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COLLEGE OF TECHNOLOGY EDUCATION KUMASI-CAMPUS

PROXIMATE AND CONSUMER ACCEPTABILITY OF BISCUIT PRODUCED FROM LOCAL RICE AND WHEAT FLOUR

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DECLARATION

STUDENT'S DECLARATION

I, Modesta Phoebe Danka do hereby declare that, this submission is my own work towards the award of a Masters of Technology education in catering and Hospitality and that no previous submission has been made here or elsewhere for the award of any other degree. However, all references made herein are fully and respectfully acknowledged in the text.

Signed………………………………….

Date……………………………………

SUPERVISOR'S DECLARATION

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

Supervisor's Name: Dr. Gilbert Owiah Sampson

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Date……………………………………

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ABSTRACT

The experiment was conducted to evaluate unpolished local rice flour as an alternative to wheat flour in composite biscuit manufacturing. Proximate composition, physicochemical and sensory characteristics of unpolished local rice and wheat flours were determined. The biscuits were prepared with the incorporation of unpolished local rice flour concentration with wheat flour. Five products, namely, products A, B, C, D and E containing unpolished local rice flour at levels of 0, 25, 50, 75 and 100% replacing equivalent amounts of wheat flour were formulated to assess the quality and acceptability of the biscuits. Prior to the study, samples of unpolished local rice flour were examined for the proximate composition. Carbohydrate, moisture and protein contents were significantly ($P < 0.05$) higher than ash, fat and crude fibre. The proximate composition of unpolished local rice was 11.67% moisture, 0.52% ash, 0.40% fat, 6.88%, 0.35% crude fibre and 80.18% carbohydrate. Statistical analysis of biscuits containing various amount of unpolished local rice flour (0, 25, 50, 75 and 100%) showed that the control biscuit (0% unpolished local rice flour) secured significantly ($P < 0.05$) higher score for all the sensory attributes such as colour, aroma, taste, after taste and overall acceptance. Apart from that, among biscuits added with unpolished local rice, the biscuit with 75% unpolished local rice flour had the highest score for colour, taste, after taste and next in overall acceptance to 100% unpolished local rice flour which was highly accepted by the panelists.

CHAPTER ONE

INTRODUCTION

1.0 Background of the study

Studies on the health impact of refined carbohydrates and of whole cereals are of great importance in the context of escalating obesity epidemic and related chronic diseases (Shobana *et al.,* 2011). Cereals such as rice and wheat are staple foods in developing countries (Khush, 2005; FAO, 2006) including Ghana. This has resulted in the world rice production growing from 468.5 million tons in the year 2010 to 482.7 metric tons in 2011, about 2.6% increase (FAO, 2012) with Ghana's rice production estimates ranging from 200,000 to 300,000 metric tons of paddy and roughly 120,000 to 130,000 metric tons of milled rice yearly (Dorman and Kula, 2009). Although rice has been a staple food for thousands of years (Toumilehto *et al.,* 2001), advancements in milling technologies to improve yield and shelf life have led to highly polished, starchy refined rice (Shobana *et al.*, 2011).

Diet is an important variable in the cause of type 2 diabetes, which has generated interest in dietary options like germinated brown rice for effective management of the disease among rice-consuming populations (Imam *et al.,* 2012). Improving the carbohydrate quality of diet by replacing the refined staple white rice with unpolished brown rice could have beneficial effects on reducing the risk for diabetes and related complications (Mohan *et al.,* 2013).

Unpolished cereals possess phytochemicals such as polyphenols, oryzanols, phytosterols, tocotrienols, tocopherols and carotenoids as well as vitamins and minerals that confer protection against cardiovascular diseases and cancer (Shobana *et al.,* 2011; Dinesh *et al.*, 2009) which is absent in polished cereals. Interestingly, refined rice is the staple food for majority of people in developing countries (Khush, 2005), where rise in the cause of type 2 diabetes has reached a crescendo (WHO, 2008). Due to rice's high glycemic index (Miller *et al*., 1992), prolonged consumption may lead to disorders such as obesity, glucose intolerance, type 2 diabetes and cardiovascular diseases (Barclay *et al*., 2008). The glycemic index of refined rice is higher than whole grain such as unpolished rice and legumes and is influenced by several factors, including the degree of processing, amylose content and cooking time (Shobana *et al.,* 2011). It is therefore, more important to encourage less consumption of refined rice in these regions by providing a better alternative that will reduce the risk of these diseases and thus promote health (Miller *et al*., 1992). Improving the quality of the cereal staples in the diet by substituting unpolished rice for polished or refined rice and by extension reducing the overall dietary glycemic load may offer substantial health benefits in the population who are at a greater risk for type 2 diabetes, heart diseases and other related problems (Mohan *et al*., 2013).

Unpolished rice or brown rice is the entire grain with only the inedible outer husk removed (Sayre *et al*., 1982). The outer coating of unpolished rice contains added minerals and protein and considered to have greater nutrition value than the refined or polished rice counterpart. It contains 8% protein and a good source of the amino acids: thiamine and niacin (Acheampong, 2011). Consumer demand is increasing for composite flour based bakery products like biscuits (Islam *et al*., 2012). Rice flour offers potential for new and traditional baked products. Rice bran contains 12-16% protein, thus improving the nutritional value, improves the amino acid lysine content of baked products and also contributes a blend pleasant flavour (Lynn, 1969). Also, certain inherent properties have been identified with unpolished rice such as providing the most suitable flours for traditional products or as substitute for wheat flour in breads and cakes (Juliana and Bechtel, 1985). There is high consumption of biscuit as snack for the worthy class as well as students. This regular snacking has contributed to an increase in obesity or diabetes among that age group. This is because of the use of polished or refined flour for the production of the biscuits (Foote *et al.,* 1996). It is therefore important to partially replace this refined flour with another grain cereal. Thus the need for composite flour

As a result of changing food habits, increasing population and urbanization, the consumption of processed baked products is gradually becoming popular. For climatic reasons many developing countries cannot grow wheat suitable for baked product manufacturing. On the other hand there is the encouragement of less consumption of refined rice which is the staple food for majority of people in developing countries due to its worsening health and nutritional benefits and other metabolic disorders. This suggests that rice consuming populations may derive nutritional and health benefits from unpolished rice more than refined or polished rice and can be used as a substitute for wheat flour or for the production of alternative wheat less biscuits.

1.1 Problem Statement

Consumer demand is increasing for composite flour based products like biscuits. As result of changing food habits, increasing population and urbanization, the consumption of leavened wheat baked products has risen dramatically in many developed and developing countries. For climatic reason many developing countries like Ghana cannot grow wheat suitable for baked products manufacturing. This has resulted in the country spending more on expensive foreign exchange to supply wheat thus, putting stress on the economy.

Majority of the cereals produced in Ghana go to waste due to poor patronage resulting from their under-utilization. In spite of the attributes or qualities of unpolished rice, its patronage by the local Ghanaians is on the low side even though it is available on the local market. This situation has resulted in high postharvest losses which serve as a disincentive to the local producers of unpolished rice.

There is therefore, the need to add value to the unpolished local rice to make it more attractive and also boost up patronage by transforming and using it in composite flour so that it can be used on multi-purpose basis other than solely boiled rice.

Also, polished rice which is the staple food for majority of people in the developed and developing countries, has negative impact on health impact due to its high glycemic index and the lack of bioactive compounds which may lead to disorders such as obesity, glucose intolerance, type 2 diabetes and cardiovascular diseases. The high bioactive content and low glycemic index of unpolished rice are needed for effective management of type 2 diabetes, obesity, glycaemia, metabolic disorders, cardiovascular and other related diseases among rice-consuming populations.

1.2 Justification of the study

First, it will promote the use of local foodstuffs in catering industry. The modern catering industry is dominated by the foreign dishes due the unattractive nature of our local foodstuffs. There is therefore, the need to research into and diversify the use of these local products in order to make them attractive to compete with their foreign counterparts in the catering industry.

Secondly, it is meant to create awareness of the use of unpolished local rice in pastry making. The use of unpolished local rice in pastry making is a bit uncommon and therefore people are not familiar with it. The success of this study will go a long way to inform caterers and the general public on the use of unpolished local rice in pastry making.

The study also, aims at adding value to Ghanaian made biscuits. Biscuits made from local Ghanaian products are of low value due to the unattractive nature of the local products. The study which aims at adding value to the local products by putting them into other uses will eventually affect the value of the biscuits made from them.

Again, the study will make the product attractive for export. The addition of value to the local product will make it more attractive for export to other countries. It will also create job opportunities for people in unpolished rice growing areas. The addition of value to the unpolished local rice by putting it into other uses will go a long way to boost up patronage thus, creating job opportunities for the people within the rice growing communities and even encourage other communities to go into rice production.

