EFFECT OF PRETREATMENT ON COCONUT MILK PRODUCTION AND USE OF SOLID RESIDUE FOR TOFFEE PREPARATION

A

THESIS

BY

AFIA BINT-E AZAD

REGISTRATION NO: 1205054

SEMESTER: JANUARY-JUNE/2013

SESSION: 2012-2013

MASTER OF SCIENCE
IN
FOOD PROCESSING AND PRESERVATION

DEPARTMENT OF FOOD PROCESSING AND PRESERVATION
HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY
UNIVERSITY DINAJPUR-5200

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JUNE, 2013

DEDICATED TO
MY
BELOVED PARENTS

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June, 2013 *The Author*

ABSTRACT

The study was conducted to evaluate the effect of pretreatment on the production of coconut milk and value added product development. The immature and matured coconuts were analyzed for their composition. The immature coconuts contained 50.16% moisture, 6.58% protein, 26.67% fat, 3.14% ash, 13.45% CHO and the matured coconut contained 45.26% moisture, 4.23 % protein, 30.84% fat, 2.76% ash and CHO 16.91%. The pretreatment of six prepared coconut milk (S_1 = Coconut milk without hardshell, S_2 = Coconut milk with hard shell, S_3= Coconut milk without hardshell (blanching), S_4 = Coconut milk without hardshell (blanching + freezing), S_5= Coconut milk with hardshell (after blanching), S_6= Coconut milk with hardshell (blanching + freezing + coconut water) were also analyzed for their chemical composition. Blanching and freezing together had a beneficial affect over the maintaining of a uniform percentage extraction of coconut milk. The statistical analysis showed that color, flavor, taste and overall acceptability of coconut milks of sample S_4 without hardshell (blanching+ Freezing) was more acceptable than other samples. Prepared coconut milks were stored at refrigeration temperature and their proximate composition also analyzed in storage period. Proximate compositions were slightly changed during storage period but sample S_4 without hardshell (blanching+ Freezing) showed more stable. Shelf life observation of coconut milk was carried out that the color of the coconut milks were good and looking creamy. The flavors were also pleasant and microbial load was in acceptable level in S_3 and S_4 during 25 days of storage. From sensory evaluation the sample S_4 i.e. blanching+ Freezing of coconut milk could be selected for commercial processing of coconut milk. The proximate composition of solid coconut meat is moisture 60.78%, ash 0.62%, protein 2.98%, Calcium 2.01mg/100gm and mg 1.26 mg/100gm. In order to best utilization of these nutrients, this study was conducted to develop toffees mixing with sugar, glucose, skim milk, hydrogenated fat. From sensory evaluation the statistical data showed that the sample B (Coconut solid+ 8% sugar) is the best toffee.

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LIST OF ABBREVIATION

ANOVA	Analysis of Variance for Overall Acceptability
AOAC	Association of Official Analytical Chemists
BBS	Bangladesh Bureau of Statistics
CFTRI	Central Food Technology Research Institute
CME	Coconut Milk Extract
DMRT	Duncan's Multiple Range Test
FAO	Food and Agriculture Organization
pH	Hydrogen-ion-concentration
TSS	Total Soluble Solid
MT	Metric Ton
°C	Degree Centigrade
°F	Degree Fahrenheit
%	Percentage
g	Gram
Kg	Kilogram
ml	Milliliter
et al.	And others

CHAPTER I

INTRODUCTION

CHAPTER I

INTRODUCTION

Coconut (*Cocos nucifera*) is one of the most nutritious of all fruit and has been a favorite food to many populations, such as Island and Asian cultures for centuries. Coconut is confined to sea coast in the humid tropics. It is an important crop in the economy of many countries of the world providing food, drink, shelter and raw materials for industries (William, 2000). It can be cultivated up to 1000 m above sea level and tends to grow best in places with a mean annual temperature of 25°C -38°C and an annual rain fall of 200 mm (Nair *et al.*, 2003).

The coconut is not only significant in socio cultural needs but also has gained considerable importance in the national economy as a potential source of employment and income generation among the plantation crops. The countrywide demand for coconuts both for edible and non-edible purpose, the adaptability of coconut palm to grow under varying soil and climatic conditions. The coconut crop of the world is estimated to 23748 million nuts and comes out from India, Indonesia, the Philippines, Sri Lanka, Malaysia and South Pacific Island (Wood, 1989). With a total production of 9200 million nuts during 1998-99, India is the third largest producer of coconut in the world (George *et al.*, 2000). Whereas, the total nuts production of 90000 tons only during 2003-2004 in Bangladesh.

Bangladesh does not produce sufficient fruits and vegetables to fulfill her requirements. But some of these are available as seasonal surpluses during certain period of the year. So, effort should be made by the consumers and producers to process at least a part of these surpluses for their own home consumption. If such efforts are increased in production world, bring better returns to the agriculturists and improve status of the people at large (Uddin, 1994).

As one of the developing countries of the world, Bangladesh suffers from severe malnutrition problems. The vast majority of its population, especially the vulnerable groups suffer from acute malnutrition. The production of milk is inadequate and there is a general shortage of milk. The shortage is becoming more acute due to rapid increase in population.

Copra and coconut oil are the two major products of the coconut processing industry. Nearly 60% of the total production of nuts is utilized for food purposes and the rest goes for oil extraction. In spite of the fact that Bangladesh has the necessary raw material to launch new product lines, minimal progress has taken place in the application of modern technology for full utilization of various coconut products such as desiccated coconut and its powder, packed coconut milk, coconut cream, coconut milk powder, tender coconut water, vinegar etc.

Coconut is well known for its nutritional benefits. Its meat, juice, oil and coconut milk extracts (CMEs), milk products are popular all over the world due to its delicious taste and abundance of vitamins, minerals and nutrients. Coconut milk contains about 81% moisture, 8% fat and 11% solid non-fat (Simuang *et al.*, 2004). It is used by primitive people to treat a number of ailments and still recognized for its nutritional and healing properties. It is rich in fat which contribute high calorie in coconut meat. Coconut provides quick and lasting boosts of energy.

Coconut is an excellent source of manganese. It also contains 11 percent iron, 9 percent phosphorus and 8 percent potassium. It contains trace amounts of other nutrients such as zinc, calcium and magnesium. Coconuts are rich in lauric acid, which is known for being antiviral, antibacterial and antifungal, and boosts the immune system. There is no so much difference of nutritional parameters between coconut and coconut product (Asian and Pacific Coconut Community and Codex Alimentarius Commission, 2003).

Extraction of standard quality milk from the fresh kernel has been proved to be technically feasible and different processes have been developed in various parts of the world. Considerable research for the development of an economically viable process to convert into protein, milk and milk products has been carried out in many centers such as Central Food Technological Research Institute, Mysore, India, Tropical Products Institute, London, Texas A&M University and National University of Science and Technology, Manilla, (Thampan, 1998).

Coconut cake or residue can also be used in toffees, laugense, candies and other sugary products as filling materials nutrient enhancer.

In Bangladesh huge quantity of coconuts is grown in the southern part but it utilization is limited within green coconut water or beverage. Sometime the housewife used it for some traditional jaggery products. However, it has a good scope for industrial use specially for various coconut based food products. Taking this in mind an attempt was made to fulfil the following objectives.

The specific objectives of the work were:

i. Extraction of coconut milk from the coconut kernel and its characterization.
ii. To study the utilization of coconut cake as an ingredient for toffee.

CHAPTER II

REVIEW OF LITERATURE

CHAPTER II

REVIEW OF LITERATURE

2.1 Coconut Production

Coconut is a benevolent tree, a nature's gift to mankind, used as a source of food, beverage, oilseed, fibre, timber, health products and also associated with mystery and omen in the life of people. The coconut tree provides clothing utensils and dwellings, therefore, is an important source of earning livelihood to the people of coconut growing states, especially in the coastal areas. The coconut therefore, is eulogized, reverently as tree of life by the people.

The coconut crop is grown in 12.5 million hectares of land which constituted about 0.7 per cent of net crop area of the world. The crop is grown in the coastal lowlands of continental South Asia and spread along the Indian and Pacific Ocean, the cultivation is mostly done by small and marginal farmers. According to FAO statistics 2007, about 57.9 billion nuts were produced, which was equivalent to 7.3 metric tones of oil. In the present scenario the trend in processing of coconut products is slowly setting in the country.

Coconut Production in Bangladesh

Bangladesh produces about 100 million nuts annually weighing about 90,000 tons in an area of 30,000 hectares in the year 2003-04 (BBS, 2004). The yield of nut in Bangladesh is very low on an average 21 nuts per growing countries in the world .Tall type cross pollinated coconut is grown in Bangladesh for its long productive life and nut quality, BBS (Bangladesh Bureau of Statistics), 2002.

Table 2.1: Production of coconut in Bangladesh (Yearbook of Agricultural Statistics of Bangladesh, 2011)

Region	Production (MT)
Chittagong	65722
Khulna	61498
Noakhali	27345
Jessore	19765
Dhaka	9800
Total	17800

International coconut Statistics

The most eminent countries exploring coconut palms for commercial production are located in Asia, Oceania, West Indies, Central and South America, East and West Africa. According to FAO-2004, the coconut crop is grown in about 90 countries across the World in an area of 14.231 million hectares producing 57.514 billion nuts or 10.52 million tons of copra. Out of World's total area under coconut, 16 major coconut producing countries accounted for 93.75 percent. Among the Asian and Pacific Coconut Community (APCC), mainly six countries i.e. Philippines, Indonesia, India, Sri Lanka, Thailand and Malaysia together accounted for 80.65 per cent of the total area under coconut cultivation and about 82 per cent of world production.

Table 2.2: Coconut production in the world in 2011

Country	Production (tonnes)	Country	Production (tonnes)
Philippines	19,500,000	Mexico	1,246,400
Indonesia	15,540,000	Vietnam	1,086,000
India	10,824100	Papua New Guinea	677,000
Brazil	2,759,044	Malaysia	555,120
Sri Lanka	2,200,000	Tanzania	370,000
Thailand	1,721,640	World	54,716,444

Source: Food And Agriculture Organization of the United Nations: Economic And Social Department: The Statistical Division

2.2 Morphology of coconut kernel

The most important and economically valuable produce of coconut palm is its fruit popularly known as 'nut'. It is made up of an outer exocarp, a thick fibrous fruit coat known as husk; underneath lays the hard protective endocarp or shell. Lining the shell is a white albuminous endosperm or *'coconut meat'* and the inner cavity is filled with a clear sweet refreshing liquid called *'coconut water'*. The kernel of a matured nut is the most precious product used for edible purpose. The dried kernel or copra is the richest source of edible oil and a by-product coconut oil cake, a source of vegetable protein used as an ingredient for livestock feed. The shell as such is used for fuel purpose, shell gasifier as an alternate source of heat Coconut fruit energy, making handicrafts, ice-cream cups and other commercial products like shell powder, shell charcoal and activated carbon. The

husk yields fibre, which is converted into coir and coir products like coil carpets, coir geo-textile, coir composite, coir safety belts, coir boards, coir asbestos, rugs fetch and coir pith. Coir pith a secondary by product obtained during defibring process is used as soil conditioner and mending all types of soils. The spongy nature of pith helps in disintegration of clay soil and allows free drainage. Its Sponginess helps to retain water and oxygen and also prevents loss of vital nutrients from soil (Malu *et al* ., 2004).

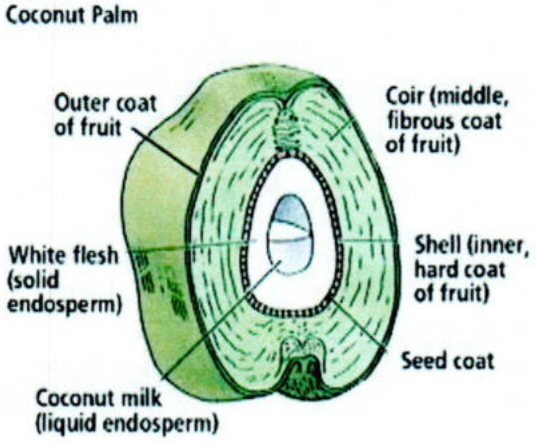

Fig.1 Coconut

2.3 Nutritional value of coconut kernel

Carbohydrates present in coconut are mainly sucrose (6-7%) and fructose. Coconut protein has received a great deal of attention from biochemists the world over as coconut is found in areas where protein deficiencies are common (Karmini, 1988).

Coconut meat contains excellent levels of copper, iron, manganese, good amounts of phosphorus, selenium, zinc and potassium and many B complex vitamins like folates, B2, niacin, B1 & B6. It is free from cholesterol and is very low in sodium. Most importantly it contains lauric acid, a saturated fatty acid but a medium chain one (Mantena *et al.,* 2003).

2.4 Biologically active substances

As plant product, coconut contains biologically active substances which have been identified to provide neutraceutical health benefits. Although studies may take years to prove the pharmacological effects of these substances, there is growing interest worldwide on the role of these biologically active substances to human health. Tocopherols, which are already known as antioxidants, have a role in the prevention of

certain chronic diseases like coronary heart disease and cancer. Tocotrienols, said to be better anti-oxidant than tocopherols, are effective in treating many diseases. Phytosterols have been known to lower blood cholesterol, specifically the "bad" cholesterol. The United States Food and Drug Administration has given phytosterols status (Mansor, 2012).

Systematic research has been in progress at CFTRI for the production of value added products from coconut (Raghavarao *et al.*, 2008; Raghavendra *et al.*, 2004, 2006, 2007, 2009; Rastogi and Raghavarao 2006).

2.5 Coconut milk

Moorjant and Subrahmanyam (1987) standardized a method for the preparation of coconut milk substitute. The milk they prepared had the following average composition: total solid 10.20%, protein 2.80%, fat 7.10%, carbohydrate 3.75% (sucrose 1.40%, reducing sugar 0.35%), minerals 1.55% (calcium 3.2 mg/ 100 gm and phosphorus 33 mg / 100 gm). They also reported that coconut milk has attractive white coir and a pleasing characteristic coconut flavor. The milk was found to be quite acceptable. Fairly good milk and curd were obtained by blending milk powder or soybean with coconut milk to the extent of 25 to 50%. The addition of skim milk improved the flavor of coconut milk.

Magda (1992) suggested that the use of a new stimulated milk from coconuts as a cheap alternative to cow's milk in developing countries is to be discussed. The use and applications of coconut milk are increased and included a fermented beverage prepared using coconut skim milk as a substrate for *lactobacillus bulgaricus* coconut milk as a substitute for sweetened and evaporated milks and for soft cheese and yogurt manufacture production of toned milk and coco-cheese production.

Chitara and Campos (1995) studied the use of the protein fraction from albumen (the edible part), corpa and cake of coconut (*cocos nucifera*) to prepare milk substitutes. Extraction of protein was tested with water, NaCl solutions in different concentrations and HCl and NaOH solutions at pH values. Best results were with a solution of NaCl 1 mol/ litre at a ratio of coconut. Solution of 100:75.2 successive treatments with the solution extracted 80% of total N_2. After separation of the proteins by precipitation with a 40% solution of trichloroacetic acid and drying, they were in the form of a white powder without taste or smell and had a solubility index in water of about 31.5%. When shaken

with water, the insoluble part gave a milk suspension with agreeable organoleptic properties.

The mature coconuts were subjected to deshelling, paring and removal of water. The white coconut kernel was disintegrated using rotary wedge cutter (Krauss Maffei, 2007). The grating was subjected to expelling in a screw press to extract coconut milk. The fat content of coconut milk (39 ± 1%) was determined by Rose–Gottlieb method (AOAC, 1990).

