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FACULTY OF AGRICULTURE
DEPARTMENT OF HORTICULTURE

DEVELOPMENT AND QUALITY ASSESSMENT OF NUTRIENT-RICH CEREAL-BASED PORRIDGE FLOUR IN THE NORTHERN REGION OF GHANA

BY
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APRIL, 2016

DEVELOPMENT AND QUALITY ASSESSMENT OF NUTRIENT-RICH CEREAL-BASED PORRIDGE FLOUR IN THE NORTHERN REGION OF GHANA

A THESIS SUBMITTED TO THE SCHOOL OF RESEARCH AND GRADUATE STUDIES, KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF PHILOSOPHY (MPHIL. POSTHARVEST TECHNOLOGY) DEGREE.

BY

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APRIL, 2016

DECLARATION

I, hereby, declare that this work submitted to the School of Graduate Studies, Kwame

Nkrumah University of Science and Technology Kumasi Ghana as a thesis for the Masters of Philosophy (Postharvest Technology) Degree is the result of my own original work and that this thesis has not been presented for any degree in this university or elsewhere, except for the literature references to other people's work, which I have duly acknowledged.

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DEDICATION

I dedicate this work to my dear mother, Madam Comfort Obuobi who singlehandedly, sacrificed her happiness to give me the best foundation in education.

AND TO

My sons, Kwame Brantuo and Kwame Yeboah and my loving husband, Rev. William Agyei Brantuo who has been my backbone throughout my tertiary education.

ACKNOWLEDGEMENT

Glory be to God Almighty for his protection, guidance, favour, directions and travelling mercies throughout this period.

I am indebted to my supervisor, Dr. Francis Appiah (Head of Horticulture Department of KNUST) and Mr. Kumah Patrick (Lecturer, KNUST) for their immense contribution towards this work in the form of guidance, useful criticisms and suggestions.

I cannot go without appreciating the support from Dr. Asamoah Larbi of IITA who financed the laboratory component of the work and Mr. E.K. Asiedu, Senior Lecturer at Soil Science encouragement and motivation which propelled me through all the stages of this program.

I am thankful to Mr. Ibrahim and Mr. Mr. Fuseini Kukurugu of IITA, Tamale for the role they played during the interaction and sensory trial stages at the communities where language barrier was a big challenge.

And to my friends and course mates, Jessica, Bashiru ,Hagar, Mr. Ewe, Esther and Rita Asante of WESCO Family Welfare and Mr. Tuffour of Afigya Kwabre DEO (C/S) who contributed in different ways to make this work successful, I say I am grateful. I am also thankful to Obeng Nana David and Damasus Yaghr, my former circuit members who were very helpful during the information gathering stage.

Finally, I want to acknowledge my family, especially my mother whose prayer, support and encouragement has been very helpful, my siblings, children and last but not the least, my husband whose attention, financial support and mentorship has helped me to realize my dream. I say God bless you all for all the support.

ABSTRACT

The research was in three phases, field survey, product development and sensory trial and laboratory analysis of treatment. All the phases took place between September 2014 and May, 2015. The main objective of the study was to enhance the protein profile of cereal-based porridge by using a legume as a fortifier .The field survey and sensory trial were done in purposely selected communities in the Northern region of Ghana (Duko and Tingoli) of the Suvelugu and Torlong districts. The laboratory analysis was conducted at the Horticulture Department of KNUST and Crop and Soil Research Institute-Kwadaso, Kumasi. In all, 120 care givers and farmers were purposely selected to respond to structured questionnaires to evaluate the bio-data, feeding patterns and to evaluate the sensory acceptability of the treatments. Ten treatments in the form of composite flour from two cereals (maize and millet) and a legume (soybean) at different levels of substitution of the conventional flour for legume flour were used. The treatments were A_1 (90% maize:10% soybean), A_2 (80% maize:20% soybean), A_3 (70% maize:30% soybean), A_4 (60% maize:40% soybean), A_5 (50% maize:50% soybean), B_1 (90% millet:10% soybean), B_2 (80% millet:20% soybean), B_3 (70% millet:30% soybean), B_4 (60% millet:40% soybean) and B_5 (50% millet:50% soybean). Sensory evaluation was done on the treatments in both communities. A_1 and B_1 were selected as the most preferred in terms of aroma, taste and colour with overall score of 1.71 and 1.39 respectively. The scoring was done on a scale of 1-7 with the least magnitude being the preferred treatment. A_1 (90% maize: 10% soybean) and B_1 (90% millet:10% soybean)were subjected to laboratory analysis and proximate composition, minerals composition and Total

Soluble Solids levels were evaluated. The results indicated that A_1 (90% maize: 10% soybean) was nutritionally better with statistically higher levels of Protein (15%),

Iron (0.11%) and Manganese (0.05%).

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CHAPTER ONE

1.0 INTRODUCTION

Improving the agricultural industry has been the primary concern of successive governments since agriculture is the mainstay for about 70% of the over twenty million Ghanaians. The industry provides employment, food for domestic consumption and export and raw materials for majority of our local industries. It forms an integral part of the economy as it accounts for almost half of the gross domestic product (GDP) and export earnings of the country.

Northern Ghana's contribution to the nation's food basket alone, according to GNA (2014), is about 80% which includes major crops like yam, maize, millet, sorghum, rice, groundnut, soybean, onions, tomatoes, cotton, tobacco and others. However, these numerous contributions by the region do not translate to better lives as about 40% of the rural people are vulnerable of becoming food insecure in the three northern regions of Ghana.

The problem may probably not be the quantity of food that is produced as various interventions and research works by government, research institutions and nongovernmental units are geared towards improving food production, especially, in the three Northern regions. The situation just emphasizes the statement made by Masset *et al.* (2011) that, agricultural intervention per se has little impact on child nutritional status.

Addition of value to food through processing to create variation and to supply the needed nutrition is paramount. Many of Ghana's staple foods lack some vital nutrients because they lack variation and foods such as maize, sorghum and millet can be enhanced by fortification to reduce the extent of deficiency diseases which may result from its consumption. This is why WHO and FAO (2006) identified food fortification as the second strategy to begin decreasing the incidence of the nutrient deficiencies at the global level. They also asserted that common foods that are fortified to improve their nutrients profile include cereals, cereal products and Infant formulas. Storecker *et al.* (2006) indicated that supplementation with legumes is one way of improving the protein quality of cereal diets which lacks some essential amino acids.

It is therefore clear that the easiest way of improving the protein intake among rural and poor communities is to resort to diverse but simple ways of incorporating the legumes which are perceived to be “poor man’s meat” into their daily meals. Legumes have a high nutrient component which can be substituted perfectly for meat, milk, fish and egg proteins (Pyke, 1968).

Report by SPORE (2014) on health indicated that, malnutrition in children in Rwanda reduced by 30% in less than 2 years through a village approach to educate mothers on how to prepare nutritious food by using food they produce on their own farms.
On this same issue, the International Institute of Tropical Agriculture (IITA, 2013) embarked on a project to ensure that the local cereals that are consumed widely by the rural poor farmers in the Northern regions are fortified with their legumes which are also common in those areas for general development.

1.1 PROBLEM STATEMENT

Despite the numerous work and interventions to increase food production in Ghana and especially in the three Northern regions, consumption of nutritious foods is still believed to be low as there is prevalence of acute malnutrition among children (stunting and wasting respectively) in the Northern and Upper regions.

Proportion of malnourished population has remained within 33 to 35 percent range in Sub-Saharan Africa (Mwaniki, 2005). This is probably due to the fact that many of the essential crops produced are not fully utilized in our daily meal preparations. For example, there is less utilization of legumes, vegetables and fruits as against the carbohydrate foods.

A joint report by FRI and IITA (2013) in selected communities in the three Northern Regions of Ghana corroborated the perception. It showed that there was consumption of less eggs, meat (<10%) and fruit (<20%). Although they are the producers, they preferred to reserve these essential commodities for sale to meet other family needs like health and educational bills because of the level of poverty in the regions. This situation is likely to exist in all farming communities and among rural/urban poor communities. The resultant effect is that, there is always protein, mineral and vitamin deficit in the nutritional profile of such people, especially, among children.

For instance, the above report indicated that, out of about 522 households that were sampled from the three Northern regions, 5.1% of the children were found to be moderately malnourished and 30.7% being marginally malnourished. In poor communities where eating of protein foods is less ,resorting to the diverse ways of utilizing legumes in daily simple meals should be the alternative to bridge the gap in protein deficit.

1.2 JUSTIFICATION OF THE RESEARCH

Despite the high protein value of legume and it ability to be substituted for the protein content in meat, eggs, fish and dairy products to supply protein energy requirement, they are still less consumed even in the regions where they are abundantly produced. This may be due to lack of knowledge and skills to process them into diverse but simple meals to bring variation for maximum utilization.

This buttresses the point made by some researchers that emphasis on postharvest conservation of produce no matter how small is more important than over production to take care of expected loss. World Bank (1994) also stressed that raising incomes and improving food security through increased production is not enough an aid to improve nutritional outcomes. As such integrating education into agricultural interventions is essential to achieving the social and behavioural changes necessary for improved nutritional outcomes.

1.3 OBJECTIVES OF THE STUDY

The main objective of the project was to develop protein-rich breakfast meals using locally produced cereals for enhanced nutrition.

The specific objectives of the work were to:

1. Identify the popular breakfast meals (porridge types) in selected communities in the northern regions of Ghana.
2. Develop strategies for improving the nutritional status of the porridge types in selected communities.
3. Determine consumer preference of the fortified porridge.
4. Determine the nutritional composition of the two most preferred porridge types.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 HISTORY OF THE CROPS

2.1.1 Maize, Millet and Soybean

There are different views and researchers have moved along different paths as far as the origin of maize is concerned. Some have reached as far as the remote areas such as China and Tibet. It is, however, generally accepted that maize has its origin in Araguaco and the name was brought back to the old world by Christopher Columbus who heard it for the first time in Caribbean Islands. The scientist, Linneaus, based on this common name and included it as a species epithet in the botanical classification Zea (Z. mays L.)(FAOUN and IPGRI, 2002).

According to Lance and Garren (2002), the western civilization discovered the story of corn in 1492 when Columbus's men discovered this new grain in Cuba. Seen as an American native, the crop was exported to Europe rather than being imported as mere other major grains. However, the exact period when corn first went to Europe is uncertain (Lance and Garren, 2002) and its exact birth place is far less certain.

Among the Maya people of the Guatemala, the origin of maize is traced to some spiritual deities which are still worshiped today (FAOUN and IPGRI, 2002) and the crop is seen as a man or woman, 'Mother of Maize'.

Maize was introduced to the Africa soil around 1500 by the arrival of the missionaries, merchants and slave traders over half a millennium (1500-1999). The crop has advanced rapidly as a major food crop in Africa in the last two decades, catching the imagination and attention of agricultural economics and international policy planners who see it as an agricultural sea change equivalent to Asia's Green Revolution of the 1970s (McCann,2001).

In southern part of Africa, maize has become the most important staple food during the last decade of the twentieth century. It accounts for over 50% of calories in local diet: In Malawi alone, the crop occupies about 90% of cultivated land and 54% of Malawians' total calories (McCann, 2001).

Irvine (1979) is of the view that, maize originated from the America continent and it was first introduced to West Africa by the Portuguese in the sixteenth century. Domestication of millet an important cereal can be traced to Africa. Pearl millet *(Pennisetum glaucum* L R.Br) is said to be a major crop of the sub- Sahelian area from Senegal to Sudan and it is cultivated in the eastern Africa and Asia (Oumar *et al.*, 2008).

Although the evolutionary history of the crop is not clearly established, the wild progenitor of pearl millet was identified as *Pennisetum glaucum* spp. monodii (Harlan, 1975;Brunken, 1977) and it is said to have originated from the tropical western Africa where greatest number of both the wild and cultivated forms occur (Wikipedia,2015). According to the source, it was about 2000 years ago when the crop was carried to Eastern and central Africa and to India and due to its excellent tolerance to drought, it became established in the drier environment.

However, the researchers in Asia claimed that domestication of millet started in China and Korea (Yang, 2005). He linked the domestication of millet to Shennong, the legendary Emperor of China. Tarannum (2006), confirmed the above assertion, basing the argument on the relative abundance of charred grains found in archaeological sites and the hypothesis by specialized archaeologist that, cultivation of millet was a greater prevalence in pre -history than rice, especially in Northern China and Korea. Tarannum (2006) further alleged that millet also formed important parts of the pre historic diet among the Indian, Chinese, Neolithic and Korean Mumun societies and hence might have originated from there

.

Broomcorn (*Panicum miliaceum*) and foxtail millet were important crops found in the Early Neolithic of China. Husk phytoliths and bimolecular components were identified at Cishan (Lu *et al.*, 2009) around 8300-6700 BC in storage pit along with remains of pit houses, pottery and stone tools related to millet cultivation.

BBC News (2005) also confirmed that a 4000year old well preserved bowl containing well preserved noodles made from foxtail millet and broomcorn millet was found at the Lajia archaeological site in China, an evidence of the prevalence of the crop in the area.

Similarly, Palaco ethno botanist have found evidence of the cultivation of millet in the Korean Peninsula dating to the middle Jeulmun pottery period (C.3500-2000BC), Crawford and Lee, 2003).

The crop has also been found to be an important element in the intensive, multicropping agriculture of the Mumum pottery period (1500-300 BC) in Korea and its wild ancestors such as barnyard grass and panic grass were cultivated in Japan during the Jomon period sometime after 4000BC (Crawford and Lee,2003).

Due to the lack of records, most of the early history of soybeans is not known but those gathered by historians are colourful according to Keith (2008).

South East Asia is considered to be the home of soybeans. However, Hymowitz (1990) asserted that, the beginning of domestication of soybean might never be known exactly but evidence shows that the crop emerged as a domesticated crop during the Zhou dynasty in the eastern half of northern China. By the first century A D, trade missionaries distributed the crop throughout China and other Asian countries and the earliest Japanese reference to the soybean crop was found in the
Kojiki (Records of Ancient Matters) in 712 AD (Hymowitz,1990).

Soybean was introduced to Europe in the early 1700s where it was grown in the Netherlands by 1737, in France between 1739 and 1740 and in England by 1790 (Shurtleff and Akiko, 2007). However, in each place it was grown as a botanical garden.

But in Africa, soybean cultivation was introduced in the late 1800s although little is known about the countries to which it was first introduced (Arvine, 1979). It is possible, or perhaps likely that soybean was cultivated at an early date on the Eastern coast of Africa since that region had long traded with the Chinese.

2.2 SCALE OF PRODUCTION

2.2.1 Scale of Maize Production

The United States grew over 62 million acres of corn as early as 1880 and by 1900 the figure had reached approximately 95 million acres. However, the highest acreage ever recorded in the united State was 111million acres in 1917 from the beginning of records from 1800s (Lance and Garren, 2002).

Vast technological advances started in the early 1940s and this reflected in the yield of corn significantly. Yields shot up in the 1960s and early 1970s and a national

average of 109.5 bushels per acre was recorded according to Lance and Garren (2002). It was observed that farmers in the United States planted over 79million acres of corn in the year 2000 representing over 40% of the world's corn production. Lowa is normally the leading state in corn production, producing an average of 145 bushels per acre on more than 12 million acres in 2000. However, it recorded the highest of all time record in corn acreage of 14.4million acres in 1980
(Lance and Garren, 2002).

Though Americans produce more in terms of total volume of their native crop, the impact of maize according to McCann (2001), may be greatest in Africa where it is grown as a major food source and it is used to combat the economic and nutritional crises in the continent. In southern Africa, maize has become the most important staple accounting for over 50% of calories in local diets; in Malawi alone the crop occupies 90% of cultivated land and 54% of Malawians' total calories (McCann, 2001).

Kirimi (2002) asserted that maize production suffered periodic fluctuation in Kenya since 1961 with the growth in maize production spanning between 1961 and 1976 while 1976 -1980 recorded a decline in production. In Kenya, small and medium scale sector produces about 75% of the nation's maize crop whiles large scale sector (farms over 25 acres) accounts for the remaining 25% (Kirimi,2002).

As noted by USDA (2015) the United State remained the highest world producer of maize giving an annual output of 273.19million metric tons in 2012/2013 crop year. There was an increase in 2013/2014 crop year to 351.27 million metric tons. Next to United States were China, South America, Brazil, Argentina, India, Mexico, Ukraine, France and Canada, and production levels are shown in the table below.

Table 2.1: Top ten producers of maize between 2012 and 2014

COUNTRY	Production (millions of metric tonnes)	
	2012/2013	2013/2014
United States	273.19	351.27
China	205.61	218.49
South America	119.77	115.13
Brazil	81.50	79.30
Argentina	27.00	25.00
India	22.26	24.19
Mexico	21.59	22.96
Ukraine	20.92	30.90
France	15.15	14.70
Canada	13.06	14.19

Source: USDA (2015)

In Ghana however, maize is the most important cereal crop produce and consume as a staple food and it has seen an increase in production level since 1965 (FOA, 2008). It is an important crop as food grain and fodder in both irrigated and rainfall agricultural systems in the semi-arid and arid tropics (Hussan *et al*. 2003).

