KWAME NKRUMAH
UNIVERSITY OF SCIENCE AND TECHNOLOGY
KUMASI, GHANA

DEPARTMENT OF BIOCHEMISTRY AND BIOTECHNOLOGY
FACULTY OF BIOSCIENCES
COLLEGE OF SCIENCE

MSC FOOD SCIENCE AND TECHNOLOGY

THESIS

Topic:

DEVELOPMENT OF CHEESE PRODUCT FROM COCONUT MILK

By:
ALFRED KABUTEY OCANSEY

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A THESIS SUBMITTED TO THE BOARD OF POST GRADUATE STUDIES, KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE MASTER OF SCIENCE (MSC) DEGREE IN FOOD SCIENCE AND TECHNOLOGY.

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Supervisor:
Prof J.H. Oldham

DECLARATION

I hereby declare that this work is the result of my own original research and that no part of it has been published part or in whole for another certificate in this university or anywhere else.

Candidate:

Name: …….

Signature: …….

Date: …….

Supervisor:

Name: …….

Signature: …….

Date: …….

Certified by:

Head of Department: …….

Signature: ……

Date: ……

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I acknowledge with contentment the fulfilled presence of God as wisdom, strength and ability throughout the period and process of fulfilling this critical obligation to my life's work.

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I acknowledge with affection the undying support and encouragement of a loving mum, a brother and a partner who constitutes my family now and into forever.

Thank You!

ABSTRACT

The project was aimed at the preparation of cheese products by partial substitution of cow's milk with coconut milk and investigating the proximate quality, textural characteristic, keeping quality and sensory attributes of the developed product. The yield of cheese was 305.4 g, 151.8 g and 270.0 g per 1000 g respectively of 100% cow's milk cheese product, 100% coconut milk product and a 50%:50% blend of both. Laboratory analysis was carried out to ascertain the extent of variation in moisture, protein, fat and ash content. Moisture, ash and fibre contents increased with increasing coconut milk content while the opposite was recorded for protein content, which peaked at 17.26% for 100% cow's milk cheese. Salting samples in 10% NaCl solution retarded the rate of change of all parameters. The keeping quality was determined to be three (3) days for all product treatments (raw, boiling in water and boiling in 10% NaCl) which was extended to seven (7) days by repeated boiling (on days 2 and 4) and to twenty (20) days by repeated boiling on days 2, 4, 8, 12 and 16 in 10% NaCl. The flavour characteristic was scored the highest in respect of sensory appeal while colour recorded the lowest average scores. The strongest correlation was between taste and curd firmness (0.226), however at $P<0.05$ level the correlation between curd firmness and colour was the most significant. The 70% cow's milk: 30% coconut milk cheese product was the most preferred and recommended for market exploration.

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CHAPTER 1

1.0 INTRODUCTION

Coconut production and processing have been the predominant economic activities in rural communities in many tropical regions of South-east Asia, the South Pacific and to a lesser extent the west coast of Africa. Traditionally, production of coconut oil from "copra" (dehydrated coconut meat) has been the largest economic sector of the coconut industry (Hagenmaier, 1977). Although copra contains proteins of reasonably good nutritional quality, its use as food has been limited for various reasons, these are lipid oxidation and microbial contamination due to the high temperature and unsanitary conditions during drying and storage (Hagenmaier, 1977). Other limiting factors are high crude fibre content and poor protein recovery as a result of the low protein content of the nut and poor protein extractability (Arkanit, 1996). Although many coconut-producing countries are in dire need of additional food proteins, most of the potentially valuable coconut proteins have thus far been wasted because of these problems.

This study was undertaken on the justification that the utilisation of coconut can be improved and new food products can be developed using coconut derivatives for the purpose of expanding its use and minimizing waste of the potentially valuable indigenous food source in the coconut-producing countries.

In most coconut-producing countries, the current capacity for local production of cow's milk is very small and the majority of cow milk and other dairy products are manufactured from imported milk. Over the years, the importation of extremely large quantities of milk to satisfy the consumer demands for milk and other dairy products has been the source of genuine concern for the governments, processors and consumers alike because the imported milk is expensive and it drains large sums of foreign exchange reserves. It is therefore regarded as urgent and timely to develop dairy-type products from less expensive alternative sources of indigenous raw materials, such as coconuts, to compliment the locally produced milk and to develop new dairy foods with minimum use of the imported dairy ingredients (Sringam, 1993).

The new products developed from coconut could potentially be of desirable nutritional composition especially in relation to cholesterol inducing fat levels, being as it is that the saturated fat content in coconut milk has been shown to be a good saturated fat, easily metabolized to give the body quick energy (Timmen and Patton, 1989).
Contrary to popular myth, coconut oil (fat) does not transform into bad cholesterol to clog up arteries. In fact, cultures around the world that depend on coconut as their main source of fat have been found to be free of heart disease. The principal fatty acid in coconut milk is lauric acid, which is the same fatty acid found in abundance in mothers' milk and is known to promote normal brain development and contribute to healthy bones (Timmen and Patton, 1989). Coconut also has important anti-carcinogenic and anti-pathogenic properties and is less likely to cause weight gain than polyunsaturated oils (Coconut Research Centre, 2004).

Among other products, the modern coconut industry is capable of producing two basic types of valuable products from coconuts for food uses: the traditional coconut oil and the coconut protein. Traditionally, the majority of coconut protein is recovered and used in the form of coconut milk, both full fat and defatted (or skimmed).

Most previous studies have focused on the preparation and stability maintenance of coconut milk. Sringam (1986) studied the effect of single-stage extraction and two-stage counter current extraction and fat–protein emulsion of coconut milk on preparation and stability maintenance of coconut milk. Vitali *et al,* (1985) studied the effect of dissolved gums and sugar on the flow behaviour of coconut milk (7.5%, 33.5% and 34.5% fat content) over the temperature range of 15–50 ^{o}C.

However, some published reports have indicated that coconut protein could be used, along with coconut fat, to prepare highly acceptable and relatively inexpensive new types of dairy-like foods such as custard-like products, various types of cheeses (soft, Cheddar and blue cheeses), yogurt and drinks. Davide *et al*. (1987) investigated the potential of water-extracted coconut milk as a less expensive substitute for butterfat in the manufacture of fresh soft cheese. Furthermore, Davide *et al*. (1986 and 1988) developed

a fresh soft cheese spiced with garlic (Queso de Ajo) starter and blue-type cheese, from a blend of skim milk powder and coconut milk. The coconut cheeses were then compared with control cheeses similarly prepared from fresh cow's milk. These notwithstanding however, information regarding the use of coconut protein as one of the major raw materials for preparation of dairy-like products is very scarce.

The potential for a cheese product from coconut and cow's milk blend is always an alternative as coconut milk is very rich in emulsifiers and it is a natural oil-in-water emulsion just like cow's milk; hence, both can mix readily. The blend also has pH of about 6.5 similar to that of milk (Hagenmaier, 1977).

1.1 OBJECTIVES

The objective of this study was to develop a cheese product from "coconut milk" using indigenous vegetable rennet as cheese coagulant.

Specific objectives

Towards the attainment of the general objective, specific activities were carried out in fulfilment of the following specific objectives;

- Preparation of cheese products from coconut milk, cow's milk and milk blends
- Proximate and textural characteristic analysis on prepared cheese products
- Keeping quality (shelf life) and sensory evaluation on prepared cheese products

CHAPTER 2

2.0 LITERATURE REVIEW

2.1 COCONUT

The coconut is essentially a tropical plant growing mostly between 20^{o}N 20^{o}S latitudes. It is a large hard-shelled oval nut with a fibrous husk containing thick white meat surrounding a central cavity filled (when fresh) with fluid or milk and is highly nutritious and rich in fibre, vitamins, and minerals (www.wikipedia.com). It is classified as a "functional food" because it provides many health benefits beyond its nutritional content (Pamplona-Roger, 2007). The scientific name for coconut is *Cocos nucifera*.

The coconut provides a nutritious source of meat, juice, milk, and oil that has fed and nourished populations around the world for generations (Coconut Research Center, 2004). There are two major varieties, the tall and dwarf varieties. A third the Hydrid variety was developed from the original two. All these varieties grow significantly well in the West African region but is only used for copra oil and fresh fruit consumption (Oil Palm Research Institute, 2008).

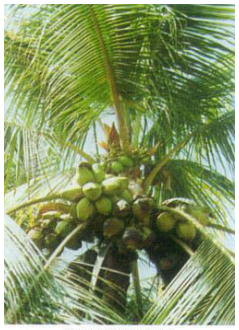

Figure 1: Coconut Varieties in Pictures

Left: West Coast Tall (Tall Variety)

Middle: Hybrid Variety

Right: Dwarf Variety

2.1.1 COCONUT FAT

Coconut possesses many health benefits due to its fibre and nutritional benefits because of its fat, coconut oil. Coconut oil was once believed to be unhealthy because of its high saturated fat content (94%). The fat in coconut oil is unique and different from most all other fats and possesses many health giving properties and is gaining recognition as a

nutritious health food (Coconut Research Center, 2004). Coconut oil has been described as "the healthiest oil on earth.”. The difference is in the type of fat molecules (Pamplona-Roger, 2007).

All fats and oils are composed of molecules called fatty acids. There are two methods of classifying fatty acids. The first is based on saturation; there are saturated fats, monounsaturated fats, and polyunsaturated fats. The other system of classification is based on molecular size or length of the carbon chain within each fatty acid. In this system there are short-chain fatty acids (SCFA), medium-chain fatty acids (MCFA), and long-chain fatty acids (LCFA) (Thompson *et al.,* 1961). Coconut oil is composed predominately of medium-chain fatty acids (MCFA), also known as medium-chain triglycerides (MCT) (Pamplona-Roger, 2007).

The vast majority of fats and oils in our diets, whether they are saturated or unsaturated or come from animals or plants, are composed of long-chain fatty acids (LCFA). Some 98 to 100% of all the fatty acids consumed are LCFA (Thompson *et al.,* 1961).

The size of the fatty acid is important because the human body responds to and metabolizes each fatty acid differently depending on its size. So the physiological effects of MCFA in coconut oil are distinctly different from those of LCFA more commonly found in our foods. The saturated fatty acids in coconut oil are predominately medium-chain fatty acids. Both the saturated and unsaturated fat found in meat, milk, eggs, and plants (including almost all vegetable oils) are composed of LCFA (Pamplona-Roger, 2007).

MCFA are very different from LCFA. They do not have a negative effect on cholesterol and help to protect against heart disease. MCFA help to lower the risk of both atherosclerosis and heart disease. It is primarily due to the MCFA in coconut oil that makes it so special and so beneficial. There are only a very few good dietary sources of MCFA. The best sources of MCFA are coconut and palm kernel oils (Coconut Research Center, 2004). The composition of coconut oil is given in Table 1.

Table 1: Composition of Coconut Oil

Fatty Acid	Carbon Atoms	Type	Proportion (%)
Caproic acid	6	Saturated	0.6
Caprillic acid	8	Saturated	7.4
Capric acid	10	Saturated	5.9
Lauric acid	12	Saturated	47.2
Myristic acid	14	Saturated	18.6
Palmitic acid	16	Saturated	9
Stearic acid	18	Saturated	5.5
Oleic acid	18	Mono-unsaturated	4.6
Linoleic acid	18	Poly-unsaturated	1.2

Source: Pamplona-Roger, 2007

2.1.2 COCONUT MEAT

Coconut meat is the edible white meat of a coconut; often shredded for use in cakes and curries. It contains essential mineral salts particularly magnesium, calcium and phosphorus which are of great importance to the musculoskeletal system. Though present in small amounts (32 mg/100 g of magnesium) in coconut meat, the Magnesium content surpasses that of all animal-based foods including meat, fish, milk and eggs (Pamplona-Roger, 2007). Nutritional data on raw coconut meat is given in Table 2.

Table 2: Nutritional Data on Raw Coconut Meat

Nutrient	Units	Value per 100 grams of edible portions
Water	g	46.99
Energy	kcal	354
Energy	kj	1481
Protein	g	3.33
Total Lipid (fat)	g	33.49
Ash (minerals)	g	0.97
Carbohydrate, by difference	g	15.23
Fibre, total dietary	g	9.00
Sugars, total	g	6.23

Source: USDA National Nutrient Database for Standard Reference, (2004)

Coconut meat has been used in traditional medicine to balance blood sugar and control diabetes, protect against cancer, ease painful colitis and the discomforts of irritable bowel syndrome. It is also used to help with weight loss, expel intestinal parasites, improve digestive function and aid in the elimination of haemorrhoids and varicose veins (www.nutritiondata.com).

2.1.3 COCONUT MILK

Coconut milk is a sweet, milky white cooking base derived from the meat of a mature coconut fruit. The colour and rich taste of the milk can be attributed to the high oil content (approximately 17%) and sugars. It should not be confused with coconut water (coconut juice), which is the naturally-occurring liquid found inside a coconut (Coconut Research Center, 2004).

Two grades of coconut milk exist: *thick* and *thin*. *Thick* coconut milk is prepared by directly squeezing grated coconut meat through cheese cloth. The squeezed coconut meat is then soaked in warm water and squeezed a second or third time for *thin* coconut milk. Thick milk is used mainly to make desserts and rich, dry sauces. Thin milk is used for soups and general cooking (www.nutritiondata.com). Some nutritional data on raw coconut milk is shown in Table 3.

Table 3: Nutritional Data on Raw Coconut milk

Nutrient	Units	Value per 100 grams of edible portions
Water	g	67.62
Energy	kcal	230
Energy	kj	962
Protein	g	2.29
Total Lipid (fat)	g	23.84
Ash	g	0.72
Carbohydrate, by difference	g	5.54
Fibre, total dietary	g	2.20
Sugars, total	g	3.34

Source: USDA National Nutrient Database for Standard Reference, (2004)

2.2 MILK

2.2.1 DEFINITION OF MILK

Milk is defined as lacteal secretion, practically free from colostrums, obtained by the complete milking of one or more healthy cows. Milk that is in the final form for beverage use should be pasteurized, and should not contain less than 8.25% milk solid –not – fat and not less than 3.25% milk fat (FDA, 1998).

2.2.2 SOURCES OF MILK

Nature designed milk as food for the young. Thousands of years ago, mankind learned of the possibilities of both milk and milk products as food not only for the young but also for adults. Accordingly, through selection and breeding, man has greatly increased the milk-producing function of those animals best adopted as a source of milk and has used milk of many animals for his own food (Bauman and Davis, 1974).

Cross and Overby (1988) reported that the cow is adapted to temperate zones and the people of Europe and in those regions where they have migrated, such as North America, Australia and New Zealand, are the main users of cow milk and its products.

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In Southern Europe the milk of goats and sheep is used, the Lapps of Northern Europe use the milk of reindeer. In Southeast Asia the milk of Water Buffalo is used. Other animals used as a source of milk for human food include the mare, the camel and the Lama. Although species mentioned above are sources of milk, the cow supplies by far the largest proportion of this product. Therefore most scientific information is focused on cow milk as reported by Cross and Overby (1988).

2.2.3. WORLD MILK PRODUCTION

Table 4 shows the total production of milk for selected countries as at 1994. Total world milk production stood at 453,733 metric tones (MT) with Europe producing the largest amount of 153,392 MT whilst Africa produced the least. World milk production figures are given in Table 4.

Table 4: World Milk Production

CONTINENT/ COUNTRY	QUANTITY (MT)
World	453,733
Europe	153,392
North America	86,481
Asia	66,792
Russian Federation	42,600
South America	34,175
Africa	14,680
Ghana	23

Source: FAO (1994)

2.2.4 MILK PRODUCTION IN GHANA

Dairying in Ghana has not been developed very well. Milk products sold in Ghana include milk powder, evaporated milk, ice cream, and yoghurt which is mostly produced from imported milk. The estimated demand per annum for dairy products from 1989 to 1995 is shown in Table 5.

Table 5: Estimated Demand for Selected Dairy Products in Ghana (Tonnes)

Year	Reconstituted Milk and cream	Evaporated Milk (sweet)	Evaporate Milk (unsweetened)	Butter	Total
1989	31,500	204.7	257.4	540.6	32,503
1990	33,070	210.8	265.2	551.4	34,097
1991	34,715	217.2	273.1	573.5	35,779
1992	36,451	223.6	281.3	584.9	37,541
1993	38,273	230.5	289.7	596.6	39,390
1994	40,187	237.3	298.4	608.6	41,331
1995	41,196	244.4	307.4	620.7	42,369

Source: CSIR (1990)

ISSER (1994) reported that imports of dairy products rose sharply to about 78% between 1992 and 1994. Increases occurred in all products; butter, cheese, milk powder and others, except liquid milk for which imports declined marginally by less than 1%.

2.2.5 CONSTITUENTS OF MILK

The major constituents of milk are water, protein, fat and lactose. The minor components are vitamins, minerals and salts. Lactose and casein most readily distinguishes milk from other foods. Table 6 shows the percent composition of milk used for human food. Milk differs widely in composition, the greatest difference being between species of mammals, but within species the composition depends on factors such as race, lactation period, and technique of feeding and milking frequency (Kaufmann and Hagemeister, 1987). There are differences in composition in the early stages of lactation (from colostrums to mature milk). There is a markedly high protein (immunoglobulin) content, especially during the first six days after calving, whereas the lactose content is reduced. Seasonal influences on composition of milk especially fat content has been attributed to factors such as stage of lactation and date of calving, kind and composition of feed ration (pasture or indoor feeding), energy supply and milk yield. Higher energy supply of rations leads to increased protein synthesis in the rumen (Kaufman and Hagemeister, 1987). In an experiment performed by Grant and Patel (1980), concentrates had no significant influence on the protein content of milk.

Table 6: Percent Composition of Milk Used for Human Food

Mammal	**Total Solids**	**Fat**	**Protein**	**Casein**	**Lactose**	**Ash**
Cow	12.60	3.80	3.35	2.78	4.75	0.70
Goat	13.18	4.24	3.70	2.80	2.80	0.70
Sheep	17.00	5.30	6.30	4.60	4.60	0.80
Water Bufallo	16.77	7.45	3.78	3.00	4.88	0.78
Zebu	13.45	4.97	3.18	2.38	4.59	0.74
Woman	12.57	3.75	1.63		6.98	0.21

Source: Potter and Hotchkiss, (1995)

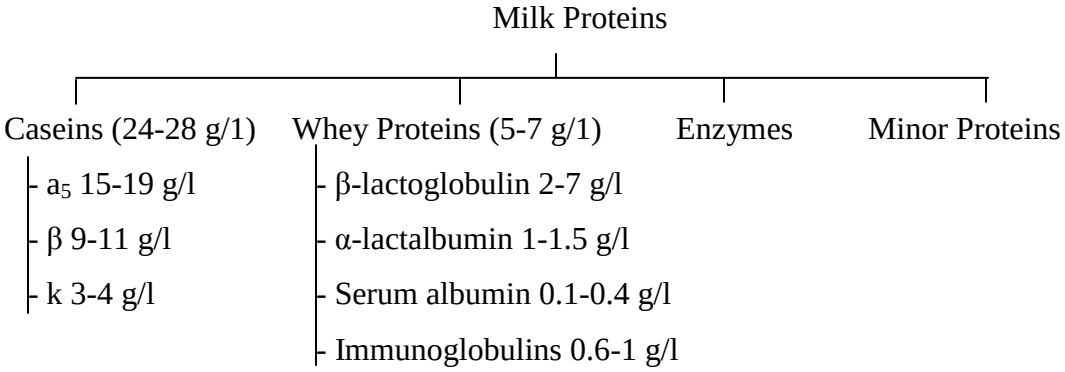
2.2.5.1. Water

Water is the major component of milk, representing 87% of the total composition. The other components are suspended or dissolved in this medium. A small amount of water is bound to the milk protein and some hydrated to the lactose and salts giving milk a water activity (a_w) of 0.993 (Jenness, 1988).