Davide *et al.*, (2002) suggested that coconut milk was prepared by initially extracting the grated meat with 230 ml water per nut. The resulting coconut meal was then re-extracted with 158 ml water. The two extracts were combined and strained through a nylon cloth before mixing with reconstituted skim milk. The cheese milk was formulated by blending 13 parts of the coconut milk and 87 parts of a 10% reconstituted skim milk

Arumugham *et al.*, (2004) conducted on experiment on the microbiological quality of coconut cream at various stages of processing and investigated together with contents of total solid (TS), fat, protein and sugar, minerals and gums. Samples studied were coconut water, water after blanching, crushed grating, milk extract, additives, milk plus additives, milk after stirring and homogenization, milk during pasteurization and pasteurized milk in a bottle collected on days of preparation, total counts/ml were respectively, 10^2-10^3, 10^3-10^4, 10^4-10^5, 0-10, 10^5-10^6, 10^2-10^3 and 10^3 percentages of TS, SNS fat, protein, sugar, minerals and added gum were 37, 12, 25, 4.5, 5.5, 1.8 and 0.4 respectively .

Coconut milk was produced according to the method of (Tangsuphoom and Coupland 2008). Briefly, thawed coconut meat was mixed with distilled water (2:1 w/w) in a waring blender. The slurry was then pressed and filtered through cheesecloth to remove the solid residue.

Ahmad Marasabessy *et al.*, (2010) reported that a traditional like Java method of coconut milk extraction assisted by paddy crabs was investigated to find out if crabs or crab derived components can be used to extract milk from coconut kernels. Using the traditional Java method the addition of crab paste liberated 54%w/w milk from grated coconut meat. Oil extraction using crab paste carried out under controlled temperature sand in the presence of antibiotics showed that enzymes from crab played a dominant role in liberating oil from grated coconut meat slurries when in curate at 30°C or 37°C. However, at higher temperature (50° c), the bacterial strains present inside crabs played a

significant role in the extraction of oil from both oil seeds tested. A thermophilic bacterial strain isolated from crab paste and identified based on 16sr RNA sequence as Bacillus strain BK23, when added as starter culture, was able to liberate 60%ww. Milk from coconut kernel slurry after 24h at 50°C. Further studies extraction process optimization is the challenges to improve milk extraction yield and process economy.

Adeiye *et al.,* (2013) reported that the influence of processing variables on some properties of stored groundnut milk extracts (GME). GMEs were prepared from fresh, roasted (170 °C, 25 min) and steeped (water, 20 min) groundnuts. The groundnuts were milled, sieved, the slurry boiled, homogenized, pasteurized and stored. The GMEs packaged in glass bottles, plastic bottles and low density polyethylene sachets, were stored in the refrigerator for 28 days and at room temperature for three days and tested for proximate composition, Physico-chemical and sensory properties. The protein contents of the GME varied between 2.05 to 2.33%; fat, 2.40 to 3.48%; carbohydrate, 5.50 to 5.60%; viscosity, 7.33 and 7.56 Cp; titratable acidity, 0.10 to 0.14% and pH, 6.82 to 6.85. The protein and fat contents of GMEs decreased with storage time regardless of the packaging materials and processing pretreatment. The GMEs were not different in terms of taste and mouth feel but recorded significant differences in colour, appearance and flavour.

2.6 Treatment of coconut milk

Huang (1998) studied that Lipase activity increases with the maturity of any fruit or vegetable thus, increasing the FFA content in the material. A higher amount of these FFAs would indicate a higher activity of the lipase enzyme, thus indicating a higher rate of spoilage of the coconut milk due to chemical degradation. The two most common enzymes, which required their activities to be arrested in coconut kernels, are lipoxygenase (LOX) and lipase (LIP). Lipases (glycerol ester hydrolases E.C. 3.1.1.3) in coconut milk hydrolyze the ester bonds of tri-acylglycerols (TAG). Pre-treatments were paid attention on the degree of inactivation of the two enzymes. Pretreatments (blanching, sanitization, vacuum packing and freezing) were the inactivation of enzymes that cause undesirable changes during the processing and subsequent storage of food products. Peroxidase (POD) and lipoxygenase (LOX) could be considered as indices of adequacy of blanching. It also showed that a significance differences in values milk extraction from coconut kernel.

Viduranga (2007) investigated that Fresh dehusked and shelled coconut kernels were subjected to blanching and freezing treatments and were tested for chemical and enzymatic deterioration and yield of milk by monitoring the percentage extraction of coconut milk, free fatty acid (FFA) content, peroxide value (PV), lipase (LIP) and peroxidase (POD) activities, once each fortnight for a total period of 8 weeks. The percentage extraction of milk varied between 31.0% and 33.5% in the blanched samples and did not show a significant change at $p > 0.05$, as compared to the values at week 0. Similar observations were seen in FFA content and the PV. The LIP activity in these samples decreased to almost 0.176% liberated FFA and POD activity to 0.387 Absorbance Units/g fresh-weights. In conclusion, the results indicated the efficiency of the pre-treatment in suppressing the chemical and enzymatic deterioration of coconut kernels, which normally results in the loss of quality of the coconut milk when extracted from coconut kernel.

White *et al.,* (2007) reported that creaming index, an indicator of emulsion stability was measured with a little modification. Coconut milk emulsion subjected to different a treatment (thermal, pH, chilling, enzyme and combination of enzyme and chilling treatments) was allowed to stand for 6 h at ambient temperature (29 ± 2°C). All samples were separated into the cream (top) and the transparent aqueous (bottom) phases. The total height of the emulsion in the test tube (HE) and the height of the aqueous layer (HS) were measured. The extent of creaming was characterized by a creaming index = 100 (HS/HE).

Raghavendra *et al.,* (2009) that coconut milk is an emulsion which is stabilized by naturally occurring proteins. To explore different methods employing thermal, pH, chilling, enzyme treatments and combination of enzyme treatments followed by chilling and thawing for effective destabilization of the coconut milk emulsion. Stability of emulsion is evaluated by measuring the creaming index and observed for the changes in structure of oil droplets, using phase contrast microscope. Combination of treatments (enzyme treatment at 37°C followed by chilling and thawing) of coconut milk emulsion has resulted in highest yield of 94.5%. Physico-chemical properties and fatty acid compositions are evaluated for coconut milk obtained by combination of treatments and compared with that of commercial milk. It is found that the milk obtained by combination of treatments is high with respect to free fatty acids and peroxide value and high in lauric acid content.

Sanful (2009) studied on storage condition and showed that the fresh middle aged coconut (7-8 months old) crushed open and the juice poured and stored in a refrigerator. 2 kg of coconut flesh was then removed from the shell, grated and homogenized in a blender together with the coconut juice for 2 min. It was then passed through a fine sieve twice, with the volume adjusted to 1.5 l and stored in a bottle in a refrigerator. The extracted coconut milk was transferred into a pot and pasteurized or heated at 90°C for 30 min and allowed to cool gradually to a temperature of 43°C. It was kept at this temperature for 12 h before it was finally cooled to room temperature of about 27°C. Commercially, shelf life extension of coconut milk has been achieved primarily through canning, aseptic packaging and spray drying.

Thitima *et al.,* (2012) reported that the effect of fat content (15–30%) and preheat temperature (70–90°C) on the apparent viscosity of coconut milk after homogenization. By using a power-law model, all samples exhibited pseudo plastic behavior with the flow behavior index (n) between 0.713 and 0.930. Overall, the results showed that preheat treatment had a significant effect on the apparent viscosity of coconut milk. At similar fat concentration, an increase in viscosity was observed at higher preheat temperatures. This phenomenon was more pronounced in the samples with increasing fat content. The microscopic study showed that smaller aggregates of fat globules were detected for the sample passing higher heating temperature. The presence of small aggregates hence increased the resistance to flow leading to an increase in the viscosity of the homogenized heat-treated coconut milk.

2.7 Utilization of residue of coconut milk extraction

Makkar (1996) reported that wet coconut milk residue can be used as an extender in meat or fish dishes for family meals, i.e. it can be mixed with meat or fish to make burgers or spring rolls and other fried food items, adding to the nutritional value of the meal, as well as being economical. Coconut milk residue is a healthy food, rich in dietary fibre and healthy fats; mainly medium-chain length saturated fatty acids. Studies done at FNRI indicate that dietary fibre from coconut residue is good for lowering cholesterol and for people who are suffering from type II diabetes (mature onset). Likewise, coconut milk residue also contains coconut dietary fat, which studies suggest has antimicrobial properties and can boost the immune system, aside from providing food energy. Dried coconut milk residue, when processed under strict sanitary conditions, can be used as a

substitute for desiccated coconut in baked food products such as breads and cookies. Because of its bland taste, it does not detract from other flavour that may be added to cookies to enhance their taste. It can also be used in making fibre-enriched foods and in the formulation of functional foods because of its high dietary fibre content.

Central Food Technology research Institute of Mysore in India (1998) developed that coconut cake (residue) can be used in the preparation of toffee and other product. For the ratio of sugar to residue is 10:1.In the preparation of toffee another ingredient were glucose, skim milk powder, hydrogenated fat.

Vetayasupom (2001) suggested that the feasibility of using coconut residue as a substrate for oyster mushroom cultivation and cattle feed. Using of coconut residue supplemented in cultivation, percentage of mushroom was increased.

Rauf (2006) studied on coconut cake or residue can also be used in preparation of toffees for human consumption. Meet up the country demand of coconut oil and then it can be used for processing of sweet flavor coconut milk and it products. Coconut cake contains valuable nutrition. The use of this coconut cake residue could meet up the nutrient deficiencies of the country population.

CHAPTER III

MATRIALS AND METHOD

CHAPTER III

MATERIALS AND METHODS

The Research work was performed in the laboratory of the Department of Food Processing and Preservation, Hajee Mohammad Danesh Science and Technology University, Dinajpur.

3.1 Materials

3.1.1 Mature coconuts Collection

The mature coconuts were collected from local market of Dinajpur.

3.1.2 Chemicals, solvents and ingredients

Chemicals and reagents used in the study were used from laboratory stock. Sugar, skim milk powder, hydrogenated fat and other ingredients were collected from local market. Chemicals and solvents used in the study were of analytical reagent grade and water was distilled. High density polythene bags were used as the packaging materials.

3.2 Methods

A number of experiments were carried out in order to accomplish the objectives proposed to achieve the goal of this study. The experiments were divided into some major sections:

a) Collection of coconut.
b) Extraction of milk from coconut kernel.
c) Pretreatment of coconut milk.
d) Analyses of total soluble solid (TSS), acidity, pH of coconut milk during storage.
e) Development of coconut toffee from coconut solid except coconut milk.
f) Sensory evaluation of coconut milk and coconut toffee.
g) Chemical analyses.

3.2.1 Extraction of milk from coconut kernel

Collected coconuts were washed by running potable water and broken into two halves. A hand coconut scraper was used to collect grated coconut. Then coconut meat was mixed with distilled water (2:1 w/w) and let it stand for 5-7 minutes. Then the mixture placed in

a blender and blend until smooth puree. The mixture was screened through a clean cotton or sieve.

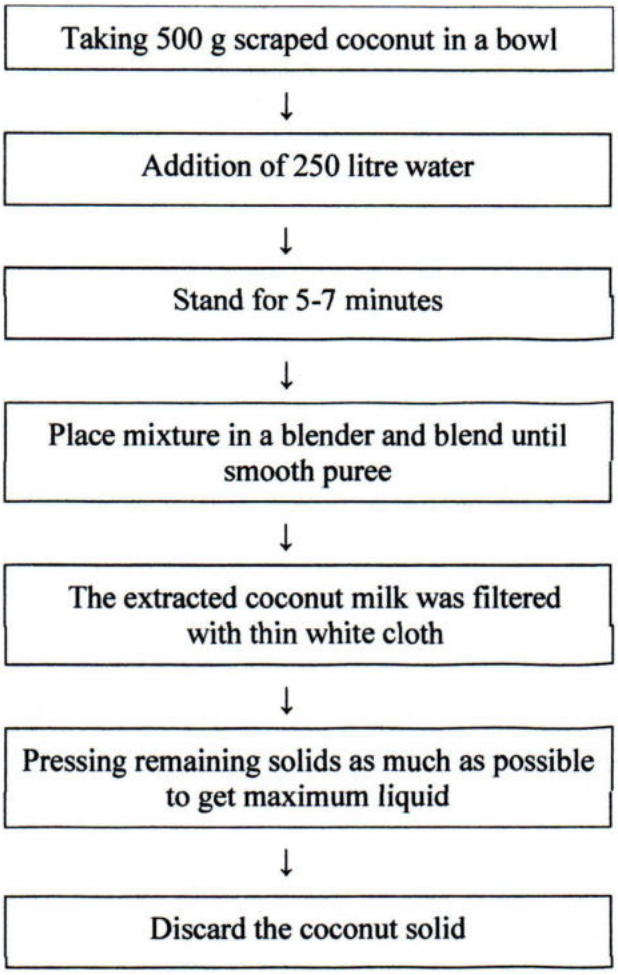

Fig: 3.1 Flow diagram of extraction of coconut milk

3.2.2 Yield of coconut milk

The percentage extraction was of Coconut milk was calculated as the volume of milk (ml) extracted per 100 gm of grated coconuts (AOAC, 1997). The formula used for calculation of the percentage of milk extraction (Srivastava, 2003) is

$$\%\,\text{milk extraction} = \frac{\text{Volume of milk extracted (ml)}}{\text{Weight of coconut meat used (gm)}} \times 100$$

3.2.3 Pretreatment of coconut milk

Approximately equal, amounts of triangular pieces of coconut kernel pretreated and used for milk extraction, and different analyses of the milk as carried out described subsequently.

Table 3.1: Treatments of coconut milk

Sample	Treatment
S_1	Coconut milk without hardshell
S_2	Coconut milk with hard shell
S_3	Coconut milk without hardshell (blanching)
S_4	Coconut milk without hardshell (blanching + freezing)
S_5	Coconut milk with hardshell (after blanching)
S_6	Coconut milk with hardshell (blanching + freezing + coconut water)

3.2.4 Utilization of coconut solid meat (copra)

The coconut cake was used for developing of coconut toffee with different composition. The formulation of toffee was outlined as follows according to Central Food Technology Research Institute, Mysore.

Table 3.2: Basic formulation of coconut toffee based on 100 g total ingredient

Ingredients	A (gm)	B (gm)	C (gm)
Coconut solid with out milk	7	7	7
Sugar	70	56	49
Glucose syrup	10	10	20
Skim milk powder	10	24	21
Hydrogenated fat	3	3	3
Vanilla and color	As per requirement		

3.2.5 Procedure for preparation of coconut toffee

In the first stage, sugar syrup was prepared in which milk was added. This mixture was then boiled and during this process liquid glucose was mixed. The boiled material was stirred continuously to avoid formation of paste. In another saucepan coconut solid was lightly fried with hydrogenated fat (Vanaspati) and it mixed with sugar syrup. The mixture was continuously stirred with a spoon during cooking, till a speck of the product put into water forms a compact solid mass and did not dissolve. Color and essences were also added. The liquid was poured in a tray of ½ - ¾ cm thickness and cooled. Then it was cut into cubes or rectangular form with a stainless steel knife.

