	8	9	9	6	7	7	7	6	7	7	9	7	7	8
14	7	7	8	9	7	8	8	7	9	9	8	7	6	7	7	6	5	7
15	6	6	8	6	6	8	9	8	9	7	7	9	6	8	8	7	8	8
16	8	8	7	8	8	8	7	8	8	7	7	5	6	7	7	8	8	9
17	9	8	7	8	8	7	7	7	9	8	8	7	7	7	8	7	6	8
18	9	9	8	9	9	8	8	8	6	8	7	7	7	8	8	6	6	7
19	8	8	7	8	8	7	8	8	9	7	6	5	7	8	7	8	7	6
20	9	9	8	8	8	7	8	7	6	8	7	5	8	7	8	8	7	6
21	8	9	8	9	9	8	6	7	7	7	6	5	7	9	7	8	9	7
22	7	9	7	7	9	7	7	7	9	7	8	7	8	8	7	7	9	8
23	9	8	8	8	7	5	7	6	6	7	8	7	8	9	8	6	7	6
24	8	7	6	8	7	6	9	7	8	7	7	6	8	8	6	7	8	6
25	7	7	7	7	7	9	8	7	8	8	7	6	8	6	6	8	7	7
26	8	8	7	6	9	7	7	6	6	7	6	6	8	7	6	7	6	5
27	9	8	6	7	8	6	7	6	5	7	6	6	7	6	6	7	6	6
28	8	7	6	6	7	6	7	8	7	6	8	7	7	8	7	8	9	8
29	7	8	7	7	8	7	6	7	7	8	7	7	6	7	6	7	6	6
30	9	8	6	7	8	6	8	8	7	6	8	7	8	8	7	7	9	7

1= **Sample Code 630**-Pineapple juice fortified corn pudding

2= **Sample Code 815**-Mango juice fortified corn pudding

3= **Sample Code 102**-wood Apple juice fortified corn pudding

APPENDIX VI

Sensory evaluation of corn pudding samples

Name: ....

Instructions:

1. You have been given two types of Corn pudding samples, in random order.

2. Please assess the characters of the samples given below in the given order using the following scale.

3. At the beginning and in between samples wash your mouth with water.

4. Don't compare the samples.

Character	Code No	
	630	724
Colour		
Appearance		
Texture		
Smell		
Taste		
Overall Acceptability		

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

Comments: ....
....
....

Thank You!

APPENDIX VII

Ranks of each parameter in sensory evaluation

Consumer Number	Colour		appearance		Texture		Smell		Taste		Overall Acceptability	
	630	724	630	724	630	724	630	724	630	724	630	724
1	9	7	9	8	9	8	9	7	8	8	9	7
2	8	4	9	4	9	9	8	7	8	6	8	6
3	7	5	7	5	5	2	8	7	6	2	6	5
4	9	6	8	6	8	5	8	7	9	7	9	7
5	9	7	9	7	8	6	9	9	9	5	9	5
6	9	7	9	7	8	6	9	7	8	8	9	7
7	8	7	8	6	7	6	8	7	9	7	9	6
8	9	8	6	7	5	7	8	8	8	4	8	5
9	8	8	8	8	4	4	7	6	6	4	7	5
10	8	7	7	9	7	9	9	9	8	9	8	9
11	9	3	9	2	7	8	8	6	7	1	7	4
12	9	8	8	8	7	7	8	7	9	6	9	7
13	8	6	7	6	8	3	8	6	4	4	6	4
14	9	8	9	8	8	7	8	7	8	7	9	7
15	7	6	7	5	7	7	6	5	5	8	8	8
16	6	3	6	5	7	6	8	6	7	6	7	6
17	8	6	8	6	7	7	8	8	6	4	8	7
18	5	4	4	4	5	4	7	6	5	4	5	4
19	9	5	8	6	9	5	7	6	9	6	9	6
20	9	4	9	2	7	4	6	6	7	3	8	4
21	9	9	9	9	5	5	6	6	8	8	8	7
22	8	6	8	6	8	6	7	6	8	5	8	6
23	9	7	9	7	8	8	9	7	9	8	9	7
24	8	5	8	4	9	8	8	7	8	9	8	6
25	9	8	9	6	9	8	9	8	9	7	9	6
26	9	7	9	8	8	7	7	6	8	8	8	8
27	9	7	9	7	9	8	9	7	8	6	8	8
28	8	7	8	7	8	7	8	6	8	7	9	6
29	8	6	8	6	8	7	7	7	8	6	8	6
30	8	8	8	8	8	7	8	7	7	6	7	6

630-Pineapple juice fortified corn pudding prepared by using immature corn pods

724-Iramusu extract fortified corn pudding prepared by using immature corn pods

APPENDIX VIII

Sensory evaluation of corn pudding samples-Statistical Analysis

(Selection of the suitable maturity stage of maize for product preparation)

Colour

Normality Test (Sample Code 410, 630)

H0: Data are normally distributed. Vs. H1: Data are not normally distributed.