2.2.5.2. Protein

The major proteins in milk are the caseins. Figure 2 shows the distribution of protein fractions in bovine milk.

Figure 2: Distribution of Protein Fractions in Bovine Milk



2.2.5.2.1. Caseins

The caseins are a group of phosphor proteins in milk. They are conjugated proteins containing phosphoric acid as the prosthetic group. Acidification of raw skimmed milk to pH 4.6 at 20^{o}C will coagulate this fraction (Eigel *et al*., 1984). The casein proteins include four groups; α_1-caseins, α_2-caseins, β-caseins, and k-caseins. The composition of the major caseins in the micelles are α_1 (38%), α_2 (10%), β (36%) and k (13%).

The primary structures of the amino acid sequences may be used to identify these components (Eigel *et al*., 1984). At the pH of milk (6.6) casein is present as a colloidal phosphate complex known as calcium calcinate and dispersed as particles called micelles. Reflection of light by the micelle is responsible for the white colour of milk.

The α- and β- caseins are calcium sensitive or insoluble, whereas k-casein is soluble in the presence of calcium. k-casein has a stabilizing effect on the casein micelle, permitting the existence of the colloidal dispersion and preventing the other caseins from precipitating. Therefore if k-casein is proteolysed by the action of the enzyme rennin, it results in destabilization of the caseinate complex, thus forming an insoluble part, the para-caseinate, and a soluble part, the whey proteose. As a result of the destabilization of the k-casein, the milk clots and a gel is formed (Berg, 1988). Until recently ɣ-casein was considered to be a distinct fraction accounting for 3% of whole casein. It has been shown by electrophoresis to be identical to the C-terminal of β-casein (Gordon *et al*., 1972; Groves *et al*., 1973).

2.2.5.2.2. Whey Proteins

"Whey" protein is a general term used to refer to milk proteins that are soluble at pH 4.6 at 20^{o}C. Proteins in the whey fraction include β-lactogolobin, α-lactalbumin, serum albumin, and immunoglobuls. In addition, the whey fraction includes fragments of β-casein and other heat-stable polypeptides (Eigel *et al*., 1984). β-lactoglobin is the major whey protein, representing 50% of the whey proteins (Farrell, 1988), followed by α-lactalbumins constituting 25% of the whey proteins (George and Lebenthal, 1981).

Whey proteins are denatured with heating above 60^{o}C. Heating also causes aggregation of the denatured whey (Morr, 1975).

2.2.5.2.3. Enzymes

Milk contains many enzymes. Kaufmann and Hagemeister (1987) suggested 3 possible origins of enzymes in milk. They are

i) Secreted by mammary tissue and released with other synthesized components
ii) From micro-organisms in milk
iii) Presence of leucocytes and various cell organelles

The enzymes found in cow's milk include lactoperoxidase, alkaline phosphomonoesterase (alkaline phosphatase), lipase, esterases, phosphatases, xanthine oxidase, protease, amylase, catalase, aldolase, ribonuclease, lysozyme, carbonic

anhydrase, and others (Whitney, 1988). The most abundant enzyme in bovine skimmed milk is lactoperoxidase with concentration of 30 mg/1 (Groves *et al.*, 1973). Lipase sometimes causes hydrolytic rancidity in dairy products made from milk that has not been heated enough to inactivate this enzyme.

2.2.5.3. Fat

Lipids are water-insoluble organic biomolecules that can be extracted from cells and tissues by non-polar solvents. According to Lehninger (1977), lipids, perform important biological functions. These functions include;

1. being structural components of membranes
2. storage and transport forms of metabolic fuel
3. as protective coating on the surface of many organisms
4. as cell surface components concerned in cell recognition, species specificity, and tissue immunity.

The bulk (99%) of bovine milk lipid exists in the form of fat globules, which average 0.13 µm in diameter. The remainder occur in membrane fragments in the skimmed milk phase (Huang and Kuksis, 1967). Each fat globule is surrounded by an interfacial layer or milk membrane (Eskin, 1990). This layer is composed mainly of triacyglycerols (95%) with small amount of triglycerides, free fatty acids, mono-glycerides, phospholipids and traces of cholesterol esters. In addition to these components, the MFGM layer also contains trace elements, enzymes, proteins and glycoprotein. The MFGM layer stabilizes the fat phase in milk. The outer surfaces of the MFGM are quite labile and can be removed by simple washing procedures and by temperature manipulation. Such losses of the outer surface have an impact on the processing and storage of milk. The lipids also include 0.5-1% phospholipids, 0.06% glycolipids, 0.3% cholesterol and traces of free fatty acids (0.1-0.4%), sterols and fat-soluble vitamins (Kurtz, 1974; Renner, 1982). Milk of ruminants contains a wide range of free fatty acids with chain lengths from C4 to C18 (Kaufmann and Hagemeister, 1987). The data in Table 7 shows the average acid composition of milk fats in various species. These are influenced by different factors such as the composition of the diet (Kirchgessner *et al.*, 1965; Christie, 1981). Changes in the

fatty acid composition of milk fat affect the keeping qualities and flavour of milk, the physical properties of milk fat and its suitability for manufacturing (Astrup *et al*., 1979).

Table 7: Average (%) Fatty Acid Composition of Milk Fats in Various Species

Fatty Acid	Human	Rabbit	Sheep	Cow	Goat	Coconut
4:0	0	0	10.3	10.5	7.5	0.000
6:0	0	0	3.4	4.6	4.7	0.136
8:0	0	44.9	2.3	2.2	4.3	1.670
10:0	1.9	23.4	3.4	4.0	12.8	1.327
12:0	7.4	1.1	4.6	4.4	6.6	10.576
14:0	8.4	0.8	5.0	11.3	11.8	4.176
16:0	24.0	8.6	20.9	25.6	24.1	2.021
16:1	2.1	0.9	1.2	1.8	2.2	0.000
18:0	5.7	1.4	15.5	7.5	4.7	1.234
18:1	29.4	8.4	27.2	18.3	16.5	1.014
18:2	15.3	9.3	2.9	1.9	2.8	0.261
18:3	0.6	0.5	2.4	1.4	0	0.000
Others	5.2	0	3.7	6.5	2.0	-

Source: Kaufmann and Hagemeister (1987)

There are as many as 400 fatty acids, both saturated and unsaturated (Jensen and Clark, 1988). Milk is distinguished from other food fats by its content of short chain fatty acids such as butyric, capprylic and capric acids.

2.2.5.4. Lactose

Lactose, the major carbohydrate of milk, is found in cows's milk at levels of approximately 4.8% (Holsinger, 1988). Of all the common sugars, lactose has the lowest relative sweetness, and it is the least soluble (17 g per 100 g at 20^{o}C) (Aurand and Woods, 1973). In addition to lactose, milk contains small amounts of glucose, galactose, and other saccharides (Jenness, 1988). When milk is coagulated, greater percentage of the lactose is present in the whey (from which it can be prepared commercially) and the

remaining in the curd. For this reason, cheese that is prepared from the curd is low in carbohydrates (Penfield and Campbell, 1990).

Upon digestion, lactose yields glucose and galactose (Holsinger, 1988). Lactose-intolerant individuals lack the enzyme, β-D-galactosidase, lactase or galactohydrolase, which breaks down lactose in the small intestine. Therefore, lactose passes down to the large intestine. Discomfort results when lactose in fermented by bacteria in the large intestine. Thus a demand exists for products in which the lactose has been removed during processing, such as natural cheeses, or has been hydrolysed during fermentation; and there is also demand for the enzyme lactase for the treatment of milk by consumers. Houts (1988) and Savaiano and Kotz (1988) in their reviews have described lactose-intolerance and the possible uses of dairy products by individuals who are lactose-intolerant.

The unique chemical and physical properties of lactose are used to advantage in the food industry. Lactose readily absorbs flavours, aromas, and colouring materials (Holsinger, 1988) hence it is used as a carrier for such substances. Lactose is a component in biscuit and other baking mixes. In baked goods, lactose readily reacts with protein via the Maillard reaction to form the golden brown colour found in the crusts. Lactose is not fermented by yeast so its emulsifying properties are effective throughout the baking process. Lactose is used in infant foods as a coating agent and for the production of lactic acid. It is also used as a preservative for flavour, colour, and consistency in meat products (Aurand and Woods, 1973).

2.2.5.5. Salts, Trace Elements, and Vitamins

According to Kaufmann and Hagemeister (1987) milk salts are important in 3 principal areas of dairy chemistry:

1. Some of the salt constituents especially Calcium and Phosphorous are of great importance in nutrition.
2. The physical state and stability of the milk proteins, particularly of casein, are strongly dependent on the composition of the salt system.

3. Certain metallic elements in milk particularly Cu and Fe, catalyse oxidation of milk lipids, which lead to undesirable flavours.

The mineral salts of milk constitute less than 1% of the milk. Anionic components include chlorides, phosphates, sulphates, carbonates and citrates and cations in the largest amounts are calcium, potassium, sodium, and magnesium (Jenness, 1988). The stage of lactation is of significant influence on the mineral content of milk as shown by Penfield and Campbell (1990) in Table 8.

Table 8: Mineral Composition of Colostrums and Transition of Normal Milk of Holstein cow (%)

Time after Calving	Na	K	Ca	Mg	P	Cl
At Parturition	0.074	0.137	0.256	0.037	0.235	0.118
6 hrs	0.061	0.128	0.196	0.027	0.178	0.118
12 hrs	0.051	0.132	0.154	0.014	0.146	0.101
24 hrs	0.050	0.145	0.150	0.013	0.137	0.102
2 days	0.049	0.139	0.148	0.013	0.127	0.098
3 days	0.065	0.146	0.176	0.013	0.176	0.099
11 days	0.036	0.153	0.130	0.011	0.113	-

Source: Penfield and Campbell, 1990

All the minerals from the soil in which the cow obtains her feed are present in milk, some of them only in trace amounts (Kaufmann and Hagemeister, 1987). Cobalt, copper and iodine may be low due to deficiencies in the soil content. Copper is significant to the sensory quality of milk because it exerts a catalytic effect on the development of oxidized flavour. Other trace elements include iron, magnesium, molybdenum, nickel and zinc (Penfield and Campbell, 1990). Metal utensils and equipment are significant sources of some elements, such as copper, iron, nickel, and zinc. Milk contains many vitamins, some of them in abundance, and some in small quantities. The fat-soluble vitamins A, D, E, and K are associated with the fat component of milk, while the water-soluble vitamins,

the B-complex and vitamin C, are found in the non-fat portion. The quantities of most of the fat-soluble vitamins in milk are principally dependent upon those present in the diet of the cow. The water-soluble vitamins and vitamin K are under normal conditions largely independent of the diet since they are synthesized by rumen flora of the cow or by the tissues. Table 9 summarizes the vitamin contents and ranges.

Table 9: Average Contents of Vitamins (Mg/1) in Cow Milk

Vitamin	**Mean**	**Range**
A	0.37	0.10-0.90
B_1 Thiamin	0.43	0.2-0.8
B_2 Riboflavin	1.74	0.81-2.58
B_6 Pyridoxine	0.6	0.17-1.90
B_{12} Cobalamine	0.0042	0.0024-0.007
Niacin	0.93	0.3-2.0
Folic Acid	0.059	0.038-0.09
Panthothenic Acid	3.39	2.58-4.9
Inositol	160	30-400
C Ascorbic Acid	20.9	15.7-27.5
D Calciferol	0.0008	0.0001-0.0020
E Tocopherol	1.0	0.2-1.84
Biotin	0.03	0.012-0.06
Choline	137	43-285

Source: Hartmann and Dryden, (1978)

Riboflavin is responsible for the light yellowish tint of skimmed milk. Exposure to light results in degradation of riboflavin. Riboflavin in skimmed milk is more susceptible to degradation than the vitamin in whole milk. Palanuk *et al*. (1988) demonstrated that skimmed milk at top of translucent container may after five days storage under light contain only 58% of the riboflavin initially present and that the fat-soluble vitamin A precursor, carotene, is responsible for the yellowish colour of milk fat.

2.2.5.6. Biological Contaminants

According to Le Jaouen (1987) perfectly healthy milk when drawn from the udder, contains a number of materials, including a large quantity of cellular waste from the blood and the udder, and bacteria usually localized in the teat which have spread into the udder itself. Among the most important micro-organisms naturally present in milk are bacteria and moulds. Some of these are useful to human health. Others are pathogenic and quite harmful to human health, such as the bacteria, which produce brucellosis or foot and mouth disease. Bacteria flora proliferate in milk which is itself an excellent culture when favourable conditions exist. While the quantity of micro-organisms is important, their quality matters much more. Useful bacteria co-habit with harmful ones. Bacteria are indispensable to events such as acidification and ripening.

Milk contamination comes from three aspects (Le Jaouen, 1987).:

1. The initial flora, which is unavoidable and present in the milk no matter what precautions are taken.
2. The initial flora which can be avoided by taking certain hygienic measures and cleaning procedures.
3. The multiplication of the flora, the abundance of which depends upon the degree of natural contamination of the milk and the precautions taken while milking.

The key to cheese makers' art and science therefore, is to know how to impede the development of harmful ones

2.2.6. PHYSICAL PROPERTIES OF MILK

2.2.6.1. Physical State

Milk is an oil-in-water emulsion whose various constituents differ widely in molecular size and solubility. The smallest molecules, those of salts, lactose, and water-soluble vitamins are in true solution. The proteins including enzymes are in colloidal state because of the large size of their molecules (0.05-0.5 μm). The fat in non-homogenized milk is present as globules of larger than colloidal size. Homogenization causes changes

in the membrane which prevent coalescence of the fat globules. The membrane exhibits a typical bi-layer membrane structure (Keenan *et al*., 1988).

2.2.6.2. Acidity

The hydrogen ion concentration of fresh milk is 6.6 at 25^{o}C. The concentration lies on the acid side of the pH scale. It is well buffered by protein and salts, especially the phosphates. The pH of milk is temperature dependent. When milk is heated, its pH decreases because hydrogen ions are liberated when calcium phosphate precipitates (Sherbon, 1988).

2.2.6.3. Viscosity

Whole and skimmed milk are Newtonian fluids (their consistency changes with rate of shear). Their viscosities depend only on temperature, whereas the viscosities of the non-Newtonian creams, concentrated milks, and butter depend also on shear rate. The quantity of dispersed solids influences the viscosity. Thus, whole milk is more viscous than skimmed milk, which is more viscous than whey (Sherbon, 1988). At 20^{o}C skimmed milk and whole milk have viscosities of 1.5 cP and 2.0 cP respectively (Cross and Overby, 1988).

2.2.6.1. Freezing Point

The freezing point of milk is slightly lower than that of water because of the presence of lactose and soluble salts. Reported values range from-2.531 to -0.570^{o}C (Sherbon, 1988). Determination of the freezing point can be used for detection of milk to which water has been added.

2.2.6.5. Surface Tension

Compared with water, the surface tension of milk is low. At 20^{0}C the surface tension of milk is 50 dyn cm^{-1}. Milk fat, proteins, free fatty acids, and phospholipids lower the surface tension of the milk (Sherbon, 1988).

2.2.6.6. Fat Stability

The milk fat globules are liquid when in the udder. The fat globules are described in section 2.1.5.3. According to Klostermeyer and Reimerdes (1976) the milk fat will

crystallize by cooling, starting from the outer part of the globule and continuing inwards when it leaves the udder. Depending on the fat composition and cooling rate, this crystallization may lead to disruption of membranes of the fat globules which causes an impairment of the fat emulsion stability.

Badings and van der Pol (1973) found that cooling below 5^0C caused an adsorption of S-containing material from the membranes to the serum phase. Patton *et al*. (1980) has shown that cooling raw milk at 2-4^0C for 24 hr will results in an increase of phospholipids in serum. Christiansen (1982) showed that cold-separation of cold-stored raw milk gives whipping cream with improved whip ability, but reduce fat emulsion stability.

2.2.7. NUTRITIONAL FUNCTIONS OF MILK

O'Conner (1993) indicated that milk is a main source of nutrients for most young mammals for lengths of time, which vary with the species. Milk serves the following broad functions: growth, supply of energy, maintenance and repair of body tissue, and appetite satisfaction.

Milk contains various nutritionally important components, namely proteins, carbohydrates, lipids, minerals, vitamins and water. The metabolically available energy is approximately 4.0, 4.1 and 8.9 kcal/g (16.8, 17.0 and 37.0 kJ/g) for lactose, protein and fat, respectively. The chief function of lactose in milk is to supply energy for muscular activity and maintenance of body temperature. Cow milk forms a firm curd in the stomach and digestion is slower than with human milk (De Wit, 1989).

Milk lipids supply the body with a concentrated source of energy and are important contributors to both desirable and undesirable flavours in milk and milk products. Certain fatty acids are not synthesized by the animal in enough quantities as indicated in Table 7 (Kaufmann and Hagemeister, 1987). They include polyunsaturated acids, linoleic ($C_{18:2}$) and linolenic acid ($C_{18:3}$). It is considered that 2-4% of the energy of the diet should be supplied by polyunsaturated acids. The linoleic acid content in human milk fat accounts

for 5% of the energy in milk. This is much higher than for cow milk, which accounts for only about 1% of the total energy. Milk is an excellent source of Vitamins A, D, E and K. Milk is a major source of some of the vitamins needed by infants and adults. It is relatively rich in Vitamins A and E, thiamin, riboflavin, folic acid and Vitamin B_{12}. However, large variations occur between human and cow milk (Adams *et al.*, 1975).

Human milk contains only 35% as much thiamin, 25% as much riboflavin and 5% as much B_{12} as cow milk. On the other hand human milk contains 10 times as much Vitamin E and 2.5 times as much ascorbic acid as cow milk. Vitamin A is central to the visual processes as a constituent of the visual pigment rhodopsin (Eckles, 1943). Vitamin D is essential for the calcification process in the body, including bone and teeth formation. The high levels of calcium and phosphorous in milk are important in bone and tooth formation in young children; both these elements play a significant role in preventing osteoporosis in elderly people (Penfield and Campbell, 1990). The mineral content is shown in Table 8 (section 2.1.5.5). Milk also contains high levels of magnesium, zinc and iodine. However, milk is a poor source of iron and neither human nor cow milk supply enough for human infants. Infants have a store of iron in the liver, which is sufficient to meet the needs of the body during the first six months (Dowd and Dent, 1937).

2.2.8. ALTERATION OF MILK THROUGH PROCESSING AND THE EFFECT ON NUTRITIVE VALUE

Prior to the consumption of milk as fluid milk or as a product from fluid milk, milk is subjected to one or more treatments that may influence the characteristics of the product. Milk is treated to preserve it. Treatment may include one or more heat treatments, coagulation and/or dehydration and may influence flavour, colour, texture, functional properties, and nutritional value (Egounlety, 1985).

2.2.8.1. Heat Treatments and their Effects

2.2.8.1.1. Pasteurization

Pasteurization is the mild heat treatment of products. It is used to destroy selected vegetative and/or pathogenic micro-organisms and inactivation of enzymes which may

cause the development of off-flavours. It results in the increase in keeping quality. It may be accomplished by one of several treatments that meet FDA requirements (FDA, 1998). Pasteurization conditions include heating at 62^{o}C for 30 minutes, 72^{0}C for 15 seconds or 138^{0}C for seconds (Hill, 1998).

Mild heat treatment such as pasteurization causes very little change in nutritive value. Severe heat treatment results in some loss of available lysine, but this has little effect on traditional quality because milk proteins are rich in lysine (Hansen, 1997).