In Ghana, the per capital consumption of maize in 2000 was estimated at 42.5kg (MoFA, 2000) and estimated national consumption of 943000 metric tons in 2006 (SRID, 2007).

Despite its important position in ensuring food security, production of maize in the country has been very low as production is done mostly by small holder farmers with less sophisticated machines and equipment and under rain fed agriculture.

2.2.2. Scale of Millet Production

Although different varieties of millet are grown worldwide, pearl millet, finger millet and prove millet accounts for a large proportion of the world production. In 1981, production of millet increased from 26million tons to 31million tons in 1988 and this was similar in 1989 and 1990 (FAO, 1992). However, Asia, Africa and former Soviet Union produced greater proportion of the world millet.

In terms of areas of production, there was a marginal decrease from 38.1million hectors in 1979-1981 to 37.6million hectors in 1990. However, production increased by 17% from 25.6million tons in 1979-89 to 29.8million tons in 1990 due to increase in production in Nigeria (65%), India (25%) and the Soviet Union (7%), but production in China decreased by 24% during the same period. (FAO, 1992) **Table 2.2: Percentage area, yield and production of millet by region, 1990**

REGION	AREA		YIELD	PRODUCTION	
	(10^3ha)	(% of total)	(Kg/ha)	(10^3t)	(% of total)
Asia	20853	55.5	804	16767	56.2
Africa	13543	36.1	669	9066	30.4
Ussr	2903	7.7	1256	3647	12.2
North And Central Africa	150	0.4	1200	180	0.6
South America	55	0.2	1655	91	0.3
Oceania	34	0.1	882	30	0.1
World	37565	100	794	29817	100

Source: FAO, 1992.

The table below also shows the major producers of millet in 1990 as follows; India (39%), China (15%), Nigeria (13%) and Soviet Union (12%) etc.

Table 2.3 Leading millet productions, 1990.

COUNTRY	AREA		PRODUCTION	
	(10^3ha)	(% of total)	10^3t	(% of total)
India	17000	45.3	11500	38.6
China	2601	6.9	4401	14.8
Nigeria	4000	10.7	4000	13.4
Ussr	2903	7.7	3647	12.2
Niger	3100	8.3	1133	3.8
Mali	900	2.4	695	2.3
Uganda	400	1.1	620	2.1
Burkina Faso	1150	3.1	597	2.0
Senegal	865	2.3	514	1.7
Nepal	200	0.5	240	0.8
Total	33119	88.2	27347	91.7
World (1990)	37565		29817	
World (1989)	37409		29962	

SOURCE (FAO, 1992)

By 2000, the annual millet production has increased in India, but per capita consumption of millet had dropped by between 50% and 75% in different regions of the country (FAO, 2011). The average yield of millet crop wide was 0.83 tons per hector in 2010 and the most productive millet farms in the world were in France with an average of 3.3 tons per hector (FAO, 2011).

Table 2.4: World leading production of millet

COUNTRY	PRODUCTION (TONNES)
India	10,910,000
Nigeria	5,000,000
Niger	2,955,000
China	1,620,000
Mali	1,152,331
Burkina Faso	1,109,000
Sudan	1,090,000
Ethiopia	807,056

Chad	582,000
Senegal	572,155
World	29,870,058

Source: FAOUN, 2013.

According to the data above, Nigeria is the second largest producer of millet next to India. Production of millet in Ghana is about 0.5% of the world's production and Ghana is number 19th in the world ranking of millet production. It produced about 155.131 in 2013. The three northern regions of Ghana, accounts for all the production of millet in Ghana because of the high tolerance of the crop to the dry weather conditions prevailing in these regions.

2.2.3. Scale of Soybean Production

According to Rowland (1993), the world soybean production is around 107million tons with USA and Brazil being the leading producers. The crop is grown on commercial levels in over 35 countries worldwide as the major oil seed (Smith & Huyser, 1987).

Work done by USDA- ERS (2009) confirmed this assertion by Rowland when it reported that USA and Brazil produced 73 and 42 million metric tons of soybean respectively which represented 33% and 25% of the world soybean output in 2008.

According to Lokuruka (2010), more than 50% of the USA soybean crop is genetically modified to boost production worldwide as a result of the discovery of the health benefit associated with the crops as human food for consumption.

However, worldwide soybeans production has not been impressive compared to the major grain production. In 1981/1982, worldwide production was approximately 450 million metric tons of wheat, 770 million metric tons of coarse grain (mainly maize) and 410 million metric tons of rice but only 87 million metric tons of soybean. The global output in 1992/93 of the three major grains rose to 560530 and 470 million metric tons of wheat, rice, and maize respectively (Potter and Hotchkiss, 1995) and 106 million metric tons of soybeans (USDA-ERS,2008).

Moreover, there has been a steady increase in world production of soybean over the years due to increased knowledge of the health and food value of the crop and subsequent intensification to increase production. In 2007, the worldwide production of soybeans rose to 221million metric tons (USDA-ERS, 2008). This reached 268.77 million metric tons in 2012/13 and 283.74 in 2013/14 (USDA,

2015).

The crop is of minor importance to Africa in terms of scale of production. The continent's total production is around 532000 tons according to Rowland (1993) with Zimbabwe and Egypt accounting for over half of this quantity.

Nassiuma and Wafula (2002) confirmed that Africa's production has not been so significant compared to the USA. It produced approximately 1.3million metric tons of soybean in 2007 (USDA-ERS, 2008). This is about 5% of the global output up from 0.6million metric tons in 2002 (more than 100% increase in 5years).

Despite the long history and official encouragement of soybean introduction in Africa because of its potential value as far back in combating the protein malnutrition, the crop has not featured well in level of home consumption due to two major problems; they took too much time and fuel to cook and the taste was not well accepted. Nevertheless, there are concerted effort to increase the production of soybean in Africa due to its nutritional value and diverse utility.

Recently, 2012/2013 and 2014, South Africa was leading in soybean production with an annual output of 0.79 and0.94million metric tons respectively.

Nigeria was second in production of soybean with 0.58 and 0.45 million metric tons during the same period and Uganda was next with 0.15 and 0.17million metric tons over the same period (USDA, 2015).

Unfortunately, soybean production in Ghana has been insignificant that, it does not feature the records of world leading producers of the crop despite it great importance. Currently, Ghana is unable to meet local demands for soybeans according to GNA (2014). In September, 2014 it was reported that in spite of the great potential of Ghana in soybean production, the country is unable to meet local consumer and industrial demands leading to the importation of 700metric tons from

Brazil by one company processing the crop into feed for fish and poultry (GNA, 2014).

Table 2.5: Ten leading Soybean producer

COUNTRY	2012/2013	2014
United states	82.79	91.39
Brazil	82.00	86.70
Argentina	49.30	54.00
China	13.05	12.20
India	12.20	9.50
Paraguay	8.20	8.20
Canada	5.09	5.36
Uruguay	3.65	3.5
Bolivia	2.63	2.40
Ukraine	2.41	2.77

World	268.77	283.74

SOURCE: USDA (2015)

2.3 NUTRITIONAL VALUE OF THE CROPS

2.3.1 Nutritional Value of Maize

Maize is a staple food in the sub- Saharan Africa, feeding an estimated population of 50% of the people. It provides about 50% of basic calories. The nutritional value of maize is as follows according to Chaudhary (1983) – 72% starch, 10% protein, 4.8% oil, 8.5% fibre, 3.0% sugar and 1% ash.

The high popularity and easy access of the maize crop makes it an ideal component of a good and balanced porridge. It also possesses core nutritional properties in significant proportion such as starch, protein, fatty acid, mineral and vitamins.

2.3.1.1. Starch

According to Pyke (1968), the main component of maize, like all other common cereals is starch which constitute the major chemical component of the maize kernel weight with about 72-73 per cent. The starch content of the maize however varies depending on the variety. The content of starch in maize ranges from 66.0-75.9.The high content of starch in maize makes it a good source of energy given food and as such a staple food in many African and developing countries including Ghana.

Other carbohydrate according to FAO (1992), are simple sugars present as glucose, sucrose and fructose in varying levels (1-3) percent of the kernel weight. Two important glucose polymers; amylase (an essentially linear molecule) and amylopectin (a branched form) makes up the maize starch. This starch composition of maize is genetically controlled according to Boyer and Shannon (1987). The composition of the Amylose and Amylopectin in common maize is between 25 to

30 per cent and 70 to 75 per cent respectively.

2.3.1.2 Protein

Next to starch in terms of nutritional value in maize is protein which also varies depending on the variety. In common maize, the proportion is between 8 to 11 percent of the kernel weight which is mostly found in the endosperm according to Landry and Mourneaux (1982).

Watt and Merrill (1963) affirm that, whole corn meal contains 9.2gm while degermed enriched and degermed un-enriched contain 7.9 gm. (expressed in 100 grams edible per dry weight). Pyke (1981) quotes the protein content of whole grain (per 100gm.) as 10g at moisture of 13g.

However, Hammond (1986), asserted that, maize like the other cereals, contains a fair amount of protein of the rather poor quality because it lacks certain vital amino acids required by the body and hence a skillful selection and combination of other plant source protein (especially legumes & nuts) is paramount in countries where animal proteins are insufficient and expensive (Vail *et al*., 1967). This assertion is affirmed by Whitney e*t al*. (2001), that some plant protein e.g. corn protein is notoriously incomplete while others are complete e.g. soy proteins.

Maize proteins is said to be incomplete because it is low in lysine but rather have adequate levels of sulphur containing amino acids.

2.3.1.3 Oil and fatty acids

Maize contains an appreciable level of oil and fatty acids which are located in the germ. Pyke (1981) indicated that, an entire whole grain contains 4.3% fat while degermed maize may contain as low as 1.3% fat. Ndungi (1982) also mentioned that the embryo of maize is a source of oil which is very healthy but the human diet is depleted of this oil when the embryo and hull are removed in a milling process. The oil in maize is dependent on the variety as it is genetically controlled. The values range from 3 to 18% and have low levels of saturated fatty acids (an average of 11% palmitic and 2% stearic acid). It however has relatively high levels of poly unsaturated fatty acid but the oils are stable because it contains only small amount of linoliec acid 0.7% and high levels of natural antioxidant (FAO, 1992).

Population that consume degermed maize are however deprived of this nutritional benefits as the grain loose such nutrients.

2.3.1.4 Minerals and vitamins

Unrefined maize grain contains some amount of minerals although very low as compared to starch and protein. The minerals and vitamins content of the grain is normally found in the germ and outer branny layers of the kernel than the starchy endosperm (Vail *et al.,* 1967). Hence, refined cereals are lower in minerals than whole grains cereals. Corn meal (whole ground) according to Watt and Merrill (1963), contains 20gm of calcium, 2.4gm of iron and some B vitamins (thiamine 0.38gm, riboflavin 0.11gm and niacin 2.0gm).

Abbey and Macdonald (1976) also added that depending on the type and variety, cereal may contain a small amount of calcium, iron and phosphorus, especially in the outer skins of the germ. But these may not be available because of the presence of phytic acid which makes them insoluble and so unavailable. They however confirmed the work of Watt and Merrill that cereals are a good source of vitamin B (thiamine, riboflavin and nicotinic acid) especially in the germ and outer layers.

The ash content in maize kernel is about 1.3% and this is slightly lower than crude fibre content (FAO, 1992). The germ is rich in mineral (about 11%) as compared to the endosperm (1%). The 11% represent about 78% of the total kernel minerals with the most abundant minerals being phosphorus, found as phosphate of potassium and magnesium. Common maize has about 0.9% phosphorus and the opaque 2 maize, contains about 0.92% of phosphorus (FAO, 1992). Maize is however low in calcium and other trace minerals.

Nuss and Tanumihardjo (2010) are of the view that, maize contains many important vitamins with the exception of vitamin B12. Yellow maize is relatively high in vitamin A because of the high carotinoids of the brand. Vitamin A appears as provitamin-A carotinoids and vitamin E as tocopherols and they are the pre dominant fat – soluble vitamins found in maize kernels. These two play important roles as antioxidants among other functions (Kurilich and Juvik, 1999).

2.3.1.5. Dietary fibre

Cereals in general are a good source of dietary fibre which do not necessary add any important chemical nutrients to the diet but plays important role of adding bulk to the diet for easy movement of the bowels (large intestines) (Seton,1963). Thus an unpolished maize and slightly processed maize has high dietary fibre than more refined processed maize. Also some of these dietary fibres are soluble and QPM, nitric has higher levels of total dietary fibre than common maize because of its higher level of insoluble fibre (FAO, 1992).

2.3.2. Nutritional Value of Millet

Millet is one of the ancient cereals found in drier regions and has a comparative advantage because of its ability to adapt well on marginal soil, nutritive value as well as numerous health benefits.

The millet grain contains about 15% protein, high carbohydrates content, high amount of fibre, B complex vitamins (including niacin, folacin, thiamine and riboflavin) It is high in iron, magnesium, phosphorus, manganese and potassium, and some levels of minerals like calcium, zinc, and also of vitamin E with amino acids e.g. methionine. It is also rich in photo-chemicals including phytic acids which is believed to lower cholesterol and phytate which is associated with reducing the risk of cancers (Ndungi, 1982; Coulibaly *et al*., 2011).

Work done by Izachi *et al.* (2012) confirmed the above findings but added that millet is also high in antioxidants. FAOUN (1995) indicated that Barnyard and finger millet contain the lowest carbohydrates and fats content respectively but pearl and little millet are high in fats. It also stated that the protein content in millet is comparable to that of wheat and maize about 11% by weight on dry millet grains but the only challenge is the high fibre content which affect digestibility of nutrients and hence limit the food value and consumer acceptance of the crop.

Millet is also a good source of dietary carbohydrate which supplies energy. The bran is rich in the B vitamins especially; niacin, B6 and folic acid: calcium, iron, potassium and magnesium (Devi *et al*., 2011) which reduce the effect of migraine and heart attacks. It is also rich in phosphorus which is special component of Adenosine (ATP), and as such a precursor of energy in the body (Badau *et al.*,
2005; Liang *et al.*, 2010).

Table 2.6: Major nutrients of the four important millets in Africa relative to other selected cereals.

	Millets				Other cereals	
Major nutrients ($g100g^{-1}$)	Pearl millet	Finger millet	Teff	Fonio	Wheat	Sorghum
Protein	11.0	7.3	9.6	9.0	7.8	7.9
Carbohydrate	70.0	74.0	73.0	75.0	71.0	73.0
Fat	4.8	1.3	2.0	1.8	1.1	2.8
Crude fiber	2.3	3.6	3.0	3.3	2.0	2.3
Ash	1.9	2.6	2.9	3.4	1.6	1.6
Food energy (KJ)	1483	1403	1411	1541	1105	1142

Table 2.7: Mineral composition of the four important millets in Africa.

	Millets				Other cereals	
Mineral ($mg100g^{-1}$)	Pearl millet	Finger millet	Teff	Fonio	Wheat	Sorghum
Calcium	37	344	159	44	30	27
Copper	9.8	0.5	0.7	-	1.1	2.4
Iron	114	9.9	5.8	8.5	4.0	6.6
Manganese	190	140	170	-	120	180
Magnesium	0.8	1.9	6.4	-	3.6	2.9
Phosphorus	339	250	378	177	400	520
Potassium	418	314	401	-	330	440
Sodium	15	49	47	-	16	14
Zinc	2.0	1.5	20.0	-	3.5	4.4
Chloride	43	84	13	-	-	-

Table 2.8: Essential amino acids in important millets of Africa

Amino acids (g16g N)$^{-1}$	Pearl millet	Finger millet	Teff	Fonio
Cystine	1.6-1.8	1.7	1.9	2.2-2.5
Isoleucine	3.9-4.6	4.0	3.2	4.0-4.3
Leucine	9.5-12.4	7.8	6.0	10.5-11.8
Lysine	2.8-3.2	2.5	2.3	1.9-2.5
Methionine	1.8-2.6	2.9	2.1	3.0-4.5
Phenylalamine	4.1	4.1	4.0	5.7-6.8
Threomine	3.3-4.1	3.1	2.8	3.3-3.7
Tryptophan	1.4-1.5	1.3	1.2	1.6
Tyrosine	3.0	4.1	1.7	3.5
Valine	4.9-6.0	6.4	4.1	5.2-5.5

Source: FAO, (1992)

2.3.3. Nutritional Value of Soybean

Soybean has varied nutritional properties which make it very useful in human diets in combating food insecurity and malnutrition especially in developing countries.

2.3.3.1. Soybean protein

As a grain legume, soybean is known to contain a good amount of carbohydrates, proteins, vitamins, minerals, fibre, iron etc. When eaten as a vegetable, soybean gives a complete protein which is nearly equivalent to the protein quality of meat, milk, and eggs and it complements the crude protein in cereals to be complete because of their lysine content (Ndungi, 1982; Banaszkiewiez, 2011).

As noted by Lokuruka, (2010), soybean protein is valuable because it is rich in a vital amino acid, lysine, which gives the crop a superior task of complementing cereals which lacks this nutrient. Potter and Hotchkiss (1995) also made the same observation but added that the crop is rather limiting in sulphur containing amino acids which are rather available in cereals. Ensminger *et al*. (1990) indicated that soybean protein is rich in the following amino acids, lysine, tryptophane, isoleucine, valine and threonine but low in sulphur-containing amino acids. (Methionine and cystine which is about 2.9g/16N) (Banaszkiewiez, 2000).

