UNIVERSITY OF EDUCATION, WINNEBA

COLLEGE OF TECHNOLOGY EDUCATION, KUMASI

FORTIFICATION OF CASSAVA STARCH BISCUIT IN AGBOZUME

ANAGLIH MARGARET YAWO

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A Dissertation in the Department of CATERING AND HOSPITALITY TECHNOLOGY EDUCATION, Faculty of VOCATIONAL EDUCATION, submitted to the School of Graduate Studies, University of Education, Winneba, in partial fulfillment of the requirements for the award of Master of Technology, (Catering and Hospitality Education) degree.

DECEMBER, 2015

DECLARATION

I, **ANAGLIH MARGARET YAWO,** declare that this Dissertation, with the exception of quotations and references contained in published works which have all been identified and duly acknowledged, is entirely my own original work, and it has not been submitted, either in part or whole, for another degree elsewhere.

SIGNATURE: ……………………………………………

DATE:…………………………………………………….

SUPERVISOR'S DECLARATION

I hereby declare that the preparation and presentation of this work was supervised in accordance with guidelines for supervision of Dissertation as laid down by the University of Education, Winneba.

NAME OF SUPERVISOR: **VIDA COMMEY (MRS)**

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DATE:…………………………………………………….

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DEDICATION

I dedicate this project to the almighty God for his excellence over my life throughout my academic struggle. This piece of project is dedicated to Mrs. Vida Commey, Mrs. Olu and her team who supported me. I also dedicate this project work to the entire ANAGLIH family especially my husband my son and daughters and my father Lucas Vigbedor.

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ABSTRACT

In developing countries like Ghana, the need for highly nutritious yet readily available and less expensive food is important. The purpose of the study was to develop a more fortified cassava starch biscuit with the introduction of a protein based ingredient in addition to the existing "Agbozume Biscuit. Cassava starch with coconut and soya bean were prepared by using process flow to come out with a suitable improved product. Sensory Evaluation of the biscuit was conducted by 90 panelists by using sensory attributes of colour, aroma, taste, texture, size and shape of the product. Results indicated a degree of likeness for all out of five, colour (4.1), aroma (4.7), shape (3.9), texture (3.9), size (3.3) and taste (4.5).Shelf life indicates that the product did not like moist therefore preferred to be stored in polythene bags and could make the product last for a period of four months without any significant change. Nutritional analysis in assessing the components of the fortified product revealed an additional increase. For every 100 gram, protein (13.0), fat (6.8), calcium (179mg), Vitamin C (29mg) thiamin (0.44) among other nutrients. This indicates a significant improvement in the Quality of the new composite cassava starch biscuit. The standardized recipe under materials can be as follows; Starch flour (dried) 250g, Soya flour 40g, Sugar 100g and Dried coconut 200g. These results showed that the 250g/40g (cassava starch/soya bean flour) composite could be a viable alternative to achieve the desired result for the popular delicacy: "Ayigbey biscuit". It is recommended that, Bakers should limit the inclusion of soya beans flour in biscuit baking as too much soya bean can result in customer rejection." Evaluation of the functionality of composite flour in test baking should be performed to ensure an increase in the use of composite flour made from many different local cereals and root/tuber plants in future instead of over reliance on imported wheat flour.

CHAPTER ONE

INTRODUCTION

1.0 Introduction

The purpose of the study was to develop a more fortified cassava starch biscuit with the introduction of a protein based ingredient in addition to the existing composition of the “Agbozume Biscuit”. The chapter presents the background and motivation for the study, the statement of the problem, the purpose, objectives and questions for the research. The significance and the organization of the study are equally presented in this chapter.

1.1 Background of the Study

Biscuit belong to the flour confectionery. It is flat crisp and may be sweetened or unsweetened according to preference. Globally there are lots of biscuit some are known as hard tact. Hard tact was hard and dry biscuit known as soldiers/ sailors bread or stone bread. If sealed in a container, could last for four months. Cassava starch biscuit unlike all other biscuit which use conventional wheat flour and fats, this biscuit use the local cassava starch and coconut milk, and because of the keeping quality of the cassava starch this biscuit can last for over four months. It is produced in the rural community called Adawukorpe of Agbozume in Volta region of Ghana.

Wheat flour biscuit is produced by mixing various ingredients like flour, fat, sweeteners and water to form dough. The dough formed unlike bread is not allowed to ferment, and then baked in the oven (Lake & Water-Worth, 1980).It could be baked in the primitive or modern oven, but the fundamental ingredient is wheat flour and other dough products. The flours that are ground from wheat, and other cereals have the unique ability to form a cohesive gluten network when worked with water. This simple discovery set the stage for the development of many yeast breads, biscuits, pastries, cakes, cookies and other baked products that are so popular today (Meyer, 1987). Biscuit and other baked food products are important items belonging to the class of food that are sold in ready to serve form. All biscuits are nutritionals, contributing valuable quantities of iron, calcium, protein, calorie, fibre and some of the B-vitamins to our diet and daily food requirement. For some years now, cassava starch and/or dough has gain some popularity in the biscuit and composite bread industry.

Cassava (Manihotesculentacrantz, also known as manioc or yucca) is one of the leading food and feed plants in the world. It ranks fourth among staple crops with a global production of about 160 million tons per year (Lawrence & Moore, 2005). Most of these are grown in three regions, West Africa and the Congo basin, tropical South America, and South East Asia (Kawano, 2003).

Cassava is a staple food that provides carbohydrates or energy, for more than 2 billion people in the tropics. Cassava is a higher producer of carbohydrate per hectare than the main cereal crops and can be grown at a considerably lower cost. Currently, Ghana is the fifth world largest cassava producing country with 14,279,547 mt annually after Nigeria, Indonesia, Thailand, and Democratic Republic of the Congo. To forestall early deterioration of cassava and also due to its bulky nature, cassava is usually traded in their processed form. The bulky roots contain much moisture (60-65%), making their transportation from rural areas difficult and expensive. Processing the tuber into a dry form reduces the moisture content and converts into a more durable and stable product with less volume which makes it more transportable (IITA, 1990; Ugwu, 1996). Over the years cassava has been transformed into a number of product both for domestic use (depending on local customs and preference) and industrial uses. Cassava in the fresh form contains cyanide which is extremely toxic to humans and animals and therefore needs to be processed to reduce the cyanide content to safe level (Eggleston, Onwaka, & Ihedioha, 1992).

Traditional cassava processing method involve several steps including peeling, soaking, grinding, steeping in water and left in air to allow fermentation to occur, drying, milling, roasting, steaming, pounding and mixing in cold or hot water. Specific combination of these steps leads to a myriad of different cassava products with acceptable taste to wide range of consumers (Bokanga & Otoo, 1991)Cassava processing by traditional method is labour intensive but the application of improved processing technology has reduced processing time, labour and encourage further production (Adeniji, Ega, Akoroda, Ugwu, & Balogun, 2001). In Ghana and Nigeria, almost all the cassava produced is used for human consumption and less than 5% is used in the industry.

One of the greatest challenges of food processing in the developing countries is the transformation of traditional or indigenous processing method into modern industrial operations. Indigenous processing techniques for making traditional food product differ within and between countries because of differences in food culture, available raw materials, and processing equipment utilized. Many traditional methods of food processing and preservation in Africa require review and upgrading for industrial production.

Over the years starch biscuit baking in Agbozume in the Volta Region of Ghana is one of the local small scale industries. It uses the locally produced cassava of which the starch is extracted for the manufacturing of the biscuit. In addition it also uses coconut and sugar as additional ingredients. It is highly patronized and is being used as a Snack which saves travelers from hunger. Even though it is mainly sold along the highways of Aflao to Accra, can also be found in other parts of the country and some West African countries like Togo Benin and Cote d'ivoire (Kekeshi 2008).

1.2 Statement of Problem

2002 population census revealed that there was high rate of malnutrition in the Ketu South District and it was revealed that the high consumption of the cassava starch biscuit was one of the factors. This is because there is no protein content in it. There raised an alarm as how the issue could be solved.

Meanwhile no one legume, tuber or cereal can provide adequate amounts of all nutrients to meet the nutritional requirements of a child or any individual. However, before knowledge on protein content, protein quality, digestibility and the nutrient requirements of humans became available, it was recognized that mixing legumes with cereals in the diet could improve overall nutrition. (FOA: UN General Assembly, 2015). As cassava starch and coconut are the main ingredient for making the cassava starch biscuit, mixing the starch with legume will improve the overall nutrition of the biscuits.

The History of the Starch Biscuit

The history of starch biscuit in Agbozume was traced back to a woman called Eyonunawo Kwame Edze 1901-1963. Since then, it has been the traditional 3-ingredients same shape and packaging of the cassava starch biscuits. Basically, no study has gone most especially into the nutritional composition and benefits of the popular delicacy "Agbozumekpornor, aka Ayigbe Biscuit". Looking at the vast consumption coverage of the biscuit, from infants to adults, including pregnant women and even in neighboring countries, the fortification of the product is long overdue. Change is always difficult most especially when people seems to be content with the present. Nevertheless, change is necessary. It is at this background that the need to research and develop a more fortified cassava starch biscuit not to only meet the take of the consuming public but to most importantly meet their nutritional needs. In this study, a varied amount of soya flour has been added to the original ingredients as a protein based ingredient.

1.3 Objectives of the Study

1.3.1 Main Objective

The main purpose of the of the study was to develop a more fortified cassava starch biscuit with the introduction of a protein based ingredient (Soya flour) in addition to the existing composition of the "Agbozume Biscuit".

1.3.2 Specific Objective of the Study

The specific objectives were to;

1. develop a new product with improved nutrition based on the existing 'Ayigbe Biscuit' using a composite of cassava and soya beans.

2. evaluate the sensory attributes of cassava starch biscuit with soya flour composition.
3. study the shelf life of the (composite) cassava starch-soya bean flour biscuit.

1.4 Research Questions

In order to achieve the specific objectives of the study, the following questions will be addressed.

1. What are the qualities of cassava starch-soya biscuit as compare to the traditional cassava starch biscuit in terms of nutrition, colour, gumminess, mouth feel, taste, flavour, and overall acceptability?
2. What are the shelf life conditions of (composite) cassava starch biscuit?
3. What proportion of starch-coconut-soya is most acceptable by the consuming public?

1.5 Significance of the Study

Issues concerning food and nutrition are critical in the health of a country and more especially when it has to do with high level of sugar and carbohydrate with no protein. This study will not only add to the existing literature in this field bot will bring to light to need of fortifying, and adding some proving scientific touch to the product. It will drastically improve the nutritional need of the consuming public. It will make the product more appealing and acceptable to people who have some concerns of the nutritional composition of the traditional starch biscuit. Final, this will serve as a source of references to other researchers in the area of baking and nutrition in general.

1.6 Limitations of the Study

The fortification of the cassava starch biscuit was mostly limited by the size of the sample size, limited sensory evaluation characteristics, suspected carryover effect and the limited time frame within which to complete the work. Even though the sensory characteristics where carefully chosen and designed, there were some sensory characteristics like size and shape that were not evaluated. For effective generalization, the sample was not large enough. Any form of generalization must be done cautiously. Even though the panelist were made to rinse their mouths after evaluation of each product, carryover effects could not be absolutely eradicated since the mind also plays some roll in carry over effect. Since the products were not serve in any particular order, this carryover will give very insignificant effect on the outcome of the results.

1.7 Scope of the Study

The scope of the study will cover starch biscuit baking in Adawukope in Agbozume. This study cannot completely eliminate the problem of nutrition in other local biscuits but it might help improve the study of biscuits.

1.8 Definition of Terms

Agbelima: Semi-dried fermented cassava flour

***Aspergillussojae*:** The fungal ferment used to produce soy sauce.

Ayigbey Biscuit: Cassava starch biscuit (biscuit made in Volta region)

Carotenoids: Also called tetraterpenoids, are organic pigments that are found in the chloroplasts and chromoplasts of plants and some other photosynthetic organisms

Cyanogenic Glucosides: Poisonous chemical in root crops mostly cassava. It is reduced by washing, drying and other processing methods.

Fufu: A staple food in most Ghanaian homes made from cassava flour or pounding boiled cassava.

Gari: Product from roosting semi-dried fermented cassava flour

Granules: It occurs during the chemical process of starch formation combining amylose and amylopectin.

Gumminess: How much elasticity is felt in a product which is normally through splitting the product or tasting (chewing) the product.

Kalpavirksha: One of the primary natural product produced from the dry fruit (copra)

Manihot esculenta Crantz: The scientific name for cassava

Mitochondrias: They are responsible for most of the useful energy derived from the breakdown of carbohydrates and fatty acids.

Modified Starch: A modified starch used for industrial applications through a series of techniques, chemical, physical and enzymatic modifications

Mouthfeel: The way an item of food or drink feels in the mouth, as distinct from its taste

Monoglyceridemonolaurin: Is the substance that keeps the infants from getting viral or bacterial or protozoal infections.

Native Starch: Native starches are produced through separation of naturally occurring starch from either grain or root crops such as cassava, maize and sweet potato, and can be used directly in producing certain foods such as noodles

Polysaccharides: they are simple form of sugar found in starch and starchy products

Retrogradation: The reaction that takes place when the amylose and amylopectin chains in cooked, gelatinized starch realign themselves as the cooked starch cools.

1.9 Organization of the Studies

The research was organized into five chapters. Chapter one included, background to the study, statement of problem, objectives, research questions, and significance of the study. Chapter two looked at the review of relevant literature related to the topic. Chapter three discussed the methodology used in the study. This included the product development structure, and process Chapter four dealt with the presentation and analysis of the results of panelist sensory evaluations as well as the discussion of the findings. Finally chapter five was on the summary, conclusions and recommendations with areas for further research suggested.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

The purpose of the of the study was to develop a more fortified cassava starch biscuit with the introduction of a protein based ingredient in addition to the existing composition of the "Agbozume Biscuit". The chapter reveals the available works, research, results and findings in respect of production, formulation, storage etc. for cassava-based biscuits throughout the world. The review also covers biscuit and baked products in general, the nutritional composition of cassava, coconut and soya beans and the general product development whiles touching on the historical background of the product understudy; cassava starch biscuit.