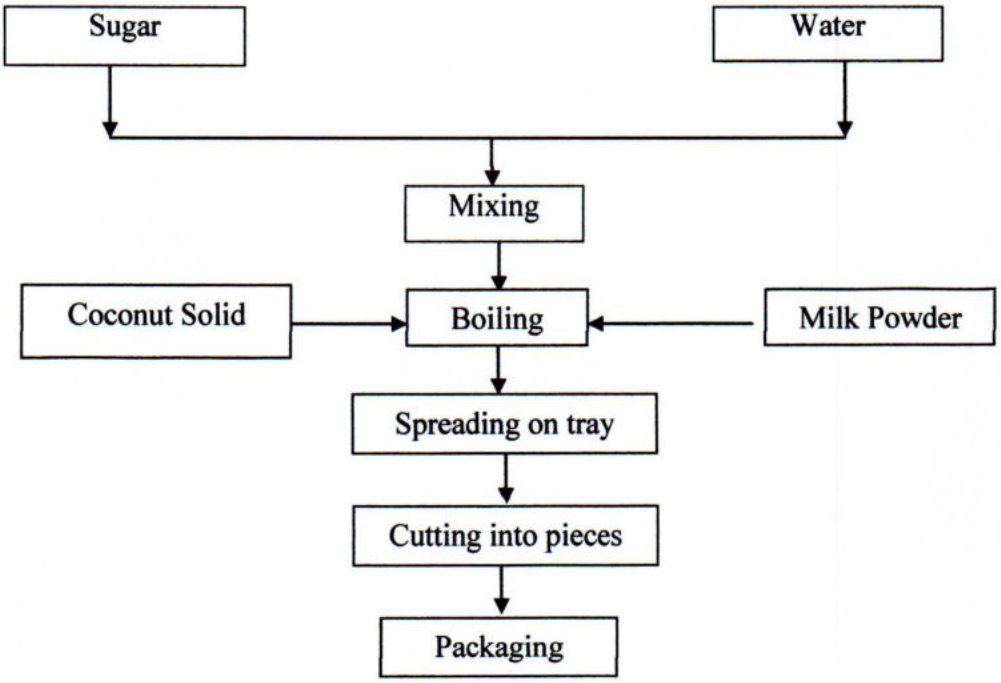

Fig: 3.2 Flow diagram of coconut toffee preparation

3.3 Proximate analysis

Proximate chemical composition represents the gross content of important chemical constituents- moisture, protein, fat, ash, total carbohydrate. The study of the proximate composition serves as an important base to study the nutritive quality of coconut, coconut milk and toffee.

3.3.1 Determination of Moisture content

The moisture content of the kernel was determined in accordance to moisture measurement method for grind grain AOAC (2004) method.

Procedure

The weights of previously dried (1 hr at 100 ^{O}C) empty crucible were taken and 5 ml of coconut milk samples were placed in each. Then the crucibles with samples were dried in an air oven at 100-105^{O}C for 24 hrs or more till constant weight. After drying the crucibles were removed from the oven and cooled in desiccators. The crucibles were removed from desiccator and weighed soon after reaching room temperature. The losses in weight were taken as the moisture loss of the samples. From these weights the percent of moisture in the samples were calculated as follows:

$$\%\,\text{moisture} = \frac{\text{Loss of weight}}{\text{Weight of sample}}$$

3.3.2 Determination of Ash

Total ash content was determined adopting AOAC method (2004).

Procedure

Five ml of each coconut milk samples were weighed and taken in dry, clean porcelain dishes. Hot air oven method was applied to remove the moisture. Then the samples were burnt on an electrical heater. This was done to avoid the loss of sample in the muffle furnace under higher temperature. Then the samples were transferred into the muffle furnace and burnt at 550^{0}C temperature for 4-6 hours and ignited until light gray ash resulted (or to constant weight). The samples were then cooled in desiccators and weighed. The ash content was expressed as:

$$\%\,\text{ash} = \frac{\text{Weight of residue}}{\text{Weight of sample}} \times 100$$

3.3.3 Determination of Fat

AOAC method (2004) was used to determine crude fat content of the samples.

Procedure

Five ml dried coconut milk sample remaining after moisture determination was transferred into a thimble and plugged the top of the thimble with fat free cotton. The thimble was dropped into the fat extraction tube of a soxhlet apparatus. The bottom of the extraction tube was attached to a soxhlet flask. Approximately 75 ml or more of anhydrous ether was poured into the flask. The top of the fat extraction tube was attached to the condenser. The sample was extracted for 16 hr. or longer on a water bath at 70 to 80^0C. The water bath was regulated so that the ether which volatilized was condensed and dropped continuously upon the sample without any appreciable loss.

At the end of the extraction period, the thimble was removed from the apparatus and most of the ether was distilled off by allowing it to collect in the Soxhlet tube. The ether was poured off when the tube was nearly full. When the ether was reached to a small volume, it was poured into a small, dry (previously weighed) beaker through a small funnel containing plug cotton. The flask was rinsed and filtered thoroughly using ether. The ether was evaporated on a steam bath at low heat, it was then dried at 100^0C for 1 hour, cooled and weighed. The difference in the weights was the ether- soluble material present in the sample. The percent of crude fat was expressed as follows:

$$\% \text{ Crude fat} = \frac{\text{Weight of the ether - soluble material}}{\text{Weight of sample}} \times 100$$

3.3.4 Determination of protein content

Principle

Protein content can be measured by estimating the nitrogen content of the material and then multiplying the nitrogen value by 6.25. This is referred to as crude protein content, since the non-protein (NPN) present in the materials was taken into consideration in the present investigation. The estimation of nitrogen was made by modified Kjeldahl method (Ranganna, S. 1992), which depends on the fact that organic nitrogen, when digested with concentrated sulphuric acid (H_2SO_4). In the presence of a catalyst, is converted into ammonium sulphate $(NH_4)_2SO_4$. Alkali is added to the sample to convert ammonium (NH_4^+) to ammonia (NH_3). The ammonia is steam distilled into a receiver flask containing boric acid and titrated with a standard acid solution. This determines % of N that is multiplied by 6.25 to give the value of crude protein.

Digestion Mixture

Potassium sulphate (K_2SO_4) and dehydrated copper sulphate ($CuSO_4.5H_2O$) in a ratio of 5g: 1g were powdered with mortar and pestle and mixed well. Concentrated HCl was used for titration.

Sodium hydroxide (40%)

Sodium hydroxide (NaOH) 40 gm was dissolved in distilled water and the volume was made up to 100 ml.

Receiver Solution

10g of boric acid was added in 500 ml deionized water in a one liter volumetric flask, heated it gently until the boric acid was dissolved. An amount of 0.02 g bromo cresol green was dissolved with 4 ml ethanol (C_2H_5OH) in a separate beaker. An amount of 0.014g methyl red was dissolved with 4 ml ethanol (C_2H_5OH) in another beaker. Some bromocresol green and methyl red solution mixture was than transferred into that volumetric flask and 0.5 ml 1N NaOH was added when the total volume was made 1000 ml with deionized water.

Procedure

The Kjeldahl method consists of the following steps:

a) Digestion of the sample

b) Distillation

c) Titration

Digestion of the sample

The coconut milk (10 ml) was taken in weighing paper and measured accurately. This sample was poured into a 100 ml clean and dry Kjeldahl flask, to which 10 gm of Digestion Mixture and 25 ml of concentrated HCl were added. To avoid frothing and bumping 2-5 glass beads was placed inside the flask. A blank was carried with all reagents except sample material for the comparison. The flask was then heated in a Fume hood Digestion chamber at 400°C until the solution became colorless. At the end of digestion period, the flasks were cooled and diluted with 100 ml distilled water. A small piece of litmus paper was placed in the solution and the reaction was found to be acidic.

Distillation

The distilling set of Kjeldahl apparatus was thoroughly washed with distilled water before starting the distillation. In a measuring cylinder 60 ml of 40% NaOH was taken and it was carefully poured down the side of the Kjeldahl flask. The mouth of the flask was closed with a stopper containing connective tube, which was ultimately connected to the ammonia-receiving flask containing 25 ml receiver solution.

The mixture was boiled at such a rate that water and ammonia distilled over at a steady moderate rate. The heating was not too slow so that the receiver solution might be sucked into the Kjeldahl flask and not to fast so that the distilling ammonia did not escape the receiver solution without absorption.

Titration

The ammonia absorbed in the receiving flask containing receiver solution was titrated with 0.1 N HCl. Similarly a reagent blank was distilled and titrated.

Calculation

Protein content of the sample on the percentage basis was calculated by the following formula:

$$\%\ \text{protein(g)} = \frac{(c-b)\times 14\times d\times 6.25}{a}\times 100$$

Where

a = sample weight (ml)

b = volume of the sodium hydroxide required for the back titration

c = volume of sodium hydroxide required for the back and to neutralize 20 ml of 0.1 N H_2SO_4 (for blank)

d = Normality of NaOH used for titration

The conversion factor of nitrogen to protein is 6.25 and atomic weight of nitrogen is 14.

3.3.5 Determination of Acidity

Five milliliter coconut milk was taken in a 100 ml measuring cylinder and volume made to 100 ml with distilled water. 10 ml of liquid was taken in a conical flask. A few drops of 1% phenolpthalein solution (indicator) was added to the flask and titrated against 0. 1N

NaOH solutions from a burette until a light pink colour appeared and persist for 15 seconds (Ranganna, 1991). Acidity was calculated

$$\% \text{ Acidity} = \frac{E \times N \times V_1 \times T \times 100}{W \times V_2 \times 100}$$

Where,

E = Equivalent weight of citric acid

N = Normality of alkali

V_1 = Volume made up

V_2 = ml. of extract taken for estimation

T = Titrate value

W = Weight of sample taken

3.3.6 Determination of Total Carbohydrate

The total carbohydrate content of the samples was determined as total carbohydrate by difference, which is by subtracting the measured moisture, ash, fat and protein from 100 (Pearson, 1970).

3.3.7 Determination of Energy:

Energy = [9x (g fat) + 4 x (g protein) + 4 x (g carbohydrates)] calories (Srivastava, 2003)

3.3.8 Determination of Total Soluble Solids (TSS)

At first the refractometer was neutralized by two drops of water at room temperature. Two drops of prepared coconut milk was taken in a refractometer (H1 96801 Romania) and the total soluble solids of the samples were read directly from the refractometer.

3.3.9 Determination of pH

The pH of the coconut milk was measured by using pH meter directly at ambient temperature.

3.3.10 Determination of Beta-carotene

Reagents:

Acetone, anhydrous sodium sulphate, petroleum ether.

Procedure

5 ml of sample was taken add in 10-15 ml acetone, adding a few crystals anhydrous sodium sulphate. Decant the supernatant into a beaker. Repeat the process twice and transfer the combined supernatant to a separatory funnel, add 10-15 ml petroleum ether and mix thoroughly. Two layers will separate out on standing. Discard the lower layer and collected upper layer in a 100 ml volumetric flask, make up the volume to 100 ml with petroleum ether and record optical density at 452 nm using petroleum ether as blank (Srivastava, 2003). The calculation of β-carotene was expressed as follows:

$$\beta\text{-carotene } (\mu g /100 \text{ gm}) = \frac{O.D \times 13.9 \times 10^4 \times 100}{\text{Weight of sample} \times 560 \times 1000}$$

$$\text{Vitamin A (I.U)} = \frac{\beta\text{-carotene } (\mu g /100 \text{ gm})}{0.6}$$

3.3.11 Vitamin C (Ascorbic acid)

Ascorbic acid was determined following the method of Ranganna (1991). The dye 2, 6-Dichloro phenol endophenol is blue in alkaline solution is reduced to light red color by an ascorbic acid at pH range of 1- 3.5.

Standardization of Dye

Five milliliter of standard ascorbic acid solution was taken in a 150 ml conical flask and 5 ml of HPO_3 was then added. A micro burette was filled with dye. The ascorbic acid solution was titrated with the dye to a pink color, which persist for 15 seconds. Dye factor (i.e. mg of ascorbic acid required to neutralize per ml of dye) determined by using the following formula:

$$\text{Dye factor} = \frac{\text{Ascorbic acid present in the solution titrated}}{\text{Titer (Volume of dye)}}$$

Preparation of samples

Ten milliliter of the coconut was taken, diluted up to 100 ml with 3% HPO_3 and then filtered. 10 ml of the aliquot was taken in a 150 ml conical flask. 1 ml of 40% formaldehyde and 0.1 ml of HCl were added to it and kept for 10 minutes. This was

titrated with the standard dye to a light pink colour (end point), which persists for 15 seconds. The calculation of vitamin C was expressed as follows:

$$\text{mg of ascorbic acid per 100 ml} = \frac{\text{Titre} \times \text{Dye factor} \times \text{Vol. made up} \times 100}{\text{Aliquot of extrat} \times \text{wt. or vol. of the sample}}$$

3.3.12 Determination of Mineral

Sample preparation

1 gm sample with 15 ml of diacid mixture (2:1) (HNO_3: HclO4) was taken in a beaker and boiled until the solution become clear. Cooled and made the volume in 100 ml. (Pearson 1976)

3.3.12.1 Estimation of Calcium (Ca)

5 ml solution mixed with 20-25 ml hot distilled water. Added 10 drops of each solution of Potassium pherocyanite, OH^- amine, hydrochloride, triethanolamine and 5 ml of NaOH buffer (10%) and 5-6 drops calcon indicator. test sample was titrated against EDTA (0.01M) solution from a burette until pink color completely turned to pure blue color.

Calculation

1 ml 1 M Na-EDTA= 40.08 mg Ca

3.3.12.2 Estimation of Magnesium

5 ml solution mixed with 20-25 ml hot distilled water. Added 10 drops of each solution of Potassium pherocyanite, OH^- amine, hydrochloride, triethanolamine, Na tungstate and 5 ml ammonium buffer and 5-6 drops EBT (Irriochrome Black-T). Test sample was titrated against EDTA (0.01M) solution from a burette until pink color completely turned to pure blue color.

Calculation

1 ml 1 M Na-EDTA=2 4.305 mg of Mg

3.3.13 Determination of total viable bacteria

For total viable count of microorganism present in the samples (milk), Standard pour plate method was followed according to the method described in "Recommended method for the microbiological examination of food" (M.A. Ali, 2008).

Preparation of media

Table 3.3 Composition of Agar media

Ingredients	Amount
Peptone	0.5%
Agar	1.8%
Nutrient broth	1.3%
Sodium chloride (NaCl)	0.2%
Distilled water	200ml

All necessary ingredients were measured with the help of electric balance and taken them in a conical flask and mixed. The conical flask was heated for proper mixing. In the time of heating, the mixture was rotted with the glass rod. When the mixture was properly mixed, the mouth of the conical flask was blocked with cotton plug and covered with aluminum foil. Then the conical flask with media was placed in autoclave for sterilization (Temperature: 121°C, Pressure: 15 Ib / inch^2 and time: 20-24hrs).

Preparation of dilution series

In order to dilute the sample consecutively 1ml of the coconut milk sample was diluted stepwise through a series of tubes containing 9ml of distilled water. At first 9ml of the distilled water was taken in a sterile test tubes and then 1ml of the original sample was taken to the first test-tube with a sterile pipette. Water with the sample was vigorously shaken for homogenous distribution of the bacterial population in the solution. This tube was denoted as "A". From the tube "F-1" another 1ml aliquot was transferred to the second tube and this tube was denoted as "F-2". In this way "F-3", "F-4", "F-5", "F-6" was prepared until the desired dilution is achieved. Now the tube "F-1" has got the dilution 10^{-1}, 10^{-2}, 10^{-3}, 10^{-4}, 10^{-5}, 10^{-6} respectively.