Moreover, the research will contribute to cutting down cost in preparing biscuits. Since the weather condition does not support the cultivation of wheat in Ghana, the country spends hard and expensive foreign exchange to supply wheat. This situation has increased the cost of wheat thus, increasing the cost of wheat products. However, replacing highly expensive wheat with less expensive unpolished local rice will help reduce the cost of preparing biscuits and other related products.

Finally, the study will make known the nutrient composition of unpolished local rice. Knowledge of the nutritional content of the product will add value and promote it use. It will also inform the caterer which products it can be substituted for by comparing their nutrient composition.

1.3 Main Objective

The main objective of the study is to evaluate the effects of preparing biscuits with the incorporation of unpolished local rice flour or brown rice flour into the various proportions of wheat flour on consumer acceptability of the biscuits.

1.3.1 Specific Objectives

The specific objectives are:

1. To assess the quality and acceptability of prepared biscuits.
2. To determine the nutrient composition of the unpolished local rice or brown rice.
3. To improve the effective way of using the unpolished local rice to boost up its patronage by the local people.
4. To determine the optimum inclusion level of brown rice for preparing biscuits.

CHAPTER TWO

LITERATURE REVIEW

2.1 Cereals

Cereals are cultivated grasses (Lean, 2006; Clarke and Herbert, 1992). According to Potter and Hotchkiss (1996) cereals are plants which yield edible grains such as wheat, rye, rice or corn. They are grown for their highly nutritious edible seeds known as grains (Clarke and Herbert, 1992). Of all the food commodities used in the diets of people in Ghana, cereals and grains form a greater part. Cereals are used in different forms throughout country and they form the staple food of most tribes (Adigbo and Madah, 2010). Cereal grains have remained relatively inexpensive because they thrive in so many different climates and soils (Clarke and Herbert, 1992). Civilized societies in all parts of the world depend upon cereals for nourishment because they produce the maximum yield of food from a given area ground (Lean, 2006). The ability to cultivate cereals crops was important since people change from a nomadic life to life in a community (Clarke and Herbert, 1992). The most important cereals according to Lean (2006) are wheat, maize, rice oats, rye and barley. The most frequently used cereal grains in Ghana include rice, maize, millet, sorghum, wheat and oats (Adigbo and Madah, 2010). Miaze, wheat, rice, barley, rye and oats have been staple foods since the beginning of civilization (Clarke and Herbert, 1992). Some form of cereal crops are produced in every area of the world (Lean, 2006). On worldwide basis, rice is probably the single most important human food, with wheat not far behind (Potter and Hotchkiss, 1996).

Wheat is the largest crop in temperate climates such as Northern Europe (Clarke and Herbert, 1992). In soil areas where wheat does not thrive, oats, barley and rye are often grown. In warmer areas, such as America, maize is an important crop and in most hot climates such as those in India and China, rice is the staple cereal (Clarke and Herbert, 1992). In recent years annual world production of wheat, rice and corn has about 560,530 and 470 million metric tons respectively (Potter and Hotchkiss, 1996).

Cereal grains provide the world with a majority of its food calories and about half of its protein. These grains are consumed directly or in modified forms as major items of diet such as flour, starch, oil, bran, sugar syrups and numerous additional ingredients used in the manufacture of other foods and are fed to livestock thereby converting into meet, milk and egg (Potter and Hotchkiss, 1996). In some developing countries are a major part of the food intake whilst in developed countries, they often about a quarter of the total energy, protein and iron in the average diet. They are also useful source of calcium, the B-vitamins and dietary fibre (Clarke and Herbert, 1992). All cereal grains contain a high proportion of carbohydrates, 70-80%, protein, 7-14%, fat, 2-7% and up to 12% water (Clarke and Herbert, 1992).

The grains have three distinct parts, the bran, the endosperm and the germ. The bran and the germ contain fats, fibre, E and B-vitamins and the endosperm also containing carbohydrates and proteins. During the hulling process, the bran and the germ may be removed leaving the white endosperm (Adigbo and Madah, 2010). They are usually milled, refined and processed in factories (Clarke and Herbert, 1992). The operations of milling generally remove much of the indigestible fibre and fat where they are to be consumed as human food (Potter and Hotchkiss, 1996). The grains contain about 10-14% moisture, 58-72% carbohydrate, 8-13% protein, 2-5%

fat and 2-11% indigestible fibre. They also contain about 300-350kcal per 100g of grain (Potter and Hotchkiss, 1996). A typical composition of cereal grains is shown in Table 2.1.

No other food commodity can be compared with cereal grains for their ease of transportation, storage, high food value and low cost (Adigbo and Madah, 2010; Clarke and Herbert, 1992). Cereal grains are versatile and can be used in the preparation of many dishes. When combined with legumes they provide all the essential amino acids (lysine, methionine, cystine, threonine and tryptophan) especially lysine, the first limiting amino acid of these cereals needed by the body (Adigbo and Madah, 2010; Potter and Hotchkiss, 1996).

In Ghana the dishes that can be made from cereals are as varied as number of ethnic groups because each ethnic group has a different way of using cereals. They can be used as breakfast cereals or as accompaniment to main dishes, for making snack foods (Adigbo and Madah, 2010). Various kinds of flour including wheat flour, corn flour and oatmeal are prepared from finely-ground cereal grains. At the beginning of the twentieth century, food technologists developed the processing of cereal grains into ready-to-eat breakfast cereal products. Corn flakes were the first breakfast cereal to be sold as convenient food. Now a large variety of breakfast cereals are produced from maize, rice wheat and oats (Clarke and Herbert, 1992).

Table 2.1: Typical Percentage Composition of Cereal Grains

Grain	Moisture	Carbohydrate Protein	Fat Fibre	Digestible	Kilo 100g)	calories(per
Corn	11	72 10	4	2	352	
Wheat	11	69 13	2	3		340
Oat	13	58 10				317
Sorghum	11	70 12	5	10		348
Barley	14	63 12	4	2		320
Rye	11	71 12	2	6		321
Rice	11	65 8	2	2		310
Buckwheat	10	54 11	2	9		318
			2	11		

Source: Potter and Hotchkiss (1996).

2.2 Wheat

Wheat is the largest cereal crop in temperate climates (Clarke and Herbert, 1992). It is by far the most important cereal in the United Kingdom (Lean, 2006). Today, the important countries growing and exporting wheat are the United States of America, Canada, Russia and Australia (Clarke and Herbert, 1992). Wheat has been cultivated since 6000 BC (Clacke and Herbert, 1992). It was first grown in the Middle East some 10,000 years ago, but in the course of the centuries its cultivation has spread and varieties of wheat suitable for cultivation in zones as climatically different as the tropics and North European areas bordering on the Artic Circle are known (Lean, 2006). It is also thought that cultivation began in Syria and Israel and spread with migrating people to both west and east (Clarke and Herbert, 1992)

Many different varieties of wheat are grown to suit different climates and soils (Clarke and Herbert, 1992). Potter and Hotchkiss (1996) classified wheat into two, hard and soft wheat. Hard wheat is higher in protein, yields stronger flour which forms a more elastic dough and better for bread making. In contrast, soft wheat is lower in protein, yields weaker flour hence weak doughs and is better for cake-making. Lean (2006) identified winter wheat and spring wheat as known varieties. Winter wheat such as English wheat contains less than 10% protein and gives weaker flour and dough that bakes into small, closed-textured loave. Spring wheat such as Canadian wheat is richer in protein (12 -14%), it is described as hard wheat because it has hard and brittle grain, produces strong flour from which strong elastic dough which produces bold, well-risen loaves and are very suitable for bread-making. He continued that English flour and other smaller weaker or soft flours are more suitable for the manufacture of cakes and biscuits and for household use. Clarke and Herbert (1992) also grouped wheat into spring wheat, grown in Canada Russia, has less starch and more protein (10 - 15%) and winter wheat, grown in middle climate, has more starch and less protein (7 -10%).

A grain of wheat is composed of the bran, the germ and the endosperm. Lean (2006) scored 15% of the whole grain for the bran, 20% for the germ and 65% for the endosperm. The contains high proportion of B - vitamins, about 50% of the mineral elements present in the grain and largely indigestible cellulose. The germ is rich in fats, proteins, vitamins B and E and iron. The scutellum contains about 60% of all thiamin present in the grain. The endosperm is mainly starch. Clarke and Herbert (1992) also gave the composition as 2%, 13% and 85% for the germ, bran and endosperm respectively. Finally, Adigbo and Madah (2010) gave the nutritive value of the wheat grain as 65 - 75% starch, 8 - 10% protein, 10 -14% water, 1 - 2% fat, 1.5 - 2.5% fibre and 0.4 - 10% ash.

Wheat is one of the most popular grains used in Ghana because it is used for making cakes, breads and biscuits (Adigbo and Madah, 2010). However, for climatic reason many developing countries including Ghana cannot grow wheat suitable for these baked products manufacturing (Islam *et al*., 2012).