The use of a High-Temperature-Short-Time (HTST) such as 72^{0}C or higher for 15 seconds, changes the flavour more than the holding method of at least 62^{0}C for 30 minutes. Some of the most common off-flavours in milk are rancid and oxidized flavours. Boiling changes the flavour of milk more than pasteurization does. Off-flavours may be attributed to free sulfhydryl, aldehydes and ketones (Hansen, 1997). Hutton and Patton (1992) reported that sulfhydryl groups of β-lactoglobulin, which give rise to hydrogen sulphide with denaturation are responsible for the cooked flavour of milk. The interaction between lysine and lactose during heating results in formation of a brown pigment (Maillard browning) that causes off-flavours to develop during storage of milk products. Oxidized flavour, is accelerated by traces of copper; this finding has caused a virtual elimination of copper containing equipment from dairies (Hutton and Patton, 1992).

2.2.8.2. Evaporation and Canning

The functions of evaporation are to;

i) pre-concentrate food for drying, freezing or sterilization,
ii) increase solid content of product
iii) reduce water activity
iv) convenience for consumer or manufacturer
v) change flavour and/or colour of food.

To produce evaporated milk, milk is warmed and concentrated to slightly more than double the solids content of the fluid whole milk (25% total milk solids including 7.5% milk fat) (FDA, 1998). Then it is homogenized, sealed in cans, and sterilized. The

characteristic ‘cooked’ flavour of evaporated milk is caused by the high temperature required in canning. The milk is sterilized at 115 to 118^{0}C for 15 to 20 minute (Morr and Richter, 1988).

Methyl sulphide, a component that is responsible for a “cowy” flavour in fresh milk (Patton *et al*., 1956), has been found at elevated levels in evaporated milk, suggesting that it plays a role in the cooked flavour. Off-colours may develop in evaporated milk stored at high temperatures for long periods of time as a result of carbonyl amine browning. Flavour deterioration in concentrated milk in the form of cooked, scorched and staled notes was greater at 20 and 37^{0}C than at 4^{0}C when concentrated milk was stored for 8 months (Loney *et al*., 1968).

2.2.8.3. Drying

Drying of food is aimed at:

i) removal of water
ii) reducing water activity
iii) reducing product weight and volume
iv) reducing microbial deterioration
v) retarding enzymatic reactions
vi) improving product transportation and storage
vii) providing convenience foods

Methods used for drying foods include cabinet drying, tunnel drying, belt drying, spray drying, drum drying, vacuum/tray drying and freeze-drying. The methods used for the product of whole dry milk powder (WDM), non-fat dry milk (NFDM) and other dried milk products are described by Knipschidt (1986) and Bodyfelf *et al*. (1988) and include spray drying and freeze-drying.

Non fat dry milk of less than 4% moisture can be stored at 21^{0}C for 18 months. Non-fat dry milk products are described by a heat treatment classification based on the extent of denaturaton of the whey proteins. Functional performance varies with the degree of denaturation (Kinsella, 1984). The dispensability of NFDM is improved by

agglomeration, a process that involves re-wetting and re-drying. Instantised NFDM produced by this process has a light, granular texture and is dispersed easily (Neff and Morris, 1998).

Whole milk powder deteriorates more rapidly in storage than Non-Fat-Dry-Milk (NFDM). Oxidation of the milk fats results in *tallowy* flavour, and the carbonyl-amine reaction is responsible for the stale flavour that develops (Penfield and Campbell, 1990). Ingredients in chocolate products, soup mixes and confections may mask the flavours of WDM (Pomeranz, 1985). In candies, the proteins from Whole Dry Milk (WDM) provide a chewy matrix. The whey proteins facilitate the air incorporation and the fat provides flavour (Kinsella, 1984). Deterioration of WDM may be delayed by preheating, reducing its moisture content, adding small amounts of antioxidant, packaging with nitrogen or carbon dioxide in a sealed container, or storing at low temperatures (Cheryan, 1975).

Not-fat dry milk is blended with thickners, sweetners, flavour components, vitamins, and minerals and then instantized to produce instant beverage products (Kinsella, 1984). Calorie content is varied by selection of sweetener.

2.2.8.4. Effect of Buttering

During buttering the fat and the fat-soluble vitamins are retained in the butter while the protein, lactose, minerals and B-vitamins remains in the buttermilk (Morr, 1969).

2.2.9. KEEPING QUALITY OF MILK

Milk is an excellent nutrient medium for spoilage agents (saprophytic bacteria) due to its complex biochemical composition and high water activity. These micro-organisms are the limiting factors of the keeping quality of milk. They are also indicators of the hygienic condition of milk (Mabbit, 1981). Milk undergoes various changes during storage. The changes may be microbial, fat breakdown, protein breakdown and fermentation of lactose.

2.2.9.1. Microbial Changes

The effect of growth of bacteria in raw milk may be important in 3 ways (Mabbit, 1981). First, the change in milk composition may interfere with manufacturing process especially if fermentation takes place and this may affect the yield quality and quantity of the product e.g. cheese. Second, the flavour of raw milk may be adversely influenced by rancidity and this may directly affect the flavour of the product made from rancid milk. Third, heat-stable bacterial enzymes may continue to act in the product, particularly during long storage periods, and adversely affect stability and/or flavour of cream and ultra high temperature (UHT) milk (Mabbit, 1981).

2.2.9.2. Fat Breakdown

The stability of the fat globule in milk is associated with the composition of a mixture of neutral and polar lipids associated with lipid-compatible proteins derived from the alveolar epithelium (IDF, 1980). The lipoproteins form a protective membrane or layer around the lipid mixture. If this membrane is damaged, for instance, by shearing in the milking machine pipeline or rough handling or stirring, free fat surfaces are exposed to hydrolytic enzymes. This lost protection may be partially regained by adsorption of milk protein at the lipid interface as it occurs after homogenization. Lipases attack only the exposed lipid. Some bacteria however have phospholipases which will also attack or breakdown the lipoprotein complexes of the membrane. The lipases of psychrotrophic bacteria are heat-tolerant (Cogan, 1980). In certain types of cheese these enzymes may cause development of rancid strains during ripening (Conolly *et al*., 1980). The oxidative deterioration of lipids is caused by oxidation (involving oxygen) of unsaturated fatty acids-mainly oleic, linolenic and linoleic acids – resulting in the production of volatile aldehydes, ketones and alcohols. The most important factor which influences the oxidation of fat is the composition of the fat. Other factors accelerating the rate of lipid oxidation are high temperature, light and trace elements (copper and iron). Oxidation is inhibited by exclusion of oxygen, refrigeration and packaging in opaque or coloured containers (O'Conner, 1993).

2.2.9.3. Protein Breakdown

Although most of the caseins in milk are in micellar form and are maintained in colloidal suspension by their surface properties the amount of casein in solution is appreciable to

provide significant concentrations of substrate for any proteases present. Psychrotrophs, like pseudomonas from milk produce extracellular proteinases throughout their exponential growth (Adams *et al*., 1975). The proteinases of the gram-negative bacteria are mainly endopeptidase. The growth of proteolytic bacteria in raw milk not only has disadvantages with respect to flavour defects and loss of product yield but in certain cases has some advantages; for instance the growth of starter bacteria can be improved (Cousin and Marth, 1977).

2.2.9.4. Fermentation of Lactose

The problems arising from fermentation of lactose in uncooled milk are caused by the mesophilic lactic acid bacteria, resulting in souring and curdling. The stability of the milk-fat emulsion and the casein suspension is dependent on interacting equillibria, particularly in relation to Ca^{2+} ions and serum protein. Small changes in the pH of milk may induce changes in heat stability as there is dramatic decrease in milk stability between pH of 6.5 and 6.3. This leads to coagulation of milk on boiling (Kitchen, 1985).

2.3 CHEESE

2.3.1 DEFINITION OF CHEESE

Cheese is the fresh or matured product obtained after coagulation and draining of milk, cream, skimmed or partly skimmed milk, buttermilk or a combination of some or all of these products (FAO/ WHO, 1973).

2.3.2 CHEESE PRODUCING POTENTIAL OF MILK

The cheese producing potential of milk is defined by the number of kilograms of cheese obtained from 10 kg of milk or the number of kilograms of cheese produced from a litre of milk. Cheese output is directly related to the amount of milk solids in the milk and more specifically, to the amount of protein (Le Jaouen 1987).

Yields of curds from unstored milk are higher than from milk which has been stored raw for several days at 4^oC before heat treatment and manufacture (Cousin and Marth, 1977). Storage at 4^oC for several days is common in advanced dairy industries. Lower yields are thought to be due to loss of low molecular-weight casein-degradation products released

by the action of heat-resistant extracellular proteinases of psychotrophic bacteria which dominates refrigerated milk micro-flora (Law *et al*., 1979).

2.3.3 COMPOSITION OF CHEESE

The composition and properties of cheese depend on the method of production, composition of milk and previous treatments of milk (Holsinger, 1988). Table 10 shows the composition of different varieties of cheese. Moisture content of cheese may be as high as 79% as in Uncreamed cottage cheese with fat as low as 0.3%. Protein content of cheese varies greatly with Cream cottage having as low as 13.3% and Parmesan as high as 37.5%.

Table 10: Nutritional Composition of some Cheeses

Variety	**Moisture (%)**	**Fat (%)**	**Protein (%)**	**Ash (Salt-free) (%)**	**Salt (%)**	**Calcium (%)**	**Phosphorus (%)**
Brick	41.3	31.0	22.1	1.2	1.8	-	-
Brie	51.3	26.1	19.6	1.5	1.5	-	-
Camconbort	50.3	26.0	19.8	1.2	2.5	0.69	0.50
Cheddar	37.5	32.8	24.2	1.9	1.5	0.86	0.6
Uncreamed Cottage	79.5	0.3	15.0	0.8	1.0	0.10	0.15
Creamed Cottage	79.2	4.3	13.2	0.8	1.0	0.12	0.15
Edam	39.5	3.8	30.6	2.3	2.8	0.85	0.55
Gorgonzola	35.8	32.0	26.0	2.6	2.4	-	-
Limburger	45.5	28.0	22.0	2.0	2.1	0.5	0.4
Neufchatel	55.0	25.0	16.0	1.2	1.0	-	-
Parmesan	31.0	27.5	37.5	3.0	1.8	1.2	1.0
Roquefort	39.5	33.0	22.0	2.3	4.2	0.65	0.45
Swiss	39.0	28.0	27.0	2.0	1.2	0.9	0.75

Source: Potter and Hotchkiss (1995)

2.3.4 CLASSIFICATION OF CHEESE

The criteria for classifying cheese depends on the type of coagulation, type of cheese making (industrial or farmstead), cheese-making technique, method, shape, geographical origin, mixed milk content, exterior aspect (colour, moulds), consistency (soft or hard) and current legislation (Le Jaouen, 1987). Penfield and Campbell (1990) reported that the

moisture content of hard cheeses and semi-soft cheeses to be in the ranges of 30-40% and 50-75% respectively. FAO/ WHO (1973) has classified cheese as indicated in Table 11.

Table 11: FAO/WHO Classification of Cheese by Fat Content

Classification	**Fat Content (%)**
High Fat	<60
Full Cream	45-60
Half Fat	25-45
Low Fat	10-25
Skimmed	<10

Source: FAO/ WHO (1973)

According to Potter and Hotchkiss (1995) the basic types of cheese evolved as products of different types of milk, regional environmental conditions, accidents, and gradual improvement by trial and error. There are over 800 names of cheeses, but many of the names describe similar products made in different localities or in different sizes and shapes. Of these, however, only about 18 are distinct types of natural cheeses, reflecting the different processes by which they are made.

Potter and Hotchkiss (1995) indicated a means of classifying the types and important varieties of cheeses. It is based largely on the textural properties of the cheeses and the primary kind of ripening. There are hard cheeses, semi-hard cheeses, and soft cheeses, depending on their moisture content, and they may be ripened by bacteria or moulds, or they may be unripened. The bacteria may produce gas, and so form eyes as in the case of Swiss cheese, or they may not produce gas as in the case of cheddar and so no eyes are formed. Table 12 illustrates classification suggested by Davies and Hammond (1988).

Table 12: Classification of Cheese

Country of Origin	Name of Cheese	Type	Colour	Texture	Flavour
Britain	Caerphilly	Semi-hard	Creamy White	Semi-smooth	Mild, slightly salty
	Cheddar	Hard	Golden orange-red,	Close	Mallow, nutty
	Cheshire	Hard	Orange-red white or blue-veined	Loose, crumbly	Mild, mellow, slightly salty
	Derby	Hard	White or honey-coloured with patches of green sage added	Smooth	Mild
	Double Gloucester	Hard	Straw to light-red	Close smooth	Mellow, quite pungent
	Lancashire	Semi-hard	White	Soft, crumbly	Mild
	Leicester	Hard	Rich red	Soft, crumby	Mild, mellow
	Stilton blue-veined	Internal mould	Creamy white with blue veins	Soft, close	Rich, creamy, mellow
	Wensleydale blue	Internal mould	Blue veins	Soft, close	Rich, creamy, sweet
France	Brie	Whitish	Semi-liquid	Semi-liquid	Mild
	Camembert	External mould	Whitish	Semi-liquid	pungent
	Port salut	Semi-hard	Creamy	Soft, rubbery	Mild
Holland	Edam	Semi-hard	Red or yellow skin-orange inside	Firm, leathery	Mild
	Gouda	Semi-hard	Red or yellow skin-paler than Edam inside	Soft	Mild
Italy	Parmesan	Hard	Skin varies, cream inside	Very hard, granular	Sharp
Switzerland	Emmental	Hard	Pale yellow	Firm with big holes	Mild, sweet

2.3.5 CHEESE PRODUCTION AROUND THE WORLD

Table 13 shows the cheese production profile around the world. Total world production was 14,907.8 tonnes in 1995 with EC-12 nations producing 38.8%. United States of

America was the single highest producer with production standing at 3,200 tonnes (21.47% of world total production)

Table 13: Cheese Production around the World (Tonnes)

Country	**1993**	**1994**	**1995**
U.S.A	2,961	3,053.0	3,200.0
France	1,442.0	1,462.0	1476.0
Germany	1,338.0	1,399.0	1450.0
Italy	640.0	630.0	630.0
Netherlands	640.0	658.0	660.0
UK	331.0	324.0	340.0
Denmark	322.4	287.7	300.0
Poland	310.0	345.0	360
Canada	270.5	281.5	290.0
Spain	265.0	271.0	268.0
Australia	210.6	233.6	225.0
India	183.0	190.0	n.a*
New Zealand	145.5	192.5	193.0
Switzerland	136.0	135.0	n.a
Sweden	126.0	133.0	n.a
Belgium	123.6	121.5	n.a
Japan	100.0	103.0	n.a
Kenya	25.0	20.0	27.0
Zimbabwe	1.3	1.4	1.5
Ghana	n.a	n.a	n.a
EC-12	5,724.0	5,736.0	5,790.0
Other W. Europe	518.6	528.1	534.0
North America	3,231.5	3,334.5	3,490.0
Pacific	456.1	529.1	519.0
Eastern Europe	2,284.6	2,205.9	2,283.4
World	14,471.3	14,65.3	14,907.8

*n.a means Not Available

Source: Bulletin of the International Dairy Federation NO. 303/1995

2.3.6 MANUFACTURE OF CHEESE, ROLE OF ENZYMES, PROTEINS AND FAT

Cheese is made most commonly from cow milk but the milk of other mammals may be used. Pasteurized milk is used in most cases. The curd is separated from the whey and may be allowed to ripen by the action of enzymes from micro-organisms or animal sources to produce a natural cheese (Shimp, 1985).

Use of milk concentrated by ultra filtration can facilitate cheese production by allowing lowering of processing temperatures (Sharma *et al*., 1989). Ultra filtration of milk, a high pressure micro-filtration process, results in removal of water and low molecular weight solutes (Kosikowski, 1986; Hettinga, 1988). The product of ultra filtration will coagulate more rapidly than fresh milk. The resultant curd is firmer than curd from fresh milk (Kosikowki, 1986).

Manufacturing of cheese involves selection of milk, coagulation of milk, cutting of curds, cooking of curds, draining of curds, salting and milling of curds, forming, pressing, curing and ripening.

2.3.6.1 Selection of Milk for Cheese-Making

Le Jaouen (1987) suggested that good cheese making milk must meet the following criteria:

1. It must be free of any visible impurity
2. It must not have any abnormal taste or odour
3. Its pH must be 6.6 or only slightly higher than at milking time.
4. The naturally occurring lactic acid producing bacteria and yeasts or the starter culture bacteria must be able to survive and reproduce to the proper number in the milk.
5. The milk must contain no foreign substances such as antibiotics, antiseptics and cleaning products.
6. The milk must not be contaminated by either pathogenic micro-organisms which may prove undesirable for the production of cheese.

2.3.6.2 Coagulation of Milk

Milk for cheese production may be clotted with acid or rennet or both.

2.3.6.2.1 Acid Coagulation

Acid coagulation (for cheese making) can be achieved by the addition of an organic acid such as citric acid, acetic acid or tartaric acid, high-acid whey or through adding starter culture. Lowering of pH may occur at room temperature without the addition of acid directly to milk for instance, as in the case of cottage cheese. The pH may be lowered on the other hand with the addition of acid at temperatures above 80^0C as in the case with Italian Ricotta. The pH of milk for cottage cheese must be lowered to 4.6. For Ricotta (above 80^0C) lowering the pH to 5.6 is sufficient (Cross and Overby, 1988). When adding acid to milk, the calcium and phosphorus are progressively removed from the milk until at the iso-electric point of pH 4.6 when the casein is completely free of salts and the caseins coagulate (DeMan, 1990).

Micro-organisms starters used for cheese, buttermilk and sour cream belong to the genus *Leuconostoc*. An active starter performs 3 important functions in the manufacture of a cultured product (Kosikowski, 1966):

First in "the making" procedure for cheese or cultured milk, there must be controlled or regulated acid production by the culture. The extent of acid production is extremely important in developing the desired consistency and texture. The stability of the calcium-casein complex of milk decreases gradually as the acidity increases. In a multiple strain starter the *streptococci* convert lactose to lactic acid and the acid formed establishes the optimum pH for *leuconostoc* to convert milk citric acid to diacetyl (Kosikowski, 1966).

A second function of the starter is to produce the desired and characteristic flavour. Flavour results from bacteria enzymatic action on the substrate and the production of metabolic compounds such as lactic, acetic and propionic acids, aldehydes, alcohols, esters and fatty acids (Kosikowski, 1966).

A third function is the prevention of growth of undesirable micro organisms that may have survived pasteurization or contaminated the product from the air, equipment and/or personnel. Inhibition is caused primarily by the production of lactic acid establishing a pH that is unfavourable to growth. Some strains of *S. lactics* and species of Leuconostoc are known to produce inhibitory substances other than acids (Kosikowski, 1966).

Starter species include *Streptococcus lactis*, *Streptococcus cremoris*, *Streptococcus diacetilactis*, and *Leuconostoc dextranicum*. Starter cultures may comprise a single strain or mixture of Streptococcus with *Leuconostac species* (Webb and Whittier, 1970). *Lactic streptococci* are homofermentative in nature in that they produce lactic acid from sugars in yields ranging from 80 – 90%. *Leuconostic* species belong to heterofermentative group of lactic acid bacteria which produces acetic acid from fermentative carbohydrate (Webb and Whittier, 1970).

2.3.6.2.2 Enzyme Coagulation

Enzymatic coagulates are used in cheese making. Formerly, the clotting of milk was achieved primarily by using rennin (calf gastric enzyme, chymosin). Rennin acts most effectively at pH 6.7 (Bingham, 1975) and a temperature of about 40^0C. Rennin coagulates milk without the decrease in pH. This property is used in cheese making to coagulate the casein. A smooth elastic gel is produced approximately 20-30 minutes after rennet addition (0.2 g rennet per kg milk). If liquid rennet is added to milk at pH 6.4, 80% of the clotting activity is observed, in most commercial preparations, due to chymosin while the remaining 20% comes from bovine pepsin. However, if the milk pH is higher e.g. pH 6.6, the clotting activity due to chymosin increases while the activity of bovine pepsin, markedly influenced by pH, is much reduced (Cross and Overby, 1988). The industrial preparation of rennin is known as rennet. Industrial rennet can be of animal or vegetable origin.