2.1 Production of Cassava around the World

Cassava is a staple food for about 40% of the population of Sub-Saharan Africa. It is predominantly an upland crop that is also cultivated inland valley swamps (ivs). In the traditional system, women employed manual methods to convert fresh cassava into chips or flour, granules and pastes (Ugwu, Technology and socio-economics in the changes in cassava processing, 1997). According to FAO (2011) cassava is produced in about 90 countries of the world. Africa stands for half of the world's production of cassava. Since 1960, cassava production has tripled to 87 million MT per year in 1999 and the yield has doubled to around 13 tonnes per ha (Nweke, 2005). Ghana is the sixth largest producer of cassava in the world with more than 14 million MT produced per year (FAO STAT 2011), which makes it the most important agricultural commodity as it stands for 22 % of

Agricultural Gross Domestic Product (Ministry of Food and Agriculture, 2005). Cassava research was earlier focused on improved yields, better cultivation practices and crop protection but since 1985, it has also encouraged mechanized processing, quality control and development of new products (Adebowale, Sanni, & Onitilo, 2008). This development has transformed cassava into a commercial cash crop aimed for urban consumers (Nweke, 2005).However, 70% of the world's production is derived from 10 countries as indicated in Table 2.1

Table 2.1: Production of cassava around the World

S/N	COUNTRY	PRODUCTION (MT)
1.	Nigeria	52.4
2.	Brazil	25.34
3.	Indonesia	24.10
4.	Thailand	21.91
5.	DR Congo	15.56
6.	Angola	14.33
7.	Ghana	14.24
8.	Mozambique	10.09
9.	Vietnam	9.8
10.	India	8.07

Source: (FAOSTAT, 2011)

2.2 Cassava Production in Ghana

Cassava, which can grow well on marginal lands, is one of the most important staple foods in Ghana. Cassava production represents approximately 50% of all roots and tubers production in the country. The majority of cassava is grown by small-scale farmers with small landholdings. At that scale production, harvesting, and post-harvest handling are carried out with limited chemical and technical inputs. It is grown in all regions of Ghana but is particularly abundant in Central, Eastern, BrongAhafo, Volta, and Ashanti regions as highlighted in Table 2.2. According to the statistics of MOFA production of cassava roots has increased by almost 40% from 2007 to 2011. In large part this is due to an increase in average yield per hectare of 26% over that period from 12.76 to 16.17 tons per hectare (Ayernor & Ocloo, 2003). The amount of land under cultivation has increased 11% in that time.

Table 2.2: Cassava Production Estimates in Ghana (2007-2011)

Region/Year	**Cassava Production Estimates in Metric Tonnes (MT)**				
	2007	**2008**	**2009**	**2010**	**2011**
Western	690,369	707,894	711,950	687,350	556,700
Central	1,861,160	1,992,384	2,036,500	1,914,979	1,976,946
Eastern	2,619,247	2,929,343	3,0622,770	3,618,825	3,858,149
Greater Accra	56,576	64,279	67,530	68,170	71,863
Volta	1,048,075	1,357,227	1,558,480	1,529,022	1,660,007
Ashanti	1,160,603	1,205,218	1,255,190	1,842,666	1,900,444
Brong Ahafo	2,426,982	2,489,550	2,606,970	2,728,351	2,883,353
Northern	354,890	605,201	931,240	1,114,723	1,333,406
Upper West	-	-	-	-	-
Upper East	-	-	-	-	-
Total	**10,217,929**	**11,351,095**	**12,23,630**	**13,504,086**	**14,240,867**

Source: MOFA/SRID 2012

2.2.1 The Cassava Root: Traditional Processing and Utilization in Ghana

Cassava (*Manihotesculenta* Crantz) is a major root crop and an important staple food for over 500 million people in the developing world (Falade & Akingbala, Utilization of Cassava for Food, 2010). Cassava is a dicotyledonous perennial plant growing in areas with tropical climate and ranging from 1 to 5 m in height. Although the leaves are edible and often consumed as vegetables, cassava is mainly grown for its starchy tubers, producing 5 to 10 tubers per plant. The crop is traditionally produced in small-scale family farms and mostly processed and consumed at household level. Cassava is a cheap, readily available and reliable source of carbohydrates, particularly in case of food shortage. This drought-tolerant crop has historically played an important role for famine prevention in Eastern and Southern Africa (Nweke, 2005). Compared to cereals such as rice, wheat and maize, cassava requires lesslabour, water, fertilizer and pesticide input and provides more dietary energy per land unit, being one of the most efficient convertors of solar energy. It is a hardy crop able to grow in dry and nutrient-depleted soils where other crops have failed. In addition, it is grown all year round and can be harvested anytime from 7 up to 18 months after planting (Balagopalan, Padmaja, Nanda, & Moorthy, 1988).

2.3 Composition of Cassava Roots

Cassava root is a high energy food with a high water and carbohydrate content. However, an important issue associated with consumption of cassava is the presence of toxic compounds, making it imperative to process the roots before ingestion. *Table 2.3* gives the average nutritional composition of fresh cassava roots. Cassava roots contain about

60-65% moisture, 30-35 % carbohydrates on fresh weight basis and 80-90 % on dry matter basis (Balagopalan *et al.*, 1988). The starch content, representing 80 % of the carbohydrates produced, reaches a peak during the 10th to 11th month after planting. However, peak starch yield differs between cassava varieties, as observed by (Apea-Bah, Oduro, Ellis, & Safo-Kantanka, 2011). The composition changes slightly with increasing age as the roots become more fibrous and the starch content declines. Cassava is a poor source of protein as it contains only 1-3% protein on dry matter basis (Montagnac, Davis, & Tanumihardjo, 2009)and is low in essential amino acids such asmethionine, lysine, tryptophan, phenylalanine and tyrosine (Falade and Akingbala, 2010). A cassava-based diet therefore requires an adequate protein source of good quality to prevent nutritional deficiency symptoms (Balagopalan *et al.,* 1988).

Table 2.3: Proximate composition of fresh cassava roots

Component	**Value**
Moisture (g/100 g)	59.4
Carbohydrates (g/100g)	38.1
Protein (g/100 g)	0.7
Fat (g/100 g)	0.2
Crude fiber (g/100 g)	0.6
Ash (g/100 g)	1.0
Calcium (mg/100 g)	50.0
Vitamin C (mg/100 g)	25.2
Energy (kcal/100 g)	157

Source: Balagopalan, 1988

It is well established that cassava is not edible raw due to the presence of toxic compounds. Cassava contains two cyanogenicglucosides, namely linamarin and lotaustralin, present in all parts of the plant with the highest concentration in the root peel. Normal levels of cyanoglucosides range from 31 to 630 ppm calculated as mg HCN/kg of fresh cassava root, although the content varies considerably depending on variety, climate and environmental conditions. Sweet cassava varieties have often lower levels of cyanide than bitter varieties but there is no established correlation between the taste and the toxicity (Falade and Akingbala, 2011). Hydrolyzing enzymes present in the plant, such as linamarase, degrade the cyanoglucosides to hydrogen cyanide HCN as soon as the plant tissue is wounded. If the root is ingested without previous processing, acute poisoning occurs due to the release of HCN in the body. Cyanide affects tissue respiration in mitochondrias, as it is a potent inhibitor of oxidase and other important enzymes in the respiratory chain (Balagopalan *et al.,* 1988). Chronic exposure of inadequately processed cassava can lead to diseases such as tropical ataxic neuropathy, goiter and cretinism. However, the toxicity can be reduced to safer levels during traditional processing (Falade and Akingbala, 2010).

2.3.1 Importance of Processing Cassava Roots

Although the cultivation of cassava requires low input of labour, post-harvest cassava processing is the most demanding of all root crops as it requires rapid handling and detoxification to make it edible (Root and Tuber Improvement Program, 2004). One of the major issues in the utilization of cassava is the high perishability of the tubers. Deterioration by biochemical changes and microbial infestation starts within 2-3 days after uprooting. Long distances between production areas and processing sites are often a problem leading to considerable post-harvest losses (Balagopalan *et al*, 1988). Since there are no effective commercial storage methods available, it is necessary to process cassava into dry shelf-stable forms by reducing moisture content and thus lowering bulk and transportation costs (Falade and Akingbala 2010).

As cassava contains toxic compounds, it requires special processing procedures that will eliminate or reduce the levels of cyanogenicglucosides, making the product safe for human consumption. Peeling reduces significantly the toxicity. Grating breaks down the internal structure of the root, releasing linamarase that will decrease the cyanoglycoside content by about 95% by hydrolyzing the glucosides into HCN (Falade and Akingbala, 2008). Since HCN is soluble in water, its amount is reduced by traditional detoxification methods such as boiling, soaking or de-watering (Dziedzoave, Abass, Amoa-Awua, & Sablah, 2006). Part of the HCN produced will evaporate into the air during drying or roasting since it is volatile. In the case of fermented cassava flours like gari, there is almost a total breakdown of glycosides during fermentation. Consequently, cassava products are safe if processed properly (RTIP, 2004).

Processing also increases the value of cassava by improving palatability and facilitating marketing of more acceptable hygienic quality products. Cassava, often considered as a low value root crop, is transformed into convenient foods to meet the increased demand from the urban population (Falade and Akingbala, 2010). Traditional processing of cassava is a widespread and labour-intensive activity often carried out by women in small-scale processing units. The different units operations like peeling, grating, drying, sifting, roasting and fermentation are time-consuming since they are often carried out by hand. Nevertheless, the introduction of motorized cassava processing equipment over the past three decades has considerably reduced the drudgery and created a higher processing rate. Mechanical graters, cassava chippers, screw presses, sieving machines, mills and mechanical dryers are now fairly established in the cassava processing industry in Ghana. However, small-scale cassava processors often lack capital to invest in equipment and keep the activity profitable (Ministry of Food and Agriculture, 2005).

2.3.2 Chemical Composition and Nutrient Content of Cassava

Fresh cassava (per 100g) contains32.8g carbohydrate, 1.5g crude protein, 0.9g fiber, 0.5g ash, 30mg Ca, 31mg P and 1.0mg Fe (Ekpenyong, 1984). According to (Wanjekenche & Keya, 1995) cassava consisted of 63% water, 21.18% starch, 6.08% sugar, 1.21% crude fiber, 1.26% crude protein and 0.72% ash. Linamarin, a cyanogenic glycoside, was found in both the leaves and roots of cassava (Hock-Hin & Cheng-kim, 1994).Cassava contained 3 isomers of B-carotene. The fresh cassava contains 66.2% moisture, 0.69% ash, 6.4% sugar, 0.92% protein, 0.50% fat and 31.69% total carbohydrate (Islam, 2003).

Cassava tubers are very low in protein, when substituted for cereals in mixed feeds, considerable amounts of supplementary protein are required. In developing countries potential for cassava use depends on the availability of cheap protein sources. Kemdirim *et al*., (1995) studied on the detoxification of cassava cultivars during traditional methods of processing to produce gari and cassava flour. The HCN cassava pulp for 96 hour during cassava processing for gari reduced the HCN by 22 (52.4%) and 20 mg/kg (57.3%) for 30572 TMS and 30555 TMS, respectively. There was no significant difference in the HCN content of the 2 cultivars.

Some traditional method of cassava processing removes cyanide with varying degree of efficiency (Arihantana, 1987). One of the principle reasons for processing cassava is to remove the cyanogenic glycosides that limit the use of its products (Nestel & Cock, 1976). Cassava flour can be obtained by various equipment after drying and percent of yield depends on peeling. Production of cassava flour at 10-12% moisture content depends upon the drying and milling performance (Orias & Calub, 1986).

Dry matter content of tubers varies from 25 to 50%. About 90% of the dry matter consists of starch, which has 20% amylose and 80% amylopectin. The digestibility in raw state is 48%, which increases to 78% on cooking. Sugars are very low, sucrose, glucose, fructose and maltose being present in decreasing order. Dietary fiber (lignin included) comprises 5% of the dry matter of the tuber. Fat is negligible. Cassava is rich in ascorbic acid (25-30 mg/100g) and B-vitamins are present in good amounts. Yellow flesh in a few cultivars is due to carotenoid pigments. Calcium, potassium and phosphorus are the minerals present in nutritionally significant amounts. Protein in cassava tuber is low in quantity and quality. Most of the nitrogen is present in the form of non-protein nitrogen (Balagopalan, Integrated technologies for value addition and post harvest management in tropical tuber crops, 2000). When raw cassava is dried protein, sugar and total carbohydrate content increased (Aziz, 2001).

Although nutritionist considers it an `inferior' crop because of its low protein content it has advantages for the producer and consumer. Cassava produces more kilojoules per unit time per unit area than most other staples. In cereals a large part of the energy from photosynthesis is needed for building stalks to support the grains, whereas in cassava there is no such requirement. Only 36.50% of the total plant mass of cereals is edible while 63-85% of the total plant mass of cassava can be consumed by humans. Cassava is principally an energy provider and in many production areas it is considered a typical reserve food crop. The energy density of starch products (in kj/volume unit prepared food) is much lower than of fats or sugars. (Domien, Bruinsma-Wouter, Witsenburg, & Wurdemann, 1985).

2.3.3 Product Development

Processing of soya beans

1 cup soya beans

Methods

- Pick stones from soya beans
- Par boil the beans
- Wash under running water to dehask the brand
- dry for three days
- mil and store in an airtight container

Composite flour

- cassava starch + soya bean flour

Table 2.4: Measurement for composite flour

Flour	Quantity	Quantity	Quantity
Starch	250g	250g	250g
Soya flour	30g	40g	50g
Composite flour	280g	290g	300g

Hozova, Zemanovic, & Chorvatova, (1995)studied the biscuits prepared from amaranth flour and tested for microbiological quality and sensory characteristics during 6 month of storage at 20°C and 62% RH. They found that biscuits were satisfactory and the presence of micro-organisms was not detected in biscuits during first 4 months of storage. Aerobic mesophilic bacteria were detected in 5th month as 58 cfu/g, rising to $1.4x10^3$cfu/g after 6 months storage. Yeast, fungi and coliforms were not detected in the biscuits. Sensory properties were acceptable over the entire 6 months of storage period.

