Some Quality Attributes of Composite Flour and Bread Produced from Wheat and African Walnut

Abstract

Aim: This study explored the potential of African walnut in the formulation of composite flour which can be used for bread production and in various food applications.

Methodology: African walnut flour was produced and used to substitute wheat flour at different levels (5 - 25%) in the production of wheat-African walnut composite flour. Functional and pasting properties of the composite flour were evaluated using standard procedures. Proximate composition, antioxidant activity, some loaf quality attributes and sensory acceptability of bread produced from the composite flour were evaluated using standard procedures. Wheat bread served as control.

Results: The composite flour showed varying functional properties which ranged from 2.43 to 3.46 (swelling capacity), 1.15 to 1.85 mL/g (water absorption capacity), 2.15 to 2.75 mL/g (oil absorption capacity), 10.80 to16.60% (foam capacity), 63.0 to 75.0% (dispersibility), 38.92 to 69.92 seconds (wetability), 0.75 to 0.79 g/mL (packed bulk density) and 0.43 to 0.47 g/mL (loose bulk density). Inclusion of African walnut reduced peak viscosity (53.92 – 148.83 RVU), trough viscosity (52.25 – 88.58 RVU), breakdown viscosity (1.67 – 60.25 RVU), final viscosity (74.08 – 191.25 RVU) and setback viscosity (21.83 – 102.67 RVU) of the composite flour. Composite bread had better protein (9.75 – 16.93%), fat (3.42 – 9.94%), ash (1.46 – 2.75%), crude fibre (0.86 – 3.64%) but reduced specific loaf volume (2.36 – 4.18 cm^3/g) and loaf height (3.00 – 5.40cm) than the control, and exhibited appreciable antioxidant activity (DPPH: 31.60 – 73.09%; FRAP: 0.51 - 4.25 mg/g). In term of sensory acceptability composite bread samples produced with 5 and 10 % levels of African walnut compared favourably with bread produced from wheat flour.

Conclusion: Composite flour produced from wheat and African walnut flours showed an array of physicochemical properties which could make it useful in different food applications. Acceptable bread could be produced from wheat flour substituted with African walnut flour at 10% level

Keywords: *African walnut, composite flour, physicochemical properties, bread, antioxidant activity, sensory acceptability*

1. Introduction

Wheat flour remains the best choice of flour for baker due to the ability of its protein fractions (glutenin and gliadin) to form gluten when hydrated; gluten determines the visco-elasticity and gas retaining ability of dough [1, 2]. It contributes significantly to good loaf texture and structure. Apart from the sensory attributes of wheat bread, which despite series of research on gluten free bread has no equal, wheat bread is nutritious with appreciable quantity of carbohydrate, protein and other micronutrients. However, little health benefit has been ascribed to wheat bread, additionally the cost of wheat bread is increasing by the day due to the cost of the ingredients especially wheat flour. The importation of wheat grains from which wheat flour is produced usually cost the tropical countries huge foreign exchange and this contribute significantly to the expensive price of wheat flour in the open market.

As a result to these shortcomings, and the fact that consumers nowadays give serious consideration to foods that offer both nutritional and health advantages, wheat is usually combined with flours from other sources to form composite flour, such combination of flours is generally called composite flour. In this way the quantity of wheat flour needed per unit production would reduced and when mix with flours that have potential health benefit may exert functional property on the final products. Composite flour is a mixture of different flours from cereals, legumes or root crops that is created to satisfy specific functional characteristics and nutrients composition [3]. Composite flour may also include flour blends without the inclusion of wheat flour. The use of such flour blends either with or without wheat flour is a possible means of producing high quality nutritious and functional food products with consequent advantage of reducing huge foreign exchange expenditure on wheat importation especially in Nigeria [4, 5]

African walnut (*Tetracarpidium conophorum)*, which is usually cooked and consumed as snack, has been identified to possess both nutritional and health benefits [6]. The nut is rich in protein and fat and it is a good source of both macro and micro minerals. It is also a rich source of bioactive phytochemicals that can exert some health benefits. Its flour could be used as a functional ingredient in bakery products due to its high water absorption capacity, solubility and rapid viscosity characteristics [3, 7]. Few authors have reported the utilization of African walnut in food formulation [3, 8], however the physicochemical properties of wheat-African walnut flour blends have not received much attention. This present study investigated the effect of African walnut flour inclusion on the physicochemical properties of wheat flour, the proximate composition, antioxidant activity and sensory acceptability of bread produced from the composite flour.

2. MATERIALS AND METHODS

2.1 Sources of Materials

Wheat flour and other baking ingredients were purchased at King's market, Ado – Ekiti, Ekiti State.
African walnuts were purchased at *Oje* market, Ibadan, Oyo State, Nigeria

2.2 Production of African Walnut Flour

African walnuts (*Tetracarpidium conophorum)*, were washed to get rid of any adhering dirt. The nuts were cooked in water for 40 minutes, de-shelled manually, diced and dried in hot air oven at 70^{o}C for 24 hours. The dried African walnut pieces were milled into walnut flour, sieved and then packaged in high density polyethylene.