Rennet has two activities in cheese making (Berg, 1988):

- To coagulate the milk
- To breakdown protein in the cheese, thus contributing to the ripening process.

Enzymatic coagulation of milk involves two (2) phases: enzymatic phase and gel formation phase. According to Cross and Overby (1988), the gel formation is highly dependent upon temperature, much more so than the enzymatic reaction. It proceeds very slowly below 15^0C. Rennin is involved in first phase (enzymatic phase), in which a specific bond of k-casein is cleaved to form insoluble para-k-casein and a soluble peptide (Bingham, 1975). The protecting effect of k-casein on the milk colloidal suspension is then lost. In the second phase, a clot is formed by the para k-casein and calcium (Cheryan *et al.*, 1975). As soon as k-casein starts splitting off, the milk micelles start to aggregate as a result of chance intermolecular collisions; chains of micelles are first formed which are later linked together by more and more bridges, thus progressively forming smaller and smaller mesh net. The coagulation of milk through the addition of an enzymatic milk clotting agent can be obtained only if Ca^{2+} ions are present (Cross and Overby, 1988). Heating milk above 65^0C and then cooling it prior to treatment with rennin reduces clotting rate and curd firmness. A heat-induced interaction between k-casein and β-lactoglobulin may delay the action of rennin on k-casein (Sawyer, 1969).

2.3.6.2.3 Rennet Substitutes

Rennet can be obtained from either animal or plant origins. The availability of rennin is limited, proteolytic enzymes from other sources may be used for clotting of milk in cheese production (NRC, 1981). Rennet from animal sources may be from veal calf, bovine, and porcine pepsin, *Mucor milhei*, *Mucor pusillus* or *Endothia parasitica* (Pszczola, 1989).

Extracts from various plants, like Ficus (ficin from the fig tree), Papaya (papain) and Bromelin from pineapple have been used, with rather unsatisfactory results. The major objection to vegetable rennet is extreme proteolytic activity, which results in extremely bitter tastes (Vieira de Sa and Barbosa, 1972). There are a few exceptions to the general rule, such as the production of Queijo da Serra (Portugal) and a few varieties of plants in West Africa with a coagulant consisting of *Cynara cardunaculus* a plant related to the antichoke or similar coagulants (Berg, 1988). Another commonly used vegetable rennet is an extract from the Dead Sea Apple shrub (*Calotropis procera*). It contains the enzyme, calotropin, which is more active at pH 6.4 (Aworh and Nakai, 1986).

2.3.6.3 Cutting

After the content of the cheese vat has "set" into the uniform rennet gel, special curd cutting knives are used to break the gel into small cubes. This initiates expulsion of whey from the gel (syneresis) (Kees, 1994).

2.3.6.4 Cooking

After cutting, the vat content is a heterogeneous mass of curd cubes (composed of protein and milk fat) floating in the aqueous phase of milk (whey). Raising the temperature of the vat content to about 35-50^{0}C (depending on the type of cheese being made) will increase the firmness of the curds by enhancing syneresis and also enhance fermentation action of the starter organisms (Ihekoronye and Ngoddy, 1985).

2.3.6.5 Draining

The cooked curd must be separated from the whey, which is accomplished by draining the whey from the vat through a sieve-like strainer. The typical pH of the rennet whey upon draining is about 5.6-5.8. Consequently, much of the calcium insoluble at this pH will be retained in the cheese. Sometimes the curd is pressed. The partial removal of water from the protein solution leads to increased concentration of all non-aqueous constituents resulting in protein-protein, protein-carbohydrate and protein-salt interactions causing extensive aggregation. Whey expulsion is retarded if the cheese cools down too quickly and too much. According to Ihekoronye and Ngoddy (1985) substantial variations of the draining and subsequent curd-handling procedures exist and make another important difference for the various products. For example, in cheddar making, the curd is not washed but is allowed to "matt" forming large blocks; this process called cheddaring is unique to cheddar making.

2.3.6.6 Salting and Milling

Salt is a flavouring preservative and it is responsible for certain functional properties in foods (Reddy and Marth, 1991). In cheese, sodium chloride reduces curd moisture, suppresses unwanted micro-organisms, modifies flavour and texture and regulates the breakdown of protein (Wolf *et al*., 1983). For proper flavour, there has to be some control of the ripening and further whey expulsion. The amount of salt used and the salting process add another important variable differentiating the cheese varieties.

In cheddar making, the matted blocks are milled into small slabs or cubes and granular salt is mixed into the pile. Curd destined for Gouda cheese is first pressed into the proper final cheese shape, and the loaves are immersed into brine. Colby and other cheese are salted during the curd washing process (Penfield and Campbell, 1990).

Thakur *et al.*, (1975) reported that the omission of salt speeds the ripening process, resulting in a pasty texture and the development of an unusual, bitter, fruity or flat flavour in cheddar cheese.

2.3.6.7 Forming and Pressing

To form the final cheese blocks, the curds are filled into cheese hoops in perforated boxes in which the curds are formed in a final loaf shape by a press. Pressing also expels the remaining whey and thus determines the extent of further microbial fermentation in the cheese blocks. The shape obtained in pressing is an important determinant for some cheese varieties (Creamer and Olson, 1982).

2.3.6.8 Curing or Ripening

Cheese when stored for some time (which may last for weeks, months or even years) acquire special desirable organoleptic qualities (texture, aroma and flavour) which differ markedly from those of the original milk. This process of change is known as ripening. Ripening is the final step in cheese making which will "make" or "break" a good cheese (Ihekoronye and Ngoddy, 1985). Ripening of cheese takes place usually in ripening rooms where temperature, humidity and other factors must be controlled differently for each type of cheese.

According to Le Jaouen (1987), the factors which come into play and condition the results of the ripening process in terms of the cheese quality and the maturation point the producer wishes to obtain are:

1. The temperature, the maximum level of which depends on the nature of the bacteria.

2. The moisture content of the cheese and the humidity of the surrounding atmosphere. Since a humid environment stimulates microbial development, the cheeses with the highest moisture content are the fastest ripening ones.
3. Ventilation brings the oxygen needed for surface flora activity.
4. Bacteria need a neutral environment while moulds need an acidic environment.
5. Salting, an important operation which hinders the development of undesirable bacteria; slightly dries the cheese surface causing hardening of the cheese.

The major reactions in cheese are fat breakdown (Camembert), development of gases (holes in Swiss cheese), acids and other flavour compounds. Longer ripening processes give richer flavours. During ripening there is increase in the acidity of the curd and with whey expulsion. As a result of the increase in acidity the para-caseinate will lose part of its calcium, thus obtaining a less elastic, more crumbly texture (Berg, 1988). Various enzymatic processes based on natural milk enzymes, as well as enzymes produced by the microbial cultures are responsible for the desirable (or sometimes undesirable) flavour development.

To retain the flavour and moisture content of cheese, it should be wrapped and stored at a temperature of 10-15^{0}C. Soft varieties are best eaten within 2-3 days of purchase (Davies and Hammond, 1988).

2.3.7 TRADITIONAL CHEESE PRODUCTION IN WEST AFRICA

Traditional cheese, known as *Wagashie* has been produced in Benin for many decades (Ruhe, 1983). Woagashie is produced by a simple process whereby fresh milk is gradually heated in a pot and rennet added. The rennet used is an extract from a shrub, Sodom Apple (*Calotropis procera*). It is common throughout the tropics and subtropics (Aworh and Nakai, 1986). The extract is obtained by crushing the leaves and stalks of *Calotrophis procera* and rinsing them out with milk in a gourd. This mixture of milk and extract of *Calotropis procera* is then sieved into the heated milk. When the milk attains a temperature between 65 and 85^{0}C it begins to curdle. As soon as the curdle is visible, the heat is increased. The curdle as well as the milk left uncurdled are boiled to a temperature

between 95 and 100^0C. Boiling is stopped when the milk becomes yellowish and transparent. At this stage, the curd which is at the bottom of the cooking pot rises to the surface and break into smaller pieces. The curds are then drained in a strainer and carefully turned (Kees, 1996). This cheese is a soft curd cheese. It takes about 5 litres of milk to produce one kilogram cheese (Otchoun *et al.*, 1991; Egounlety *et al.*, 1994). The cheese are boiled in salt solution and dyed red with millet stalk.

2.3.8 CHANGES IN CHEESE DURING RIPENING

The principal chemical and physio-chemical changes taking place in cheese during ripening involve lactose, fat and casein.

2.3.8.1 Protein Content

The ripening of cheese is accompanied by partial protein degradation (Metwalli *et al.*, 1982). The nutritional value of protein is a combination of two factors: total essential amino acid content of the protein and digestibility which is an indicator of the availability of the essential and non-essential amino acids in the protein. The net protein utilisation (NPU) is related directly to dietary intake of nitrogen and it is equivalent to biological value x digestibility (Ihekoronye and Ngoddy, 1985). The Net Protein Utilization is a measure of the digestibility of food protein. With increasing breakdown of protein into amino acid during ripening, protein digestibility improves (Metwalli *et al.*, 1982).

Proteolytic enzymes such as rennin are responsible for the formation of nitrogenous products of intermediate size, such as proteoses, peptones, polypeptides, peptides and free amino acids. Enzymes of micro-organisms act on these and other substances to form products like amino acids, amines, fatty acids, esters, aldehydes, alcohols and ketones (Berg, 1988). Part of the water-insoluble casein is converted into water-soluble nitrogenous compounds and may be lost through whey expulsion (Cross and Overby, 1988). Strainer *et al.*, (1987) stated that in certain cheeses, protein break down is restricted. In Cheddar and Swiss cheese only 25 to 35% of the protein is converted to soluble products. In soft cheeses, such as Camembert and Limburger, essentially all the

protein is converted to soluble products. According to Ling (1994), salt has a retarding influence on protein breakdown.

2.3.8.2 Fat content

There is a gradual decrease in fat content during ripening due to breakdown of fat, salt uptake and continuous loss of degraded components of cheese (Metwalli *et al.*, 1982). Some known facts concerning milk fat and ripening are: skimmed milk cheese ripens much faster than whole cheese; a low fat content in the cheese may stimulate the development of putrefying micro-organisms which can spoil the cheese; and substances which result from the transmutation of fat contribute substantially to the quality and originality of the cheese aroma (Le Jaouen, 1987). Lipolytic enzymes liberate fatty acids (Ohren and Tuckey, 1969).

2.3.8.3 Lactose Content

Lactose is one of the basic nutrients consumed by lactic acid producing micro-organisms. Lactose remaining in the curd is converted into lactic acid. Lactic acid inhibits the growth of undesirable micro-organisms. It is very important in production of flavour in the cheese. It determines the smoothness of the body of the cheese (Le Jaouen, 1987).

2.3.8.4 Weight Changes and Moisture Content

There is loss of weight and moisture in cheese during storage. The weight loss in cheese during ripening has been attributed mainly to the loss of moisture (Metwalli *et al.*, 1982). The uptake of salt also affects the loss of moisture (Le Jaouen, 1987). When cheese is salted in brine, there is a relation between the inward migration of salt into the cheese and the accompanying transport of water to the outside of the cheese. Cheeses during ripening in brine conform to the 'Donnan equilibrium' which controls the partition of ions between the curd and the brine (Metwalli *et al.*, 1982). Increase in cheese acidity, which affects the loss of moisture, is the additional factor responsible for the decrease in weight as the ripening proceeds (Metwalli *et al.*, 1982).

2.3.8.5 Acidity in Cheese

The development of acidity is caused by the production of lactic acid, free fatty acids and amino acids as a result of the breakdown of carbohydrates, fat and protein (Aurand *et al.*,

1987). The production of lactic acid plays a major part in the acidity of soft cheese (Berg, 1988).

2.3.9 SPOILAGE OF CHEESE

Cheese is a very good substrate for micro-organisms to proliferate (Berg, 1988). Uncontrolled proliferation of microbes seriously affects the quality of many cheese varieties. Microbes that cause food spoilage or poisoning have very similar nutritional requirements to humans. Growth conditions are: nutrient supply, water, optimum pH, optimum temperature, appropriate gaseous environment (Ihekoronye and Ngoddy, 1985). These growth conditions are readily present in cheese.

According to Collins and Lyne (1989), apart from streptococci, lactobacilli and fungi that are deliberately inoculated or encouraged the following organisms may be found: contaminant moulds, *Penicillium*, *Scopulariosis*, *Oospora*, *Mucor* and *Geotriculum*. Putrefying anaerobes (*Clostridium spp.*) give desirable flavours. *Rhodotorula* gives pink slime and *Torulopsis* yellow slime. Gassiness (unless deliberately encouraged by propioni bacterium in Swiss cheeses) is usually due to *Enterobacter* spp., but they are not found if the milk is properly pasteurized. Psychrophilic spoilage is common due to *Alcaligenes* and *Flavobacterium spp.* Bacteriophages which attack the starters and ripeners can lead to spoilage.

The most common spoilage pattern displayed by bacteria is slimy curd. *Alcaligenes spp.* have been reported to be among the most frequent causative organisms, although *Pseudomnas, Proteus*, *Enterobacter* and *Acinetobacter spp.* have been implicated. *Penicilliium, Mucor, Alternatia* and *Geotrichum* all grow well on cottage cheese, to which they impart stale, musty, mouldy and yeasty flavours (Foster *et al.*, 1975). The keeping quality of commercially produced cottage cheese in Alberta, Canada was found to be limited by yeasts and moulds (Roth *et al.*, 1971). While 48% of fresh samples contained coliforms, these organisms did not increase upon storage in cottage cheese at 204^{o}C or 16 days. Quality indicators in hard cheese are *Clostridium spp* and keeping

quality can be increased by their control. Microbial quality indicators are spoilage organisms whose increasing numbers result in loss of product quality.

Potter and Hotchkiss (1995) indicated that anaerobic bacteria sometimes cause spoilage of the products when appropriate water activity (a_w) permits growth to occur. *Clostridium spp*., especially C. *pasteurianum*, C. *butyricum* and C. *sporogenes* have been reported to cause gassiness of cheese. *Bacillus polymyxa*, an aerobic sporeformer, has been reported to cause gassiness. These organisms are responsible for the gassy condition of cheese.

2.3.10. OCCURANCE OF PATHOGENS IN CHEESE

According to Rose (1982), starter strains produce enough lactic acid to suppress growth of the pathogens found most in milk and curd. Pathogens isolated from cheese include species of *Staphylococcus*, *Salmonella*, enteropathogenic strains of *E. coli*, species of *clostridium* (also gives undesirable flavours) and *Mycobacterium tuberculosis*. *Staphylococcus aureus* which can cause food poisoning have been reported in cottage cheese in the USA. Most of these organisms can only multiply if starter failure or slowness results in production of a high pH value, low-acid cheese, though *Mycobacterium tuberculosis* can survive in normal cheese and is best avoided by primary eradication. Viral infections from cheese are rare but not unknown. Several types of virus including *coxsackie*, *echovirus* and foot and mouth disease virus have been shown to survive in cheese.

2.3.11 STORAGE AND PRESERVATION OF CHEESE

According to Berg (1988), general methods used for preservation of cheese include drying, smoking, pickling, chilling, packaging and chemical treatment. Some cheese varieties are dried for preservation. For instance, Zurpi cheese (Nepal) is preserved by drying on roofs or over open fire. Dry cheeses are hard and can be consumed after grating for cooking and other purposes. Industrially, drying methods used for cheese include tray-drying, roller-drying, spray-drying and freeze-drying. Smoking of cheese retards protein and fat decomposition. Smoking also gives cheese specific flavours (Berg, 1988).

Some cheeses are preserved in strong salt brine until consumed. The method of pickling varies. Sometimes, salt is added prior to pressing. Pickled cheeses lose a considerable amount of water, and weight during storage in brine. Losses of 50% are possible. High temperatures increase the loss in weight. As a result of loss of moisture and absorption of salt, the cheese acquires a firm consistency. Cheeses have a tendency to remain soft at higher pH (Sacharow and Griffin, 1970).

Moisture, vapour and oxygen barriers are critical in cheese packaging applications and as a result materials used to package cheese all involve the use of polyvinylidene chloride (PVDC) to some degree. PVDC gives the final composite extremely low in oxygen and moisture vapour transmission and in combination with polyethylene (PE), the moisture transmission rate becomes even more insignificant. Most cheese require an average barrier which will pass no more than 5cc/100sq in/24hr at 22.8^0C and 50% RH relative to oxygen (Sacharow and Griffin, 1970).

The cheese ripens in the film, which takes the function of the natural rind. Cheeses may be packaged by wrapping in a film, or by packaging in a special bag, which shrinks at elevated temperature, thus covering the cheese tightly. By this method of packaging cheese, losses are minimized, because there is no rind formation and no loss of moisture by evaporation (Berg, 1988).

To prevent mould from developing on the surface of the cheese and to reduce the loss of moisture, and consequently weight by evaporation, cheese may be coated with wax or plastic. This is sometimes done to give the cheese more attractive appearance. Paraffin wax and others are melted in a bath and the cheeses are submerged in the bath for a few seconds. After dipping, the waxes on the cheese are allowed to solidify. Plastic coatings are applied in the form of polymer dispersion. After the dispersion is put on the cheese, it is allowed to dry, leaving a plastic coating on the surface of the cheese. Fungicides (which give an extra protection against mould growth) may be added to the coatings. Cheese can be treated with solutions of propionic acid (about 7.5%) or sorbic acid (about 0.1%) or with vegetable oils, like olive oil (Berg, 1988).

Russel and Gould (1991) indicated that, the use of antibiotics in food preservation may trigger development of resistant micro-organisms. Nisin, a heat-resistant polypeptide of 34 amino acids, is used as an additive in the preservation of dairy products and pimaricin (natamycin) is effective against yeast and moulds in products undergoing ripening such as cheese (Potter, and Hotchkiss, 1996). Natamycin is used on certain cheeses for surface treatment of rind when the cheese is ripened under aerobic conditions (Swaisgood, 1982). Lysozyme, a B-1, 4-N-acetylmuramidase, has been used widely to control lactate fermentation by *Clostridium tryrobutyricum* in semi-hard and hard, brine-salted cheeses (Grappin, 1985). The bactericidal activity of the lactoperoxidase system (LPS) has been shown to kill F. coli and *Salmonella typhymurium* in cottage cheese and *Listeria mnocytogenes* on the surface of French soft cheese (Noomen, 1978).

2.4 UTILIZATION OF COCONUT MILK IN THE MANUFACTURE OF "SOFT CHEESE" (COCONUT CHEESE)

The demand for dairy products, particularly cheese varieties, is increasing rapidly in coconut-producing countries; however, not enough fresh milk is available for processing into these products. Skimmed milk powder and coconut milk, on the other hand, are more readily available than fresh milk.

The potential of water-extracted coconut milk as a less expensive substitute for butterfat in the manufacture of fresh soft cheese manufacture was investigated (Davide *et al*., 1987). Also, Davide *et al*. (1986 and 1988) developed a fresh soft cheese spiced with garlic (Queso de Ajo), with starter and blue-type cheese, from a blend of skimmed milk powder and coconut milk. The coconut cheeses were then compared with control cheeses similarly prepared from fresh cow's milk.

2.4.1 FRESH SOFT CHEESE (CADTRI CHEESE)

A low-fat soft cheese prepared from coconut milk named "Cadtri" (from the acronym for College of Agricultural Dairy Training and Research Institute, University of Philippines at Los Banos) and a skimmed milk cheese (control) were prepared (Davide *et al*., 1987).