Analysis of the nutrient content of some Bangladeshi biscuits namely glucose type (6 brands) and cracker-type biscuits (7 brands) have been reported by (Kabirullah, et al., Analysis of Nutrients of Bangladeshi Processed Foods. Part I-Different types of biscuits, 1995). The authors reported that the sweet biscuits contain moisture 4.06 - 4.97%; ash 0.74 - 1.01%; fat 8.90 - 19.33%; protein 6.88 – 9.38%; carbohydrate 65.57 - 79.1%; total sugar 5.90 - 6.21% respectively. He also found that cracker biscuits: moisture 4.53 - 6.37%; ash 0.97 - l.68%; fat 3.32 - 19.60%; protein 9.09 - 11.78%, carbohydrate 64.31 - 81.45% and total sugar 3.35 – 6.46% respectively.

The typical saltine cracker contains: Flour 100%, water 20%, yeast 0.4%, fat 11%, salt 1.8% and baking soda 0.45% (Hoseney, 1986). Kent, (1990) reported that the hard sweet biscuits contain 17% water, 0.7% salt, 22% sugar, 2.6% milk powder, 17% fat and 11% backing powder The soft sweet biscuits contain higher amount of sugar (30%) and fat (25%) than that of hard sweet biscuits.

Kabirullah *et al.* (1996) analyzed crackers and salted biscuits for protein, fat and some other nutrient content. They reported that nutrient content was encouraging but fat and protein quality was poor. Proteins were severely denatured and fats were mainly saturated and rancid. Acid values exceeded permitted amounts and peroxide values were also high.

2.4 Traditional Uses of Cassava in Ghana

It is estimated that cassava accounts for 30 % of the daily calory intake in Ghana and is grown by nearly every farming family (Odedina and Adebayo, 2012). About 30 % of the cassava produced is consumed by the producers themselves. The rest is sold at the market or processed into various types of fermented flours, such as gari and agbelima, which are the most widely used cassava products. (Ministry of Food and Agriculture, 2005). Cassava is also consumed boiled or roasted, along with spices and vegetables. Fufu is prepared by pounding the fresh, peeled and boiled cassava roots into a thick and smooth paste (Apea-Bah *et al.*, 2011). Food Research Institute of the Council for Scientific and Industrial Research and other private entrepreneurs have started to produce new convenient foods made from cassava such as fufu flours to promote consumption of cassava and add value to the root. The products are popular among Ghanaian consumers but their price is not yet competitive (Ministry of Food and Agriculture, 2005).

High value and shelf stable cassava products that may offer export opportunities and possibility to earn foreign exchange include cassava starch and High Quality Cassava Flour. Starch extracted from cassava roots is used as an important raw material in the food industry but also in the non-food industry for textile, paint, cement, detergents, plywood, paper and for pharmaceutical uses. Some characteristics of cassava starch include high paste viscosity, high paste clarity and high freeze-thaw stability, which are valuable for many industries (Odedina & Adebayo, 2012).

2.5 Starch Production

Starch is one of the most abundant substance in nature, renewable and almost unlimited resources Starch is produced from grain and root crops. It is mainly used as food but it is also readily converted chemically, physically and biologically into many useful products to date (James and West, 1997; Matsui et al., 2004). Starch is used to produce such diverse product as food, paper textile, adhesives, beverages, confectionary, pharmaceuticals and building materials (Daramola and Osanyinlusi, 2005).

Cassava starch has many remarkable characteristics, including high paste viscosity, high paste clarity, and high freeze – thaw stability, which are advantageous to many industries. Gomes, Mendes da Silva, & Ricardo, (2005); Nzigamasabo and Ming, 2006; Zaidul et al, 2007). Cassava starch is produced primarily by wet milling of fresh cassava roots but in some countries such as Thailand, it is produced from dry cassava chips (Larotonda, 2002;

Ceballos et al, 2006). Starch is the main constituent of cassava; about 25% starch may be obtained from mature, good quality tuber. About 60% starch may be obtained from dry cassava chips and about 10% dry pulp may be obtain per 100 kg of cassava roots. The development of both the food and nonfood uses of cassava starch has made much progress and continues to have a bright future (Abraham, Raja, Manoharan, & Mathew, 1984; Srirotha et al, 1999; Jyothi et al, 2007). (Jyothi, Sasikiran, Nambisan, & Balagopalan, 2005).

2.6 Starch in Foods

2.6.1 Composition of Starch

The major component of High Quality Cassava Flour or dough is starch. Starch is composed of two polysaccharides and plays an important role for the storage of energy in most plants, especially tubers. Amylose, the minor component, has a linear structure of α-D-glucopyranose units joined by α (1-4) D-glucosidic linkages, while amylopectin, with a higher molecular weight, has a branched structure due to the presence of α (1-6) linkages. The structural differences of the two polymers give them different properties in aqueous solutions. Amylopectin is more stable due to its branched nature and amylose molecules have a tendency to precipitate spontaneously due to the formation of hydrogen bonds between aligned molecules (Balagopalan *et al*, 1988).

2.6.2 Functional Properties of Starch

The behaviour of starch in foods is often studied in excess water systems. Swelling power and solubility are important properties that vary according to botanical origin of starches and are often regarded as the main criterion of starch quality for bakers and manufacturers. Swelling power, expressed as the weight of sediment per gram of starch, is defined as the maximum increase in volume and weight that the starch undergoes when heating in excess water. Solubility is the percentage of starch that is dissolved after heating. There is thus a direct relationship between swelling power and solubility. The swelling volume is the volume of the undissolved sediment obtained after centrifugation of the sample (Balagopalan *et al*, 1988).

2.6.3 Starch Gelatinization

In the preparation of cereal-based foods, the starch is at some point heated in the presence of water. The unique character of many foods results from the changes that starch undergoes during heating and subsequent cooling; it is therefore important to understand what happens to starch under relevant cooking conditions (Delcour and Hoseney, 2010). When an aqueous solution of starch is heated, water molecules enter the native starch granules and disrupt the hydrogen bonding between the starch polymers. The granules absorb a large amount of water and swell. When a critical temperature is reached, the irreversible process known as gelatinization occurs. It is characterized by a loss of birefringence of the starch granules and is accompanied by a sharp rise in viscosity. Viscosity, an important property of starch solutions, can be recorded using a Brabenderviscoamylograph. During the pasting test, the mixture is gradually heated to 95°C under constant stirring, temperature is maintained for a fixed hold period and cooled to 50 °C. The gelatinization or pasting temperature is characteristic for a particular type of starch and indicates the minimum temperature required to cook a sample of starch and consequently also energy costs. It is often expressed as a range of temperature of around 10°C, showing that gelatinization is a granule-by-granule event. Above this temperature, during the hold period, starch granules rupture and amylose molecules leach out and align in the direction of shearing, leading to a decrease in viscosity often referred as shear thinning (Adebowale *et al.*, 2008). During subsequent cooling, the starch paste undergoes retrogradation, which corresponds to an increased rigidity in the starch gel when starch molecules re-associate by hydrogen bonding. Retrogadation is strongly influenced by the amylose content of the starch. The Brabender curve gives five points of interest. Peak viscosity is the highest viscosity the starch paste can reach. Viscosity at 95°C gives an idea of the ease of cooking of starch. Viscosity during hold period at 95°C reflects the ability of the paste to resist breakdown on shearing. Setback is the viscosity of cooked paste during cooling. Final viscosity indicates the stability of the cooked paste after a definite period at 50°C (Balagopalan *et al,* 1988).

2.6.4 Native Starch

Native starches are produced through separation of naturally occurring starch from either grain or root crops such as cassava, maize and sweet potato, and can be used directly in producing certain foods such as noodles (Wang, White, & Pollak Jane, 1993). The raw starches produced still retain the original structure and characteristics and are called "native starch" (Ene, 1992). Native starch is the basic starch product that is marketed in the dry powder form under different grades for food, and as pharmaceutical, human and industrial materials. Native starch has different functional properties depending on the crop source and specific types of starch are preferred for certain applications.

Native starches have limited usage, mainly in the food industry, because they lack certain desired functional properties. The native granules hydrate easily when heated in water. They swell and gelatinize, the viscosity increases to a peak value, followed by a rapid decrease, yielding weak boiled, stringy, and cohesive paste of poor stability and poor tolerance to the acidity with low resistance to shear pressure, as commonly employed in modern food processing (Balagopalan et al., 1988). However, food metallurgic, pharmaceutical, paper and cardboard, and textile industries among others use native starch in its traditional form.

2.6.5 Modified Starch

For those characteristics which are maintainable with native starch, modified starch can be used for other industrial applications through a series of techniques, chemical, physical and enzymatic modification (Feuer, 1998). Thus, modified starch is native starch that has been changed in its physical and/or chemical properties. Modification may involve altering the form of granule or changing the shape and composition of the constituent amylose and amylopectin molecules. Modification is therefore carried on the native starch to confer it with properties needed for specific uses in many industries such as food, pharmaceutical, textile, petroleum and paper pulp industries (Fringant, Desvrieres, & Rinaudo, 1996; Curvelo, De Carvalho, & Agnelli, 2001). The reasons why native starch is modified include: modifying cooking characteristics (gelatinization); to reduce retrogradation and paste stability when cooled or frozen; to increase transparency and texture of pastes and gels; and to improve adhesiveness between different surfaces such as in paper applications (Table 2.4).

Table 2.5: Some of the positive attribute of modified starch.

SN	Positive Attribute of Modified Starch
1.	To modify pasting attributes
2.	To decrease the retrogradationcrystallinity
3.	To decrease gelling tendencies of paste
4.	To increase freeze-thaw stability of paste
5.	To decrease paste and/or gel syneresis
6.	To improve paste and/or gel clarity/sheen
7.	To improve paste and/or gel texture
8.	To improve film formation
9.	To improve adhesion
10.	To add hydrophobic groups for emulsion stabilization

Source: James and West, (1997).

2.7 Utilization of Cassava Starch in the Industries

2.7.1 Paper Industry

The paper industry uses various types of starches for different purposes. Currently, the most common starches used for paper manufacture are from maize, potato and cassava. Cassava starch has very good properties that are highly desirable for the paper manufacturer. Cassava starch, as a dominant source of starch in Nigeria, possess a strong film, clear paste, good water holding properties, and stable viscosity (Srirotha, et al., 1999). It should be the most suitable material for the paper industry in West Africa. In the paper and board industries, starch is used in large quantities at three points during the manufacturing process.

- At the end of wet treatment, when the basic cellulose fiber is beaten to the desired pulp to increase the strength of the finished paper and to impart body and resistance to scuffing and folding.
- At the size press, when the paper sheet or board has been formed and partially dried, starch generally oxidized (or modified) is usually added to one or both sides of the paper sheet or board to improve the finished product appearance, strength and printing properties.
- In the coating operation, when a pigment coating is required for paper, starch acts as coating agents and as adhesive.

Cassava starch has been widely used as tube size and a beater size in the manufacture of paper in the past mainly on account of its low price. A high colour (whiteness), low dirt and fiber content and above all, uniformity of lots are needed in this instance. An important new application of starch is in the machine coating magazine paper, formally done exclusively with caseins (Essers, 1994). There are indications that cassava is particularly well-suited to the purpose, however, definite specification for the starch still has worked out.

2.7.2 Textile Industry

In the textile industry, the properties of the starch used are abrasion resistance, flexibility, ability to form a bond to the fiber, to penetrate the fiber bundle to some extent and to have enough water holding capacity so that the fiber itself does not rob the size of its hydration. Textile printing or the impression of the design on fabrics requires a carrier for the dyes and pigment and modified starches have found special uses in this application.

Printing pastes are high viscosity of media that preferably will not change on ageing and will not resist the effect of added acids or alkalis as required by the colour agent. A sharp image is required and thus a short non-stringy paste. Modified starches are frequently mixed with other industrial gums to give the required viscosity and paste characteristics (Balagopalan et al., 1988).

2.7.3 Adhesive Industry

Starch is a popular base for adhesives, particularly those designed to bond paper in some form to itself or to other materials such as glass, mineral wool, and clay. Starch can also be used as a binder or adhesive for non-paper substance such as charcoal in charcoal briquettes, minerals wool in ceiling tiles and ceramics before firing. The starches most commonly used for the manufacturing of adhesives are from maize, potato and cassava, (Graffham et al, 1998) of this, cassava starch appears more suitable in several respects. Cassava starch adhesives are more viscous and smoother for working. They are fluid, stable glues of neutral pH that can be easily prepared and can be combined with many synthetic resin emulsions (Dziedzoave et al, 1999). For top quality work, cassava starch is thought to be ideal, because it is slightly stronger than potato starch adhesive while being odourless and tasteless, excellent as an adhesive for postage stamps, envelope flaps, and labels (Graffham et al, 1998). Certain potato pastes have bitter tasting properties while cereal starch exhibit a cereal flavour.

Satisfactory texture or slip properties may be achieved via cross-linking. Properties required include low shear resistance or “slip” permitting the paper to be aligned precisely without losing contact with the substrate, good open time (range of tack), and slow setting speed (Delcour, Vansteelandt, Hythier, & Abe'cassis, 2000). To meet these requirements, it is important that the starch should have little or no tendency to retrograde in the dried film. Using starches low in amylose can readily achieve this property and/or by subjecting the starch to retrogradation inhibiting treatment on base starches such as cassava, potato, or waxy cereal starches which are the preferred approaches.