2.3 Formulation of Composite Flour and Production of Bread

Wheat flour was substituted with African walnut flour in the following proportions: 100%:0%, 95%:5%, 90%:10%, 85%:15%, 80%:20% and 75%:25% respectively. In the production of bread each sample of composite flour (100%) were mixed together with other ingredients (salt (2%), yeast (2%), fat (4%), sugar (13%) and appropriate quantity of water) to form dough; the dough was rolled with the use of rolling board and pin, kneaded, moulded into shape and placed in a well clean greased baking pan. The pan containing the dough was covered and proofed at 35^{o}C for 1 hour. The proofed dough samples were baked in oven at 200^{o}C for 30 minutes. After baking the bread loaves were removed from the baking pan, allowed to cool and then packaged.

2.4 Analysis of Physicochemical Properties of Composite Flour

2.4.1 Functional Properties

Functional properties were determined using established methods: swelling power at 60^{o}C was determined according to the method described by Kaur *et. al.* [9]. Water absorption capacity and oil absorption capacity was determined by the method of Sathe *et. al.* [10]. Foaming capacity and wetability were determined according to the procedure reported by Onwuka [11]. Dispersibility was evaluated by using the procedure of Adegunwa *et. al.*[12]. Loose and packed bulk densities were determined using the method of Mpotokwane *et. al.* [13], loose bulk density was calculated as the ratio of the weight of the sample to the volume while packed bulk density was calculated as the ratio of the tapped weight of the sample to volume.

2.4.2 Pasting Properties

Pasting properties (peak viscosity, trough viscosity, breakdown viscosity, final viscosity, setback viscosity, pasting temperature and peak time) were determined using Rapid Visco Analyser (RVA 4500; Perten Instruments, Sweden). Suspension of sample (12%) was prepared in the RVA canister; the canister paddle was put in place and its blade was trotted through the suspension for about 6 times to ensure proper mixing of the suspension. The canister, fitted with the paddle, was then placed in the machine as recommended. The 12minutes profile was used; idle time and temperature were 1minutes and 50^{o}C respectively, sample was heated from 50^{o}C to 95^{o}C in 3minutes 45seconds, held at 95^{o}C for 2minutes 30seconds and then cooled back to 50^{o}C over 3minutes 45 seconds period, this was followed by 2 minutes period when the temperature was maintained at 50^{o}C.

2.5 Analysis of Proximate Properties of Bread

Proximate compositions of bread loaves were determined according to the methods of AOAC [14]; protein (AOAC 975.17), fat (973.22), ash (922.02), crude fibre (962.09) and moisture (929.02); carbohydrate content was obtained by difference. The energy content was calculated using Atwater conversion factor.

2.6 Analysis of Antioxidant Activity of Bread

Total phenolic content was determined using the method described by Mahloko *et al.*[15]. DPPH (*1,1-diphenyl-2-picryl-hydrazyl*) radical scavenging assay was carried out using the method described by Moodley *et. al*. [16]. Ferric reducing antioxidant power (FRAP) was evaluated by using the procedure described by Nyau *et. al.*[17].

2.7 Analysis of Dough Yield, Loaf Height and Specific Loaf Volume of Bread

Dough yield (%) was determined from the weight of the flour and the resulting dough.

$$Dough\ Yield\ (\%) = \frac{\text{Weight of Dough}}{\text{Weight of Flour}} \times 100$$

The evaluation of loaf height and specific loaf volume were carried out one hour after baking. Each sample of loaf was sliced into three equal portions and the height of each portion was measured. Loaf height was reported as the average of the three values in cm. The volume of loaf was evaluated by using the displacement procedure of AACC [18]. Millet was used to replace rapeseed. The specific volume for each loaf was obtained from the ratio of the volume of loaf to the weight of loaf and reported in cm^3/g.

2.8 Sensory Evaluation of Bread

Sensory evaluation was carried out by presenting the composite bread samples including the control to 20 panelists who assessed the samples for taste, aroma, texture, appearance/shape and overall acceptability. Nine points hedonic scale was used where 9 represents extremely like and 1 represents dislike extremely.

2.9 Statistical Analysis

Data obtained from the analysis were subjected to analysis of variance using SPSS 21 computer programme.

