EFFECT OF PARTIAL SUBSTITUTION OF WHEAT FLOUR WITH BREADFRUIT AND BREADNUT FLOUR ON BREAD QUALITY AND CONSUMER PERCEPTION

BY

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CERTIFICATION

This work has not been presented elsewhere for the award of a degree, or any other purpose.

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DEDICATION

To the glory of Awesome and Ever-merciful God.

To those that put in all their efforts and supports; in seeing me reaching higher heights in life.

ACKNOWLEDGMENT

"He who started the work in my life, will surely finish it". I therefore give praises, honour, adoration and glory to my creator, beginning, end, benefactor and my hope. He is "I AM THAT I AM."

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TABLE OF CONTENTS

		PAGE
Title Page		i
Certification		ii
Dedication		iii
Acknowledgement		iv
Table of Contents		v
List of Tables		viii
List of Figures		x
Abstract		xi
CHAPTER ONE		
1.	Introduction	1
1.1	Objectives of the Study	5
1.2	Justification of the Study	6
1.3	Expected Contribution to Knowledge	6
CHAPTER TWO		
2.	Literature Review	7
2.1	The Importance of Bread	7
2.2	Bread across different Cultures	8
2.3	Breadfruit and Breadnut	10
CHAPTER THREE		
3.	Materials and Methods	18
3.1	Materials	18
3.2	Methods	18

3.2.1 Production of breadfruit flour and breadnut flour 18

3.2.2 Composite flour blend formulation 18

3.2.3 Rheological properties of dough prepared from composite flours 21

3.2.4 Determination of % gluten in flour 21

3.2.5 Bread making 22

3.2.6 Chemical composition of composite flours and bread samples 25

3.2.7 Evaluation of physical properties and bread quality 28

3.2.8 Sensory evaluation 28

3.2.9 Statistical analysis 29

CHAPTER FOUR

4. Results and Discussion 30

4.1 Proximate Composition of Composite Flours 30

4.2 Rheological Properties of the Doughs 30

4.3 Gluten Composition of the Composite Flour 34

4.4 Pasting Properties of Composite Flours 35

4.5 Consumer Preferences 38

4.5.1 Socio- economic background of the respondents 38

4.5.2 Bread quality preferences among consumers in Akure metropolis 41

4.6 Physical Properties of Composite Bread 48

4.7 Chemical Composition of Bread Samples 52

4.7.1 Proximate composition 52

4.7.2 Mineral composition of the composite bread 55

4.7.3 Anti- nutrient composition of bread samples 57

4.8 Sensory Properties of Bread Samples 59

CHAPTER FIVE

5. Conclusion and Recommendation 62

5.1 Conclusion 62

5.2 Recommendation 63

References 64

Appendix 75

LIST OF TABLES

		PAGES
Table 2.1	Proximate composition of breadfruit and breadnut per 100 g (dry weight) edible portion	16
Table 3.1	Bread formulation/ Recipe	24
Table 3.2	Wavelength (nm) of the Metals with AAS	26
Table 4.1	Proximate composition of the composite flour	31
Table 4.2	Rheological properties of the dough from composite flour	32
Table 4.3	Gluten content (%) in the composite flour	35
Table 4.4	Pasting properties of the composite flour	37
Table 4.5	Socio- economic background of the respondents	39
Table 4.6	Respondent classification on the basis of socio-economic group and frequency of bread consumption	40
Table 4.7	Summary table showing effect of socio- economic background on frequency and time of bread consumption	42
Table 4.8	Summary table showing effect of socio- economic background and frequency of bread consumption on bread quality parameters	43
Table 4.9	Consumer perception (%) of the importance of taste of bread on the basis of age, education and frequency of consumption	45
Table 4.10	Influence of flavourings on consumer acceptability	46
Table 4.11	Influence of flavour type on consumer acceptability	47
Table 4.12	Loaf weight, loaf volume, specific volume and loaf shape of bread	49
Table 4.13	Bread quality characteristic/ evaluation	51
Table 4.14	Proximate composition of the composite bread	53

Table 4.15	Mineral composition of the composite bread (mg/ 100g)	56
Table 4.16	Anti- nutrient composition of the composite bread	58
Table 4.17	Sensory evaluation of bread samples serving as control sample	60
Table 4.18	Sensory evaluation of composite bread samples	61

LIST OF FIGURES

		PAGES
Figure 2.1	Mature Breadfruit.	12
Figure 2.2	Mature Breadnut	13
Figure 3.1	Flow chart for the production of breadfruit flour	19
Figure 3.2	Flow chart for the production of breadnut flour	20
Figure 3.3	Flow chart for the production of bread	23

ABSTRACTS

Breadfruit and breadnuts have been found to be useful in baking industry because of its starchy and protein components. This study therefore aimed at utilizing breadfruit and breadnut to substitute wheat for bread making. A survey was conducted in Akure metropolis using five hundred (500) respondents to determine bread quality attributes. Flours were processed from Breadfruit (*Artocarpus integrifolia*) and Breadnut (*Artocarpus atilis*) by blanching at 100 °C, 5 min; drying at 105 °C, 1– 3 h and packaged in well labelled flour sack. The flours were mixed with wheat flour at a ratio of 5:95, 10:90, and 15:85, respectively. Rheological, pasting properties, percentage gluten of dough prepared from the composite flours were determined and the flours were used to bake bread. The sensory attributes, physical properties, proximate, mineral and anti nutrients composition of the bread samples were determined. The survey showed that 46% of the respondents are male; 54% female and distributed in the following age groups: 20- 29 (32.6%), 30- 39 (30.4%), 40- 49 (12.6%), 50- 59 (9.8%), below 20 (11.8%) and above 60 years (2.8%); singles (55%), married (44.6%), unknown marital status (0.4%); educational level, tertiary (55.8%), secondary (23%), primary (6.4%), informal education (14.6%), unknown (0.2%). The protein content of the composite flours ranged from 9.50 to 10.50%, dough development time (1.50- 1.75 minutes), dough stability time (7.50- 12 minutes), gluten content (14- 18.30%), peak viscousity (45- 300 BU), starch stability (35- 175 BU), ease of cooking (6- 11 minutes) and setback values (70- 935 BU). The composite bread had protein content (10.66- 11.96%), carbohydrate content (42.22- 47.14%), energy value (261.40- 274.17 kcal/ 100g), loaf weight (550- 600g), loaf specific volume (2.08- 3.39 cm^3 /g), Na content (257.68- 885.32mg/ 100g), K content (97.11- 404.49mg/ 100g), Fe content (0.32- 4.14 mg/ 100g) with no detectable presence of lead. Also, the oxalate, phytate and tannin contents were in the ranges of 2.70 to 3.96 mg/g; 5.64 to 7.33 mg/g and 0.18 to 0.42 mg/g respectively. Moreover, the products were well acceptable in terms of taste, appearance, aroma and overall acceptability at 5% BF/ 95% WF and 10% BNF/ 90% WF ratio. It was thus concluded that bread produced from mixtures of 5% BF/ 95% WF and 10% BNF/ 90% WF gave the best products without significant anti-nutritional factor with high acceptability. The composite flours have potential as alternative to whole wheat imported flour.

CHAPTER ONE

1. INTRODUCTION

Bread is one of the oldest prepared foods, dating back to the Neolithic era. The development of leavened bread can be traced to pre-historic times. Fresh bread is priced for its taste, aroma and texture. Bread is a staple food prepared by baking dough of flour and water (Osuji, 2006). It may be leavened or unleavened. Salt, fat and a leavening agent such as yeast, are common ingredients, though breads may contain a range of other ingredients: milk, egg, sugar, spice, fruit (such as raisins), and vegetables such as onion), nuts (such as walnuts) or seeds (such as poppy seeds) (Encyclopaedia Britannica, 2006).

Retaining its freshness is important to keep it appetizing (Giami *et al.*, 2004). The inner, soft part of bread is known to bakers and other culinary professionals as 'crumb' which is not to be confused with small bits of bread that often fall off, called 'crumbs'. The outer hard portion of bread is called the 'crust' (Samuel, 2000). Bread can be served at any temperature ranging from room temperature to hot. Once baked, it can subsequently be toasted. Meals made of bread, such as sandwich, however substantial they may be, are considered as light snacks in the eyes of the elderly generation.

Owing to its high levels of gluten (which gives the dough sponginess and elasticity), common wheat (also known as bread wheat) is the most common grain used for the preparation of bread, but bread is also made from the flour of other grains like rye, maize (or corn), barley, oats, or roots like cassava, usually in combination with wheat flour (Spiekermann, 2006). High protein content is often related to good bread-making quality. But quantity alone is not sufficient to explain all the variations in bread-making quality (Jood *et al.*, 2000). FAO (2006) reported that flour from indigenous raw materials could be added in proportions that will not affect the original and intended colour, flavour and the particle size of the product adversely.

Bakery products are essential food items for a large segment of Nigerian population. The popularity of bakery products has contributed to increased demand for ready-to-eat, convenience food products, such as bread, biscuits and other pastry products (David, 2006). In recent years, the consumption of wheat bread has risen in many developing nations, including Nigeria, as a result of increasing populations, urbanization and changing food habits (Onabolu *et al.* 1998; Oloye, 2006). However, most developing countries, including Nigeria, for climatic reasons, cannot grow wheat hence the reliance on expensive wheat imports, paid for with scarce foreign currency.

There have been several attempts aimed at the partial substitution of wheat flour with flour from readily available, cheap, indigenous crops like maize, cassava, cocoyam, bread fruit and sorghum (Ekop *et al.*, 2007; Lin *et al.*, 2009). Flours from these crops have rheological properties which may make them suitable for consideration for use in dough making (Oluwole *et al.*, 2006). Targets described in the Nigeria's Millennium Development Goal (MDG) (2006), sought to expand the utilization of cheap, readily available, locally produced and easily- processed agricultural commodities.

The potentials of composite flours in bread making, pastry products and domestic consumption has been reported by many researchers in the last ten years. For example, Lin *et al.* (2009) reported that substitution up to 15% level of buckwheat into wheat flour gave no statistically significant differences in appearance, colour and overall sensory attributes between the composite bread and the control, whereas buckwheat enhanced wheat bread was better in flavour and mouth feel sensory attributes. It contained more functional components; *rutin* and *quercetin* as expected. Maribel *et al.* (2009) reported that pasta products containing banana flour exhibit a low rate of carbohydrate enzymatic hydrolysis and they could help broaden the range of low glycaemic index foods available to the consumer. Moreover, this food contained increased levels of indigestible compounds (resistant starch and non-starch polysaccharides) that may be beneficial for intestinal health.

Mepba *et al.* (2007) produced composite bread and biscuit from mixed flours of wheat and plantain at up to 30% plantain flour supplementation. However, this has a negative effect on acceptability of the product. This notwithstanding, a successful substitution of up to 15% level of composite flour will go a long way in reducing cost and enhance utilization. Salim-ur *et al.* (2007) investigated the partial substitution of wheat flour with vetch (*Lathyrus sativus L*) flour at 5, 10, 15, and 20g/100g to produce doughnuts. The report showed that substitution at 15g/100g (vetch:wheat) was found to be acceptable with significant increase in protein and lysine. Although vetch flour is generally considered a "poor man's diet" in India (Hanbury *et al.*, 1999), it contains about 28.70g/ 100g protein content, thereby making it nutritionally suitable for use in various food supplementation schemes. Incorporation of modified corn starch (via cross linking) into wheat flour for use in bread making led to increased gelatinization temperature, set back viscosity and a decrease in the transition enthalpy of gelatinization (Woo and Seib, 2002). Nonetheless, it improved the resistance and extensibility of dough observed during mixing and stretching. This contributes to bigger loaf volume and softer bread crumb than conventional wheat flour bread (Pham and Naofumi, 2004). Retardation of starch retrogradation in bread during storage can be achieved by substituting waxy corn starch into wheat flour (Morita *et al.*, 2002; Lee *et al.*, 2001).

