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Full Length Research Paper

Chemical composition, rheological properties and bread making potentials of composite flours from breadfruit, breadnut and wheat

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This study assessed the quality of bread produced from breadfruit and breadnut-wheat composite flour. Matured and freshly harvested breadfruit (*Artocarpus integrifolia*) and breadnut (*Artocarpus atilis*) were obtained from local market in Akure. They were thoroughly washed, peeled, washed again, drained, chipped, oven dried, milled, sieved and packaged. Six blends were prepared by homogenously mixing breadfruit and breadnut flours with wheat flour in the percentage proportions: 5:95, 10:90, 15:85 (BF: WF and BFN: WF) and later used to bake bread. Chemical, rheological and physical properties of the composite flour and bread made from the flours were examined. Panelists were assigned to assess the bread samples as well. The results of the proximate composition showed that the protein content of the breadfruit and breadnut flours are 3.35 and 3.62 mg/100 g; fat, 0.51 and 1.85 mg/100 g; ash, 2.69 and 1.24 mg/100 g; fibre, 3.67 and 4.52 mg/100 g; carbohydrate, 73.50 and 62.17 mg/100 g respectively and the protein content of the bread samples ranged from 10.66 to 11.96 mg/100 g; fat, 4.13-5.62 mg/100 g; ash, 1.67-2.10 mg/100 g; moisture 35.51- 39.06 mg/100 g; carbohydrate, 42.22- 46.93 mg/100 g; energy value, 261.40-274.17 Kcal/100 g. The rheological study of composite flour samples had 9.50-10.50 mg/100 g of protein content; water absorption capacity, 62.90-72.30%; dough development time, 1.50-1.75 min; dough stability time, 7.50-12.00 min. Bread samples had sodium, 257.68-885.32 mg/100 g; calcium, 32.05-112.59 mg/100 g; potassium, 92.88-404.49 mg/100 g; iron, 0.32-4.14 mg/100 g. The bread loaf weights ranged from 550 to 600 g; loaf volume, 1229.01- 1886.03 cm^3 and specific loaf volume, 2.08-3.39 cm^3/g. There is no significant difference in the crust colour, crumb holes, stability, elasticity, firmness, shape regularity and appearance of the samples. No panelist showed a total dislike for the taste of any of the samples. All the qualities evaluated did not significantly (p≤ 0.05) affect the acceptability and preference of the samples. Hence, it was concluded that wheat flour could be substituted with breadfruit and breadnut flour up to 15% level in bread making which will still retain much of the nutritional and sensory properties.

Key words: Breadfruit, breadnut, composite flour.

INTRODUCTION

Bread is a bakery product priced for its taste, aroma and texture. It is a staple food prepared by baking dough of flour and water (Osuji, 2006). Salt, fat and yeast, are common ingredients, in addition to a wide range of other ingredients, namely, milk, egg, sugar, spice, fruits, vegetables, nuts and seeds (Encyclopaedia Britannica, 2006). 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 population, urbanization and changing food habits (Onabolu et al., 1998; Oloye, 2006). However, the tropical climate of

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many developing countries does not encourage commercial wheat cultivation, leading to reliance on wheat importation to support flour milling industries.

Wheat is the grain of choice in bread preparation due to its high gluten level. There have been reports of bread made from flours of other cereal grains such as rye, maize, barley and oats; roots like cassava in combination with wheat flour (Spiekermann, 2006). 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. To this end, there have been several attempts at 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 that are useful during dough making (Oluwole et al., 2006).

The potentials of wheat-based composite flours comprising buckwheat (Lin et al., 2009), plantain (Mepba et al., 2007), modified corn starch (Woo and Seib, 2002), waxy corn starch (Morita et al., 2002; Lee et al., 2001), sunflower flour (Biljana and Bojana, 2008), chick pea (Manuel et al., 2008), bean flour (Alex et al., 2008), tiger nut (*Cyperus esculentus*) (Ade-Omowaye et al., 2008), cowpea flour (Hallen et al., 2004), lupin flour (Doxastakis et al., 2002), soybean and plantain flours (Olaoye et al., 2006) for use in bread production have been investigated with promising results showing that partial substitution may be possible. Olaoye et al. (2007) reported that breadfruit flour substitution in wheat flour at 15% level gave biscuits with acceptable sensory attributes.