2.7.4 Glucose Production (Monosodium Glutamate)

Cassava tubers processing for large scale production of starch result in solid and liquid waste (Balagopalan et al, 1988). The fibrous slurry constitute about 15-20% of the cassava chips/tuber processed, which contain about 5070% starch on dry weight basis. The residue from cassava tubers are naturally rich in organic matters which render it suitable as a good substrate for microorganisms for the production of different product like organic acids, flavour and aroma compounds (Adriane-Medeiros, Carlos, & Pandey, 2000; Nair, Padmaja, & Moorthy, 2011). In view of the high starch content, various starch-derived products like maltose, malto-dextrin, corn syrup solids, etc. can also be produced from cassava residues (Ghildyal and Lonsane, 1990; Pandey et al, 2000). Monosodium glutamate (MSG), the sodium salt of L-glutamic acid is a popular flavour enhancer and an additive for foods. It was used primarily in Asian foods but its use is now widespread (Jyothi et al, 2005). The product is used extremely in many parts of the continent in powder or crystal form as a flavouring agent in food such as meats, vegetables, sauces, and gravies. Cassava starch and molasses are the major raw materials used in the manufacture of monosodium glutamate in the Far East and the Latin American countries (Sanni et al., 2005). The starch is usually hydrolyzed into glucose by boiling with hydrochloric or sulphuric acid solution in closed converters under pressure. The glucose is filtered and converted into glutamic acid by bacterial fermentation. The resulting glutamic acid is refined, filtered and treated with caustic soda to produce monosodium glutamate, which is then centrifuged and dried in drum driers. The finished product is usually at least 99% pure (Sanni et al, 2005).

2.7.5 Animal Feed

During recent years, there has been a remarkable increase in livestock production in the third world. Because of this, the requirement for animal feed materials also is increasing. The spiraling price hike of cereals has necessitated the search for alternative source of energy for animals (Balagopalan et al., 1988). Being a cheap carbohydrate source capable of supplying adequate calories, cassava tubers offer great potentials as an animal feed. Cassava is widely used in most tropical areas in feeding pigs, cattle, sheep and poultry. Dried peel of cassava roots are fed to the sheep and goats, and raw or boiled root are mixed into a mash with protein concentrate such as maize, sorghum, groundnut or oil palm kernel meal and mineral salts for livestock feeding (Onuma, Kosikowski, & Markakis, 1983).

Cassava is similar to feed grain as it consists almost entirely of starch and it's easy to digest. The roots are, therefore especially suited to feeding young animals and fattening pigs. Many feeding experiments have shown that cassava provide a good quality carbohydrate, which may be substituted for maize or barley and that cassava rations are especially suitable for swine, dairy cattle and poultry (Nzigamasabo and Ming, 2006). However cassava cannot be used as a sole feedstuff because of its deficiency in protein and vitamins, but must be supplemented by other feeds that are rich in these elements (Ajibola, 1988; Charles, Chang, Ko, Sriroth, & Huang, 2004). The maximum cyanide content that can be ingested safely depends not only on the cyanide content of the dried cassava chips but also on the level of inclusion of the cassava meal in animals diet and the age of the animal (Taiwo, 2006). The composition of the compound animal feed varies according to the animal (cattle, pigs and poultry) as well as the kind of production (diary meat or egg). There are many constituent that could be used to supply the main element in the compound feed, such as starch, protein, fat, mineral and vitamins. Cassava can be incorporated in practical ration at levels of 20-30% for broiler (0-8 weeks) and 30-40% for growing pigs weaning to market weight, (Gomez and Valdivieso, 1984). The amount of cassava used in animal feed production have not been estimated but with the Nigeria Federal Government regulation on local sourcing and the need to use cheaper energy sources, the inclusion of cassava in animal feed formulation becomes urgent (Taiwo, 2006).

Proper formulation of the diet is equally important to make the feed nutritionally balanced, since animal performance is highly dependent on it. Cassava leaf meal is a highly nutritious protein-rich ingredient that offers a vast scope for inclusion in root meal diets. However the leaves have to be properly detoxified by drying prior to its inclusion in compound feeds. Cassava leaves have been found to contribute substantially to the energy requirement of poultry, swine and ruminants (Balagopalan, 2002).

2.8 Soybean and Nutrition

Soybean [Glycine max (L) Merr.] is a major protein source for humans and other animals. About 90% of soluble proteins in soybean seeds are globulins and more than 70% of globulins are glycinin (G) (11S globulin) and β-conglycinin (βc) (7S globulin). G is relatively rich in s containing amino acids (methionine and cysteine) (3%-4.5%) and is stored primarily in cotyledons of seeds where it is deposited in protein bodies (Nielsen, Dickinson, & Cho, 1989).

Soybean is recognized as an oil seed containing several useful nutrients including protein, carbohydrate, vitamins, and minerals. Dry soybean contain 36% protein, 19% oil, 35% carbohydrate (17% of which dietary fiber), 5% minerals and several other components including vitamins (Liu, 1997).

Soybean protein is one of the least expensive sources of dietary protein (Derbyshire, Wright, & Boulter, 1976). Soybean protein is considered to be a good substituent for animal protein (Sacks, et al., 2006), and their nutritional profile except sulfur amino acids (methionine and cysteine) is almost similar to that of animal protein because soybean proteins contain most of the essential amino acids required for animal and human nutrition. Researches on rats indicated that the biological value of soy protein is similar to many animal proteins such as casein if enriched with the sulfur-containing amino acid methionine (Hajos, et al., 1996). According to the standard for measuring protein quality, Protein Digestibility Corrected Amino Acid Score, soybean protein has a biological value of 74, whole soybeans 96, soybean milk 91, and eggs 97(FAO/WHO, 1989). Soybeans contain two small storage proteins On the other hand, Soy vegetable oil is another product of processing the soybean crop used in many industrial applications. Soybean oil contains about 15.65% saturated fatty acids, 22.78% monounsaturated fatty acids, and 57.74% polyunsaturated fatty acids (7% linolenic acid and 54% linoleic acid) (Wolke, 2007). Furthermore, soybeans contain several bioactive compounds such as isoflavones among other, which possess many beneficial effects on animal and human health (Young, 1991).

Soybean is very important for vegetarians and vegans because of its rich in several beneficial nutrients. In addition, it can be prepared into a different type of fermented and non-fermented soy foods. Asians consume about 20–80 g daily of customary soy foods in many forms including soybean sprouts, toasted soy protein flours, soy milk, tofu and many more. Also fermented soy food products consumed include tempeh, miso, natto, soybean paste and soy sauce among other (Wang & Murphy, 1994; Fournier, Erdman, & Gordon, 1998). This quantity intake of soy foods is equivalent daily to 25 and 100 mg total isoflavones (Messina, McCaskill-Stevens, & Lampe, 2006) and between 8 and 50 g soy protein (Erdman, Jadger, Lampe, Setchell, & Messina, 2004). On the other hand, western people consume only about 1–3 g daily soy foods mostly as soy drinks, breakfast cereals, and soy burgers among other processed soy food forms (Fournier, Erdman, & Gordon, 1998).

Soybean is used as the raw material for oil milling, and the residue (soybean meal) can be mainly used as source of protein feedstuff for domestic animals including pig, chicken, cattle, horse, sheep, and fish feed and many prepackaged meals as well (Liu, 1997). It is widely used as a filler and source of protein in animal diets, including pig, chicken, cattle, horse, sheep, and fish feed (Riaz, 2006). In general, soybean meal is a great source of protein ranged from 44-49%, but methionine is usually the only limiting amino acid and contains some anti-nutritional factors such as trypsin inhibitor and hemaglutinins (lectins) which can be destroyed by heating and fermenting the soybean meal before use. Textured vegetable protein (TVP) is another soybean byproduct has been used for more than 50 years as inexpensively and safely extending ground beef up to 30% for hamburgers or veggie burgers, without reducing its nutritional value and in many poultry and dairy products (soy milk, margarine, soy ice cream, soy yogurt, soy cheese, and soy cream cheese). as well (Liu, 1997; Joseph, 2001; Hoogenkamp, 2005; Riaz, 2006) The total estimates of feed consumed for broilers, turkeys, layers and associated breeders production over the world in 2006 was about 452 million tones (Leesons & Summers, 2005). This estimated value is calculated depending on poultry feeds containing about 30% soybean meal on average. Therefore, 136 million tons of soybean meal are used annually in poultry feeds. As a generalization, the numbers shown can be multiplied by 0.3 for an estimate of the needs of soybean meal. Soy-based infant formula (SBIF) is another soybean product that can be used for infants who are allergic to pasteurized cow milk proteins. It is sold in powdered, ready-to-feed, and concentrated liquid forms without side effects on human growth, development, or reproduction (Strom, 2001; Giampietro, 2004; Merritt & Jenks, 2004).

There are several types commercially available of non-fermented soy foods, including soy milk, infant formulas, tofu (soybean curd), soy sauce, soybean cake, tempeh, su-jae, and many more. However, fermented foods include soy sauce, fermented bean paste, natto, and tempeh, among others. Fermented soybean paste is native to the East and Southeast Asia countries such as Korea, China, Japan, Indonesia, and Vietnam (Kwon, Daily, Kim, & Park, 2010). Korean soy foods including kochujang (fermented red pepper paste with soybean flour) and long-term fermented soybean pastes (doenjang, chungkukjang, and chungkookjang) are now internationally accepted foods (Kwon, Daily, Kim, & Park, 2010). Furthermore, natto and miso are originally Japanese soy food types of chungkukjang and doenjang, respectively. China also has different fermented soybean products including doubanjiang, douche (sweet noodle sauce), tauchu (yellow soybean paste), and dajiang. Chungkukjang is a short-term fermented soy food similar to Japanese natto, whereas doenjang, kochujang, and kanjang (fermented soy sauce) undergo long term fermentation as do Chinese tauchu and Japanese miso.

In general, this fermentation of soy foods changes the physical and chemical properties of soy food products including the color, flavor and bioactive compounds content. These changes differ according to different production methods such as the conditions of fermentation, the additives, and the organisms used such as bacteria or yeasts during their manufacture. These changes differ as well as whether the soybeans are roasted as in chunjang or aged as in tauchu before being ground. In addition to physicochemical properties, the fermentation of these soybean products changes the bioactive components, such as isoflavonoids and peptides, in ways which may alter their nutritional and health effects.

Also, the nutritional value of cooked soybean depends on the pre-processing and the method of cooking such as boiling, frying, roasting, baking, and many more. The quality and quantity of soybean components is considerably changed by physical and chemical or enzymatic processes during the producing of soy-based foods (Park, Lee, Kim, & Lee, 1994; Garcia, Torre, Marina, & Laborda, 1997; Nakajima, Nozaki, Ishihara, Ishikawa, &Tsuji, 2005; Yamabe, Kobayashi-Hattori, Kaneko, Endo, & Takita, 2007; Jang, Park, &Lim, 2008), (Baek, Park, Park, & Lee, 2008). Fermentation is a great processing method for improving nutritional and functional properties of soybeans due to the increased content of many bioactive compounds. On the other hand, the conformation of soy protein (glycinin) is easily altered by heat (steaming) and salt (Kim, Kim, Yang, & Kwon, 2004). Many large molecules in raw soybean are broken down by enzymatic hydrolysis during fermentation to small molecules, which are responsible for producing new functional properties for the final products. For example, isoflavones, which are mostly present as 6-O-malonylglucoside and β-glycoside conjugates and associated with soybean proteins, are broken down by heat treatment and fermentation (Choi, Yoon, Kim, & Kwon, 2007). In general, the chemical profiles of various minor components related to health benefits and nutritional quality of products are also affected by fermentation (Kim, Song, Kwon, Kim, & Heo, 2008). It is usual to heat-treat legume components to denature the high levels of trypsin inhibitors soybean (Teakle & Jensen, 1985). The digestibility of some soy foods are as follows: steamed soybeans 65.3%, tofu 92.7%, soy milk 92.6%, and soy protein isolate 93–97% (Liu, 1997).

2.8.1 Bioactive Compounds of Soybean

Many bioactive compounds are isolated from soybean and soy food products including isoflavones, peptides, flavonoids, phytic acid, soy lipids, soy phytoalexins, soyasaponins, lectins, hemagglutinin, soy toxins, and vitamins and more (Davis, et al, 2007). Flavonoids are low-molecularweightpolyphenolic compounds classified according to their chemical structure into flavonols, flavones, flavanones, isoflavones, catechins, anthocyanidins and chalcones(Rice-Evans, 2001). Typical flavonoids are kaempferol, quercetin and rutin (the common glycoside of quercetin), belonging to the class of flavonols. Isoflavones (soy phytoestrogens) is a subgroup of flavonoids. The major isoflavones in soybean are genistein, daidzein, and glycitein, representing about 50, 40, and 10% of total isoflavone profiles, respectively. Soy isoflavones, daidzein and genistein, are present at high concentrations as a glycoside in many soybeans and soy food products such as miso, tofu, and soy milk. Soybeans contain 0.1 to 5 mg total isoflavones per gram, primarily genistein, daidzein, and glycitein, the three major isoflavonoids found in soybean and soy products (Park & Surh, 2004). These compounds are naturally present as the β-glucosidesgenistin, daidzin, and glycitin, representing 50% to 55%, 40% to 45%, and 5% to 10% of the total isoflavone content, respectively depending on the soy products (Young, 1991). Formononetin is another form of isoflavone found in soybeans and can be converted in the rumen (in sheep and cow) into a potent phytoestrogen called equol (Tolleson, Doerge, Churchwell, Marques, & Roberts, 2002).

Recently, there has been increased interest in the potential health benefits of other bioactive polypeptides and proteins from soybean, including lectins (soy lectins are glycoprotein) and lunasin. Lunasin is a novel peptide originally isolated from soybean foods (Galvez, Revilleza, & de Lumen, 1997). Lunasin concentration is ranged from 0.1 to 1.3 g/100 g flour (de Mejia, Vasconez, de Lumen, & Nelson, 2004; Wang, Dia, Vasconez, Nelson, & de Mejia, 2008), and from 3.3 to 16.7 ng/mg seed (de Mejia & Dia, Chemistry and biological properties of soybean peptides and proteins, 2010). Soybean phytosterols usually include four major or types: β-sitosterol, stigmasterol, campesterol, and brassicasterol, all of which make good raw materials for the production of steroid hormones. Triterpenoidsaponins in the mature soybean are divided into two groups; group A soy saponins have undesirable astringent taste, and group B soy saponins have the health promoting properties (Shiraiwa, Harada, & Okubo, 1991; Kuduo, Tonomura, & Tsukamoto, 1993). Group A soy saponins are found only in soybean hypocotyls, while group B soy saponins are widely distributed in legume seeds in both hypocotyls (germ) and cotyledons [39]. Saponin concentrations in soybean seed are ranged from 0.5 to 6.5% (Ireland, Dziedzic, & Kearsley, 1986; Berhow, Kong, Vermillion, & Duval, 2006).