2.3 Flour

Wheat is used mostly in making flour which can be used for making backed products like bread, cakes, pastries, biscuits, pudding, pasta, breakfast cereals and as an accompaniment for main dishes (Adigbo and Madah, 2010). According to Lean (2006) and Potter and Hotchkiss (1996) wheat grains are always reduced to flour by milling before eating. Archaeological evidence shows that flour was made in hand mills in the Neolithic era. In later times, windmills or water mills were used in which all the wheat grain was ground between two circular grooved stones to produce whole wheat flour which contained the germ, bran, scutellum and the endosperm. The modern milling process however, differs. It is carried out using steel rollers in place of the revolving flat stones and the germ, bran and scutellum removed so that the flour produced consists essentially of powdered endosperm (Lean, 2006). As the flour is progressively milled in a miller, it becomes whiter in colour, better in bread making quality but lower in vitamin and mineral content (Potter and Hotchkiss, 1996). Flour produces proteins and starch that make up the structure of the baked product. Glutenin and gliadinin are the two main types of protein found in flour. Wheat is used more often than other types of flour becase of its gluten content which gives it the elastic nature (Adigbo and Madah, 2010). Clarke and Herbert (1992) also mentioned stone milling as the two main types of milling processes.

Lean (2006) grouped flours into high and low-protein flour, agglomerated flour, self- rising flour and enzyme inactive flour. Clarke and Herbert (1992) also identified whole meal flour, brown flour (wheat meal), wheat germ flour, strong plain white flour, plain wheat flour, self-rising flour and starch reduced-flour as the types of flour. Adigbo and Madah (2010) also classified wheat into soft or pastry flour, hard bread flour and all-purpose flour.

2.3.1 Nutritive value of flours

The starch and protein composition of flour, no matter how fine it is ground in the milling process, depend on the variety and kind of wheat that was ground. Thus the protein- to- starch ratio of flour made from hard wheat will be greater than that of flour made from soft wheat (Potter and Hotchkiss, 1996). They continued that the kind of flour produced during conventional milling is largely dependent on the kind wheat available. Because vitamins and minerals are lost from wheat during milling of flour of low extraction rate, millers are required by law to add certain nutrients to all flours other than whole meal flour of 100% extraction rate. Sufficient iron, thiamin, niacin and purified chalk must be added to ensure that 100g of the will contain not less than 1.65mg of iron, 0.24mg of thiamin, 1.60mg of niacin and between 235 and 390mg of calcium carbonate (Lean, 2006). He continued that flour of any extraction rate may be produced provided that the above nutrients are present in the stated amounts.

Analysis of wheat and unpolished brown rice flours showed that they contained all the proximate components. In their study to determine the physicochemical and functional properties of unpolished brown rice and wheat flours and quality of composite biscuit made thereof, Islam *et al.* (2012) analyzed both wheat and unpolished brown rice flours for their proximate composition

(Table 2.2).They observed significant (P < 0.05) differences in moisture, ash, crude fibre, carbohydrate and protein contents of unpolished brown rice and refined wheat flour. Unpolished brown rice flour showed lower protein content (8.50%) and higher fat (2.80%), ash (1.77%), crude fibre (1.23%) and carbohydrate (77.31%) in comparison to refined wheat flour. Wheat flour on the other hand contained highest protein (12.58%) and moisture (12.98%) contents than unpolished brown rice flour. The fat (2.80%), ash (1.77%) and carbohydrate (77.31%) contents of unpolished rice flour were more or less similar to refined wheat flour contents but the crude fibre content was observed in higher value than refined wheat flour.

Table 2 2: Proximate composition of flours

Parameter	Brown rice flour	Refined wheat flour
Moisture (%)	9.6±0.12[b]	12.98±0.02[a]
Protein (%)	8.50±0.14[b]	12.58±0.01[a]
Fat (%)	2.80±0.03	1.80±0.04[a]
Ash (%)	1.77±0.04[a]	1.40±0.01[b]
Fibre (%)	1.23±0.05[a]	0.85±0.01[b]
Carbohydrates (%)	77.31	71.2

Source (Islam *et al.*,2012)

2.3.2 Uses of flours

According to Potters and Hotchkiss (1996) the use of wheat flour in the baking industry include the making of breads, sweet doughs, cakes, biscuits, doughnuts, crackers gravies soups, confections and alimentary pastries such sa macaroni, spaghetti and other forms of noodle and pasta. Clarke and Herbert (1992) also indicated that flour can be used in thickening liquids and for baking.

2.3.3 Functional properties of flours

The functional properties of flours play important role in the manufacturing of bakery products (Islam *et al*., 2012). Elmoneim *et al*. (2010) measured the functional properties and amylase activity of germinated unpolished brown rice flour and recorded higher water absorption, oil absorption and bulk density for the germinated flour samples than those from the ungerminated flours. In addition germination significantly changed the pasting properties of rice flour and increased the amylose activity. Rodel *et al. (*2010) reported higher water absorption index, water solubility index and swelling power in sprouted black rice and unpolished brown rice they evaluated the potential of sprouted unpolished brown rice for the production of functional beverages. They also reported that the acceptability of the rice beverages was comparable to one another. Islam *et al.* (2012) analyzed unpolished brown rice flour and wheat flour for their functional properties. The water absorption capacity of unpolished brown rice flour was significantly ($P < 0.05$) lower than that of wheat flour. The oil absorption capacity of unpolished brown rice was significantly higher than that of refined wheat flour ($P < 0.05$). The swelling capacities of unpolished brown rice flour and refined wheat flour were 16.04 and 16.98ml respectively. The foaming capacity of unpolished rice flour was higher than that of refined wheat flour. The bulk density of unpolished rice flour was significantly higher ($P < 0.05$) than that of refined wheat flour. The unpolished rice flour higher least gelation concentration than refined wheat flour. According to Sathe *et al.* (1982) variation in gelling properties of flours may be attributed to the relative ratio of proteins, carbohydrates and lipids that made up the flours and the interaction between such components.

2.4 History of rice

As far back as 2500 B.C, rice has been a source of food for people (Eijkman, 2010). Rice production originated in China and was spread to countries such as Sri Lanka and India (Eijkman, 2010). It is believed that rice was brought to West Asia and Greece in 300 B.C. by Alexander the Great's Armies (*htt;//www.livestrong.com.*). In 800 A.D., people in East Africa traded with people from India and Indonesia and were introduced to rice ((*htt; //www.livestrong.com.*). It is very difficult to say exactly how rice was brought over to North America. One story says that a damaged ship was forced to dock in the Corolinas. In return for repairs, the captain of the ship gave the colonizers a bag of rice. In addition, it is believed that slaves from Africa brought rice from their land. In 1700, 300 tonnes of American rice was shipped to England. After the civil war, rice was produced all over the south. In United States, rice is mainly grown in California, Mississippi, Texas, Arkansas and Louisiana. According to Rost (1997) rice was brought to Brazil from Portugal and from Spain to Central and South America. Rice could be taken to many parts of the world due to its verstility (Adigbo and Madah, 2010, Rost, 1997). Clarke and Herbert (1992) noted that 90% of the world's rice is grown and consumed in Asia. They continued that British imports rice from U.S.A., Italy, China and Australia either as raw grain requiring milling or in various forms as a finished product.

2.4.1 Varieties of rice

Rice can be grown in a multitude of conditions. It can be grown in desert lands as well as wetlands. Today, rice is grown in four different ecosystems: irrigated, rain fed lowland, upland and flood-prone (*http;//www.livestrong.com.;*Eijkman, 2010). Eijkman (2010) categorized rice into four worldwide as indica, japonica, aromatic and glutinous rice. He also grouped into varieties as African, Australia, Bangladesh Chinese, Bangladeshi Butanese, United States, Sri Lankan, Spanishish, Thai, Dominican etc varieties. In all there are about 2000 varieties of rice; these are generally divided into two categories: long grain and short grain (Foote *et al.,* 1996). Cultivated rice can be dived into two separate species: *Oryza* sativa and *Oryza* glaberrima . *Oryza sativa* is grown in Asia while *Oryza glaberrima* is grown in Africa. Acheampong (2011) gave varieties of rice grown as long, medium, short, and aromatic and basmati grains.

2.4.2 Types of rice

There are four main types of rice. They include long grain brown rice, short grain and wild rice (Foote *et al.,* 1996). Clarke and Herbert (1992) identified brown rice, long grain rice, easy-cooked or parboiled rice, pre-cooked or instant rice, boil-in-the bag rice, short or round-grain rice, ground rice and flaked rice the types of rice.

