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Evaluation of blends of wheat (*Triticum aestivum*) flour and African walnut *(Tetracarpidium conophorum) flour in* biscuit production

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ABSTRACT

The use of underutilized crops has been the focus of recent research in developing countries like Nigeria because of inadequacy of protein supply in diets. In attempt to improve the use of underutilized crops, biscuit samples were produced from flour blends containing different combinations of African walnut flour and wheat flour. The 100% wheat flour served as control. The African walnut and wheat flours were mixed in ratios 10:90, 20:80, 30:70, 40:60 and 50:50%. The proximate composition, functional and pasting properties of the blends as well as physical and sensory properties of the biscuits were determined The results showed the increase in the level of protein, ash, fat and moisture content of the blends with increasing levels of walnut flour. The bulk density, water absorption and swelling power of the blends reduced, while oil absorption capacity, emulsion capacity and least gelation concentration increased with increasing levels of walnut flour. Variations exist in the pasting properties of the blends. The diameter of the biscuits increased with increase in the level of walnut flour, hence the spread ratio increased from 3.52 to 6.56. There were significant differences between the biscuit samples in terms of aroma, taste and appearance. However, biscuit sample with inclusion level of 30% walnut flour compared favourably with the control in terms of sensorial quality.

Introduction

Biscuits are ready-to-eat, cheap and convenient food products that are consumed among all age groups in many countries (Hussein et al., 2006; Iwegbue, 2012). Biscuits are rich in fat and carbohydrate; hence they can be referred to as energy giving food as well as good sources of protein and mineral (Kure et al., 1998). In many parts of Sub-Saharan Africa and especially in Nigeria, advancing prosperity and urbanization coupled with tremendous increase in population in recent years have led to an increase in the consumption of wheat-based products, especially biscuits and breads. However, the production of wheat is low and far below domestic requirements in Nigeria. Compositing wheat flour with locally available cereals and root crops has been reported to be desirable (Oyerakua and Adeyeye, 2009). Considerable efforts have been focused on the use of composite flour for bread and baked products (Mepba et al., 2007; Mohammed et al., 2011).

The African walnut (*Tetracarpidium conophorum)* is a perennial agricultural plant. It is a climbing shrub that is found in moist forest zones of Sub-Sahara Africa. It belongs to the *Euphorbiacaea* family (Enujiugha, 2003). It is a popular farm product among peasant farmers. The African walnut is locally called *"asala"* or *"awusa"* in Yoruba and *"okwe"* in Edo. The fruit is capsular in shape and contains sub globular seeds. The African walnut has got a thin, brown shell that resembles that of the temperate walnut. It is also known botanically as *Plukenetia-conophora*. The African walnut kernel is edible. It is traditionally processed by boiling the nuts in water to soften the kernels. The kernels are oil bearing and the cake left after expression of the oil contains protein (Edem et al., 2009). The kernel is also a good source of vitamins and minerals (Ojobor et al., 2015; Laverdine et al., 2000).

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There are different types of walnuts, which range from the English walnut (*Juglandaceae*), found in Southeast Europe, to Japan and to African walnut which has got two types – *Euphorbiaceae* and *Olacaceae*. Each family has their own distinction. *Tetracarpidium conophorum* of the *Euphorbiaceae* is found in Nigeria and Cameroon, while *Coula edulis*, which is also referred to as African walnut, is found in Congo, Gabon and Libya. However, it is important to note that African walnut is largely underutilized in developing countries like Nigeria and this resulted in high wastage due to the short shelf of the nut. There is no known commercial production and industrial utilization of the nut in Nigeria. Edem *et al*. (2009) noted that the researches in the past concentrated on the agronomics and neglected the process of indigenous crops. Therefore, the objective of this work was to evaluate the proximate, functional and sensory properties of biscuits made from African walnut flour and wheat flour blend.

Materials and methods

Materials

The African walnut was purchased from the local market, Ibadan, Oyo State Nigeria. Other ingredients, such as wheat flour (Honeywell), sugar and salt (Dangote), baking powder (Longman), margarine (Pomo), milk (Dano) and eggs were bought at Bodija market in Ibadan.

Methods

The African walnut was sorted, and then washed to remove extraneous materials. It was then cooked for 1 hr in excess water and then soaked in 0.2% potassium metabisulphite for 5 min to facilitate easy removal of the shells of the walnut. The shelled walnut was diced with a stainless steel kitchen knife to increase the surface area and then soaked in water (at room temperature) to remove the bitter taste for 30 min and also blanched by adding boiling water and allowed to stand for 5 min before draining. This process helps reducing the tannin content of the walnut (Adebayo-Oyetoro et al., 2012). The blanched walnut was then dried in hot air oven at 60 °C for 10 hr and ground to produce walnut flour. The flour was packaged in a clean air-tight polyethylene bag.