According to Lokuruka (2010), soybean proteins are between the ranges 38-44% which is higher than that of other legumes (20-30%) and are much higher than that of cereals (8-15%). Work done by Hans *et al.* (2008) shows that soybean and sorghum complement are another very well (because of the above analysis) in meeting the protein and AA requirement of poultry because the grain has low concentration of protein (lysine and trypophan) which is abundant in soybean.
Digestibility is however a challenge with soybean when it is subjected to heating alone during processing but this can be overcome by soaking, sprouting, fermenting, grinding and hot water extraction (Watanabe, Ebine and Ohda, 1971). This lower digestibility may be due to the presence of considerable levels of trypsin and chymotrysin inhibitors in soy fours, soybean lipids and micro nutrient.

Soybean is also a very good source of oil. Bates and Matthew (1975) discovered that soybean oil provides calories, essential fatty acids and vitamin A and E. the oil value of soybean oil seed is of 134 and is comparable to that of sunflower oil. The oil seed value of groundnut butter, maize and palm oils are lower in saturation as compared to soybeans oil (Weiss, 1983).

Soybean oil is high in poly-saturated and unsaturated fatty acids and this makes it superior to some other oils. The lipid fraction of soybean seed is about 99% of triglycerides in which are polyunsaturated fatty acids (linoleic and linolenic) and saturated (oleic acid) According to Pyke (1968), the former reduce the concentration of cholesterol in blood while the later has little effect on blood cholesterol. This makes the consumption of soybean beneficial in the tropical and developing countries where dietary intake of essential fatty acids is low (Lokuruka, 2010).

Soybean is also rich in Omega-3 fatty acids. It also contains good amount of omega – 6 which emphasize its potential to be classified as both omega – 3 and omega- 6 sources. (Covington,2004). The omega–3 oil has the potency which is antiinflammatory, anti-thrombotic, anti-arrhythmic and vasodilatory because of these eicosanoids present and these are reported by Bruckner (2000) and Covington (2004) to protect the heart against cardiovascular diseases.

2.3.3.2. Soybean carbohydrates

The carbohydrates composition of soybean and its nutritional value may be affected by factors such as cultivar, genotype and processing techniques (Lokuruka, 2010) e.g. Woodworth *et al.* (2001) reported that screw-pressed soybean meal usually contain more energy than solvent extracted meals because of the farms method yields a greater concentration of fat than the later method. Likewise de-hulled soybean meals contain more energy than non-de-hulled because of the lower concentration of fibre.

According to Banaszkiewiez (2011), soybean contains about 35% carbohydrates and about half of the carbohydrates are non-structural in nature which includes: low molecular weight sugars, oligosaccharides and small amount of starch. KarrLilienthal *et al*. (2005) added that 5% of soybean dry matter is made up of galacto oligosaccharides (raffinose, starchyose and verbascose) while starch present less than 1%. The carbohydrate in soybean as a legume grain is located in there.

2.3.3.3. Soybean minerals

Lokuruka (2010) reported that dry soybean contains about 5% ash and the composition is mostly potassium, sulphates, phosphate and carbohydrates. The order in terms of concentration from the highest is as fellows; potassium, phosphorus, magnesium, sulphur, calcium, chloride and sodium. Minor minerals with the range of 001-140ppm that are found in soybean includes; silicon, iron, zinc, manganese, copper, molybdenum, fluoride, chromium, selenium, cobalt, cadmium, lead, arsenic, mercury and iodine. Hammond (1986) earlier asserted that soybean crop is a food source of calcium and iron.

Work done by Cook *et al*., (1981) postulated that mineral bio-availability is a challenge in consumption of plant food than animal source food as calcium, zinc and phytate in soy food interact to form a highly insoluble complex which reduces zinc absorption to a greater extent than phytate alone. They further reported that haeme iron was found in animal foods is readily available than non-haeme iron as found in soybeans.

In contrast, work done by Bodwell (1983) revealed that soybean proteins used in feeding programs had no adverse effect on iron bioavailability. Hans *et al.* (2008) suggested that the main limiting factor for increasing the usage of soybean in pet foods is the presence of flatulence- causing oligosaccharides. He stated that soybean meals contain 6-8% sucrose, 3-5% stachyose and 1-2% raffinose which are nondigestible and when subjected to colonic fermentation, can lead to gas production in the gastrointestinal tract of dogs. But there is a panacea as research has revealed that genetic manipulation of soybeans had resulted in the creation of varieties that contain negligible quantities of raffinose and stachyose, according to Batal and Parsons (2003).

2.3.3.4. Soybean vitamins

Hammond (1986) reported that soybean as a member of the legume family, contains some amount of the B vitamins but no vitamin A and C, Lokuruka (2010) is of the view that vitamin C is available but in negligible quantities in the mature beans. He further stated that the oil of soybean contains the following oil soluble vitamins A and E (retinol and tocopherol) of which the vitamin A exists as the pro-vitamin Bcarotene. The A and C vitamins are however in measurable levels in immature and germinated seeds (Lokuruka, 2010) while the tocopherol content depends on the variety.

2.4 USES OF THE CROPS

2.4.1 Uses of Maize

There are several uses of maize such as food for human consumption, feed for animals and for industrial purposes.

Lance and Garren (2002) stated that corn has over 500 uses and it forms an important component of food for humans such as canned corn, baby foods, homing, mush, puddings, tamales etc. they also indicated that the crop can be used for industrial purses such as packing materials, insulating materials, explosive paint, paste, abrasives, dies, insecticides and for pharmaceutical purposes etc.

Nielson (2003) confirmed the above assertion that corn has varied uses ranging from domestic purpose (foods and feed for livestock) to health (pharmaceutical) and industrial. According to them, corn can be used in the production of alcoholic and other beverages, snack foods, condiments, confectionary, fats and oils, chemicals, animal feed, building materials, formulate dairy products etc.

Due to the variable nature of maize, many countries have diverse uses for the crop. The developed countries like USA, EU, and Canada etc. use maize mainly as animal feed and as a raw material to feed their extraction/fermentation industries whereas the developing countries (Latin America and Africa) mainly use maize as food.

However, the Asians use the crop as both food and feed.

The global estimation of the use of maize as food is about 21% as it forms an important ingredient in the food preparation industry. The crop is the 3rd most important food grain in India after wheat and rice, according to (Kirimi, 2002) and about 28% of maize produce is used for food purposes, about 11% as feed for livestock, 48% as poultry, 12% in wet milling industry (starch and oil production) and 1% as seed.

In Ghana, maize is the most common staple food and a cereal consumed in many homes and across all the regions. It is used for the preparation of main dishes such as Banku, TuoZaafi, Kenkey (Ga and Fante types), Akple, porridge (different types including tom brown which has other cereals and legumes inclusion). The fresh corn can also be boiled or roasted and chewed which supply the nutritional value as well as high fibre to the individual. The grains can also be eaten as confectionary when it is roasted or chewed with or without groundnut and as popcorn.

Some people also use the maize in production of fermented alcoholic beverages. The husk is also used as a wrapper for food and the dried cob and stem are used as source of fuel (setting fire) and door mats. The bran as well as the grains is used to feed both livestock and poultry.

2.4.2 Uses of Millet

Millet is used as a staple food for people living in drought prone Africa (SAT) for its high tolerance and prevalence in such regions. It is also useful in such regions for its high calories and nutritious value e.g. cysteine, lysine and methionine (ICRISAT, 1996).The crop has three major uses across the regions. Thus, it is used as food, feed and in the brewing industries to produce both alcoholic and non-alcoholic beverages.

About 78% of millet produced is utilized as food to supply energy and protein for about 130 million people in sub-Saharan Africa (SSA) (Obilana, 2002). This special trait of the crop (tolerant in higher regions and nutritional value) makes it important in the lives of poor people in such regions during food scarcity and nutrition and health interventions. As food, the grain is processed into flour for making pastries (flat bread) and in thin and thick porridges and as composite flours.

In Ghana, apart from being used in popular and generally prepared porridge known as "Hausa Kooko" across all the regions, it is also used in infant formulas with other cereals and legumes to prepare "tom brown." Additionally, the grains are also used in the malting and brewing industries to produce alcoholic and non-alcoholic beverages in southern Africa (Obilana, 2002) e.g. pearl millet has been found to possess dietetic powers similar to sorghum and makes just as good beer brewing with good quality malts (Pelembe, 2001). However, in local Ghanaian communities, the grains are malted, fermented and processed by small-scale processors into local popular drinks e.g. "Elewonyo" which is normally served with milk and or iced cubes.

In general, commercialization of millet products is in advanced form in southern African markets than in West Africa whereas the traditional beer brewing from pearl and finger millet has advanced to large scale commercial levels in eastern, central and southern Africa.

For the poultry and the livestock industry, only about 2% of the grains produced are use d as feed for the animals.

2.4.3 Uses of Soybean

The early uses of soybean was for their seeds which were used in preparing large variety of fresh, fermented and dried food products. These were considered to be an integral part of oriental diets (Gibson & Garren, 2005). However, in United States, the crop was used purposely as forage and to some extent as green manure. One of the major uses of the crop is in preparation of soybean meal for poultry, fish and livestock industries.

Work done by Gatlin in association with United Soybean Board and American Soybean Association revealed that at an inclusion level of up to 60% of the total diet used to feed freshwater omnivorous fishes has been very possible because of its acceptable taste, excellent nutritional value, thus (high crude protein, complementary amino acids profile and relatively high nutrient digestibility) which has been 90% consistently in certain fishes.

It has also been discovered that certain fishes fed with soybean meal used in fish formulations have proved similar or better than formulations with fish meal component in terms of efficiency (Wu *et al.*, 1995; Robinson and Li, 1999). This subsequently reduced cost of production of the fishes. Also, the rich protein remaining after oil extraction are processed into soybean flour for human food or incorporated into animal feed as a low cost but rich protein source to feeds (Gibson and Garren, 2005).

In the food industry, varied dishes and food items could be prepared from the seeds/soybean grains around the globe. In Ghana, the soybean seeds are processed into various infant formulas known as "Weani-mix" which are products of legumes and cereals at different combination levels roasted and milled together. Work done by the FRI/ IITA (2013) also revealed that the people within the catchment areas in the three northern regions have been taught to incorporate the soybean in their dishes like "Zonkom" and "TuoZaafi".

Oil production is another important use of the crop. Large quantities of the crop are processed into oil for various uses according to Gibson and Garren (2005). Some of the uses of the oil from soybean seeds are preparation of margarine, as cooking oil (it accounts for about 80% or more of the edible oils consumed in the United States) and salad dressings, mayonnaise. Some other beneficial uses of soy oil other than food are as industrial paints, varnishes, caulking compounds, linoleum, candles, soy crayons, printing inks and as an oil-based lubricant and renewable fuel (bio diesel) (North Carolina Soybean Production Association, 2014).

The crop is also known to be an important cash crop to United States who contributes about 40% of the world's soybean trades. It is the US second largest cash crop and the number one export crop (Gibson and Garren, 2005). Some other important uses of soybean in the farming industry are as fungicides, insecticides and as herbicides (Palle Pedersen, 2003-2015).

2.5 TRADITIONAL FOOD PROCESSING AND PREPARATORY METHODS THAT AFFECT FOOD QUALITY

Processing and preparation methods can affect the dietary qualities of food positively or otherwise. While some practices and methods release the micronutrients in the food and make them useful, some other methods or practices may render the needed nutrients unavailable for utilization. Notwithstanding, the sensory quality of some foods as well as management of some microbes that affect food quality could be improved through processing and preparation methods. Not only the above can make the food nutrients unavailable but also anti-nutrients such as phytate, polyphenols and oxalate which predominately limit the quality of plant based diets (Golden, 1991; Gibson, 1994).

However, a combination of some traditional processing methods such as thermal, mechanical, soaking, fermentation and malting plus intake of some other micronutrient-rich foods increase the bioavailability of micronutrients by decreasing the content of anti-nutrients such as phytate which is a potential threat to iron, zinc and calcium absorption (Hotz and Gibson, 2007). The energy value of soybean products, for example, depends on techniques used to process which affect the chemical composition, digestibility and availability of nutrients (Banaszkiewiez, 2011).

2.5.1. Thermal Processing

This is one of the common traditional methods of food processing which has been used for a long time at both household and industrial levels.

This process has the potential to enhance the bioavailability of micronutrients such as thiamine and iodine through the destruction of anti-nutritional factors like goitrogens, thiaminases (Erdman & Pneros-Schneires, 2002). Thermal method of food processing can also improve the bioavailability of vitamin B6, niacin, folate and carotenoids. This is made possible by releasing them from the plant matrix according to (Yeum & Russel, 2002 and Rodriguez-Amaya, 1997).

Also, a maximum improvement in protein (95.7-105%) and starch (117-138%) digestibility have been recorded on cooking legumes at a temperature of 121°C for 10 minutes whereas ordinarily heating would result in protein and starch digestibility of legumes up to 86-93.3% and 84.0- 90.4% respectively (Zia-ur R &

Shah, 2004; Hotz and Gibson, 2007) added that there is a possibility of thermal processing to break down phytate which is a potential inhibitor to iron, zinc and calcium absorption depends on the plant species, temperature and pH.

According to Liu (2005), although thermal processing may break down bound phytochemicals (phenolic acids and carotenoids) as glycosides to the cell matrix and insoluble fibres to elevate the bio accessible phytate chemicals and antioxidant activity in processed vegetables, it can lead to loss in some nutrients e.g. vitamin C. Also, unstable nutrients like folate, thiamine and vitamin C may be affected through heat processing methods.

According to Parsons *et al.* (1992) and Anderson-Haferman *et al.* (1992), appropriate levels of heat application (100-105°C) to soybean processing enhance the decomposition of anti-nutrient factors e.g. trypsin inhibitors, resulting in an improved level of lysine, methionine and systine amino acids. However, too high temperature may be deteriorate the lysine and affect its digestibility and availability. Also, heat application controls/prevent the activities and effects of micro-organisms on food which would cause food related diseases.

2.5.2 Mechanical Processing

In processing of cereals, pounding is done to remove the bran and sometimes the germ. The modern way of doing that is by milling. When the bran is removed, the phytate which is an anti-nutrient is gotten rid of from the cereals and hence, iron, zinc and calcium are made bio-available (Hotz & Gibson, 2007).

However, when the pounding is intensively done or the milling process is so refined, the outer layer of the grain (aleurone layer) as in rice, sorghum and wheat and the germ of maize could be removed (O'Dell *et al.* 1972) and this will consequently reduce some minerals and vitamins. Breaking down of food into smaller portions also promotes the inclusion of roughage portion of plants into the diets as dietary fibre.

Work done by Chowdhary and Punia (1997) indicated that, milling and heat treatment of millet to prepare flour for *chapti* (unleavened bread) yielded a lowered polyphenol and phytic acid content but a significant improvement in digestibility of protein and starch.

2.5.3 Soaking

Soaking has been one of the common methods of preparing both thin and thick porridges from cereal/legume flours and grains. When the water is decanted, there is the possibility of getting rid of phytate and water soluble Sodium, Potassium and Magnesium depending on the species, pH and length of time of soaking (Perlas and Gibson, 2002; Hotz & Gibson, 2001).

Moreover, dried grains could be soaked to soften and the enzymatic activities are quickened in the presence of moisture. Examples of grains that are soaked during processing include maize, millet, sorghum and legumes such as beans, peas, soybeans etc.

The process is known to shorten cooking time and hence, save some nutrients that would have been lost through prolonged time and energy (fuel).

According to Erdman and Pneros-Schneier (2002), soaking may get rid of some polyphenols and oxalates which are iron and calcium inhibitors and appropriate methods of soaking is reported to have enhanced the absorption of iron, zinc and calcium by infants fed with cereal-based foods prepared with reduced phytate contents (Yadav and Sehgal, 2002).

2.5.4 Fermentation

Fermentation of cereals during the preparation of flour and dough in the food industry is a common practice. Both thin and thick porridges are prepared from fermented flour. The enzymatic activities/reactions are enhanced through the fermentation process and these enzymatic effects help to improve the eating quality, microbiological and keeping quality (Hotz & Gibson, 2001) of food.

The protein quality and digestibility and vitamin B content of cereals are also improved through fermentation which reduces the phytate by hydrolysis (Sandberg, 1991). The phytate hydrolysis by phytases during fermentation results in the reduction of the pH of the flour and this gives the fermented flours (and products from such flours) its characteristic sour taste. For instance, work done by Teucher *et al.* (2004) reveals that, low molecular weight organic acids (e.g. citric, malic and lactic acids) are produced during fermentation and these acids potentially enhance the absorption of iron and zinc. The acids produced also optimize the activities of endogenous phytase from cereal and legume flours.

2.5.5 Malting

Germination of seeds (malting) is employed mostly in the brewing industry during the preparation of beverages as well as in the preparation of infant formulas for thin porridges. In Ghana and in most African countries, cereals e.g. millet, sorghum and maize are malted for the preparation of alcoholic and non-alcoholic beverages like pito, *nmadaa (Ahei,AsanaaLiha)* (Pyler and Thomas, 2000: Plahar, 1976). The malting process modifies the grains physically, chemically and biologically according to Briggs, (1998) to give it desirable characteristics as starch and proteins are hydrolyzed into sugars and amino acids respectively (Palmer, 2006).