2.4.3 Polished white

White or polished rice is the name given to milled rice that has its husk, bran and germ removed (Eijkman, 2010). It is the staple food for majority of people in developing countries of Asia and Africa (Khush, 2005). Advancements in milling technologies to improve yield and shelf life have led to this highly polished, starchy white rice (Achaya, 2009). The milling process removes the outer layers, leaving whole white grains (Clarke and Herbert, 1992). This alters the flavor, texture and appearance of the rice and helps prevent spoilage and extends its storage life. The milling and polishing processes both remove important nutrients (Eijkman, 2010). A study by Radhikan *et al.* (2010) showed that cereal grains, including polished white rice, are staple foods in India and contribute to nearly half of the daily caloric intake. Because of polishing, the outer bran and germ layers of white rice have been removed, resulting in the loss of many vital nutrients and phytonutrients, including fibre, which is found in the bran. Thus, polished rice is left with the starchy endosperm composed of mostly easily digestible carbohydrates. According to Lean (2006) polished rice contains about 85% starch and 7% protein. In the view of Carke and Herbert (1992) about half the B-vitamins, the dietary fibre and some proteins are lost in the milling process. A recent study by Shobana *et al.*(2011) indicated that polishing of brown rice proportionately decreased its protein, fat, dietary fibre, vitamins, *y*-orizyanol, polyphenols and oxidant activity and increased the available carbohydrate content. According to Eijkman (2010) a diet based on enriched white refined rice leaves people vulnerable to the neurological disease beriberi due to a deficiency of thiamin (vitamin B1). In supporting this statement Clarke and Herbert (1992) stated that where refined white rice is the staple food in the developing countries nutritional problems such as beriberi are found due to a deficiency of the B-vitamin, thiamin in the diet. White or refined rice lacks phytochemicals such as polyphenols, oryzanol, phytosterols, tocotrienols, tocopherols and carotenoids as well as vitamins and minerals that confer protection against heart disease and cancer (Criello, 2005; Hodge *et al.,* 2004). In the opinion of Hu *et al.* (2012) it is likely that refined white rice may play some role in the growing incidence and prevalence of type 2 diabetes. The glycemic index value of refined rice varies and are influenced by several factors including the degree of processing the amylose content and cooking time (Miller *et al.,* 1992). However, in the estimation of Panlasigui (2006) the glycemic index value of refined rice varieties is higher than unpolished rice and legumes. Due to its high to glycemic index, prolong consumption may lead to disorders like obesity, glucose intolerance and cardiovascular disease (Barclay *et al.*, 2008). Limited option may be the reason why refined rice has a wide patronage around the world. So it is important to encourage less consumption of refined rice by providing a better alternative that will reduce the risk of the disease and promote health (Panlasigui, 2006). As an antidote to the low nutrient content and consequently encouragement of its less consumption, Eijkman (2010) has suggested the enrichment of refined white rice with vitamin B1 and B2 and iron that were lost during its processing. The nutrient composition of rice kernel in Table 2.4.

Table 2.3: Composition of rice kernel

Nutrient	Composition (%)
Carbohydrate	80
Protein	6.8 -8
Fat	2
Moisture	11
Ash	0.5
Fibre	0.2

(Adigbo and Madah, 2010)

2.4.4 Unpolished rice

Unpolished rice or brown rice is whole grain with only the outer husk removed (Clarke and Herbert, 1992; Islam *et al.,* 2012). It can be any rice which has the outer covering removed but retains its bran, making the grain look brown (Foote *et al.,* 1996). Unpolished rice has a mild, nutty flavour, chewier and more nutritious than refined white rice, but goes rancid more quickly because the bran ant the germ contain fats that can spoil (WHFoods, 2012;). It can take longer time to cook than refined rice and is generally used for savoury recipes (Footes *et al.*, 1996). Clarke and Herbert (1992) also agreed that unpolished rice has nutty flavour and requires longer cooking than refined rice. With the advent of health eating practices in the 1990's, unpolished rice is now quite popular with chefs and the retail markets (Foote *et al.*, 1996). Any rice, including long grain, short-grain or glutinous rice may be eaten as unpolished brown rice (Sohn, 2014).

2.4.5 Nutritional value of unpolished rice

Unpolished brown rice is a natural wholesome food rich in essential minerals such as manganese, iron, zinc, phosphorus, calcium, selenium, magnesium and potassium (Moogngarm and Saetung, 2010). At various times, starting in the 19th century, unpolished rice has been advocated as healthier alternative. The bran contains significant dietary fibre and the germ contains many vitamins and minerals (Eijkman, 2010). Vitamins wealth of unpolished rice include vitamin B1 (thiamin), vitamin B2 (riboflavin), vitamin B3 (niacin), vitamin B6, folate, vitamin E (alpha-tocopherol) and vitamin K. It is a source of protein and adds good amount of fibre content to our diet. Along with this, unpolished rice is also a provider of supportive vital fatty acids (Ramiccio, 2012). Although widely believed to be superior nutritionally to refined white rice, the nutritive value of unpolished brown rice has recently been challenged deu to concerns over arsenic levels (Ware, 2015; Yandell, 2014).

2.4.6 Health benefits of unpolished rice

Whole grains are important part of any diet and have often been labeled the healthiest grains that anybody can eat. One of those whole grains is unpolished brown rice, which is rice that is natural and unrefined. Many people choose to eat unpolished brown rice instead of refined white rice because of its health benefits (Ramiccio, 2012).

Before refined white rice went through the refining process, it at one time looked exactly like unpolished brown rice. Brown rice, unlike refined white rice, still has the side hull and bran, which renders quicker cooking times and makes it easier to digest as it's much "lighter" in the in the stomach. The side hulls and brans provide "natural wholeness" to the grain and are rich in proteins, thiamine, calcium, magnesium, fiber, and potassium. For those trying to lose weight or those suffering from diabetes, brown rice can prove a healthful staple given its low glycemic rating which helps reduce insulin spikes (Kennedy, 2014).

Unfortunately, all white rice packaging has a label that reads "enriched." Since white rice has been stripped of iron, vitamins, zinc, magnesium and other nutrients during the refining process, manufacturers must add unnatural fortifications in the form of synthetic vitamins and iron so it can be marketed to the public as a "nutritious food." Although white rice is fortified, it still doesn't reach the minimum nutritional requirements for one serving of food as specified by the FDA.

Unpolished brown rice is rich in selenium which reduces the risk for developing common illnesses such as cancer, heart disease and arthritis. One cup of brown rice provides 80% of our daily manganese requirements. Manganese helps the body synthesize fats. Manganese also benefits our nervous and reproductive systems. Unpolished rice is rich in naturally-occurring oils which are beneficial for the body as these healthful fats help normalize cholesterol levels.

Unpolished rice promotes weight loss. The fiber content of unpolished brown rice keeps bowel function at its peak since it makes digestion that much easier. Brown rice is the perfect addition to the daily diet for that seeking bowel regularity. In addition, brown rice also makes the tummy feel full which translates to smaller meal portions.

Brown rice is considered a whole grain since it hasn't lost its "wholeness" through the refinement process. Whole grains are proven to reduce the buildup of arterial plaque and reduce the risk of heart disease and high cholesterol.

Unpolished rice is rich in anti-oxidants. This is one of the best kept secrets regarding unpolished brown rice. Anti-oxidant rich foods are usually associated with blueberries, strawberries and other fruits and vegetables. The antioxidant capacity of brown rice is right up there with these super stars.

Unpolished brown rice is high in fiber and on top of the list for foods that can help prevent colon cancer. This can be attributed to the high levels of fiber naturally contained in brown rice. These fibers attach to substances that cause cancer as well as to toxins in the body, thus eliminating them and keeping them from attaching to the colon wall.

Unpolished brown rice helps stabilize blood sugar levels; therefore, it's an excellent food choice for those suffering from diabetes. Studies show that those who consume one half cup of brown rice daily reduce their risks of developing diabetes by 60%. On the other hand, those who consume white rice regularly increase their chances of developing diabetes one hundred-fold.
Unpolished brown rice cereal or unpolished brown rice itself is the perfect baby's first food due to the dense natural nutrition and fiber it contains. This is a much better choice than refined white

rice cereal products as rapidly growing babies and toddlers require nutrient rich diets to help maintain rapid growth cycles.

Unpolished brown rice is the perfect adjunct for candida yeast infection treatments given that high glycemic and otherwise sugary or starchy foods are prohibited during most candida treatment protocols. The natural digestibility of brown rice coupled with the high fiber content can help sensitive digestive systems heal from an overgrowth of candida organisms.

Finally, unpolished brown rice is simply delicious and a fantastic staple for both vegetarian and vegan diets. Unpolished brown rice can be used as a white rice alternative in most vegetarian recipes and provides a full, rich and somewhat nutty flavor. Unpolished brown rice flour can be used for vegetarian pancakes, breads and other baked goods. All in all, brown rice is clearly the $healthy choice (Kennedy, 2014; Ramiccio, 2012)).