3. Results and Discussion

3.1 Functional Properties of Wheat-African Walnut Composite Flour

Functional properties are those physicochemical properties that can be used to predict or describes the behavior of food materials during processing, preparation and storage. The functional properties of wheat-African walnut composite flour are presented in Table 1. Swelling capacity and water absorption capacity ranged from 2.43 to 3.46 and 1.15 to 1.85 mL/g respectively. Replacement of wheat flour with African walnut flour at different levels of substitution caused an increase in water absorption and swelling values of the composite flour. This may be attributed to higher content of protein and fibre in African walnut which have capacity to absorb moisture and contribute to swelling. Research has shown that African walnut flour has higher protein and fibre than wheat flour [8]. Apart from carbohydrate, fibre has high hydration property and it is able to associate with water under limited water condition. Similar increase in water absorption capacity has been reported when wheat flour was substituted with soybean flour [19]. It is important to note that the higher water absorption capacity and swelling power of wheat-African walnut composite flour as reported in this study did not translate to higher dough yield (Table 5). However, the appreciable values of these two functional properties suggest that the composite flour may be a suitable material in the development of ready to eat food products and baked products. There was significant difference in the oil absorption capacity of the samples especially at higher level of African walnut inclusion. Inclusion of African walnut in the composite flour increased the capacity of the samples to absorb oil; this may be attributed to higher protein content of African walnut; the lipophilic association between the side chains of non polar amino acids of protein and hydrocarbon chains of oil might have enhanced the ability of the samples to absorb oil [20]. The oil absorption capacity of the composite flour (2.15 - 2.75 mL/g) was higher than the water absorption capacity (1.15 – 1.85 mL/g).

Foaming capacity measures the ability of solution of food material to produce foam after vigorous whipping or shaking. It is influenced by types, proportion and solubility of protein in food materials, pH, viscosity and surface tension [21]. The inclusion of African walnut increased the ability of the composite flour to foam; this may be due to the development of a multilayer protein film at the interface which might have enhanced foam formation. The foaming capacity values of the composite flour were higher than 5.25 – 9.20% reported for wheat-groundnut protein concentrate flour blends by Ocheme *et. al.* [1]. Good foaming ability is desirable in some food products because it improves the sensory attributes of mouthfeel, texture and even appearance. The dispersibility values, which ranged from 63.0 to 75.0%, reduced with increase in the proportion of African walnut. The relative high dispersibility value of the samples indicates the ability of the samples to reconstitute easily, this could result in smooth consistency dough with low tendency to form clumps during mixing [4, 12]. There were significant differences in the values of wetability; increase in the proportion of African walnut reduced the wetability value of the composite flour. Low value of wetability is preferred because it shows the ability of the particles of the sample to quickly get soak in water for good mixing and probably for better consistency. There were fluctuations in the values of packed and loose bulk density; sample with 15% African walnut had the highest value. Bulk density generally determines the heaviness of a sample and it has influence on the packaging and transportation requirement of a material. High bulk density offers packaging and transportation advantages because greater quantity can be packaged within a constant volume. However low bulk density allows adequate intake of calorie and nutrients and promotes easy digestibility due to formation of gel with low viscosity especially in complementary feeding [19].

Table 1 Functional Properties of Wheat-African Walnut Composite Flour

Samples	Swelling Capacity	Water Absorption Capacity (mL/g)	Oil Absorption Capacity (mL/g)	Foaming Capacity (%)	Dispersibility (%)	Wetability (Seconds)	Packed Bulk Density (g/mL)	Loose Bulk Density (g/mL)
WH	2.43^{c}	1.15^{d}	2.15^{d}	10.80^{d}	73.0^{b}	69.92^{a}	0.75^{b}	0.43^{c}
WW5	2.45^{c}	1.30^{c}	2.25^{d}	10.80^{d}	75.0^{a}	63.56^{b}	0.75^{b}	0.44^{bc}

WW10	2.63^{c}	1.40^{c}	2.45^{c}	12.77^{c}	71.0^{c}	55.11^{c}	0.76^{b}	0.46^{ab}
WW15	2.87^{b}	1.60^{b}	2.60^{b}	13.93^{b}	68.0^{d}	50.75^{d}	0.79^{a}	0.47^{a}
WW20	3.08^{b}	1.85^{a}	2.60^{b}	16.60^{a}	65.0^{e}	44.42^{e}	0.77^{ab}	0.45^{abc}
WW25	3.46^{a}	1.70^{b}	2.75^{a}	16.10^{a}	63.0^{f}	38.92^{f}	0.76^{b}	0.43^{c}

Means in the same column followed by different superscripts are significantly different ($P \leq 0.05$).
Sample WH: 100% Wheat flour
Sample WW5: 95%wheat flour and 5% walnut flour
Sample WW10: 90%wheat flour and 10% walnut flour
Sample WW15: 85%wheat flour and 15% walnut flour
Sample WW20: 80%wheat flour and 20% walnut flour
Sample WW25: 75%wheat flour and 25% walnut flour

3.2 Pasting Properties of Wheat-African Walnut Composite Flour

Pasting properties are usually used to assess the suitability of starch and starch products for food and non food applications. The result showed that inclusion of African walnut reduced the peak viscosity from 148.83 RVU for 100% wheat flour to 53.92 RVU for composite flour with 25 % African walnut inclusion (Table 2). The final viscosity also reduced from 191.25 RVU to 74.08 RVU. Similar reduction in peak and final viscosity was reported when groundnut protein concentrate was used to substitute wheat flour [1]. The reduction in the peak viscosity and final viscosity could be attributed to the reduction in the relative starch content of the sample and interactive effect of non carbohydrate components such as fat and protein on viscosity. High peak viscosity has been reported to indicate high starch content [22]. African Walnut is rich in fat and protein with a lesser amount of carbohydrate [8, 23]. The high fat content of the composite flour might have enhanced formation of amylose-lipid complex which has inhibitory effect on granules swelling and pasting. Peak viscosity is the highest viscosity developed during heating before breakdown of starch while final viscosity indicates the ability of starch based food to form a viscous paste or gel after cooking and cooling.