The malting and fermentation process helps to reduce the viscosity of porridges as in maize-soybean weaning blends (Amankwah, 2009; Gibson *et al.*, 1998). Activities of endogenous phytase in cereals, legumes and oil seeds and increased by germination/malting and this promotes the phytate hydrolysis when prepared as porridge for infants and young child feedings.

Iron absorption is also enhanced by germination/malting as a result of the reduction of polyphenols and tannins in legumes and red sorghum through gradual degradation of oligosaccharides (Gibson, 1998; Camacho *et al.*, 1992).

2.6 FACTORS AFFECTING FOOD QUALITY

2.6.1 Farming Practices

Food treated with pesticides or antibiotics, as is the case with a lot of conventionally grown products and animal products areas not as good as organically grown food. The pesticides and hormones used can be harmful to human health, affecting reproduction in men and women. Pesticide exposure is especially dangerous for children and pregnant women, potentially causing developmental problems in young children and foetus (Logan, 2014).

2.6.2 Storage

The amount of time food is stored before eating and the conditions in which it is stored affect its quality. Produce is especially vulnerable to long storage times; generally, the longer the time between when the produce is harvested and when it is eaten lowers its nutritional value. The temperature in storage also affects food quality, foods deteriorate quickly when they are stored in hot, humid conditions
(Logan, 2014).

According to Andrews (2015), proper food storage plays as important a role in food quality as proper food handling. Most green vegetables do best stored at 32 to 39 F with a relative humidity of 95 percent. Most melons and tubers, such cantaloupes, zucchini and potatoes are preserve best when stored between 45 and 50 F with a relative humidity between 90 and 95%. Hot peppers, winter squash and sweet potatoes like it warm, and do best when stored between 50 and 60 F. Food produce should be washed as soon as possible and stored in perforated food-storage bags with 2- to 4-1/2 inch holes for ventilation.

2.6.3 Processing and Handling

Fresh cut fruits and vegetables are commonplace at many supermarkets because they offer convenience to the consumer. However, fresh cut produce deteriorates more quickly than intact produce. The article cites decreased nutritional value as one of the symptoms of this minimal form of processing. Other foods, such as packaged foods, are heavily processed, often enhanced with artificial flavoring or color, man-made fats and other unhealthy additions that reduce their nutritional quality and value (Logan, 2014).

2.6.4 Cooking

The way and manner in which food is prepared affect its quality. Logan (2014) argued that, the four common methods of cooking - microwaving, boiling, stirfrying, and stir-frying then boiling caused substantial losses in chlorophyll, vitamin C and glucosinolates, active compounds that may have cancer-fighting effects. Steaming is the only cooking method that does not result in such significant losses.

Heat degrades food even when cooked for the right amount of time; overcooking takes the natural degradation of vitamins and minerals to the maximum level and causes irreversible damage to the food's taste and texture. Cooking food to the lowest temperature that kills the microorganisms that cause food-borne illnesses is the best way to retain as much nutrient value as possible. Cook vegetables quickly and with high heat whenever possible, and cook meats just until they reach the U.S. Department of Agriculture's minimum internal temperature thresholds for safe consumption: 165 F for poultry and ground meats and 145 F for whole beef, fish and pork (Andrews, 2015).

2.6.5 Time and Temperature

The temperature gradient between 40 and 140 degrees Fahrenheit affect food quality significantly. The longer food stays between 40 and 140 F, known as the "danger zone" in food-safety terminology, the faster the bacteria the food naturally contains multiplies and reaches food-borne-illness-inducing levels. The toxins that develop after food sits in the danger zone too long are not killed by heat either and reheating a chicken let to sit out overnight, to 165 F would not decrease the chances of contracting a food-borne illness when it is eaten. To preserve food quality and keep the risk of food-borne illness to a minimum, keep the time it spends in the temperature danger zone to a minimum, and always less than two hours (Andrews, 2015).

2.6.6 Oxidation and Exposure

The longer fruits and vegetables are exposed to air the more vitamins and minerals they lose from oxidation. Fruits and vegetables are disadvantaged from the start when it comes to vitamin and mineral retention. The skins of produce and fruit are nutrient-rich, so those vitamins and minerals are loss when peeled. Oxidation of the flesh begins after peeling. Cutting fruits or vegetables not only increase their exposed surface area, which increases susceptibility to nutrient loss, also increase enzyme activity, which degrades vitamins even more. Vitamin and mineral loss from peeling and cutting is unavoidable. However, it can be minimized by blanching peeled-and-cut produce in boiling water for one minute then submerging it in ice water to lower the temperature. Cut and peeled vegetables should be eaten as soon as possible to get the most nutrients from them (Andrews, 2015).

2.7 METHODS OF FOOD PREPARATION

According to Alfaro (2014), cooking methods in the culinary arts are divided into two categories; dry heat cooking and moist heat cooking.

2.7.1 Dry Heat Cooking

Dry heat cooking refers to any cooking technique where the heat is transferred to the food item without using any moisture. Dry-heat cooking typically involves high heat, with temperatures of 300°F or hotter. Baking or roasting in an oven is a dry heat method because it uses hot air to conduct the heat. Pan-searing a steak is considered dry-heat cooking because the heat transfer takes place through the hot metal of the pan. Dry-heat cooking methods include; Sautéing and pan frying,
Roasting & Baking, Broiling & Grilling and Deep-Frying.

2.7.2 Moist Heat Cooking

Moist heat cooking methods include any techniques that involve cooking with moisture whether it's steam, water, stock, wine or some other liquid. Cooking temperatures are much lower, anywhere from 140°F to a maximum of 212°F, because water doesn't get any hotter than that. Moist-heat cooking methods include; poaching, simmering & boiling, steaming and braising & stewing.

2.8 CAUSES OF FOOD SPOILAGE

Food spoilage refers to undesirable changes occurring in food due to the influence of air, heat, light, moisture, which foster the growth of microorganisms (Ashiya, 2012).Food spoilage is caused by physical changes such as temperature and mechanical effects caused by the inappropriate transport, handling and storage. Biological factors; microbiological bacteria, yeasts, moulds (most common) and macrobiological rodents, insects, birds, parasites chemical, biochemical factors nonmicrobial or enzymatic changes usually involving oxygen oxidation processes activity of endogenous tissue enzymes (food of vegetable or animal origin). The major causes of food spoilage include: micro-organisms, spoilage by enzymes and spoilage by insects (Ashiya, 2012).

2.8.1 Micro-Organisms

The micro-organisms responsible for food spoilage are moulds, yeast and bacteria. Moulds are in the form of threads developed on perishable foods and are easily visible to the eye. They contain spores which can spread through the air and start new mould plants. When these moulds find a favorable environment, they germinate and produce a fluffy growth, often white or grey but sometimes bluish-green, red, orange or some other colour, depending upon the variety of the mould. Most moulds are not harmful. A relatively small proportion of the moulds, found on foods are capable of producing toxic materials known as mycotoxins of which aflatoxins is an example.

2.8.1.2 Yeasts

Yeasts are tiny organisms which are not visible to the naked eye, but which can be seen through the microscope. They multiply very fast and cause fermentation by acting on certain components of the perishable foods like fruit juices, syrups etc. During yeast fermentation, the sugars present in the food are broken up to form alcohol and carbon dioxide. Foods liable to be spoiled by yeasts are fruit juices, syrups, molasses, honey, jams and jellies.

2.8.1.3 Bacteria

Bacteria are unicellular organism and are much smaller in size than either yeasts or moulds. They occur in different sizes and shapes and are classified as coccus (spheroidal), bacilli (cylindrical) or spirillae (spirillar) on the basis of their shape as seen under the microscope. They also vary in their requirement for food, moisture, acidity, temperature and oxygen. Bacteria can grow and develop rapidly between 20°C and 53°C. Bacteria are classified according to the temperature ranges that they need for growth (Ashiya, 2012). As indicated by Josh (2013) bacterial waste is the cause of the foul smell and rotten appearance of spoiled food.

2.8.2 Spoilage by Enzymes

Enzymes are organic catalyst present in living cells. The life of every living cell depends upon the chemical reactions activated by these enzymes. Hence, they cause food spoilage due to the chemical reactions as in cutting apples; it becomes brown while tomato cause develops a black scum. Enzymes are sensitive to heat and are easily destroyed by heat. They can act from 0°C to 60°C; their optimum temperature of reaction is usually 37°C. All enzymes are inactivated by temperatures above 80°C. Therefore, enzyme activity can be prevented by heating foods to temperature which inactivate the enzymes. It can also be prevented by cooling (as in freezing and refrigeration) by elimination of air, by protection from light and by addition of anti-oxidants (Ashiya, 2012).

2.8.3 Spoilage by Insects

Worms, bugs, weevils, fruit flies, moths cause extensive damage to food and reduce its nutritional value and make it unfit for human consumption. Insects destroy cereal grains by not only consuming the food but contaminating the food.

CHAPTER THREE

3.0 MATERIALS AND METHOD

3.1 STUDY AREA AND SCOPE OF THE STUDY

For the purpose of the study, the northern region of Ghana was targeted. The region produces major cereals and grains including the crops under study. However, based on the variability of the different crops grown in the northern region and also for limited time and resources for the work, two districts namely; Sevelugu and Torlong were selected. A community was purposely selected from each district, thus Duko and Tingoli respectively. The major crops produced in these communities include maize, yam, groundnut, millet, cowpea, soybean, sorghum, onion, rice, sheabutter etc.

3.2 QUESTIONNAIRE ADMINISTRATION

Two sets of questionnaires were used to gather data for the study. The questionnaires were administered in the two districts at different periods. Other secondary data and relevant information and literature were gathered from official sources and statistical materials. Structured questionnaires made of open and close – ended questions were designed and used to gather the following bio- data of respondents: age , gender, level of formal education, type of breakfast meal, ingredients used in preparation of porridge, how the raw materials are processed for the porridge, other ingredients added during processing, whether some of the porridge flours are sold, stored or utilized at once, how long they are stored (if that is the case), the quality of porridge from stored flour, other food eaten together with the porridge, whether young ones are fed with the same porridge, ages of the children who are fed with the same porridge and reasons for taking porridge as breakfast meal.

The second set of questionnaire was administered to evaluate the sensory characteristics of the treatment (composite flour). The data gathered from this set of questionnaire was respondents' preference for the treatment in terms of aroma, colour and taste. This was to enable the researcher determine the most preferred treatment for laboratory analysis and development and subsequent adoption by the communities.

The questionnaires were pre-tested on a smaller sample of respondents at the KNUST campus for context variability as specified by Rogers (1995). The data for the study was generated from a survey from caregivers and farmers of these two communities.

3.3 SAMPLING PROCEDURE AND DATA COLLECTION

In all, 120 respondents were selected for the study. Sixty of them responded to the questionnaire on food stuff used in preparing breakfast porridge and the other 60 on the sensory characteristics of the treatments. The respondents were selected from care givers and farmers. Many of them were women. The selected group for the study was a subset of the farmers under IITA catchment area on project to better the lives of the rural farmers. The respondents were purposely selected

3.4 PHASE ONE: THE DATA COLLECTION

The research was done in phases. The first phase involved a review of popular crops grown and eating patterns of households in the selected communities. This was to ascertain whether the farmers really make use of the important crops they produce from their farms to enhance the nutrient profile of their diets or not as emphasized by the World Bank (1994) that the relationship between food production and food consumption is more complex.

3.5 PHASE TWO: DEVELOPMENT OF COMPOSITE FLOUR

Samples of the raw materials (maize, millet and soybean) were collected from the open market. The focus of the study was to try to improve the cereal-based porridge commonly eaten in the targeted communities with a legume (soybean) to make them nutritionally enhanced.

The millet was washed and sieved to separate the grains from the sand and stones. Smaller grains are noted to contain sand and stones because of the way they are processed after harvesting. Un-wholesome grains and other materials were also picked from the maize to make them clean. The millet was soaked in water over night (24 hours) to ferment and softened before milling. The fermentation process, according to Alnwick *et al.* (1988), is a household level food technology that reduces the viscosity of stiff porridges and raises the levels and bio-availability of proteins, vitamins and minerals. It also enriches the foods through the synthesis of some B vitamins, adds flavour and helps to protect the food from diarrhoea – causing microorganisms.

The soybean on the other hand was cleaned of all stones and debris by picking and roasted before milling. The application of heat through the roasting process reduced the cooking time as well as improved the eating quality of the food.

Different ratios of cereal: legume mixtures were made (in terms of volume) to form composite flour. Thus five maize: soybean and five of millet: soybean representing the treatments were made as follows:

A (Maize : Soybean)	B (Millet : Soybean)
90% maize : 10% soybean	90% millet : 10% soybean
80% maize : 20% soybean	80% millet : 20% soybean

70% maize : 30% soybean	70% millet : 30% soybean
60% maize : 40% soybean	60% millet : 40% soybean
50% maize : 50% soybean	50% millet : 50% soybean

3.6 PRE-TESTING AND FIELD TRIALS (SENSORY TRIALS)

All the ten (10) compounded porridge flours, which represent the treatments, were pre-tested at the Horticulture Department of Kwame Nkrumah University of Science and Technology. This was to evaluate the acceptability (level of preference) of the treatment in terms of colour, aroma and taste.

Porridges were made from the different composite flours and students were made to observe smell and taste. They were made to evaluate and score from 1-7 scale of preference with the least magnitude indicating the preferred treatment.

The actual sensory trials was done in the two selected communities (Duko and Tingoli) respectively. The farmers, many of whom were women, were made to score using the same procedure and instructions as above.

However, instead of rinsing their mouths with water after tasting each treatment, the scorers were made to chew a bit of biscuit (cream cracker) to neutralise the mouth after tasting each sample.

3.7 LABORATORY ANALYSIS

The best two preferred porridge were subjected to laboratory analysis to evaluate their nutritional compositions. This was to help determine whether there has been enhancement of nutrients in the cereal flours as a result of the legume addition for the adoption.

3.7.1 Proximate Composition

3.7.1.1 Moisture content determination

Moisture content was determined by weighing 2g each of the flours into well labeled petri dishes using an electronic weighing scale (ADAM AAA 100LE scale), placed in a Magtech oven for about 24 hours at 60 ^{0}C and dried to constant weights. The petri dishes and flours were allowed to cool and reweighed afterwards. Percentage moisture and dry matter content were then determined using AOAC (1990) method:

$$\%Moisture = \frac{M_{INITIAL} - M_{DRIED}}{M_{INITIAL}} \times 100$$

Where, $M_{INITIAL}$ and M_{DRIED} are the mass of the sample before and after drying.

3.7.1.2 Crude protein determination

The crude protein was obtained by determining the organic nitrogen content of the sample using the Kjeldahl method (AOAC, 1990). Two (2) g of each flour was weighed into a 500ml digestion flask. 10ml of distilled water was added and one digestion tablet was added to it as a catalyst. 2 ml of concentrated Sulphuric acid and 2ml of 30% hydrogen peroxide was added to the digestion flask. The sample was digested for 30 minutes till a colourless solution was obtained. The digest was then cooled, diluted with a small quantity of distilled ammonia-free water (100ml) and transferred into a distillation apparatus. The Kjeldahl flask was then rinsed with distilled water to make sure all the digest has been transferred. 10ml out of the 100ml digest was pipetted into a distillation flask and 90ml distilled water was added to it. 125 ml Erlenmeyer flask with 6ml boric acid solution and 3 drops of indicator solution was placed under a condenser. 8ml of sodium hydroxidesodium thiosulphate solution was added to still and steam distilled until about 50ml distillate was collected. Solution was titrated to gray end point or first appearance of violet. A reagent was run blank with equal volume of distilled water and the titration volume was subtracted from that of the sample titration volume. The Nitrogen content of the sample was calculated as:

$$\% \text{ Nitrogen} = \frac{\text{(ml acid x normality of standard acid)}}{\text{Weight of sample (g)}} \times 0.014 \times 100$$

Thus, % Crude Protein= Total Nitrogen (N_T) x 6.25(Protein factor)

3.7.1.3 Ash content determination

The ash content of the flours was estimated by igniting a weighed sample of 2g in a weighed crucible at a temperature of 500° C for about 3-4 hours in a muffle furnace. The crucible was removed from the furnace, allowed to cool and weighed.

The ash content was calculated using the formula (AOAC, 1990):

$$\% \text{ A}\textit{sh content} = \frac{\text{Weight of ash}}{\text{Weight of sample}} \times 100$$

3.7.1.4 Fat determination

The doxhlet extraction method was used to determine the fat content of the flours. An extraction flask was placed in an oven for about 5 minutes at 110^0C, cooled and then weighed. The sample was placed in a piece of filter paper and then a second filter paper was wrapped, which is left open at the top like a thimble. A piece of cotton wool was placed at the top to evenly distribute the solvent as it drops on the sample during extraction. The sample packet was placed in the butt tubes of a soxhlet extraction apparatus. The extract was heated for about 3 hours with 200ml of petroleum ether and the sample was allowed to cool. The ether was evaporated on a steam bath or water bath. The fat content was collected and calculated by the formula (AOAC, 1990):

$$\% \text{ Fat content} = \frac{\text{Weight of ether soluble material}}{\text{Weight of sample}} \times 100$$

3.7.1.5 Crude fibre determination

The crude fiber was organic residue which remains after the sample has been treated under standard conditions with standard boiled acid and alkali solutions (AOAC, 1990). It was determined by hydrolyzing the sample with of 0.125 ml H_2SO_4 and 0.25 ml of NaOH.