The dilutions were as follows:

Tube No.	Dilution	Volume of original fluid per ml	
1	1/10	0.1	or 10^{-1}
2	1/100	0.01	or 10^{-2}
3	1/1,000	0.001	or 10^{-3}
4	1/10,000	0.0001	or 10^{-4}
5	1/100,000	0.00001	or 10^{-5}
6	1/1,000,000	0.000001	or 10^{-6}

Procedure of plating

Now from the test-tube "F-1", 1ml of the sample solution was taken in a sterile petridish containing 9ml of agar medium. The agar with bacterial sample was mixed by rotating the petridish. This petridish was marked as "A". In this way "B", "C", "D", "E", "F" marked petridishes were prepared from the tubes "F-2", "F-3", "F-4","F-5" and "F-6"respectively. Then these petridishes were placed on a level surface for few minutes for solidifying the agar medium.

Incubation and colony count

After solidification petridishes were placed in the incubator at 36-37 ° C for 20-24 hours, the over loaded petridishes were avoided and the petridishes containing countable colony were selected. Colonies were counted with the aid of a magnifying glass and finally the total number of bacteria per gram of sample was calculated by the following equation:

Colony count (per ml) = Number of colonies (per plate) × Reciprocal of the dilution

3.4 Sensory evaluation of Coconut milks and toffee

The sensory evaluation of six types of coconut milk and three types of toffee were evaluated for color, flavor, taste, texture and overall acceptability parameters by 10 tasters. The panelists were selected from the teachers, students and employees of the Department of Food Processing and Preservation, Hajee Mohammad Danesh Science and Technology University, Dinajpur. For evaluation six types of coconut milk and three types of toffee were given to 10 panelist and randomly coded sample. They were asked to

rate the given sample a 9 point hedonic scale with ratings of: 9 =Like extremely, 8 = Like very much, 7 = Like moderately, 6 = Like slightly, 5 = Neither like or unlike, 4 =Dislike slightly, 3 =Dislike moderately, 2 = Dislike very much, 1 = Dislike extremely. The results were evaluated by Analysis of Variance and Duncan's Multiple Range Test (DMRT) procedures of MSTATC.

3.5 Storage Condition and Packaging

Processed coconut milk was stored at refrigerated temperature below 4°C. Shelf life of coconut milk was assessed by objective and subjective tests at different time intervals. The prepared coconut milk was kept in high density polythene bag. The moisture, ash, fat, acidity, color, flavor, TSS, pH and microbial load were observed initial stage up to 25days at 5 days interval.

CHAPTER IV

RESULTS AND DISCUSSION

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4.1 Proximate composition of fresh matured and immatured coconut

The fresh immature coconut contained 50.16 % moisture, 6.58 % protein, 26.67 % fat, 3.14 % ash, 13.45 % carbohydrate on the other hand matured coconut contained 45.26 % moisture, 4.23 % protein, 30.84 % fat, 2.76 % ash and carbohydrate 16.91 %. The composition of immature stage and matured stage coconut under this study more or less agree with those reported (Laureles *et al.*, 2000) that 4.10% protein, 11.2 % carbohydrate, 28.93 % fat, moisture 54.69 % and ash 1.02 %. This is attributed to several factors such as location and varietal differences as well as age of the nuts (Balleza and Sierra 1976; Pham 1994 and 1996), time of the year the nuts are harvested, age of copra before expelling.

The fresh matured and immatured coconuts were analyzed for their physicochemical composition. The proximate compositions of the coconuts are shown in table 4.1

Table 4.1 Compositions of fresh coconut

Parameters	Immature		Matured	
Moisture (%)	50.16	(100.64)	45.26	(82.68)
Ash (%)	3.14	(6.30)	2.76	(5.04)
Fat (%)	26.16	(52.49)	30.84	(56.34)
Protein (%)	6.81	(13.20)	4.89	(9.02)
Carbohydrate (%)	13.91	(27.92)	16.45	(30.33)

*Number in parenthesis is the percentage on dry weight basis.

4.2 Chemical compositions of coconut milks

The proximate composition of coconut milk from pretreated samples was shown in Table 4.2. The protein content of pretreated samples ranged between 4.47 % and 5.12 %, with the blanched with freezing sample having the highest value of 5.12%. This was not unexpected since coconut proteins undergo slightly change during pretreated (Weiss, 2003). The protein contents of the untreated (3.82 to 4.35%) samples were lower than the protein contents of coconut samples before milk extraction. The moisture content varied

between 83 to 87% with the hard shell sample was exhibiting the lowest value after that the blanched with freezing sample shown. Sample S_1 was shown higher moisture content. The moisture content values obtained in this study were within the range of values previously reported for groundnut by Olaofe and Sanni (2000) and Oyenuga (1998). The lowest moisture content had an advantage when shelf life was considered. The low moisture content of the coconut milk with hard shell was not unexpected but the hard shell might be affected the composition of milk also spoiled rapidly during storage period. On the other hand heating much after the extraction, denatured the proteins and affected their fat content and milk characteristics (Gbadamosi and Ogunsua, 2006). Sample S_2 and Sample S_6 coconut milk samples had comparable ash contents which were higher than in the other samples which may be attributed to the presence of hard shell in sample S_2 and coconut water in sample S_6 (Ihekoronye and Ngoddy, 1998). The fat content was higher in Sample S_1 and Sample S_2. The pretreated samples were shown the lower fat content. The low fat content of coconut milk is an advantage for the keeping quality of the product as well as the probability of rancidity taking place would be greatly reduced (Sunny-Roberts *et al.,* 2004). The mineral composition of prepared coconut milks under this study more or less agree with those reported by Adeiye *et al.*, (2013) that calcium 3.82 mg/ 100 ml and magnesium 2.67 gm /100 ml.

The Chemical compositions of prepared coconut milks were analyzed and the results are presented in Table 4.2

Table 4.2: Chemical composition of coconut milks

Nutrient	Coconut milks					
	S_1	S_2	S_3	S_4	S_5	S_6
Moisture content (%)	87	83	85	84	85.51	86
Protein (%)	3.92	4.35	4.47	5.12	3.92	3.82
Fat (%)	5.57	4.56	4.37	4.51	5.63	4.78
Ash (%)	0.282	1.00	0.394	0.311	0.163	0.812
Carbohydrate (%)	3.23	7.07	5.76	6.06	4.78	4.59
Energy (kcal/100 gm)	78.73	86.8	80.25	85.31	85.47	80.5
TSS (%)	13	17	15	16	14.49	14
pH	4.75	4.65	5.92	6.00	5.10	5.50
Acidity (%)	1.107	1.115	0.095	0.080	0.1	0.103
Vitamin C (mg/100 ml)	1.00	0.97	0.82	0.88	0.51	0.72
Vitamin A (IU)	0.025	0.051	0.014	0.022	0.031	0.027
Calcium (mg/100 ml)	3.206	3.561	3.021	3.670	3.415	3.973
Magnesium (mg/100 ml)	2.001	2.951	2.312	3.001	2.115	2.097

S_1 = Coconut milk without hardshell, S_2 = Coconut milk with hard shell, S_3= Coconut milk without hardshell (blanching), S_4 = Coconut milk without hardshell (blanching + freezing), S_5= Coconut milk with hardshell (after blanching), S_6= Coconut milk with hardshell (blanching + freezing + coconut water)

4.3 Yield of coconut milk

The yield of coconut milks was determined for six samples. The S_1 was pretreatment free (control sample); S_2 sample was treated with hard shell; S_3 was treated with blanching; S_4 was treated with both blanching and freezing; S_5 was treated with blanching after extraction and S_6 was treated with coconut water. The results are shown in Table 4.3

Table 4.3 Yield of coconut milk extraction from coconut kernel

Sample	Percentage extraction of coconut milk (%)	Sample	Percentage extraction of coconut milk (%)
S_1	52	S_4	76
S_2	44	S_5	52
S_3	68	S_6	58

S_1 = Coconut milk without hardshell, S_2 = Coconut milk with hard shell, S_3= Coconut milk without hardshell (blanching), S_4 = Coconut milk without hardshell (blanching + freezing), S_5= Coconut milk with hardshell (after blanching), S_6= Coconut milk with hardshell (blanching + freezing + coconut water)

Table 4.3 showed that the yield of coconut milk is more in pretreated sample S_4. A decrease in the percentage extraction of milk was observed throughout the period of extraction, in the coconut samples, which were not subjected to any blanching treatment shown in Fig. (Appendix XI.II). The percentage extraction of milk in unblanched samples was 52 % and 44 % whereas the pretreated sample (blanched) was 68 % and blanching with freezing treatment sample extraction rate was 76 %. However, unblanched samples showed a lower rate of extraction than the pretreated samples. The blanched sample did not show any significant differences in values with blanching plus freezing sample. This clearly shows that blanching has a beneficial effect on the extractability of milk from coconut kernels. The percentage extraction level of coconut milk under this study was more or less agree with those reported by Philip *et al*., (2006) that unblanched sample 58 %, blanched sample 70 % and blanched with freezing sample 80 %.

4.4 Shelf life observation of prepared coconut milks (at refrigeration temperature in high density polyethylene)

Coconut milk samples were preserved at refrigeration temperature (0-4°C) in high density polyethylene. Proximate composition like moisture, TSS, fat, acidity, pH and visual observation color, flavor, coagulation, microbial growth were observed initial stage up to 25 days at 5 days intervals.

Table 4.4 Proximate composition of coconut milk in storage condition (refrigeration temperature in high density polyethylene)

Nutrient	Sample							Average
	S_1	S_2	S_3	S_4	S_5	S_6	LSD (P<0.05)	
Moisture Content (%)	91.65 ± 3.38^{a}	91.11 ± 5.22^{ab}	88.00 ± 2.36^{c}	85.72 ± 1.60^{d}	89.61 ± 3.56^{bc}	88.80 ± 2.21^{c}	1.653	89.14±1.25
Ash Content (%)	0.181 ± 0.074^{bc}	0.523 ± 0.307^{a}	0.315 ± 0.620^{b}	0.278 ± 0.311^{b}	0.117 ± 0.040^{c}	0.650 ± 0.157^{a}	0.1303	0.344±0.106
Fat Content (%)	3.85 ± 1.154^{a}	2.49 ± 1.36^{b}	4.017 ± 0.314^{a}	4.287 ± 0.214^{a}	4.25 ± 1.124^{b}	3.93 ± 0.663^{a}	0.5837	3.80±0.472
pH	4.36 ± 0.375^{c}	4.16 ± 0.42^{d}	5.753 ± 0.167^{a}	5.87 ± 0.105^{a}	4.60 ± 0.384^{c}	5.23 ± 0.373^{b}	0.3853	4.90±0.310
Acidity (%)	0.228 ± 0.20^{ab}	0.316 ± 0.29^{a}	0.121 ± 0.019^{c}	0.116 ± 0.025^{c}	0.147 ± 0.064^{bc}	0.130 ± 0.023^{bc}	0.0376	0.141±0.018
TSS	8.35 ± 3.39^{d}	8.87 ± 5.22^{cd}	12 ± 2.36^{b}	14.28 ± 1.60^{a}	10.40 ± 3.57^{bc}	11.20 ± 2.71^{b}	1.652	10.85±1.25

Means (mean ± SD) within a row followed by different letters are significantly different ($p < 0.05$)

S_1 = Coconut milk without hardshell, S_2 = Coconut milk with hard shell, S_3= Coconut milk without hardshell (blanching), S_4 = Coconut milk without hardshell (blanching + freezing), S_5= Coconut milk with hardshell (after blanching), S_6= Coconut milk with hardshell (blanching + freezing + coconut water)

4.4.1 Proximate chemical properties of coconut milk

The results in Table 4.4 had shown some of the proximate chemical properties of the milk extracts obtained from different pretreated coconut samples. The moisture varies from 85.72 to 91.65%. The coconut milk had a significant difference ($P<0.05$) of a moisture content in refrigeration at different storage period. Sample S_1 had shown significantly ($P<0.05$) higher (91.65 %) and S_4 had shown significantly ($P<0.05$) lower (85.72%) moisture content. For this reason S_4 (blanching + freezing) was better than other samples during storage condition at refrigerated temperature. Acceptable average moisture content was 91.5%. Ash content varies from 0.117 to 0.650 %. It had shown also a level of significant difference ($P<0.05$) between pretreated and untreated coconut milk in refrigeration temperature at different storage period. Sample S_6 Coconut milk with hardshell (blanching + freezing + coconut water) and S_2 (coconut milk with hard shell) shown significantly higher ash content than other samples because present of coconut water and hardshell (S_6) and only hardshell (S_2). Fat content of coconut milk (after blanching) showed significantly higher (5.63%) than other samples. While the fat content of milk from coconut milk without hardshell (blanching) was 4.017 %, coconut milk without hardshell (blanching + freezing) was 4.287 % and this two samples fat content was shown more stability in refrigeration during different storage period. A normal decreasing value was also observed by Onyeike and Onwuka (1999) when they evaluated the physicochemical and sensory characteristics of groundnut milk samples prepared from blanching, autoclaved, boiled and roasted. The similar trend was also observed in soymilk prepared from dehulled and undehulled samples (Akanni *et al.*, 2005). Adoga (2006) attributed that this loss may be the action of lipases and other lipolytic enzymes some of which are present in milk secreted by organisms. The acid content of coconut milk was shown a related result with pH. The samples had shown significant differences ($P<0.05$) of acid content during storage period. Sample S_2 had shown significantly higher (0.316%) acid content. Pretreated sample S_3 and S_4 were shown significantly lower acid content 0.121% and 0.116% respectively. The pH of refrigerated milk was not influenced by pretreatment. pH was significantly higher in treated samples S_3 and S_4 5.75 and 5.87 respectively. pH was significantly lower in sample S_2. TSS also had shown a significant difference in samples during storage period. Pretreated sample S_4 (blanching + freezing) without hardshell shown significantly higher value (14.28%) than other samples and S_1 shown lower value (8.35%). Acceptable value as milk is TSS not lower than 8.5% and fat content 3.5%. The implication of this is that coconut milk may be a good substitute for cow milk with respect to these attributes.