Trough and breakdown viscosity is within the range 52.25 – 88.58 RVU and 1.67 – 60.25 RVU respectively. Trough viscosity is the lowest viscosity during the isothermal stage while breakdown viscosity is the difference between peak viscosity and trough viscosity. Breakdown viscosity reflects the ability of sample to withstand heating and shear stress [24], and form a stable paste. The inclusion of African walnut reduced the breakdown viscosity of the composite flour. The low breakdown values of samples with African walnut may be attributed to the non carbohydrate component of the samples which might have interfered with the pasting process and probably reinforce the structural integrity of starch granules making them to be able to withstand breakdown. Such sample would have high thermal paste stability which may be preferred in some food formulations. However in bread production this may not be of advantage because sufficient breakdown/disintegration of starch (moderate to high breakdown value) is essential for the production of bread of good loaf quality attributes [25]. Setback is the region where retrogradation of starch molecules occurs; higher setback value indicates higher tendency for retrogradation to occur, which may also suggests reduced dough digestibility [26]. Setback viscosity ranged from 21.83 to 102.67 RVU, setback value reduced with increase in the proportion of African walnut in the composite flour. This suggests that inclusion of African walnut may reduce the retrogradation tendency and staling process when such composite flour is used in bread production. There were fluctuations in the pasting temperature and peak time. Inclusion of African walnut increased the pasting temperature from 69.40 to 89.60°C. As for peak time, the values for the composite flour were lower than that of wheat flour except for sample with highest proportion of African walnut which had the highest peak time. Pasting temperature is a measure of the minimum temperature required to cook a given sample while peak time is a measure of cooking time, the two pasting parameters have direct correlation with the energy cost of preparing food sample.

Table 2: Pasting Properties of Wheat-African Walnut Composite Flour

	Peak Viscosity (RVU)	Trough Viscosity (RVU)	Breakdown Viscosity (RVU)	Final Viscosity (RVU)	Setback Viscosity (RVU)	Pasting Temperature (^{o}C)	Peak Time (Mins)
WH	148.83^{a}	88.58^{a}	60.25^{a}	191.25^{a}	102.67^{a}	69.40^{e}	6.00^{b}
WW5	129.75^{b}	74.33^{c}	55.42^{b}	157.25^{c}	82.92^{c}	70.20^{d}	5.87^{c}
WW10	127.92^{b}	84.33^{b}	43.58^{c}	174.25^{b}	89.92^{b}	71.80^{c}	5.53^{d}
WW15	106.17^{c}	65.92^{d}	40.25^{c}	144.00^{d}	78.08^{d}	84.75^{b}	5.53^{d}
WW20	67.42^{d}	58.17^{e}	9.25^{d}	88.17^{e}	30.00^{e}	70.20^{d}	5.53^{d}
WW25	53.92^{e}	52.25^{f}	1.67^{e}	74.08^{f}	21.83^{f}	89.60^{a}	6.93^{a}

Means in the same column followed by different superscripts are significantly different ($P \leq 0.05$).
Sample WH: 100% Wheat flour
Sample WW5: 95%wheat flour and 5% walnut flour
Sample WW10: 90%wheat flour and 10% walnut flour
Sample WW15: 85%wheat flour and 15% walnut flour
Sample WW20: 80%wheat flour and 20% walnut flour
Sample WW25: 75%wheat flour and 25% walnut flour

3.3 Proximate Composition of Bread Produced from Wheat-African Walnut Composite Flour

There were significant differences in moisture contents of the bread samples (Table 3), the moisture content reduced with increase in the level of African walnut. The protein and fat contents, which ranged from 9.75 to 16.93% and 3.42 to 9.94% respectively, were significantly increased with the inclusion of African walnut. Similar increase in protein and fat contents was reported when Bambara groundnut [27] and walnut [8] were used to supplement wheat flour in the production of bread. This trend of results, aside from improving nutritional quality of the bread, may contribute positively to the crumb texture and structure of the bread samples. The inclusion of optimum level of fat and protein based ingredients usually help to improve the baking performance of flour and contribute to good dough texture. There were significant differences in the ash content of samples, 100% wheat bread had the least ash content of 1.46% while sample with the highest level of African walnut had the maximum value of 2.75%. Ash content of food material is an indication of the inorganic elements present in the sample. The ash contents reported in this study were comparable to 1.71 – 2.44% reported for bread produced from wheat-bambara groundnut flour blends [28]. The inclusion of African walnut also increased the fibre content of bread samples from 0.86 to 3.64%. Fibre which is the indigestible portion of food derived from plants has been reported to help in reducing risk of chronic diseases, obesity and cardiovascular disease [29]. The carbohydrate and energy contents of the bread samples were significantly different due to the inclusion of different levels of African walnut flour, their values ranged from 45.86 to 56.34% and 295.14 to 340.62 Kcal/100g respectively. Carbohydrate content reduced with increase in the level of African walnut in the sample, opposite trend was observed with respect to energy content. The increase in energy content as the level of African walnut increased may be attributed to the significant contribution of African walnut to the protein and fat contents of the composite flour. Fat has the highest energy content among all the proximate constituents.