The Kolmogorov-Smirnov test's p-value indicates that, at α levels smaller than 0.150; there is evidence that the data follow a normal distribution

Appearance

Normality Test (Sample Code 410, 630)

H0: Data are normally distributed. Vs. H1: Data are not normally distributed.

The Kolmogorov-Smirnov test's p-value indicates that, at α levels smaller than 0.150; there is evidence that the data follow a normal distribution

Texture

Normality Test (Sample Code 410, 630)

H0: Data are normally distributed. Vs. H1: Data are not normally distributed.

The Kolmogorov-Smirnov test's p-value indicates that, at α levels smaller than 0.150; there is evidence that the data follow a normal distribution

Smell

Normality Test (Sample Code 410, 630)

H0: Data are normally distributed. Vs. H1: Data are not normally distributed.

The Kolmogorov-Smirnov test's p-value indicates that, at α levels smaller than 0.150; there is evidence that the data follow a normal distribution

Taste

Normality Test (Sample Code 410, 630)

H0: Data are normally distributed. Vs. H1: Data are not normally distributed.

The Kolmogorov-Smirnov test's p-value indicates that, at α levels smaller than 0.150; there is evidence that the data follow a normal distribution

Overall Acceptability

Normality Test (Sample Code 410, 630)

H0: Data are normally distributed. Vs. H1: Data are not normally distributed.

The Kolmogorov-Smirnov test's p-value indicates that, at α levels smaller than 0.150; there is evidence that the data follow a normal distribution

Comparison of Corn pudding samples prepared by using mature Corn pods and immature Corn pods

Two-Sample T-Test and CI: Colour, Sample Code

```
Two-sample T for colour

Sample
Code      N    Mean  StDev  SE Mean
410      30    7.67   1.12     0.21
630      30   8.267  0.980     0.18


Difference = mu (410) - mu (630)
Estimate for difference:  -0.600000
95% CI for difference:  (-1.145589, -0.054411)
T-Test of difference = 0 (vs not =): T-Value = -2.20  P-Value = 0.032  DF=56
```

Interpreting the results

H0: α=0 vs.
H1: α≠0 (α = 1…….i)

According to the P value (P<0.05) for colour there is significant difference in colour of corn pudding samples which are prepared by using mature corn pods and immature corn pods. Therefore according to the mean value, the colour was best of pineapple juice fortified corn pudding samples which are prepared by using immature Corn pods.

Two-Sample T-Test and CI: Appearance, Sample Code

```
Two-sample T for Appearance

Sample
Code      N  Mean  StDev  SE Mean
410      30  7.53   1.14     0.21
630      30  8.00   1.17     0.21


Difference = mu (410) - mu (630)
Estimate for difference:  -0.466667
95% CI for difference:  (-1.064201, 0.130868)
T-Test of difference = 0 (vs not =): T-Value = -1.56  P-Value = 0.123  DF=57
```

Interpreting the results

H0: $\alpha=0$ vs.
H1: $\alpha\neq0$ ($\alpha = 1.......i$)

According to the P value (P>0.05) for appearance there is no evidence for a difference in appearance of corn pudding samples which is prepared by using mature corn pods and immature corn pods. But when referring to the mean value the appearance was best of pineapple juice fortified corn pudding samples which are prepared by using immature corn pods.