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 indigenous crops used in composite flour production. The research reported here was designed to enhance increased utilization of breadfruit and breadnut flour in bakery products. Finding further uses for breadnut, 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.

The objectives of this work are to evaluate the chemical composition, rheological and bread making properties of wheat-breadfruit and wheat-breadnut composite flours.

MATERIALS AND METHODS

Commercial hard wheat flour (100%), baking yeast (DSM bakery ingredient, Dordrecht, Holland), baking fat (PT Intiboga Sejahtera, Jakarta, Indonesia), sugar (Dangote Groups (Nig.) Ltd., Lagos Nigeria), improver (Vit C), water and salt were obtained from a baking ingredients store in Akure, Ondo State, Nigeria. Mature, insect free breadfruit (*Artocarpus integrifolia*), breadnut (*Artocarpus atilis*) were obtained from a local farm in Akure, Nigeria. The crops were authenticated in the Crop, Soil and Pest Management Department of the Federal University of Technology Akure (FUTA). The following equipment, namely, Kenwood mixer (Model A 907 D, Kenwood Ltd, England), electric oven (SL- 9 Infrared Food Oven, Hubert, China) and other baking equipment were used in the Federal University of Technology Akure (FUTA) bakery.

Production of breadfruit flour and breadnut flour

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

Composite flour preparation

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

Determination of the 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 (method 54-21 AACC, 2000). Dough was made from 300 g of each composite flour with 100 ml of warm water filled inside a burette. The water is allowed to drop gradually into flour in mixing bowl where it formed dough with the aid of 2 z- shaped mixing blades, after which the remaining water in the burette is measured. The dynamometer of the farinograph was connected to a lever and scale system, and to a pen which traces a curve on a Kymograph chart. The pasting properties of the composite flours were studied using a Brabender Amylograph (D-47055, Brabender Ohgduisburg, Germany) (method 22–12, AACC, 2000). Sixty five grams of each composite flour 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 read off the amylogram. Ease of cooking, gelatinization index, setback and stability of the starch were calculated from peak, breakdown and final viscosities.

Determination of % gluten in flour

About 20 g of each composite flour sample was weighed into a Petri dish of known weight and thoroughly mixed with 1 ml of water 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 (method 38-10, AACC 2000).

The % gluten is calculated as follows:

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

Bread making

Bread was produced using the straight dough process. Baking trials

Table 1. Proximate composition of the composite flour (Dry weight basis).

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

were carried out under laboratory conditions to optimize baking conditions prior to the actual runs. Flour and dough weighing was carried out on laboratory-scale (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°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°C, 80% relative humidity). Baking was done at 230°C in an electric oven (Electric oven SL- 9 Infra red Food Oven, Hubert, China) until the golden brown colour is formed. The resulting bread samples were allowed to cool to room temperature (37°C*)* for 2 h before further analysis were carried out.

Chemical composition of composite flours and bread samples

Proximate composition

The proximate composition of the individual flours (wheat, breadfruit, breadnut), composite flours (wheat-breadfruit, wheat-breadnut) and bread samples (wheat bread and composite flour 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 size) before analysis.

Mineral composition

Mineral composition, namely: Na, K, Ca, Mg, Fe, Cu, Zn and Pb were determined by the wet ashing method. 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.

Antinutrients composition

The tannin, phytate and oxalate contents were determined using standard methods (AOAC, 1990).

Evaluation of the physical properties of bread samples

Loaf weight: Bread loaves were weighed 20 min after baking, using a laboratory scale (CE- 410I, Camry Emperors, China) and the readings recorded in grammes.

Loaf volume: The loaf volume was determined using Rapeseed displacement method (AACC, 2000, Standard 10-05). Sorghum grains were loaded 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: Bread height and diameter was measured using a measuring ruler. Loaf shape was measured in terms of height to diameter ratio while specific volume was thereafter calculated as volume to mass ratio (cm^3/g)

Sensory evaluation

Composite flour bread samples were subjected to sensory evaluation. The following sensory attributes, namely, 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 (Anonymous, 2008).

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.

RESULTS AND DISCUSSION

Proximate composition of composite flours

Table 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 were 76.50%, 388.87 kcal/100 g, 73.50%, 311.96 kcal/100g, 62.17% and 279.83 kcal/100g (WF, BF and BNF) respectively. These results are comparable with previous reports (Ragone, 2003; Omobuwajo, 2003; Olaoye and Onilude, 2008).

Table 2. Proximate composition of the composite bread.