Table 3 Proximate Composition of Bread Produced from Wheat-African Walnut Composite Flour

Sample	Moisture (%)	Protein (%)	Fat (%)	Crude Fibre (%)	Ash (%)	Carbohydrate (%)	Energy Content (Kcal/100g)
WH	28.17^{a}	9.75^{e}	3.42^{f}	0.86^{e}	1.46^{c}	56.34^{a}	295.14^{f}

WW5	27.95^{a}	10.06^{d}	4.08^{e}	1.29^{d}	1.45^{c}	55.17^{a}	297.64^{e}
WW10	24.72^{b}	12.45^{c}	5.95^{d}	2.81^{c}	1.50^{c}	52.57^{b}	313.63^{d}
WW15	22.89^{c}	13.91^{b}	7.56^{c}	3.14^{b}	2.00^{b}	50.50^{c}	325.68^{c}
WW20	21.17^{d}	15.29^{a}	8.85^{b}	3.17^{b}	2.73^{a}	48.79^{d}	335.97^{b}
WW25	20.88^{d}	16.93^{a}	9.94^{a}	3.64^{a}	2.75^{a}	45.86^{e}	340.62^{a}

Means in the same column followed by different superscripts are significantly different ($P \leq 0.05$).
Sample WH: 100% Wheat flour
Sample WW5: 95%wheat flour and 5% walnut flour
Sample WW10: 90%wheat flour and 10% walnut flour
Sample WW15: 85%wheat flour and 15% walnut flour
Sample WW20: 80%wheat flour and 20% walnut flour
Sample WW25: 75%wheat flour and 25% walnut flour

3.4 Antioxidant Activity of Bread Produced from Wheat-African Walnut Composite Flour

The total phenolic content of the bread samples ranged from 6.55 to 17.21mg/g (Table 4). Total phenolic content gives an indication of the total phenolic compounds present in the samples which invariably suggest the potential of such sample to exhibit biological activity. Though bread is basically consumed for its nutritional values, the recent trend in food science has widened research scope to include consideration for both nutritional and health benefit properties of foods. One of the health benefit factors of food is antioxidant activity, which depict the ability of foods to neutralize free radicals known to support degenerative diseases in the body. The ability of the bread samples to scavenge free radical was assessed using DPPH; DPPH value for 100% wheat bread was 31.60%, this value was higher than 29.00% reported by Meral and Dogan [30]. There was significant increase in DPPH values with increase in the inclusion of African walnut in the samples; with inclusion of 25% African walnut DPPH values increased to 73.09%. Similar trend was observed for FRAP with 100% wheat bread having 0.51 mg/g and sample with highest level of African walnut having 4.25 mg/g. FRAP measures reducing power which is associated with antioxidant property. These results corroborate previous reports that African walnut is rich in phenolic compounds and has high antioxidant activity [23, 32, 33, 34]. The inclusion of African walnut increased the antioxidant activity of bread produced from wheat flour; therefore these bread samples if consumed regularly may help reduce degenerative effect of free radicals in human body. However, it is important to note that the inclusion of the nut negatively affected the consumer acceptability of the bread as reflected in the sensory evaluation result.

Table 4 Antioxidant Activity of Bread Produced from Wheat –African Walnut Composite Flour

Samples	Total Phenolic Content (mg/g)	DPPH (%)	FRAP (mg/g)
BWH	6.55^{e}	31.60^{d}	0.51^{f}
BWW5	8.51^{d}	42.03^{c}	0.89^{e}
BWW10	8.85^{d}	69.45^{b}	1.43^{d}
BWW15	9.57^{c}	70.59^{b}	2.10^{c}
BWW20	11.53^{b}	72.81^{a}	3.48^{b}
BWW25	17.21^{a}	73.09^{a}	4.25^{a}

Means in the same column followed by different superscripts are significantly different ($P \leq 0.05$).
Sample BWH: Bread Produced from 100% Wheat flour
Sample BWW5: Bread Produced from 95%wheat flour and 5% walnut flour
Sample BWW10: Bread Produced from 90%wheat flour and 10% walnut flour
Sample BWW15: Bread Produced from 85%wheat flour and 15% walnut flour
Sample BWW20: Bread Produced from 80%wheat flour and 20% walnut flour