Soybeans also contain isoflavones called genistein and daidzein, which are one source of phytoestrogens in the human diet. Soybeans are a significant source of mammalian lignan precursor secoisolariciresinol containing 13–273 μg/100 g dry weight (Adlercreutz, et al., 2000). Another phytoestrogen in the human diet with estrogen activity is coumestans, which are found in soybean sprouts. Coumestrol, an isoflavonecoumarin derivative is the only coumestan in foods (De Kleijn, Van Der Schouw, Wilson, Grobbee, & Jacques, 2002; Valsta, et al., 2003). Soybeans and processed soy foods are among the richest foods in total phytoestrogens present primarily in the form of the isoflavonesdaidzein and genistein (Thompson, Boucher, Liu, Cotterchio, & Kreiger, 2006).

2.9 Soybean and Health

2.9.1 Beneficial Effects of Soybean

Recent research of the health effects of soy foods and soybean containing several bioactive compounds received significant attention to support the health improvements or health risks observed clinically or *in vitro* experiments in animal and human.

2.9.2 Effects on Cancer

Recent studies suggested that soy food (soy milk) and soybean protein containing flavonoid genistein, Biochanin A, phytoestrogens (isoflavones) consumption is associated with lowered risks for several cancers including breast (Messina, McCaskill-Stevens, & Lampe, 2006; Peterson, Barnes, & Biochanin, 1993; Wu, et al., 1996; Wu A. , et al., 1998; Zheng, et al., 1999; Boyapati, et al., 2005; Lof & Weiderpass, 2006), prostate (Peterson & Barnes, 1991; Jacobsen, Knutsen, & Fraser, 1998), endometrial (Lof & Weiderpass, 2006), (Jacobsen, Knutsen, & Fraser, 1998), lung (Swanson, et al., 1992), colon (Azuma, Machida, Saeki, Kanamoto, & Iwami, 2000), liver (Kanamoto, Azuma, Miyamoto, Saeki, & Tsuchihashi, 2001), and bladder (Sun, et al., 2002) cancers.

Isoflavones (genistein) use both hormonal and non-hormonal action in the prevention of cancer, the hormonal action of isoflavones has been postulated to be through a number of pathways, which include the ability to inhibit many tyrosine kinases involved in regulation of cell growth, to enhance transformation growth factor-β which inhibits thecell cycle progression, as well as to influence the transcription factors that are involved in the expression of stress response-related genes involved in programmed cell death (Akiyama, et al., 1987; Zhou & Lee, 1998). Other nonhormonal mechanisms by which isoflavones are believed to increase their anticarcinogenic effects are via their anti-oxidant, anti-proliferative, anti-angiogenic and anti-inflammatory properties (Gilani & Anderson, 2002).

On the other hand, soy proteins and peptides showed potential results in preventing the different stages of cancer including initiation, promotion, and progression (Berhow, Kong, Vermillion, & Duval, 2006). They noted that Kunitz trypsin inhibitor (KTI), a protease inhibitor originally isolated from soybean, inhibited carcinogenesis due to its ability to suppress invasion and metastasis of cancer cells. Also, (Kim, Kim, Yang, & Kwon, 2004) found that soybean lectins and lunasin were able to possess cancer chemopreventive activity *in vitro*, *in vivo* (in human).

Cell culture experiments have demonstrated that a novel soybean seed peptide (lunasin) prevented mammalian cells transformation induced by chemical carcinogens without affecting morphology and proliferation of normal cells (Kim, Song, Kwon, Kim, & Heo, 2008). Lunasin purified from defatted soybean flour showed potent activity against human metastatic colon cancer cells. Lunasin caused cytotoxicity in four different human colon cancer cell lines (Kanamoto, Azuma, Miyamoto, Saeki, & Tsuchihashi, 2001). It has been also demonstrated that lunasin causes a dose-dependent inhibition of the growth of estrogen independent for human breast cancer (Adlercreutz, et al., 2000).

2.9.3 Effect on Hypercholesterolemia and Cardiovascular Diseases

Soy food and soybean protein containing isoflavones consumption lowered hypercholesterolemia (Wu, et al, 1996; Wu, A. et al, 1998; Zheng, et al, 1999; Boyapati, et al, 2005; Lof & Weiderpass, 2006). Many studies reported that soybean protein consumption lowered incidence of cardiovascular diseases (Hajos, et al., 1996). Soy isoflavone suppress excessive stress induced hyperactivity of the sympatho-adrenal system and thereby protect the cardiovascular system (Sacks, et al., 2006).

Several studies reported a relation between soybean protein consumption and the reduction in cardiovascular risk in laboratory animal's models by reducing plasma cholesterol levels (Wu, et al, 1996; Wun A. et al, 1998; Zheng, et al, 1999; Boyapati, et al, 2005; Lof & Weiderpass, 2006), Reduction in the incidence of hypercholesterolemia and cardiovascular diseases in Asian countries depending on their diets rich in soy protein was reported (de Mejia & Dia , 2010). Another study found that the substitution of the animal protein with soybean protein resulted in a significantly decrease in plasma cholesterol levels, mainly LDL (low-density lipoprotein) cholesterol (de Mejia & Dia , 2010). In the same way, (Berhow, Kong, Vermillion, & Duval, 2006) showed that after replacing animal protein with soybean protein consumption for hypercholesterolemia persons resulted in a significant decrease of 9.3% of total plasma cholesterol, mainly 12.9% of LDL cholesterol level and 10.5% of triglycerides. The health beneficial effect for replacing animal protein with soy protein consumption showed the most effective in the highest hypercholesterolemic depend on the initial plasma cholesterol levels Kim, Song, Kwon, Kim, & Heo, (2008) without or with the lowest effects in normocholesterolemic persons.

Several research attentions have been paid to the high dietary intake of isoflavones because of their potentially beneficial effects associated with a reduction in the risk of developing cardiovascular diseases. On the other hand, other studies conducted out to establish whether soybean protein and/or isoflavones could be responsible for the hypocholesterolemic effects of soybean diets and therefore their beneficial effects on cardiovascular disease. By studying the effect of soy bean protein and isoflavones, (Wang, Dia, Vasconez, Nelson, & de Mejia, 2008) reported that these major components of soybean flour (soybean proteins and soybean isoflavones) independently decreased serum cholesterol. Recent study reported that soybean protein containing isoflavones significantly reduced serum total cholesterol, LDL cholesterol, and triacylglycerol and significantly increased HDL (high-density lipoprotein) cholesterol, but the changes were related to the level and duration of intake, and gender and initial serum lipid concentrations of the persons (Kim, Song, Kwon, Kim, & Heo, 2008).

Some studies have shown that soybean oil is effective in lowering the serum cholesterol and LDL levels, and likely can be used as potential hypo-cholesterolemic agent if used as a dietary fat and ultimately help prevent atherosclerosis and heart diseases (Kummerow, Mahfouz, & Zhou, 2007). Soybean oil is a rich source of vitamin E, which is essential to protect the body fat from oxidation and to scavenge the free radicals and therefore helps to prevent their potential effect upon chronic diseases such as coronary heart diseases and cancer (Kummerow, Mahfouz, & Zhou, 2007). The FDA granted the following health claim for soy: "25 grams of soy protein a day, as part of a diet low in saturated fat and cholesterol, may reduce the risk of heart disease (Lof & Weiderpass, 2006).

2.9.4 Effect on Osteoporosis and Menopause

Soy food and soybean iso-flavones consumption lowered osteoporosis, improved bone health and other bone health problems (Giampietro, et al., 2004; Leesons & Summers, 2005). In addition, consumption of soy foods may reduce the risk of osteoporosis and help alleviate hot flashes associated with menopausal symptoms which are major health concerns for women (Kummerow, Mahfouz, & Zhou, 2007).

2.9.5 Hypotensive Activity

Soy food kochujang extract consumption lowered hypertension (Baek, Park, Park, & Lee, 2008). The angiotensin I converting enzyme inhibitory peptide isolated from soybean hydrolysate and Korean soybean paste enhanced anti-hypertensive activity *in vivo*(Berhow, Kong, Vermillion, & Duval, 2006), causing a fall in blood pressure compared with thiazide diuretics or beta-blockers for mild essential hypertension (Baek, Park, Park, & Lee, 2008).

2.9.6 Effect on Insulin Secretion and Energy Metabolism

Increasing the insulin secretion followed by glucose challenge was recorded when male monkeys fed soybean protein and isoflavones (Kummerow, Mahfouz, & Zhou, 2007). Flavonoid genistein, tyrosine kinase inhibitor, inhibited insulin signaling pathways (Akiyama, et al., 1987). Dietary isoflavones induced alteration in energy metabolism in human (Giampietro, et al., 2004). They also noted an inhibition of glycolysis and a general shift in energy metabolism from carbohydrate to lipid metabolism due to isoflavone interference.

2.9.7 Effect on Blood Pressure and Endothelial Function

Reduction in the blood pressure via renin-angiotensin system activity (one of the most important blood pressure control systems in mammals) was recorded by feeding rats on diet containing commercial purified soybean saponin (Riaz, 2006). They found that soybean saponin inhibited renin activity *in vitro* and that oral administration of soybean saponin at 80 mg/kg of body weight daily to spontaneously hypertensive rats for 8 weeks significantly reduced blood pressure. In addition, (Strom, 2001) studied the effects of dietary intake of soybean protein and isoflavones on cardiovascular disease risk factors in high risk, 61 middle aged men in Scotland. For five weeks, half the men fed diets containing at least 20 g of soybean protein and 80 mg of isoflavones daily. The effects of isoflavones on blood pressure, cholesterol levels, and urinary excretion were measured, and then compared to those of the remaining men who were fed placebo diet containing olive oil. Men that fed soybean in their diet showed significant decrease in both diastolic and systolic blood pressure. In addition, (Shiraiwa, Harada, & Okubo, 1991) found that feeding soy nut significantly decreased systolic and diastolic pressure in hypertensive postmenopausal women. On the other hand, (Gilani & Anderson, 2002) found no effect of soybean protein with isoflavones on blood pressure in hypertensive persons. Soy protein and soy isoflavones intake improved endothelial function and the flow-induced dilatation in postmenopausal hypercholesterolemia women by raising the levels of endothelial nitric oxide synthase (eNOS), a regulator of the cardiovascular function (de Mejia, Vasconez, de Lumen, & Nelson, 2004; Wang, Dia, Vasconez, Nelson, & de Mejia, 2008). Furthermore, chronic administration of genistein increased the levels of NOS in spontaneously hypertensive rats (Wang, Dia, Vasconez, Nelson, & de Mejia, 2008).

2.9.8 Effects on Platelet Aggregation and Fibrinolytic Activity

The effect of genistein, a protein tyrosine kinase inhibitor on platelet aggregation was exhibited, (Wang, Dia, Vasconez, Nelson, & de Mejia, 2008). Nattokinase, a strong fibrinolytic enzyme, in the vegetable cheese natto (a popular soybean fermented Japanese food) showed approximately fourtimes stronger activity than plasmin in the clot lysis assay (Berhow, Kong, Vermillion, & Duval, 2006). However, intraduodenal administration nattokinase decreased fibrinogen plasma levels in rats (Baek, Park, Park, & Lee, 2008) and in humans (Merritt & Jenks, 2004). In addition, soybean protein and peptides exhibited anti-fatigue activity helping in performing exercise and delaying fatigue (Adlercreutz, et al., 2000), antioxidant (Berhow, Kong, Vermillion, & Duval, 2006), anti-aging, skin moisturizing, anti-solar, cleansing, and hair-promoting agent (De Kleijn, Van Der Schouw, Wilson, Grobbee, & Jacques, 2002).

The beneficial effect of Soy isoflavonne (daidzein) on human health extends to the prevention of cancer (Kanamoto, Azuma, Miyamoto, Saeki, & Tsuchihashi, 2001), cardiovascular disease (Choi, Yoon, Kim, & Kwon, 2007). Also, soybean isoflavones (genistein, daidzein, and their beta glycoside conjugates) showed antitumor (Giampietro, et al., 2004), estrogenic (Hoogenkamp, 2005), antifungal activities (Joseph, 2001). Soy isoflavonne (daidzein) stimulates catecholamine synthesis at low concentrations (Hoogenkamp, 2005). However, daidzein at high concentrations (1-100 μM) inhibited catecholamine synthesis and secretion induced by stress or emotional excitation. Recent studies recoded an improvement in cognitive function, particularly verbal memory (Kim, Song, Kwon, Kim, & Heo, 2008) and in frontal lobe function (Joseph, 2001) with the use of soy supplements. Glyceollins molecules are also found in the soybean and exhibited an antifungal activity against *Aspergillussojae*, the fungal ferment used to produce soy sauce (Wolke, 2007). They are phytoalexins with an antiestrogenic activity (Sacks, et al., 2006).

2.10 Coconut and Nutrition

Products containing coconut continue to increase in popularity. Products such as coconut oil and coconut water are flooding the market. It is difficult to walk into a grocery store without seeing a coconut-containing product on display. There are hundreds of blogs and diets that sing the praises of health benefits they claim are linked to coconut products, including weight loss, cancer prevention and improved brain function in Alzheimer's disease.

Coconut (*Cocosnucifera L*) grown in about 93 countries in an area of 11.8 Million ha produces 10.9 million tonnes of copra equivalent. Coconut provides food, drink, medicine, health, shelter, aesthetics and wealth. Since every part of coconut is used for mankind, it is known as 'Tree of Life', 'Tree of Heaven', 'Natures' Super Market', 'Kalpavirksha'. One of the primary natural product produced from the dry fruit (copra) of coconut is coconut oil which has been used from time immemorial as food, food ingredient and functional foods, besides used in pharmaceuticals, nutriceuticals, cosmetics and industrial uses including bio fuel. It is known as 'Miracle Oil'.