Samples	Protein (%)	Fat (%)	Moisture (%)	Ash (%)	Carbohydrate (%)	Energy value (kcal/ 100 g)
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.

Chemical composition of bread samples

Proximate composition

Table 2 shows that crude protein (CP) content of 5% BF/95% WF (11.96%) is significantly different from the control sample (11.07%). There is no significant difference in the CP content of 10% BF and 5% BNF and 10% BNF and 15% BNF. The CP decreased as the amount of breadfruit flour and breadnut flour increased. This may be because protein contents of BF and BNF flours used (3.35 and 3.62%, respectively) are low (Ragone, 2003). Crude fat (CF) content of the composite samples in the range of 4.13 to 4.29% (BF) and 4.29 to 5.62% (BNF) were significantly different when compared with the control (3.41%).

It was observed that the CF decreased as level of breadfruit flour increased and increased as the level of breadnut flour increased. This may be due to the high CF content in BNF compared with BF. 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 BN and BF flours positively impacted inorganic nutrients in composite flour 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 and the higher carbohydrate content in the bread, makes it a 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/100 g. The higher value is observed in those supplemented with the breadfruit flour because they possessed high carbohydrate content. Findings in this study suggest that bread could serve as source of energy for the metabolic process in the mammalian body (Bennet and Nozzolillo, 1987).

According to US Nutritional Recommendation (values per 100 g) of white bread consumption for Adults, it is given that it should provide 270 kcal (1110 kJ), 8 g protein, 3 fat, 51 g carbohydrate and 681 mg/100 g sodium (Anonymous, 2008a). Therefore, to meet the daily energy requirements of 25 to 55 year old active adult male and 20 to 45 year old active adult female, about 78g of BF/WF bread and 79 g of BNF/WF bread has to be consumed.

Mineral composition of composite bread

Table 3 shows that bread sample made from composite flour had between 257.68 to 885.32 mg/100 g of sodium and 32.05 to 112.59 mg/100 g calcium, with the 15% BF sample being significantly different from the other samples. The magnesium (Mg) content ranged between 37.15 to 168.88 mg/100 g, with 5% BF significantly different from the control (138.80 mg/100 g). The iron (Fe) content was 0.32 to 4.14 mg/100 g with 15% BNF having the lowest value (0.32 mg/100 g), though not significantly different from that of 5% BF when compared with the control (4.69 mg/100 g). By comparing the individual composite samples, it is observed that there issignificant differences in them as BF/WF samples had sodium (430 to 885 mg/100 g), calcium (38 to 112 mg/100 g), Iron (1 mg/100 g) and potassium

Table 3. Mineral composition of the composite bread.

Element	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.

(92 to 239 mg/100g) while BNF/WF had sodium (257 to 691 mg/100 g), calcium (32 to 107 mg/100 g), Iron (4 mg/100 g) and potassium (97 to 404 mg/100 g) when compared with their corresponding control samples which has sodium (834 mg/100 g), calcium (141 mg/100 g), Iron (4 mg/100 g) and potassium (314 mg/100 g). The addition of breadnut flour and breadfruit flour did not significantly increase the contents of calcium, sodium and iron of the bread samples. However, as level of substitution increases with BF and BNF, the mineral contents 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 ranges from 92.88 to 404.49 mg/100 g with 15% BNF (404.49 mg/100 g) significantly different when compared with the control (314.07 mg/100 g). The potassium content increased significantly within the groups with the increasing breadnut levels. The zinc content of the composite bread samples (0.42 to1.72 mg/100 g) is significantly lower and different from the control (2.60 mg/100 g). The copper content increased and decreased with the increasing levels of breadfruit and breadnut flours respectively, but not significantly different in that of 5 to 15% BF and 5 to 10% BN substituted flours. The implication of this is that the bread samples could potentially contribute to enhancement of zinc status in aged people or those taking medications such as hormone replacements or diuretics. The samples may also be capable of contributing to the absorption of copper in view of concerns that suboptimal copper status may be involved in developing many inflammatory and degenerative conditions such as osteoporosis and heart disease (Roberts-Nkrumah and Badrie, 2008). There was no detectable presence of lead (Pb), a heavy metal known to be hazardous to the health of the consumers. Table 4 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 to 3.96 mg/g; 5.64 to 7.33 mg/g and 0.18 to 0.42 mg/g respectively. The levels of the toxic substances were not high enough to cause concern as about 80 mg/g diet is detrimental to health. It is, however noteworthy that some of these toxicants, namely phytic acid, oxalic acid and tannin, can reduce nutrient bioavailability. 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