2.4.2 COCONUT MILK AND FILLED CHEESE MILK

Coconut milk is low in protein but very rich in fat and emulsifiers **(Table 14)** and it is a natural oil-in-water emulsion just like a cow's milk; hence, both can mix readily (Davide *et al*., 1987). As a carrier of vegetable fat to substitute butterfat, water-extracted coconut milk would be less expensive and much easier to blend with skimmed milk than coconut oil (Adedeji and Nwanekezi, 1987).

Table 14: Gross Composition of Coconut Milk Extract (Ccm) and Cadtri Cheese Milk

Composition	Coconut Milk[a]	Cheesemilk[b]
Total Solids, %	16.4	10.4
Fat, %	12.5	1.5
Total protein, %	1.5	3.8
Total Ash, %	9.6	0.8
Titrable Acidity, %	9.1	0.2
pH	6.	6.4

a Extracted with 388 ml water per nut.

b RCM/CCM blend. Blended from 13 per cent CCM and 8.7 per cent skimmed milk powder.

Source: Davide *et al*., 1987

The 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 skimmed milk. The cheese milk was developed by blending 13 parts of the coconut milk and 87 parts of a 10 per cent reconstituted skimmed milk (Davide *et al*., 1987).

2.4.2.1 Characteristics of Cadtri Cheese

Cadtri cheese was relatively low in fat content (7.3 per cent), but rich in protein (13.2 per cent) and salt (1.7 per cent), and the pH (6.20) did not differ greatly from those soft cheeses that simulate the traditional "Kesong Puti" of the Philipines (Sringam, 1986**) (Table 15).**

Table 15: Gross Composition, Yield and Sensory Scores of Cadtri and Fresh Soft Cheese from Skimmed Milk and Cow' S Milk a, b

Attribute	Cadtri	Skim milk	Cow's milk
Moisture, %	72.8b	77.2b	63.8b
Fat, %	7.3b	0.0	19.1a
Total protein, %	13.2b	15.8a	12.5
Salts, %	1.7a	1.6a	1.8a
pH	6.2b	6.2b	6.4a
Yield, %	21.9b	25.4a	21.9b
Flavour and Aroma	7.2a	5.9b	7.5a
Body and texture	7.5a	6.2b	7.1a
Colour	7.9a	7.1b	6.8b

a-Values on the same row with different letter are significantly different at 5% level.

b-Score of 5 means neither like nor dislike, 6 like slightly and 7 like moderately.

Source: (Sringam, 1986)

2.4.2.2 Sensory Evaluation and Consumer Acceptance

Sensory evaluation and consumer acceptance data indicated a higher preference for Cadtri cheese **(Tables l4** and **15).** About 79 per cent of the consumers liked Cadtri cheese slightly to extremely, although a small percentage of consumers neither liked nor disliked it, and still others disliked it slightly (Sringam, 1986). Evidently, the addition of coconut milk gave it the desired firm body, smooth texture, and mild coconut flavour in contrast to the skimmed milk cheese which had a tougher but brittle body, coarse texture, and astringent "skimmed milk powder flavour" (Davide *et al*., 1987). When refrigerated, Cadtri cheese had a shelf-life of 6-7 days. With slow drainage of the whey during storage, the cheese became slightly firmer in body, yet, no objectionable changes in sensory qualities were observed.

2.4.3 USE OF COCONUT IN BLUE-TYPE CHEESE PRODUCTION

Davide *et al*. (1986) developed a blue cheese production technology from coconut milk-skimmed milk powder blends. It was observed that the filled Blue cheese had somewhat lower fat content (24.2%) than the control cow's milk Blue cheese (27.7 %). The filled Blue cheese retained more moisture than did the cow's milk cheese. The filled Blue cheese made from a 15% reconstituted skimmed milk-coconut milk blend contained a

significantly higher moisture (49.9%), total protein (23.5%) and yield (13.5%) but lower fat (19.8%) contents than those of cow's milk.

Furthermore, the addition of more skimmed milk powder to the blend caused the cheese to retain more moisture and significantly increased its protein content. The higher pH observed in the six-week-old control and 15 per cent reconstituted skimmed milk-coconut milk experimental cheese, as compared to that of the cheese obtained from the 12% reconstituted skimmed milk-coconut milk blend and control cheese of the same age, could be due to more proteolysis and lipolysis resulting from the higher level of fungal spores (0.005%) added to the cheese milk (Davide *et al*., 1986).

2.4.4 FORMULATIONS OF COCONUT AND SKIMMED MILK IN WHITE SOFT CHEESE PRODUCTION

Davide and Foley (1981) reported that filled cheese like Cheddar made from milk fat/coconut oil blends did not give any desirable flavour of its own nor develop the flavour and physical attributes of Cheddar cheese. The cheese was brittle, crumbly and appeared very coarse. Its loose moisture increased proportionately with the concentration of coconut oil substituted. On the other hand, coconut milk-blended soft cheese was comparable to the product made of 100 % fresh cow's milk in body, texture and general acceptability.

Sanchez and Rasco (1983a,b) conducted a study to utilize coconut milk as a cow' s milk extender in processing white soft cheese using formulations of various combinations of coconut milk and skimmed milk.

Also, the effects of the amounts of rennet on the coagulation time of cheese milks consisting of coconut milk plus reconstituted skimmed milk at different concentrations were studied (Davide and Foley, 1981).

Using rennet and a starter consisting of *Streptococcus lactis* and *S. diacetilactis*, the coagulation studies of cheese milks consisting of various combinations of coconut milk and skimmed milk with added salt (3 per cent), rennet (3 per cent), starter (10 per cent)

and 0.1 per cent aqueous solution of 25 per cent calcium chloride showed that as the amount of coconut milk increased with corresponding decrease in skimmed milk, the time required for curd formation increased (Sringam, 1986).

CHAPTER 3

3.0 MATERIALS AND METHODS

3.1 MATERIALS

Standard laboratory materials including sample preparation ingredients, reagents, apparatus, equipment and tools as specified in the standard methods were used in carrying out the analyses of samples. These materials are specified within the description of methods respectively.

3.2 METHODS

3.2.1 PREPARATION OF COCONUT MILK

Fresh matured coconuts of the *West African Tall* variety sourced by vendors from farms in the Western Region were purchased from the open market in Kumasi, Ghana. The de-husked nuts were cracked open into halves. The split nuts were de-shelled to separate the coconut 'meat' (kernel). Coconut meat of 300 g was washed and comminuted using an electric blender (Sanyo SM-B12M) with 250 ml of water. This was then pressed through a linen cloth and strained to obtain coconut 'milk'.

3.2.2 PREPARATION OF *CALOTROPIS PROCERA* EXTRACT (Enzyme)

Three grams of young *Calotropis procera* leaves freshly harvested from the KNUST Botanical Gardens were carefully washed, crushed and soaked in 50 ml of distilled water for 20 minutes and strained through a fine sieve. This extract was then used in the preparation of cheese.

3.2.3 PREPARATION OF CHEESE

Three cheese products were produced from two sources, prepared coconut milk and freshly obtained cow's milk, under proper hygienic conditions.

3.2.3.1 Coconut Milk Cheese

One litre of coconut milk was heated gradually in a container. One table spoonful (about 10 ml) of *Calotropis procera* extract was added to the coconut milk. The temperature was then quickly raised to 90^{o}C till the coagulation was completed. Cheese cloth was used for

draining the whey till the curd was firm and well formed. The product was then kept in a refrigerator for storage prior to proximate analyses.

3.2.3.2 Fresh Cow Milk Cheese

Fresh whole milk purchased from the KNUST Dairy Research Station in Kumasi was strained and used in the preparation of milk cheese by the same method outlined in 3.2.3.1.

3.2.3.3 Coconut Milk – Fresh Cow Milk Blend Cheese

Cheese products were developed from milk blends of coconut and cow milk in ratios of 20:80, 30:70, 40:60, 50:50, 60:40, 70:30 and 80:20. The ratios were determined using software Design Expert, (2007). The same method outlined in 3.2.3.1 was used.

3.3 PROXIMATE ANALYSIS OF CHEESE PRODUCTS

Proximate analyses were carried out on 100% coconut and cow milk cheese products as well as blend cheese products. All analyses were carried out in triplicates.

3.3.1 MOISTURE CONTENT

Moisture content of cheese samples was determined in triplicate using the Official Methods of Analysis (AOAC, 1990) for food. Three grams of samples were weighed into pre-dried and weighed moisture dish with tight-fit cover. Samples were partially dried and weighed on a steam bath prior to oven combustion (MIDO/3/SS/F Model D3S, Genlab Widens, England) at 105^{o}C for 8 hrs. Moisture content was determined by difference and expressed as a percentage of the initial weight of cheese product (Appendix 7.7.1).

3.3.2 CRUDE PROTEIN CONTENT

Percent nitrogen content of the cheese products were determined using the micro Kjedahl method (AOAC, 1990) and crude protein content calculated using the factor 6.38

A. Digestion

Two grams of samples was placed into digestion tubes and 1 g of selenium based catalyst added. Concentrated H_2SO_4 (25 ml) was added and well shaken. The tubes were then placed on a digestion burner and heated slowly until bubbling ceased and

the resulting solution was clear. The tube was then cooled to room temperature and the digested samples completely transferred into a 100 ml volumetric flask and made up to the mark with distilled water.

B. Distillation

1. The apparatus was flushed before use by boiling the distilled water in a steam generator of the distillation apparatus, with the connections arranged to circulate through the inner decomposition flask and out through the condenser for at least 10 mins.
2. Boric acid of 2% was pipetted into a 250 ml volumetric flask and 2 drops of mixed indicator added.
3. Liquid from the steam trap was drained leaving the stopcock which drains the steam trap open.
4. The volumetric flask and its contents was placed under the condenser in such a position that the tip of the condenser immersed in the solution.
5. Ten millilitres of digested sample solution was measured, the stopcock of the steam jacket opened and the sample poured into the flask. Seventeen and a half millilitres of 40% NaOH was measured into the decomposition flask and the funnel stopcock closed. The stopcock was then shut on the steam trap outlet to drive the liberated ammonia into the collection flask forcing steam through the decomposition chamber.
6. The distillation was timed for 15 mins after the boric acid turns green and the burner removed from the steam generator.

C. Titration

The distillate was titrated with 0.1NHCl solution until the solution was colourless. The same procedure was followed for the blank determination and the protein content calculated (Appendix 7.7.2).

3.3.3 FAT CONTENT

De-moisturised samples were transferred into 22×80 mm paper and were placed in thimbles. A small ball of cotton wool was placed into the thimble hole to prevent lose of

sample. Anti bumping granules were added to a previously dried 250 ml round bottom flask and weighed accurately. A quantity of 150 ml of petroleum ether was added to the flask and the apparatus assembled. A condenser was connected to a Soxhlet extractor and refluxed for 16 hrs at 40^{o}C on the heating mantle. The flask was removed and evaporated on a steam bath. The flask and oil then heated for 1 hr in an oven at 80^{o}C. The flask and its contents were cooled at room temperature of 26^{o}C in a dessicator and accurately weighed (Appendix 7.7.3).

3.3.4 CRUDE FIBRE DETERMINATION

Determination of crude fibre was by the method of AOAC (1990). Each sample of cheese sample from crude fat determination was transferred into a 750 ml Erlenmeyer flask and 0.5 g asbestos added. Two hundred millilitres of boiling 1.25% H_2SO_4 was added and connected to a cold finger condenser and immediately brought to the boil on a hot plate for 30 mins. The flask was removed and the content filtered through a linen cloth in a funnel and washed with boiling water until no longer acidic. The charge and residue was washed back into the flask with 200 ml of boiling 1.25% NaOH solution. The flask was again connected to the condenser, boiled for 30 mins, filtered through a linen cloth and thoroughly washed with boiling water. The residue was transferred into a porcelain crucible, washed with 15 ml of 95% ethanol and dried at 100^{o}C in an oven for 2 hrs. The flask was cooled in a dessicator, weighed and ignited in a pre-heated muffle furnace (Gallenkemp, England) at 600^{o}C for 30 mins. The flask was again cooled and reweighed. The weight difference was recorded and the percent crude fibre content calculated (Appendix 7.7.4).

3.3.5 ASH DETERMINATION

Ash determination was by method of AOAC (1990). For each sample 5 grams was weighed into a previously ignited and weighed porcelain crucible. The crucible and content were placed in a pre-heated furnace (FSE-470-110R, APP No. 7B-9943) and heated to 600^{o}C for 2 hrs. The crucible was cooled in a dessicator, weighed and percent ash content of the initial weight calculated (Appendix 7.7.5).

3.3.6 TITRABLE ACIDITY

Acidity of cheese samples in triplicates was determined using the Official Method of Analysis (AOAC, 1990). Each sample was ground and thoroughly mixed. Ten grams was taken and 105 ml distilled water was added and vigorously shaken and then filtered. Twenty-five millilitres portion of the filtrate was titrated with 0.1N NaOH using phenolphthalein as indicator. Results were expressed as percentage lactic acid of the sample (Appendix 7.7.6).

3.3.7 CURD FIRMNESS

Curd firmness was measured as a test for texture. Texture is a measure of the feel and appearance of the cheese surface, especially how compact the curd formation is. An improvised instrument as described by Metwalli *et al*. (1982) was used in the determination. The instrument comprised of a round aluminium plate (4 cm diameter) with four pointed end stands. This was placed on the surface of the curd. Weights were added to drive the stands into the curds and recorded as gram weight added.

3.3.8 RANCIDITY (THIOBARBITURIC ACID COLORIMETRIC TEST)

Thiobarbituric acid (TBA) test was carried out to estimate the extent of rancidity in cheese samples. This test was devised for dairy products (Yeshajahu and Clifton, 1978). The rancidity is due to the oxidation of unsaturated fatty acids. The pigment produced in the sensitive colour reaction is a condensation product of two molecules of TBA and one molecule of the malonic dialdehyde.

For each formulation a 1.5 g sample in triplcate was weighed into a glass stoppered-tube. The sample was dissolved in 5 ml benzene. Five millilitres of TBA reagent was pipetted onto the sample and shaken in a horizontal position for 4 mins. The content of the tube was transferred into a separating funnel. The aqueous layer was drawn into a 25×200 mm test tube and immersed in boiling water for 30 mins and cooled. The absorbance was read at 530 nm against distilled water. The TBA number was calculated as milligrams of malondealdehyde per kilogram of sample by multiplying the absorbance by a factor of 7.8 as given by Yeshajahu and Clifton (1978).

3.4 DETERMINATION OF KEEPING QUALITY OF CHEESE PRODUCT SAMPLES

3.4.1 SINGLE BOILING PROCESS

Cheese product samples were cut into lumps and pre-treated by boiling once in water only or 10% NaCl only for 10 mins. The effect of pre-treatment and storage on weight, moisture, protein, fat, acidity levels and rancidity was determined for samples. The samples were kept in a box (with netted sides). The set up was placed in the laboratory (at a place where sunlight enters) with windows opened and under ambient conditions of 26.4 ^{o}C and relative humidity of 88.14%.

3.4.2 REPEATED (CONTINUOUS) BOILING PROCESS

In procedures for extension of keeping quality, pre-treatments were given as described in section 3.3.1. However, boiling was repeated on day 2 and 4 and thereafter every four (4) days of storage. The control was raw sample which was neither boiled in water nor in 10% NaCl solution.

Cheese samples were judged to have gone bad when there was

1. Sharp pungent smell
2. Off-flavour
3. Sliminess

Results were expressed as averages of triplicates.

3.5 SENSORY EVALUATION

The subjective analysis of the cheese samples was determined by carrying out a sensory evaluation using a 30-member untrained sensory panel to establish the sensory properties of the samples using the scaling method (Larmond, 1977). The sensory evaluation form presented in Appendix 7.1 was used for data collection. The panellists were all Ghanaians and familiar with traditionally prepared soft cheese (wagashie).

3.4.1 PREPARATION OF SAMPLES FOR SENSORY EVALUATION

The samples were prepared and put in a refrigerator at a temperature of 4^{o}C for 6 hrs. The cooled samples were coded using a 3 digit system and then served to panellists. The following digits represented the stated samples;

269 - C50:50 (Cheese product from 50% Coconut milk: 50% Cow's milk blend)
418 - C60:40 (Cheese product from 60% Coconut milk: 40% Cow's milk blend)
315 - C70:30 (Cheese product from 70% Coconut milk: 30% Cow's milk blend)
524 - C50:50 Salted
(Salted cheese product from 50% Coconut milk: 50% Cow's milk blend)
273 - C60:40 Salted
(Salted cheese product from 60% Coconut milk: 40% Cow's milk blend)
357 - C70:30 Salted
(Salted cheese product from 70% Coconut milk: 30% Cow's milk blend)
914 - C100:0 wagashie (Cheese product from 100% Cow's milk)
Control Sample

Samples of each of the seven (7) products were displayed in a randomised order on separate tables in a room. Panellists were ushered into the room one at a time and allowed to scored the samples according to the sensory characteristics on separate sheets of paper for each sample.Panellists scored samples under the parameters of Colour, Flavour, Taste, Curd Firmness and Overall Acceptability using the following key;

1	DVM	- Dislike Very Much	4	LS	- Like Slighly
2	DS	- Dislike Slightly	5	LVM	- Like Very Much
3	NLDL	- Neither Like nor Dislike			

3.5 STATISTICAL ANALYSIS

Analysis of Variance (ANOVA) was carried out on data from proximate analysis and Paired T-test analysis carried out on the data from sensory evaluation as suggested by Larmond, 1977. Correlation analysis was done on sensory parameters using the scores obtained from the sensory panellists (Kramer and Twigg, 1970).

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 YIELD OF CHEESE

The yield of cheese products was determined on the basis of weight of coagulated milk product (in grams) collected by means of cheese cloth. Table 16 shows that cheese yield increased with increase in cow's milk content. The cheese product was formed by the coagulation of proteins in the cow and coconut milk, thus the greater protein content the greater the yield of cheese product (Adedeji and Nwanekezi, 1987). Cow's milk produced a yield of 305.4 g which was more than double the 151.8 g yield recorded by 100% coconut milk. The 50:50% blend recorded 270.0 g. Sringam (1993) reported that enzymatic coagulation of coconut proteins using rennet is not wholly feasible due to the totally different characteristics of coconut protein from cow's milk protein in structure and functional properties. The poor functional properties added to the low amount of proteins in coconut milk may have contributed to the lowering yield of cheese with increasing coconut milk content.

Table 16: Weight Yield of Cheese Produced Per Milk Blend

Cow milk: Coconut milk ratio	Mass (g per 1000g of milk)
0.0%:100	151.8 (2.61)
20%:80	226.8 (1.20)
30%:70	244.5 (1.91)
40%:60	264.8 (3.21)
50%:50	270.2 (0.41)
60%:40	271.3 (2.18)
70%:30	275.0 (3.41)
80%:20	297.5 (2.00)
100%:0.0	305.4 (1.75)

( ) – Standard Deviation

4.2 PROXIMATE ANALYSIS AND TITRABLE ACIDITY OF CHEESE SAMPLES

The results of proximate analysis of the cheese samples are shown in Table 17. The moisture content of cheese samples composed of 100% coconut milk was highest recording 70.93% with the lowest being 55.33% composed of 100% fresh cow's milk. The trend observed was that increasing content of coconut milk resulted in an increase in moisture content. This is justified and explained by the fact that coconut milk preparation requires addition of water at the blending stage resulting in coconut milk having a higher water composition than fresh cow's milk. This resulted in the cheese products of coconut milk having elevated moisture composition with the gross difference being 15.6 percentage points and a mean moisture composition of 63.21% that falls within the 50:50% formulation. The moisture levels recorded agrees with literature values of between 67% and 79% for soft cheese (Ogundiwin and Oke, 1983).