Sample BWW25: Bread Produced from 75%wheat flour and 25% walnut flour

3.5 Dough Yield and Loaf Quality Attributes of Bread Produced from Wheat-African Walnut Composite Flour

The dough yield ranged from 162.24 to 167.80% (Table5), there was significant reduction in the dough yield as the proportion of African walnut increased in the composite flour. This reduction may be due to the low carbohydrate content of the composite flour; food components like carbohydrate with high water absorption and swelling capacities have been reported to contribute to yield and consistency [31]. The inclusion of African walnut in the bread samples caused a decrease in the loaf height and specific loaf volume, which ranged from 3.00 to 5.40 cm and 2.36 to 4.18 cm^3/g respectively. These observations especially the reduction in specific loaf volume may be attributed to the dilution effect on starch and gluten components of wheat flour as a result of inclusion of African walnut flour, a non gluten flour. The combination of starch and gluten form the starch-protein matrix which enclosed the gas cells during mixing, this enable the dough to trap CO_2 as it is being produced during yeast fermentation [25]. With the reduction in the level of these two components especially gluten in the composite flour, the capacity of the dough to adequately retain gas reduced and hence reduction in specific loaf volume. The ability of flour to retain gas during yeast fermentation has a positive correlation with loaf volume. Also the increase in the fibre content of the composite flour as a result of inclusion of African walnut might have interfered with dough extensibility and caused a negative effect on the gas retention ability of the composite flour resulting in low specific loaf volume.

Table 5 Dough Yield and Loaf Quality Attributes of Bread Produced From Wheat-African Walnut Composite Flour

Samples	Dough yield (%)	Loaf height (cm)	Specific loaf volume (cm^3/g)
BWH	167.80^a	5.40^a	4.18^a
BWW5	167.50^a	5.40^a	4.12^a
BWW10	165.93^b	4.60^b	3.70^b
BWW15	164.40^c	4.00^c	3.15^c
BWW20	163.98^c	3.60^c	2.87^c
BWW25	162.24^d	3.00^d	2.36^d

Means in the same column followed by different superscripts are significantly different ($P \leq 0.05$).
Sample BWH: Bread Produced from 100% Wheat flour
Sample BWW5: Bread Produced from 95%wheat flour and 5% walnut flour
Sample BWW10: Bread Produced from 90%wheat flour and 10% walnut flour
Sample BWW15: Bread Produced from 85%wheat flour and 15% walnut flour
Sample BWW20: Bread Produced from 80%wheat flour and 20% walnut flour
Sample BWW25: Bread Produced from 75%wheat flour and 25% walnut flour

3.6 Sensory Acceptability of Bread Produced from Wheat-African Walnut Composite Flour

There were significant differences in the sensory attributes of bread produced from wheat-African walnut composite flour (Table 6). The score for the taste of bread produced from 100% wheat flour was the highest, however it was not significantly different from the taste of bread produced from composite flour with 5% and 10% African walnut. Bread produced from composite flour with highest level of African walnut received the lowest taste score which may be due to the bitter after taste of African walnut. In terms of aroma, bread produced from 100% wheat flour and that with 5% African walnut were significantly the same, however the two were significantly different from the aroma of other bread samples. There was no significant difference in the texture of all bread samples produced from the composite flour except sample with 25% African walnut, which received the lowest score. When compared with the control, bread produced from the composite flour with up to 15% African walnut inclusion had significantly the same texture with the control sample. The scores for appearance/shape of the bread samples were lower than that of control sample; however the difference was not significant for sample with 10% and 15% African walnut. In terms of overall acceptability bread produced from composite flours with 5% and 10% African walnut inclusion compared favourably with the control as there was no significant difference between these samples and the control. Other bread samples were significantly different from the control. This sensory result suggests that acceptable bread could be produced from wheat flour substituted with 10% African walnut flour.

Table 6 Sensory Acceptability of Bread Produced from Wheat-African Walnut Flour blends

Sample	Taste	Aroma	Texture	Appearance/ Shape	Overall Acceptability
BWH	7.92^{a}	7.83^{a}	7.75^{a}	7.92^{a}	8.17^{a}
BWW5	7.17^{ab}	7.67^{a}	7.17^{ab}	6.50^{bc}	7.67^{ab}
BWW10	6.58^{ab}	6.42^{b}	6.83^{ab}	7.00^{ab}	7.33^{ab}
BWW15	6.10^{b}	5.92^{b}	6.67^{ab}	6.75^{abc}	5.83^{c}
BWW20	5.17^{b}	5.58^{bc}	6.58^{b}	5.58^{c}	6.75^{bc}
BWW25	4.00^{c}	4.50^{c}	5.25^{c}	5.67^{c}	5.08^{d}

Means in the same column followed by different superscripts are significantly different ($P \leq 0.05$).
Sample BWH: Bread Produced from 100% Wheat flour
Sample BWW5: Bread Produced from 95%wheat flour and 5% walnut flour
Sample BWW10: Bread Produced from 90%wheat flour and 10% walnut flour
Sample BWW15: Bread Produced from 85%wheat flour and 15% walnut flour
Sample BWW20: Bread Produced from 80%wheat flour and 20% walnut flour
Sample BWW25: Bread Produced from 75%wheat flour and 25% walnut flour