2.5 Biscuits

Fortification of Biscuits

Biscuits can hardly be regarded as a healthy snack because they usually contain high levels of rapidly digested carbohydrate, high fat, generally low levels of fiber and only modest amounts of protein (Klunklin & Savage 2018). Several studies have used blended flours or composite flours to produce biscuits. There have also been a number of attempts to improve their nutritional characteristics by partially replacing the wheat flour with non-wheat ingredients in the production of biscuits. Replacing wheat flour with different types of flour mostly affects their nutritional values and physical characteristics, such as hardness and spread ratio as well as color parameters, which can be observed. According to Klunklin and Savage (2018) brown rice flour has been used to improve the nutritive values of biscuits together and increase the overall acceptability of the fortified biscuit. In consideration of the development of a new product, it is important to use locally sourced ingredients, as the tastes would then be appreciated by the ethnic groups the products were intended for. They argued that texture, flavor and appearance of biscuits are major attributes that affect biscuit acceptability. Moreover, many studies have investigated the properties of gluten-free biscuits using different types of rice flours, such as white rice flour with buckwheat flour, waxy rice flour, brown rice flour and a composite rice flour, together with green gram flour and potato flour, or broken rice mixed with cocoyam flour (Caleja, et al., 2017 and Chauhan, et. al., 2015).

Unfortunately, rice protein cannot generate a viscoelastic network like gluten in wheat, which retains carbon dioxide during biscuit dough fermentation (Chauhan, et. al., 2015). Therefore, the addition of rice to a biscuit mix can have a significant effect on the textural qualities of the cooked biscuit. Recently, products with high protein and fiber contents are more commonly chosen by consumers to reduce the risk of diabetes and obesity. The protein enrichment of biscuits can be achieved by adding different kinds of ingredients, such as Nile tilapia fish bones, soya protein, and defatted green-lipped mussel powder. The development of a high protein containing biscuit is a worthwhile challenge when the overall nutritional status of underprivileged sections of the population is considered. Dietary fiber in the bran and germ of cereal grains has been added to biscuit formulations that originally contained almost no dietary fiber in the original recipe (Chauhan, et. al., 2015). Substitution of purple rice flour for wheat flour will not only increase the dietary fiber and bioactive contents, but it is also a cheaper raw material. Consumers are always concerned about the fat content of biscuits. In recent years, an enormous amount of research work has been carried out to study the possibility of adding healthy fats to biscuits without changing the flavor and texture of the final products. Fat and sugar replacement using dietary fiber, such as inulin, β-glucan, potato fiber, mango peel, rice bran, wheat bran, arabinoxylan and complex oligosaccharides, have been added to increase the nutritional quality of biscuits (Agu and Okoli 2014). Garden cress seed oil has been used to enrich the linolenic acid content of biscuits. It was added to produce fatty acid-rich biscuits in order to increase antioxidant properties of the product. Grape marc extracts have been added to biscuits and this has increased their antioxidant activity and phenolic contents compared to control biscuits made using wheat flour. The overall flavor and cross-sectional structure and appearances of the biscuits were improved by these additions. According to Protonotariou et. al., (2016) since biscuits are easy to consume as a snack or dessert with long shelf life when efficiently packed, many food manufacturers are interested in developing new and nutritional biscuits. Commercial bakery products generally contain high levels of carbohydrates and fats with small amounts of protein and fiber.

Composite flour biscuit is the most widely used baked product items in urban and sub-urban areas (Adigbo and Madah, 2010). Biscuits are made from flour with the addition of other ingredients such as salts, fat, sugar and flavouring agents (Lean, 2006). Baking powder is sometimes added to make them rise a little and some biscuits such as cream crackers are leavened with yeast in much the same way as bread (Lean, 2006). Biscuits are made using the same method used for cakes, that is, rubbing in, creaming, melted fats and sponge methods (Adigbo and Madah, 2010). The dough is rolled to a thin sheet and cut into appropriate shapes (Lean, 2006). Liquids such as watery milk, fruit juice and eggs may or may not be added. Only sufficient liquid is used to bind the dry ingredients so that the dough could be moulded or rolled (Adigbo and Madah, 2006). The dough should be slightly kneaded to get it smooth and even (Adigbo and Madah, 2010). The rolled and cut dough is quickly baked at a high temperature (Lean, 2006). Biscuits with fat content can be baked on greased or lined tins. Very moderate heat should be used to allow moisture to be driven off slowly from the biscuit. Biscuits should be cooked half-way up the oven and allowed to cool on the baking tray. They should be stored in airtight containers because they absorb moisture from the atmosphere and become flat easily (Adigbo and Madah, 2010). Biscuits are classified on the basis of their method of mixing and moulding. Rubbed - in, creamed, sponged or fatless and melted fat biscuits are the types of mixing methods. The methods of moulding biscuits include drop, pressed and piped, moulded, refrigerator, bar and rolled biscuits (Adigbo and Madah, 2010).

2.5.1 Ingredients and basic recipe for biscuits

Adigbo and Madah (2010) outlined the following steps as the basic rules when they used flour, pinch salt, margarine and sugar as ingredients in making short bread biscuits.

1. Sift flour and salt;
2. Rub margarine into flour;
3. Combine all ingredients into a smooth paste and knead;
4. Roll carefully on a floured table to a round shape;
5. Place on a slightly greased baking sheet pricked with a fork and mark into a desired shape;
6. Bake at 180 – 200^{o}C for 15 – 20 minutes.

2.5.2 Nutritive value of biscuits

According to Lean (Lean, 2006) the energy value of sweet biscuits may be twice as high as that of bread because of their low water content, extra sugar and fat contents. The water content of biscuits is only about 3% compared with about 39% in bread. The proximate composition of biscuits as analyzed by Islam *et al.* (2012) is shown in Table 6. They recorded higher ash, fat and crude fibre contents of unpolished brown rice flour biscuits than the control biscuits. They however, recorded low or decreased moisture, protein and carbohydrate contents of the unpolished brown rice. Rosniyana *et al.* (2011) reported that high dietary fibre and mineral content of unpolished brown rice flour may be responsible for the increase in ash content of the biscuits. The decrease in moisture content was due to the decrease in protein content (Islam *et al.* 2012).

2.5.3 Biscuit Production

The four main processes to make biscuits are mixing, cutting, baking and packing. Biscuit production needs precise preparation to make a successful product (Okpalan & Egwu, 2015). Biscuit production needs precise preparation to make a successful product (Uchenna & Omolayo, 2017).The ingredients are mixed to form a dough using mixers that are either operated manually or using a pre-set mixing program (Whitely, 1971). As the dough is mixed, the protein molecules form long strands of gluten resulting in an elastic web, which, essentially, controls the quality of wheat flour-based products. Once the dough is mixed, it is then made into different shape and sizes. This process leads to an increase in the stress on the gluten structure.

Baking is a very important process to achieve good quality biscuits. This process transforms the physical and chemical characteristics of the dough when baked in an oven, where the temperature and time will be accurately controlled. The oven temperature affects the moisture loss during baking, which plays an important role in achieving a good texture and the structure of the biscuits (Khater & Bahnasawy, 2014). Since gluten needs a large amount of water to form and develop a gluten web as well as hydrate the starch granules. The structure of the biscuits is formed, and free water evaporated when gluten and starch have been sufficiently hydrated. The evaporation starts from the dough surface, achieving about a 2-5% moisture content in the final products. Baking also alters the color of the biscuit surface known as the browning process. There are three main browning processes: caramelization of sugars, dextrinization of starch and the Maillard reaction in reducing sugars and amino acids, associated with the biscuit production (Whitely, 1971). These processes occur when the biscuit surface is already dry and the temperature is high (above 100°C). Coloring of the biscuits takes place in the final stage of the baking process. Packaging is used as a barrier to protect the biscuits and prevent the deterioration following absorption of moisture from the air. Moreover, biscuits can be protected from cracking and being broken by choosing the right packaging materials. Selecting and handling the materials used to pack the biscuits are crucial for the life and qualities of the final products. Biscuit production changes in both the chemical and physical characteristics, which result in the structure, texture and color changes in the biscuits (Khater & Bahnasawy, 2014). Overall, the characteristics of high quality biscuits also depend on the type and proportions of the ingredients.

2.5.4 Fortification of Biscuits

Biscuits can hardly be regarded as a healthy snack because they usually contain high levels of rapidly digested carbohydrate, high fat, generally low levels of fiber and only modest amounts of protein. Several studies have used blended flours or composite flours to produce biscuits

(Oladale & Aina, 2007; Khouryieha & Aramouni, 2012; Okpala, Okoli, & Udensi, 2013; Chauhan, Saxena, & Singh, 2015; Okpalan & Egwu, 2015; Park et al., 2015; Akesowan, 2016; Mir, Bosco, Shah, Santhalakshmy, & Mir, 2017; Raihan & Saini, 2017; Uchenna & Omolayo, 2017; Adeola & Ohizua, 2018; Gbenga-Fabusiwa, Oladele, Oboh, Adefegha, & Oshodi, 2018).. There have also been a number of attempts to improve their nutritional characteristics by partially replacing the wheat flour with non-wheat ingredients in the production of biscuits. Replacing wheat flour with different types of flour mostly affects their nutritional values and physical characteristics, such as hardness and spread ratio as well as color parameters, which can be observed in Table 1. Brown rice flour has been used to improve the nutritive values of biscuits together and increase the overall acceptability of the fortified biscuit. In consideration of the development of a new product, it is important to use locally sourced ingredients, as the tastes would then be appreciated by the ethnic groups the products were intended for (Khater & Bahnasawy, 2014).