4.5 Visual observation of refrigerated coconut milk in high density polyethylene with Time (Stability test)

Storage period	Sample	Color	Flavor	Coagulation	Remarks
0 days	S_1	Creamy white	pleasant	No	Good
	S_2	Creamy white	pleasant	No	Good
	S_3	Creamy white	pleasant	No	Good
	S_4	Creamy white	pleasant	No	Good
	S_5	Creamy white	pleasant	No	Good
	S_6	Creamy white	pleasant	No	Good
5 days	S_1	Creamy white	pleasant	No	Good
	S_2	Creamy white	pleasant	No	Good
	S_3	Creamy white	pleasant	No	Good
	S_4	Creamy white	pleasant	No	Good
	S_5	Creamy white	pleasant	No	Good
	S_6	Creamy white	pleasant	No	Good
10days	S_1	Creamy white	pleasant	No	Good
	S_2	**Slightly change**	**Slightly change**	**Slightly**	**Spoilaged**
	S_3	Creamy white	pleasant	No	Good
	S_4	Creamy white	pleasant	No	Good
	S_5	Creamy white	pleasant	No	Good
	S_6	Creamy white	pleasant	No	Good

S_1 = Coconut milk without hardshell, S_2 = Coconut milk with hard shell, S_3= Coconut milk without hardshell (blanching), S_4 = Coconut milk without hardshell (blanching + freezing), S_5= Coconut milk with hardshell (after blanching), S_6= Coconut milk with hardshell (blanching + freezing + coconut water)

4.6 Visual observation of refrigerated coconut milk in high density polyethylene with Time (Stability test)

Storage period	Sample	Color	Flavor	Coagulation	Remarks
15 days	S_1	**Slightly change**	**Slightly change**	**Slightly**	**Spoilaged**
	S_2	**lightly change**	**lightly change**	**Lightly change**	**Spoilaged**
	S_3	Creamy white	pleasant	No	Good
	S_4	Creamy white	pleasant	No	Good
	S_5	Creamy white	pleasant	No	Good
	S_6	Creamy white	pleasant	No	Good
20days	S1	**Lightly change**	**Lightly change**	**Lightly change**	**Spoilaged**
	S2	**Watery**	**Off flavor**	**Largely**	**Spoilaged**
	S3	Creamy white	pleasant	No	Good
	S4	Creamy white	pleasant	No	Good
	S5	**Slightly change**	**Slightly change**	**Slightly**	**Spoilaged**
	S6	Creamy white	pleasant	No	Good
25days	S1	**Watery**	**Off flavor**	**Largely**	**Spoilaged**
	S2	**Watery**	**Off flavor**	**Largely**	**Spoilaged**
	S3	Creamy white	pleasant	No	Good
	S4	Creamy white	pleasant	No	Good
	S5	**Lightly change**	**Lightly change**	**Lightly change**	**Spoilaged**
	S6	**Slightly change**	**Slightly change**	**Slightly**	**Spoilaged**

S_1 = Coconut milk without hardshell, S_2 = Coconut milk with hard shell, S_3= Coconut milk without hardshell (blanching), S_4 = Coconut milk without hardshell (blanching + freezing), S_5= Coconut milk with hardshell (after blanching), S_6= Coconut milk with hardshell (blanching + freezing + coconut water

4.4.2 Color and Flavor

The color and flavor of all the prepared six coconut milk samples were creamy white and pleasant (Table 4.5 and 4.6) up to five days but after 10 days S_2 (coconut milk with hard shell) was slightly changed in the storage period .Other combinations were unchanged. S_2 was spoiled fast because presence of hard shell and then spoilaged S_1 (only coconut milk) after that S_5 (coconut milk after blanching). S_3 (blanching) and S_4 (blanching with freezing) samples were unchanged up to 25 days.

4.4.3 Microbial load

The microbial load of coconut milk was showed in fig (4.1). According to Hans *et al.*, (2005) human's acceptable safety level of microorganisms is 105×10^4 cfu/ ml. S_3 and S_4 samples were good up to 25 days because of the combination of pretreatment blanching and freezing shown in fig (Appendix XI.I).

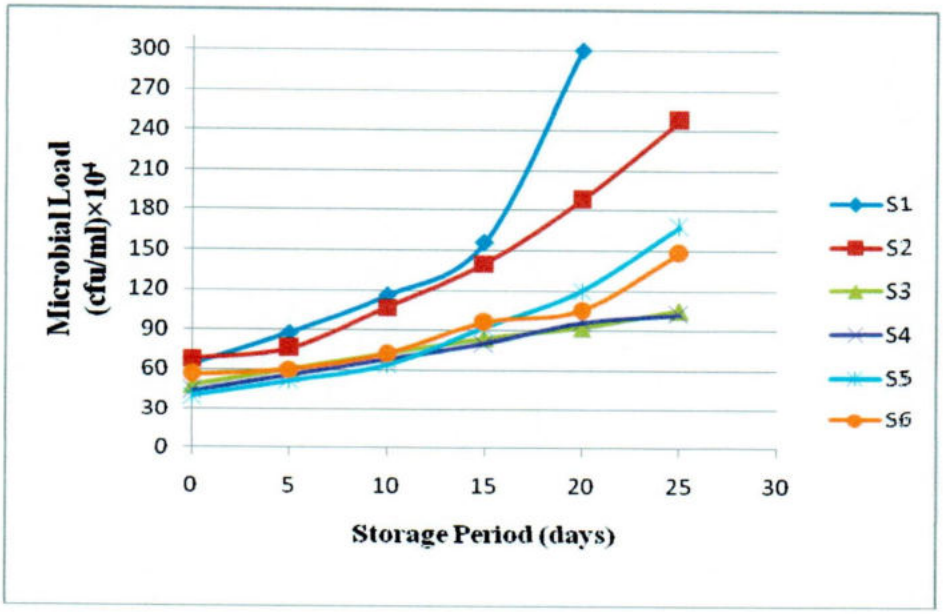

Fig. 4.1 Effect of pretreatment on the microbial load of stored coconut milk in high density polyethylene at refrigeration condition

4.5 Effect of pretreatment on the proximate composition of coconut milk during storage

Figure 4.2 showed changes in the moisture content of coconut milk obtained from pretreated coconut and the coconut milk stored in single layer high density polyethylene at refrigeration (0-4°C) condition. The figure shown increase of the moisture content of coconut milk during storage. This agrees with the findings of Miller (2000) who reported an increase in the moisture content of coconut milk during storage. However milk samples from pretreated coconut exhibited relatively high stability in moisture content over a longer period. Moisture content of coconut milk at storage period of sample S_1 (87%) was higher than coconut milk from the other samples (Appendix I.I). The changes of samples agreed with the results of Beuchat and Nail (1978) who reported that higher moisture content in untreated coconut milk than the pretreated milk samples.

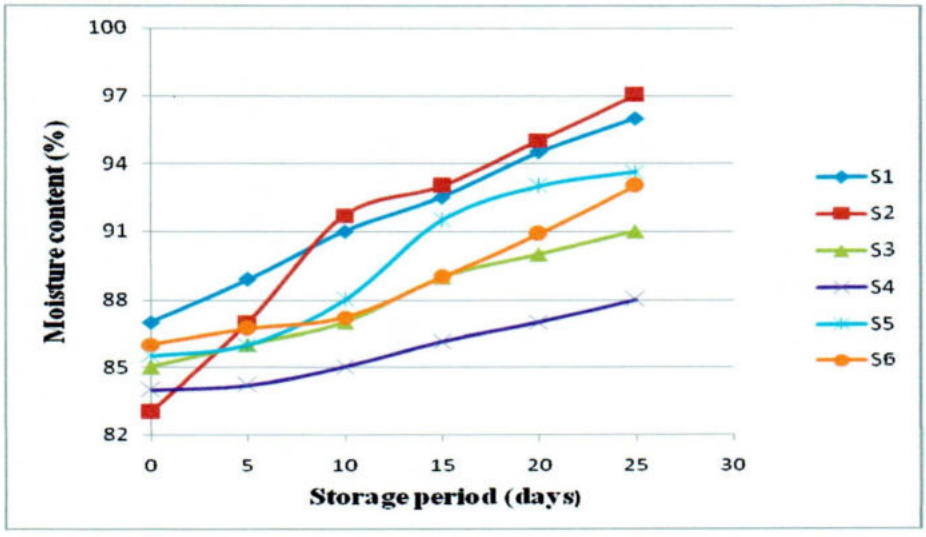

Fig. 4.2 Effect of pretreatment on the moisture content of stored coconut milk in high density polyethylene at refrigeration condition

Alkanhal *et al*., (2000) suggested that processing variables were responsible for the general change in composition and coconut milk could be stored in any packaging materials (Plastic, glass containers or sachet) without any significant changes in composition during storage period.

In case of ash content (Appendix I.I) related to moisture content. If moisture was increased then ash content was decreased. Sample S_3 and S_4 showed in fig 4.3 a medium ash content and stability in storage period.

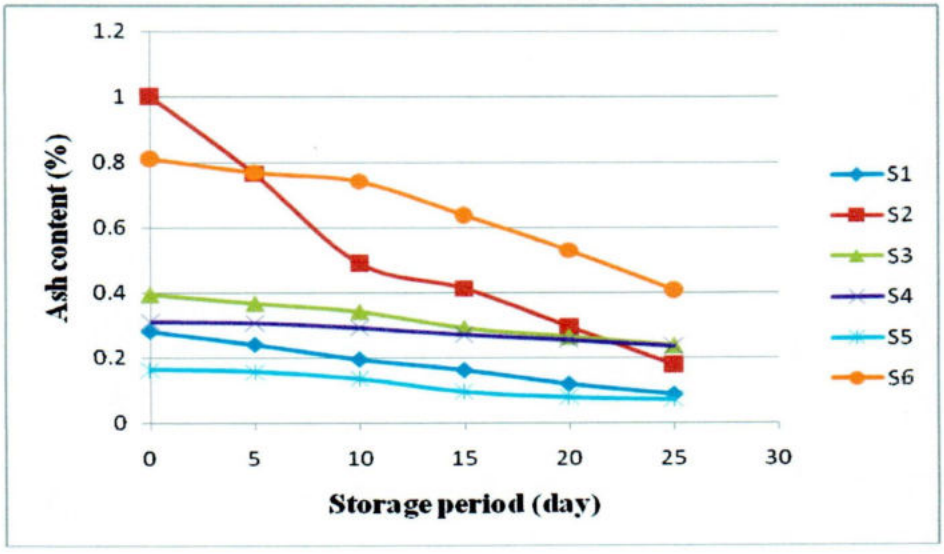

Fig. 4.3 Effect of pretreatment on the ash content of stored coconut milk in high density polyethylene at refrigeration condition

Figure 4.4 showed that the fat content (Appendix I.I) was stable in Sample S_3 and S_4 over the storage period while there was a significant drop in the fat content of milk stored without any pretreatment.

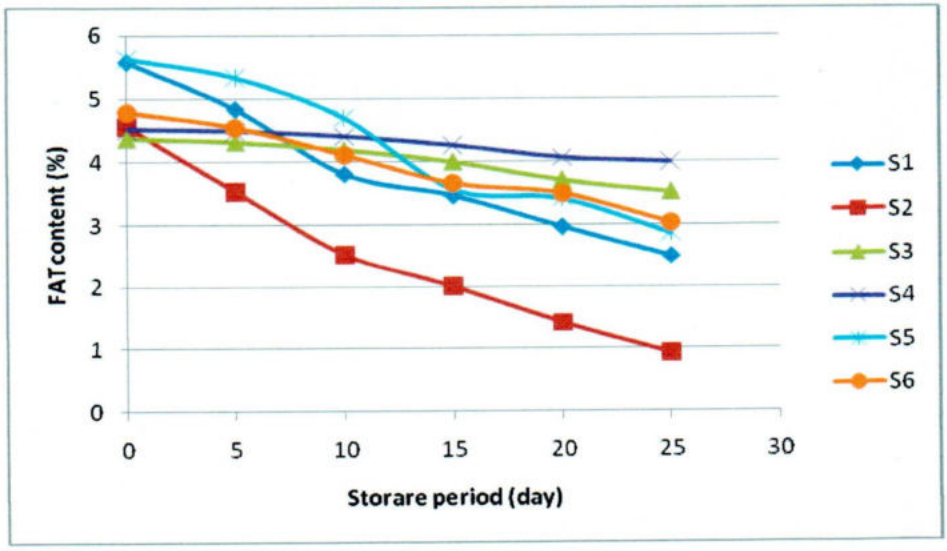

Fig. 4.4 Effect of pretreatment on the fat content of stored coconut milk in high density polyethylene at refrigeration condition

The decrease of pH (Appendix I.I) continued until the end of the storage period on day 25 shown in fig 4.5. pH of refrigerated coconut milk was not influenced by pretreatment.

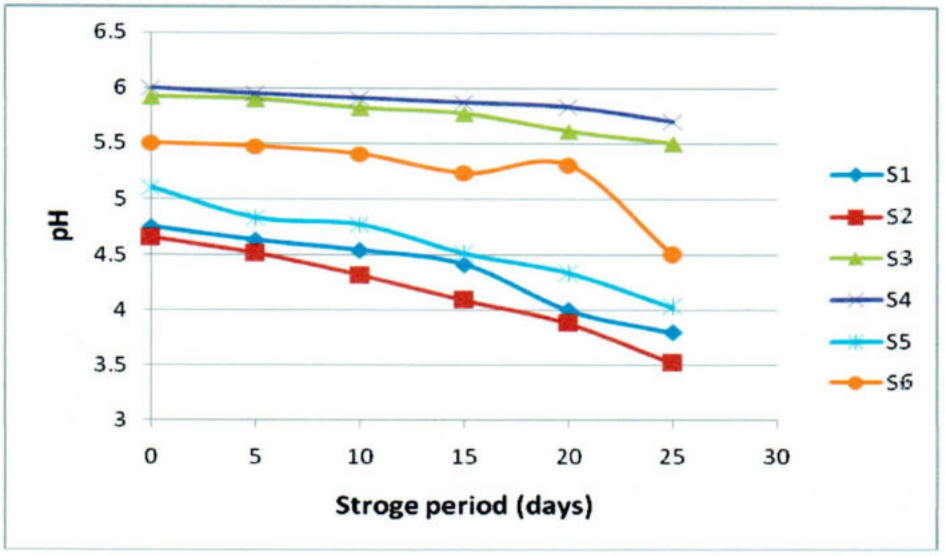

Fig. 4.5 Effect of pretreatment on the pH of stored coconut milk in high density polyethylene at refrigeration condition

Acid content (Appendix I.I) was related with pH vise versa. pH was decreased so acidity was increased with time in storage period which was shown in fig 4.6. It was probable that the increase of acidity may be a result of anaerobic microbial activities resulting in the formation of lactic acid and other organic acids. The values observed in this study (0.07 to 0.88) were less than reported value 0.24 to 0.36 by Onweluzo and Nwakalor (2009) for different vegetable milk extracts and 0.88 to 1.0 Sunny-Roberts *et al.*, (2004) for fermented coconut milk.

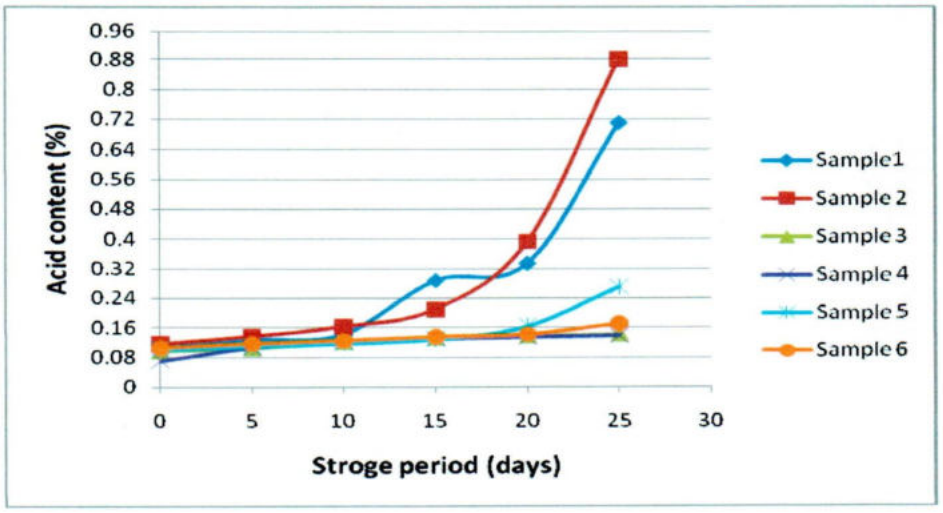

Fig. 4.6 Effect of pretreatment on the acidity of stored coconut milk in high density polyethylene at refrigeration condition

TSS indicated (Appendix I.I) total soluble solid. In fig 4.6 showed that Sample S_2 indicated higher TSS and also decreased fast because of presence of hard shell. However milk samples from pretreated coconut exhibited relatively high stability in TSS over a longer period in storage. Mean of all samples composition were shown in table 4.4 and in fig (Appendix XI.III and XI.IV). Mean score also showed the same results that pretreated were effective on storage period of coconut milks.