The fat content of cheese samples was relatively average in comparism with literature values of between 20% to 30%. A peak content of 25.85% was recorded by 100% fresh cow's milk cheese product. The median composition of milk (50:50) for cheese product recorded a 21.58% fat content. The lowest value of 20.58% was recorded by 40:60% cow's milk to coconut milk cheese product while 100% coconut milk cheese product recorded 24.07% fat content.

Table 17: Percent Nutritional Composition of Developed Cheese Samples

Sample (M:CoM*)	Moisture	Fat	Protein	Ash	Fibre
0.0%:100	70.93 (0.99)	24.07 (1.00)	2.35 (0.25)	1.94 (0.21)	0.69 (0.06)
20%:80	68.35 (1.17)	22.58 (0.89)	6.63 (0.36)	1.88 (0.34)	0.52 (0.26)
30%:70	67.61 (4.82)	21.45 (1.82)	8.59 (0.57)	1.85 (0.34)	0.49 (0.05)
40%:60	66.59 (2.70)	20.58 (1.82)	10.54 (0.94)	1.82 (0.33)	0.46 (0.08)
50%:50	63.65 (0.52)	21.58 (1.48)	12.62 (0.59)	1.79 (0.58)	0.35 (0.02)
60%:40	61.38 (2.09)	21.52 (0.37)	15.04 (0.83)	1.73 (0.43)	0.32 (0.03)
70%:30	57.82 (3.07)	23.55 (2.92)	16.63 (0.66)	1.71 (0.35)	0.27 (0.03)
80%:20	57.23 (3.52)	23.89 (1.63)	16.98 (1.77)	1.63 (0.33)	0.25 (0.04)
100%:0.0	55.33 (1.17)	25.85 (3.81)	17.26 (0.95)	1.45 (0.49)	0.10 (0.01)

( ) – Standard Deviation *M – Milk, CoM – Coconut milk

Protein content of 17.26% for 100% cow's milk cheese product, the highest recorded, was consistent with literature of 15% to 19.6% for soft cheese.

The ash content of cheese products from the different milk compositions were high ranging from 1.45% to 1.94%. Literature indicates that the ash content is influenced by the mineral content of forage consumed by cows in the case of fresh cow's milk (Davide et al., 1987) and the soil mineral content of coconut plantation in the case of coconut milk (Coconut Research Center, 2004).

The fibre content followed the trend of increasing value with increasing coconut milk content which was similar to the ash content. The highest and lowest values of 0.69% (coconut milk) and 0.10% (cow milk) were recorded indicating a gross difference of 0.59 percentage points which is not considered significant.

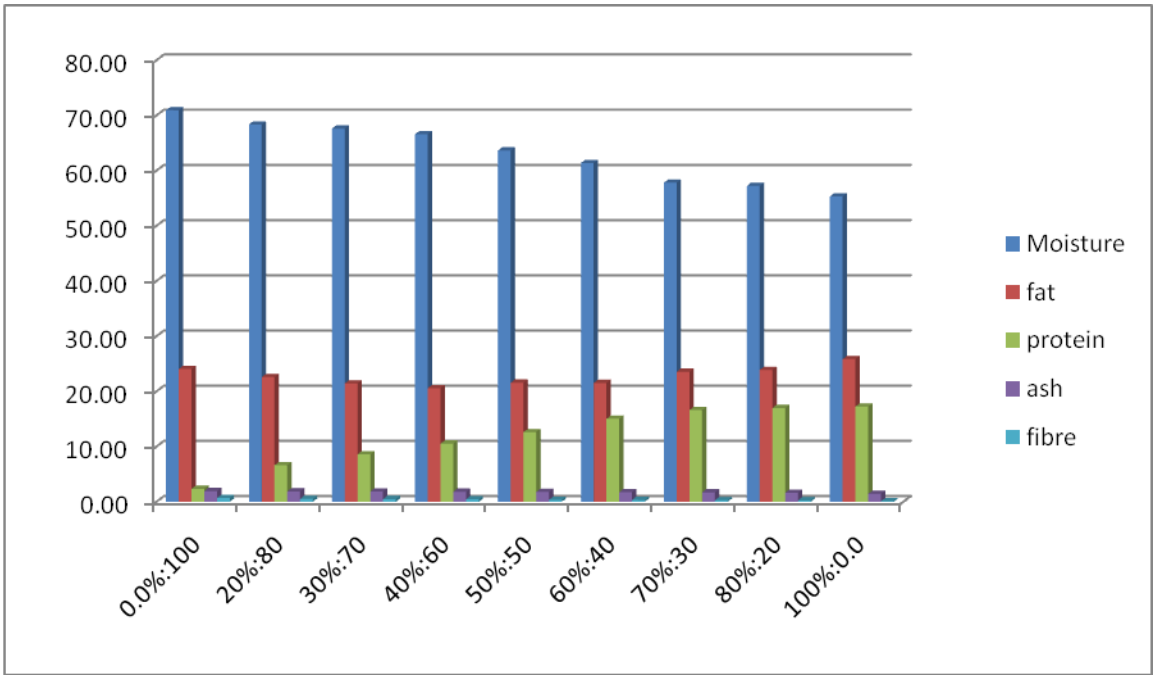


Figure 3: Graph of Proximate Analysis Results on developed cheese samples

4.3 KEEPING QUALITY OF CHEESE SAMPLES

The keeping quality of cheese samples was determined at ambient conditions. The determination was carried out on raw samples as well as samples singly or repeatedly boiled in water or 10% NaCl.

4.3.1 SINGLE BOILING PROCESS

Monitoring of keeping quality of cheese formulations using the single boiling process was carried out to determine how long they could keep. The samples were produced as described in 3.1.2. Cheese products were stored under ambient conditions of mean temperature 26.3^{o}C and relative humidity of 88.14%. This was to replicate the conditions of storage adopted by traditional producers. The results of determination of keeping quality of cheese products showed that the keeping quality of all treatments (raw, boiling in water and boiling in 10% NaCl) was three (3) days. After three days the samples developed pungent, rotten smell sometimes with slime and maggots. Parameters monitored were weight loss, moisture content, protein content, fat content, and acidity and rancidity levels. No significant difference was found at $P<0.05$ between samples produced from different cow's milk and coconut milk formulations thus monitoring was carried out on 100% coconut milk cheese, 100% cow's milk cheese and cheese from 50:50 cow's milk and coconut milk blend.

Tables 18 to 23 show the changes in the parameters monitored on the cheese samples. Moisture, protein and fat contents decreased while percentage loss in weight, titratable acidity and oxidative rancidity levels increased.

Table 18: Loss in Weight (%) Of Cheese Samples during Storage

Sample	Loss in weight (%) of cheese samples Storage period (days)				
	0	**1**	**2**	**3**	**4**
Raw sample treatment					
100% coconut milk cheese	0 (0)	17.4 (0.53)	26.7 (0.38)	30.2 (1.02)	31.9 (0.29)
50%:50 blend cheese	0 (0)	14.5 (0.22)	23.7 (0.24)	27.1 (1.07)	28.9 (1.06)
100% cow's milk cheese	0 (0)	11.3 (0.16)	20.5 (1.29)	24.4 (2.70)	25.3 (0.71)
Boiled in water sample treatment					
100% coconut milk cheese	0 (0)	19.34 (0.22)	28.89 (0.48)	32.45 (0.82)	33.93 (0.04)
50%:50 blend cheese	0 (0)	15.13 (0.54)	25.32 (1.56)	29.44 (0.47)	30.86 (3.80)
100% cow's milk cheese	0 (0)	12.78 (0.17)	22.89 (2.60)	26.1 (0.81)	26.93 (1.10)
Boiled in 10% NaCl sample treatment					
100% coconut milk cheese	0 (0)	21.26 (1.72)	32.04 (2.53)	35.56 (0.54)	36.74 (0.63)
50%:50 blend cheese	0 (0)	17.48 (1.39)	27.92 (1.46)	30.61 (2.28)	31.84 (0.18)
100% cow's milk cheese	0 (0)	14.33 (1.66)	24.73 (0.96)	27.3 (1.32)	28.46 (1.22)

Generally, there was increasing percentage loss in weight for all cheese samples during storage irrespective of the milk composition. As shown in Table 18, the weight losses were 17.4%, 19.34% and 21.26% for raw, boiled and salted 100% coconut milk cheese after one day of storage while that for 100% cow's milk cheese was 11.3%, 12.78% and 14.33% respectively. The loss in weight was attributed to corresponding loss of moisture from the samples. Moisture loss was highest for samples boiled in 10% NaCl followed by those boiled in water and the least for the raw samples. According to Metwalli *et al*. (1980) weight loss of cheese is attributed mainly to moisture loss. The additional factor responsible for decrease in weight of cheese is the uptake of salt which affects the loss of moisture. Berg (1988) reported losses up to 50% in weight in cheese pickled with salt. The salted samples lost much weight because they showed the greatest loss of moisture during storage. Samples boiled in water without salting showed lower loss of weight because they lost less moisture compared with the salted samples. Moisture loss was least for the raw samples hence, the least loss of weight.

Table 19: Moisture Levels (%) for Cheese Samples during Storage

Moisture levels (%) for cheese samples during storage					
	Storage period (days)				
Sample	**0**	**1**	**2**	**3**	**4**
Raw sample treatment					
100% coconut milk cheese	70.93 (0.90)	65.81 (2.33)	59.06 (1.02)	57.1 (0.84)	56.5 (1.18)
50%:50 blend cheese	63.65 (1.23)	58.91 (0.62)	52.39 (0.92)	50.28 (0.97)	49.53 (1.14)
100% cow's milk cheese	55.33 (1.45)	50.32 (0.92)	45.06 (1.42)	42.85 (0.47)	41.16 (1.53)
Boiled in water treatment					
100% coconut milk cheese	70.93 (0.72)	63.48 (0.81)	53.94 (1.22)	51.06 (1.45)	50.34 (2.18)
50%:50 blend cheese	63.65 (0.42)	56.82 (1.36)	47.61 (0.74)	44.78 (1.64)	44.21 (0.57)
100% cow's milk cheese	55.33 (0.92)	48.79 (1.25)	39.46 (2.30)	37.55 (0.10)	36.12 (1.15)
Boiled in 10% NaCl treatment					
100% coconut milk cheese	70.93 (0.79)	61.38 (1.37)	51.44 (1.18)	48.84 (0.73)	43.01 (0.43)
50%:50 blend cheese	63.65 (0.97)	54.13 (0.11)	45.28 (1.16)	42.18 (1.53)	37.48 (0.64)
100% cow's milk cheese	55.33 (0.25)	46.98 (1.50)	35.49 (1.82)	33.38 (0.74)	29.73 (0.47)

Table 19 shows a general decline in moisture content for all samples. From day 1 to day 4 the rate of decrease was highest for samples boiled in 10% NaCl solution, followed by those boiled in water with the raw samples recording the least rate of decrease in moisture content. Metwalli *et al.* (1980) made similar observations of loss in moisture during storage. Thakur *et al.* (1975) also reported that whey separation is enhanced by heating and this explains why cheese samples boiled in water and 10% NaCl solution had greater loss of about 20% and 26.5% respectively of moisture during storage compared with the raw samples (about 14%).

It was observed that cheese samples boiled in 10% NaCl showed greater loss of moisture than the boiled samples and this is explained by the fact that NaCl further reduces moisture through osmotic dehydration (Wolf *et al*, 1983; Le Jaouen, 1987). Thus the cheese samples boiled in salt solution had the combined effect of enhanced whey separation by heating and osmotic dehydration resulting from salting. The absence of

these factors in the raw samples resulted in the lower decline in moisture content over the storage period. Coconut milk cheese decreased by 27.92% and 14.43% from 70.93% to between 43.01% and 56.50% respectively across the three treatments while 100% cow's milk cheese also decreased by 25.6% and 14.17% from 55.33% to between 29.73% and 41.16% across all three treatments. The results for the 50% blend products decreased by 26.17% and 14.12% from 63.65% to between 37.48% and 49.53% respectively across treatments.

Table 20 Protein Levels (%) for Cheese Samples during Storage

Protein levels (%) for cheese samples during storage					
	Storage period (days)				
Sample	**0**	**1**	**2**	**3**	**4**
Raw sample treatment					
100% coconut milk cheese	2.35 (0.24)	1.86 (0.08)	1.50 (0.09)	1.39 (0.25)	1.23 (0.26)
50%:50 blend cheese	12.62 (0.78)	9.97 (0.19)	8.05 (0.20)	7.47 (0.33)	6.61 (0.12)
100% cow's milk cheese	17.26 (0.78)	13.64 (0.06)	11.02 (0.34)	10.21 (0.18)	9.03 (0.73)
Boiled in water treatment					
100% coconut milk cheese	2.35 (0.58)	1.95 (0.30)	1.49 (0.10)	1.38 (0.43)	1.32 (0.04)
50%:50 blend cheese	12.62 (0.20)	10.48 (0.44)	8.02 (0.30)	7.41 (0.37)	7.07 (0.25)
100% cow's milk cheese	17.26 (0.40)	14.34 (0.12)	10.97 (0.14)	10.13 (0.34)	9.67 (0.36)
Boiled in 10% NaCl treatment					
100% coconut milk cheese	2.35 (0.19)	1.92 (0.22)	1.57 (0.07)	1.44 (0.38)	1.36 (0.20)
50%:50 blend cheese	12.62 (0.24)	10.31 (0.17)	8.41 (0.19)	7.71 (0.13)	7.33 (0.33)
100% cow's milk cheese	17.26 (0.11)	14.11 (0.16)	11.51 (0.41)	10.55 (0.28)	10.02 (0.23)

Protein content of all cheese products declined with storage for all the treatments as shown in Table 20. The level of decrease in protein was 0.99%, 1.03% and 1.12% from 2.35% to 1.36%, 1.32% and 1.23% respectively in the case of 100% coconut milk cheese for salted, boiled and raw treatments respectively compared to 100% cow's milk cheese samples which recorded a decline from 17.26% to 10.02%, 9.67% and 9.03% for the

treatments respectively. The results for protein also show that protein content declined faster in raw cheese samples followed by samples boiled in water. The samples boiled in 10% NaCl solution had the least rate of decline.

Studies by Metwalli *et al*. (1982) have shown that there is a decrease in protein content of cheese during ripening. Cross and Overby (1988) also reported that part of the water insoluble casein is converted into water soluble nitrogenous compounds and are lost through whey expulsion during storage which was also observed in this study during storage. Wolf *et al*. (1983) reported that salt has selective effect against proteolytic micro-organisms. The minimum decline recorded for salted samples may be due to the inhibition of micro-organisms and enzyme activity. The raw samples experienced no inhibition of micro-organisms or enzyme activity resulting in proteolysis proceeding faster than in the samples boiled in water and in 10% NaCl solution. Proteolysis of large protein molecules into amino acids increases the digestibility of the proteins in the cheese product. Blanc (1982) reported that cheese ripening increases digestibility of proteins.

Table 21: Fat Levels (%) for Cheese Samples during Storage

	Fat levels (%) for cheese samples during storage				
	Storage period (days)				
Sample	**0**	**1**	**2**	**3**	**4**
	Raw sample treatment				
100% coconut milk cheese	24.07 (0.34)	19.30 (0.03)	15.89 (0.25)	13.11 (0.23)	12.57 (0.21)
50%:50 blend cheese	21.58 (0.16)	17.31 (0.15)	14.25 (0.08)	11.76 (0.08)	11.27 (0.11)
100% cow's milk cheese	25.85 (0.11)	20.73 (0.48)	17.07 (0.13)	14.08 (0.18)	13.50 (0.14)
	Boiled in water treatment				
100% coconut milk cheese	24.07 (0.19)	20.27 (0.08)	16.52 (0.04)	15.27 (0.04)	13.94 (0.21)
50%:50 blend cheese	21.58 (0.08)	18.17 (0.17)	14.81 (0.09)	13.69 (0.03)	12.50 (0.08)
100% cow's milk cheese	25.85 (0.11)	21.77 (0.06)	17.74 (0.10)	16.40 (0.08)	14.97 (0.08)
	Boiled in 10% NaCl treatment				
100% coconut milk cheese	24.07 (0.13)	20.94 (0.03)	18.06 (0.05)	16.71 (0.03)	16.43 (0.09)
50%:50 blend cheese	21.58 (0.01)	18.77 (0.05)	16.19 (0.04)	14.98 (0.22)	14.73 (0.10)
100% cow's milk cheese	25.85 (0.10)	22.49 (0.034	19.39 (0.02)	17.94 (0.15)	17.65 (0.05)

The result for changes in fat content of cheese samples during storage is shown in Table 21. There was a decline in fat content for all samples across all treatments. Fat level in 100% coconut milk cheese samples changed from 24.07% to a range of 12.57% and 16.43% while that of 100% cow's milk cheese decreased by 12.35% and 8.2% respectively from 25.85% to a range of 13.5% and 17.65% across the three treatments. Cheese product samples boiled in 10% NaCl solution recorded a lower rate of decline in fat content compared to samples boiled in water while raw samples recorded the highest rate of decline. Salt inhibits the growth of lipolytic micro-organisms which produces enzymes for fat breakdown. Salt inhibition results in the retardation of lipolysis in the salted samples (Wolf *et al*., 1983). Boiling samples in water resulted in reduced microbial proliferation and inactivation of lipolytic enzymes present in the sample leading to reduced lipolytic activity in the boiled samples.

The decline in fat content was higher in the boiled samples than in the salted samples. This may be due to further inhibition of microbial proliferation leading to inhibition of micro-organisms. Microbial growth was not inhibited in the raw samples and this resulted in faster proliferation of micro-organisms leading to higher lipolytic activity. Metwalli *et al.* (1982) observed a decline in fat content of cheese during ripening and according to Ohren and Tuckey (1969), lipolysis of fat results in liberation of fatty acids. Free fatty acids arise from degradation of fat in cheese and acts as precursors for other chemical reactions. Free fatty acids resulting from the lipolysis of triglycerides are considered important to the flavour of cheese (Nakae and Elliot, 1965).

The determination of titratable acidity was used as a measure for acidity of cheese product samples. The titratable acidity levels for all the samples increased with time as shown in Table 22. The titratable acidity increased from 0.016% to between 0.161 and 0.185 for coconut milk cheese across the raw, boiled in water and boiled in 10% NaCl solution treatments. These values were slightly lower than the values recorded for 100% cow's milk cheese which increased from 0.019% to between 0.163% and 0.196% across the three treatments respectively. The rate of increase in titratable acidity was higher in

the raw samples followed by those boiled in water. Samples boiled in 10% NaCl solution had the lowest percentage increase in titratable acidity.