2.10.1 Nature of Coconut Juice and Oil

Coconut oil is a colourless to pale brownish yellow oil with a melting point ranging from 23^0 to 26^0 C whiles the juice is normally white-milky in colours. The coconut oil is mostly extracted from the juice of matured-dry coconut. The glycerides of coconut oil are invariably a mixture of one, two or three fatty acids. Though coconut oil is known as triglyceride or lipid, also contains minor proportions of mono and diglycerides and has highest content of glycerol (13.5 % to 15.0 %). Glycerol is a carbohydrate with chemical composition similar to that of simple sugar. This implies that with coconut oil as a dietary fat, the actual intake of fatty substances is much less than that with same quantity of any other oil. Almost 70% of saturated fatty acids present in coconut oil will exhibit dietary properties which are specific to the group of short and medium fatty acids. Coconut oil rich in fatty acids of 12 carbons or less is classified as Medium Chain Fatty Acids (MCFA). Coconut oil triglycerides are characterised by high laurate in the beta position (Ening, M. 2001). The coconut oil has the lowest cholesterol amounts (5-24 parts per million) compared to palm kernel oil, sunflower oil, palm oil, soy oil, cottonseed oil, rapeseed oil and corn oil (table 2.5).

Coconut oil is more or less constant in composition irrespective of the country of origin. It has the highest saponification value (251 to 263) and the lower iodine value (8.0 to 9.6). Because of low iodine value it is classed as now drying oil.

Table 2.6: Estimated amounts of cholesterol in vegetable oils and animal fats

Oil/fat	Range (Parts per million)
Coconut	5-24
Palm kernel	9-40
Sunflower	8-44
Palm	13-19
Soy	20-35
Cottonseed	28-108
Rapeseed	25-80
Corn	18-95
Beef tallow	800-1400
Butter	2200-4100
Lard	3000-4000

Source: Inform, Vol. 13, 2002

Coconut oil is an important component in imitation dairy products like filled cheese, coffee, whiteners, milk shake mix chocolate filled with milk; ice cream, desert topping, spray oil for crackers, cookies and cereals. It is used in these products not only because it resists oxidation, but also because it is bland in flavour. It is extremely stable on storage and possess a unique liquefying property that contribute to month feel of the food of which it is component.

2.11 Coconut Oil for Health and Nutrition

Historically, coconuts and their extracted oil have served man as important foods for thousands of years. The use of coconut oil for shortening was advertised in the United States in the popular cook books at the end of 19^{th} century. Both the health promoting attributes of coconut oil and those functional properties useful to the homemaker were recognized 100 years ago. These attributes, in addition to some new attributes should be great interest to both producing as well as consuming countries (Enig, 2001).

Coconut oil has been a life saver for many people. The health and nutritional benefits derived from coconut oil is unique and compelling (Enig, 1996 and Dayrit., et al, 2001) had stated that medium chain triglyceride, a fraction of coconut oil has been identified as an important, medically efficacious food. Indeed, diet for critically ill children, premature infants and hospitalised patients use medium chain triglycerides as principle source of fat. Coconut oil when used in usual diets containing all classes of fat proves to be anticholesterogenic.

2.11.1 Increases Digestibility and Control Diabetics

It is medicinally used in special food preparations for those who suffer digestive disorders and have trouble in digesting fats. Considerably, more is known about digestibility of coconut oil in men. It is nearly completely absorbed as are most other natural dietary fat (Lang and Holmes, 1997), (Hoagland and Snider, 1998; Thomasson, 2006). For the same reason, it is also used in infant formulations for the treatment of malnutrition. The absorption of calcium and magnesium and also amino acids has been found to increase when infants are fed with diet containing coconut oil. Coconut oil has been used to enhance absorption of Ca and Mg when deficiency of these nutrients exist. For those who get older, coconut oil is useful for slowing down the degenerative process by improving mineral absorption. Coconut oil also helps to supply energy to cells (because it is easily absorbed without the need of enzymes) as well as improve insulin serration and utilisation of blood glucose (Garfinkel, Lee, Opara, & Akkwari, 1992). Those people with diabetes would greatly benefit by adding coconut oil to daily diet.

2.11.2 Helps to Reduce Weight

MCFA do not circulate in blood stream like other fats but sent directly to the liver where they are immediately converted into energy – just like a carbohydrate. So when coconut oil is consumed the body immediately, make energy rather than body fat. The weight loss effect of coconut oil has been proved by many researchers.

2.11.3 Improve Cardiovascular Health

No topic related to coconut oil has been given more prominence than its relation to cholesterol metabolism in animals (Kaunitz, Toxic effects of polyunsaturated vegetable oils, 1996). It has been claimed that the inhabitants of Thailand have low rate of heart attacks and strokes although coconut oil is their leading dietary fat (Saikku, 1997). In a study on two groups of Polynesians, it was found that the group eating 89 % of their fat as coconut oil has lower blood pressure values than those eating 7%. Heart attack was not observed in either group. There were of course many other differences between the groups (Gerster, 2008). In another study on Polynesians, it was found that Pukapukans consuming large amount of coconut oil had lower serum cholesterol level and lower incidence of arteriosclerosis than Maoris (and Europeans) who consumed an European type of diet (Shotland, Cleary, & Phillips, 2009). (Wickramanayake, 2011) had said that a prolonged daily intake of coconut fat, in quantities of 50 g or less produces a sustained rise in blood cholesterol and or increased ahezogenesis had not been demonstrated. He further indicated that in 1952, the International Bank for Reconstruction and Development estimated Sri Lankan consumption to be 1300 nuts per head per year (equivalent about 48g coconut fat/day). Whereas, the Central Bank report of 1981 estimates per capita consumption of 990 nuts / year (or less than 34 g coconut fat per day). Any increase in Ischaemie Heart Disease cannot be due to increased coconut consumption. In a study at Philippines, 10 medical students tested diets consisting of different levels of animal fat and coconut oil. When the ratio of animal fat and coconut oil at ratio of 1:1, 1:2, 1:3 no significant change in cholesterol but when animal fat level increased total calories reached 40% and blood cholesterol increased. This study had indicated that not only did coconut had no effect on cholesterol levels, it even reduced the cholesterol elevating effects of animal fat. A review of epidemiological and experimental data regarding coconut eating populations show that the dietary coconut oil does not lead to high blood cholesterol or coronary heart disease (Kaunitz & Dayrit, 1992). When native people change their diet and give up eating coconut oil in favour of polyunsaturated vegetable oils their risk of heart disease had shown to increase (Kurup & Rajmohan, 1994; Mendis, Kumara, & sunderam, 1990).

Dr. Ian Prior and his colleagues showed that, island populations that eat very high amounts of saturated fat coconut oil showed no sign of heart disease. But when they migrate to New Zealand and began eating less coconut oil and less saturated fat but more poly unsaturated fats, the incidence of heart disease and other illness greatly increased (Prior, Davidson, Salmond, & Czochanska, 2008). Numerous studies clearly demonstrated that coconut oil has a neutral effect on cholesterol levels (Garfinkel, Lee, Opara, & Akkwari, 1992; Enig M. G., Diet, 1993; Wickramanayake, 2011). Enig (2001) while reviewing the health and nutritional benefits from coconut oil has stated that some studies reported thirty and more years ago should have cleared coconut oil of any implication in the development of heart disease ((Garfinkel, Lee, Opara, & Akkwari, 1992; Enig M. G., Diet, 1993; Wickramanayake, 2011) fed 15% of the fat ration as coconut oil (24% energy) to 83 adult normocholesterolemics (61 males, 22 females). Relative to baseline values, the highest value of total cholesterol increased 17%, HDL cholesterol increased 21.4% and LDL/HDL ratio decreased 3.6%. Those who blindly state that all saturated fats are unhealthy or coconut oil consumption leads to heart disease are ignorant of facts. There is no evidence to support the notion that saturated fat in coconut oil is harmful (Enig, 1993). Indeed there is strong evidence now that coconut oil can help to prevent heart disease (Enig, 2001).

2.12.4 Immune System Support

Polyunsaturated oils put a heavy strain on the immune system. They cause the immune system to shift into feverish activity while at the same time interfering with its ability to form protective compounds. Antioxidants are quickly used up fighting free radicals produced by unsaturated oils. When antioxidants such as Vit. A, C, and E becomes depleted, the immune system slow down becomes effective. Vegetable oils produce an overall depressive effect on immune system. Coconut oil on the other hand supports immune system. It causes no stress. The coconut oil is nontoxic to body so does not burden immune system. Saturated fats are very stable and do not oxidize easily, so antioxidants are not used up. Sixty three percent of coconut oil is composed of antimicrostial MCFA, and therefore can be powerful all with the immune system in fight against microscopic invaders. Coconut oil is ideal for immune suppressed individuals. For this reason, it is now being studied as a treatment for HIV / AIDS patients whose immune systems are severely compromised.

2.11.5 Protection against Disease

Coconut oil may be useful in preventing a wide assortment of diseases. Because of its unique metabolic properties, it can help shed unwanted weight, thus reducing risk of many health problem associated with obesity. Since 1950, it is used to treat mal-absorption problems in adults and infants.

2.11.6 Inhibit Induction of Carcinogenic Properties

Dr. Robert L. Wickremasinghe, head of Serology division of the Medical Research Institute, Sri Lanka reported that coconut oil may even possess anti carcinogenic properties. Studies have shown that coconut oil inhibits the induction of carcinogenic agents of colon as well as mammary tumours in test animal (Wickramanayake, 2011). Gerster, (2008) had indicated that in a 50 year review made during 1987, showed the anticancer effect of coconut oil. In chemically induced cancers of colon and breast, coconut oil was by far more protective than unsaturated oil. For example 32% of corn oil users got colon cancer whereas only 3% of coconut oil eaters got the cancer. (Lang & Holmes, 1997) has reviewed 50 years literature showing anti carcinogenic effect from dietary coconut oil.

2.11.7 Reduce Degenerative Disease

The biggest advantage of using coconut oil is that it can displace the use of hydrogenated and processed vegetable oils that are known to be involved in the development of numerous diseases as well as premature aging. While coconut oil may not prevent or cure all these conditions directly, it can limit the amount of potentially toxic hydrogenated and polyunsaturated oil in our bodies thus reduce chances of suffering prematurely from degenerative disease.

2.11.8 Anti-Microbial

Coconut oil with 48% lauric acid (an 12 chain saturated fat), 7% capric acid (an 10 chain saturated fat), 8% caprylic acid (an 8 chain saturated fat) and 5% caproic acid (an 6 chain saturated fat) which makes up triglyceride molecule, form antimicrobial properties of coconut oil. These are generally absent from all other vegetable and animal fat except butter. Human breast milk and milk of other mammals contain MCFA. These fatty acids protect the new born baby from harmful germs. For years MCFA have been added to infant formula as protection because it supplies easily digestible nutrients. A mother who consumes coconut oil will have more MCFA in her milk to help protect and nourish her baby. Those babies make from lauric acid, they get from their mother's milk. The monoglyceridemonolaurin is the substance that keeps the enfants from getting viral or bacterial or protozoal infections. Until just recently, this important benefit has been largely overloaded by medical and nutritional community.

MCFA found in coconut oil have been shown in laboratory experiments to be effective in destroying viruses that cause influenza, measles, herpes, mononucleosis, hepatitis C and AIDS; bacteria which can cause stomach ulcers, throat infections, pneumonia, sinusitis, ear ache, rheumatic fever, dental cavities, food poisoning, urinary tract infections, meningitis, gonorrhoea and toxic shock syndrome; fungi and yeast which leads to ringworm, candida and thrush and parasites which can cause intestinal infections such as giardiasis. Several researchers and hospitals are currently patenting formulations derived from MCFA in coconut oil for this purpose (Enig, 2001).

2.11.9 Body Lotion/Cosmetics

Coconut oil has a natural creamy texture comes from vegetable source, it is used in cosmetics. Whether applied topically or internally, coconut oil helps to keep skin young, healthy and free of disease. Polynesian women are famed for their beautiful skin, even though they are exposed every day to hot blistering sun and the chafing of the ocean breeze. Coconut oil has been used by them to make the skin soft and smooth. Virgin coconut oil is used to make natural soaps and other health products and is said to promote luxurious hair growth and protect the skin from bacterial and viral infection. In Ayurvedic medicine, coconut oil is said to nourish the body and increases strength while application of coconut oil to the skin is said to help fixation of vitamin D in the body. The cosmetic applications of coconut oil include:

Hair and Skin Oil

Coconut oil mixed with herbal oils and different scents is used as hair oil and is preferred because of its low viscosity. Without chemical modification, it promotes emolliency; gloss lubricity and adhesion and is said to prevent dandruff. Different preparations of coconut oil are also used to protect the skin from bacterial, protozoal and other infections in body and baby oils.

In Natural Shampoo

Coconut oil is used to prepare natural shampoos, in which the extract of amla fruit and soapnut powder are sometimes incorporated to add value.

Herbal/Medicinal oils

Coconut oil with various herbs/medicinal plants is used for preparing medicated oils such as skin and massage oils. Some people use coconut oil with lime for healing wounds.

Scent- making

Caproic acid, capric acid and caprylic acid obtained from coconut oil are mixed with methyl alcohol, ethyl alcohol, isopropyl alcohol, butyl alcohol and their esters and utilised in scents as well as food products.

Beauty Care Products

Coconut oil has a high level of myristic acid which, in combination with isopropyl myristate. This is used in many beauty products as an additive. Coconut oil lauric acid is also used in toothpaste.

2.12 Conclusion

Beyond how a food product appeal and appears to the consuming public, the most important of all is what consumers benefit from the consumption of the product. Whiles cassava starch and coconut juice/oil provide consumers of the popular “Ayigbe biscuit” with high and quality carbohydrate and saturated oil, the fortification seems to make the product more nutritionally balanced with the introduction of soya beans flour. It is important to note that the fortified cassava starch biscuit with soya make the product more nutritionally friendly to all groups of consumers.

CHAPTER THREE

METHODOLOGY

3.0 Introduction

The purpose of the study was to develop a more fortified cassava starch biscuit with the introduction of a protein based ingredient in addition to the existing composition of the "Agbozume Biscuit". This chapter deals with the methodology adopted for the study and the production of the various samples of the cassava starch-soya fortified biscuit.

3.1 Research Design

The study was a day one-group cross sectional sensory test design.