Two-Sample T-Test and CI: Texture, Sample Code

```
Two-sample T for Texture

Sample
Code      N  Mean  StDev  SE Mean
410      30  6.80   1.21     0.22
630      30  7.40   1.38     0.25


Difference = mu (410) - mu (630)
Estimate for difference:  -0.600000
95% CI for difference:  (-1.272076, 0.072076)
T-Test of difference = 0 (vs not =): T-Value = -1.79  P-Value = 0.079  DF=57
```

Interpreting the results

H0: $\alpha=0$ vs.
H1: $\alpha\neq0$ ($\alpha = 1.......i$)

According to the P value (P>0.05) for Texture there is no evidence for a difference in texture of corn pudding samples which is prepared by using mature corn pods and immature corn pods. But when referring to the mean value, the texture was best of pineapple juice fortified corn pudding samples which are prepared by using immature corn pods.

Two-Sample T-Test and CI: Smell, Sample code

```
Two-sample T for Smell

Sample
code      N   Mean   StDev  SE Mean
410      30   7.37    1.45     0.26
630      30   7.20    1.49     0.27


Difference = mu (410) - mu (630)
Estimate for difference:  0.166667
95% CI for difference:  (-0.594690, 0.928023)
T-Test of difference = 0 (vs not =): T-Value = 0.44   P-Value = 0.663   DF =57
```

Interpreting the results

H0: α=0 vs.
H1: α≠0 (α = 1.......i)

According to the P value (P>0.05) for smell there is no evidence for a difference in Smell of corn pudding samples which is prepared by using mature corn pods and immature corn pods. But when referring to the mean value, Smell was best of pineapple juice fortified corn pudding samples which are prepared by using immature corn pods.

Two-Sample T-Test and CI: Taste, Sample code

```
Two-sample T for Taste

Sample
code      N   Mean   StDev  SE Mean
410      30   7.20    1.16     0.21
630      30   7.57    1.33     0.24


Difference = mu (410) - mu (630)
Estimate for difference:  -0.366667
95% CI for difference:  (-1.011573, 0.278239)
T-Test of difference = 0 (vs not =): T-Value = -1.14   P-Value = 0.260   DF=56
```

Interpreting the results

H0: α=0 vs.
H1: α≠0 (α = 1.......i)

According to the P value (P>0.05) for taste there is no evidence for a difference in taste of corn pudding samples which is prepared by using mature corn pods and immature corn pods. But when referring to the mean value, the taste was best of pineapple juice fortified corn pudding samples which are prepared by using immature corn pods.

Two-Sample T-Test and CI: Overall Acceptability, Sample No

```
Two-sample T for Overall Acceptability

Sample
No        N  Mean  StDev  SE Mean
410      30  7.27   1.01     0.19
630      30  8.00   1.05     0.19


Difference = mu (410) - mu (630)
Estimate for difference:  -0.733333
95% CI for difference:  (-1.267324, -0.199343)
T-Test of difference = 0 (vs not =): T-Value = -2.75  P-Value = 0.008  DF=57
```

Interpreting the results

H0: $\alpha=0$ vs.
H1: $\alpha\neq0$ ($\alpha = 1.......i$)

According to the P value ($P<0.05$) for overall acceptability, there is significant difference in overall acceptability of corn pudding samples which is prepared by using mature corn pods and immature corn pods. Therefore according to the mean value, overall acceptability was best of pineapple juice fortified corn pudding samples which are prepared by using immature corn pods.

APPENDIX IX

Sensory Evaluation of Corn pudding Samples-Statistical Analysis

(Selection of the most suitable fruit juice fortification for product preparation)

<u>**Colour**</u>

Normality Test (Sample Code 630, 815, 102)

H0: Data are normally distributed. Vs. H1: Data are not normally distributed.

The Kolmogorov-Smirnov test's p-value indicates that, at α levels smaller than 0.150; there is evidence that the data follow a normal distribution

<u>**Appearance**</u>

Normality Test (Sample Code 630, 815, 102)

H0: Data are normally distributed. Vs. H1: Data are not normally distributed.

The Kolmogorov-Smirnov test's p-value indicates that, at α levels smaller than 0.150; there is evidence that the data follow a normal distribution

<u>**Texture**</u>

Normality Test (Sample Code 630, 815, 102)

H0: Data are normally distributed. Vs. H1: Data are not normally distributed.

The Kolmogorov-Smirnov test's p-value indicates that, at α levels smaller than 0.150; there is evidence that the data follow a normal distribution

<u>**Smell**</u>

Normality Test (Sample Code 630, 815, 102)

H0: Data are normally distributed. Vs. H1: Data are not normally distributed.