The texture, flavor and appearance of biscuits are major attributes that affect biscuit acceptability. Moreover, many studies have investigated the properties of gluten-free biscuits using different types of rice flours, such as white rice flour with buckwheat flour, waxy rice flour, brown rice flour and a composite rice flour, together with green gram flour and potato flour, or broken rice mixed with cocoyam flour (More, Ghodke, & Chavan, 2013). Unfortunately, rice protein cannot generate a viscoelastic network like gluten in wheat, which retains carbon dioxide during biscuit dough fermentation. Therefore, the addition of rice to a biscuit mix can have a significant effect on the textural qualities of the cooked biscuit. Recently, products with high protein and fiber contents are more commonly chosen by consumers to reduce the risk of diabetes and obesity. The protein enrichment of biscuits can be achieved by adding different kinds of ingredients, such as Nile tilapia fish bones, soya protein, and defatted green-lipped mussel powder. The development of a high protein containing biscuit is a worthwhile challenge when the overall nutritional status of underprivileged sections of the population is considered (More, Ghodke, & Chavan, 2013). Dietary fiber in the bran and germ of cereal grains has been added to biscuit formulations that originally contained almost no dietary fiber in the original recipe. Substitution of purple rice flour for wheat flour will not only increase the dietary fiber and bioactive contents, but it is also a cheaper raw material. Consumers are always concerned about the fat content of biscuits. In recent years, an enormous amount of research work has been carried out to study the possibility of adding healthy fats to biscuits without changing the flavor and texture of the final products.

Fat and sugar replacement using dietary fiber, such as inulin, β-glucan, potato fiber, mango peel, rice bran, wheat bran, arabinoxylan and complex oligosaccharides, have been added to increase the nutritional quality of biscuits (Giuberti, Marti, Fortunati, & Gallo, 2017). Garden cress seed oil has been used to enrich the α-linolenic acid content of biscuits. It was added to produce ω-3 fatty acid-rich biscuits in order to increase antioxidant properties of the product. Grape marc extracts have been added to biscuits and this has increased their antioxidant activity and phenolic contents compared to control biscuits made using wheat flour. The overall flavor and cross-sectional structure and appearances of the biscuits were improved by these additions. Since biscuits are easy to consume as a snack or dessert with long shelf life when efficiently packed, many food manufacturers are interested in developing new and nutritional biscuits (Okpalan & Egwu, 2015). Commercial bakery products generally contain high levels of carbohydrates and fats with small amounts of protein and fiber. Modifying the composition of biscuits is a way to increase the nutritional value of the product, such as by adding rice to increase protein and fiber content of final product.

2.5.3 Sensory characteristics of biscuits

In countries where food is abundant, people choose foods based on the number of factors which is sum up as 'quality'. Quality is defined as the degree of excellence and includes things such as taste, appearance and nutritional content which have significance and make for acceptance (Pottrer and Hotchkiss, 1996). Appearance factors include size, shape, wholeness, and different forms of damage, gloss, transparency, colour and consistency. Texture includes hand feel and mouth feel of firmness, softness, juiciness, chewiness and grittiness. The texture of food is often a major determinant of how little or well the food is liked. Flavour factors include both sensations perceived by the tongue which include sweet, salty, sour, bitter and aroma perceived be the nose. Food colour not only helps to determine quality, it tells many things. It is an index of ripeness or spoilage. Bor *et al.* (1991) reported that the rice bran present in unpolished brown rice powder has light tan colour which has effect on the colour of the unpolished brown rice-incorporated product. According to Rosniyana *et al.* (2005) the rice bran present in unpolished brown rice powder has a sweet, slightly toasted, nutty flavor which may be the main factor affecting the taste of products. Also the presence of saponin in the rice bran found in unpolished brown rice is responsible for the bitter taste of the products. They continued that the amount of saponin in the products depends on the levels of unpolished brown rice in the formulation of the product. Ayo *et al.* (2007) reported that rice bran has a characteristic bland flavor that is neither bitter nor sweet. The flavor is described as insipid rancid, musty and sour due to its ready deterioration in commercial lots. Also, Bor (2003) noted that fresh rice bran is associated with volatile compounds and its odour is composed of alcohols and carbonyls, which could be a hindering factor in its use as an ingredient in human foods.

The sensory characteristics of biscuits prepared from unpolished brown rice flour and refined wheat flour were analysed by Islam *et al.* (2012). They observed significant differences ($P < 0.05$) in flavour, texture, overall acceptability between control biscuits and biscuits containing unpolished brown rice flour.They also observed that as the levels of unpolished brown rice flour in the formulation increased, the sensory scores for colour, texture, appearance and flavour of biscuits decreased. The colour and overall acceptability scores of control biscuits and biscuits with 10% unpolished brown rice flour was stastistically similar. The score of texture reduced at increasing concentration of unpolised brown rice flour. They attributed this to the cracks formed with the addition of gluten free unpolished brown rice. The score of flavour reduced significantly for both control and unpolised brown rice flour. According to Schober *et al.* (2003) the use of non-glutenous composite flours in cookie preparation reduces the textural strength of cookies where such strength is dependent upon approximate levels of gluten development. This is because in contrast to bread, the gluten network in cookies is to be only slightly cohesive without being too elastic. Alice and Rosli (2015) recorded a significantly ($P < 0.05$) higher score for the control product in all the sensory attributes such as appearance, colour, taste, overall acceptability and firmness. Bunde *et al.* (2010) also reported higher values for the control in all the sensory attributes except in colour where 20% soybean and 10% rice bran substitution of wheat showed a significant difference with the control (100% wheat).

CHAPTER THREE

MATERIALS AND METHOD

3.0 Materials

The ingredients used for the experiment were wheat flour, unpolished local rice or brown rice flour, margarine, sugar and eggs.

3.1 Sources of ingredients

The test ingredients were purchased from Kumasi Central Market.

3.2 Sample preparation

The dehusked unpolished local rice was sorted out, washed twice, sun dried for a minimum of two days, milled and left to cool. The milled unpolished local rice flour was oven dried to desirable moisture content, packed in a clean dry container with a tight fitting lid.

3.3 Product formulation

The biscuits were prepared with the incorporation of unpolished local rice flour concentration with wheat flour. Five (5) products namely, products A, B, C, D and E containing unpolished rice flour at levels of 0, 25, 50, 75 and 100% replacing equivalent amounts of wheat flour, were formulated. The percentage composition of the products is shown in Table 3.1. Apart from wheat flour and unpolished brown rice flour which were included at varying amounts for the five products, the other ingredients were included at the same levels for each of the products. The unpolished rice flour, wheat flour and other ingredients were weighed accurately into a basin. The fat was rubbed in until mixtures of fine bread crumbs were obtained. The sugar was then be mixed in. The egg was be beaten and added to bind the mixture to a stiff paste. It was then rolled out, cut into shapes and placed on a slightly greased baking sheet. It was baked in a moderate oven at 140ºC for 15 minutes, cooled to ambient temperature on racks.

Table 3.1: Percentage composition of formulated products.

Product Formulation					
Ingredients	A(Control)	B	C	D	E
Brown rice flour (g)	0	25	50	75	100
Wheat flour (g)	100	75	50	25	0
Sugar (g)	40	40	40	40	40
Margarine (g)	40	40	40	40	40
Egg	1	1	1	1	1
Salt (g)	0.25	0.25	0.25	0.25	0.25

A = 0% Brown rice (control); B = 25% Brown rice; C = 50% Brown rice; D = 75% Brown rice; E = 100% Brown rice.

3.4 Physicochemical properties on the flour and products

Protein, fat, moisture, ash and crude fibre will be determined by AOAC (2012) method. The carbohydrate content will be calculated by subtraction method.

The proximate composition of the flour and baked products were determined using AOAC (2012) method.

3.4.1 Determination of moisture content

Moisture content was determined by the method of A.O.A.C. No. 945.38 (A.O.A.C., 2005). Two grams of unpolished rice flour were weighed and transferred into a previously dried and weighed glass crucible and placed in a hot air oven to dry at 105 °C for 5 h. Samples were cooled in a desiccator, weighed, and returned to the oven to dry to constant weight. Loss in weight was calculated as percentage moisture (Appendix 1).