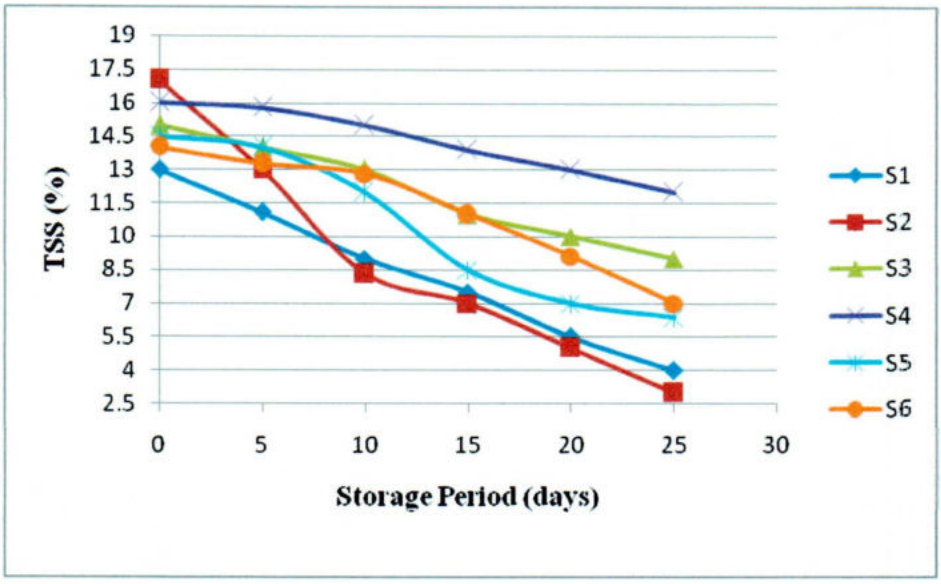

Fig. 4.7 Effect of pretreatment on the TSS of stored coconut milk in high density polyethylene at refrigeration condition

4.6 Sensory evaluation of coconut milks

Six coconut milk samples treated with various pretreatment and subjected to sensory evaluation. The color, flavor, taste and overall acceptability of these prepared coconut milk samples were evaluated by a panel of 10 tasters and the scores are presented in Appendix II, III, IV and V. A one way analysis of variance (ANOVA) showed that the calculated "F" value is higher than that of tabulated "F" value which includes that sensory attributes of different samples were significantly different at 5% level of significance($p<0.05$).Hence the DMRT test will reveal the exact variation or differentiation among the quality attributes.

Table 4.7 Mean score for color, flavor, taste and overall acceptability of Coconut milks

Sample code	Sensory attributes			
	Color	Flavor	Taste	Overall acceptability
S1	6.5^{bc}	7.3^{bc}	6.6^{c}	6.9^{bc}
S2	5.4^{d}	7.3^{bc}	5.9^{d}	5.8^{d}
S3	7.1^{b}	7.7^{ab}	7.3^{b}	7.3^{b}
S4	8.1^{a}	8.3^{a}	7.7^{ab}	8.0^{a}
S5	6.2^{c}	7.0^{c}	6.5^{c}	6.6^{c}
S6	6.6^{bc}	8.0^{a}	8.0^{a}	8.1^{a}
LSD (P<0.05)	0.7340	0.6102	0.5479	0.5837

Mean with same superscript within a column are not significantly different but Means within a column followed by different letters are significantly different ($p < 0.05$)

S_1 = Coconut milk without hardshell, S_2 = Coconut milk with hard shell, S_3= Coconut milk without hardshell (blanching), S_4 = Coconut milk without hardshell (blanching + freezing), S_5= Coconut milk with hardshell (after blanching), S_6= Coconut milk with hardshell (blanching + freezing + coconut water)

As shown in Table 4.7 the DMRT test revealed that the sample S_4 scored significantly better color than other samples. The sample S_4 secured the highest score 8.1 and ranked as "Like very much." But there were no significant difference in color preference of the samples $S_1$and S_6 Sample. The samples S_1 and S_6 ranked as "Like less moderately" by securing score 6.5 and 6.6 respectively. The sample S_3 ranked as "Like moderately." and securing score 7.1. S_5 ranked as "Like slightly" and securing score 6.2.The lowest value of sample S_2 and ranked as "less like". The highest score for color was obtained by sample S_4. The pretreatment combination of the sample S_4 was coconut cubes (blanching + freezing).

In case of flavor preference among the samples the DMRT test revealed that the sample S_4 and S_6 scored significantly better flavor than other samples. There was no significant difference between them. The samples S_4 and S_6 secured the highest score 8.3 and 8.0 ranked as "Like very much." But there were significant differences in flavor preference among the samples S_1, S_5 and S_3 samples. S_3 ranked as "Like much" and securing scored

7.7. S_1 and S_2 ranked as "Like moderately" and securing scored 7.3. No significant difference between them. S_5 securing scored 7.0 and ranked as "Like slightly".

In case of Taste preference among the samples the DMRT test revealed that the sample S_6 scored significantly better taste than other samples. The sample S_6 secured the highest score 8.0 and ranked as "Like very much." The best taste acceptability of S_6 was obtained because of using coconut water instead of water during extraction milk. Samples S_1, S_2, S_3 and S_4 were significantly differ from each other. But there was no significant difference between S_1 and S_5. Ranked as "Like slightly" and securing scored 6.6, 6.5 respectively. The sample S_3 "Like moderately" by securing score 7.3. S_4 ranked as "Like much" and securing scored7.7. Sample S_2 "less like" by securing score 5.9 than other all samples.

In case of overall acceptability preference among the samples the DMRT test revealed that the sample S_4 and S_6 scored significantly better overall acceptability than other samples but no significant difference between them. The sample S_4 and S_6 secured the highest score 8.0 and 8.1 also ranked as "Like very much." But there were significant difference in overall acceptability preference of the samples S_1, S_2, S_3 and S_5. Sample S_3 ranked as "Like moderately" by securing score 7.3. Sample S_1 ranked as "Like slightly moderately" and securing score 6.9. The Lowest score for overall acceptability preference among the all other samples was obtained by sample S_2 and ranked as "less like" because presented of hard shell. This agrees with the sensory evaluation result of groundnut milk extracts from Bambara groundnut (Brough *et al.*, 1993). The figures are shown in fig (Appendix XI.V and XI.VI).

4.7 Proximate composition of coconut solid

After extraction of coconut milks, the proximate composition of coconut cake was analyzed and the result was moisture 43.78%, ash 0.62%, protein 2.98%, calcium 2.01mg/ 100 gm and magnesium 1.26 mg/100 gm. It was more similar with Divina (2011) who reported that moisture 38.01 %, ash 0.57 %, protein 2.77 %.

4.8 Sensory evaluation of coconut toffee

Three samples developed from coconut solid and subjected to sensory evaluation. The color, flavor, texture, taste and overall acceptability of these formulated coconut toffee samples were evaluated by a panel of 10 tasters and the scores are presented in Appendix

VI, VII, VIII, IX and X. A one way analysis of variance (ANOVA) indicated that all these sensory attributes of different samples were significantly different ($p<0.05$) and thus the sensory attributes of the samples showed various degrees of acceptability.

Table 4.8 Mean score for color, flavor, texture, taste and overall acceptability of Coconut toffees

Sample code	Sensory attributes				
	Color	Flavor	Texture	Taste	Overall acceptability
A	7.4^{a}	7.5^{a}	6.5^{b}	6.7^{b}	7.1^{b}
B	8.0^{a}	8.0^{a}	7.8^{a}	8.3^{a}	8.2^{a}
C	6.1^{b}	6.6^{b}	5.5^{c}	5.9^{c}	6.4^{b}
LSD (P<0.05)	0.6690	0.6981	0.6023	0.6570	0.7522

Mean with same superscript within a column are not significantly different but means within a column followed by different letters are significantly different at $p<0.05$

A = Coconut solid + 10% Sugar

B = Coconut solid + 8% Sugar

C= Coconut solid + 7% Sugar

As shown in Table 4.8 the DMRT test revealed that the sample A, B scored significantly better color than C. The sample B secured the highest score 8.0 and A secured score7.4 also ranked as "Like very much". The samples C ranked as "Like moderately." and securing score 6.1. The difference of color scored for sugar concentration.

In case of flavor preference among the samples the DMRT test revealed that the sample A, B scored significantly better flavor than C. There was no significant difference between Samples A and B in flavor preference. The sample A and B secured score 8.0, 7.5 respectively and ranked as "Like very much''. Sample C as "Like moderately" and securing score 6.6.

In case of texture preference among the samples the DMRT test revealed that there was a significant difference among all samples. Sample B scored significantly better texture than other samples. The sample B secured the highest score 7.8 and ranked as "Like very much." The sample C ranked as "Like slightly" and securing score 5.5. And the sample A

ranked as "Like moderately" by securing score 6.5 and significantly ($P<0.05$) better than C.

In case of taste preference among the samples the DMRT test revealed that the sample B scored significantly better taste than other samples. The sample B secured the highest score 8.3 and ranked as "Like very much." The sample C ranked as "Like slightly" and securing score 5.9. And the sample A ranked as "Like moderately" by securing score 6.7 and significantly ($P<0.05$) better than C.

In case of overall acceptability preference among the samples the DMRT test revealed that the sample B scored significantly better overall acceptability than other samples. The sample B secured the highest score 8.2 and ranked as "Like very much." But there was no significant difference in overall acceptability preference of the samples A and C. The samples A, and C can be ranked as "Like moderately" by securing score 7.1 and 6.4 respectively. Figures are showed (Appendix XI.VII and XI.VIII) same results.

Fig 4.1: Grated Coconut

Fig 4.2: Smooth puree

Fig 4.3: Coconut milk

Fig 4.4: Treated cubed coconut

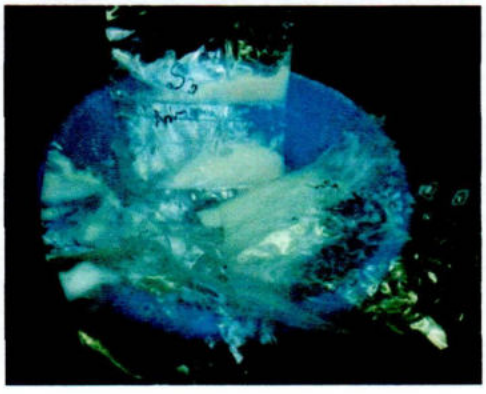

Fig 4.5 Refrigerated coconut milk

Fig 4.6: Coconut Toffee

CHAPTER V

SUMMARY AND CONCLUSION

CHAPTER V

SUMMARY AND CONCLUSION

The purpose of the study was to prepare coconut milk from locally available coconuts and to increase its shelf life by pretreatment, also to develop coconut toffee from coconut solid except coconut milk with different composition. For this purpose the premature stage and matured stage coconuts were analyzed for their composition. The nutritive value was high in mature coconut than immature coconut. For this reason mature coconut was selected for this research work.

The coconut kernels were treated with various pretreatments for increasing extraction level and nutritional quality. The treatments were sample S_1 (only coconut milk) as a control; sample S_2 (Coconut milk with hard shell); sample S_3 (blanching); sample S_4 (blanching + freezing); sample S_5 (after blanching) and finally sample S_6 (Coconut milk + coconut water). Analysis had shown better result for Sample S_4.

The pretreatments investigated in this research were unique as they were applied to the coconuts before the extraction of coconut milk. Blanching and freezing together had a beneficial effect over maintaining a uniform percentage extraction of coconut milk, as compared to the unblanched samples or the controls, over the time period of the study. No rancid off-flavors were detected in any of the blanching or (blanching + freezing) samples. These results suggest that the blanching treatments were successful in the elimination of deteriorative enzymatic reactions, enabling the preservation of coconut milk over a long period of time under frozen conditions. Therefore, fresh coconut kernels may be blanched and stored frozen for extended periods of time to extract fresh coconut milk without significantly lowering the extractability or the quality of coconut milk.

The statistical analysis showed that color, flavor, taste and overall acceptability of coconut milk of sample S_4 (blanching + freezing) was most acceptable than other samples and the samples S_1, S_2, S_3, S_5 and S_6 were ranked as like moderately.

Prepared coconut milks were stored at refrigeration temperature. The total soluble solids showed a small change throughout the storage period at refrigeration conditions .TSS was more stable in sample S_4 up to 25 days. The increase of TSS might be due to the conversion of sugar and fat during the storage periods.

Fat content of coconut milk (after blanching) was highly comparable (5.63%) to that of other samples. The low fat content of coconut milk is an advantage for the keeping quality of the product as the probability of rancidity taking place would be greatly reduced (Sunny-Roberts *et al.,* 2004), which was shown in sample S_3 and S_4.

Shelf life observation of coconut milks showed that the color of the coconut milk was good and looking creamy white. The flavor was also pleasant. After 10 days color and flavor were slightly changed of sample S_2. Initially acceptable level of microbial growth was observed but after 10 days the growths were detected. The moisture content, acidity of the coconut milks were slightly increased with the slightly decrease of pH in storage condition.

Considering the physico-chemical changes and overall acceptance of sensory evaluations the sample S_4 (blanching + freezing) of coconut milk with the use of coconut water instead of water during milk extraction could be selected for commercial processing of coconut milk. The study was conducted to standardize the processing method for coconut milk from coconut to enhance the diversified use of coconut.

The statistical analysis also showed that color, flavor, texture, taste and overall acceptability of developed coconut toffee of sample B (coconut solid + 8% Sugar) was most acceptable than sample A (coconut solid + 10 % Sugar) and C (coconut solid + 7 % Sugar).

The extraction procedure requires no specialized equipment. Further studies need to be conducted to improve the shelf life using preservatives, stabilizer and emulsifier and also of flavours.