4. Conclusion

The substitution of wheat flour with African walnut flour in the production of the composite flour increased swelling capacity, water absorption capacity, oil absorption capacity and foaming capacity of the composite flour. Wheat-African walnut composite flour exhibited lower values of pasting properties except pasting temperature when compared with wheat flour. The results indicate that apart from bread, the composite flour could find usefulness in other food formulations where high oil absorption and foaming capacities and lower paste viscosity are desired. Inclusion of African walnut improved the nutrients density (protein, fat, ash, crude fibre) and antioxidant activity of the composite bread; however dough yield, loaf height and specific loaf volume were reduced. Bread produced from wheat-African walnut composite flour with 10% African walnut compared favourably with bread produced from wheat flour in term of sensory acceptability.

Reference

1. Ocheme OB, Adedeji OE, Chinma CE, Yakubu CM, Ajibo UH. Proximate composition, functional, and pasting properties of wheat and groundnut protein concentrate flour blends. Food Sci Nutr.2018; 6:1173– 1178. https://doi.org/10.1002/fsn3.670

2. Ajatta MA, Akinola SA, Osundahunsi OF. Proximate, functional and pasting properties of composite flours made from wheat, breadfruit and cassava starch. Applied Tropical Agriculture 2016; 21(3): 158-165.

3. Barber LI, Obinna-Echem PC. Nutrient composition, physical and sensory properties of wheat-African walnut cookies. Sky Journal of Food Science. 2016; 5(4): 024 – 030.

4. Ohizua ER, Adeola AA, Idowu MA, Sobukola OP, Afolabi TA, Ishola RO. Ayansina SO, Oyekale TO, Falomo A. Nutrient composition, functional, and pasting properties of unripe cooking banana, pigeon pea, and sweetpotato flour blends. Food Sci Nutr. 2017; 5:750–762. https://doi.org/10.1002/fsn3.455

5. Vaughan IO, Afolami CA, Oyekale TO, Ayegbokiki AO. An analysis of Nigeria food imports and bills. Int. J. Econ. Commerce Manage. 2014; 2: 1–14.

6. Santos J, Alvarez-Ort M, Sena-Moreno E, Rabad´an A, Pardo JE, Beatriz PP, Oliveira M. Effect of roasting conditions on the composition and antioxidant properties of defatted walnut flour. Journal of the Science of Food and Agriculture.2018; 98 (5): 1813–1820.

7. Ndie EC, Nnamani CV, Oselebe HO. Some physicochemical characteristics of defatted flours derive from African walnut (*Tetracarpidium conoforum*): an underutilized legume, Pak. J. Nutr. 2010; 9 (9): 909 – 911.

8. Almoraie NM. The effect of walnut flour on the physical and sensory characteristics of wheat bread. International Journal of Food Science. 2019; 1 – 7 https://doi.org/10.1155/2019/5676205

9. Kaur M, Oberoi DPS, Sogi DS, Gill BS. Physicochemical, morphological and pasting propertiesof acid treated starches from different botanical sources. Food Science and Technology. 2011; 48(4):460–465.

10. Sathe SK, Desphande SS, Salunkhe DK. Functional properties of lupin seed (*Lupinus mutabilis*) proteins and protein concentrates. J. Food Sc. 1982; 47, 491-497. https://doi.org/10.1111/j.1365-2621.1982.tb10110.x

11. Onwuka GI. Food Analysis and Instrumentation; Theory & Practice. Lagos, Nigeria: Naphthali Prints, Chapter 10, 133. 2005

12. Adegunwa MO, Sanni LO, Adegoke, GO. Physicochemical, functional and sensory properties of bread from cassava and sweet potato starches. Cameroon Journal of Agricultural Science. 2017; 3 (2): 29 – 36.

13. Mpotokwane SM, Gaditlhatlhelwe E, Sebaka A, Jideani VA. Physical properties of bambara groundnuts from Botswana. J. Food Eng. 2008; 89, 93 - 98. https://doi.10.1016/j.jfoodeng.2008.04.006.

14. Association of Official Analytical Chemist (AOAC). Official Methods Analysis Analytical Chemist International 18th ed. Gathersburg, MD USA. 2012.

15. Mahloko LM, Silungwe H, Mashau ME, Kgatla TE. Bioactive compounds, antioxidant activity and physical characteristics of wheat-prickly pear and banana biscuits. Heliyon 2019; (10): e02479. https://doi.org/10.1016/j.heliyon.2019.e02479

16. Moodley T, Amonsou EO, Kumar S. Nutritional quality and acceptability of Buddleja saligna herbal tea. Journal of Food Science and Technology 2015; 52 (11): 7519-7524.

17. Nyau V, Prakash S, Rodrigues J, Farrant J. Antioxidant activities of Bambara groundnuts as Assessed by FRAP and DPPH Assays. American Journal of Food and Nutrition 2015; 3 (1): 7-11.