The use of legume-wheat flour composite flours has also been reported on by various authors. Manuel *et al.* (2008) investigated the use of wheat-chick pea flour blends in preparing cake and concluded that partial substitution is possible, though with changes in quality being dependent on different varieties of chick peas. Biljana and Bojana (2008) inferred that sunflower flour could be added to bread at up to 16% level without significant adverse effect on crust and crumb colour, structure and uniformity.

Alex *et al.* (2008) reported that substitution up to 25% bean flour in wheat flour demonstrated acceptable textural parameters and improved nutritional profile when compared with wheat flour only in production of *tortillas.* While the consumption of fresh bread was up by 0.3%, the increase in tortilla sales was up by 3.5% in comparison with the previous year. Ade-Omowaye *et al.* (2008) reported that substitution of wheat flour with tiger nut (*Cyperus esculentus*) flour up to 10% level would give dough with good viscoelastic properties and acceptable bread with qualities similar to 100% wheat bread. Olaoye *et al.* (2006) investigated the use of supplementation of soybean and plantain flours with wheat flour and showed that satisfactory bread can be obtained at up to 15% substitution level. Although, wheat-soy formulations were known to give very poor dough and baking quality (Liu, 1997), Maforimbo *et al.* (2006) reported that while wheat protein favour hydrophobic interactions due to their low solubility, soy proteins are more water-soluble and exhibit hydrophilic characteristics in a soy-wheat composite dough system. The report showed that current efforts at utilizing wheat-soy formulations are geared towards improving the dough from this composite flour via heat treatment. This will increase the size distribution of soy protein and its hydrophobicity. Hallen *et al.* (2004) reported that substituting wheat flour with cowpea flour at up to 20% level gave bread with characteristics similar to 100% wheat bread. Doxastakis *et al.* (2002) reported that lysine, is a limiting amino acid in wheat. Hence, lupin flour, with its high lysine and low methionine content, would complement wheat flour proteins, and will thus be an excellent choice for improving the nutritional value of bread.

Apart from the nutritional value, functional properties of food protein determine the degree of utilization as the food ingredients in food formulation operations (Fasasi *et al.* 2007). Preliminary investigations by Fasasi *et al.* (2004) on the effect of traditional processing like germination, fermentation, roasting and defatting on the chemical properties of breadnut flour showed significant increase in proteins and decrease in antinutritional factors. Olaoye *et al.* (2007) reported that breadfruit flour substitution in wheat flour at 15% level would give biscuit with acceptable sensory attributes.

Apart from using breadfruit for food and confectionary production, it also found use in the pharmaceutical industry. For example, Adebayo and Itiola (2003) reported that incorporation of breadfruit and cocoyam starch mucilage binders in paracetamol tablet formulations produced tablets with short disintegration times and fast dissolution rates comparable with those of official corn starch mucilage binders.

The use of composite flours may be advantageous in developing countries where adequate technology for the production of dry protein concentrates/ isolates is not available or affordable in order to utilize proteins.

1.1 Objectives of the Study

The objectives of this work are to:

1. assess consumer expectations on bread quality via well designed questionnaires.,
2. produce and assess quality attributes of bread from breadfruit-wheat and breadfruit nut-wheat composite flour,
3. determine the chemical composition of the bread and the rheological properties of the dough.

1.2 Justification of the Study.

With the progressive increase in the consumption of bread and other baked products in Nigeria, the composite flour programme has the potential to conserve foreign exchange and improve the economic importance of these indigenous crops.

1.3 Expected Contribution to Knowledge

This project is expected to enhance increased utilization of breadfruit and breadnut flour in bakery products. Finding use for the nut, hitherto discarded as waste or eaten as snacks in most homes, adds value to it by enhancing its cultivation, and by extension, the economy of the cultivators and intermediate processors.

CHAPTER TWO

2. LITERATURE REVIEW

2.1 The Importance of Bread

Bread is of cultural and political importance in every human community. It is a foodstuff of great historical and contemporary importance in many cultures in the west and near and Middle East, with significance beyond nutrition (Jacob, 1997). The lord's prayers, for example, contains the line *"give us today our daily bread"* here, bread is commonly understood to mean necessities in general (NKJV, 2001).

In Israel, the most usual phrase in work related demonstration is *"lekhem, avoda"* (bread, work), and during the 1950s, the beatnik community used the term bread as a euphemism for money (as also in the case with the word dough) (Jacob, 1997). The cultural importance of bread goes beyond slang, however, to serve as a metaphor for basic necessities and living conditions in general. A "bread winner" is a household's main economic contributor and has little to do with actual bread-provision, for example. This also goes along with the phrase "putting bread on the table". A remarkable or revolutionary innovation is often referred to as "the greatest thing since sliced bread". In the USSR, Lenin and his fellow Bolsheviks promised "peace, land, and bread," which thereby became a mainstay slogan of soviet propaganda (Khatkar *et al,* 1996). In Newfoundland (Canada), bread is viewed as having the power to protect against fairies (imaginary creature with magic powers that look like a small person with wings). The term "bread basket" is often used to denote an agriculturally productive region. In Slavic cultures, bread and salt is offered as a welcome to all guests (Kaplan, 2006).

The political significance of bread is considerable. In Britain, in the nineteenth century, the inflated price of bread due to the Corn Laws caused major political and social divisions, and was central to the debate over free trade and protectionism. The Assize of Bread and Ale in the thirteenth century showed the importance of bread in medieval times by setting heavy punishment for short changing bakers (Encyclopaedia britannica, 2006).

2.2 Bread across different Cultures

Sour dough breads like *baguette* and round bread begin with a starter passed down from excess batter from a previous loaf (Davidson, 1999). There are many variations on the basic recipe of bread, including pizza, chappatis, tortillas, brioche, pitas, lavash, pretzele, naan, bagels and puris (McGee, 2004). In Mexico, bread is called *Pan*. Although corn *tortillas* are the staple bread in most of Mexico, bread rolls in many varieties are an important daily food for city dwellers. Popular breads in Mexico include the *bolillo* and *pan dulce*. Pan Dolce, which is Spanish for sweet bread, is primarily eaten at breakfast. In Spain, bread is also called Pan, and there are many varieties about 315. There is a region called "Tierra del pan" (literally translated as "Land of the Bread"), located in the province of Zamora, where economy was in the past joined to this activity (McGee, 2004).

In the Philippines, Pandesal (or pan de sal; literally, salt bread) is a rounded bread usually eaten by Filipinos during breakfast. Germany prides itself to have the largest variety of breads worldwide. More than 300 – 500 basic kinds of bread come together with more than 1000 types of small bread-rock and pastries. It has been estimated that the basic kinds of bread are so widely varied by more than 16,000 local bakeries that more than 1,000 different breads have been presented at a 2005 cologne bread show (Anonymous, 2008). Germans are worldwide the biggest consumers (per capital) of bread followed by Chile (Anonymous, 2008). Finland and Russia both have dark, four dough bread made of rye. Traditional finish rye bread is disc-shaped, with a hole in the centre for easier storing. These breads have a rougher composition and a stronger taste than wheat bread, and can thus be stored for longer periods of time (Kaplan, 2006).

In the United States, the most popular bread has traditionally been soft-textured, usually made with milk and slightly sweet, with a thin crust; this is the type that is generally fold ready-sliced in packages. It is usually eaten with the crust, but some eaters or prepares may remove the crust due to a personal reference or style of serving, as for afternoon tea. Some of the softest bread including Wonder bread is referred to as "balloon bread". Though, white "sandwich bread" is the most popular, American are trending towards more whole grain and artisan and breads (Neff, 2007).

Jews have traditionally baked challah, a type of egg bread with a thin, hard crust and a soft, well-leavened centre. It is made by wrapping plaits of dough and then lightly baking them in an oven. Challah is sometimes sweetened using honey and sometimes includes raisins. During Passover, unleavened bread in the form of various type of matzo is required due to the Biblical injunction to avoid any form of leaven during this time of year (Jacob, 1997).

In Morocco and West North Africa, round bread which is roughly four inches tall is used to eat most of the Mediterranean's watery cuisine. They also have thick and chewing fried bread which is smothered in oil before hand. The Rghifa bread is a staple in Morocco's food and consists of several layers of lightly cooked bread (Neff, 2007). In France, pan bread is known as *pain de mie* and is used only for toast or for making stuffing, standard bread (in the form of baguettes or thicker breads) has a thick crust and often has large bubbles of air inside. It is often baked three times daily and is sold totally unwrapped to keep the crust crisp. Some fancy bread contain walnuts or are encrusted with poppy seeds (Klein, 2007).

In Ireland, it is traditionally held that the end of a loaf of bread (the "heel" or 'hilt' of the loaf) is the best part of the loaf. Other stories and myths surround this piece of the bread in Irish Mythology. Irish soda bread, developed to make the most of the soft wheat grown in Ireland, is unusual for European bread in that it is a quick bread, using the reaction of butter milk and baking soda rather than yeast to rise (Spiekermann, 2006). Italy sports many different kinds of bread with its high geographical variability and its long history of political division contributing to the development of widely different bread making recipes and traditions.

2.3 Breadfruit and Breadnut

The breadfruit tree is grown widely in tropical area where it is an important food source. It is known by the botanical names *Artocarpus integrifolia* (breadfruit) and *Artocarpus altilis* (breadnut) (Cox, 1980). Despite its ease of cultivation in the tropics, breadfruit appears to be underexploited as a food principally because of its poor post- harvest storage behaviour. Nevertheless conversion of the fruit into a stable form such as dry flour offers a solution to storage stability problems (Negron de Bravo *et al.*, 1983).

Atchley and Cox (1985) reported that the seedless type of breadfruit is often boiled, roasted or fried in Nigeria while the Oceanians preserve it by fermentation. The fermented fruit is later consumed as *bwiru* (pungent smelling product). When boiled or fried, the fruit has the consistency of the potato and is used as a substitute for potato and mandioca in some areas. The breadfruit tree (*Moraceae*) is originally from the Sonda Archipelago (Indonesia). It is cultivated in the low tropics. The tree is tall (12- 15 metres), with many alternate, large and deeply divided leaves. The fruit is syncarpous and weighs between one to three kilograms (Fig 2.1a) (Garcia- Barriga, 1974).

Purseglove (1974) reported that the edible portion of a seedless breadfruit is about 70%. The fact that this fruit is a mass of unobstructed starchy material that can be easily fashioned into common forms of food accounts for its greater popularity. Negron de Bravo *et al.* (1983) reported that seed number per fruit, in case of seeded breadfruit (sometimes called breadnut), ranged from 46 to 94 in 20 fruits sampled in Puerto Rico. The oblong or globose fruit, 10- 30 cm in diameter, has a yellowish green rind covered with fleshly prickles (Fig 2.1b) with little edible pulp. The entire interior of the fruit is dominated by a mass of brown seeds, rounded or flattened by compression, and about 2.5 cm long. The fruits are not picked before maturity, as is the case for the seedless breadfruit, but are allowed to drop. The seeds are then removed from the rotting pulp and rind, boiled in salted water (or roasted), peeled (i.e. the seed coats removed), and eaten. They are chestnut- like in size and flavour; hence, they are called *chataigne* in French- speaking areas and *castana* in Spanish- speaking areas (Bennett and Nozzolillo, 1987). Quijano and Arango (1979) reported that 20% of dry matter of the seeds is protein with a good balance of essential amino acids. Negron de Bravo *et al*. (1983) found them to be a rich source of essential minerals.

Figure 2.1: Mature Breadfruit.

Figure 2.2: Mature Breadnut.

Nature and Traditional Utilisation of Breadfruit

Breadfruit is a versatile food that can be cooked and eaten at all stages of maturity, although it is most commonly consumed when mature but still firm, and is used as a starchy staple. The relatively bland fruit can form the basis for an array of dishes, and it takes on the flavor of other ingredients in the dish. Very small fruits, 2 – 6 cm or larger in diameter, can be boiled and have a flavor similar to that of artichoke hearts. These can be pickled or marinated. Mature and almost mature breadfruit can be boiled and substituted for potatoes in many recipes. Ripe fruits are very sweet and can be eaten raw or used to make pies, cakes, and other desserts. In the Philippines, candied breadfruit is made by boiling slices in coconut and sugar (Ragone, 2003). Although breadfruit is highly nutritious, cheap and readily available in overwhelming abundance, especially at the peak of the two fruiting seasons in May and August, it has long been underexploited in Nigeria due to its low social esteem. However, breadfruit is fast gaining recognition as a staple and is being substituted for yam in the Nigerian diet because of persistent food shortages and because it can be prepared into the same food forms as yam.