Preparation of composite flours and production of biscuits

The walnut-wheat blends were prepared in the ratios 10:90, 20:80, 30:70, 40:60, 50:50 and 0:100, respectively. The baking recipe used was as described by Maohar and Rao (2002) with slight modification. tTe biscuits were baked at 190 °C, cooled and packed into an air-tight zip-lock bags.

Proximate composition analyses

The samples were analyzed chemically according to AOAC (2005). The determination of moisture content, crude fibre, crude protein, crude fat, ash, and carbohydrate by difference was carried out in triplicate.

Functional properties of the blends

The bulk density was determined according to the method described by Narayana and Narasinga (1984). The emulsion capacity was prepared in a calibrated centrifuge tube at 200 rpm for 5 min. It was expressed as the height of the emulsion layer to the total height of the mixture in the tube expressed in percentage. Least gelation concentration was determined according to Coffman and Garcia (1977) method. The water and fat absorption capacities were determined according to Sosulki et al. (1976) methods. The swelling power of the samples was determined according to the method described by Leach et al. (1989).

Pasting properties of the samples

The pasting properties for each sample were determined using the Rapid Visco-Analyzer as described by Olapade and Adeyemo (2014). The detrmined pasting properties include pasting temperature, peak viscosity, time to peak, temperature at peak, hot and cold viscosity breakdown, set back and final viscosity.

Physical analysis of biscuits

The weight and diameter of the baked biscuits were determined using a weighing balance and a vernier calliper, respectively. The spread ratio was calculated as described by Gomez et al. (1997).

Sensory evaluation of biscuits

Biscuit samples were served to untrained 25-member panel. ThepPanel comprised students of the University of Ibadan. The panellists were asked to evaluate each sample based on its taste, appearance, texture, aroma and general acceptability using a 9-point t Hedonic scale(9 = like extremely and 1 = dislike extremely).

Statistical data analysis

The data obtained were subjected to analysis of variance to detect significant difference ($p<0.05$) among the sample means. The Duncan multiple tests were used to separate the means using the statistical package for social science, SPSS 17.0 software.

Results and discussion

Proximate composition of the biscuits

The proximate composition of the samples is presented in Table 1. There were significant differences ($p \leq 0.05$) in protein (12.4-19.5%), fat (10.2-20.5%), ash (2.03-4.50%), carbohydrate (42.8-62.7%), moisture content (10.7-11.4%) and fibre (1.42-2.07%) among the samples. The crude protein, ash, ether extract and moisture increased, while crude fibre and carbohydrate decreased with the increase in the walnut flour substitution. Similar trends but lower values were observed by earlier researchers (Offia-Olua, 2014; Barber and Obinna-Echem, 2016). A protein content of about 29.0% was reported for mature African walnut (Enujiugha, 2003) compared to 12.4% protein content obtained for 100% wheat flour (Table 1). The high protein content in the African walnut-wheat blend biscuits would be of a great nutritional benefit in developing countries like Nigeria where the biscuits are mainly carbohydrate and energy foods. The increase in fat content of the blends compared to the control was also attributed to the added walnut flour. Earlier study revealed the oil content of African walnut to be 55.8-61.6% (Edem et al., 2009). This would improve the energy supply to the consumer (Okaka, 2005). The moisture content of the biscuits is generally low which conferred an advantage of better keeping quality of the samples as it was generally believed that moisture below 12% would not support growth of spoilage microorganisms.

Table 1. Proximate composition of the blends of African walnut-wheat flour

Sample Walnut: Wheat (%)	Moisture content (%)	Crude protein (%)	Ash (%)	Ester Extract (%)	Crude fibre (%)	Carbohydrate (%)
0:100	$10.7^{bc}\pm0.3$	$12.4^{e}\pm0.34$	$2.03^{d}\pm0.06$	$10.2^{e}\pm1.04$	$1.97^{a}\pm0.15$	$62.7^{a}\pm1.78$
10:90	$10.9^{abc}\pm0.3$	$14.8^{d}\pm0.20$	$3.27^{c}\pm0.25$	$13.3^{d}\pm0.64$	$2.07^{a}\pm0.21$	$55.7^{b}\pm0.55$
20:80	$10.6^{c}\pm0.5$	$15.5^{cd}\pm0.50$	$3.10^{c}\pm0.10$	$14.4^{cd}\pm0.53$	$1.90^{ab}\pm0.10$	$54.5^{bc}\pm0.75$
30:70	$10.8^{abc}\pm0.2$	$16.1^{c}\pm0.40$	$3.00^{c}\pm0.15$	$15.6^{c}\pm0.53$	$1.67^{bc}\pm0.06$	$52.0^{c}\pm0.50$
40:60	$11.2^{ab}\pm0.3$	$17.7^{b}\pm0.58$	$3.77^{b}\pm0.25$	$18.8^{b}\pm0.76$	$1.47^{c}\pm0.15$	$47.0^{d}\pm0.63$
50:50	$11.4^{a}\pm0.2$	$19.5^{a}\pm0.55$	$4.50^{a}\pm0.20$	$20.5^{a}\pm0.50$	$1.42^{c}\pm0.10$	$42.8^{e}\pm0.38$