Gluten composition of composite flours

The percentage wet gluten content of the composite flours is presented in Table 5. It ranged from 14.00 to 18.30%. The highest wet gluten is present in the 5% BNF substitution (18.30%) while the lowest was in 15% BF (14.00%) when compared with the control 24.90%. Gluten content decreased as the level of substitution increased. Dough from 5% BNF and 5% BF flours were elastic during kneading and washing under water, thus enabling more washing of the starch from gluten fraction.

As expected, the yields of gluten fraction were closely associated with protein contents of their flours (based on values in Table 6). Having examined the protein content (Table 6) and gluten content (Table 5) of the composite flours, it is assumed that these flours (BF and BNF) could be substituted into wheat flour and the composite flours still maintaining its protein nature for better

Table 4. 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.

Table 5. 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.

rheological and higher dough formation. Past research works (Ragone, 2003; Omobuwajo, 2003; Olaoye and Onilude, 2008) have also proved this statement to be true on substitution of wheat flour with breadfruit flour to form different confectionery products.

Rheological properties of the dough

The farinograph data of the composite flours are summarized in Table 6. The protein content of the flours ranged from 9.50 to 10.50% with samples 5% BF and 10% BNF not significantly different from each other. The protein content of the substituted flours decreased with increasing substitution. The moisture content of the substituted flours ranged from 12.70 to 13.40% and that of control is 13.30%.

Water absorption of the composite flour dough ranged from 60.50 to 72.30% and was significantly higher than 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 of the flour samples, according to Table 6 increased with every increment of flour blends.

Water absorptions were monitored up to calibrated points on the burette at which the dough became sticky. Although, such absorptions resulted in larger loaf volumes, these water levels could not be considered optimal because the workability of the dough was impaired. The arrival time of dough made from the substituted flours (5% BF and 10% BNF) was the same with control (1 min), shortened for 5% BNF (0.98 min) and lengthened for 10, 15% BF and 15% BNF during mixing, while the stability time of these dough was longer (7.75 to 12.00 min) than that of the control except for 5% BF which is the same with the control (7.50 min).

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 to 1.75 min). This shows that the composite flours, though with different water absorption, started forming and developing during mixing as recorded by dynamometer on a kymograph chart. The level of substitution therefore does not appear to affect the arrival and development time of the composite flours.

Pasting properties of composite flours

The effects of breadfruit flour and breadnut flour inclusion in wheat flour on pasting properties are presented in Table 7. The gelatinization (69 to 74°C) and peak

Table 6. Rheological properties of the dough from composite flour

Samples	Protein (%)	Moisture (%	Water absorption (%)	Arrival time (min)	Dough development time (min)	Dough stability time (min)
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,

Table 7. Pasting properties of composite flour.

	Sample						
Variable	M1	M2	M3	M4	M5	M6	CONTROL
Tp (°C)	69c	70c	72c	62ab	68bc	74c	61a
Mg (min)	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 (min)	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 (min)	10a	9a	10a	10a	10a	11a	6a
Ve- Vp (BU)	240b	230b	70a	400c	195b	115a	935d
Ve- Vr (BU)	340e	300d	100b	460f	235c	80a	1110g
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 min 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.

temperatures (84 to 89°C) of the composite flours were significantly higher than those of the control (61and 71°C respectively). There is no significant difference in pasting temperature as levels of breadfruit flour increased, whereas there is significant difference in the pasting temperature viscosities (80 to 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 as the level of addition of breadnut flour increases. Peak (45 to 300 BU) and breakdown composite flours were lower than

Table 8. Loaf weight, loaf volume, specific volume and loaf shape of composite 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.

that of the control and decreased with the increase in the level of BF and BNF added.

Additionally, the substitution of the breadfruit flour and breadnut flour also has lower setback than the control. This implies that the bread from these composites will be prone to high retrogradation and the starch will experience setback easily than the control. Other rheological properties like stability of the starch and gelatinization index were highest in 5% level of substitution of both flours when compared with other levels of substitutions, but significantly lower than the control. It was also observed that there is no significant difference in the ease of cooking for flours at 5, 15% BF, 5 and 10%BNF levels of substitution (10 min) and the control. These results showed that level of substitution had a greater effect on the pasting properties; hence, results from the rheological and pasting properties had shown that dough from BF and BNF/Wheat composite flour up to 10% level would be suitable for bread production. This is in accordance with the reports of Olaoye and Onilude (2008) that recommended 10% BF substitution in wheat flour as potential raw materials for bread production.