Ripe fruits generally go to waste or are used as animal food, and there has been little attention given to expanding the use of ripe fruits. A greater proportion of the breadfruit crop could be utilized and marketed if food products incorporating ripe breadfruit, such as baby foods, baked goods, and desserts, are developed. Breadfruit is a reliable, easy-to-grow, nutritious staple food which has the potential to be more widely grown and used in the world's tropical regions. This can best be accomplished by selecting cultivars that extend the fruiting season and developing better methods of post harvest handling and simple, economical means of processing the fruits (Omobuwajo, 2003).

A major limitation on the greater utilization of bread fruit is the seasonal nature of the crop – the trees typically bear fruits for just several months of the year – and the highly perishable nature of the fruit. Small-scale commercial processing of breadfruit involves canning slices in brine in Jamaica for local and export markets. Breadfruit flour and chips have been made on a limited basis, and the flour has been evaluated as a substitute for enriched wheat flour and as a base for instant baby food. The starch has been extracted and may find use in industrial applications such as textile manufacture (Obasuyi and Nwokolo, 2006).

Composition of Breadfruit and Breadnut.

Obasuyi and Nwokoro (2006) reported that breadnut has about 18.27 % protein. Fasasi *et al.* (2007) also reported that African breadnut contained about 17.9% protein content. However, Ragone (2003) reported that breadnut contained about 7.9 - 8.1% protein, 1.9 - 22.6 mg ascorbic acid and 1.8- 2.1 mg niacin; but when milled into flour, it has about 2.9 - 5.0 % protein, 4 – 20 mg ascorbic acid and 0.04 - 0.29 IU β- carotene and this breadfruit to be the best indigenous crop for substitution into wheat flour. Breadfruit's carbohydrate content is as good as or better than that of other widely used major carbohydrate foods. Compared to other staple starch crops, it is a better source of protein than cassava and is comparable to sweet potato and banana. It is a relatively good source of iron, calcium, potassium, riboflavin, and niacin. The nutritional composition of breadfruit varies among cultivars and should aid in the selection of cultivars for different uses for fresh consumption and processed products. Fruit quality and attributes fruit texture is an important attribute that affects cooking and processing. Seedless and few-seeded breadfruits both exhibit a wide range of textures at the mature stage (Olaoye and Onilude, 2008).

Table 2.1: Proximate composition of breadfruit and breadnut per 100g (dry weight) edible portion.

	Breadnut[ab]	Breadfruit[bc]
Water (%)	56.0–66.2	47.7–61.9
Protein (g)	13.3–19.9	7.9–8.1
Carbohydrate (g)	76.2	26.6–38.2
Fat (g)	6.2–29.0	2.5–4.9
Calcium (mg)	66–70	46.6–48.3
Potassium (mg)	380–1620	
Phosphorus (mg)	320–360	186–189
Iron (mg)	8.7	2.3
Magnesium (mg)	10.0	
Niacin (mg)	8.3	1.8–2.1
Sodium (mg)	1.6	
Thiamin		0.13–0.33
Riboflavin		0.08–0.10
Ascorbic acid		1.9–22.6

Source: [a]Negron de Bravo et al. (1983), [b]Quijano and Arango (1979), [c]Ragone (2003)

Potential Industrial Utilisation of Breadfruit

Preferred fruits are generally those that are dense, smooth, and creamy when cooked. There are cultivars with mealy flesh, as well as ones with fibrous, stringy flesh, and spongy ones which are full of what appear to be fine threads of latex. The quality of cooked fruit also depends on the method of preparation: different cultivars provide different results when boiled, roasted, or baked. Some cultivars are suitable for roasting but become mushy and fall apart when boiled. The potential for wide-scale processing by freezing, canning, or production of flour will be enhanced by selection of suitable cultivars (Olaoye and Onilude, 2008). There is a general awareness of the potential of breadfruit in food applications as evidenced from some reports (Olaoye *et al.* 2007; Udio *et al.* 2003) and thereby promote new uses for breadfruit especially at the industrial level. Although breadfruit had featured in the diet of many tropical countries at the household level for decades, its industrial applications have not been exploited.

Processing of breadfruit into these fast-moving snack food items suitable for production in fast food service systems will stimulate demand for breadfruit as an industrial raw material. Furthermore, it will complement research and product development efforts in the snack food industry in particular and the entire food industry at large (Ragone, 2003).

CHAPTER THREE

3. MATERIALS AND METHODS

3.1 Materials

The 100% commercial hard wheat flour used in this work was obtained from commercial stores in Akure, Ondo State. Mature, insect free breadfruit (*Artocarpus integrifolia*), breadnut (*Artocarpus atilis*), baking yeast (DSM bakery ingredient, Dordrecht, Holland), baking fat (PT Intiboga Sejahtera, Jakarta, Indonesia), sugar (Dangote Groups (Nig.) Ltd., Lagos Nigeria), improver, water and salt were obtained from a baking ingredients store at Akure, Ondo State.

Kenwood mixer (Model A 907 D, Kenwood Ltd, England), electric oven (SL- 9 Infrared Food Oven, Hubert, China) and other baking equipment used in the work were obtained from the Federal University of Technology, Akure bakery.

3.2 Methods

3.2.1 Production of breadfruit flour and breadnut flour.

Breadfruit (*A. integrifolia*) and Breadnut (*A. atilis*) are thoroughly washed (separately), peeled, washed again, drained, sliced, blanched (100 °C, 5 min), drained, oven dried in laboratory oven (LCON53CF, Genlab, England), (105 °C, 1 – 3 h), milled, sieved (0.35mm mesh size) and packaged in well labeled flour sack (Figures 3.1 and 3.2) until it is used in composite flour preparation.

3.2.2. Composite flour blend formulation

Six blends were prepared by mixing breadfruit flour and breadnut flour with wheat flour in the percentage proportions of 5:95, 10:90, 15:85, respectively, using a Kenwood food processor (Model A 907 D, Kenwood Ltd, England).

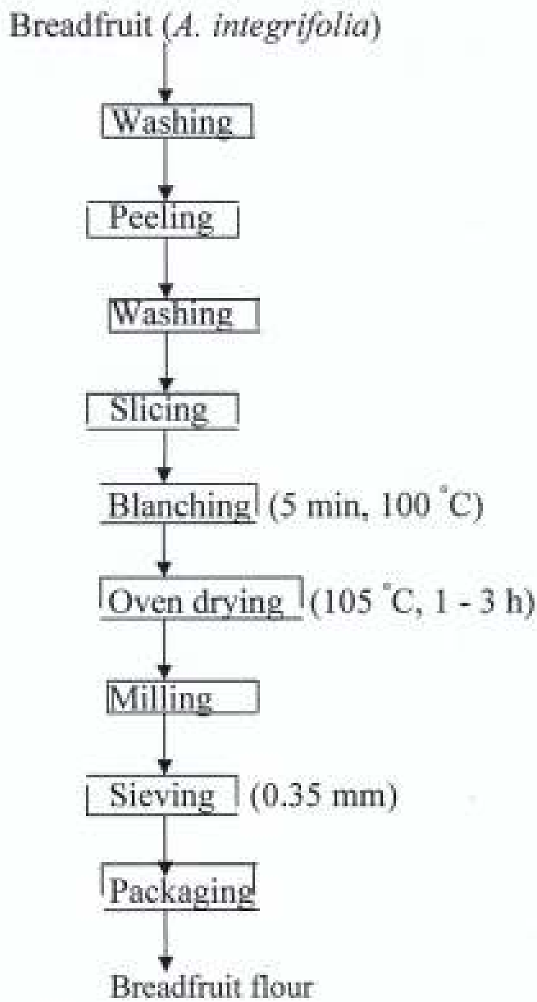

Figure 3.1: Flow chart for the production of breadfruit flour

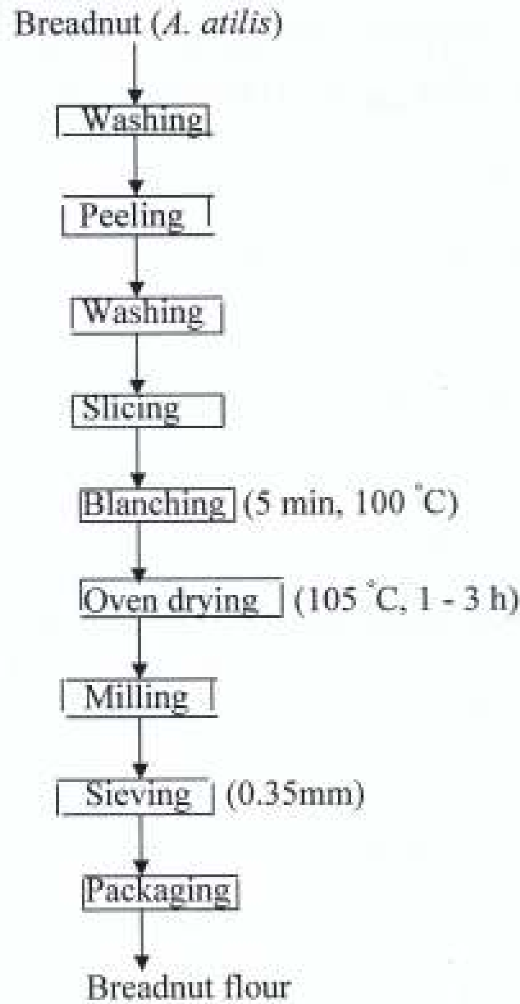

Figure 3.2: Flow chart for the production of breadnut flour

3.2.3 Rheological properties of dough prepared from composite flours

Water absorption, development time and stability of dough prepared from the composite flours were determined using a Brabender Farinograph (T150 Electronic, Brabender Ohgduisburg, Germany) equipped with a 50 g stainless bowl according to approved method 54- 21 (AACC, 2000). The dough was made from 300 g of the composite flours and an optimum amount of warm water filled inside the burette. It is then switched on and water dropped gradually into flour in mixing bowl where it formed dough with the aid of 2 z- shaped mixing blades. The dynamometer of the farinograph is connected to a lever and scale system, and to a pen which traces a curve on a Kymograph chart.

The pasting properties of the substituted flours were tested using a Brabender Amylograph (D-47055, Brabender Ohgduisburg, Germany) according to approved method 22–12 (AACC, 2000). Sixty five grams of the substituted flours were homogeneously dispersed in 450 ml distilled water. The suspension was heated from 30 to 95 °C (at 1.5 °C/min), kept at 95 °C for 15 min and cooled to 50 °C (at 1.5 °C/min). Finally, the paste was held at 50 °C for 15 min. Gelatinization and peak temperatures, peak and final viscosities were determined by the Amylogram. Ease of cooking, gelatinization index, setback and stability of the starch were calculated from peak, breakdown and final viscosities.

3.2.4 Determination of % gluten in flour

The % Gluten content of flour was determined according to AACC (2000) method No. 38-10. The petri dish was weighed. About 20g of the flour samples were weighed into the petri dish and 1ml of water was added, thoroughly mixed to form dough. The dough is kneaded under running water to remove starch and later put into petri dish and weighed. It was then dried in an oven (LCON53CF, Genlab, England) and weighed after drying.

The % gluten is calculated as follows:

$$\%\ wet\ gluten = \frac{weight\ of\ gluten}{weight\ of\ original\ flour} \times 100$$

3.2.5 Bread making

Bread was produced according to the formulation in Table 3.1, using the straight dough process. Baking trials were carried out under laboratory conditions to optimize baking conditions. Flour and dough weighing was carried out on laboratory-scale equipment (CE- 410I, Camry Emperors, China). Dough was mixed to optimum consistency in a Kenwood mixer (Model A 907 D, Kenwood Ltd, England) with low speed of 85 rpm for 1 min. Final dough temperature was 30 $^{\circ}$C. Dough rested in bulk for 45 min, kneaded and left to proof for 15 min. After proofing the dough was scaled into 500 g portions, manually rounded, rolled, put in tin baking pans (75 min, 30 $^{\circ}$C, 80% relative humidity). Baking was done at 230 $^{\circ}$C in an electric oven (Electric oven SL- 9 Infra red Food Oven, Hubert, China) until the golden brown colour is formed. Afterwards, the baked bread were taken out of the oven, cooled to room temperature for 2 h and kept for further analysis (Figure 3.3).