The residue from the fat extract was transferred into a 750ml Erlenmeyer flask. 0.125 ml of boiling H_2SO_4 solution was added as well as a 0.5g of asbestos. The digestion flask was connected to a condenser and heated for about 30 minutes after which the flask was removed, filtered immediately through linen and washed with boiling water until the washings were no longer acidic. 0.25 ml of NaOH solution was heated and kept under a temperature under reflux condenser. The residue was then washed into the flask into the NaOH solution. The flask under reflux condenser was boiled for 30 minutes after which the flask was removed and filtered immediately through the Gooch crucible. After thorough washing with boiling water, the residue was washed with about 15ml of 95% ethanol. The crucible and its content were dried at 100°C to constant weight and weighed. Contents of the crucible was incinerated in muffle furnace at 600ºC for 30 minutes until the carbonaceous matter has been consumed. The loss in weight was recorded as crude fibre and crude fibre was calculated as:

$$\%\textit{Crude fiber} = \frac{\text{Loss in weight}}{\text{Weight of sample}} \times 100$$

3.7.1.6 Carbohydrate (Nitrogen Free Extract, NFE) determination

The carbohydrate content was determined as difference after analyzing the ash, crude fibre, fat and crude protein (AOAC, 1990). The calculation was made by addition of all the percentage values on dry matter of these analysed contents and subtracted from 100%. The Carbohydrate was calculated as follows:

% Carbohydrate (NFE) on dry matter basis= 100%- (% Ash content on DM basis+ % Crude fibre content on DM basis + % fat content on DM basis + % Protein content on DM basis)

3.7.2 Mineral Composition

Using the Association of Analytical Chemist method (AOAC, 1990), the mineral components such as the iron, zinc, potassium, phosphorus, calcium, manganese, sodium and magnesium were determined. Two (2) g each of flour samples were placed in a crucible for 1-2 hours and pre-ash until the sample was completely charred on a hot plate. The pre-ash samples were then placed on a muffle furnace and again ash at 500°C for about 3hours until the ash turned white. The ash sample was cooled, weighed and then transferred into a 50 ml volumetric flask.

The crucible was then washed carefully with 5 ml of 30 % HCl and diluted with iodized water to a 50 ml volume. The solution was then used for individual determination of mineral using spectrophotometer and flame photometer.

3.7.2.1 Iron (Fe) determination

Aliquots of standard sample and blank were pipetted into test tubes and absorbance measured at 248 nm using air-acetylene flame. Calibration curve of absorbance was then drawn against the concentration of iron to determine the iron concentration (AOAC, 1990).

3.7.2.2 Phosphorus (P) determination

Using the AOAC (1990) method, 5ml digest of each flour sample was measured and put into a 50 ml volumetric flask. 10 ml of vanadomolybdate was then added to each sample and the volumes in the flasks were made up with distilled water to the 50 ml volumetric. The flask content was thoroughly mixed by shaking and kept for 30 minutes. A yellow colour which developed was read at 430 mm wavelength on a spectrophotometer. Percentage transmittance was recorded and absorbance level determined. The content of the phosphorus was determined using a standard curve developed from a standard phosphorus solution (AOAC, 1990).

3.7.2.3 Potassium (K) determination

The potassium concentration was determined using the flame photometry method. The digest was diluted and the potassium emissions measured in air-acetylene flame. A calibration curve of potassium emission against concentration was drawn and compared to that of a standard solution (AOAC, 1990).

3.7.2.4 Calcium (Ca) determination

Ten (10) ml of 10 % KOH solution was added to 5 ml aliquot of the sample solution followed by 1ml of 30% triethanolamine. Three drops of 10 % KCN solution and a few crystals cal-red of indicator were added, mixed thoroughly and shaked. The mixture was then titrated against 0.02 N EDTA solution from a red colour until a blue end point was obtained. Calcium concentrations were then calculated (AOAC, 1990) as:

Calcium in mg = Titre value of EDTA x 0.40

3.7.2.5 Magnesium (Mg) determination

Using the AOAC (1990) method with slight modifications, 5 ml ammonium chloride – ammonium hydroxide buffer solution was added to 5 ml aliquot of sample solution in a 100ml conical flask followed by 1 ml of triethanolamine. Three drops of 10% KCN solution and few drops of EBT indicator solution were then added. The flask content was thoroughly mixed, shaken and then titrated agaist 0.02 N EDTA solution from a red to blue end point. Magnesium concentrations were then calculated as:

Magnesium (mg) = Titre value of EDTA x 0.24

3.7.3 Determination of Micronutrients

Samples weighing 0.5g were weighed into crucibles and placed in a muffle furnace at a temperature of 450°C for 3 hours. They were left to cool after which the samples were removed from the furnace and 10ml of 1:2 dilute Nitric acid solution was added to each sample. They were placed on a hot plate until the first sign of boiling was observed, after which the samples were filtered into 20ml flask and made to the mark

with distilled water. The various concentrations of the elements were determined using the Atomic Absorption Spectrophotometer (AAS) after calibrating the AAS with standards of the elements to be determined (Soil
Laboratory Staff, CSIR-SRI).

3.8 EXPERIMENTAL DESIGN

The experimental design used was a Completely Randomized Design (CRD). Each treatment was replicated three times.

3.9 DATA ANALYSIS

The field data was analysed using Statistical Package for Social Sciences (SPSS). Results were presented in tables and graph.

The data from the laboratory analysis were analysed statistically using STATISTIX Version 16.0 and subjected to analysis of variance (ANOVA). The differences between treatment means were determined using least significant difference (LSD) at 1% level of significance (p=0.01).

CHAPTER FOUR

4.0 RESULTS

4.1 GENDER OF RESPONDENTS

From the results (Figure 4.1), 76.7% of the respondents were female while 23.3% were male.

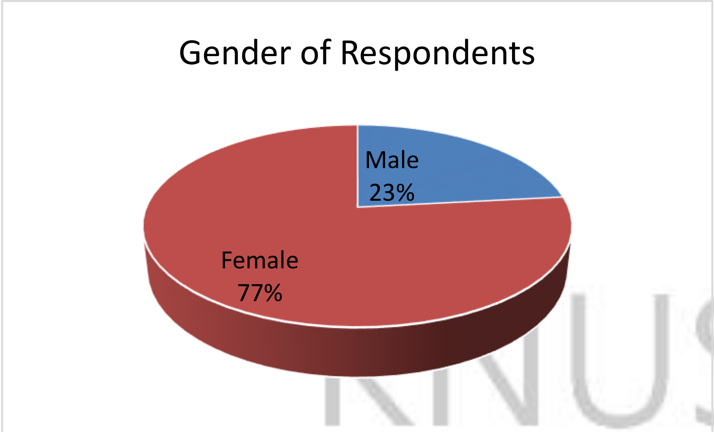

Figure 4.1: Gender of respondents

4.2 AGE OF RESPONDENTS

Figure 4.2 shows the age distribution of the respondents. Few (3.3%) of the respondents were less than 20 years, 18.3%, 20%, 38.3% and 15% were between 21-25 years, 26-30 years, 31-35 years and 36-40 years respectively. Five percent (5%) were 40 years and above.

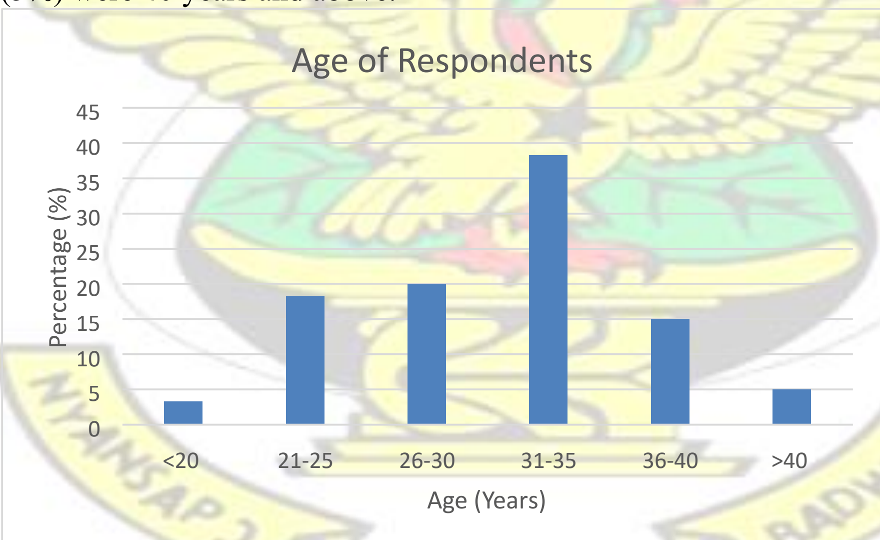

Figure 4.2: Age of respondents

4.3 EDUCATIONAL BACKGROUND OF RESPONDENTS

Figure 4.3 shows that 51.7%, 26.7%, 11.7% and 10% of the respondents had no formal education, basic education, secondary education and tertiary education respectively

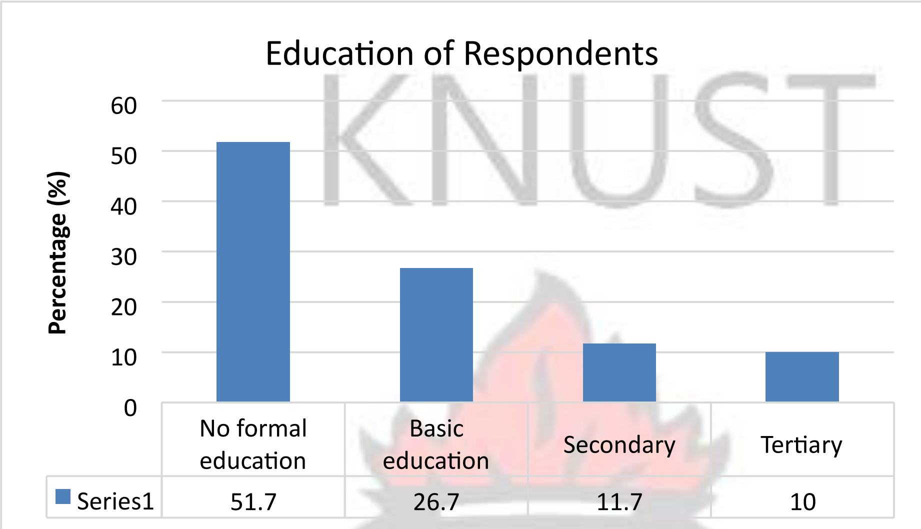

Figure 4.3: Educational background of respondents

4.4 RESPONDENTS BREAKFAST

Majority (98%) of the respondents took porridge for breakfast while 2% had tea for breakfast (Figure 4.4).

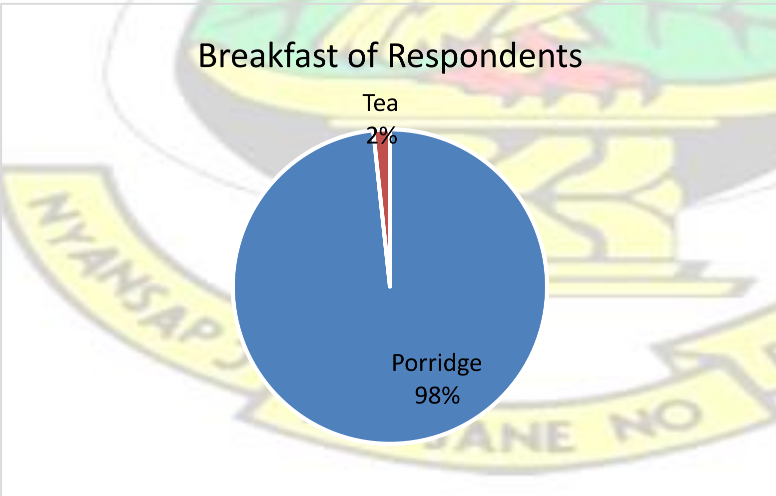

Figure 4.4: Breakfast of respondents

4.5 CONSTITUENT OF PORRIDGE FLOUR

From Figure 4.5, majority (51.7%) used only maize flour in preparing porridge for breakfast, 18.3% only millet flour, 23.3% used only sorghum flour, 1.7% millet and soybean flour while 5% used maize and soybean flour.

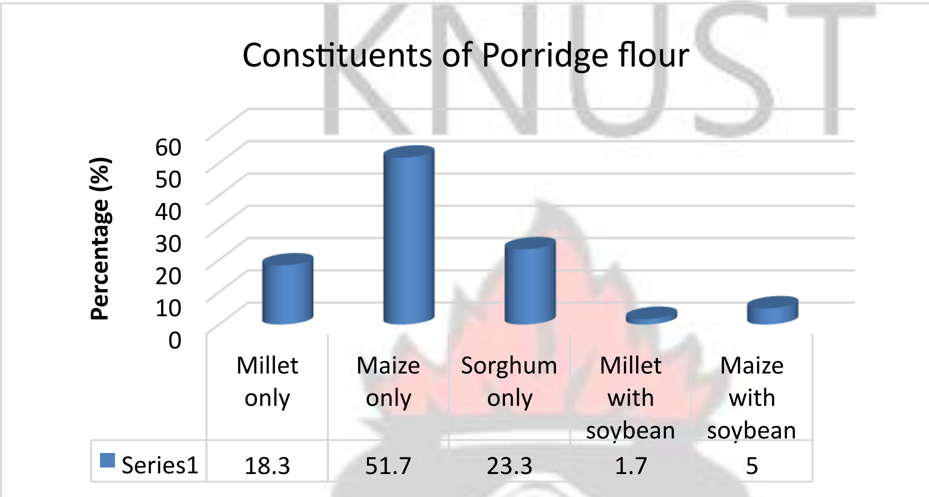

Figure 4.5: Constituents of flour used for porridge preparation

4.6 PROCESSING METHODS OF FLOUR BEFORE PORRIDGE PREPARATION

From the interview (Figure 4.6), most (45%) of the respondents soaked, milled and fermented their flour before preparing the porridge, 6.7% only roasted and milled while 48.3% milled dried their flour before preparing the porridge.

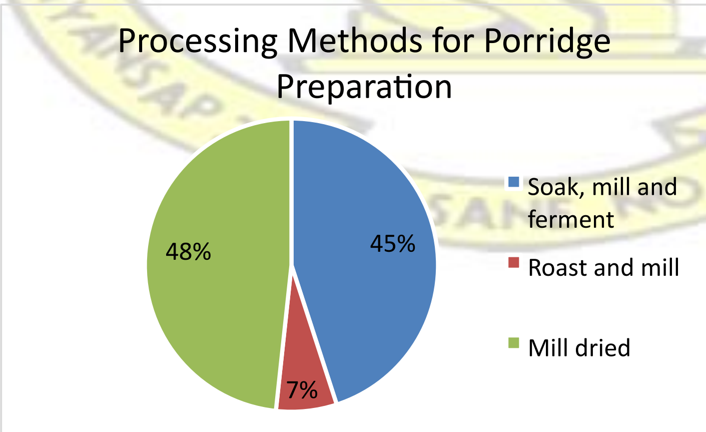

Figure 4.6: Processing methods of flour before porridge preparation

4.7 OTHER INGREDIENTS FOR PORRIDGE PREPARATION

Figure 4.7 shows that most (83.3%) of the respondents added other ingredients during preparation of porridge while 16.7% did not. The ingredients used included millet, ginger and pepper (5%); pepper and ginger (46.7%); pepper, ginger and "kanafiri" (13.3%); small amount of sorghum (5%); pepper, ginger and "mosoolo" (8.3%); pepper, ginger, "mosoolo" and "chimbu" (3.3%) and pepper, ginger, "kanafiri" and "mosoolo" (1.7%) (Figure 4.8).