3.4.2 Determination of ash content

Ash content was determined by the method of A.O.A.C. No. 936.07 (A.O.A.C., 2005). In this method, 2.0 g of dried unpolished rice flour from 3.5.1.1 were transferred into a pre-ignited and pre-weighed porcelain crucible and combusted in a muffle furnace at 600 °C for 2 h. The crucibles containing ash were cooled and re-weighed. Loss in weight was calculated as percentage ash content (Appendix 2)

3.4.3 Determination of crude fat content

Crude fat determination followed the method of A.O.A.C. No. 2003.05 (A.O.A.C., 2005). Two grams of sample were transferred into a 22 × 80 mm paper thimble and capped with glass wool, dropped into a thimble holder and attached to a pre-weighed 500 ml round bottom flask containing 200 ml hexane and assembled on a semi-continuous soxhlet extractor. Contents of the thimble were refluxed for 16 h after which the hexane was recovered on a steam water bath. The flask containing the fat was heated for 30 minutes in an oven at 103 ºC, cooled in a desiccator and weighed. Increase in weight of flask was recorded from which the percentage crude fat was calculated (Appendix 3).

3.4.4 Determination of protein content

Protein content was measured following the Kjeldahl nitrogen determination of A.O.A.C. No.2001.11 (A.O.A.C., 2005). In this method, 2.0 g of dried unpolished rice flour in a Kjedahl flask was added to 25 ml concentrated (98 %) HS_2O_4 and digested till the colour of the solution turned clear. The solution was transferred into a 100 ml volumetric flask and the volume made up to the mark with distilled water. Ten milliliters of the solution were distilled and titrated against 0.1M hydrochloric acid against a blank. Titre values of duplicate samples were recorded and percentage nitrogen calculated (Appendix 4). Percentage nitrogen (% N) was converted to percent crude protein by multiplying by a factor of 6.25.

3.4.5 Determination of crude fibre content

Crude fibre was determined according to the procedure of A.O.A.C. 920.86 (A.O.A.C. 2005). To 2.0 g of defatted unpolished rice flour in a 750 ml Erlenmeyer flask was added to 200 ml of boiling 1.25% HS_2O_4 and refluxed for 45 min. The mixture was screened with cheese cloth and residue washed with large volumes of boiling water till filtrate was no longer acidic. The reflux was repeated with 1.25 % sodium hydroxide (NaOH), screened and washed to remove all alkali. The residue was transferred to a previously weighed porcelain crucible (M1), dried for 1h at 100°C, cooled in a desiccator and re-weighed (M2). The crucible was ignited in the muffle furnace at 600 °C for 30 min and re-weighed after cooling in a desiccator (M3). Increase in weight was calculated as percentage crude fibre (Appendix 5).

3.4.6 Determination of available carbohydrate content

Available carbohydrate content was calculated by difference [(100- total of M)] where M is moisture + crude fat + ash + crude fibre + crude protein (A.O.A.C. No. 986.25) (A.O.A.C., 2005). All proximate determinations were done in triplicate.

3.5 Functional properties of biscuits

Water and oil absorption capacities were determined by the method of Sosulski *et al. (*1986)

3.6 Sensory evaluation

Sensory evaluation was conducted by eighteen semi-trained panelists recruited from the Departments of Food Science and Technology and Department of Biochemistry and Biotechnology of Kwame Nkrumah University of Science and Technology, Kumasi. Panelists were introduced to the control biscuit and individual seven-point hedonic rating scale for five attributes, namely, colour, appearance, flavour (aroma), texture, taste and overall acceptability.

3.7 Statistical analysis

Data collected was subjected to analysis of variance (ANOVA) using the software, statistical package for social science (SPSS).

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Proximate composition of flours

The proximate composition of unpolished rice flour sample as analyzed is shown in Table 4.1.

Table 4. 1: Proximate composition of unpolished brown rice flour

Proximate Parameters	Mean	Standard Deviation
Moisture	11.67	0.05
Protein	6.88	0.05
Fat	0.4	0.03
Ash	0.52	0.03
Crude fibre	0.35	0.05
Carbohydrate	80.18	0.02

The carbohydrate, moisture and protein contents were significantly ($P < 0.05$) higher than ash, fat and crude fibre contents. This result agrees with Clarke and Herbert (1992) who stated that all cereal grains contain very high proportions of carbohydrates (70-80%), protein (7-14) and water (12%). Similarly, Islam *et al.* (2012) recorded a higher percentage composition of carbohydrate, protein and moisture than crude fibre, ash and fat when they analyzed unpolished rice flour samples. The protein, ash, crude fibre and fat contents were significantly lower than the typical percentage composition of cereal grains as indicated by Potter and Hotchkiss (1996) and also that of Islam *et al.* (2012). However, the carbohydrate and moisture contents were higher than those of Potter and Hotchkiss (1996) and Islam *et al.* (2012). A significant difference (P < 0.05) was also observed between the unpolished brown rice flour and wheat flour as analyzed by Islam *et al.* (2012). Apart from carbohydrate content (80.18%) which was significantly (P < 0.05) higher, unpolished brown rice flour showed lower protein (6.88%), moisture (11.67%), ash (0.52%), fat (0.4%) and crude fibre (0.35%) contents in comparison to refined wheat flour analyzed by Islam *et al.* (2012). The difference in the protein and carbohydrate contents of refined wheat and unpolished brown rice may be attributed to the variety and kind of wheat that was ground or used. According to Potter and Hotchkiss (1996), the starch and protein composition of flour depends on the variety of wheat that was ground and that the protein- to- starch ratio of flour made from hard wheat will be greater than that of flour made from soft wheat.

4.2 Sensory evaluation of biscuits

4.2.1 Colour

Colour generally refers to the appearance of the product. It is one of the sensory attributes consumers explore in purchasing new products due to its aesthetic appeal. The colour of the products produced from unpolished brown rice and wheat were evaluated and presented in Table 4. 2

Table 4.2 Descriptive statistics of colour of biscuits.

Product Formulation					
Statistics	**A**	**B**	**C**	**D**	**E**
Mean	1.35[a]	2.10[b]	1.80[b]	1.75[b]	2.00[b]
Std Dev.	0.59	1.25	0.77	0.79	1.03
Median	1.00	2.00	2.00	2.00	2.00
CV (%)	44	60	43	45	51
Min.	1	1	1	1	1
Max.	3	6	3	3	4

A = 0% Brown rice (control); B = 25% Brown rice; C = 50% Brown rice; D = 75% Brown rice; E = 100% Brown rice.

In the current study, panelists rated the colour of the various products between 1.35 and 2.00, with product A being rated as the best followed by D, C, E and B. From the hedonic Scale, product A was rated to be like extremely while the rest of the products were rated like very much. The product A was significantly ($P < 0.05$) different from the rest of the products (B, C, D, E). Similar to this finding, Alice and Rosli (2005) reported that the sensory score of *Kuih Talam Pandami (KTP)* added with 30-90% of unpolished brown rice powder received significantly ($P < 0.05$) lower score for colour compared to the control sample (0% unpolished rice). The results however, differed from Bunde *et al.* (2010) who reported no significant ($P < 0.05$) difference in colour the control (100% wheat flour) biscuits and 10-40% rice bran flour. From the table, product B recorded the worse score for colour and can be can be explained by the fact that there was no wheat flour in the formula. This is because wheat flour contributes to the development of desirable colour in baked products. The difference in colour may be attributed to the colour of the unpolished brown rice incorporated in the formula. Bor *et al.* (1991) reported that the rice bran present in the unpolished brown rice powder has light tan colour which can influence the colour of baked products.

4.2.2 Aroma

Aroma of a product is the sensation perceived by the nose (Potter and Hotchkiss, 1996). Most products are patronized by consumers due to their aroma. Table 4.3 shows the evaluated aroma of products produced from unpolished brown rice and wheat.

Table 4.3 Descriptive statistics of the aroma of biscuits.

Product Formulation					
Statistics	**A**	**B**	**C**	**D**	**E**
Mean	1.50^{a}	1.95^{b}	1.75^{ab}	1.95^{b}	2.00^{b}
Std Dev.	0.61	0.76	0.85	0.89	0.86
Median	1.00	2.00	2.00	2.00	2.00
CV(%)	41	39	49	46	43
Min.	1	1	1	1	1
Max.	3	3	4	4	3

A = 0% Brown rice (control); B = 25% Brown rice; C = 50% Brown rice; D = 75% Brown rice; E = 100% Brown rice.

The sensory evaluation for aroma at 5% level of significance of biscuit treatments ranged between 1.50 and 2.00. Product C (50% wheat, 50% unpolished brown rice) did not differ significantly in aroma with the control while all the other products showed significant difference with the control. Preference for aroma or odour of biscuits products decreased with increasing level of substitution of unpolished brown rice. Product A (Control) recorded the highest mean value with product E recording the lowest mean value. Product A thus received the highest rating followed by C, B, D and E respectively. The hedonic Scale indicated that product A was extremely liked, product C moderated liked with the other products like moderately. Product E had the lowest score because there was no wheat flour in the formula. This result may be associated with Bor (2003) who reported that fresh rice bran is associated with volatile compounds and its odour is composed of alcohols and carbonyls, which could be a hindering factor in its use as an ingredient in human foods. This result is similar to Bunde *et al*. (2010). It can be deduced that, even though product A was most preferred for aroma, product C (50% wheat and 50% unpolished brown rice) could be developed for use.