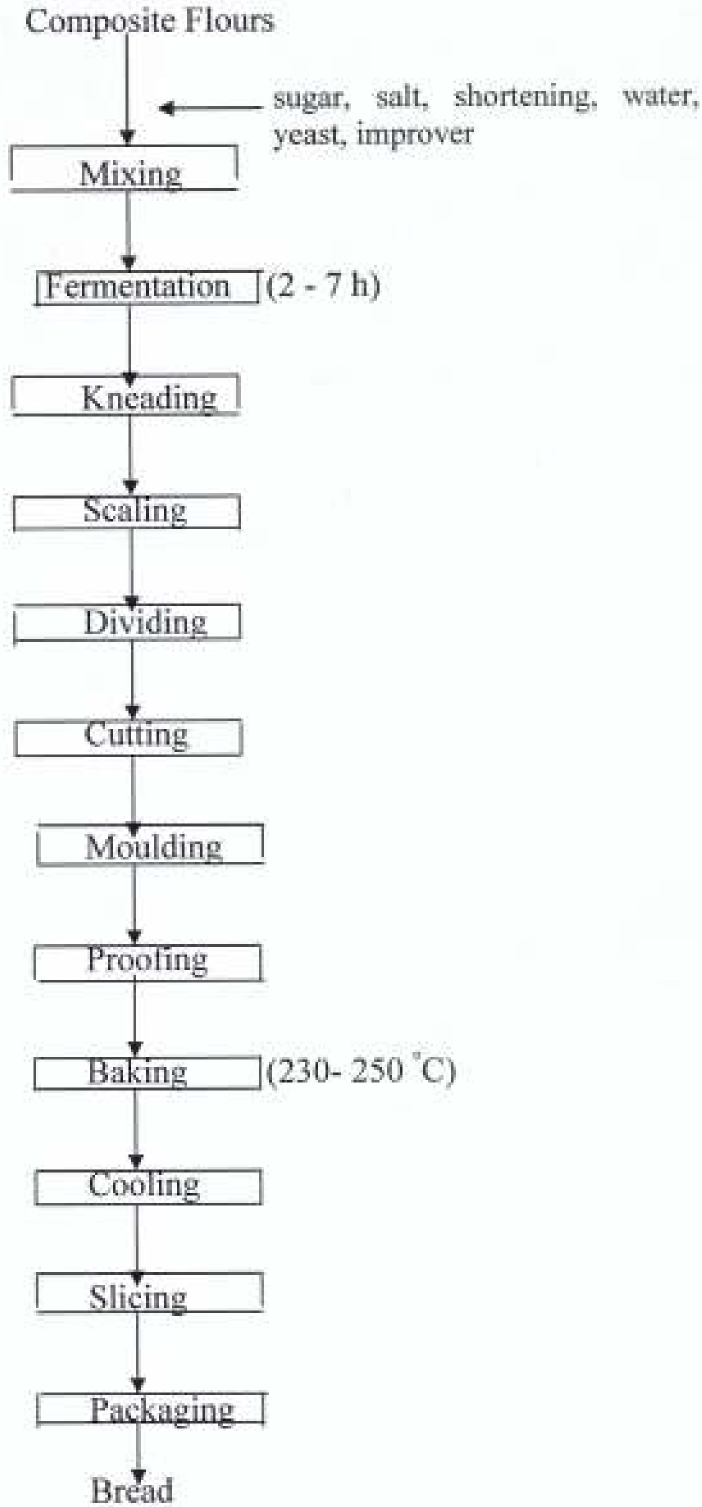

Figure 3.3: Flow chart for the production of bread

Table 3.1: Bread formulation/ Recipe

Ingredient	*value (per 100g of flour)
Flour	100
Sugar	6
Shortening	3
Compressed yeast	5
Salt	1.5
Commercial improver	0.3
Water	55

*Amount is based on 100g of flour.

3.2.6 Chemical composition of composite flours and bread samples

Proximate Composition

The proximate composition of the individual flour and composite bread samples were determined as described by AOAC (1990) methods 14.091, 14.103, 14.093, 14.111 and 14.108, respectively. The nitrogen conversion factor used for crude protein calculation was 5.70. The carbohydrate content was obtained by difference. Energy contents were calculated by multiplying protein, fat and carbohydrate contents by factors of 4, 9 and 4, respectively. For each type of bread, three loaves were frozen, dried and ground into a coarse powder (60 mesh) for further analysis.

Mineral Composition

Mineral composition, namely: Na, K, Ca, Mg, Fe, Cu, Zn and Pb were determined by wet ashing of bread samples as described by Osborn & Voogt (1978). The Atomic Absorption Spectrometer (Chem. Tech Analytical) (Alpha Model No 2543, Jenway Ltd, England) was used to determine the concentrations of the metals in the samples by flame atomization, using air acetylene flame and single element hollow cathode lamp and following the equipment procedures (Weltz, 1985 and Beaty, 1988). The wavelength at which measurement was done is presented in Table 3.2

Calibration curve preparation

In preparation of calibration curve for the metals analysis, five different concentrations (0.1, 0.25, 0.50, 1.00, 2.50 ppm) of each metals were prepared from the stock solution (1000 ppm) for each cation. These were used in preparing a linear curve, passing through zero, for each of the metals.

Table 3.2: Wavelength (nm) of the Metals with AAS

Elements	wavelength (nm)
Pb	217.0
Na	589.0
Fe	248.3
Mg	285.2
Cu	324.7
Zn	213.9
Ca	422.7

Source: Centre for Energy Research and Development, Obafemi Awolowo University, Ile Ife, Nigeria.

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Source: Centre for Energy Research and Development, Obafemi Awolowo University, Ile Ife, Nigeria.

Antinutrients composition (bread samples)

Tannin: Gravimetric determination of tannin was done according to the method of Makkar *et al.,* (1993) with 0.2g of the deffated samples weighed into test tubes and tannin was extracted in 10ml 70% acetone. It was then placed in iced water bath for 10min to allow for complete extraction of tannin. Exactly 0.2ml of the filtrate was placed in test tubes and made up to 1ml with distilled water. 2.5ml of 20% Na_2CO_3 and 0.5ml folin's reagent diluted 1:1 with distilled water, were added and the content was mixed properly. The solution was incubated for 45mins at room temperature to develop colour (blue colour).

Standard tannic acid solution (1 ml) ranging from 0.01- 0.05 mg/ml was also prepared, followed by the addition of 2.5ml Na_2CO_3 and 0.5ml folin's reagent. The absorbent of each sample was read at wavelength 700nm using a Corning Colorimeter (Corning 253, Corning Ltd, Essex, England) against a reagent blank. The tannin content in each sample was deduced from the standard tannic curve.

Phytate: Phytate was determined according to the method of Hebner and Stadler (1914) and Young and Greaves, (1939). Samples (4g each) were soaked in 100ml; of 2% HCl for 3 hours and then filtered. About 25ml of the filtrate was placed in a conical flask, 5ml of 0.3% ammonium thiocyanate solution was added as indicator and 53.3ml of distilled water was also added to give it proper acidity. This was titrated with standard Fe_2Cl_3 solution. Until a brownish yellow colour persisted for 5minutes.

$$phytate\ in \frac{mg}{100g} = titre\ value\ \times 564.11$$

Oxalate: The determination was done according to Day and Underwood (1986). The bread samples (1g each) were put into separate plastic bottles followed by the addition of 75ml of 1.5N H_2SO_4. The content was mixed properly and allowed to extract for 1 hour with constant agitation using a mechanical shaker. This was then filtered and 25ml of the filtrate was titrated with 0.1ml $KMnO_4$ while hot (80- 90 °C) until a purple colour was observed at end point. The titre value was then multiplied by 0.9004 to give the result expressed as mg/ g.

3.2.7 Evaluation of the physical properties of bread samples

Loaf weight: The loaf weight was determined by weighing the bread loaves 20 mins after baking, using the laboratory scale (CE- 410I, Camry Emperors, China) and the readings recorded in grammes.

Loaf volume: The loaf volume was determined by using Rape seed displacement method (AACC, 2000, Standard 10-05). This was done by loading sorghum grains into an empty box with calibrated mark until it reached the marked level and unloaded back. The bread sample was put into the box and the measured sorghum was loaded back again. The remaining sorghum grains left outside the box was measured using measuring cylinder and recorded as loaf volume in cm^3.

Specific volume: The specific volume (volume to mass ratio) (cm^3/g) was thereafter calculated. Bread height and diameter were measured by using a measuring ruler and the loaf shape (height to diameter ratio) was also calculated from these values.

3.2.8 Sensory evaluation

A survey of five hundred (500) randomly selected respondents across the geographical zones of Akure metropolis, Southwestern Nigeria, was carried out to determine consumption pattern and bread quality attributes important to consumers in the metropolis using a well-designed questionnaire (Appendix 1). The impact of socio-economic factors on bread quality preferences was also examined. The questionnaire was designed to obtain information on the sex, educational level, age-group, frequency and time of bread consumption. Thereafter, a survey of nine (9) bread samples produced in Akure metropolis was carried out to determine the most acceptable locally produced bread sample and used as control. Bread made from the composite flours were subjected to the sensory evaluation. The following sensory attributes, viz: taste, aroma, texture, appearance and overall acceptability, were assessed on bread samples from the composite flours and the control within 3 to 6 h of baking. The crumb and crust colour, crumb holes, stability, crumbling, surface resistance to light of the bread samples were also evaluated after sufficient cooling. The reflective surface colour of bread samples were measured by changing the surfaces of the bread towards light rays.

3.2.9 Statistical analysis

All determinations were performed in triplicate. The statistical analyses were conducted using either one-way or two-way ANOVA procedures depending on the experimental design. Statistical differences in samples were tested for at $p < 0.05$. Duncan's multiple-range test (DMRT) was used to differentiate between the mean values. All the analyses were done with SPSS (11.0) software.

CHAPTER FOUR

4. RESULTS AND DISCUSSION

4.1 Proximate Composition of Composite Flours

Table 4.1 shows that the crude protein (CP) content for wheat flour, breadfruit flour (BF) and breadnut flour (BNF) were 15.70%, 3.35% and 3.62% respectively. The carbohydrate and energy value for the flours were76.50%, 388.87 kcal/ 100g, 73.50%, 311.96 kcal/ 100g, 62.17% and 279.83 kcal/ 100g (WF, BF and BNF) respectively. It is then assumed that these flours (BF and BNF) could be substituted into wheat flour and the composite flours still maintaining its protein nature for better rheological and higher dough formation (Ragone, 2003; Omobuwajo, 2003; Olaoye and Onilude, 2008).

4.2 Rheological Properties of the Doughs

The Farinograph data of the substituted flours from wheat, breadfruit and breadnut are summarized in Table 4.2. It was observed that the protein content of the flours ranged from 9.50 to 10.50% with samples M1 and M5 very closer to the control (10.60%). The protein content of the substituted flours decreased as the level of substitution increased. The moisture content of the substituted flours ranged from 12.70 to 13.40% and that of control is 13.30%.