Table 22: Titrable Acidity Levels (%) for Cheese Samples during Storage

Acidity levels (%) for cheese samples during storage					
	Storage period (days)				
Sample	**0**	**1**	**2**	**3**	**4**
Raw sample treatment					
100% coconut milk cheese	0.016 (0.002)	0.061 (0.001)	0.108 (0.002)	0.147 (0.002)	0.185 (0.003)
50%:50 blend cheese	0.018 (0.001)	0.051 (0.002)	0.111 (0.002)	0.149 (0.003)	0.160 (0.003)
100% cow's milk cheese	0.019 (0.002)	0.068 (0.001)	0.113 (0.006)	0.151 (0.002)	0.196 (0.002)
Boiled in water treatment					
100% coconut milk cheese	0.016 (0.001)	0.051 (0.001)	0.088 (0.003)	0.117 (0.002)	0.177 (0.002)
50%:50 blend cheese	0.018 (0.002)	0.048 (0.003)	0.08 (0.002)	0.119 (0.002)	0.182 (0.002)
100% cow's milk cheese	0.019 (0.002)	0.061 (0.002)	0.092 (0.002)	0.125 (0.001)	0.185 (0.002)
Boiled in 10% NaCl treatment					
100% coconut milk cheese	0.016 (0.002)	0.047 (0.003)	0.079 (0.002)	0.109 (0.002)	0.161 (0.002)
50%:50 blend cheese	0.018 (0.002)	0.041 (0.001)	0.074 (0.001)	0.103 (0.002)	0.159 (0.002)
100% cow's milk cheese	0.019 (0.003)	0.063 (0.001)	0.082 (0.001)	0.122 (0.002)	0.163 (0.003)

The high increase in acidity registered by the raw samples was because there was no inhibition of microbial growth (through heating and salting). The micro-organisms were able to proliferate and convert carbohydrate (lactose) into lactic acid. In addition, fat and protein breakdown were more pronounced in the raw samples resulting in release of free fatty acids and amino acids respectively. The samples boiled in water did not have as much proliferation of micro-organisms and hence showed lower rate of acid production. Those boiled in 10% NaCl solution had the lowest rate of increase because of the acid-base neutralisation between the acid produced and the NaCl. A study by Metwalli *et al*. (1982) reported increase in acidity up to the end of the ripening period of four (4) months for Domaiti cheese. Development of acidity in cheese is caused by the production of

lactic acid, free fatty acids and amino acids resulting from breakdown of carbohydrates, fats and proteins respectively. The major factor inducing acidity in soft cheese is lactic acid production (Metwalli *et al.*, 1982). Wolf *et al.* (1983) also reported that NaCl suppresses the growth of micro-organisms. Reduction of microbial load leads to reduction in amount of acid produced from the fermentation of lactose.

Table 23: Rancidity Levels (Mg/ Kg Malonaldehyde) during Storage

Rancidity levels (mg/ kg malonaldehyde) during storage					
	Storage period (days)				
Sample	**0**	**1**	**2**	**3**	**4**
Raw sample treatment					
100% coconut milk cheese	0.023 (0.002)	3.049 (0.005)	5.486 (0.004)	8.528 (0.003)	12.285 (0.008)
50%:50 blend cheese	0.029 (0.002)	3.203 (0.003)	6.022 (0.003)	9.321 (0.003)	12.577 (0.005)
100% cow's milk cheese	0.033 (0.002)	3.326 (0.002)	6.434 (0.009)	9.652 (0.006)	12.873 (0.005)
Boiled in water treatment					
100% coconut milk cheese	0.023 (0.002)	2.342 (0.004)	5.143 (0.006)	7.216 (0.005)	11.651 (0.004)
50%:50 blend cheese	0.029 (0.006)	2.566 90.007)	4.368 (0.007)	6.922 (0.005)	11.506 (0.006)
100% cow's milk cheese	0.033 (0.005)	2.701 (0.005)	3.338 (0.001)	6.269 (0.008)	11.409 (0.006)
Boiled in 10% NaCl treatment					
100% coconut milk cheese	0.023 (0.008)	2.218 (0.008)	3.246 (0.002)	5.432 (00.009)	10.496 (0.011)
50%:50 blend cheese	0.029 (0.007)	2.498 (0.007)	3.276 (0.010)	5.906 (0.005)	10.977 (0.012)
100% cow's milk cheese	0.033 (0.006)	2.765 (0.014)	3.386 (0.006)	6.351 (0.007)	11.636 (0.013)

Rancidity levels increased in storage in all the samples irrespective of milk composition and this was due to fat deterioration. Rancidity level for 100% coconut milk cheese increased from 0.023 mg/ kg malon aldehyde to the range of 10.496 to 12.285 mg mg/ kg malon aldehyde while that for 100% cow's milk cheese increased from 0.033 mg/ kg malon aldehyde to the range of 11.636 to 12.873 mg/ kg malon aldehyde. The raw samples had the highest increase in rancidity levels followed by the samples boiled in water and 10% NaCl correspondingly. The non-inhibition of microbial growth resulted in

enhanced lipolysis to produce more fatty acids thus increasing the rancidity level of the raw samples.

The lower levels of rancidity recorded by the samples boiled in water compared to the raw samples can be explained by the fact that boiling results in inhibition of microbial growth and loss of activity of lipolytic enzymes. The salted samples had the lowest level of rancidity over the storage period due to inhibitory effect of boiling and salting on the microbial activity and growth by lowering water activity. Lipid deterioration according to Ihekoronye and Ngoddy (1985), is a major problem in the storage of many foods especially those with high fat content. One of the major changes taking place in lipids is rancidity during which ester linkages of the lipids are hydrolysed by lipolytic enzymes into free fatty acids. Rancidity taking place through free radical chain reaction with oxygen (auto-oxidation) results in formation of peroxides or hydroperoxides. The peroxides decompose to yield aldehydes (such as malon aldehydes), ketones and alcohols.

4.3.2 REPEAT (CONTINUOUS) BOILING PROCESS

Cheese formulations were repeatedly boiled during storage and keeping quality monitored to assess the influence of repeated boiling on the keeping quality of cheese samples under ambient conditions. This is a practice that is carried out by some traditional producers and retailers of indigenous cheese (woagashie). Repeat boiling (on days 2 and 4) extended the keeping quality of the samples. Seven (7) days was achieved for samples boiled in water, the eighth (8) day presented sharp off flavours and repugnant smell which indicated deterioration. Repeated boiling on days 2, 4, 8, 12 and 16 in 10% NaCl solution kept the cheese sample wholesome for 20 days beyond which the product became especially hard and developed off flavours.

There was a decrease in weight of 32.45% for 100% coconut milk cheese sample and the 100% cow's milk cheese sample recorded a decrease of 27.96% during continuous boiling. There was a decrease in protein content of 2.01% for coconut cheese and 10.02 for cow's milk cheese. Fat content decreased from 25.01% to 12.18% for coconut cheese and from 26.13% to 13.61% for cow's milk cheese. Increases were recorded for titratable acidity and rancidity from 0.017% to 0.184% and 0.023 to 11.873 mg/ kg malon aldehyde

while that of cow's milk cheese recorded values from 0.019% to 0.192% for titratable acidity and 0.035 to 11.411 mg/ kg malon aldehyde.

Boiling repeatedly during storage retarded spoilage of cheese samples because micro-organisms are inhibited in their growth and activity or destroyed while recontamination of cheese samples is almost eliminated. With the salted samples, salt further enhanced storage by acting to retard microbial activity and hence lipolysis and proteolysis. According to Berg (1988), uncontrolled proliferation of microbes seriously affects the quality of cheese during storage.

4.4 SENSORY EVALUATION OF CHEESE SAMPLES

The results for sensory evaluation of the selected developed products are shown in Tables 24 to 28.

The mean score values for colour (Table 24) was in the following order; 1.93, 2.07, 2.47, 2.67, 2.90, 3.57 and 3.47 representing samples 269 (C50:50), 524 (C50:50 salted), 273 (C60:40 salted), 418 (C60:40), 914 (C100:0 wagashie), 315 (C70:30) and 357 (C70:30 salted) respectively. The results generally showed that panellists scored samples with increased milk content higher for colour. This may be attributed to the creamier visual appeal with increasing milk content. There were significant differences ($P<0.05$) in the responses of the sensory panellists to the colour of all developed samples except that samples 418 and 315 were not significantly different from 524, that sample 315 was not significantly different from 273 and sample 357 was not significantly different from 914.

Table 25 shows panellists' response to flavour of samples. At $P<0.05$ sample 269 was significantly different from all other samples. Sample 418 (C60:40) was significantly not different from sample 315 (C70:30) only. Additionally, sample 524 (C50:50 salted) was significantly different from samples 273 (C60:40 salted) and 357 (C70:30 salted); sample 273 (C60:40 salted) was significantly different from 357 (C70:30 salted) while sample 357 (C70:30 salted) was also significantly different from sample 914 (C100:0 wagashie). From the mean score values, panellists preference for flavour of developed samples was in the following order; 315, 269, 418, 273, 524, 357 and 914 with respective mean score of 4.27, 4.00, 4.00, 3.43, 3.40, 3.30 and 2.80.

Table 24: Panellists' Scoring for Colour of Selected Formulations of Cheese

Sample (CODE)	SCALE (A)	COLOUR FREQUENCY (B)	SCORE (A×B)	MEAN SCORE ∑(A×B)/30
C50:50 (269)	1	8	8	**1.93**
	2	16	32	
	3	6	18	
	4	0	0	
	5	0	0	
C60:40 (418)	1	3	3	**2.67**
	2	10	20	
	3	12	36	
	4	4	16	
	5	1	5	
C70:30 (315)	1	0	0	**3.57**
	2	4	8	
	3	10	30	
	4	11	44	
	5	5	25	
C50:50 Salted (524)	1	6	6	**2.07**
	2	16	32	
	3	8	24	
	4	0	0	
	5	0	0	
C60:40 Salted (273)	1	4	4	**2.47**
	2	13	26	
	3	9	27	
	4	3	12	
	5	1	5	
C70:30 Salted (357)	1	0	0	**3.47**
	2	4	8	
	3	11	33	
	4	12	48	
	5	3	15	
C100:0 wagashie (914)	1	1	1	**2.90**
	2	8	16	
	3	15	45	
	4	5	20	
	5	1	5	

1 DVM - Dislike Very Much
2 DS - Dislike Slightly
3 NLDL - Neither Like nor Dislike
4 LS - Like Slighly
5 LVM - Like Very Much

Table 25: Panellists' Scoring for Flavour of Selected Formulations of Cheese

Sample (CODE)	SCALE (A)	FLAVOUR FREQUENCY (B)	SCORE (A×B)	MEAN SCORE ∑(A×B)/30
C50:50 (269)	1	0	0	**4.00**
	2	1	2	
	3	5	15	
	4	17	68	
	5	7	35	
C60:40 (418)	1	0	0	**4.00**
	2	1	2	
	3	5	15	
	4	17	68	
	5	7	35	
C70:30 (315)	1	0	0	**4.27**
	2	0	0	
	3	2	6	
	4	18	72	
	5	10	50	
C50:50 Salted (524)	1	0	0	**3.40**
	2	3	6	
	3	15	45	
	4	9	36	
	5	3	15	
C60:40 Salted (273)	1	1	1	**3.43**
	2	5	10	
	3	8	24	
	4	12	48	
	5	4	20	
C70:30 Salted (357)	1	2	2	**3.30**
	2	6	12	
	3	6	18	
	4	13	52	
	5	3	15	
C100:0 wagashie (914)	1	3	3	**2.80**
	2	9	18	
	3	10	30	
	4	7	28	
	5	1	5	

1 DVM - Dislike Very Much

2 DS - Dislike Slightly

3 NLDL - Neither Like nor Dislike

4 LS - Like Slighly

5 LVM - Like Very Much

The mean score values for taste (Table 26) was in the following order; 357 (70:30 salted), 273 (C60:40 salted), 315 (C70:30), 914 (C100:0), 524 (C50:50 salted), 418 (C60:40) and 269 (C50:50) representing 3.27, 2.93, 2.83, 2.80, 2.37, 2.20 and 2.20 respectively. The statistical analysis of responses of panellists for taste showed significant differences between all the developed samples.

Curd firmness was determined by feeling between the fingers. Analysis of responses of panellists (Table 27) revealed that there were no significant differences ($P<0.05$) between all the developed samples. The mean scores for developed samples showed a short range of between a maximum of 2.67 and 2.23 as minimum.

The responses of panellists for overall acceptability are presented in Table 28. All developed samples showed significant differences at $P<0.05$ except between samples 418 (C60:40) and 524 (C50:50 salted) which showed no significant difference. The means scores indicate panellists' preference for developed samples in the order 357 (C70:30 salted), 315 (C70:30), 273 (C60:40 salted), 914 (C100:0 wagashie), 418 (C60:40), 524 (C50:50) and 269 (C50:50).

Table 26: Panellists' Scoring for Taste of Selected Formulations of Cheese

		TASTE		
Sample (CODE)	**SCALE (A)**	**FREQUENCY (B)**	**SCORE (A×B)**	**MEAN SCORE ∑(A×B)/30**
C50:50 (269)	1	12	12	**2.20**
	2	6	12	
	3	8	24	
	4	2	8	
	5	2	10	
C60:40 (418)	1	10	10	**2.20**
	2	9	18	
	3	7	21	
	4	3	12	
	5	1	5	
C70:30 (315)	1	4	4	**2.83**
	2	7	14	
	3	10	30	
	4	8	32	
	5	1	5	
C50:50 Salted (524)	1	8	8	**2.37**
	2	10	20	
	3	7	21	
	4	3	12	
	5	2	10	
C60:40 Salted (273)	1	4	4	**2.93**
	2	7	14	
	3	8	24	
	4	9	36	
	5	2	10	
C70:30 Salted (357)	1	2	2	**3.27**
	2	6	12	
	3	7	21	
	4	12	48	
	5	3	15	
C100:0 wagashie (914)	1	2	2	**2.80**
	2	10	20	
	3	12	36	
	4	4	16	
	5	2	10	

1	DVM	- Dislike Very Much	4	LS	- Like Slighly
2	DS	- Dislike Slightly	5	LVM	- Like Very Much
3	NLDL	- Neither Like nor Dislike			

Table 27: Panellists' Scoring for Curd Firmness of Selected Formulations of Cheese

	CURD FIRMNESS			
Sample (CODE)	**SCALE (A)**	**FREQUENCY (B)**	**SCORE (A×B)**	**MEAN SCORE ∑(A×B)/30**
C50:50 (269)	1	8	8	**2.27**
	2	12	24	
	3	5	15	
	4	4	16	
	5	1	5	
C60:40 (418)	1	6	6	**2.33**
	2	12	24	
	3	9	27	
	4	2	8	
	5	1	5	
C70:30 (315)	1	7	7	**2.67**
	2	5	10	
	3	10	30	
	4	7	28	
	5	1	5	
C50:50 Salted (524)	1	8	8	**2.23**
	2	12	24	
	3	6	18	
	4	3	12	
	5	1	5	
C60:40 Salted (273)	1	6	6	**2.67**
	2	7	14	
	3	9	27	
	4	7	28	
	5	1	5	
C70:30 Salted (357)	1	5	5	**2.67**
	2	9	18	
	3	9	27	
	4	5	20	
	5	2	10	
C100:0 wagashie (914)	1	4	4	**2.67**
	2	10	20	
	3	10	30	
	4	4	16	
	5	2	10	

1 DVM - Dislike Very Much
2 DS - Dislike Slightly
3 NLDL - Neither Like nor Dislike
4 LS - Like Slighly
5 LVM - Like Very Much

Table 28: Panellists' Scoring for Overall Acceptability of Selected Formulations of Cheese

Sample (CODE)	SCALE (A)	FREQUENCY (B)	SCORE (A×B)	MEAN SCORE ∑(A×B)/30
C50:50 (269)	1	5	5	**2.57**
	2	12	24	
	3	7	21	
	4	3	12	
	5	3	15	
C60:40 (418)	1	4	4	**2.70**
	2	10	20	
	3	9	27	
	4	5	20	
	5	2	10	
C70:30 (315)	1	2	2	**3.23**
	2	6	12	
	3	11	33	
	4	5	20	
	5	6	30	
C50:50 Salted (524)	1	4	4	**2.70**
	2	11	22	
	3	8	24	
	4	4	16	
	5	3	15	
C60:40 Salted (273)	1	3	3	**2.83**
	2	10	20	
	3	8	24	
	4	7	28	
	5	2	10	
C70:30 Salted (357)	1	1	1	**3.53**
	2	5	10	
	3	8	24	
	4	9	36	
	5	7	35	
C100:0 wagashie (914)	1	3	3	**2.77**
	2	10	20	
	3	11	33	
	4	3	12	
	5	3	15	

1 DVM - Dislike Very Much
2 DS - Dislike Slightly
3 NLDL - Neither Like nor Dislike
4 LS - Like Slighly
5 LVM - Like Very Much

4.4.1 CORRELATION BETWEEN PARAMETERS OF DEVELOPED SAMPLES

The correlation between sensory parameters of colour, flavour, taste, curd firmness and overall acceptability is shown in Table 29. The strongest correlation was between taste and curd firmness (0.226), however at P<0.05 level the correlation between curd firmness and colour was the most significant.

Table 29: Correlation between Sensory Parameters

		Colour	Curd firmness	Flavour	Taste	Overall acceptability
Colour	Pearson Correlation	1				
	Sig. (2-tailed)					
	N	30				
Curd firmness	Pearson Correlation	-.428*	1			
	Sig. (2-tailed)	.018				
	N	30	30			
Flavour	Pearson Correlation	.048	-.049	1		
	Sig. (2-tailed)	.801	.797			
	N	30	30	30		
Taste	Pearson Correlation	-.283	.226	-.120	1	
	Sig. (2-tailed)	.130	.230	.527		
	N	30	30	30	30	
Overall acceptability	Pearson Correlation	-.208	-.115	.060	.065	1
	Sig. (2-tailed)	.270	.545	.752	.732	
	N	30	30	30	30	30

*. Correlation is significant at the 0.05 level (2-tailed).

CHAPTER 5

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

The results of the study lead to the conclusion that the partial substitution of cow's milk with coconut milk yields sufficiently significant products. The yield of cheese was 305.4 g, 151.8 g and 270.0 g per 1000g respectively of cow's milk, coconut milk and a 50% blend of both. Moisture, Ash and Fibre contents increased with increasing coconut milk content while the opposite was recorded for protein content, which peaked at 17.26% for 100% cow's milk cheese. Salting samples in 10% NaCl solution retarded the rate of change of all parameters. The keeping quality was determined as three (3) days for all product treatments (raw, boiling in water and boiling in 10% NaCl) which was extended to seven (7) days by repeated boiling (on days 2 and 4) and to twenty (20) by repeated boiling on days 2, 4, 8, 12 and 16 in 10% NaCl. The flavour characteristic was scored the highest in respect of sensory appeal while colour recorded the lowest average scores. The strongest sensory correlation was between taste and curd firmness (0.226), however at $P<0.05$ level the correlation between curd firmness and colour was the most significant. Salting of samples greatly enhanced its taste, flavour and overall acceptability. Overall, "cocowag" (cheese from blend of cow's milk and coconut milk) was concluded to be a worthy product for development; C70:30 and C60:40.

5.2 RECOMMENDATIONS

It is recommended that further research should be carried to determine;

- The possibility of extraction of coagulant for storage
- The possibility of using other vegetable coagulants
- Appropriate packaging for the developed cheese product.
- The commercial viability of the product

CHAPTER 6

6.0 REFERENCES

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CHAPTER 7

7.0 APPENDICES

7.1. APPENDIX 1 - SENSORY EVALUATION FORM

DEPARTMENT OF BIOCHEMISTRY
KNUST - KUMASI
SENSORY EVALUATION FORM

Form Number: ……

Name: ……...……..….. Sex: ……. Age: …….

Product: ……

INSTRUCTION
Using the numbers 1, 2, 3, 4, 5 (as shown below), please indicate the intensity of the various characteristics of the coded products below.

1 - Dislike Very Much
2 - Dislike Slightly
3 - Neither Like Nor Dislike
4 - Like Slightly
5 - Like Very Much

CODE	COLOUR	FLAVOUR	TASTE	FIRMNESS	OVERALL ACCEPTABILITY
315	……	……	……	……	……
269	……	……	……	……	……
418	……	……	……	……	……
357	……	……	……	……	……
524	……	……	……	……	……
273	……	……	……	……	……
914	……	……	……	……	……

Optional Comments:
……
……
……
…….. Thank You.