3.2 Study Area

The area to be studied is Agbozume orKlikor-Agbozume is a town in Ketu Municipal District in the Volta region of southeastern Ghana· It is located on the coordinates of 6°4′n and 1°2′e. Agbozume lies on the main road between Accra and the border with Togo. Aflao, a border town is about 20 km away from Agbozume, as well as the coast of the gulf of guinea. The village is adjacent to another place, Klikor, which is separated by only one path. The two settlements are often referred to together with Klikor-Agbozume. The main language spoken is the ewe language. By settlement only Agbozume town has a population of 5,073 (2000 population headcount)

Agbozume is a commercial town. The town has a large market, which takes place every four days. The market is popular for the sale of the starch biscuit, cassava dough, gari, cassava starch. Coconut oil, salt fish animals as well as the Kente cloth where traders from Burkina Faso, Togo Benin and Nigeria come to buy cloth for export

The district is heterogeneous in ethnicity a feature, which promotes development. The ethnic groupings include ewes, Akan's, Gas, Hausas, and Ga- Adangmes. About 62% of the sample populations are Ewes, Akans, Gas and Hausas constitute 36"o (each group has 6%) and the Ga-Adangmes 2%.

The district exhibits both the rural and urban types of settlement but is largely rural. About 35% of populations live in a few urban centers while the remaining 65% live in 707 rural settlements.

The district has some challenges beneficial to the study:

- Increasing Malnutrition rate among children especially in rural areas
- Low production and revenue base
- Inadequate investment/working capital
- Inadequate credit facilities
- Low savings incomes
- Low internally Generated Revenue (IGR)
- Low level of technology and skilled labor
- Inadequate storage facilities

3.2.1 Sampling Procedure and Technique

- The study area has a population of over 5000 hence for the study; the purposive sampling technique as well as the cluster sampling technique will be used for the study.This is because Adawukorpe, (the selected suburb) is a location where the product is frequently produced. Also it has a heterogeneous population (people from all walks of life live there).
- Stakeholders as well as the public will be found as part of the population hence yielding more accurate results.
- The chosen size was 200. This is because it is quite large and made the purpose of the study accurate. It is also based on calculation with the formula with about 6% being the percentage error.

3.2.2 Data Gathering and Instrument Design

- Gathering data were done primarily. Participants had face to face interaction. Questionnaires were administered; Experiment and observation were made at various stages. There was focus group of structured interviews. Discussion was done with the stakeholders as well as interviews for the bakers. They also have privilege to test the acceptability of the product.
- Critical experiments and observation were exercised to develop standardized recipe for the various local industries in the community to use. Stories as well as histories were tolerated for clearer and deeper information.
- Secondary data was also gathered at the Ketu municipal office.

3.2.3 Pre-Test and Ethical Considerations

- Pre-testing of survey instruments were done to check acceptability of the product and the shelf life. This was done on some class mates, family members, friends as well as Student and staff of Hohoe E.P. Senior High School members, where the reasecher is teaching.
- Twenty people were responded to the pre-testing.
- Notes have clearly been outlined in the data gathering instruments to serve as a security check of the respondents/participants and also to assure them. The culture, taboos and customs of the people under study have been carefully taken care of in order to bring ethical sanity in the study.

3.2.4 Mode of Data Analysis

The processing and the analyses of the data were done with computer software applications such as the SPSS application and the Microsoft Excel application. Manual writing, tabulation as well as calculations were also very useful.

3.3 Sample Size and Sampling Technique

The panelists were conveniently selected based on their accessibility for the study period and as regular consumers of the biscuit. The panelists were from both formal and informal sectors and including few SHS students who could respond objectively to the sensory evaluation items. A total of 50 panelists were involved in the studies.

3.4 Materials

The cassava starch was bought from Agbozume in the Volta Region were a lot of cassava farms produced cassava dough for consumption and gari processing and the starch is extracted from the cassava juice from the dough which is left to settle as starch.

Coconut was also bought in Agbozume were there are lot of coconut plantation which produce coconut for the manufacturing of coconut oil. The soya bean was also bought from markets in Agbozume.

3.5 The Processing Flow

Figure 3.1: Cassava Processing

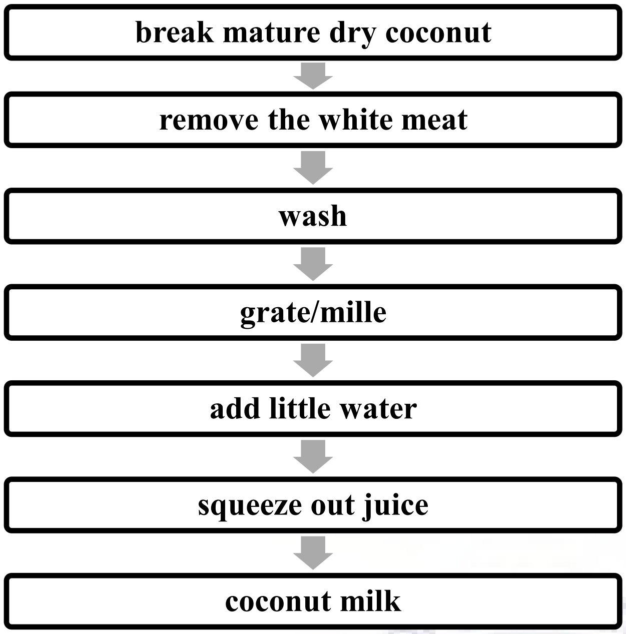

Figure 3.2: Coconut Processing

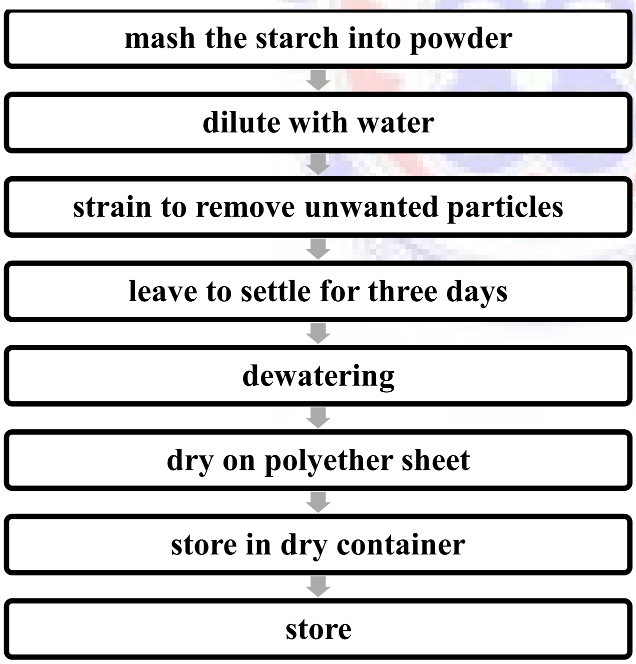

Figure 3.3: Washing of Starch

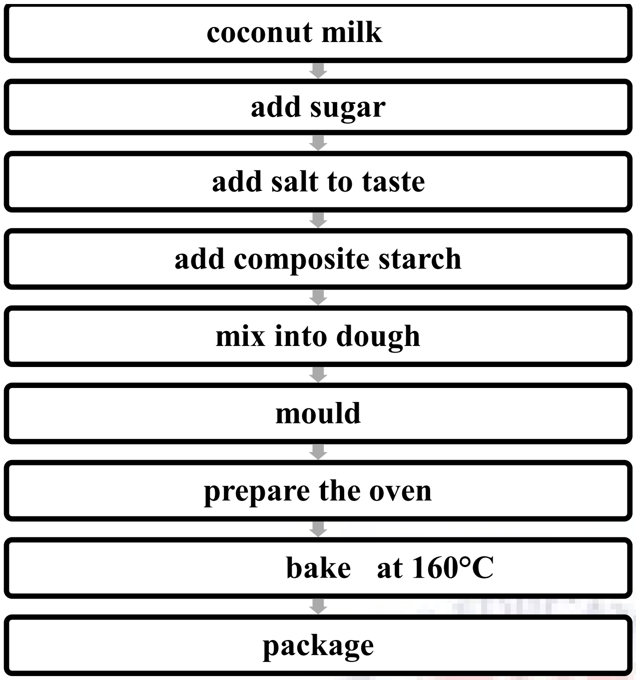

Figure 3.4: Preparations of Starch-Soya Biscuits

Table 3.1: The standardized recipe and formulation of the Biscuits

Sample/Ingredients	Control	A	B	C
Starch flour (dried) (g)	250	250	250	250
Soya flour (g)	-	30g	40g	50
Sugar(g)	100	100	100	100
Dried coconut(g)	200 gm	200gm	200g	200g
Salt(g)	-	20	20	20
Vanilla (ml)	-	10	10	10

3.6 Sensory Evaluation

The biscuits produced (both control and compoint) were subjected to sensory evaluation. The products were assessed by 50 panelists from the catchment area and students of Hohoe E. D. Senior High School where the researcher teaches. Panelists were familiar with the starch biscuit and were introduced to the individual seven-hedonic rating scale, a score of 1 represented dislike extremely and 7 represented like extremely, for seven sensory attribute namely; appearance, colour, taste, gumminess, flavour, mouth feel and overall acceptability of biscuit samples. The biscuit samples were presented in identical containers, coded with 3-digits random numbers served simultaneously to ease the possibility of the panelists to re-evaluate a sample preference. Panelists rinsed their mouths with water after each stage of sensory evaluation to prevent carry–over flavor and effect during tasting.

3.7 Data Analysis

A total of 200 of biscuits pieces were evaluated, comprising appearance, colour, taste, gumminess, flavour, mouth feel and overall acceptability of biscuit samples. All the experiments were replicated in triplicate unless otherwise stated. The coefficient of variability of all the tests was lower than 10%. Analysis of variance (ANOVA) and the linear regressions followed by Turkey's test in addition to the correlations between factors were performed using SPSS 16.0 (SPSS Inc., Chicago, IL, USA). All the calculations were done at the significance level of $p < 0.05$. Correlation coefficients were run between the different variables using Microsoft Excel at the significance level of $p <$ 0.05, 0.01, and 0.005.

3.8 Shelf Life

The shelf life of the product was that when product was kept in an open, sensory evaluation was conducted on feel it was soft and when it was conducted on taste it looses its crispness within three days.

When kept in transparent polythene bag for four month; when sensory evaluation was conducted on taste, it retains its taste crispness and colour. When it was kept in polythene bag and put in the freezer, during the process of thawing the sweet stained the colour of the product and the crispness was also affected. After four month when additional two months was added the product loses it crispness when the sensory evaluation was conducted on touch, taste and flavour. From the result of the sensory evaluation it has reveal that the shelf life of the product can last for four month when put in polythene bag and pack in a curtain.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Introduction

The purpose of the study was to develop a more fortified cassava starch biscuit with the introduction of a protein based ingredient in addition to the existing composition of the “Agbozume Biscuit”. This chapter deals with consumer acceptability of cassava-starch/soya (composite) biscuits. The chapter presents the result from the sensory evaluation.

4.1 Descriptive Statistics for Sensory Parameters

The first point of attraction for every product is colour; it is for that matter that colour is a very critical parameter in sensory evaluation. In the current study all the products including the control sample received mean ratings of more than the mid-point mark of 5 (the midpoint score). From the results of the four samples on the colour as presented in Table 4.1, the colour of the product sample with 30gsoya flour composite recorded the highest mean rating of 8.17 followed by 40g cassava replacement with a mean rating of 7.43 then the control sample recorded a value of 7.40 with the 50g replacement recording a value of 7.37. The results showed a colour preference order of 30g, 40g, control and 50g.

Colour of biscuit crust is an important sensory attribute, which can enhance its acceptability. The local population thinks that pale coloured crust is indicative of improper baking. Besides it is assumed that a slightly brownish colour is what imparts nutrients, especially iron on the product. Browning of bread and biscuit crust is an origin of Millard reactions during baking in the presence of amino acids, reducing sugars, temperature, time of baking and moisture levels of the fermented dough (Dendy, 2013). The results showed that as more soya flour was substituted into cassava starch blends, the intensity of browning increase and the biscuits made from the 100% cassava starch flour was less brown than the other types of the biscuits. This was expected since the increase amount of soya flour in the biscuits made from different proportions of the soya: cassava starch composite meant increase proteins in the Millard reactions which is one of the reactions responsible for brown colour. However, these findings are inconsistent with other similar studies where it was reported that cassava flour (starch) when supplemented in composite with wheat or legume for baking did not change the caramelization process which forms the brown colour during baking (Eddy, Udofia, & Eyo, 2007). It was also noted that the amount of soya flours in the composite biscuit though varied in mean rating were not statistically different at p=0.05.

Table 4.1: Descriptive Statistics for Colour

Product/Statistic	**Control**	**30g Composite**	**40g Composite**	**50g Composite**
Mean (Brown colour)	8.17^{b}	7.68^{a}	7.43^{a}	7.37^{a}
SD(±)	1.45	0.75	1.68	1.56
Median	8.00	8.00	8.00	7.50
Minimum	4.00	7.00	4.00	3.00
Maximum	9.00	9.00	9.00	9.00

Numbers in rows followed by different superscripts are significantly different at $P<0.05$.

In Table 4.2 is the descriptive statistics of the taste of the four product samples. The taste of the product sample with 40gsoya composite was rated with the highest rating for taste with a mean value of 7.63, followed by 30gsoya composite ranked second as far as taste is concerned with a mean value of 7.20, followed by the control sample with mean of 7.13. The taste ranking followed as 40g, 30g, control and 50g. From the results, there is a strong indication that, the biscuit sample with 40gsoya flour composite with the cassava starch gave panelists the highest and the most preferred taste followed by a 30g cassava flour replacement however there was no significance difference between the control and 30gsoya flour composite but there was a significant difference between the former (control and 40gsoya flour composite) and the 30g and 50gsoya flour composite samples. Taste is an important sensory attribute of any food. Intake of biscuits are often enhanced by taste (Sim & Tam, 2001). The results as indicated in Table 4.2 does not show any one practically trend in increasing or decreasing order in the mean score of samples. Table 4.2 also shows that biscuit sample from 30g and 40gsoya flour composite and the control sample, showed high sensory scores on taste than the sample with 50gsoya flour composite. The taste of biscuits made from the 100% cassava starch was comparable to the biscuit made from the soya flour composite of 40g in statistical significance terms whist significantly different from the 30g and 50gsoya flour composite.