18. Approved methods of the American Association of Cereal Chemists (10th ed.). American Association of Cereal Chemists (AACC), St. Paul, MN, USA. 2000).

19. Akubor PI, Fayashe TO. Chemical composition, functional properties and performance of soybean and wheat flour blends in instant fried noodles. Sou. As. J. Food Techno. Environ. 2018; 4 (2): 690 – 699.

20. Eltayeb ASM, Ali AO, Abou-Arab AA, Abu-Salem FM. Chemical composition and functional properties of flour and protein isolate extracted from Bambara groundnut (*Vigna subterranean*). African Journal of Food Science 2011; 5 (2):82 – 90.

21. Eguono EE, Akubor PI. Effect of debittering methods on the proximate composition, sensory and functional properties of orange (*Citrus sinensis*) seed flour. IOSR Journal of Environmental Science, Toxicology and Food Technology 2016; 10(9): 9 – 16.

22. Adebowale AA, Adegoke MT, Sanni SA, Adegunwa MO, Fetuga GO. Functional properties and biscuit making potential of sorghum- wheat flour composite. American Journal of Food Technology 2012; 7 (6): 372 – 379. DOI: 10.3923/ajft.2012.372.379

23. Arinola SO, Adesina K. Effect of thermal processing on the nutritiona, antinutritional and antioxidant properties of *Tetracarpidium conophorum* (African walnut). Hindawi Journal of Food Processing. 2014; (418380). http://dx.doi.org/10.1155/2014/418380

24. Awoyale W, Oyedele H, Maziya-Dixona B. Functional and pasting properties of gari produced from white-fleshed cassava roots as affected by packaging materials and storage periods, and sensory attributes of the cooked gari dough (eba). International Journal of Food Studies 2021; 10: 233 - 247 doi: 10.7455/ijfs/10.1.2021.a9.

25. Arinola SO, Akingbala JO. Effects of soy flour on the quality attributes of gluten free bread produced from breadfruit flour. Croatian Journal of Food Science and Technology. 2022; 14 (1): 1-8. DOI:10.17508/CJFST.202.2.14.1.13

26. Alamu EO, Maziya-Dixon B, Dixon AG. Evaluation of Proximate Composition and Pasting Properties of High Quality Cassava flour (HQCF) from Cassava Genotypes (*Manihot Esculenta Crantz*) of β-Carotene-Enriched Roots. LWT—Food Sci.Technol. 2017; 86: 501– 506. doi:10.1016/j.lwt.2017.08.040.

27. Oguntuase SO, Ijarotimi OS, Oluwajuyitan TD, Oboh G. Nutritional, antioxidant, carbohydrate hydrolyzing enzyme inhibitory activities, and glyceamic index of wheat bread as influenced by bambara groundnut substitution. SN Applied Sciences. 2022; 4 (121): 1-16 doi.org/10.1007/s42452-022-05018-8

28. Yusufu MI, Ejeh DD. Production of bambara groundnut substituted whole wheat bread: Functional properties and quality characteristics. Journal of Nutrition and Food Science 2018; 8:731

29. Lonită-Mîndrican CB, Ziani K, Mititelu M, Oprea E, Neacs SM, Moros E, Dumitresc DE, Ros CA, Drăgănescu D, Negrei C. Therapeutic Benefits and DietaryRestrictions of Fiber Intake: A State of the Art Review. Nutrients. 2022; 14, 264

30. Meral R, Dogan IS. Quality and antioxidant activity of bread fortified with flaxseed. Ital. J. Food Sci., 2013; 25 – 2013.

31. Bamigbola YA, Awolu OO, Oluwalana IB. The effect of plantain and tigernut flours substitution on the antioxidant, physicochemical and pasting properties of wheat based composite flours. Cogent Food & Agriculture. 2016; 2:1, 1245060. doi.org/10.1080/23311932.2016.1245060.

32. Oke OS, yaniyi T, Adewumi OT, Bamigboye OT, Lawah MO, Jatto KA, Adara CT, Marizu JT, gunbela AA. Economic, nutritional and medicinal values of African walnut (*Tetracarpidium conophorum*) in Nigeria (Hutch. & Dalziel): A REVIEW. Journal of Research in Forestry, Wildlife & Environment. 2020; 12(2): 80-89.

33. Udedi SC, Ani ON, Anajekwu BN, Ononamadu CJ, Igwilo IO, Ibeabuchi CG, Ifemeje JC, Lukong CB, Ogbuozobe GO. Nutritional compositionand antioxidant activity of African Walnut, *Tetracarpidium conophorum*. The Journal of Applied Biochemistry. Photon. 2014; 107, 170-180.

34. Fasogbon BM, Akinwande FF, Ademuyiwa OH, Bamidele OP. The Influence of Cooked Grated African Walnut on the Nutritional Composition, Antioxidant and Sensorial Properties of a Cookie Snack, Journal of Culinary Science & Technology. 2021. doi: 10.1080/15428052.2021.1955797

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