Table 4.1: Proximate composition of the composite flour

Proximate composition	Breadfruit flour (BF)	Breadnut flour (BNF)	Wheat flour (WF)
Protein (%)	3.35 ± 0.05	3.62 ± 0.05	15.70 ± 0.36
Fat (%)	0.51 ± 0.05	1.85 ± 0.06	2.60 ± 0.36
Fibre (%)	3.67 ± 0.08	4.52 ± 0.05	0.30 ± 0.03
Ash (%)	2.69 ± 0.04	1.24 ± 0.02	0.61 ± 0.04
Carbohydrate (%)	73.50 ± 0.70	62.17 ± 0.32	76.50 ± 0.36
Energy value (kcal/ 100g)	311.96 ± 2.90	279.83 ± 0.55	388.87 ± 4.46

Table 4.2: Rheological properties of the doughs from composite flour

Samples	Protein (%)	Moisture (%)	Water Absorption (%)	Arrival Time (mins)	Dough Development Time (mins)	Dough stability Time (mins)
M1	10.50b±0.03	13.40a±0.03	62.90e±0.02	1.00b±0.03	1.50b±0.02	7.50e±0.03
M2	9.90e±0.02	13.40a±0.02	67.30b±0.03	1.25a±0.03	1.50b±0.03	8.00c±0.02
M3	9.50f±0.06	13.40a±0.01	72.30a±0.04	1.25a±0.04	1.75a±0.02	7.75d±0.02
M4	10.20c±0.02	13.10c±0.02	60.50f±0.03	0.98b±0.02	1.50b±0.01	12.00a±0.10
M5	10.50b±0.03	12.70d±0.06	63.60d±0.06	1.00b±0.03	1.50b±0.02	10.00b±0.10
M6	10.01d±0.01	12.70d±0.01	66.20c±0.03	1.25a±0.02	1.50b±0.03	8.03c±0.12
CONTROL	10.60a±0.06	13.30b±0.02	57.80g±0.03	1.00b±0.02	1.75a±0.02	7.50e±0.04

Values with the same letters in the same column are not significantly different.

CONTROL = 100% WF, M1 = 5% BF/ 95% WF, M2 = 10% BF/ 90% WF, M3 = 15% BF/ 85% WF, M4 = 5% BNF/ 95% WF, M5 = 10% BNF/ 90% WF, M6 = 15% BNF/ 85% WF

Water absorption of the composite flour doughs ranged from 60.50 to 72.30% and slightly increased when compared with the control (57.80%). The absorption of more water during mixing is a typical characteristic of composite starches (Doxastakis *et al.* 2002). Several studies also reported that the dough made from composite flour absorbed more water than that made from wheat flour alone (Lee *et al.* 2001; Morita *et al.* 2002). The amount of water (absorption) required to centre the farinogram curve on the 500 BU (Brabender Units) line increased steadily with every increment of flour blends. Water absorption level was negatively correlated with loaf volume, and was significantly different in all cases investigated.

Water absorptions were evaluated up to levels at which the doughs became sticky. Although such absorptions resulted in larger loaf volumes, these water levels could not be considered optimal because the workability of the doughs was impaired. Similar effects have been previously reported for lupin flour (Doxastakis *et al.* 2002), corn flour (Pham and Naofumi, 2004), sunflour (Biljana and Bojana, 2008) and soy protein (Maforimbo *et al.* 2008). The arrival time of dough made from the substituted flours (5% BF and 10% BNF) was the same with control (1min), shortened for 5% BNF (0.98 min) and lengthened for 10% BF, 15% BF and 15% BNF during mixing, while the stability time of these dough was longer (7.75- 12.00 mins) than that of the control except for 5% BF which is the same with the control (7.50 mins).

Development time is the time from the first addition of water to the time the dough reaches the point of greatest torque. During this phase of mixing, the water hydrates the flour components and the dough is developed. There was no significant difference in the development time between the dough with or without substitution (1.50- 1.75 mins). Dough-mixing studies showed that inclusion of BF and BNF blends increased farinograph arrival time and dough stability when substituted for wheat flour in a bread system (Doxastakis *et al.* 2002). As the level of flour blends in composite dough increased, farinograph absorption, mixing time and dough stability increased as well. These results showed that the substitution of BF and BNF for wheat flour improved the texture of dough i.e. making the dough stronger than the control. These factors are good for bread making and might be due to the level of cross linkage of the starches, which developed the cohesive, rubbery texture of the dough during mixing. Also, Olatunji and Akinrele (1978) studied breadfruit flour as a component of composite flour and concluded that at 10% substitution of wheat flour with breadfruit flour, there were no great changes in rheological dough properties and bread quality.

4.3 Gluten Composition of Composite Flours

The % wet gluten content of the composite flours is presented in Table 4.3. It ranged from 14.00 to 18.30%. High wet gluten present in the 5% BNF substitution (18.30 g/100 g) while the lowest was in 15% BF (14.00 g/100 g) when compared with the control (24.90%). It was also observed from the table that the gluten content decreased as the level of substitution increased. The dough produced from 5% BNF and 5% BF flours maintained their cohesiveness and elasticity during kneading and washing under water, thus enabling more washing of the starch from gluten fraction (Curic *et al.* 2008).

As expected, the yields of dry gluten fraction were closely associated with protein contents of their flours (based on values in Table 4.2), but the dry gluten contents were found more, might be due to the retention of starch and other non glutinous matters. The gluten from 15% BF flour became sticky during kneading and retained more starch impurities. Generally, commercial glutens have been found to contain 73–80 g/100 g protein on dry basis (Salim- ur *et al.* 2007).

Table 4.3: Gluten content (%) of composite flour

Samples	% Gluten
95% WF/ 5% BF	17.50c ± 0.15
90% WF/ 10% BF	15.70e ± 0.10
85% WF/ 15% BF	14.00g ± 0.05
95% WF/ 5% BNF	18.30b ± 0.10
90% WF/ 10% BNF	16.80d ± 0.15
85% WF/ 15% BNF	15.40f ± 0.10
CONTROL	24.90a ± 0.10

Values with the same letters in the same column are not significantly different.

4.4 Pasting Properties of Composite Flours

The effects of substitution of breadfruit flour and breadnut flour in wheat flour on rheological properties are presented in Table 4.4. The gelatinization (69- 74 °C) and peak temperatures (84- 89 °C) of the composite flours were significantly higher than those of the control (61 °C and 71 °C respectively). These temperatures were increasing as the level of addition of breadfruit flour increased with no significant difference. Meanwhile, there was significant difference in the increased temperatures as level of addition of breadnut flour increased.

Peak (45- 300 BU) and breakdown viscosities (80- 240 BU) of the substituted flours were significantly lower than those of the control (575 BU and 400 BU respectively). The final viscosities of the composite flours were lower than that of the control and decreased with the increase in the level of substitution (Pham and Naofumi, 2004). Additionally, the substitution of the breadfruit flour and breadnut flour also exhibited the resistance to retrogradation as indicated by lower setback and total setback viscosities than those of the control. Other rheological properties like stability of the starch and gelatinization index were highest in 5% level of substitution of the flours but significantly lower than that of control. It was also observed that the ease of cooking was the same for 5% BF, 15%, 5% BNF and 10% BNF (10 mins), but there was no significant difference among all the samples and the control (Adeyemi *et al.* 1996). These results showed that level of substitution had a greater effect on the pasting properties; hence, a dough mixture of up to 15% substitution of breadnut flour and breadfruit flour would be more suitable for bread production (Olaoye and Onilude, 2008).

Table 4.4: Pasting properties of composite flour

	SAMPLES						
	M1	M2	M3	M4	M5	M6	CONTROL
Tp (°C)	69c	70c	72c	62ab	68bc	74c	61a
Mg (mins)	26abc	27abc	28bc	29c	26abc	22ab	21a
Tvp (°C)	84bc	84bc	88c	70a	80b	89c	71a
Vp (BU)	300b	240c	130d	300b	260bc	45e	575a
Mn (mins)	36bc	36bc	38bc	39c	37ab	33b	27a
Vi (BU)	240b	200b	120c	240b	210b	60d	415a
Vr (BU)	200bc	170c	100d	240b	220b	80d	400a
Ve (BU)	540c	470d	200e	700b	455d	160e	1510a
Mn- Mg (mins)	10a	9a	10a	10a	10a	11a	6a
Ve- Vp (BU)	240b	230b	70a	400c	195b	115a	935d
Ve- Vr (BU)	340c	300d	100f	460b	235e	80f	1110a
Vp- Vr (BU)	100b	70bc	30d	60cd	40cd	35e	175a

Values with the same letters in the same column are not significantly different.

CONTROL = 100% WF, M1 = 5% BF/ 95% WF, M2 = 10% BF/ 90% WF, M3 = 15% BF/ 85% WF, M4 = 5% BNF/ 95% WF, M5 = 10% BNF/ 90% WF, M6 = 15% BNF/ 85% WF

Tp = Pasting temperature; Mg = Gelatinization time; Tvp = Temperature at peak viscosity; Vp = Peak viscosity during heating; Mn = Time to reach peak viscosity; Vi = Viscosity at 95 °C; Vr = Viscosity after 15 mins holding at 95 °C; Ve = Viscosity on cooling to 50 °C; Mn- Mg = Ease of cooking; Ve- Vp = Setback values; Ve- Vr = Gelatinization index; Vp- Vr = Stability of the starch.

4.5 Consumer Preferences

4.5.1 Socioeconomic background of respondents

The socio- economic background of the 500 respondents drawn across the geographical zones in Akure metropolis for this survey is presented in Table 4.5. The distribution of the respondents by gender was 46% male and 54% female. Most respondents were of working age with 32.6%, 30.4%, 12.6% and 9.8% in the 20–29, 30- 39, 40–49 and 50- 59 age groups respectively, whereas only 11.8% of the respondents were less than 20 years old and 2.8% more than 60 years old. Most respondents (55%) were singles and 44.6% were married, while 0.4% of the respondents did not give response to their marital status. The respondents were fairly evenly distributed among the tertiary level of education (55.8%), followed by secondary education level (23%), primary education level (6.4%) and informal education had 14.6% of the respondents, whereas, 0.2% gave no response to the questions posed to them.

The result presented in Table 4.6 revealed the frequency of bread consumption among the respondents of different socio- economic background. Bread had the status of being a highly appreciated staple among its consumers. This was indicated by the rate of its consumption in their meal irrespective of their age, educational and marital background, the frequency of consumption and the tendency to use it as the major carbohydrate source in a meal. Further evidence revealed that single people were highest no of consumers (275) and increased number at tertiary level (279) with female respondents having upper hands in the responses. The desirability of bread consumption was provided by the higher number of requests twice in a day as obtained from the result (141), while the least consumption was recorded for six times a day (7).

Table 4.5: Socio-economic background of respondents

Parameters		Number of Respondents	Percent
Sex	Male	230	46
	Female	270	54
	Total	**500**	**100**
Marital Status	Single	275	55
	Married	223	44.6
	Uncompleted	2	0.4
	Total	**500**	**100**
Educational Level	None	73	14.6
	Primary	32	6.4
	Secondary	115	23
	Tertiary	279	55.8
	Uncompleted	1	0.2
	Total	**500**	**100**
Age group	< 20	59	11.8
	20 – 29	163	32.6
	30 – 39	152	30.4
	40 – 49	63	12.6
	50 – 59	49	9.8
	> 60	14	2.8
	Total	**500**	**100**

Table 4.6: Respondent classification on the basis of socio-economic group and frequency of bread consumption

Socio-economic factors			Age – Group						
			< 20	20 – 29	30 – 39	40 – 49	50 – 59	> 60	Total
Marital Status	Single	Male	25	68	38	6	1	0	**138**
		Female	29	67	33	7	1	0	**137**
		Total	**54**	**135**	**71**	**13**	**2**	**0**	**275**
	Married	Male	0	9	29	24	23	6	**91**
		Female	5	18	52	26	24	7	**132**
		Total	**5**	**27**	**81**	**50**	**47**	**13**	**223**
Educational level	None	Male	0	4	8	3	11	6	**32**
		Female	0	6	15	8	7	5	**41**
		Total	**0**	**10**	**23**	**11**	**18**	**11**	**73**
	Primary	Male	6	2	4	0	1	0	**13**
		Female	9	4	3	2	1	0	**19**
		Total	**15**	**6**	**7**	**2**	**2**	**0**	**32**
	Secondary	Male	10	20	8	8	1	0	**47**
		Female	21	18	16	7	5	1	**68**
		Total	**31**	**38**	**24**	**15**	**6**	**1**	**115**
	Tertiary	Male	9	52	47	19	11	0	**138**
		Female	4	57	51	15	12	2	**141**
		Total	**13**	**109**	**98**	**34**	**23**	**2**	**279**
Frequency of consumption	Once	Male	11	17	10	6	9	5	**58**
		Female	9	21	15	7	3	3	**58**
		Total	**20**	**38**	**25**	**13**	**12**	**8**	**116**
	Twice	Male	3	25	21	8	10	0	**67**
		Female	8	22	24	7	10	3	**74**
		Total	**11**	**47**	**45**	**15**	**20**	**3**	**141**
	Thrice	Male	3	16	16	8	3	1	**47**
		Female	4	21	27	6	9	0	**67**
		Total	**7**	**37**	**43**	**14**	**12**	**1**	**114**
	Four times	Male	2	8	10	3	0	0	**23**
		Female	3	11	5	3	0	0	**22**
		Total	**5**	**19**	**15**	**6**	**0**	**0**	**45**
	Five times	Male	1	2	0	1	1	0	**5**
		Female	2	1	1	1	0	1	**6**
		Total	**3**	**3**	**1**	**2**	**1**	**1**	**11**
	Six times	Male	1	2	1	0	0	0	**4**
		Female	1	1	0	0	1	0	**3**
		Total	**2**	**3**	**1**	**0**	**1**	**0**	**7**
	Daily	Male	4	8	9	4	1	0	**26**
		Female	7	8	13	9	2	1	**40**
		Total	**11**	**16**	**22**	**13**	**3**	**1**	**66**

Several past reports (David, 2006; Oloye, 2006; Onabolu *et al.* 1998) had supported this result which revealed the choice of bread as a staple and as an alternative to other starchy foods. These findings, therefore, indicated a positive change in the attitude to bread consumption among consumers with different socio- economic background, unlike in the past times where its acceptance and consumption was traditionally low and considered as poor man's diet.