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APPENDICES

APPENDICES

Appendix I.I Shelf life Observation of Coconut Milks (at refrigeration temperature in high density polyethylene)

Nutrient	Sample	Processing Days					
		0 day	5 day	10 day	15 day	20day	25 day
Moisture Content (%)	S_1	87	88.9	91	92.51	94.5	96
	S_2	83	87	91.68	93	95	97
	S_3	85	86.01	87	89	90	91
	S_4	84	84.22	85	86.12	87	88
	S_5	85.51	86	88	91.5	93	93.62
	S_6	86	86.72	87.2	89	90.88	93
Ash Content (%)	S_1	0.282	0.241	0.195	0.162	0.119	.087
	S_2	1.00	0.764	0.489	0.412	0.294	0.176
	S_3	0.394	0.367	0.341	0.290	0.263	0.263
	S_4	0.311	0.307	0.292	0.270	0.253	0.233
	S_5	0.163	0.157	0.135	0.096	0.079	0.072
	S_6	0.812	0.770	0.742	0.638	0.529	0.406
Fat Content (%)	S_1	5.57	4.82	3.80	3.46	2.96	2.50
	S_2	4.56	3.53	2.53	2.00	1.42	0.92
	S_3	4.37	4.31	4.19	4.00	3.71	3.52
	S_4	4.51	4.48	4.40	4.26	4.07	4.00
	S_5	5.63	5.33	4.69	3.57	3.42	2.87
	S_6	4.78	4.54	4.11	3.66	3.50	3.03
pH	S_1	4.75	4.63	4.54	4.41	4.00	3.8
	S_2	4.65	4.51	4.31	4.09	3.88	3.52
	S_3	5.92	5.9	5.82	5.77	5.61	5.50
	S_4	6.0	5.95	5.91	5.87	5.83	5.70
	S_5	5.10	4.83	4.77	4.51	4.33	4.03
	S_6	5.50	5.47	5.40	5.23	5.30	4.51
Acid Content (%)	S_1	0.107	0.126	0.141	0.288	0.394	0.710
	S_2	0.115	0.135	0.162	0.209	0.392	0.880
	S_3	0.095	0.103	0.120	0.131	0.136	0.141
	S_4	0.080	0.105	0.121	0.129	0.133	0.137
	S_5	0.100	0.109	0.117	0.128	0.163	0.270
	S_6	0.103	0.115	0.123	0.133	0.140	0.169
TSS (%)	S_1	13.00	11.10	9.00	7.49	5.50	4.00
	S_2	17.00	13.00	8.32	7.00	5.00	3.00
	S_3	15.00	13.99	13.00	11.00	10.00	9.00
	S_4	16.00	15.78	15.00	13.88	13.00	12.00
	S_5	14.49	14.00	12.00	8.50	7.00	6.38
	S_6	14.00	13.28	12.80	11.00	9.12	7.00

Table I.II ANOVA (Analysis of variance) for Moisture Content (%) of Coconut Milks

Source	Degree of freedom	Sum of squares	Mean square	F-value	
				Calculated	Tabulated
Sample	5	141.019	28.204	14.5944	2.6029
Duration	5	286.459	57.292	29.6463	2.6029
Error	25	48.313	1.933		
Total	35	475.792			

Coefficient of variation: 1.56%

Table I.III ANOVA (Analysis of variance) for Ash Content (%) of Coconut Milks

Source	Degree of freedom	Sum of squares	Mean square	F-value	
				Calculated	Tabulated
Sample	5	1.251	0.250	21.2805	2.6029
Duration	5	0.360	0.072	6.1304	2.6029
Error	25	0.294	0.012		
Total	35	1.906			

Coefficient of variation: 31.54%

Table I.IV ANOVA (Analysis of variance) for Fat Content (%) of Coconut Milks

Source	Degree of freedom	Sum of squares	Mean square	F-value	
				Calculated	Tabulated
Sample	5	13.298	2.660	11.0483	2.6029
Duration	5	19.195	3.839	15.9479	2.6029
Error	25	6.018	0.241		
Total	35				

Coefficient of variation: 10.08%

Table I.V ANOVA (Analysis of variance) for pH of Coconut Milks

Source	Degree of freedom	Sum of squares	Mean square	F-value	
				Calculated	Tabulated
Sample	5	23.109	4.622	44.2039	2.6029
Duration	5	4.541	0.908	8.6862	2.6029
Error	25	2.614	0.105		
Total	35	30.264			

Coefficient of variation: 6.59%

Table I.VI ANOVA (Analysis of variance) for Acid Content (%) Color of Coconut Milks

Source	Degree of freedom	Sum of squares	Mean square	F-value	
				Calculated	Tabulated
Sample	5	0.021	0.004	11.0101	2.6029
Duration	5	0.033	0.007	17.6689	2.6029
Error	25	0.009	0.001		
Total	35	0.063			

Coefficient of variation: 13.74%

Table I.VII ANOVA (Analysis of variance) for TSS (%) of Coconut Milks

Source	Degree of freedom	Sum of squares	Mean square	F-value	
				Calculated	Tabulated
Sample	5	141.019	28.204	14.5944	2.6029
Duration	5	286.459	57.292	29.6464	2.6029
Error	25	48.313	1.933		
Total	35				

Coefficient of variation: 12.81%

Appendix -II

Table II.I Rating Score for Color of Coconut Milk

Panelist NO.	Samples (Treatment)					
	S_1	S_2	S_3	S_4	S_5	S_6
1	5	4	7	9	6	6
2	5	5	7	9	5	7
3	7	5	6	8	7	8
4	7	6	8	8	7	7
5	6	7	6	7	6	7
6	7	6	7	8	7	7
7	6	5	7	7	6	6
8	7	6	8	8	6	7
9	7	5	8	9	5	6
10	8	5	7	8	7	5
Total	65	54	71	81	62	66
Mean	6.5	5.4	7.1	8.1	6.2	6.6

Hedonic scale used: 9 =Like extremely, 8 = Like very much, 7 = Like moderately, 6 = Like slightly, 5 = Neither like or unlike, 4 =Dislike slightly, 3 =Dislike moderately, 2 = Dislike very much, 1 = Dislike extremely.

Table II.II ANOVA (Analysis of variance) for Color of Coconut Milk

Source	Degree of freedom	Sum of squares	Mean square	F-value	
				Calculated	Tabulated
Sample	5	40.950	8.190	12.3330	2.4221
Panelist	9	6.817	0.757	1.1405	2.0958
Error	45	29.883	0.664		
Total	59	77.650			

Coefficient of variation: 12.25%

Appendix -III

Table III.I Rating Score for Flavor of Coconut Milk

Panelist NO.	Samples (Treatment)					
	S_1	S_2	S_3	S_4	S_5	S_6
1	8	7	7	9	6	8
2	8	8	8	8	8	8
3	8	7	8	8	7	9
4	7	6	7	8	6	8
5	8	7	8	8	7	7
6	6	8	8	9	6	9
7	7	7	8	8	8	8
8	7	8	8	8	7	7
9	6	8	7	9	8	8
10	8	7	8	8	7	8
Total	73	73	77	83	70	80
Mean	7.3	7.3	7.7	8.3	7.0	8.0

Hedonic scale used: 9 =Like extremely, 8 = Like very much, 7 = Like moderately, 6 = Like slightly, 5 = Neither like or unlike, 4 =Dislike slightly, 3 =Dislike moderately, 2 = Dislike very much, 1 = Dislike extremely.

Table III.II ANOVA (Analysis of variance) for Flavor of Coconut Milks

Source	Degree of freedom	Sum of squares	Mean square	F-value	
				Calculated	Tabulated
Sample	5	12.00	2.400	5.2258	2.4221
Panelist	9	3.733	0.415	0.9032	2.0958
Error	45	20.667	0.459		
Total	59	36.400			

Coefficient of variation: 8.92%

Appendix -IV

Table IV.I Rating Score for Taste of Coconut Milks

Panelist NO.	Samples (Treatment)					
	S_1	S_2	S_3	S_4	S_5	S_6
1	6	5	8	8	6	9
2	7	6	7	8	7	8
3	6	5	7	7	7	8
4	5	4	7	8	6	8
5	7	7	8	8	6	7
6	7	6	7	7	6	8
7	6	6	6	7	6	7
8	7	7	8	8	7	8
9	7	6	7	8	7	9
10	8	7	8	8	7	8
Total	66	59	73	77	65	80
Mean	6.6	5.9	7.3	7.7	6.5	8.0

Hedonic scale used: 9 =Like extremely, 8 = Like very much, 7 = Like moderately, 6 = Like slightly, 5 = Neither like or unlike, 4 =Dislike slightly, 3 =Dislike moderately, 2 = Dislike very much, 1 = Dislike extremely.

Table IV.II ANOVA (Analysis of variance) for Taste of Coconut Milks

Source	Degree of freedom	Sum of squares	Mean square	F-value	
				Calculated	Tabulated
Sample	5	32.00	6.400	17.2800	2.4221
Panelist	9	11.333	1.259	3.4000	2.0958
Error	45	16.667	0.370		
Total	59	60.00			

Coefficient of variation: 8.69%

Appendix -V

Table V.I Rating Score for Overall Acceptability of Coconut Milk

Panelist NO.	Samples (Treatment)					
	S_1	S_2	S_3	S_4	S_5	S_6
1	6	4	8	9	7	8
2	7	6	8	8	6	8
3	7	7	7	8	8	9
4	7	5	6	7	6	7
5	5	5	7	7	6	8
6	7	6	7	8	6	8
7	8	7	8	9	7	8
8	7	7	7	8	6	8
9	7	6	7	8	7	9
10	8	5	8	8	7	8
Total	69	58	73	80	66	81
Mean	6.9	5.8	7.3	8.0	6.6	8.1

Hedonic scale used: 9 =Like extremely, 8 = Like very much, 7 = Like moderately, 6 = Like slightly, 5 = Neither like or unlike, 4 =Dislike slightly, 3 =Dislike moderately, 2 = Dislike very much, 1 = Dislike extremely.

Table V.II ANOVA (Analysis of variance) for Overall Acceptability of Coconut Milk

Source	Degree of freedom	Sum of squares	Mean square	F-value	
				Calculated	Tabulated
Sample	5	38.283	7.657	18.2462	2.4221
Panelist	9	13.017	1.446	3.4466	2.0958
Error	45	18.883	0.420		
Total	59	70.183			

Coefficient of variation: 9.10%

Appendix -VI

Table VI.I Rating score for Color of developed Coconut toffee

Panelist NO.	Samples (Treatment)		
	S_1	S_2	S_3
1	6	8	6
2	8	8	5
3	7	8	7
4	8	7	6
5	8	8	6
6	7	8	7
7	7	8	6
8	8	8	5
9	8	9	6
10	7	8	7
Total	74	80	61
Mean	7.4	8.0	6.1

Hedonic scale used: 9 =Like extremely, 8 = Like very much, 7 = Like moderately, 6 = Like slightly, 5 = Neither like or unlike, 4 =Dislike slightly, 3 =Dislike moderately, 2 = Dislike very much, 1 = Dislike extremely.

Table VI.II ANOVA (Analysis of variance) for Color Developed Coconut toffee

Source	Degree of freedom	Sum of squares	Mean square	F-value	
				Calculated	Tabulated
Sample	2	18.867	9.433	18.5912	3.555
Panelist	9	2.167	0.241	0.4745	2.456
Error	18	9.133	0.507		
Total	29	30.167			

Coefficient of variation: 9.94%

Appendix -VII

Table VII.I Rating Score for Flavor of Developed Coconut toffee

Panelist NO.	Samples (Treatment)		
	S_1	S_2	S_3
1	7	8	6
2	8	8	7
3	6	9	6
4	8	7	7
5	8	8	5
6	6	7	6
7	7	8	7
8	8	8	7
9	8	9	8
10	9	8	7
Total	75	8.	66
Mean	7.5	8.0	6.6

Hedonic scale used: 9 =Like extremely, 8 = Like very much, 7 = Like moderately, 6 = Like slightly, 5 = Neither like or unlike, 4 =Dislike slightly, 3 =Dislike moderately, 2 = Dislike very much, 1 = Dislike extremely.

Table VII.II ANOVA (Analysis of variance) for Flavor of Developed Coconut toffee

Source	Degree of freedom	Sum of squares	Mean square	F-value	
				Calculated	Tabulated
Sample	2	10.067	5.033	9.1208	3.555
Panelist	9	8.967	0.996	1.8054	2.456
Error	18	9.933	0.552		
Total	29	28.967			

Coefficient of variation: 10.08%

Appendix -VIII

Table VIII.I Rating Score for Texture of Developed Coconut toffee

Panelist NO.	Samples (Treatment)		
	S_1	S_2	S_3
1	7	8	6
2	5	8	6
3	7	9	5
4	8	8	7
5	6	7	5
6	6	8	6
7	5	7	4
8	6	7	5
9	8	8	6
10	7	8	5
Total	65	78	55
Mean	6.5	7.8	5.5

Hedonic scale used: 9 =Like extremely, 8 = Like very much, 7 = Like moderately, 6 = Like slightly, 5 = Neither like or unlike, 4 =Dislike slightly, 3 =Dislike moderately, 2 = Dislike very much, 1 = Dislike extremely.

Table VIII.II ANOVA (Analysis of variance) for Texture of Developed Coconut toffee

Source	Degree of freedom	Sum of squares	Mean square	F-value	
				Calculated	Tabulated
Replication	2	26.60	13.30	32.3514	3.555
Factor A	9	13.20	1.467	3.5676	2.456
Error	18	7.40	0.411		
Total	29	47.20			

Coefficient of variation: 9.71%

Appendix -IX

Table IX.I Rating Score for Taste of Developed Coconut toffee

Panelist NO.	Samples (Treatment)		
	S_1	S_2	S_3
1	7	9	5
2	6	9	5
3	8	9	7
4	6	8	6
5	7	8	7
6	7	7	6
7	6	8	5
8	7	8	7
9	6	9	6
10	7	8	5
Total	67	83	59
Mean	6.7	8.3	5.9

Hedonic scale used: 9 =Like extremely, 8 = Like very much, 7 = Like moderately, 6 = Like slightly, 5 = Neither like or unlike, 4 =Dislike slightly, 3 =Dislike moderately, 2 = Dislike very much, 1 = Dislike extremely.

Table IX.IIANOVA (Analysis of variance) for Taste of Developed Coconut toffee

Source	Degree of freedom	Sum of squares	Mean square	F-value	
				Calculated	Tabulated
Sample	2	29.867	14.933	30.5455	3.555
Panelist	9	6.300	0.700	1.4318	2.456
Error	18	8.80	0.489		
Total	29				

Coefficient of variation: 10.04%

Appendix -X

Table X.I Rating score for overall acceptability of Developed Coconut toffee

Panelist NO.	Samples (Treatment)		
	S_1	S_2	S_3
1	6	9	6
2	8	8	8
3	7	8	5
4	6	9	6
5	7	8	6
6	7	8	8
7	8	8	6
8	7	8	5
9	7	8	7
10	8	8	7
Total	71	82	64
Mean	7.1	8.2	6.4

Hedonic scale used: 9 =Like extremely, 8 = Like very much, 7 = Like moderately, 6 = Like slightly, 5 = Neither like or unlike, 4 =Dislike slightly, 3 =Dislike moderately, 2 = Dislike very much, 1 = Dislike extremely.