Physical properties of composite bread

The loaf weight of the composite bread samples ranged from 550 to 600 g as shown in Table 8, with 15% BF significantly different from others. The loaf volume of the composite bread samples ranged from 1229.01 to 1886.03 cm^3 with 5% BNF significantly different from others. This result showed that as level of substitution increases, the loaf volume decreases. The specific volume of the composite bread samples decreased significantly with the addition of breadfruit and breadnut flour and ranged from 2.08 to 3.39 cm^3/g with M4 significantly different from others including the control (Table 9). The specific volume of breadfruit/ wheat bread was significantly lower than that of breadnut/ wheat bread. Therefore, loaf weight reduction during baking is an undesirable quality attribute as consumers are often attracted to bread with high 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). In view of this, it is believed that bread from breadnut/wheat mixes had the considerable loaf sizes. 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 at 5% BNF met the pass levels of specific volumes.

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. It was also observed that incorporation of higher level of breadfruit and breadnut flour had a negative effect on the volume of bread. This is in accordance with the report of Akobundu et al. (1988) that said the reduction in the wheat structure forming proteins and a lower ability of the dough to enclose air during proofing might have a volume depressing effect on bread. The observed scores for the crust and crumb colour showed that the level of substitution of BF and BNF flour in composite bread does not reduce the caramelization process which forms the brown colour during baking. The crumb firmness and shape regularity of bread composite flours are comparable with the control. All these might be as a result of desirable attributes of the two crops.

Sensory evaluation

Sensory properties of bread samples

Preliminary sensory evaluation of bread types was undertaken and the most acceptable in terms of taste,loaf

Table 9. 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	2.33ab	2.05ab	2.35ab	2.32bc
536	1.84a	1.63ab	1.83ab	2.05ab	2.17abc	2. 63b	2.21ab	1.77ab	1.79ab
883	2.67bc	2.67cd	2.41b	2.33bc	2.41b	2.28ab	2.28ab	2.93bc	2.39bc
357	3.17c	3.00d	2.29b	2.78c	2.77b	2.53b	2.59b	2.94bc	2.78c
679	1.74a	2.00bc	2.28b	2.05ab	2.11ab	2.21ab	2.16ab	1.88ab	1.84ab
759	2.47b	2.58cd	2.44b	2.65bc	2.29b	2.44ab	2.74b	3.88c	2.32bc
247	1.44a	1.28a	1.47a	1.61a	1.59a	1.56a	1.61a	1.41a	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.

Table 10. Sensory evaluation of bread samples serving as control sample.

Samples	Taste	Loaf weight	Aroma	Loaf shape	Crust colour	Crumb colour	Crumblings	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.

shape, weight, crust and crumb colour, texture and overall acceptability was taken and used as control (Table 10). Table 11 shows that samples 536 (5% BF/ 95% WF) and 883 (10% BNF/ 90% WF) were not significantly different from each other and have comparable ratings with the control sample in terms of appearance, taste and texture. This suggests that bread from wheat flour substituted with breadfruit flour up to 5% and breadnut flour up to 10% level does not significantly affect desirable sensory attributes of the bread. Olaoye and Onilude (2008) in their report also affirmed this by suggesting that addition of breadfruit flour to wheat flour up to 10% level will give bread without changing its organoleptic properties.

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. This observation is consistent with previous reports by Eddy et al. (2007) that observed changes in the quality of bread produced from cassava-wheat composite flours at different levels of substitutions.

Table 11. Sensory evaluation of composite bread samples.

Samples	Taste	Aroma	Texture	Appearance	Mouth feel	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.

Conclusion

Findings in this study have shown the potential for the production of bread of acceptable quality from wheat-based composite flours containing breadfruit and breadnut. 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 structure and uniformity. 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.

It was thus concluded that bread produced from mixtures of 5% BF/ 95% WF and 10% BNF/ 90% WF gave the best products 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 said to be more beneficial in terms of improving the nutritional status of the consumers since bread consumption is very high in Nigeria. A further study on the biological and toxicological impact of the composite flours and bread samples is required.

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