The Kolmogorov-Smirnov test's p-value indicates that, at α levels smaller than 0.150; there is evidence that the data follow a normal distribution

Taste

Normality Test (Sample Code 630, 815, 102)

H0: Data are normally distributed. Vs. H1: Data are not normally distributed.

The Kolmogorov-Smirnov test's p-value indicates that, at α levels smaller than 0.15; there is evidence that the data follow a normal distribution

Overall Acceptability

Normality Test (Sample Code 630, 815, 102)

H0: Data are normally distributed. Vs. H1: Data are not normally distributed.

The Kolmogorov-Smirnov test's p-value indicates that, at α levels smaller than 0.150; there is evidence that the data follow a normal distribution

Comparison of Pineapple juice fortified sample, Mango juice fortified sample and Wood apple juice fortified sample

One-way ANOVA: Colour versus Sample

```
Source  DF      SS     MS     F      P
Sample   2  10.689  5.344  6.70  0.002
Error   87  69.367  0.797
Total   89  80.056

S = 0.8929   R-Sq = 13.35%   R-Sq(adj) = 11.36%

                               Individual 95% CIs For Mean Based on
                               Pooled StDev
Level   N    Mean   StDev  ------+---------+---------+---------+---
102    30  7.2667  0.9803  (-------*-------)
630    30  8.1000  0.8847                    (-------*--------)
815    30  7.8000  0.8052              (-------*-------)
                           ------+---------+---------+---------+---
                               7.20      7.60      8.00      8.40

Pooled StDev = 0.8929

Hsu's MCB (Multiple Comparisons with the Best)

Family error rate = 0.05
Critical value = 1.94

Intervals for level mean minus largest of other level means

Level    Lower   Center   Upper   -+---------+---------+---------+--------
102    -1.2808  -0.8333  0.0000   (------*-------------)
630    -0.1475   0.3000  0.7475                  (------*------)
815    -0.7475  -0.3000  0.1475            (------*------)
                                  -+---------+---------+---------+--------
                                -1.20     -0.60      0.00      0.60
```

Interpreting the results

H0: α=0 vs.
H1: α≠0 (α = 1.......i)

In the ANOVA table, the p-value (0.002) for colour indicates that there is sufficient evidence that not all the means are equal when alpha is set at 0.05. Hsu's MCB comparisons, compares the means of corn pudding samples (102 and 815) to the mean of corn pudding sample (630), because it is the largest. corn pudding sample 630 or 815 may be best because the corresponding confidence interval contain positive values. No evidence exist that 102 corn pudding sample is the best because the upper interval end points are 0, the smallest possible value. If corn pudding sample 815 is best, it is no more than 0.1475 better than its closest competitor, and it may be as much as 0.7475 worse than the best of the other level means.

One-way ANOVA: Appearance versus Sample

```
Source  DF      SS     MS     F      P
Sample   2   6.067  3.033  3.16  0.047
Error   87  83.533  0.960
Total   89  89.600

S = 0.9799   R-Sq = 6.77%   R-Sq(adj) = 4.63%

                               Individual 95% CIs For Mean Based on
                               Pooled StDev
Level   N    Mean   StDev  ---+---------+---------+---------+------
102    30  7.2333  1.1043  (---------*---------)
630    30  7.8000  0.9965                 (---------*---------)
815    30  7.7667  0.8172                (---------*---------)
                           ---+---------+---------+---------+------
                            7.00      7.35      7.70      8.05

Pooled StDev = 0.9799
```

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

Family error rate = 0.05
Critical value = 1.94

Intervals for level mean minus largest of other level means

Level    Lower   Center   Upper  ------+---------+---------+---------+---
102    -1.0577  -0.5667  0.0000  (-----------*-------------)
630    -0.4577   0.0333  0.5244               (-----------*-----------)
815    -0.5244  -0.0333  0.4577             (-----------*-----------)
                                 ------+---------+---------+---------+---
                                    -0.80     -0.40     -0.00      0.40
```

Interpreting the results

H0: α=0 vs.
H1: α≠0 (α = 1.......i)

In the ANOVA table, the p-value (0.047) for appearance indicates that there is sufficient evidence that not all the means are equal when alpha is set at 0.05. Hsu's MCB comparisons, compares the means of corn pudding samples (102 and 815) to the mean of corn pudding sample (630), because it is the largest. Corn pudding sample 630 or 815 may be best because the corresponding confidence interval contain positive values. No evidence exists that 102 corn pudding sample is the best because the upper interval end points are 0, the smallest possible value. If corn pudding sample 815 is best, it is no more than 0.4577 better than its closest competitor, and it may be as much as 0.5244 worse than the best of the other level means.

One-way ANOVA: Texture versus Sample