Table X.II ANOVA (Analysis of variance) for overall acceptability of Developed Coconut toffee

Source	Degree of freedom	Sum of squares	Mean square	F-value	
				Calculated	Tabulated
Sample	2	16.467	8.233	12.8497	3.555
Panelist	9	5.367	0.596	0.9306	2.456
Error	18	11.533	0.641		
Total	29	33.367			

Coefficient of variation: 11.07%

Appendix –XI

Table XI.I Microbial load in storage period

Microbial load (cfu/ ml)×10⁴	Sample	Processing Days					
		0 day	5 day	10 day	15 day	20day	25 day
	S_1	52	64	88	116	156	300
	S_2	68	76	107	140	188	248
	S_3	48	60	72	84	92	105
	S_4	44	56	68	80	96	102
	S_5	40	52	64	92	120	168
	S_6	56	60	72	96	105	148

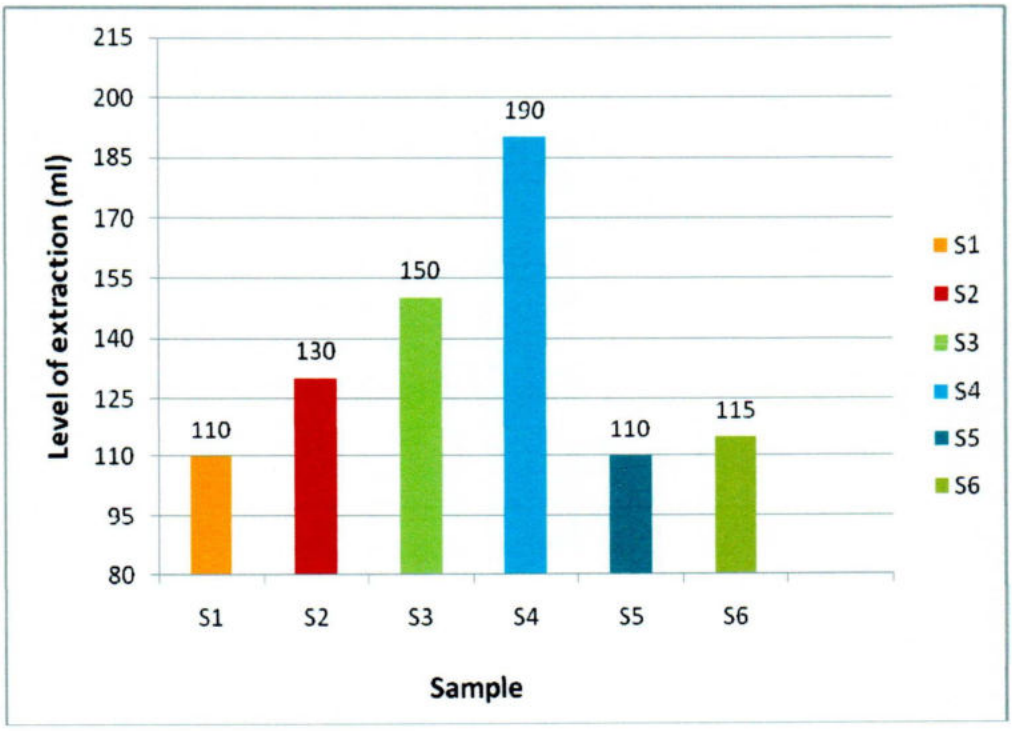

Fig. XI.II Effect of pretreatment on the level of extraction of coconut milk

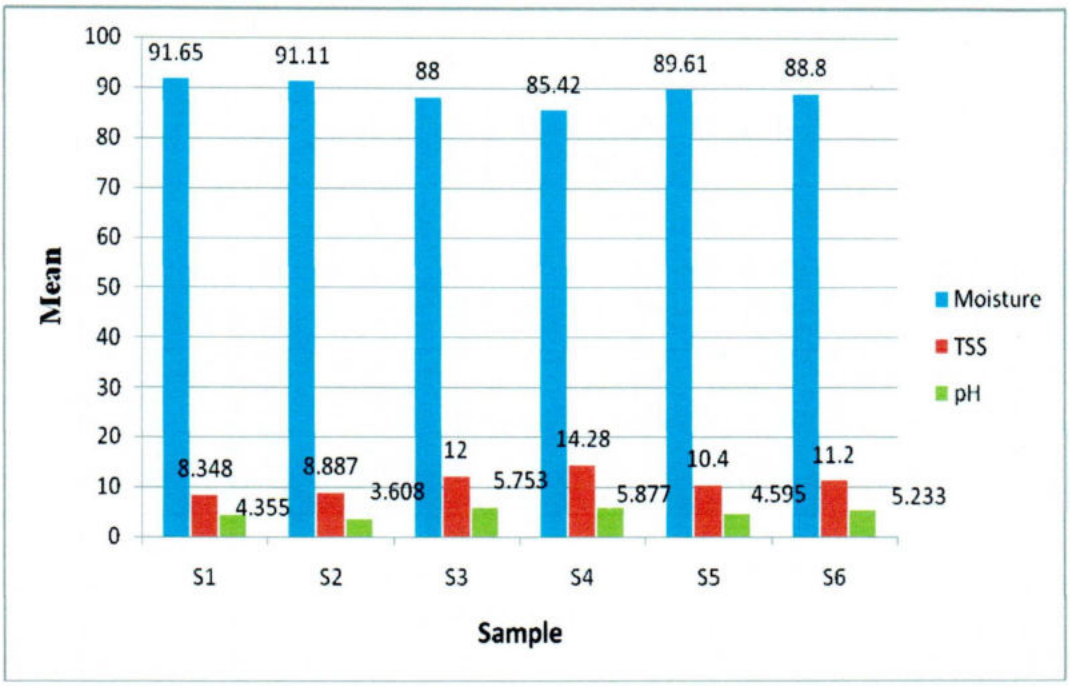

Fig. XI.III Effect of pretreatment on the mean of moisture, TSS and pH of stored coconut milk in high density polyethylene at refrigeration condition

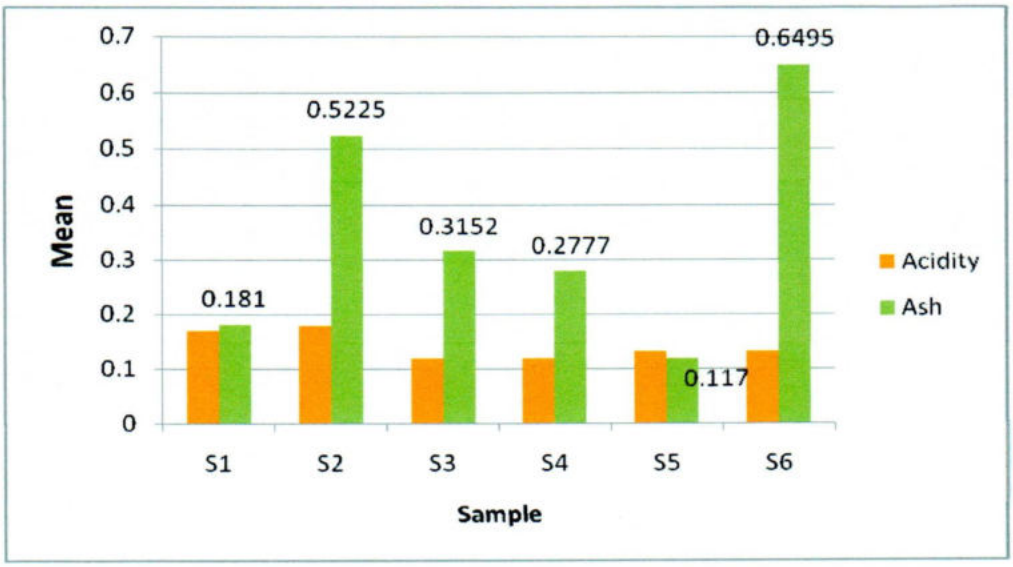

Fig. XI.IV Effect of pretreatment on the mean of ash and acidity of stored coconut milk in high density polyethylene at refrigeration condition

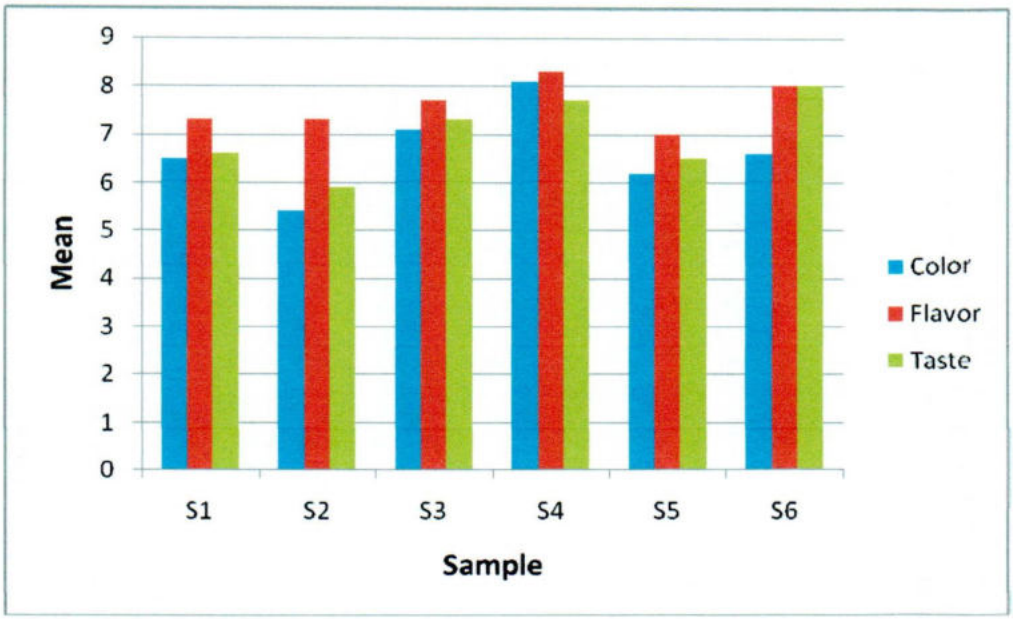

Fig. XI.V Acceptability of coconut milk preference based on mean score of parameters

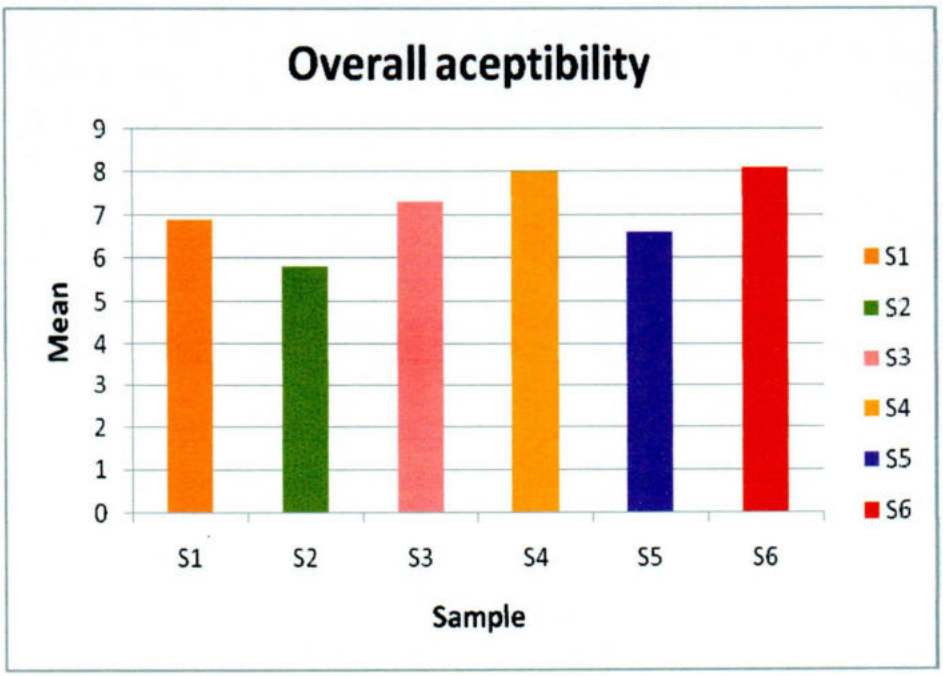

Fig. XI.VI Overall acceptability of coconut milk preference based on mean score

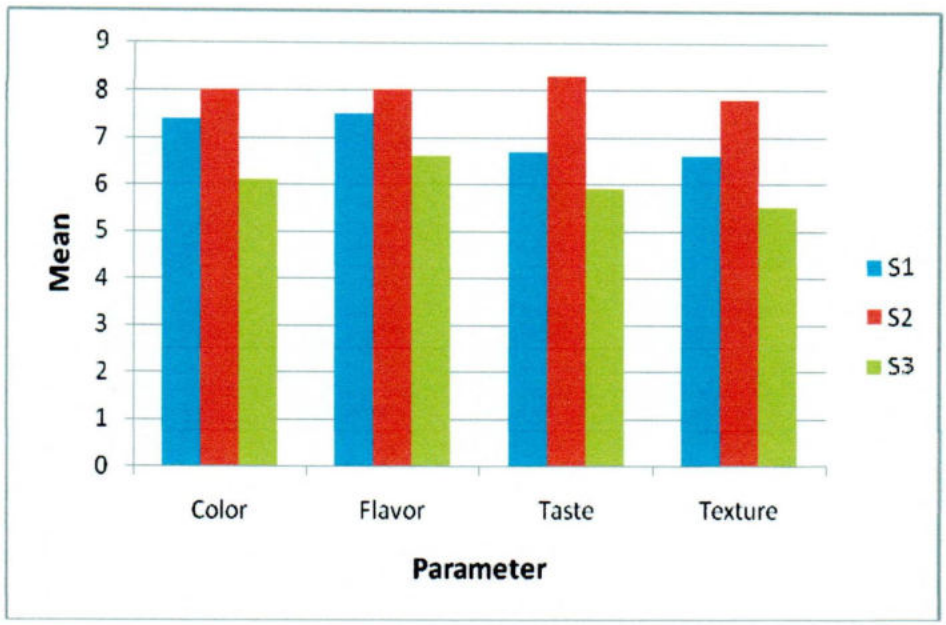

Fig. XI.VII Acceptability of coconut toffee preference based on mean score

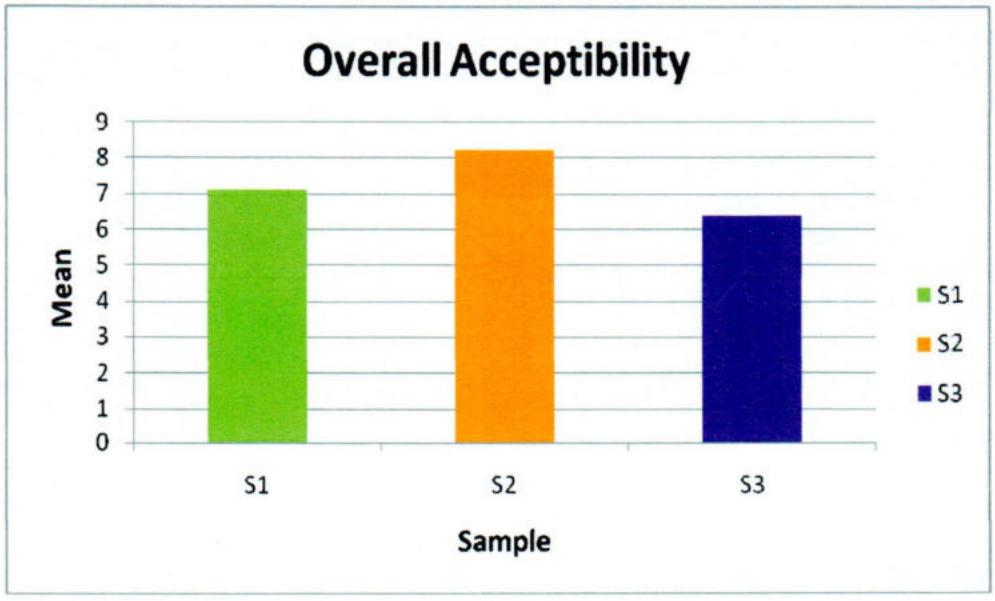

Fig. XI.VIII Overall acceptability of coconut toffee preference based on mean score

APPENDIX XII

SCORE CARD FOR HEDONIC RATING TEST OF COCONUT MILKS

Name of the Tester: ..... Date: .....

Please taste these samples and check how much you like or dislike each one on four sensory attributes such as color, flavor, taste and overall acceptability. Use the appropriate scale to show your attitude by checking at the point that describes your feeling about sample. You can also give your comments on each sample, if any you have.

Parameters	Sample Identity					
	S_1	S_2	S_3	S_4	S_5	S_6
Color						
Flavor						
Taste						
Overall acceptability						

Hedonic scale used:

Like extremely=9	Dislike slightly=4
Like very much=8	Dislike moderately=3
Like moderately=7	Dislike very much=2
Like slightly=6	Dislike extremely=1

Extra comments on each sample, if any

.....

Signature

APPENDIX XIII

SCORE CARD FOR HEDONIC RATING TEST OF DEVELOPING COCONUT TOFFEES FROM COCONUT SOLIDS WITH DIFFERENT COMPOSITION

Name of the Tester: ..... Date: .....

Please taste these samples and check how much you like or dislike each one on five sensory attributes such as color, flavor, Texture, taste and overall acceptability. Use the appropriate scale to show your attitude by checking at the point that describes your feeling about sample. You can also give your comments on each sample, if any you have.

Sample Identity	Parameters				
	Color	Flavor	Texture	Taste	Overall acceptability
A					
B					
C					

Hedonic scale used:

Like extremely=9	Dislike slightly=4
Like very much=8	Dislike moderately=3
Like moderately=7	Dislike very much=2
Like slightly=6	Dislike extremely=1

Extra comments on each sample, if any

.....

Signature