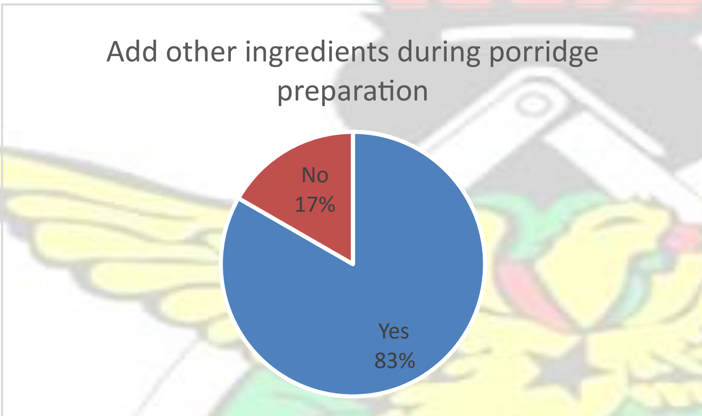

Figure 4.7: Other ingredients added during porridge preparation

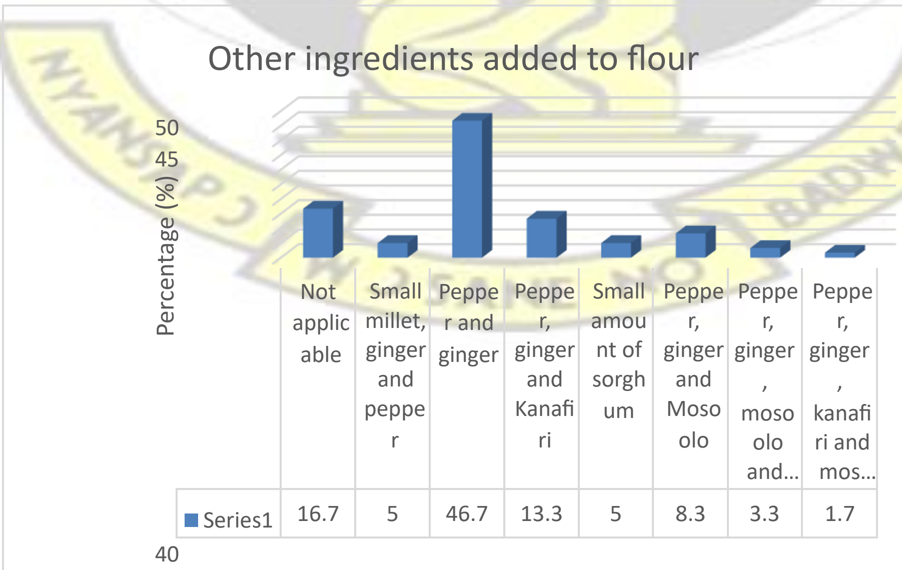

Figure 4.8: Other ingredients added to flour before preparation of porridge

4.8 STORAGE OF PROCESSED FLOUR

Table 4.1 shows how processed flour were stored. Majority (90%) of the consumers did not consume processed flour on the same day while 10% of them did. Some respondents (3.3%) stored their flour in the refrigerator, 75% of them dried and stored it in plastic container with cover, 6.7% dried and stored it in pots while 6.7% stored it in fertilizer bags. 38.3% of the respondents stored processed flour for less than a week, 45% 1-2 weeks, 5% 3-4 weeks and 3.3% stored the flour for 5-8 weeks

(3.3%). However, 8.3% of the respondents did not store the flour.

Table 4.1: Storage methods and duration of processed flour

STORAGE OF PROCESSED FLOUR	DESCRIPTION	PERCENTAGE (%)
Consume processed flour same day	Yes	10
	No	90
Total		**100**
Storage Methods	Store in refrigerator	3.3

	Dry and store in plastic container with cover	75
	Dry and store in pots	6.7
	Store in fertilizer bags	6.7
	Do not store	8.3
Total		**100**
Storage Duration	Less than a week	38.3
	1-2 weeks	45
	3-4 weeks	5
	5-8 weeks	3.3
	Do not store	8.3
Total		**100**

4.9 QUALITY OF STORED FLOUR

Most of the respondents (38.3%) indicated that the stored flour had the same quality as when not stored, 5% indicated the stored flour was better in quality while 48.3% indicated that store flour had poorer quality than when not stored (Figure 4.9). However, 8.3% did not store their flour.

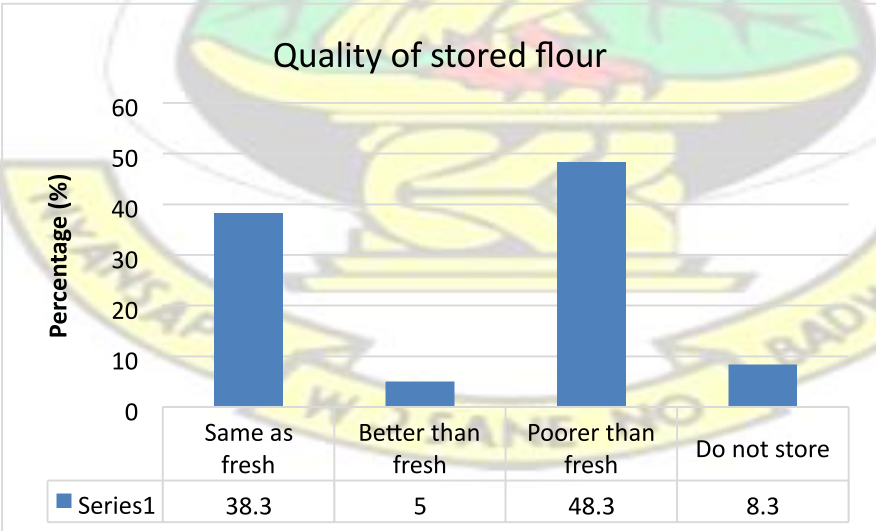

Figure 4.9: Quality of stored flour

4.10 QUALITY EVALUATION OF STORED FLOUR

From Figure 4.10, most respondents (28.3%) indicated the flour becomes sour after storage, 20% indicated the flour changes in flavour while 5% indicated the flour had a bad odour after storage. However, 46.7% did not experience any of these because they did not store their flour or the stored flour did not change in quality.

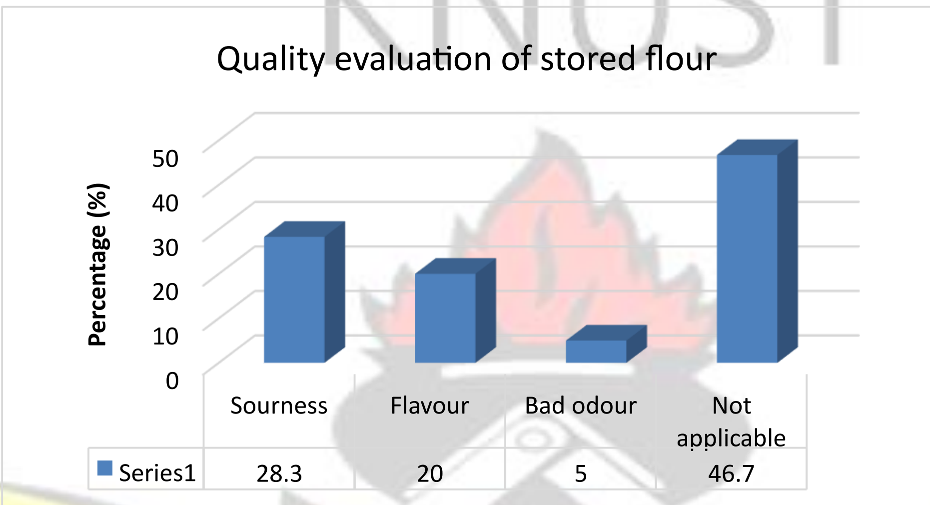

Figure 4.10: Quality evaluation of flour by respondents

4.11 COMPLEMENTS TO PORRIDGE FOR BREAKFAST

Figure 4.11 shows that most of the respondents (38.3%) added roasted groundnut to the porridge as breakfast, 31.7% added "koose", 3.3% added "maasa", 10% added bread, 1.7% added doughnut (bofrot), 11.7% added only sugar while 3.3% added kulikuli.

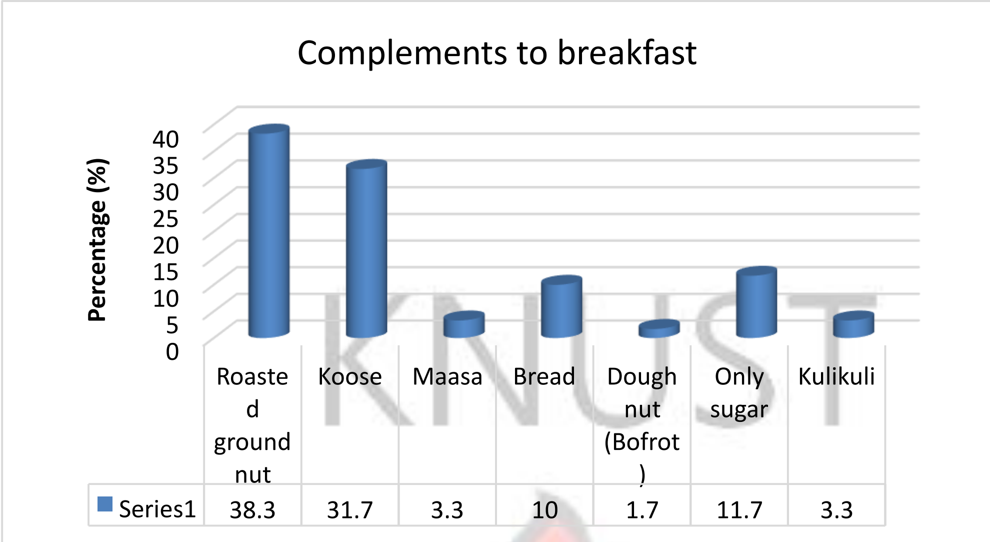

Figure 4.11: Complements to porridge for breakfast

4.12 PORRIDGE FLOUR FOR CHILDREN

From the interview (Figure 4.12), most respondents (86.7%) used the same flour prepared for adults to prepare food for their children while 13.3% did not. Of those who did not use the same flour (Figure 4.13), 6.7% used smoother and less chaff flour for the children, 3.3% did not add ginger to the flour, 1.7% prepared maize and soybean flour while 1.7% added milk or groundnut paste to the porridge prepared from the flour.

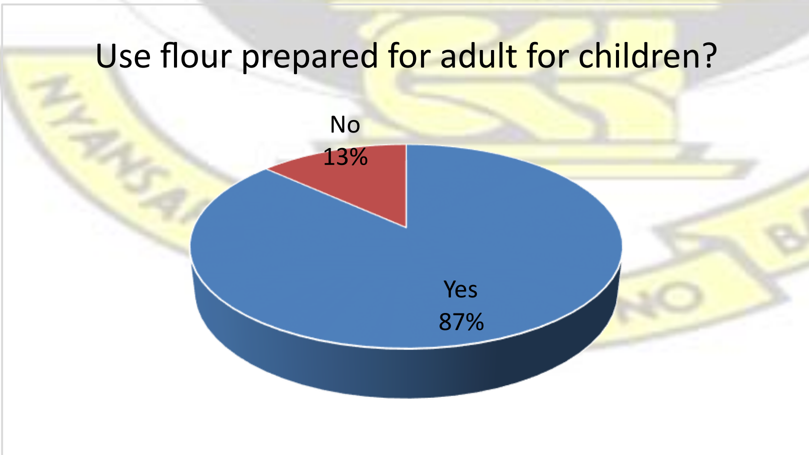

Figure 4.12: Use flour prepared for adult for children?

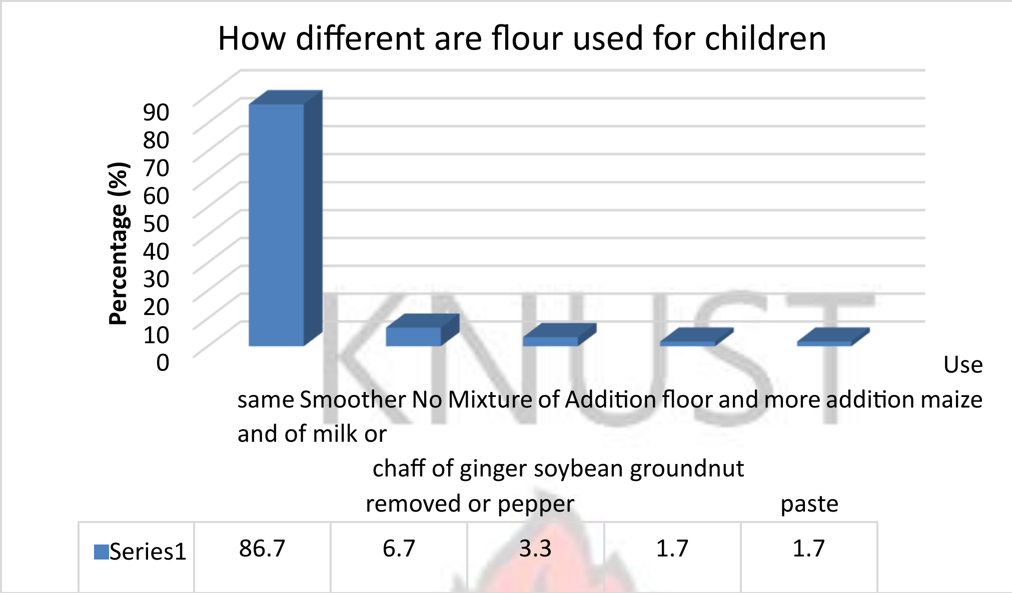

Figure 4.13: Difference in flour used for children

4.13 AGE OF RESPONDENTS' CHILDREN

The age distribution of respondents children were less than six months (5%), 6-12 months (16.7%), 1-2 years (35%), more than 2 years (38.3%) and all the mentioned years (5%).

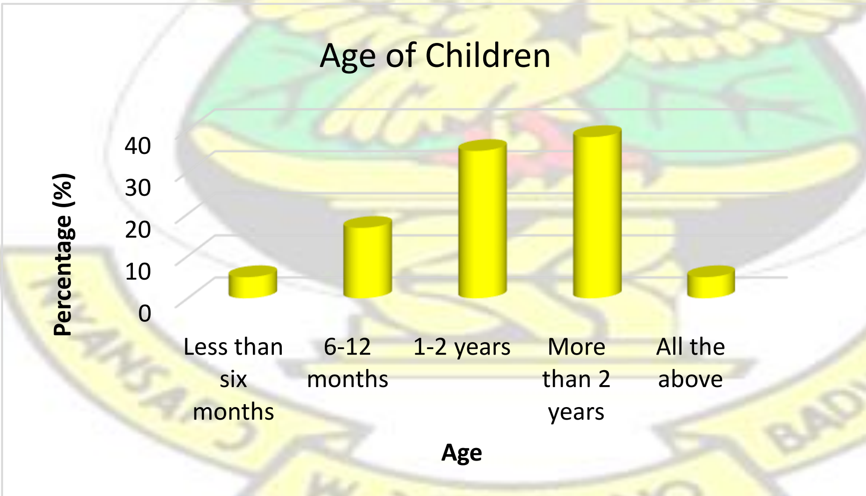

Figure 4.14: Age distribution of respondents' children

4.14 REASONS FOR CONSUMING PORRIDGE FOR BREAKFAST

From Figure 4.14, respondents consumed porridge for breakfast because it was tasty (25%), it gave them energy (60%) and because it was nutritious (8.3%). However, 6.7% consumed it to satisfy their hunger.

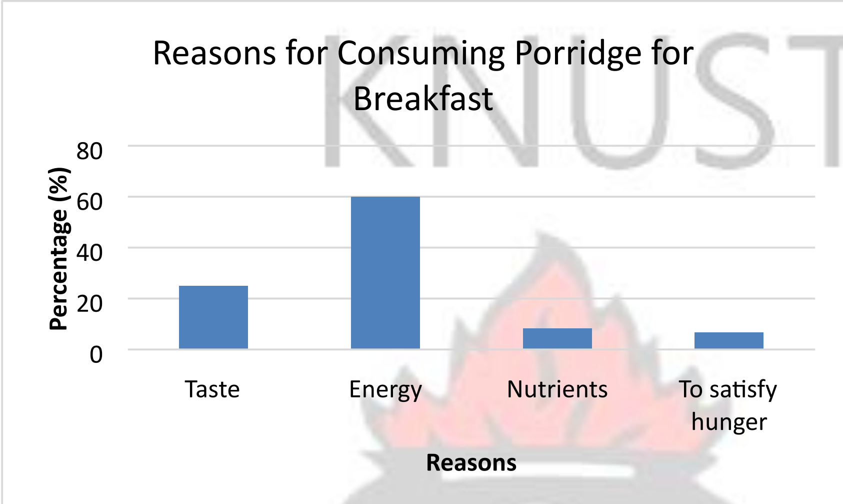

Figure 4.14: Reasons for consuming porridge for breakfast

4.2 SENSORY EVALUATION OF PORRIDGE

4.2.1 Sensory evaluation of maize-based porridge flour (%Maize: % Soybean)

The sensory results on table 4.2 show that, there were some divergent views in terms of preferences for aroma, colour and taste for the maize: soybean composite flour. However, maize: soybean (90%: 10%) was the most preferred by all measure. It recorded the least mean value of 1.71 which was significantly different from all the others (maize: moybean (80%: 20%); maize: soybean (70%: 30%); maize: soybean (60%:40%) and maize: soybean (50%: 50%) at (P=0.01).

Table 4.2 Sensory evaluation of maize-based porridge.

Treatment	Aroma	Colour	Taste	Overall Acceptability
Maize: Soybean (90%: 10%)	2.39_b	1.27_b	2.60_a	1.71_c

Maize: Soybean (80%: 20%)	2.99_{ab}	2.41_{a}	2.70_{a}	2.68_{b}
Maize: Soybean (70%: 30%)	3.61_{a}	2.9_{a}	2.84_{a}	3.20_{ab}
Maize: Soybean (60%: 40%)	3.70_{a}	2.97_{a}	2.66a	3.56_{a}
Maize: Soybean (50%: 50%)	3.33_{a}	2.77_{a}	3.10_{a}	3.64_{a}
Lsd (0.01)	0.875	0.733	0.900	0.722

4.2.2. Sensory Evaluation of Millet-Based Porridge (%Millet: %Soybean) Table 4.3 above shows the sensory analysis and results of millet: soybean composite flour. Porridge prepared from millet: soybean (90%: 10%) composite flour was preferably outstanding in terms of aroma, colour and taste. The overall acceptability (mean value) of 1.39 was also significantly better than the rest of the treatments (millet: soybean (80%: 20%); millet: soybean (70%: 30%); millet: soybean (60%: 40%) and millet: soybean (50%: 50%).