4.5.2 Bread quality preferences among consumers in Akure metropolis

Table 4.7 shows that age and educational qualifications significantly influence frequency and time of consumption while sex and marital status had no effect on frequency of consumption. It shows that gender and marital background did not significantly affect the rate at which people consume bread. Marital status had a significant influence on time of consumption because some respondents preferred eating bread at particular time of the day. The most significant parameters influencing bread acceptability were identified to be age-group, educational qualifications and frequency of consumption. These parameters were therefore used as basis for gauging desirable bread attributes.

Table 4.8 shows that there is a significant variation in age-group preference with respect to taste, colour, taste × texture interaction, flavour and tolerable percent increase with increased bread quality. Preferences on the basis of educational qualification varies significantly with respect to texture, choice of flavour, shape of bread and percent increase in cost. Frequency of consumption is significantly influenced by taste, texture × colour, taste × colour × texture interactive effects, aftertaste, flavour, choice of flavour, shape of bread and percent increase in cost with increased quality. Percent increase in cost appears to be a major factor in view of its dependence on all the three factors evaluated.

Table 4.7: Summary table showing effect of socio-economic background on frequency and time of bread consumption.

Parameters	Frequency of consumption	Time of consumption
Age	✓	✓
Sex	X	X
Marital Status	X	✓
Educational qualification	✓	✓

x: not significant
✓: significant

Table 4.8: Summary table effect of socio- economic background and frequency of bread consumption on bread quality parameters

Parameters	Age	Educational qualification	Frequency of consumption
Taste	✓	×	✓
Colour	✓	×	×
Texture	×	✓	×
Taste × Colour	×	×	×
Taste × Texture	✓	×	×
Texture × Colour	×	×	✓
Taste × Colour × Texture	×	×	✓
Aftertaste	×	×	✓
Flavour	✓	×	✓
Choice of flavour	×	✓	✓
Bread shape			
Shape Type	×	✓	✓
Packaging	×	×	×
No packaging influence	×	×	×
Pay more for higher quality	×	×	×
% increase in cost	✓	✓	✓
Cost not important if good quality	×	×	✓

x: not significant
✓: significant

Taste was the sensory characteristic most appreciated by consumers and was the criterion used most frequently to rank rate of bread acceptability. From the results presented in Table 4.9, it could be seen that 83% of the respondents in terms of age, educational level and frequency of consumption agreed that consumer perception and acceptability of bread is mainly dependent on taste basis, whereas 11.4% disagreed totally and 5.6% were unable to give their decision to whether taste affects consumer perception or not.

Wootton and Tumaalii (1984) had previously noted consumer preference for breadfruit consumption in the mature but unripe stage due to its flavouring production. This was confirmed in this study as evident from the result shown in Table 4.10 that 209 respondents out of 500 interviewed showed preference for slightly flavoured bread, followed by 202 respondents showing preference for strongly flavoured bread. It was further revealed that 79 people showed preference for unflavoured bread, while the remaining 10 did not give any response to the raised question.

Table 4.11 presents the result of the influence of different kinds of flavour in bread on consumer acceptability. However, among a significant percentage of the respondents, there was strong acceptability of chocolate flavoured bread (167), while for others; it was a distinct second choice. A notable proportion of the respondents preferred vanilla flavoured bread (106), banana flavoured bread (53) and pineapple flavoured bread (16). Besides it was also shown by the result that equal number of respondents (79) showed preference for strawberry flavoured and unflavoured bread respectively.

From these results and findings on consumer preference above, it could be concluded that people preferred bread with good taste, flavour, colour, aroma and other bread qualities at affordable cost.

Table 4.9: Consumer perception (%) of the importance of taste of bread on the basis of age, education and frequency of consumption

Factors	Basis	Agree	Disagree	Undecided	Total
Age	< 20	11	0.4	0.4	11.8
	20 – 29	27.4	3.8	1.4	32.6
	30 – 39	24.2	3.8	2.4	30.4
	40 – 49	8.8	2.6	1.2	12.6
	50 – 59	9	0.6	0.2	9.8
	> 60	2.6	0.2	0	2.8
	Total	**83**	**11.4**	**5.6**	**100**
Education	None	11	3	0.6	14.6
	Primary	5.4	0.8	0.2	6.4
	Secondary	19.2	2.6	1.2	23
	Tertiary	47.2	5	3.6	55.8
	No	0.2	0	0	0.2
	Total	**83**	**11.4**	**5.6**	**100**
Frequency of consumption per week	Once	20	2	1.2	23.2
	Twice	24.8	2.6	0.8	28.2
	Thrice	18.4	3.6	0.8	22.8
	Four times	7.4	0.8	0.8	9
	Five times	1.6	0.2	0.4	2.2
	Six times	1.2	0.2	0	1.4
	Daily	9.6	2	1.6	13.2
	Total	**83**	**11.4**	**5.6**	**100**

Table 4.10: Influence of flavourings on consumer acceptability

		Slightly flavoured	Strongly flavoured	Unflavoured	Undecided	Total
Age group	< 20	24	29	5	1	59
	20 – 29	81	62	18	3	163
	30 – 39	71	52	24	5	152
	40 – 49	18	28	17	0	63
	50 – 59	12	25	12	0	49
	> 60	3	6	3	2	14
	Total	209	202	79	10	500
Educational Level	None	34	22	15	2	73
	Primary	7	19	5	1	32
	Secondary	36	62	15	2	115
	Tertiary	132	98	44	5	279
	Uncompleted	0	1	0	0	1
	Total	209	202	79	10	500
Frequency of Consumption	Once	58	42	15	1	116
	Twice	50	64	24	3	141
	Thrice	55	42	14	3	114
	Four times	26	10	8	1	45
	Five times	3	8	0	0	11
	Six times	1	4	1	1	7
	Daily	16	32	17	1	66
	Total	209	202	79	10	500

Table 4.11: Influence of flavour type on consumer acceptability

		Vanilla	Strawberry	Chocolate	Banana	Pineapple	None	T
Age group	< 20	12	15	21	4	3	4	
	20 – 29	37	33	50	16	3	24	1
	30 – 39	32	19	59	15	6	21	1
	40 – 49	12	6	21	7	3	14	
	50 – 59	9	5	13	8	1	13	
	> 60	4	1	3	3	0	3	
	Total	106	79	167	53	16	79	
Educational Level	None	19	5	22	13	4	10	
	Primary	4	7	19	0	0	2	
	Secondary	18	24	45	12	5	11	1
	Tertiary	65	43	81	28	7	56	
	Total	106	79	167	53	16	79	
Frequency of Consumption								
	Once	34	20	36	9	3	14	
	Twice	30	25	40	21	5	20	
	Thrice	16	18	48	12	2	18	
	Four times	7	8	15	6	2	7	
	Five times	1	1	6	2	1	0	
	Six times	2	2	2	1	0	0	
	Daily	16	5	20	2	3	20	
	Total	106	79	167	53	16	79	

4.6 Physical Properties of Composite Bread

The loaf weight of the composite bread samples ranged from 550 to 600g as shown in Table 4.12, with M3 having the highest value. The loaf volume of the composite bread samples ranged from 1229.01 to 1886.03 cm^3 with M4 having the highest value. This result showed reduced loaf volume as proportion of breadfruit and breadnut flour increased in the flour mixes. However, volume of bread produced from 5:95 breadnut- wheat flour mixes was more significant than those produced from 100% commercial wheat flour (Ade-Omowaye *et al*. 2008).

The specific volume of the composite bread samples decreased significantly with the addition of breadfruit and breadfruit seed flour and ranged from 2.08 to 3.39 cm^3/ g with M4 significantly different from others including the control. The specific volume of breadfruit/ wheat bread was significantly lower than that of breadnut/ wheat bread (Biljana and Bojana, 2008).

Shittu *et al*. (2007) reported that higher loaf weight and volume have positive economic effect on bread at the retail end. Therefore, loaf weight reduction during baking is an undesirable economic quality to the bakers as consumers often get attracted to bread loaf with higher weight and volume believing that it has more substance for the same price. The specific volume, which is the ratio of the two properties, has been generally adopted in the literature as a more reliable measure of loaf size (Shittu *et al*. 2007).

According to China Grain Products Research and Development Institute, CGPRDI (1983), the specific volume of standard bread should be 6 cm^3/ g and should not be less than 3.5 cm^3/ g (Lin *et al*. 2009). It seems that only sample M4 met the passing level of specific volumes.

Table 4.12: Loaf weight, loaf volume, specific volume and loaf shape of bread

Samples	Loaf weight (g)	Loaf volume (cm^3)	Specific loaf volume (cm^3/ g)	Loaf shape (h/d)
M1	550.00b±2.11	1278.93d±6.46	2.32d±0.02	1.75c±0.00
M2	560.00b±4.23	1229.01e±7.76	2.20e±0.01	1.98d±0.02
M3	600.00a±2.11	1245.91e±4.63	2.08f±0.00	2.07e±0.01
M4	556.00b±1.69	1886.03a±7.92	3.39a±0.01	1.44b±0.01
M5	557.00b±1.27	1520.46c±7.68	2.73c±0.02	1.74c±0.00
M6	558.00b±0.84	1281.27d±1.24	2.30d±0.01	1.96d±0.02
CONTROL	550.00b±2.11	1826.64b±0.68	3.32b±0.03	1.38a±0.02

Values with the same letters in the same column are not significantly different.

CONTROL = 100% WF, M1 = 5% BF/ 95% WF, M2 = 10% BF/ 90% WF, M3 = 15% BF/ 85% WF, M4 = 5% BNF/ 95% WF, M5 = 10% BNF/ 90% WF, M6 = 15% BNF/ 85% WF

Though, the results still suggested that substituting 15% of wheat flour in the bread formula with breadfruit and breadnut flour would not interfere with bread specific volume.

The addition of breadfruit and breadnut generally affected the shapes of the composite bread (described by height/diameter ratio) giving flatter products. These changes were less pronounced for breadnut bread types where the samples were closer significantly when compared with the corresponding control.

Incorporation of higher level of breadfruit and breadnut flour had a negative effect on the volume of bread (Hallen *et al*. 2004). This might be due to reduction in the wheat structure forming proteins and a lower ability of the dough to enclose air during proofing which had a volume depressing effect (Akobundu *et al*. 1988). Although, the flour having 15% breadfruit had the volume depressing effect on bread, 15% breadnut flour produced bread with greater volume. This is in accordance with the report of Salim-ur *et al*. 2007.