```
Source  DF     SS    MS     F      P
Sample   2   2.60  1.30  1.23  0.297
Error   87  91.80  1.06
Total   89  94.40

S = 1.027   R-Sq = 2.75%   R-Sq(adj) = 0.52%


                            Individual 95% CIs For Mean Based on
                            Pooled StDev
Level   N   Mean  StDev  ---------+---------+---------+---------+
102    30  7.400  1.303     (------------*-----------)
630    30  7.700  0.837             (------------*-----------)
815    30  7.300  0.877  (-----------*------------)
                         ---------+---------+---------+---------+
                               7.20      7.50      7.80      8.10

Pooled StDev = 1.027


Hsu's MCB (Multiple Comparisons with the Best)

Family error rate = 0.05
Critical value = 1.94

Intervals for level mean minus largest of other level means

Level   Lower  Center  Upper  --------+---------+---------+---------+-
102    -0.815  -0.300  0.215   (---------*---------)
630    -0.215   0.300  0.815            (---------*---------)
815    -0.915  -0.400  0.115  (---------*---------)
                              --------+---------+---------+---------+-
                                   -0.50      0.00      0.50      1.00
```

Interpreting the results

H0: α=0 vs.
H1: α≠0 (α = 1.......i)

In the ANOVA table, the p-value (0.297) for texture indicates that there is sufficient evidence that not all the means are equal when alpha is set at 0.05. Hsu's MCB comparisons, compares the means of corn pudding samples (102 and 815) to the mean of corn pudding sample (630), because it is the largest. corn pudding sample 630 or 815 or 102 may be best because the corresponding confidence interval contain positive values. If corn pudding sample 815 or 102 is best, it is no more than 0.115 or 0.225 better than its closest competitor, and it may be as much as 0.815 worse than the best of the other level means.

One-way ANOVA: Smell versus Sample

Source	DF	SS	MS	F	P
Sample	2	8.60	4.30	4.17	0.019
Error	87	89.80	1.03		
Total	89	98.40			

S = 1.016   R-Sq = 8.74%   R-Sq(adj) = 6.64%

```
                               Individual 95% CIs For Mean Based on
                               Pooled StDev
Level   N   Mean  StDev  +---------+---------+---------+---------
102    30  6.767  1.194   (--------*--------)
630    30  7.467  0.860                   (---------*--------)
815    30  7.367  0.964                 (--------*--------)
                         +---------+---------+---------+---------
                       6.40      6.80      7.20      7.60

Pooled StDev = 1.016


Hsu's MCB (Multiple Comparisons with the Best)

Family error rate = 0.05
Critical value = 1.94

Intervals for level mean minus largest of other level means

Level   Lower  Center  Upper  ----+---------+---------+---------+-----
102    -1.209  -0.700  0.000  (---------*-------------)
630    -0.409   0.100  0.609                (----------*---------)
815    -0.609  -0.100  0.409            (---------*---------)
                              ----+---------+---------+---------+-----
                               -1.00     -0.50      0.00      0.50
```

Interpreting the results

H0: α=0 vs.
H1: α≠0 (α = 1.......i)

In the ANOVA table, the p-value (0.019) for smell indicates that there is sufficient evidence that not all the means are equal when alpha is set at 0.05. Hsu's MCB comparisons, compares the means of corn pudding samples (102 and 815) to the mean of corn pudding sample (630), because it is the largest. Corn pudding sample 630 or 815 may be best because the corresponding confidence interval contain positive values. No evidence exists that 102 corn pudding sample is the best because the upper interval endpoints are 0, the smallest possible value. If corn pudding sample 815 is best, it is no more than 0.409 better than its closest competitor, and it may be as much as 0.609 worse than the best of the other level means.

One-way ANOVA: Taste versus Sample

```
Source  DF      SS     MS     F      P
Sample   2   1.267  0.633  0.94  0.393
Error   87  58.333  0.670
Total   89  59.600