Table 4.3 Sensory evaluation of millet-based porridge

Treatment	Aroma	Colour	Taste	Overall Acceptability
Millet: Soybean (90%: 10%)	1.70_{b}	1.17_{c}	1.62_{b}	1.39_{c}
Millet: Soybean (80%: 20%)	3.08_{a}	2.30_{b}	2.88_{a}	2.96_{ab}
Millet: Soybean (70%: 30%)	3.07_{a}	3.23_{a}	2.98_{a}	3.40_{a}

Millet: Soybean (60%: 40%)	3.67_a	3.18_a	2.82_a	2.98_{ab}
Millet: Soybean (50%: 50%)	3.10_a	2.35_b	2.92_a	2.69_b
Lsd (0.01)	0.955	0.814	0.934	0.644

4.3 LABORATORY ANALYSIS OF THE MOST PREFERRED MAIZE AND MILLET BASED FLOURS

Table 4.4 shows the proximate analysis of the most preferred treatment; maize: soybean (90%: 10%) and millet: soybean (90%: 10%). Ash (1.59%), carbohydrate (73.64%), fat (6.0%) and moisture (7.75%) content in the millet: soybean mix and maize soybean mix were statistically the same. However, the protein (15.0%) in the maize: soybean was significantly higher than that in the millet: soybean mix.

Table 4.4 Proximate Analysis of maize and millet based flour.

Treatment	Ash	Carbohydrate	Fat	Fibre	Moisture	Protein
Maize 90%: Soybean 10%	1.45_a	66.94_a	5.5_a	4.6_a	6.50_a	15.0_a
Millet 90%: Soybean 10%	1.59_a	73.64_a	6.0_a	4.1_a	7.75_a	6.88_b
P-value	0.83	0.87	0.48	0.50	0.16	0.00

The results (Table 4.5) showed that phosphorus (P), potassium (K), sodium (Na), calcium (Ca), magnesium (Mg) and zinc (Zn) content of the maize: soybean and millet: soybean were statistically similar (P>0.05). However, maize: soybean mix was higher in iron (0.11mg/100g) and manganese (0.05 mg/ 100g) than that in the millet: soybean mix.

Table 4.5: Minerals of the maize and millet based flour

Treatment	P	K	Na	Ca	Fe	Mg	Mn	Zn
Maize 90%: Soybean 10%	0.23_a	0.15_a	0.40_a	0.11_a	0.11_a	0.20_a	0.05_a	1.04_a
Millet 90%: Soybean 10%	0.16_a	0.4_a	0.30_a	0.11_a	0.07_b	1.16_a	0.03_b	1.03_a
P-value	0.35	0.76	0.22	1.0	0.02	0.30	0.06	0.98

CHAPTER FIVE

5.0 DISCUSSION

5.1 SURVEY

5.1.1 Background Information of Respondents

The study showed that majority of the respondents was females. This could be explained from the numerous roles women play in our societies as care-givers. They do not only support the men in the production of crops but most importantly they are also responsible for preparing acceptable dishes from the produce as well as adding value to the crops through processing to better the lives of the entire family which depends mostly on such farm produce as food and for its proceeds. Many men refused to be part of the preliminary stage of the research because they did not know what goes into the food preparation process although the play key roles in the production stages.

The highest age range of the respondents which was 31-35 years indicated that many of the women were active care-givers and home-makers.

On the educational profile of the respondents, it was realized that out of the 90 farmers and care-givers interviewed, majority had no formal education (51%) or only basic education (26.7%). The implication is that, although the people produce many important crops in the region that could be used to provide the nutritional needs of their families, they may not know the value of such crops and how to utilize them in their dishes to provide variations that could be appreciated and enjoyed by all on regular basis. This confirms the assertion by World Bank (1994) that the relationship between agriculture and human nutrition is far more complex than the economic relationship between food supply and food demand.

The about 88.4% illiteracy rate also means that a lot of community sensitization needs to be done at the community levels on the important nutrients that could be obtained from eating the grain produce in those areas as well as how to prepare and process such crops into dishes that are consumed regularly. Such moves will help improve the dietary quality of the people which is an important consideration in solving the problem of deep-rooted food insecurity and malnutrition (Singh and Raghuvanshi, 2012).

5.1.2 Breakfast of Respondents

Figure 4.4 indicated that, majority (98%) of the people sampled who took porridge type of breakfast, had their porridges prepared from only maize flour (51.7%), only millet flour (18.3%) and only sorghum flour (23.3%). However, a few (6.7%) prepared their porridges from maize: soybean or millet: soybean flour, but the level of inclusion of the soybean which is the legume could not be told exactly during the interview. All these grains used to prepare the porridge flours were produced by the people in the Northern Region as indicated by GNA (2014) and it was therefore less expensive and readily available than the other beverage types of breakfast which were consumed by only 2% of the respondents. With fewer people (6.7%) purposefully adding soybean to their cereals (maize and millet) meant that, most of their breakfast diet could supply the energy needs of the people but the protein profile may not be adequate, especially for the growing children who are fed with the same porridge as the adults (54.7%) and who could not chew the other complements such as groundnuts and “koose” or “maase” etc. even if the parents could afford to buy them.

5.1.3 Processing Methods

The respondents used one processing method or the other during the preparation of flour for porridge. The method used depended on the type of cereal used for the porridge flour. Majority (48%) of the people milled their grains in the dry state to produce a fine or course flour for the porridge preparation while 45% (Figure 4.6) preferred to soak, mill and ferment to produce dough for their porridge preparation. However, a few (6.7%) roasted their grains before milling into flour for porridge. This probability represents those who took the tom brown type of porridge (maize + soybean) roasted and milled together (figure 4.5).

All the above are traditional household food processing methods which have some unique effects on the physiochemical as well as the eating quality (sensory quality) of the food.

In this research work, the cereals (maize and millet) were subjected to the process of soaking, milling and fermentation while the legume was roasted before milling.

The roasting method adopted, which is an example of thermal processing method, has the potential to reduce cooking time of the porridge which will in turn help to bring out the original starchy characteristics of porridge when prepared from cereals (maize or millet) alone.

The roasting of the soybean also had the ability and possibility of enhancing the decomposition of anti-nutrient factors such as trypsin inhibitors to improve the levels of lysine, methionine and systine amino acids according to Parsons *et al.,* (1992) and Anderson -Haferman *et al.,* (1992).

The roasting of the soybean before cooking had the potential to control/prevent the activities and effects of micro-organisms on food and hence reduced the incidence of diarrhea related to the consumption of legumes by some people, especially children.

The flavour and taste of soybean also are enhanced through the roasting process. The soaking process, on the other hand, softened the grains and had the potential to enhance enzymatic activities because of the moisture. There was the possibility of reducing the phytate content of the grains through the decanted water and thereby enhancing the absorption of iron, zinc and calcium as asserted by Yadav and Sehgal (2002). However, water soluble minerals like sodium, potassium and magnesium might be lost through the decanted water (Perlas and Gibson, 2002).

All the samples were milled to reduce the particle size and to produce the flour for the porridge. Through the milling process, some dietary fibres might have been incorperated into the porridge for human use. It was also likely that the digestibility of protein and starch might have been enhanced through a lowered polyphenol and phytic acid content as discovered by Chowdhary and Punia (1997).

The fermentation of cereal flour might have also not only improved the taste of the porridge but also affected the viscosity of the porridge to look like the original porridge taken by the people through enzyme activity.

5.1.4 Duration of Storage and Quality of Stored Flours

One of the most convenient and economical way of living in smaller communities where the income/purchasing power of the people is lower such as in the villages is to produce/process in bulk quantity and store. In such communities, the people may not even have access to regular electricity or milling machine for regular processing and as such, has to commute to the closest town or city for such facilities.

For this research, 90% of the respondents did not utilize all their processed porridge flours on the same day and they stored them in different containers such as plastics (75%), traditional pots (6.7%) and sacks (fertilizer bags), 6.7% and refrigerators (3.3%). However, 8.3% did not store their flour at all. Such people probably processed and prepared what they can use daily for domestic purposes or prepare porridge for sale to the public.

Some respondents stored their porridge flours for up to 56 days (table 4.1) and this prolonged period of storage coupled with the processing methods used (figure 4.6) and uncontrolled storage environments probably resulted in the deterioration of flour reported by 48.3% of the respondents (Figure 4.9).

Almost forty percent (38.3%) of the respondents accepted that the taste of their processed porridge flour remained the same and this may be as a result of the grains being milled dry without any addition of moisture. The dry samples will have less chemical reactions taking place in it over a period of time but this state may change when chemical reactions begin to take place within the storage media in the presence of oxygen and other micro-organisms. The 5% of the respondents who confirmed that their flour tasted better after storage could be as a result of fermentation reaction in the dough. This is reported by Hotz and Gibson (2001) that the fermentation process enhances the enzymatic reactions and the resultant effect is that, the eating quality (sensory), microbiological and keeping quality of the food is improved. Also, work done by Teucher *et al.* (2004) indicated that low molecular weight organic acids e.g. citric, malic and lactic acids are produced during fermentation. These give the characteristic sour taste of fermented food products. However, due to a longer period of time may had resulted in the reduction of the pH of the flour to the extent of becoming too sour to be appreciated as seen in the report of 28.3% of the respondents at figure 4.10.

Microbial growth in some of the storage system might have accounted for the bad odour and flavour of some stored flours.

The appropriate storage system that could have controlled the storage environment (temperature) and microbial as well as the enzymatic reactions was the refrigeration which was rather not available/assessable to many of the respondents because they could not afford them or they may not be connected to the national grid yet.

5.1.5 Porridge Flour for Children

In most of our rural communities, people feed the young ones with the same food prepared for the adults with little or no moderation. This may be due to ignorance of the consequences, time factor or poverty levels of the people as the case may be. The same situation is seen in this research as 86.7% used the same flour prepared for the adults to feed the children (Figure 4.12). Few (3.4%) of the 90 people interviewed intentionally added a protein source compliment like groundnut paste, soybean flour or milk to their children's porridge. Some of these children may be as young as below 6 months (Figure 4.14).

This means that about 56.7% or more (less than 2 years and a little over 2 years) of the correspondents' children are not fed with balanced diets and their protein needs could not be met although the energy requirement of the diet could be supplied as confirmed by work done by FRI & IITA (2013) that there is still protein malnutrition among growing children in the Northern and upper regions of Ghana although about 90% of the household prepare their own food. This is because such children (2 years and below) cannot chew the other compliments such as groundnuts, “koose”, “maasa” or kulikuli (Figure 4.11) that could supply some proteins and soil/fat to balance the carbohydrate content from the cereals. In this case, incorporating a protein source food into the cereal-based porridge for such children would be the best way of controlling malnutrition in children for healthy growth and proper development.

5.1.6 Reasons why Respondents take Porridge as Breakfast

The respondents had various reasons for consuming porridge for breakfast. Being a farming community and considering formal education level, majority (60%) consumed porridge for energy (Figure 4.14) and to some, for its taste (25%). The porridge may probably be the most convenient and fastest way of getting their energy to start the day’s work but since their children were also fed with the same, purposeful education and skill training on how to utilize the legumes (especially soybeans) in the porridge flour to provide all-in-one composite flour that would not only provide energy but also proteins, fats and other minerals for proper growth and development is very paramount. Such social intervention will help to efficiently translate production into proper nutritional health of the people.

5.2 SENSORY EVALUATION OF TREATMENTS

5.2.1 Sensory Analysis of Maize/Soybean Composite Flour

The result from Table 4.2, the maize: soybean mix (90%: 10%) recorded aroma (2.39), colour (1.27), taste (2.60) and overall acceptability (1.71) which were statistically better than the mean values of the other four treatments. This indicated that the people (respondents) preferred the treatment with the least level of inclusion of soybean, thus, 90% of maize and 10% of soybean for its aroma, colour and taste.

Colour is critical in the appearance of food, according to Rogers (1995) and it is one of the features that attracts people to like or dislike a particular food.

The reason could be probably due to the characteristic taste and aroma of soybean.

Rowland (1993) reported that, “Despite official encouragement of soybean because of its potential value in combating protein malnutrition, the crop has not proved very acceptable to African tastes.”

Also, the respondents preferred the maize: soybean (90%: 10%) because it may be closer to what they are used to (the maize without any legume) and had close/similar sensory characteristics as their own. Switching to something similar in taste, aroma and colour was easier and acceptable than those with sharp contrast.

5.2.2 Sensory Analysis of Millet/Soybean Composite Flours

The millet: soybean mix scored aroma (1.70), colour (1.17) taste (1.62) and overall acceptability (1.39) which were statistically better than the mean values of the other four treatments.

Again, reasons might be attributed to the characteristic taste and aroma of soybean.

According to Rowland (1973), “Despite official encouragement of soybean because of its potential value in combating protein malnutrition, the crop has not proved very acceptable to African tastes.”

Respondents also preferred the millet: soybean (90%: 10%) because it may be closer to what they are used to (the millet without any legume) and had close/similar sensory characteristics as their own. Switching to something similar in taste, aroma and colour was easier and acceptable than those with sharp contrast.

5.3 LABORATORY ANALYSIS OF MAIZE AND MILLET BASED FLOURS

5.3.1 Proximate Composition of the Flours

5.3.1.1 Ash

The proximate results (Table 4.4) showed ash contents of 1.45 and 1.59 for maize: soybean (90%:10%) and millet: soybean (90%:10%) and the values were statistically the same at ($P=0.01$).

FAO (1992), however, reported that maize kennel has an ash content of 1.3 which was slightly lower than what was recorded in this work. The slightly increased value of ash was expected and may be due to the ash content of the fortifier (10% soybean) which is noted to be higher in ash (Lokuruka, 2010). The presence of ash in the composite flours may also be because the bran and the germ of the cereals were not removed during processing as confirmed by Abbey and Macdonald (1976). The ash content recorded in the Millet: soybean (90%:10%) also was not in confirmation with the work of FAO (1992) which reported that depending on the variety, millet may contain between 1.9% and 3.4% of ash. Recording some amount of ash in the composite flours (Maize: soybean (90%:10%) and Millet: soybean (90%:10%)) implies that, consumption of porridge prepared from such flours will provide the individuals some mineral energy for general body performance.

5.3.1.2 Carbohydrate

Both cereals, maize and millet, are good sources of carbohydrate and as such, rich source of energy to the body (Pyke, 1981). This work just confirmed the above assertion as A_1 and B_1recorded 66.94% and 73.64% carbohydrates respectively which were not significantly different ($p \geq 0.01$). This result also implies that consumption of porridges prepared from these composite fours will meet the goals of about 60% of the respondents who take porridge to gain energy (Figure 4.14).

5.3.1.3 Fat

Soybean is known to be an oil seed, producing good amount and quality oil in addition to its rich protein content (Convington, 2004). The high fat contents of the Maize: soybean (90%:10%) and Millet: soybean (90%:10%) composite flours of 5.5 and 6.0% may be due to the effect of or contribution from the soybean which was used as the fertilizer. Pyke (1981) and FAOUN (1995) reported that depending on the variety, unpolished maize and millet may contain 4.3% and up to 4.8% of fat. The implication is that, the difference in fat values recorded from the proximate result may be assigned to the soybean oil and hence, consumption of porridges made from the composite flours would afford the individuals the opportunity to get more energy in addition to Omega-3 oil which is good for the heart and antioxidants
(FAO, 1992) which are good for blood circulation.

5.3.1.4 Fibre

Crude fibre is a component of cereals and grains when they are not polished and they do not necessarily add nutrients to the diet but add bulk to the diet for bowel movement (FAO, 1992; Seton, 1963).

Maize composite flour and millet composite flour recorded 4.6% and 4.1% of crude fibre. These figures were quite higher than what was reported by FAOUN (1995) that, the crude fibre content of millet ranges from 2.3-3.3 % (depending on the variety). The maize bran consists of 75% hemicellulose, 25% cellulose and 0.1% lignin on dry weight basis.

This work confirmed that since the grains were not polished and some levels of crude fibres were recorded, consumption of porridges from such composite flour will help to reduce constipation and its associated colon problems would be minimized.

5.3.1.5 Moisture

The result showed that maize: soybean (90%: 10%) contained moisture content of 65% while the millet: soybean (90%: 10%) was 7.75%. There are no significant differences ($p \geq 0.01$) between the moisture content of the two treatments but these levels of moisture recorded has the tendencies of affecting the storage quality of the composite flour as reputed by Ashiya (2012) that air, heat, light, moisture etc. are among other things that, influence the activities of micro-organism that causes food spoilage.