Table 4.13 shows that sample 536 (5% BF/ 95% WF) is the most significant of all the experimental samples when compared with the control sample. Samples 883 (10% BNF/ 90% WF), 679(10% BF/ 90% WF) and 357 (15% BNF/ 85% WF) were not significantly different in terms of crumb colour, holes and firmness.

Table 4.13: Bread quality characteristic/ evaluation

Samples	Crust colour	Crumb colour	Crumblings	Crumb holes	Crumb stability	Reflective colour Surface	Crumb elasticity	Crumb firmness	Shape regularity
149	2.53bc	2.42cd	2.22b	2.17abc	2.65b	2.35ab	2.33ab	2.05ab	2.32bc
536	1.84a	1.63ab	1.83ab	2.05ab	2.17abc	1.77ab	2.63b	2.21ab	1.79ab
883	2.67bc	2.67cd	2.41b	2.33bc	2.41b	2.93bc	2.28ab	2.28ab	2.39bc
357	3.17c	3.00d	2.29b	2.78c	2.77b	2.94bc	2.53b	2.59b	2.78c
679	1.74a	2.00bc	2.28b	2.05ab	2.11ab	1.88ab	2.21ab	2.16ab	1.84ab
759	2.47b	2.58cd	2.44b	2.65bc	2.29b	3.88c	2.44ab	2.74b	2.32bc
247	1.44a	1.28a	1.47a	1.61a	1.59a	1.41a	1.56a	1.61a	1.28a

Values with the same letters in the same column are not significantly different.

247 = CONTROL, 883 = 10% BNF/ 90% WF, 759 = 5% BNF/ 95% WF, 149 = 15% BF/ 85% WF, 357 = 15% BNF/ 85% WF, 536 = 5% BF/ 95% WF, 679 = 10% BF/ 90% WF

Samples 536 and 679 were not significantly different from the control sample in terms of crust colour (Olaoye and Onilude, 2008). This is showing that the composite flour could still be used up to 15% level of breadnut flour. The observed scores for the crust and crumb colour showed that the level of substitution of BF and BFS flour in composite bread does not reduce the caramelization process which forms the brown colour during baking. The crumb firmness and shape regularity of the composite bread samples were in total compatibility with the control. All these qualities did not significantly ($p< 0.05$) affect the acceptability and preference of the composite bread samples, this may have been caused by the attributes and organoleptic properties of the samples and long period of consumption of breadfruit and breadnut without nutritional toxicity and disorder (Obasuyi and Nwokoro, 2003; Omobuwajo, 2003; Ragone, 2003).

4.7 Chemical Composition of Bread Samples

4.7.1 Proximate composition

Table 4.14 shows that crude protein (CP) content of sample M1 (11.96%) is even greater than the control sample (11.07%). There is no significant difference in the CP content of samples M2 & M4 and M5 & M6. The CP decreased as the amount of breadfruit flour and breadnut flour increased. Generally, the protein contents of all the samples were relatively low because wheat, breadfruit and breadnut were poor sources of protein (Ragone, 2003; Okaka *et al*. 2002). Crude fat (CF) content of the samples were higher in the composite samples given as 4.29%, 4.26%, 4.13%, 4.29%, 5.00% and 5.62% for M1, M2, M3, M4, M5 and M6 respectively than the control (3.41%).

Table 4.14: Proximate composition of the composite bread

Samples	Protein (%)	Fat (%)	Moisture (%)	Ash (%)	Carbohydrate (%)	Energy value (kcal/ 100g)
M1	11.96a±0.05	4.29c±0.04	35.51f±0.04	1.67d±0.03	46.93b±0.17	274.17b±0.06
M2	11.23b±0.09	4.26c±0.05	35.29e±0.03	2.08a±0.04	47.14b±0.21	271.82c±0.02
M3	10.66d±0.05	4.13d±0.03	36.94d±0.02	2.10a±0.04	46.17c±0.14	264.49d±0.12
M4	11.17b±0.09	4.29c±0.04	38.15c±0.04	1.78c±0.02	44.61d±0.19	261.73f±0.04
M5	11.03c±0.02	5.00b±0.04	38.98b±0.03	1.92b±0.07	43.07e±0.16	261.40g±0.18
M6	11.03c±0.01	5.62a±0.06	39.06a±0.04	2.07a±0.06	42.22f±0.17	263.58e±0.11
Control	11.07c±0.03	3.41e±0.03	33.51g±.0.04	1.56e±0.03	50.45a±0.12	276.77a±0.15

Values with the same letters in the same column are not significantly different.

CONTROL = 100% WF, M1 = 5% BF/ 95% WF, M2 = 10% BF/ 90% WF, M3 = 15% BF/ 85% WF, M4 = 5% BNF/ 95% WF, M5 = 10% BNF/ 90% WF, M6 = 15% BNF/ 85% WF

It was observed that the CF decreased as level of breadfruit flour increased and the CF increased as the level of breadnut flour increased. This is in line with the report of Obasuyi and Nwokoro, (2006) who reported that the seeds had higher fat content than the breadfruit. Moisture content (MC) of the samples ranged from 33.51 to 39.06%. At the baking temperature (230- 250 °C) the MC of the raw materials must have greatly reduced. However, different food materials have different capacity for absorbing/ retaining moisture which may exist as occluded or absorbed water. As a result, it can be deduced that even at the high baking temperature, some moisture will be found in the samples as observed during this study (Eddy *et al*. 2007). The ash contents of the composite bread samples were 1.56% (control); 1.67% (M1); 2.08% (M2); 2.10% (M3); 1.78% (M4); 1.92% (M5) and 2.07% (M6) respectively. Generally, the ash content of composite bread samples increases as the level of supplementation increases implying that the inorganic nutrients in the composite bread is richer than that of wheat bread.

The carbohydrate content of the bread samples ranged from 42.22 to 50.45% with higher values in flour substitution with breadfruit flour than those with breadnut flour when compared with the control samples. This observation may be attributed to the high content of carbohydrate in breadfruit than breadnut. According to Enwere (1998), who reported that of all the solid nutrients in starchy crops, carbohydrate predominates. Carbohydrate supplies quick source of metabolisable energy and assists in fat metabolism.

The energy values of the bread samples ranged from 261.40 to 276.77 kcal/ 100g. The higher value is observed in those supplemented with the breadfruit flour. In general, it is believed from the report of this study that bread could serve as source of energy for the metabolic process in the mammalian body (Bennet and Nozzolillo, 1987).

4.7.2 Mineral composition of composite bread

Table 4.15 shows that bread made from composite flour had between 257.68- 885.32 mg/100g of sodium (Na), with that of 15% BF substitution having the highest value (885.32 mg/100g) than the control sample (835.36 mg/100g). The calcium (Ca) content for the composite bread samples ranged from 32.05 to 112.59 mg/ 100g, with 5% BFS having the lowest value compared to the control (141.67 mg/100g). The magnesium (Mg) content ranged between 37.15- 168.88 mg/100g, with 5% BF having the highest value (168.88 mg/100g) compared to the control (138.80 mg/100g). The iron (Fe) content was 0.32- 4.14 mg/100g with 15% BFS having the lowest value (0.32 mg/100g), though not significantly different from that of 5% BF when compared with the control (4.69 mg/100g).

The addition of breadnut flour and breadfruit flour did not significantly increase the contents of calcium, sodium and iron of the bread samples. Significant increment between the contents of these minerals was found only as the level of substitution increases except for iron in BNF composite samples that decreased as level of substitution increases. There was significant increase and decrease in the magnesium content as level of substitution increase in BNF and BF samples respectively.

The potassium (K) level was around 92.88- 404.49 mg/100g with 15% BNF (404.49 mg/100g) having the highest value when compared with the control (314.07 mg/100g). The potassium content increased significantly within the groups with the increasing breadnut levels. Supplemented breads increased significantly in zinc content as level of supplementation increases with values ranging from 0.42 to 1.72 mg/100g when compared with the control (2.60 mg/100g). The copper content increased and decreased with the increasing level of addition of breadfruit flour and breadnut flour respectively, but not significantly different (0.35 mg/100g (10% BF, 15% BF, 5% BNF); 0.32 mg/ 100g

Table 4.15: Mineral composition of the composite bread (mg/ 100g)

	M1	M2	M3	M4	M5	M6	CONTROL
Na	430.12e±7.03	441.68e±1.04	885.32a±3.52	257.68f±3.39	486.40d±3.59	691.04c±3.31	834.36b±7.37
Ca	38.89f±2.58	83.68d±2.99	112.59b±0.26	32.05g±0.03	62.43e±2.13	107.24c±1.76	141.67a±1.78
Mg	168.88a±2.99	85.98c±2.99	37.15g±1.87	59.47f±1.78	64.74e±1.76	75.86d±2.31	138.80b±2.58
Fe	0.42f±0.04	1.40e±0.07	1.74c±0.17	4.14b±0.10	1.72d±0.10	0.32f±0.04	4.69a±0.27
K	239.16d±0.32	92.88f±2.81	139.59e±2.60	97.11f±2.25	255.63c±0.13	404.49a±2.23	314.07b±5.34
Zn	0.42f±0.03	1.18d±0.04	1.74b±0.07	0.64e±0.05	1.40c±0.04	1.72b±0.08	2.60a±0.22
Cu	0.30b±0.04	0.35b±0.04	0.35b±0.01	0.35b±0.02	0.32b±0.03	0.21c±0.04	0.52a±0.04
Pb	N.D	N.D	N.D	N.D	N.D	N.D	N.D

Values with the same letters in the same column are not significantly different.

CONTROL = 100% WF, M1 = 5% BF/ 95% WF, M2 = 10% BF/ 90% WF, M3 = 15% BF/ 85% WF, M4 = 5% BNF/ 95% WF, M5 = 10% BNF/ 90% WF, M6 = 15% BNF/ 85% WF. N.D = NOT DETECTED.

(5% BF and 10% BNF), except for the lowest value (0.21 mg/100g) for 15% BNF when compared to the corresponding control (0.52 mg/100g) (Biljana and Bojana, 2008).

There was no detectable presence of lead (Pb), a heavy metal known to be hazardous to the health of the consumers. This therefore, made these composite breads edible, healthy and free for consumption (Negron de Bravo *et al.* 1983).

4.7.3 Antinutrient composition of bread samples

Table 4.16 shows the levels of some anti- nutrient composition found in the composite bread. It was shown that the oxalate, phytate and tannin content were in the ranges of 2.70- 3.96 mg/g; 5.64- 7.33 mg/g and 0.18- 0.42 mg/g respectively. The levels of the toxic substances were not high enough to cause concern. It is, however, worth noting that some of these toxicants, such as phytic acid, oxalic acid and tannin, can interact with other nutrients and thus render them unusable by the consumer (Edet *et al.* 1985). Conversely, the condensed tannins may be more important nutritionally to the ruminants. Studies by Barnes and Gustin, (1972) have shown that at regulated dietary levels (20- 40 g/kg diet dry matter) condensed tannin may have some beneficial effect in rumen protein metabolism, largely by protecting some proteins against microbial degradation in the rumen. However, higher levels (e.g 76- 90 g/kg diet) were considered to be detrimental to the ruminants.

Meanwhile, researches made recently have studied and proved tannin to be an anti oxidant and as such not to be classified as anti nutrients any longer. On the whole, it appears that breadfruit and breadnut could serve as a good source of some nutrients and hence may be used to substitute wheat flour in baking and confectionery foods without posing any fear of danger resulting from nutritional disorder after consuming such food.

Table 4.16: Anti- nutrient composition of the composite bread

Samples	Oxalate(mg/g)	Phytate(mg/g)	Tannin(mg/g)
M1	2.70a±0.03	7.33c±0.03	0.18a±0.04
M2	3.51d±0.02	6.77b±0.06	0.23b±0.03
M3	3.33c±0.03	7.33c±0.03	0.21ab±0.01
M4	2.79b±0.04	7.33c±0.03	0.19ab±0.03
M5	3.96e±0.03	5.64a±0.04	0.42c±0.02
M6	3.51d±0.02	7.33c±0.03	0.40c±0.03

Values with the same letters in the same column are not significantly different.