S = 0.8188   R-Sq = 2.13%   R-Sq(adj) = 0.00%


                            Individual 95% CIs For Mean Based on
                            Pooled StDev
Level   N    Mean   StDev   ---+---------+---------+---------+------
102    30  7.2333  0.8584   (-----------*-----------)
630    30  7.5000  0.8200             (-----------*-----------)
815    30  7.4667  0.7761            (-----------*-----------)
                            ---+---------+---------+---------+------
                             7.00      7.25      7.50      7.75

Pooled StDev = 0.8188


Hsu's MCB (Multiple Comparisons with the Best)

Family error rate = 0.05
Critical value = 1.94

Intervals for level mean minus largest of other level means

Level    Lower   Center   Upper  ---+---------+---------+---------+------
102    -0.6770  -0.2667  0.1437  (-------------*-------------)
630    -0.3770   0.0333  0.4437           (-------------*-------------)
815    -0.4437  -0.0333  0.3770         (-------------*-------------)
                                 ---+---------+---------+---------+------
                                 -0.60     -0.30      0.00      0.30
```

Interpreting the results

H0: $\alpha=0$ vs.
H1: $\alpha\neq0$ (α = 1.......i)

In the ANOVA table, the p-value (0.393) for taste indicates that there is sufficient evidence that not all the means are equal when alpha is set at 0.05. Hsu's MCB comparisons, compares the means of Corn pudding samples (102 and 815) to the mean of corn pudding sample (630), because it is the largest. Corn pudding sample 630 or 815 or 102 may be best because the corresponding confidence interval contain positive values. If corn pudding sample 815 or 102 is best, it is no more than 0.3770 or 0.1437 better than its closest competitor, and it may be as much as 0.4437 worse than the best of the other level means.

One-way ANOVA: Overall Acceptability versus Sample

```
Source  DF      SS     MS     F      P
Sample   2   3.267  1.633  1.65  0.199
Error   87  86.333  0.992
Total   89  89.600

S = 0.9962   R-Sq = 3.65%   R-Sq(adj) = 1.43%

                               Individual 95% CIs For Mean Based on
                               Pooled StDev
Level   N    Mean   StDev   --------+---------+---------+---------+-
102    30  7.0333  1.0981   (-----------*-----------)
630    30  7.5000  0.8200                (-----------*-----------)
815    30  7.2667  1.0483           (-----------*-----------)
                            --------+---------+---------+---------+-
                                  6.90      7.20      7.50      7.80

Pooled StDev = 0.9962


Hsu's MCB (Multiple Comparisons with the Best)

Family error rate = 0.05
Critical value = 1.94

Intervals for level mean minus largest of other level means

Level    Lower   Center   Upper  ---------+---------+---------+---------+
102    -0.9659  -0.4667  0.0326  (---------*---------)
630    -0.2659   0.2333  0.7326               (---------*---------)
815    -0.7326  -0.2333  0.2659     (---------*---------)
                                 ---------+---------+---------+---------+
                                      -0.50      0.00      0.50      1.00
```

Interpreting the results

H0: $\alpha=0$ vs.
H1: $\alpha\neq0$ (α = 1…….i)

In the ANOVA table, the p-value (0.199) for overall acceptability indicates that there is sufficient evidence that not all the means are equal when alpha is set at 0.05. Hsu's MCB comparisons, compares the means of corn pudding samples (102 and 815) to the mean of corn pudding sample (630), because it is the largest. corn pudding sample 630 or 815 or 102 may be best because the corresponding confidence interval contain positive values. If Corn pudding sample 815 or 102 is best, it is no more than 0.2659 or 0.0326 better than its closest competitor, and it may be as much as 0.7326 worse than the best of the other level means.

Taste

Normality Test (Sample Code 630, 724)

H0: Data are normally distributed. Vs. H1: Data are not normally distributed.

The Kolmogorov-Smirnov test's p-value indicates that, at α levels smaller than 0.145; there is evidence that the data follow a normal distribution

Overall Acceptability

Normality Test (Sample Code 630, 724)

H0: Data are normally distributed. Vs. H1: Data are not normally distributed.

The Kolmogorov-Smirnov test's p-value indicates that, at α levels smaller than 0.150; there is evidence that the data follow a normal distribution

Comparison of Corn pudding samples prepared by fortifying pineapple fruit juice and iramusu herbal extract

Two-Sample T-Test and CI: Colour, Sample Code

```
Two-sample T for Colour

Sample
Code      N    Mean  StDev  SE Mean
630      30   8.267  0.980     0.18
724      30    6.30   1.58     0.29