Evidence from literature supported the fact that the loaf size and texture, colour of the crust and taste were the most undesirable attributes for bread and biscuits baked with high cassava flour concentrations (Aboaba & Obakpolor, 2010).

Table 4.2: Descriptive Statistics for Taste

Product/Statistic	Control	30g Replacement	40g Replacement	50g Replacement
Mean	7.13^{b}	7.20^{a}	7.63^{b}	6.83^{c}
SD(±)	1.76	1.45	1.30	1.78
Median	7.00	8.00	7.00	7.00
Minimum	3.00	4.00	4.00	3.00
Maximum	9.00	9.00	9.00	9.00

Numbers in rows followed by different superscripts are significantly different ($P<0.05$).

Aroma is an important parameter of food (Iwe, 2002). 'Good' aroma from food excites the taste buds, making the system ready to accept the product. 'Poor' aroma may cause outright rejection of food before they are tasted. A good level of aroma intensity influences taste (Eddy, Udofia, & Eyo, 2007). Over the years, coconut flavour was the main and only aroma providing ingredient in the "Ayigbey" biscuit. Despite the mass acceptability, for this aroma provided by the coconut flavour, an enhancement in this aroma with carefully selected food vanilla is an added advantage. From the results of the sensory evaluation of the four products under study, the control product (all starch) recorded the above average rating. However, products with added food flavour recorded higher mean rating for aroma, giving them a better preference for aroma over the control product. The product with 30gsoya flour composite was rated most preferred with respect to aroma with mean of 8.57, with the product replacement of 40gsoya flour composite pooling a mean rating of 8.43, whiles the product with 50g cassava flour replacement was rated last with 8.40. Even though all the products recorded mean ratings above the mid-point mark of 4.5, the results indicated that, the more soya bean flour the less the product was accepted as far as aroma is concern.

Table 4.3: Descriptive Statistics for Flavour

Product/Statistic	Control	30g Replacement	40g Replacement	50g Replacement
Mean	7.90^{a}	8.57^{b}	8.43^{c}	8.40^{d}
SD(±)	1.45	1.04	1.11	1.73
Median	8.00	8.00	7.00	7.00
Minimum	4.00	6.00	5.00	2.00
Maximum	9.00	9.00	9.00	9.00

Numbers in rows followed by different superscripts are significantly different ($P<0.05$).

Gumminess describes how much elasticity is felt in a product which is normally through splitting the product or tasting (chewing) the product. The cassava starch biscuit when well-baked and kept dry is less gummy and very easy to break. This is a characteristic consumers' look out for but sellers fear this because a least mistake will cost them to lose it attractiveness when broken. With the current products, control product was noted with the highest level of gumminess pooling a mean rating of 7.80. The gumminess level of the 30g soya flour composite product stood at 7.27. The 40 gsoya flour composite was at M= 6.83 whiles the 50 gsoya flour composite saw a significantly lower mean level rating at 6.60. Normally, the lower the gumminess, the better the product most especially with bread, biscuits and other flour products. At 95% confidence level, there were insignificant between all four bread samples with a negative correlation between the amount of soya flour added and the level gumminess of the samples. The more the soya flour in the composite, the lesser the level of gumminess.

The addition of soya bean flour to the cassava starch/coconut flours decreased the cohesiveness, and resilience in samples; and, also decreased the gumminess. The results of springiness (which indicates the percentage recovery of biscuit), and resilience (which express the ability or speed of material to return to its original shape after a stress) was not seen in any of the samples since they were flat and well dried.A similar study by Taha (2000) indicates that gumminess increased with an increased amount of cassava flours in the blends. Furthermore, her results revealed that gumminess and chewiness values are highly dependent on hardness rather than on cohesiveness or springiness values and thereby increasing the gumminess level.

Table 4.4: Descriptive Statistics for Gumminess

Product/Statistic	**Control**	**30g Replacement**	**40g Replacement**	**50g Replacement**
Mean	7.80^{a}	7.27^{b}	6.83^{c}	6.60^{c}
SD(±)	1.13	1.58	1.49	1.48
Median	8.00	7.00	7.00	7.00
Minimum	6.00	3.00	4.00	3.00
Maximum	9.00	9.00	9.00	9.00

Numbers in rows followed by different superscripts are significantly different ($P<0.05$).

Table 4.5 presents the descriptive characteristic of the mouth-feel nature of the products under study. The control product was rated the least as far as mouth-feel concern with mean rating of6.70. The 30g soya bean flour was rated at 7.30, whiles the 40g soya bean flour was rated with a mean value of 7.80. The 50g product pooled a mean rating of 7.50. The products were rated in the order of 40g, 50g, 30g, and control.

Similarly to a study by Adgelghafor*et al.,* (2011), which suggests that when the proportion of cassava flours increased in breads and biscuits and other flour products, the softness and mouth feel scores decreased significantly, the mouth feel of the products understudy increased significantly with 40g and 50g soya flour replacements. From the results, there was not statistical significant difference in the mean value of the control product and the 30g soya composite. However, there was a significance difference in the mean ratings of the above mentioned product samples and the 40g and 50g soya flour substitutions.

Table 4.5: Descriptive Statistics for Mouth-feel

Product/Statistic	Control	30g Replacement	40g Replacement	50g Replacement
Mean	6.70^{a}	7.30^{a}	7.80^{b}	7.50^{c}
SD(±)	0.90	1.37	1.37	1.66
Median	7.50	7.50	7.50	7.00
Minimum	6.00	5.00	5.00	2.00
Maximum	9.00	9.00	9.00	9.00

Number in rows followed by different superscripts are significantly different (P<0.05).

In Table 4.6 is the descriptive statistics of the overall satisfaction panelists assigned to all the products. The overall acceptability goes a long way to tell the willingness of customers to accept and purchase such commodities. The mean rating as indicated in Table 4.6 suggest that, the product with the 40g soya bean flour added was the most preferred with mean rating of as 8.37, followed the 30g soya bean flour supplemented product with 7.83, then the control product (7.30), and finally the 50g soya flour replacement with 6.97. It was noted that, there was significant difference in the overall acceptability of the 40g soya flour product and the rest of the sample products. However, there was no significant difference in the control product and the 30g soya replacement. The results on acceptability agreed with those reported in previous related studies where it was found out that substitution level of soya flour influenced overall acceptance of bread, biscuits and other flour products. Overall acceptability scores decreased with an increase in cassava flour supplementation level for cassava composite biscuit enriched with soy flour (Owuamanam, 2007, Oluwamukoni, Oluwalana, & Akinbowale, 2011) High Quality soy flour has potential to succeed for use in bakery products as partial substitute for wheat flour but commercial production and consumption of bread and biscuits made from composite flour will depend on their price and local acceptance characteristics. Considerable promotion is probably required to drive market demand for composite wheat/cassava products (Estelle, 2013).

Table 4.6: Descriptive Statistics for Overall Acceptance

Product/Statistic	Control	30g Replacement	40g Replacement	50g Replacement
Mean	7.30^{a}	7.83^{a}	8.37^{b}	6.97^{c}
SD(±)	1.32	1.38	1.51	1.90
Median	8.50	8.00	7.50	7.00
Minimum	3.00	4.00	3.00	2.00
Maximum	9.00	9.00	9.00	9.00

Numbers in rows followed by different superscripts are significantly different (P<0.05).

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATION

5.0 Introduction

The purpose of the study was to develop a more fortified cassava starch biscuit with the introduction of a protein based ingredient in addition to the existing composition of the "Agbozume Biscuit. In this chapter, the conclusion and recommendations are discussed.

5.1 Summary

The focus of this project, fortification of the popular delicacy, cassava-starch biscuit "the Ayigbey biscuit to the high level carbohydrate (cassava starch) component of the biscuit to a protein base level.

Drawing from the communities where the biscuit is produced and mostly consumed, a sensory evaluation was done with four biscuit products (control = the traditional cassava starch biscuit; A = 250/30g cassava starch/soya bean flour; B = 250/40g cassava starch/soya bean flour; 250/50g cassava starch/soya bean flour). Seven sensory attribute namely; appearance, colour, taste, gumminess, flavour, mouth feel and overall acceptability of biscuit samples were evaluated.

From the results, it can be concluded that soy flour substitution mostly up to 40g significantly affect the sensory characteristics and overall acceptability of biscuits.

Increased substitution level of soy flour above 40g correspondingly affect the sensory characteristics in terms of texture taste and aroma.

Generally, index to volume (Mean) scores were higher in a 40g substitution level if soy flour is recommended for acceptable sensory attributes in biscuits made from cassava starch-soy flour blends.

5.2 Conclusion

From the results, it can be concluded that soy flour substitution mostly up to 40g significantly affect the sensory characteristics and overall acceptability of biscuits made from cassava starch-soya beans flour blends.

While cassava-starch and coconut juice/oil provide consumers of the popular "Ayigbe biscuit" with high level and quality carbohydrate and saturated oil, the fortification seamed to make the product more nutritionally balanced with the introduction of the soya flour.

Generally, index to volume (Mean) scores were higher in a 40g substitution level, as recommended for acceptable sensory attributes in biscuits made from composite flour.

Although the proximate composition of the composite biscuit were slightly different from that of control sample, it has been found that biscuits baked with 30g composite starch/flour was not so significantly different in most sensory attributes, and acceptability from the control. Biscuits baked from 50g soy flour showed low mean scores to most of the attributes. There was a tendency for biscuits baked with 30 and 40g of soy flour composite to be rated higher than the control especially in aroma, colour, flavor, and general acceptability which will lead to consumers' preference to buy. These results showed that the 30g and 40g soy/cassava starch composite flour biscuit recipe could be a viable alternative to achieve the desired economic, food security and health and nutrition the consumers need.ch inclusion were rated higher in aroma, colour, flavour, general acceptability and preference than the control sample.

5.3 Recommendation

Drawing from the sensory evaluation results, I (the researcher) strongly recommend that; Bakers should fortify most of the cassava and wheat based products with soya flour or milk to improve their protein levels and their general acceptability. Composite flour shows good potential for use as a functional agent in bakery products, therefore the evaluation of the functionality of composite flour in test baking should be performed to ensure an increase in the use of composite flour made from many different raw materials in future to improve the nutritional components of baked products.

a) Employing technology in indigenous food crop blends

Technology must be employed in the development of such blends to lead to improved utilization of indigenous food crops apart from cassava and soya bean in countries such as Ghana, where the import of wheat flour is a necessity.

b) The need to adjust the ingredients and baking techniques

There is also the need to adjust the mixing ingredients and baking techniques in order to improve the composite bakery qualities. Much effort is needed to find the optimization of composite flour used for any bakery products by mixing different types of crop flours to maximize the composite bakery quality using the mixture response surface methodology.

c) The need to reduce starch content of cassava before use

Because of the functional properties of the starch which affects the pasting profile and since cassava flours exhibited an early gelatinization, high peak viscosity, large paste breakdown and low retro-gradation tendency compared to wheat flour it is recommended to reduce the starch content by dough-compressing and sun-drying.

5.4 Areas for Further Study

I strongly suggest that, all indigenous plants that produce flour be explored in composite bread and biscuit baking.

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APPENDICES

APPENDIX A

QUESTIONNAIRE

The purpose of the of the study was to develop a more fortified cassava starch biscuit with the introduction of a protein based ingredient in addition to the existing composition of the "Agbozume Biscuit". You are kindly requested to read through the items and respond to them as objectively as possible after tasting the samples. Please note that this exercise is purely for academic purpose. All information given will be treated as confidential as possible.

Please tick [√] the appropriate box

1. Gender
   a. Male [ ]
   b. Female [ ]
2. Please indicate your age group
   a. Below 21 [ ]
   b. 21-30 [ ]
   c. 31-40 [ ]
   d. 41-50 [ ]
   e. 51-60 [ ]
   f. 61+ [ ]
3. Please indicate your educational level
   a. No formal [ ]
   b. Basic [ ]

c. Secondary [ ]

d. Tertiary [ ]

SENSORY EVALUATION

4. **Please indicate your level of likeness for the following sensory characteristics;**

Tick the Appropriate box [√]

Scale of measurement Like Extremely (LE=9); Like Very Much (LVM=8); Like Moderately (LM=7); Like Slightly (LS=6); (Neither Like or Dislike (NLD=5); Dislike Slightly (DS=4); Dislike Moderately (DM=3); Dislike Very Much (DVM=2); Dislike Extremely (DE=1)

Product	**Sensory Analysis**	**LE**	**LVM**	**LM**	**LS**	**NLD**	**DS**	**DM**	**DVM**	**DE**
A		**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**
	Colour									
	Taste									
	Flavour									
	Gumminess									
	Mouth-feel									
	Overall acceptability									

Product	**Sensory Analysis**	**LE**	**LVM**	**LM**	**LS**	**NLD**	**DS**	**DM**	**DVM**	**DE**
B		9	8	7	6	5	4	3	2	**1**
	Colour									
	Taste									
	Flavour									
	Gumminess									
	Mouth-feel									
	Overall acceptability									

Product	**Sensory Analysis**	**LE**	**LVM**	**LM**	**LS**	**NLD**	**DS**	**DM**	**DVM**	**DE**
C		**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**	**1**
	Colour									
	Taste									
	Flavour									
	Gumminess									
	Mouth-feel									
	Overall acceptability									

Product	Sensory Analysis	LE	LVM	LM	LS	NLD	DS	DM	DVM	DE
D		9	8	7	6	5	4	3	2	1
	Colour									
	Taste									
	Flavour									
	Gumminess									
	Mouth-feel									
	Overall acceptability									

APPENDIX B

THE CASSAVA CROP AND PRODUCE

APPENDIX C

THE COCONUT PLANT AND ITS PRODUCE

APPENDIX D

THE SOYA BEAN

APPENDIX E

THE PICTURES OF THE CASSAVA STARCH BISCUIT DURING THE FORTIFICATION PROCESS

APPENDIX F

SAMPLE FINISHED PRODUCTS

CONTROL

PRODUCT A

PRODUCT B

PRODUCT C