4.2.3 Taste

Taste is one of the sensory characteristics that refer to sensation perceived by the tongue which include sweet, salty, sour and bitter (Potter and Hotchkiss, 1996). The taste of the products produced from unpolished brown rice and wheat were evaluated and presented in Table 4.4. The score of the taste attribute of the control biscuit (0% unpolished brown rice) was significantly ($P < 0.05$) higher than biscuits containing unpolished brown rice flour. The taste of biscuits containing unpolished brown rice (products B, C, D and E) were significantly the same. According to Ayo *et al.* (2007) Rice bran has a characteristic bland flavor that is neither bitter nor sweet. The flavor is described as insipid rancid, musty and sour due to its ready deterioration in commercial lots. Rosniyana *et al.* (2005) reported that rice bran present in the unpolished brown rice flour had a sweet, slightly toasted, nutty flavour which may be the main contributing factor in affecting the taste of the biscuits. The recorded results may be associated with these reasons. The results also revealed that the panelists preferred the taste of the control (product A) followed by D, E, B and C respectively. From the hedonic scale, the taste of product A was rated extremely liked with the rest rated very much liked. The score of the taste attribute obtained in this study was similar to those of Alice and Rosli (2015) and Islam *et al.* (2012).

Table 4.4 Descriptive statistics of the taste of biscuits

Product Formulation					
Statistics	**A**	**B**	**C**	**D**	**E**
Mean	1.35[a]	2.20[b]	2.30[b]	1.85[b]	2.05[b]
Std Dev.	0.59	1.28	0.57	0.75	0.83
Median	1.00	2.00	2.00	2.00	2.00
CV(%)	44	58	25	40	40
Min.	1	1	1	1	1
Max.	3	6	4	3	4

A = 0% Brown rice (control); B = 25% Brown rice; C = 50% Brown rice; D = 75% Brown rice; E = 100% Brown rice.

4.2.4 After taste

After taste refers to the comments or remarks made by the panelists after tasting the products. In this study, the remarks made by the panelists after tasting the products were rated between 1.40 and 2.32 as presented in table 4.5.

Table 4.5 Descriptive statistics of the after taste of biscuits.

Product Formulation					
Statistics	**A**	**B**	**C**	**D**	**E**
Mean	1.40^{a}	2.20^{b}	2.32^{b}	1.95^{b}	2.10^{b}
Std Dev.	0.68	1.20	0.82	0.60	0.91
Median	1.00	2.00	2.00	2.00	2.00
CV (%)	49	54	35	31	43
Min.	1	1	1	1	1
Max.	3	6	4	3	4

A = 0% Brown rice (control); B = 25% Brown rice; C = 50% Brown rice; D = 75% Brown rice; E = 100% Brown rice.

From the table, product A was significantly ($P < 0.05$) different from the rest of the products. Product A recorded the highest mean mark and was rated as the best followed by D, E, B and C respectively. From the hedonic scale, product A was rated to be extremely liked and the rest of the products were rated very much liked. Products B, C, D and E were similar in after taste rating with product C (50% wheat flour and 50% unpolished brown rice flour) recording the worse score. This means that the panelists remarked that products B, C, D and E had bitter after taste. According to Bunde *et al.* (2010) the after taste bitterness remarks on samples of biscuits with higher levels of unpolished brown rice flour substitution were subjective to age, since adult panelists seemed to prefer these samples. The bitter after taste may be associated with the presence of saponin in the rice bran found in unpolished brown rice flour. Rosniyana *et al.* (2005) reported that bitter taste of unpolished brown rice is associated with saponin present in the rice bran found in unpolished brown rice powder and the amount of saponin in the products depends on the levels of the unpolished brown rice powder in the formulation of the product. This result is also similar to those of Alice and Rosli (2015) and Islam *et al.* (2012).

4.2.5 Overall acceptance

Consumers choose foods based on the quality which is the degree of excellence and include taste, appearance and nutritional content which have significance and make for acceptance (Potter and Hotchkiss, 1996). Table 4.5 shows the overall acceptance of biscuits.

Table 4.5 Descriptive statistics of overall acceptance of biscuits.

Product Formulation					
Statistics	**A**	**B**	**C**	**D**	**E**
Mean	1.45^{a}	1.95^{b}	1.90^{b}	1.85^{b}	1.75^{b}
Std Dev.	0.51	1.78	0.72	0.75	0.85
Median	1.00	2.00	2.00	2.00	2.00
CV (%)	35	40	38	40	49
Min.	1	1	1	1	1
Max.	2	3	3	3	3

A = 0% Brown rice (control); B = 25% Brown rice; C = 50% Brown rice; D = 75% Brown rice; E = 100% Brown rice

In the current study, panelists rated the overall acceptance of the various products between 1.45 and 1.95. The panelists preferred the control (0% unpolished brown rice) which had the highest score (1.45) for the overall acceptability of biscuits. Biscuit added with 25% unpolished rice was the least preferred product which had lowest score (1.95). Product A was significantly ($P < 0.05$) different from the rest of the products. From the hedonic scale, product A was rated to be liked extremely with the rest of the product rated to be very much liked. The acceptability scores for the current study support the statement made by Potter and Hotchkiss (1996) that consumers choose foods based on the quality which is the degree of excellence and include taste, appearance, texture, colour, odour and nutritional content which have significance and make for acceptance. This result is similar to Alice and Rosli (2015) and Islam *et al.* (2012). Increase in acceptability was observed as the level of substitution of unpolished brown rice increased. The trend was as follows product A was the highest followed by E (100% unpolished brown rice), D (75% unpolished brown rice), C (50% unpolished brown rice) and B (25% unpolished brown rice). Product A (100% wheat flour) was extremely accepted because of the gluten content of wheat flour. Adigbo and Madah (2010) reported that wheat flour is preferred or used more often than other types of flour because of its gluten content which gives it the elastic nature.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Conclusion based on major findings

The results of the study showed that unpolished local rice flour has high carbohydrate, protein and moisture contents comparable to wheat flour. The sensory evaluation showed that biscuit without the addition of unpolished brown rice flour was generally preferred for all the attributes. Apart from that, among biscuits added with unpolished local rice, the biscuit with 75% unpolished local rice flour had the highest score for colour, taste and after taste and next in overall acceptance to 100% unpolished local rice flour which was highly accepted by the panelists. The incorporation of increasing levels of unpolished local rice flour into the biscuit increased the overall acceptability of the biscuits. Generally, the addition of 75% and 100% unpolished local rice flour in biscuits could be recommended as the ideal level of preparing biscuits.

5.2 Recommendations based on conclusions

The analysis of the respondents indicated that the overall acceptability of the five products were encouraging. All the products of local are recommended to the general public. In view of this;

- The products should be tested and improved upon for export.
- Further studies should be conducted to confirm the actual level of substitution of unpolished local rice in biscuits production.
- Further studies should be conducted to determine the functional properties of biscuits such as water and oil.

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APPENDIX

Appendix 1: Calculation of moisture content

$$\% \text{ Moisture} = \frac{(\text{weight of wet sample} - \text{weight of dry sample}) \times 100\ \%}{\text{weight of wet sample}}$$

Appendix 2: Calculation of ash content

$$\% \text{ Ash} = \frac{(\text{weight of crucible and ash residue} - \text{weight of empty crucible}) \times 100\ \%}{\text{weight of sample}}$$

Appendix 3: Calculation of crude fat content

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$$\% \text{ Crude fat} = \frac{(\text{weight of flask and fat residue} - \text{weight of dry empty flask}) \times 100\ \%}{\text{weight of sample}}$$

Appendix 4: Calculation of total nitrogen content

$$\% \text{ Total nitrogen} = \frac{100\ (S_T - S_b) \times 0.1 \times 0.01401 \times 100\ \%}{\text{weight of sample} \times 10}$$

Appendix 5: Calculation of crude fibre content

$$\% \text{ Crude fibre} = \frac{(\text{weight of crucible and sample before ignition} - \text{weight of crucible and ash}) \times 100\ \%}{\text{weight of sample}}$$

APPENDIX – SAMPLE QUESTIONNAIRE

NAME……………………………………………………………………………………………

SEX………………………………..

You have been provided with unpolished brown rice biscuit, you are expected to make a fair assessment based on seven point's hedonic scale.

1 = Like extremely

2 = Like very much

3 = Like moderately

4 = neither like nor dislike

5 = Dislike moderately

6 = Dislike very much

7 = Dislike extremely

CODE COLOUR TASTE AROMA AFTER TASTE OVERALL ACCEPTANCE

A. CONTROL WHEAT (0) ……….. ……….. …………. ………………..

B. 100% (UNPOLISHED BROWN RICE) ……….. ………… ………… ………………. …………………

C. 50 + 50 %(WB) …………. ……….. ………… ……………….. …………………