Difference = mu (630) - mu (724)
Estimate for difference:  1.96667
95% CI for difference:  (1.28443, 2.64890)
T-Test of difference = 0 (vs not =): T-Value = 5.80  P-Value = 0.000  DF =48
```

Interpreting the results

H0: α=0 vs.
H1: $\alpha \neq 0$ (α = 1.......i)

According to the P value (P<0.05) for colour there is significant difference in colour of corn pudding samples which is prepared by fortifying Pineapple juice and Iramusu extract. Therefore according to the mean value, the colour was best of pineapple juice fortified corn pudding other than Iramusu extract fortified corn pudding.

Two-Sample T-Test and CI: Appearance, Sample Code

```
Two-sample T for Appearance

Sample
Code      N  Mean  StDev  SE Mean
630      30  8.00   1.17     0.21
724      30  6.23   1.79     0.33


Difference = mu (630) - mu (724)
Estimate for difference:  1.76667
95% CI for difference:  (0.97986, 2.55347)
T-Test of difference = 0 (vs not =): T-Value = 4.51  P-Value = 0.000  DF =49
```

Interpreting the results

H0: $\alpha=0$ vs.
H1: $\alpha\neq0$ (α = 1…….i)

According to the P value (P<0.05) for appearance there is significant difference in appearance of corn pudding samples which is prepared by fortifying pineapple juice and Iramusu extract.. Therefore according to the mean value, appearance was best of pineapple juice fortified corn pudding other than Iramusu extract fortified corn pudding.

Two-Sample T-Test and CI: Texture, Sample

```
Two-sample T for Texture

Sample    N  Mean  StDev  SE Mean
630      30  7.40   1.38     0.25
724      30  6.37   1.73     0.32


Difference = mu (630) - mu (724)
Estimate for difference:  1.03333
95% CI for difference:  (0.22322, 1.84345)
T-Test of difference = 0 (vs not =): T-Value = 2.56  P-Value = 0.013  DF =55
```

Interpreting the results

H0: $\alpha=0$ vs.
H1: $\alpha\neq0$ (α = 1…….i)

According to the P value (P<0.05) for texture there is significant difference in texture of corn pudding samples which is prepared by fortifying pineapple juice and Iramusu extract. Therefore according to the mean value, texture was best of pineapple juice fortified corn pudding other than Iramusu extract fortified corn pudding.

Two-Sample T-Test and CI: Smell, Sample Code

```
Two-sample T for Smell

Sample
Code      N   Mean  StDev  SE Mean
630      30  7.833  0.913     0.17
724      30  6.800  0.925     0.17


Difference = mu (630) - mu (724)
Estimate for difference:  1.03333
95% CI for difference:  (0.55827, 1.50840)
T-Test of difference = 0 (vs not =): T-Value = 4.36  P-Value = 0.000  DF =57
```

Interpreting the results

H0: α=0 vs.
H1: α≠0 (α = 1…….i)

According to the P value (P<0.05) for smell there is significant difference in smell of corn pudding samples which is prepared by fortifying pineapple juice and Iramusu extract. Therefore according to the mean value, smell was best of pineapple juice fortified corn pudding other than Iramusu extract fortified corn pudding.

Two-Sample T-Test and CI: Taste, Sample Code

```
Two-sample T for Taste

Sample
Code      N  Mean  StDev  SE Mean
630      30  7.57   1.33     0.24
724      30  5.97   2.03     0.37


Difference = mu (630) - mu (724)
Estimate for difference:  1.60000
95% CI for difference:  (0.71126, 2.48874)
T-Test of difference = 0 (vs not =): T-Value = 3.62  P-Value = 0.001  DF =50
```

Interpreting the results

H0: α=0 vs.
H1: α≠0 (α = 1…….i)

According to the P value (P<0.05) for taste there is significant difference in taste of corn pudding samples which is prepared by fortifying Pineapple juice and Iramusu extract. Therefore according to the mean value, taste was best of pineapple juice fortified corn pudding other than Iramusu extract fortified corn pudding.

Two-Sample T-Test and CI: Overall Acceptability, Sample Code

```
Two-sample T for Overall Acceptability

Sample
Code      N  Mean  StDev  SE Mean
630      30  8.00   1.05     0.19
724      30  6.17   1.29     0.24