M1 = 5% BF/ 95% WF, M2 = 10% BF/ 90% WF, M3 = 15% BF/ 85% WF, M4 = 5% BNF/ 95% WF, M5 = 10% BNF/ 90% WF, M6 = 15% BNF/ 85% WF

4.8: Sensory Properties of Bread Samples

Table 4.17 shows that sample 147 (FUTA bread) is the most significant among all the samples tested, in terms of those attributes earlier preferred by the consumers, i.e taste, loaf shape, weight, crust and crumb colour, texture, even their overall acceptability and it is therefore assumed to be used as the control sample for further organoleptic analysis of the experimental samples. Table 4.18 shows that samples 536 (5% BF/ 95% WF) and 883 (10% BNF/ 90% WF) were not significantly different from each other and had comparable ratings to the control sample in terms of appearance, taste and texture. It is then believed to conclude that bread can be produced from composite flour substituted with breadfruit flour up to 5% and breadnut flour up to 10% level without affecting the original sensory attributes of the bread (Olaoye and Onilude, 2008).

The ratings for the taste of the composite breads were compared with the control; no panelist showed a total dislike for the taste of any of the samples, implying that the taste of the samples was not affected by the level of supplementation. Aroma is related to taste with a high level of its intensity influencing the taste. However, the acceptability of the samples was comparable to the mean score of the control, with that of control higher and lowest for 5% BNF substitution. This suggests that the quality of bread that can be produced from wheat- breadfruit flour and wheat- breadnut flour mixture depends on the level of substitution (Eddy *et al*. 2007).

Table 4.17: Sensory evaluation of bread samples serving as control sample

Samples	Taste	Loaf Weight	Aroma	Loaf shape	Crust colour	Crumb colour	Crumbl-ings	Texture	Overall accept
147	1.18a	1.82a	1.41a	1.88a	1.41a	1.94a	1.94a	1.59a	1.41a
149	2.77c	2.24a	2.71b	2.00a	2.18bcd	2.12ab	2.77cd	2.47b	2.65b
257	1.77ab	1.65a	2.12b	1.59a	1.94ab	1.82a	2.00ab	1.88ab	2.35b
279	3.59d	2.88b	3.47c	2.59bc	2.88d	2.77bc	3.29de	3.12c	3.71c
483	2.18bc	1.88a	2.18b	1.65a	1.82ab	1.77a	2.06ab	1.88ab	2.24b
536	2.00b	1.88a	2.29b	2.18abc	2.12abc	1.77a	2.59bc	1.82ab	2.47b
759	2.18bc	1.71a	2.53b	2.06ab	1.71ab	1.88a	2.35abc	1.77a	2.41b
852	2.29bc	2.06a	2.47b	1.88a	2.24bcd	2.47abc	2.41abc	1.94ab	2.41b
963	4.00d	3.65c	3.41c	2.71c	2.77cd	2.88c	3.41e	3.65c	3.53c

Values with the same letters in the same column are not significantly different.

147 = FUTA bread, 149 = B.S.B Bakers bread, 257 = Adefisoye Special bread, 279 = K.K.K Special bread, 483 = Lowo Ori Butter bread, 536 = Dele Special bread, 759 = Omo Oroki Butter bread, 852 = Butter Plus bread, 963 = Diamond Special bread

Table 4.18: Sensory evaluation of composite bread samples

Samples	Taste	Aroma	Texture	Appearance	Mouthfeel	Overall Accept.
247	1.12a	1.22a	1.33a	1.24a	1.24a	1.06a
149	2.06b	2.16b	2.37b	2.37b	2.17b	2.47bc
536	2.17b	2.32b	1.84b	1.63a	2.33bc	2.32b
883	2.35b	2.83bc	2.06b	2.56b	2.47bc	2.78bcd
357	3.24c	3.11cd	2.50b	2.94b	2.82c	3.00cd
679	3.39c	2.84bc	2.26b	1.63a	2.50bc	2.26b
759	3.89c	3.74d	2.47b	2.50b	3.56d	3.32d

Values with the same letters in the same column are not significantly different.

247 = Control, 883 = 10% BNF/ 90% WF, 759 = 5% BNF/ 95% WF, 149 = 15% BF/ 85% WF, 357 = 15% BNF/ 85% WF, 536 = 5% BF/ 95% WF, 679 = 10% BF/ 90% WF

CHAPTER FIVE

5. CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The data presented in this study have demonstrated the potential for the production of bread from breadfruit and breadnut. Processing of these indigenous crops into the confectionery food items suitable for production and distribution in fast food service systems will enhance food security in many tropical countries where breadfruit and breadnut are staples, and also stimulate demand for them as an industrial raw material.

From the present paper it may be inferred that breadfruit and breadnut could be added to bread up to levels of 15% (flour basis) without significant adverse effects regarding the crust colour, crumb grain structure and uniformity. Adding breadfruit flour and breadnut flour significantly decreased crumb elasticity compared to the control samples but not to the level that would disqualify the product. Adverse effects of supplementation on the crumb elasticity were not confirmed by % gluten index.

Besides sensory properties, breadfruit flour and breadnut flour supplemented bread samples were more acceptable in many nutritional aspects as they contained significantly more protein, copper, zinc, and fat. Such bread samples would contribute to enhancement of zinc status of certain population groups since dietary surveys suggest that many individuals (particularly aged people or those taking medications such as hormone replacements or diuretics) fail to achieve the dietary reference value for zinc. It is also important that a portion of these products would contribute to absorption of copper; its deficiency is rare in Western populations but there are concerns that suboptimal copper status may be involved in developing many inflammatory and degenerative conditions such as osteoporosis and heart disease.

It was thus concluded that bread produced from mixtures of 5% BF/ 95% WF and 10% BNF/ 90% WF gave the best products which is safer for consumption due to its protein, mineral and lesser anti- nutrient contents as well as their acceptability to the consumers. In any case, consumption of bread samples supplemented with breadfruit flour and breadnut flour could be beneficial for improving the nutritional status of the general population since Nigeria is a developing country with high bread consumption.

5.2 Recommendation

It is recommended that the composite bread samples were safer for consumption as they contain very minimal amount of anti- nutrients or toxic components which might be hazardous to the consumers' health.

It is also assured that there will be marketing and operational success for the potential bakery owners as observed from the result of the survey, which reflects the greater desirability to the consumption of bread

Further analysis should be done on the composite bread to study its amino acid composition and vitamin contents. The economical implication of substituting wheat flour with breadfruit and breadnut flour should also be examined.

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QUESTIONNAIRE ON ACCEPTABILITY AND QUALITY ATTRIBUTES OF BREAD IN AKURE

Instruction: Please kindly indicate your feelings using the following options provided for each of the questions. Agree strongly, agree slightly, neither agree nor disagree, disagree slightly, disagree strongly. Please circle the one that most appropriately describe your feelings to each question.
Thank you.

SECTION A

Date:

Sex: Male ☐ Female ☐ **Marital Status:** Single ☐ Married ☐

1. Educational level

No formal education ☐
Primary School ☐
Secondary School ☐
Tertiary Institution ☐
No formal education ☐

2. Age – group

<20 ☐
20 – 29 ☐
30 – 39 ☐
40 – 49 ☐
50 – 59 ☐
$\geq$60 ☐

How often do you eat bread in a week?
Once
Twice
Thrice
Four times
Five times
Six times
Daily

What time of the day do you take bread:
Morning
Afternoon
Evening
Anytime

Weekdays only
Weekends only

SECTION B

1. The most important criterion in the acceptability of bread is taste. (a) Agree strongly (b) Agree slightly (c) Neither agree nor disagree (d) Disagree slightly (e) Disagree strongly.
2. The most important criterion in the acceptability of bread is colour. (a) Agree strongly (b) Agree slightly (c) Neither agree nor disagree (d) Disagree slightly (e) Disagree strongly.
3. The most important criterion in the acceptability of bread is texture (a) Agree strongly (b) Agree slightly (c) Neither agree nor disagree (d) Disagree slightly (e) Disagree strongly.
4. The most important criteria in the acceptability of bread are taste and colour. (a) Agree strongly (b) Agree slightly (c) Neither agree nor disagree (d) Disagree slightly (e) Disagree strongly.
5. The most important criteria in the acceptability of bread are Taste and texture. (a) Agree strongly (b) Agree slightly (c) Neither agree nor disagree (d) Disagree slightly (e) Disagree strongly.
6. The most important criteria in the acceptability of bread are colour and texture. (a) Agree strongly (b) Agree slightly (c) Neither agree nor disagree (d) Disagree slightly (e) Disagree strongly.
7. The most important criteria in the acceptability of bread are colour, taste and texture. (a) Agree strongly (b) Agree slightly (c) Neither agree nor disagree (d) Disagree slightly (e) Disagree strongly.
8. If the taste is O.K, I do not worry about after taste. (a) Agree strongly (b) Agree slightly (c) Neither agree nor disagree (d) Disagree slightly (e) disagree strongly.
9. I prefer: (a) Slightly peppered bread (b) Strongly peppered bread (c) No pepper.
10. Shape of bread can influence my acceptability. (a) Agree strongly (b) Agree slightly (c) Neither agree nor disagree (d) Disagree slightly (e) disagree strongly.
11. I prefer: (a) round, ovoid shape (b) sliced bread (c) unsliced bread
12. Packaging can influence my acceptability of bread. (a) Agree strongly (b) Agree slightly (c) Neither agree nor disagree (d) Disagree slightly (e) disagree strongly.
13. As long as I like the product, I do not worry about packaging. (a) Agree strongly (b) Agree slightly (c) Neither agree nor disagree (d) Disagree slightly (e) disagree strongly.
14. I can pay a little more for more nutritious, tasty bread. (a) Agree strongly (b) Agree slightly (c) Neither agree nor disagree (d) Disagree slightly (e) disagree strongly.
15. I will still buy nutritious bread if the cost is: (a) 10% more than other types (b) 20% more than other types (c) 30% more than other types (d) 40% more than other types (e)50% more than other types
16. Nutritive, well-packaged bread is desirable, I'll buy without considering what other types cost. (a) Agree strongly (b) Agree slightly (c) Neitner agree nor disagree (d) Disagree slightly (e) disagree strongly

FEDERAL UNIVERSITY OF TECHNOLOGY, AKURE, ONDO STATE, NIGERIA.

DEPARTMENT OF FOOD SCIENCE AND TECHNOLOGY.

Questionnaire on acceptability and desirable quality attributes of bread

Date…………………..

Instruction: You are provided with samples of bread. Please indicate your feelings using the following scale:

1: Like extremely

2: Like slightly

3: Neither like nor dislike

4: Dislike slightly

5: Dislike very much

Please feel free to make additional comments on any (or all) of the samples using the space provided. Thank you.

Quality attributes	Bread samples								
	759	**536**	**279**	**483**	**149**	**257**	**963**	**852**	**147**
Taste									
Loaf weight									
Aroma									
Loaf shape									
Crust Colour									
Crumb Colour									
Crumblings									
Texture									
Overall Acceptability									

Comments:……………………………………………………………………………………………
………
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FEDERAL UNIVERSITY OF TECHNOLOGY, AKURE, ONDO STATE, NIGERIA.

DEPARTMENT OF FOOD SCIENCE AND TECHNOLOGY.

Questionnaire on acceptability and desirable quality attributes of bread

Date......................

Instruction: You are provided with samples of bread. Please indicate your feelings using the following scale:

1: Like extremely

2: Like slightly

3: Neither like nor dislike

4: Dislike slightly

5: Dislike very much

Please feel free to make additional comments on any (or all) of the samples using the space provided. Thank you.

Quality attributes	Bread samples						
	759	**536**	**679**	**883**	**149**	**357**	**247**
Taste							
Loaf weight							
Aroma							
Loaf shape							
Crust Colour							
Crumb Colour							
Crumblings							
Texture							
Overall Acceptability							
Crumb holes							
Crumb stability/ volume							
Reflective surface colour in light							
Crumb elasticity							
Appearance							
Mouth feel							
Crumb firmness							
Shape regularity							

Comments:...

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