5.3.2 MINERALS

Analysis of the mineral components of the treatments (A_1 and B_1) revealed the presence of the following minerals phosphorus, potassium, sodium, calcium, iron, magnesium, manganese and zinc which were said to be important in body building (Seton, 1963). There were no significant differences ($p \geq 0.01$) among the treatment except in iron and manganese of which maize: soybean (90%: 10%) values where significantly higher than millet: soybean (90%: 10%).

5.3.2.1 Phosphorus (P)

Maize: soybean (90%: 10%) and millet: soybean (90%: 10%) recorded 0.23% and 0.16% of phosphorus but the differences between values were insignificant ($p \geq 001$).

The presence of phosphorus in the samples confirms work done by Abbey and Macdonald (1976) and Vail *et al*. (1967) that depending on the type and variety cereals may contain a small amount of minerals, including phosphorus especially at the outer skins of the germ.

Lokuruka (2010) also reported that dry soybean contains about 5% ash which includes phosphorus and Devi *et al.* (2011) reported that millet is rich in phosphorus which form a special component adenosine and triphosphate as such a precursor of energy in the body.

However, the figure recorded in this work was lower than what was reported by FAO (1992) that maize may contain 0.9% phosphorus Perhaps a higher level of inclusion of the soybean which is a rich source of the phosphorus would have produced a different picture but notwithstanding, the presence of some levels of phosphorus in maize: soybean (90%: 10%) and millet: soybean (90%: 10%) composite flours implies that consumption of porridges could lead to formation of strong bones and teeth in children and nerve functioning (Whitney *et al.,* 2001).

5.3.2.2 Potassium (K)

Some levels of potassium was recorded in this work and this confirmed earlier work by Lokuroka, (2010); Devi *et al.*, 2011 and FAO, 1992) that soybean, millet and maize contain some amount of potassium in the bran although these crops are not very good source of the mineral (K). The K was seen as the component of the mineral analyzed probably because the grains were not polished to rid of the bran dusting processing and the presence is also indication that consumption of porridges from these flours will enhance muscle contraction and cell metabolism.

5.3.2.3 Sodium (Na)

Maize: Soybean (90%: 10%) flour recorded 0.40% and millet: soybean (90%: 10%) flour had 0.30% and were statistically similar. The presence of sodium in the composite flours may be due to the soybean which was reported by Lokuruka (2010) as having the low concentration of the element among other micro elements. Being a minor element, the presence though low, may help in muscle and nerve activities in the body of consumers of the porridges prepared from such flours.

5.3.2.4 Calcium (Ca)

Equal values of 0.11% were recorded by both maize: soybean (90%: 10%) and millet: soybean (90%: 10%) composite flours. This study confirmed work done by Watt and Merrill (1963), and Devi *et al.* (2011), that maize, millet and soybean depending on the variety may contain some level of calcium which is located mostly in bran. However, the result was contrary to what was reported by Hammond (1986) and Devi *et al*. (2011) who asserted that millet and maize bran are good source the element calcium and hence, higher values would have been expected in millet: soybean (90%: 10%).

Perhaps, a higher percentage or level of inclusion of the soybean could compliment the cereal better to provide calcium needed for strong bones and teeth development in growing children.

5.3.2.5 Iron (Fe)

The mineral iron (Fe), which is needed in diet of people especial children’s diet for the formation of red blood pigment (hemoglobin) which is responsible for carrying oxygen to all part of body were recorded in this work.

The maize: soybean (90%: 10%) flour recorded 0.11% of Fe which was significantly higher millet: soybean (90%: 10%) flour (0.07%) and this reduce iron value in the millet composite flour could be due to the formation of processing method as asserted by Osman (2011).

The implication of the result is that, consumption of porridge prepared from maize: soybean (90%: 10%) flour will better reduce the occurrence of anemia in children and frequent fatigue as more red blood cells are likely to be built than the millet: soybean (90%: 10%) flour.

5.3.2.6 Magnesium (Mg)

Maize: Soybean (90%: 10%) and millet: soybean (90%: 10%) flours recorded some level of magnesium but there were no significant difference between the values of 0.20% and 1.16%.

The presence of the mineral (Mg) in both composite flours is a confirmation of work done by FAO (1992), Devi *et al*. (2011) and Lokuraka (2010) which revealed that all the crops under study have some levels of the magnesium especially in the germ and the bran. The joint effect is that, consumption of can help reduce the effect of migraine and heart attack and among other things.

5.3.2.7 Zinc (Zn)

The level of zinc recorded in maize: soybean (90%: 10%) (1.04%) and Millet: Soybean (90%: 10%) (1.03%) were statistically similar. These levels of the minerals at 10% inclusion of the soybean in the grain composite flour may have the capability of helping in wound healing as well as protein metabolism. The presence may be possibly due to the soybean which is noted to contain some levels of the minor minerals such as zinc (Hammond, 1986).

5.3.2.8 Manganese (Mn)

Maize: Soybean (90%: 10%) and millet: soybean (90%: 10%) composite flours recorded 0.05% and 0.03% of manganese respectively which were significantly different. This implies that consumption of porridges from both flours would provide the individual some health benefit such as protein and carbohydrate synthesis and strengthening of bones especially in growing children. However, the maize: soybean (90%: 10%) flour would have a superior health benefit than millet: soybean (90%: 10%) flour.

CHAPTER SIX

6.0 CONCLUSION AND RECOMMENDATIONS 6.1 CONCLUSION

The study revealed that

- Majority of the respondents (98%) consumed porridge type of breakfast which were prepared from solely cereals (93.3%), thus maize, millet and sorghum flours while only 6.7% added soybean to their cereal flours to fortify them.
- The respondents used the same conventional flours to feed the entire family including children from the ages of six months to two years and above.
- Majority of the respondents (83.3%) stored these conventional flours for convenient and economic reasons up to two weeks which affected the quality of the flours.
- Fortifying the conventional flour with the soybean resulted in improved nutritional composition of the cereal flours.
- The preferred porridges were those fortified with 10% level of soybean.
- The most preferred had protein content of 15% (maize type) and 6.88% (millet type).

6.3 RECOMMENDATIONS

1. It is recommended that A_1 (90% maize: 10% soybean) could be used for preparation of porridge for children who need a lot of protein and mineral for their growth and development since it was nutritionally higher and better.
2. Nonetheless, since the purpose was to improve the protein profile of the conventional porridge, further research should be carried out to analyze the individual amino acids present in the composite flour to really ascertain that those amino acids lacking in the cereals have been replaced adequately by the inclusion of 10% soybean flour.
3. Community sensitization to accept a higher level of inclusion of the soybean flour could probably be done.

4. Lastly, further studies could be done to assess the best storage containers and storage time that will not affect flour quality extensively.

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APPENDICES

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY
FACULTY OF AGRICULTURE DEPARTMENT OF HORTICULTURE

QUESTIONNAIRE ON FOODSTUFFS USED IN PREPARING BREAKFAST PORRIDGE

PROFILE OF RESPONDENTS

Tick or supply the necessary information where applicable.

1. LOCATION …………………………………………………………………
2. AGE:

LESS THAN 20 YEARS 21 – 25 26 – 30 31 – 35 36 – 40

40 AND ABOVE

3. GENDER: MALE FEMALE
4. LEVEL OF FORMAL EDUCATION

i. NO FORMAL EDUCATION

ii. BASIC EDUCATION

iii. SECONDARY

iv. TERTIARY

5. WHAT FOOD DO YOU NORMALLY CONSUME FOR BREAKFAST?

PORRIDGE TUO ZAAFI TUBANI FUFU KOOSE RICE BALLS OTHERS

(SPECIFY)……………………………………

6. WHICH OF THE FOLLOWING FOOD INGREDIENTS IS/ARE USED FOR THE PREPARATION OF THE PORRIDGE?

i. MILLET ONLY

ii. MAIZE ONLY

iii. SORGHUM ONLY iv. MILLET WITH GROUNDNUT

v. MILLET WITH COWPEA

vi. MILLET WITH SOYBEAN

vii. MAIZE WITH GROUNDNUT viii. MAIZE WITH COWPEA

ix. MAIZE WITH SOYBEAN

x. SORGHUM WITH GROUNDNUT xi. SORGHUM WITH COWPEA xii. SORGHUM WITH SOYBEAN

7. HOW DO YOU PROCESS THEM FOR PORRIDGE PRODUCTION?

i. SOAK (for 1 or 2 days), MILL AND FERMENT

ii. ROAST AND MILL

iii. MILL DRIED iv. OTHERS (SPECIFY)

…………………………………………………………………

8. DO YOU ADD ANY OTHER INGREDIENT DURING PROCESSING?

YES NO

9. IF **YES,** LIST THEM.

………………………………………………………………………………………

………………………………………………………………………………………

…………………………………………

10. DO YOU PRODUCE KOKO FLOUR FOR SALE OR STORAGE?

YES ☐ NO

IF YES,

11. DO YOU CONSUME / USE THE PROCESSED FLOUR OR DOUGH THE SAME DAY? YES ☐ NO ☐

12. IF NO, HOW DO YOU STORE THE REMAINING FLOUR/DOUGH?

i. STORE IN A REFRIGERATOR ☐

ii. DRY AND STORE IN A PLASTIC CONTANER WITH COVER ☐

iii. DRY AND STORE IN POTS iv. OTHERS ☐

(SPECIFY)……………………………………………………………………

13. FOR HOW LONG DO YOU STORE?

i. LESS THAN 1 WEEK ☐

ii. 1 – 2 WEEKS iii. 2 – 4 ☐

WEEKS iv. 5 – 8 WEEKS ☐

v. MORE THAN 8 WEEKS ☐

14. HOW IS THE ☐ QUALITY OF PORRIDGE PRODUCED USING THE STORED FLOUR DOUGH? ☐

i. SAME AS FRESH ii.

BETTER THAN FESH ☐

iii. POORER THAN FRESH ☐

15. IF DIFFERENT, HOW DOES IT DIFFER FROM THE ORIGINAL?

i. SOURNESS ☐

ii. FLAVOUR ☐

iii. OTHERS

(SPECIFY)………………………………………………………………………

16. WHAT OTHER FOOD DO YOU EAT TOGETHER WITH YOUR PORRIDGE?

i. ROASTED GROUNDNUT

ii. KOOSE

iii. MAASA

iv. BREAD

v. DOUGHNUT(BOFF LOAF/BOFF LOAT)

17. DO YOU FEED THE YOUNG ONES WITH THE PORRIDGE? YES
NO

18. DO YOU USE THE SAME FLOUR OR DOUGH FOR THE CHILDRENS PORRIDGE? YES NO

19. IF NO, HOW DIFFERENT IS THE CHILDREN'S PORRIDGE FROM THE ADULT?

……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………………………………………………………………
……………………………………

20. WHAT ARE THE AGES OF THE CHILDREN?

i. LESS THAN SIX MONTHS

ii. 6 – 12 MONTHS

iii. 1 – 2 YEARS

iv. MORE THAN 2 YEARS

v. ALL THE ABOVE

21. WHY DO YOU CONSUME PORRIDGE FOR BREAKFAST?

i. TASTE

ii. ENERGY

iii. NUTRIENTS

iv. OTHERS, (SPECIFY)

....

....

......

Questionnaire on sensory evaluation of cereal/legume blend

<u>Instructions:</u>

Evaluate and score the samples on **<u>COLOUR</u>**, **<u>AROMA</u>**, and **<u>TASTE (MOUTH FEEL)</u>** by ticking the appropriate box using a 1-7 scale of preference {one (1) being the most preferred and seven (7) the least preferred} with regard to the sensory attributes.

NB. Please rinse your mouth with water before tasting each sample.

A1

	1	2	3	4	5	6	7
Colour	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
Aroma	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
Taste	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

A2

	1	2	3	4	5	6	7
Colour	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
Aroma	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
Taste	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

A3

	1	2	3	4	5	6	7
Colour	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
Aroma	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
Taste	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

A4

	1	2	3	4	5	6	7
Colour	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
Aroma	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
Taste	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

A5

	1	2	3	4	5	6	7
Colour	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
Aroma	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
Taste	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

B1

	1	2	3	4	5	6	7
Colour	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
Aroma	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
Taste	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

B2

	1	2	3	4	5	6	7
Colour	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
Aroma	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
Taste	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

B3

	1	2	3	4	5	6	7
Colour	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
Aroma	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
Taste	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

B4

	1	2	3	4	5	6	7
Colour	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
Aroma	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
Taste	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

B5

	1	2	3	4	5	6	7
Colour	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]
	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]	[ ]

[ ] [ ] [ ] [ ] [ ] [ ] [ ]Aroma

Taste

Completely Randomized AOV for aroma

Source	**DF**	**SS**	**MS**	**F**	**P** sample
4	80.30	20.0743	5.02	0.0006	
Error	345	1378.30	3.9951		
Total	349	1458.60			

Grand Mean 3.2029 CV 62.41

Homogeneity of Variances F P
Levene's Test 3.33 0.0108
O'Brien's Test 3.28 0.0117
Brown and Forsythe Test 2.95 0.0202

Welch's Test for Mean Differences Source DF F P sample 4.0
5.26 0.0005
Error 172.0

Component of variance for between groups 0.22970
Effective cell size 70.0

sample	**Mean**
A1	2.3857
A2	2.9857
A3	3.6143
A4	3.7000
A5	3.3286

Observations per Mean 70
Standard Error of a Mean 0.2389
Std Error (Diff of 2 Means) 0.3379

Completely Randomized AOV for colour

Source	**DF**	**SS**	**MS**	**F**	**P**
sample	4	141.33	35.3329	12.62	0.0000
Error	345	965.99	2.8000		
Total	349	1107.32			

Grand Mean 2.4771 CV 67.55

Homogeneity of Variances F P
Levene's Test 10.8 0.0000
O'Brien's Test 10.6 0.0000
Brown and Forsythe Test 21.9 0.0000

Welch's Test for Mean Differences Source DF F P sample 4.0
28.54 0.0000
Error 163.8

Component of variance for between groups 0.46476
Effective cell size 70.0

sample Mean
A1 1.2714
A2 2.4143
A3 2.9571
A4 2.9714
A5 2.7714
Observations per Mean 70
Standard Error of a Mean 0.2000
Std Error (Diff of 2 Means) 0.2828

Completely Randomized AOV for taste

Source DF SS MS F P sample
4 11.22 2.80429 0.66 0.6180
Error 345 1458.84 4.22853
Total 349 1470.06

Grand Mean 2.7800 CV 73.97

Homogeneity of Variances F P Levene's
Test 1.94 0.1034
O'Brien's Test 1.91 0.1081
Brown and Forsythe Test 1.19 0.3155

Welch's Test for Mean Differences Source DF F P sample 4.0
0.56 0.6944
Error 172.3

Component of variance for between groups -0.02035
Effective cell size 70.0

sample Mean
A1 2.6000
A2 2.7000
A3 2.8429
A4 2.6571
A5 3.1000
Observations per Mean 70
Standard Error of a Mean 0.2458
Std Error (Diff of 2 Means) 0.3476

Completely Randomized AOV for aroma

Source DF SS MS F P sample
4 127.59 31.8967 7.83 0.0000
Error 295 1201.65 4.0734
Total 299 1329.24

Grand Mean 2.9233 CV 69.04

Homogeneity of Variances F P

Levene's Test	3.92	0.0040
O'Brien's Test	3.86	0.0045
Brown and Forsythe Test	9.56	0.0000

Welch's Test for Mean Differences

Source DF F P sample
4.0 11.14 0.0000
Error 146.3

Component of variance for between groups 0.46372
Effective cell size 60.0

sample	**Mean**
B1	1.7000
B2	3.0833
B3	3.0667
B4	3.6667
B5	3.1000

Observations per Mean 60
Standard Error of a Mean 0.2606
Std Error (Diff of 2 Means) 0.3685

Completely Randomized AOV for colour

Source DF SS MS F P sample
4 169.85 42.4617 14.36 0.0000
Error 295 872.30 2.9569
Total 299 1042.15

Grand Mean 2.4467 CV 70.28

Homogeneity of Variances F P

Levene's Test	10.0	0.0000
O'Brien's Test	9.87	0.0000
Brown and Forsythe Test	11.9	0.0000

Welch's Test for Mean Differences Source DF F P sample 4.0
30.11 0.0000
Error 136.4
Component of variance for between groups 0.65841
Effective cell size 60.0

sample Mean
B1 1.1667
B2 2.3000
B3 3.2333
B4 3.1833
B5 2.3500
Observations per Mean 60
Standard Error of a Mean 0.2220
Std Error (Diff of 2 Means) 0.3140

Completely Randomized AOV for taste

Source DF SS MS F P sample
4 79.92 19.9800 5.13 0.0005
Error 295 1148.92 3.8946
Total 299 1228.84

Grand Mean 2.6433 CV 74.66

Homogeneity of Variances F P
Levene's Test 1.97 0.0985
O'Brien's Test 1.94 0.1038
Brown and Forsythe Test 6.40 0.0001

Welch's Test for Mean Differences
Source DF F P sample
4.0 7.30 0.0000
Error 146.7

Component of variance for between groups 0.26809
Effective cell size 60.0

sample Mean
B1 1.6167
B2 2.8833
B3 2.9833
B4 2.8167
B5 2.9167
Observations per Mean 60
Standard Error of a Mean 0.2548
Std Error (Diff of 2 Means) 0.3603