Difference = mu (630) - mu (724)
Estimate for difference:  1.83333
95% CI for difference:   (1.22500, 2.44167)
T-Test of difference = 0 (vs not =): T-Value = 6.04  P-Value = 0.000  DF =55
```

Interpreting the results

H0: $\alpha=0$ vs.
H1: $\alpha\neq0$ ($\alpha = 1 \ldots\ldots i$)

According to the P value ($P<0.05$) for overall acceptability, there is significant difference in overall acceptability of corn pudding samples which is prepared by fortifying pineapple juice and Iramusu extract.. Therefore according to the mean value, overall acceptability was best of pineapple juice fortified corn pudding other than Iramusu extract fortified corn pudding.

APPENDIX XI

Proximate composition of the best product

Moisture and Total solids content of the product

Weight of moisture dish (W_1)	= 18.2112g
Weight of the sample with the dish (W_2)	= 25.2130g
Constant weight with the dish (W_3)	= 20.2820g
The moisture content (on wet basis)	= (25.2130g-20.2820g) * 100 / (25.2130g-18.2110g)
	=70.42%
Total solid content	= (100-70.42) %
	=29.58%

Free fat content of the product

Weight of the flask with fat	= 126.3338g
Weight of the flask	= 126.3223g
Weight of the sample	= 10g
% free fat content of the sample	= (126.3338g-126.3223g) *100 / 10g
	= 0.115%

Total fat content of the product

Weight of the flask	=139.8930g
Weight of the flask with fat	=139.9359g
Weight of the sample	= 2g
% Total fat content of the sample	= (104.7147g-104.6882g) *100 / 2g
	=1.325%

Protein content of the product

Sample titration	= 1.2 ml
Blank titration	= 0.1 ml
Normality of HCl	= 0.01mol/l
Volume made up of the digestion	= 100 ml
Aliquot of the digestion taken	= 25ml
Weight of the sample	=1g

$$\text{Nitrogen \%} = \frac{(1.2-0.1)\ \text{ml} * 0.1\ \text{mol/l} * 14 * 100\ \text{ml} * 100}{25\text{ml} * 1\text{g} * 1000}$$

$$= 0.616\ \%$$

$$\text{Protein \%} = 0.616 * 6.25$$

$$= 3.85\%$$

APPENDIX XII

Variation of P^H value, Total Soluble Solids (Brix value) and Titrable Acidity (TA) of corn pudding during fifteen days storage time

Days	P^H value			Total Soluble Solids (Brix value)			Titrable Acidity (TA)		
	410	630	724	410	630	724	410	630	724
1	4.1	4.1	4.2	10.0	10.0	10.2	0.128	0.128	0.128
2	4.1	4.1	4.2	10.0	10.0	10.2	0.128	0.128	0.128
3	4.1	4.1	4.2	10.0	10.0	10.2	0.154	0.128	0.128
4	4.1	4.1	4.1	10.1	10.0	10.1	0.154	0.128	0.136
5	4.0	4.1	4.1	10.0	10.0	10.1	0.136	0.136	0.136
6	4.0	4.1	4.1	10.1	10.1	10.2	0.136	0.136	0.136
7	4.0	4.1	4.1	10.1	10.0	10.2	0.136	0.141	0.136
8	4.0	4.1	4.1	10.0	10.0	10.3	0.136	0.141	0.141
9	4.0	4.1	4.1	10.0	10.1	10.3	0.136	0.141	0.141
10	4.0	4.1	4.1	10.0	10.1	10.3	0.141	0.141	0.141
11	4.0	4.0	4.1	10.0	10.0	10.3	0.141	0.141	0.141
12	4.0	4.0	4.1	10.0	10.0	10.3	0.141	0.141	0.154
13	4.0	4.0	4.0	10.0	10.0	10.3	0.141	0.141	0.154
14	4.0	4.0	4.0	10.0	10.0	10.3	0.141	0.141	0.154
15	4.0	4.0	4.0	10.0	10.0	10.3	0.141	0.141	0.154

410-Pineapple juice fortified corn pudding prepared by using mature corn pods
630-Pineapple juice fortified corn pudding prepared by using immature corn pods
724-Iramusu extract fortified corn pudding prepared by using immature corn pods

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Mrs. T.N.NEIGHSOOREI
(MSSc.PGD.ASLA,BA)
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Sabaragamuwa University of Sri Lanka
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