7.2 APPENDIX 2 - ANOVA OF DATA ON YIELD OF CHEESE SAMPLES

ANOVA

Yield

	Sum of Squares	df	Mean Square	F
Between Groups	50633.84	8	6329.231	1245.007
Within Groups	91.50647	18	5.083693	
Total	50725.35	26		

7.3 APPENDIX 3 - ANOVA OF DATA ON NUTRITIONAL COMPOSITION OF CHEESE SAMPLES

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Moisture	Between Groups	741.41027	8	92.6762833	13.74045022	3.17088E-06
	Within Groups	121.406	18	6.74477778		
	Total	862.81627	26			
Fat	Between Groups	67.781319	8	8.47266481	2.091639183	0.092291282
	Within Groups	72.913133	18	4.05072963		
	Total	140.69445	26			
Protein	Between Groups	657.17076	8	82.1463454	107.3470622	1.34766E-13
	Within Groups	13.774333	18	0.76524074		
	Total	670.9451	26			
Ash	Between Groups	0.5230741	8	0.06538426	0.468368619	0.862536583
	Within Groups	2.5128	18	0.1396		
	Total	3.0358741	26			
Fibre	Between Groups	0.733363	8	0.09167037	9.936170213	3.18432E-05
	Within Groups	0.1660667	18	0.00922593		
	Total	0.8994296	26			

7.4 APPENDIX 4 - PAIRED T-TEST ON DATA SENSORY ANALYSIS

A. Colour

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S269 - S418	-.73333	1.22990	.22455	-1.19258	-.27408	-3.266	29	.003

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S269 - S315	-1.63333	1.24522	.22735	-2.09831	-1.16836	-7.184	29	.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S269 - S524	-.13333	.57135	.10431	-.34668	.08001	-1.278	29	.211

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S269 - S273	-.53333	1.22428	.22352	-.99049	-.07618	-2.386	29	.024

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S269 - S357	-1.53333	1.07425	.19613	-1.93447	-1.13220	-7.818	29	.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S269 - S918	-.96667	1.06620	.19466	-1.36479	-.56854	-4.966	29	.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S418 - S315	-.90000	1.09387	.19971	-1.30846	-.49154	-4.506	29	.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	S418 - S524	.60000	1.19193	.21762	.15493	1.04507	2.757	29	.010

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	S418 - S273	.20000	1.37465	.25098	-.31330	.71330	.797	29	.432

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	S418 - S357	-.80000	1.27035	.23193	-1.27436	-.32564	-3.449	29	.002

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	S418 - S918	-.23333	1.30472	.23821	-.72052	.25386	-.980	29	.335

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S315 - S524	1.50000	1.22474	.22361	1.04267	1.95733	6.708	29	.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S315 - S273	1.10000	1.32222	.24140	.60627	1.59373	4.557	29	.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S315 - S357	.10000	1.37339	.25075	-.41283	.61283	.399	29	.693

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S315 - S918	.66667	1.49328	.27263	.10907	1.22427	2.445	29	.021

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S524 - S273	-.40000	1.19193	.21762	-.84507	.04507	-1.838	29	.076

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S524 - S357	-1.40000	1.06997	.19535	-1.79953	-1.00047	-7.167	29	.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S524 - S918	-.83333	1.05318	.19228	-1.22660	-.44007	-4.334	29	.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	S273 - S357	-1.00000	1.11417	.20342	-1.41604	-.58396	-4.916	29	.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	S273 - S918	-.43333	1.33089	.24299	-.93030	.06363	-1.783	29	.085

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	S357 - S918	.56667	1.00630	.18372	.19091	.94243	3.084	29	.004

B. Flavour

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	S269 - S418	-.70000	1.26355	.23069	-1.17182	-.22818	-3.034	29	.005

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	S269 - S315	-.96667	.96431	.17606	-1.32674	-.60659	-5.491	29	.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	S269 - S524	-.10000	1.26899	.23169	-.57385	.37385	-.432	29	.669

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	S269 - S273	-.13333	1.04166	.19018	-.52230	.25563	-.701	29	.489

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S269 - S357	.00000	1.61885	.29556	-.60449	.60449	.000	29	1.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S269 - S914	.50000	1.57020	.28668	-.08632	1.08632	1.744	29	.092

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S418 - S315	-.26667	.86834	.15854	-.59091	.05758	-1.682	29	.103

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S418 - S524	.60000	.96847	.17682	.23837	.96163	3.393	29	.002

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	S418 - S273	.56667	1.35655	.24767	.06012	1.07321	2.288	29	.030

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	S418 - S357	.70000	1.29055	.23562	.21810	1.18190	2.971	29	.006

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	S418 - S914	1.20000	1.18613	.21656	.75709	1.64291	5.541	29	.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	S315 - S524	.86667	.89955	.16424	.53077	1.20257	5.277	29	.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S315 - S273	.83333	1.01992	.18621	.45249	1.21418	4.475	29	.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S315 - S357	.96667	1.24522	.22735	.50169	1.43164	4.252	29	.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S315 - S914	1.46667	1.30604	.23845	.97898	1.95435	6.151	29	.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S524 - S273	-.03333	1.15917	.21163	-.46618	.39951	-.158	29	.876

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S524 - S357	.10000	1.39827	.25529	-.42212	.62212	.392	29	.698

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S524 - S914	.60000	1.16264	.21227	.16586	1.03414	2.827	29	.008

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S273 - S357	.13333	1.50249	.27432	-.42771	.69437	.486	29	.631

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	S273 - S914	.63333	1.37674	.25136	.11925	1.14742	2.520	29	.018

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	S357 - S914	.50000	1.59201	.29066	-.09446	1.09446	1.720	29	.096

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Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S269 - S418	.00000	1.61885	.29556	-.60449	.60449	.000	29	1.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S269 - S315	-.63333	1.73172	.31617	-1.27997	.01330	-2.003	29	.055

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S269 - S524	-.16667	1.76329	.32193	-.82509	.49176	-.518	29	.609

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S269 - S273	-.73333	1.74066	.31780	-1.38331	-.08336	-2.308	29	.028

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S269 - S357	-1.06667	1.72073	.31416	-1.70920	-.42413	-3.395	29	.002

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S269 - S914	-.60000	1.37966	.25189	-1.11517	-.08483	-2.382	29	.024

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S418 - S315	-.63333	1.42595	.26034	-1.16579	-.10087	-2.433	29	.021

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	S418 - S524	-.16667	1.55549	.28399	-.74750	.41416	-.587	29	.562

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	S418 - S273	-.73333	1.61743	.29530	-1.33729	-.12937	-2.483	29	.019

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	S418 - S357	-1.06667	1.65952	.30299	-1.68634	-.44699	-3.521	29	.001

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S418 - S914	-.60000	1.69380	.30924	-1.23248	.03248	-1.940	29	.062

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S315 - S524	.46667	1.75643	.32068	-.18920	1.12253	1.455	29	.156

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S315 - S273	-.10000	1.62629	.29692	-.70727	.50727	-.337	29	.739

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S315 - S357	-.43333	1.47819	.26988	-.98530	.11863	-1.606	29	.119

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S315 - S914	.03333	1.58622	.28960	-.55897	.62564	.115	29	.909

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S524 - S273	-.56667	1.45468	.26559	-1.10985	-.02348	-2.134	29	.041

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S524 - S357	-.90000	1.68870	.30831	-1.53057	-.26943	-2.919	29	.007

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	S524 - S914	-.43333	1.63335	.29821	-1.04323	.17657	-1.453	29	.157

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	S273 - S357	-.33333	1.76817	.32282	-.99358	.32691	-1.033	29	.310

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	S273 - S914	.13333	1.38298	.25250	-.38308	.64975	.528	29	.601

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	S357 - S914	.46667	1.45586	.26580	-.07696	1.01030	1.756	29	.090

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Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S269 - S418	-.06667	1.31131	.23941	-.55632	.42299	-.278	29	.783

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S269 - S315	-.40000	1.81184	.33079	-1.07655	.27655	-1.209	29	.236

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S269 - S524	.03333	1.73172	.31617	-.61330	.67997	.105	29	.917

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S269 - S273	-.40000	1.75381	.32020	-1.05488	.25488	-1.249	29	.222

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	S269 - S357	-.40000	1.83077	.33425	-1.08362	.28362	-1.197	29	.241

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	S269 - S914	-.40000	1.49943	.27376	-.95989	.15989	-1.461	29	.155

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	S418 - S315	-.33333	1.64701	.30070	-.94834	.28167	-1.109	29	.277

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S418 - S524	.10000	1.49366	.27270	-.45774	.65774	.367	29	.717

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S418 - S273	-.33333	1.56102	.28500	-.91623	.24956	-1.170	29	.252

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S418 - S357	-.33333	1.29544	.23651	-.81706	.15039	-1.409	29	.169

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S418 - S914	-.33333	1.56102	.28500	-.91623	.24956	-1.170	29	.252

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S315 - S524	.43333	1.40647	.25679	-.09185	.95852	1.688	29	.102

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S315 - S273	.00000	1.68154	.30701	-.62790	.62790	.000	29	1.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S315 - S357	.00000	1.46217	.26695	-.54598	.54598	.000	29	1.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S315 - S914	.00000	1.74198	.31804	-.65046	.65046	.000	29	1.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S524 - S273	-.43333	1.50134	.27411	-.99394	.12728	-1.581	29	.125

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S524 - S357	-.43333	1.43078	.26122	-.96759	.10093	-1.659	29	.108

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S524 - S914	-.43333	1.50134	.27411	-.99394	.12728	-1.581	29	.125

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S273 - S357	.00000	1.48556	.27123	-.55472	.55472	.000	29	1.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S273 - S914	.00000	1.46217	.26695	-.54598	.54598	.000	29	1.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	S357 - S914	.00000	1.68154	.30701	-.62790	.62790	.000	29	1.000

E. Overall Acceptability

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	S269 - S418	-.13333	1.45586	.26580	-.67696	.41030	-.502	29	.620

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	S269 - S315	-.66667	1.93575	.35342	-1.38949	.05615	-1.886	29	.069

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	S269 - S524	-.13333	1.85199	.33813	-.82488	.55821	-.394	29	.696

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	S269 - S273	-.26667	1.76036	.32140	-.92399	.39066	-.830	29	.413

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S269 - S357	-.96667	1.44993	.26472	-1.50808	-.42525	-3.652	29	.001

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S269 - S914	-.20000	1.84578	.33699	-.88922	.48922	-.593	29	.557

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S418 - S315	-.53333	1.54771	.28257	-1.11126	.04459	-1.887	29	.069

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S418 - S524	.00000	1.76166	.32163	-.65781	.65781	.000	29	1.000

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S418 - S273	-.13333	1.22428	.22352	-.59049	.32382	-.597	29	.555

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S418 - S357	-.83333	1.87696	.34268	-1.53420	-.13246	-2.432	29	.021

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S418 - S914	-.06667	1.65952	.30299	-.68634	.55301	-.220	29	.827

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S315 - S524	.53333	1.81437	.33126	-.14417	1.21083	1.610	29	.118

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S315 - S273	.40000	1.42877	.26086	-.13351	.93351	1.533	29	.136

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S315 - S357	-.30000	1.85974	.33954	-.99444	.39444	-.884	29	.384

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S315 - S914	.46667	1.43198	.26144	-.06804	1.00138	1.785	29	.085

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S524 - S273	-.13333	1.63440	.29840	-.74363	.47696	-.447	29	.658

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S524 - S357	-.83333	1.51050	.27578	-1.39736	-.26930	-3.022	29	.005

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S524 - S914	-.06667	1.89251	.34552	-.77334	.64001	-.193	29	.848

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S273 - S357	-.70000	1.93248	.35282	-1.42160	.02160	-1.984	29	.057

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	S273 - S914	.06667	1.77984	.32495	-.59794	.73127	.205	29	.839

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	S357 - S914	.76667	1.85106	.33796	.07547	1.45787	2.269	29	.031

7. 5 APPENDIX 5 - MEAN SCORES OF PANELLISTS ON SENSORY PARAMETERS

Sample (CODE)	MEAN SCORES				
	Colour	**Flavour**	**Taste**	**Curd Firmness**	**Overall Acceptability**
C50:50 (269)	1.93	4.00	2.20	2.27	2.57
C60:40 (418)	2.67	4.00	2.20	2.33	2.70
C70:30 (315)	3.57	4.27	2.83	2.67	3.23
C50:50 Salted (524)	2.07	3.40	2.37	2.23	2.70
C60:40 Salted (273)	2.47	3.43	2.93	2.67	2.83
C70:30 Salted (357)	3.47	3.30	3.27	2.67	3.53
C100:0 wagashie (914)	2.90	2.80	2.80	2.67	2.77

7. 6 APPENDIX 6 - RAW SCORE OF SENSORY PANELLISTS

Colour

Panelist	269	418	315	524	273	357	914
1	1	2	3	3	3	4	3
2	3	2	4	3	3	3	2
3	2	3	3	2	2	4	3
4	2	3	4	2	2	2	4
5	1	1	2	1	2	4	4
6	2	2	2	2	1	2	3
7	2	4	3	2	3	4	3
8	1	3	4	1	3	3	3
9	2	3	5	2	4	5	3
10	1	3	4	1	5	4	2
11	3	5	4	3	1	4	3
12	2	4	5	2	2	3	2
13	3	1	3	3	3	3	2
14	3	2	3	3	2	5	4
15	1	4	5	1	2	2	1
16	2	3	4	2	4	3	4
17	2	2	2	2	3	4	5
18	2	3	3	2	2	4	4
19	1	4	4	3	3	3	3
20	2	3	4	2	3	5	3
21	2	3	3	3	2	3	3
22	2	2	3	2	2	3	2
23	1	2	3	1	2	4	2
24	2	2	4	2	1	4	3
25	2	1	5	2	2	2	2
26	3	3	2	2	3	3	3
27	3	2	3	3	4	4	2
28	1	3	4	1	2	4	3
29	2	3	4	2	1	3	3
30	2	2	5	2	2	3	3

Flavour Panelist	269	418	315	524	273	357	914
1	3	5	3	2	2	4	3
2	1	4	4	2	2	3	1
3	3	3	4	2	3	2	3
4	2	3	4	3	4	5	4
5	3	3	5	3	3	3	3
6	3	2	3	3	3	4	2
7	4	3	5	3	4	4	1
8	5	3	5	3	4	3	2
9	4	4	4	4	4	4	4
10	3	4	4	3	5	4	3
11	3	4	4	3	3	4	2
12	4	4	4	4	2	1	4
13	5	5	5	3	5	2	3
14	3	4	4	4	4	2	4
15	4	5	5	5	4	5	3
16	1	4	4	3	3	3	4
17	3	4	4	4	4	4	5
18	4	4	4	3	4	3	4
19	3	5	5	3	2	4	3
20	3	4	4	4	5	1	3
21	5	4	5	3	5	5	2
22	3	4	4	4	3	4	1
23	3	4	4	4	4	4	3
24	4	4	4	4	4	2	2
25	5	4	5	4	4	2	2
26	2	4	5	5	3	3	2
27	3	5	4	5	3	4	4
28	3	4	4	3	2	2	3
29	2	5	4	3	1	4	2
30	5	5	5	3	4	4	2

Taste Panelist	269	418	315	524	273	357	914
1	5	3	3	2	3	4	3
2	1	4	3	1	2	4	2
3	1	2	3	2	3	3	3
4	2	1	3	2	2	4	2
5	3	2	4	3	5	4	3
6	1	4	4	3	3	3	3
7	1	3	3	4	4	5	4
8	3	2	3	5	2	2	2
9	2	1	3	1	2	3	3
10	5	3	4	1	1	4	2
11	4	1	2	4	3	4	5
12	3	2	2	3	3	2	4
13	2	1	5	2	3	5	3
14	1	3	3	2	3	3	2
15	1	1	4	2	2	3	1
16	3	2	4	1	4	4	4
17	2	5	3	3	4	2	1
18	1	3	4	3	4	1	3
19	3	1	2	1	5	1	3
20	4	2	1	1	4	2	5
21	1	1	1	4	4	4	2
22	3	3	2	5	4	2	2
23	1	1	1	3	4	4	3
24	2	2	2	2	3	5	2
25	1	2	4	1	2	4	4
26	3	3	2	1	2	3	3
27	2	1	3	2	1	2	3
28	1	1	1	2	1	4	3
29	3	4	2	3	1	4	2
30	1	2	4	2	4	3	2

Curd Firmness

Panelist	269	418	315	524	273	357	914
1	1	4	3	2	3	4	1
2	2	3	3	2	3	3	3
3	2	3	4	2	3	4	4
4	2	2	4	4	4	3	2
5	1	3	3	3	4	4	3
6	2	3	4	3	2	2	3
7	3	2	4	2	2	3	3
8	3	2	3	1	2	3	2
9	2	2	3	4	3	3	2
10	4	2	2	2	1	2	2
11	2	1	3	1	1	2	1
12	2	1	2	1	3	1	4
13	1	2	1	3	4	2	2
14	2	1	2	3	2	1	5
15	1	2	4	5	1	2	3
16	1	3	1	2	1	5	3
17	3	3	1	2	2	4	2
18	4	3	3	3	3	3	4
19	2	2	1	2	2	2	2
20	1	1	4	1	4	2	1
21	3	2	2	1	4	1	3
22	5	2	1	3	4	2	3
23	1	1	1	2	5	3	5
24	1	2	4	4	3	4	2
25	2	1	5	2	3	5	2
26	2	2	3	1	2	2	4
27	4	3	3	1	1	1	3
28	3	3	2	2	1	1	1
29	2	4	3	2	4	3	2
30	4	5	1	1	3	3	3

Overall Acceptability

Panelist	269	418	315	524	273	357	914
1	2	3	3	5	3	2	3
2	5	2	1	3	2	5	2
3	2	2	2	3	4	4	3
4	2	3	4	4	4	2	3
5	3	2	4	2	3	5	2
6	2	2	5	4	2	4	3
7	1	3	3	2	1	3	4
8	1	1	5	1	3	3	5
9	3	4	2	2	2	4	3
10	4	5	3	1	4	3	3
11	3	3	2	2	4	3	2
12	4	2	3	2	2	4	3
13	5	3	4	1	2	5	2
14	3	5	5	3	5	2	2
15	2	2	2	4	4	3	2
16	2	1	1	5	2	5	1
17	4	1	3	3	2	4	2
18	3	3	2	2	3	4	3
19	2	2	5	1	3	3	5
20	3	3	2	3	1	3	5
21	1	4	4	3	3	3	4
22	2	4	4	2	3	4	1
23	3	4	3	4	4	5	1
24	2	3	3	2	4	2	2
25	1	3	5	2	5	1	3
26	2	2	5	5	2	5	2
27	5	4	3	2	2	2	3
28	2	1	3	2	1	4	4
29	2	2	3	3	3	4	2
30	1	2	3	3	2	5	3

7. 7 APPENDIX 7 – FORMULAS FOR PROXIMATE CALCULATIONS

7.7.1 MOISTURE CONTENT

$$\% \text{ Moisture} = \frac{\text{Initial mass} - \text{Dry Mass}}{\text{Initial mass of sample}} \times 100$$

7.7.2 CRUDE PROTEIN CONTENT

$$\% \text{ Crude Protein} = \frac{(V_S - V_B) \times N_A \times 6.38}{W} \times 100$$

V_S - Volume of acid used in titration
V_B - Volume of base
N_A - Normality of acid
W - Mass of sample

7.7.3 FAT CONTENT

$$\% \text{ Crude fat} = \frac{\text{Mass of fat obtained}}{\text{Dry mass of sample}} \times 100$$

7.7.4 CRUDE FIBRE DETERMINATION

$$\% \text{ Crude Fibre} = \frac{\text{Mass of fibre}}{\text{Dry mass of sample}} \times 100$$

7.7.5 ASH DETERMINATION

$$\% \text{ Ash Content} = \frac{\text{Mass of Ash}}{\text{Dry mass of sample}} \times 100$$

7.7.6 TITRABLE ACIDITY

$$\% \text{ Acidity} = \frac{\{[x \text{ ml of } 0.1N \text{ NaOH}] \times [0.009g \text{ lactic acid}]\}}{\text{Mass of sample}} \times 100$$

[1ml 0.1N NaOH = 0.00900 g lactic acid].

Where x is the volume of NaOH or titre volume.