Means of three replicate analysis; Means within the same column not followed by the same superscripts are significantly ($p \leq 0.05$) different

Table 2. Functional properties of blends of African walnut-wheat flour

Sample Walnut: Wheat (%)	Bulk density (g/ml)	Water absorption (g/g)	Fat absorption (g/g)	Emulsion capacity (%)	Swelling power	Least Gelation Capacity (%)
0:100	$1.43^{a}\pm0.03$	$1.02^{a}\pm0.03$	$1.50^{ab}\pm0.50$	$47.5^{e}\pm0.50$	$2.12^{a}\pm0.06$	$6.33^{b}\pm0.58$
10:90	$1.17^{b}\pm0.06$	$1.00^{ab}\pm0.00$	$1.34^{b}\pm0.29$	$47.8^{de}\pm1.03$	$1.97^{a}\pm0.06$	$8.67^{a}\pm1.15$
20:80	$1.03^{c}\pm0.06$	$0.95^{ab}\pm0.05$	$1.53^{ab}\pm0.05$	$49.2^{cd}\pm0.72$	$1.80^{b}\pm0.10$	$7.30^{ab}\pm1.15$
30:70	$0.90^{d}\pm0.10$	$0.92^{abc}\pm0.03$	$1.60^{ab}\pm0.10$	$50.2^{bc}\pm0.76$	$1.70^{bc}\pm0.10$	$870^{a}\pm1.15$
40:60	$0.90^{d}\pm0.08$	$0.91^{bc}\pm0.01$	$1.83^{ab}\pm0.15$	$50.8^{b}\pm1.04$	$1.67^{bc}\pm0.12$	$7.30^{ab}\pm1.15$
50:50	$0.73^{e}\pm0.06$	$0.83^{c}\pm0.11$	$1.86^{a}\pm0.15$	$52.5^{a}\pm0.50$	$1.60^{a}\pm0.10$	$8.70^{a}\pm1.15$

Means of three replicate analyses; Means within the same column not followed by the same superscripts are significantly ($p \leq 0.05$) different

Functional properties of the blends

Table 2 shows the functional properties of the blends. The bulk density, water absorption capacity and swelling power decreased, while fat absorption and emulsion capacities and least gelation concentration of the blends increased with increased level of substitution of walnut flour. The bulk density ranged from 0.73 to 1.43g/ml. The bulk density of a sample could be used in determining its packaging requirements (Akubor and Obiegbuna, 1999). There were significant differences in functional properties among the blends. Water absorption capacity ranged from 0.83 to 1.02 g/g, while fat absorption capacity ranged from 1.50 to 1.86 g/g. High water absorption capacity was attributed to lose structure of the starch polymers, while low value indicated the compactness of the molecular (Adebowale et al., 2005). Bhat et al. (2008) reported that oil absorption capacity is an important functional trait in food industries for the retention of flavour in foods and for the improvement of shelf-life and palatability.

Pasting properties of the blends

The pasting characteristics of the flour are affected by the interactions of starch granules by binding water in competition with starch and other factors such as the components of the starch granules i.e. amylose and amylopectin ratio, starch granules size and other physical and chemical properties (Henshaw et al., 1996). The results obtained for pasting properties of African walnut-wheat blends are shown in Table 3. The results were significantly different in the pasting properties except for the peak time and pasting temperature which are not significant among the blends.

The peak viscosity ranged from 128.5 to 301.08 RVU in 50:50 blend and 100% wheat flour, respectively. Peak viscosity is a measure of the ability of the starch to form a paste on cooking. Peak viscosity occurs at equilibrium between granule swelling which increases viscosity and granule rupture and alignment, which cause its decrease. High peak viscosity is an indication of high starch content and it relates to water binding capacity (Adebowale et al., 2005). The control (100% wheat flour) has got the highest peak viscosity.
The trough is the minimum viscosity value in the constant temperature phases of RVA profile and its measures the ability to withstand breakdown during cooling and the highest value was also observed for the control (240.33RVU) and decreased as the wheat flour reduced in the blends. The breakdown is an index of the stability of starch and its value was the least for the 50:50 blend (22.08 RVU) and the final viscosity was the highest (413.53 RVU) in the control sample. The peak time is a measure of time for attaining the pasting temperature and it ranged from 5.09 to 5.35min and the pasting temperature is the temperature at which an increase in viscosity is noticed and measured and it was the highest at 40:60 blend.

Physical properties of biscuits

Physical characteristics of biscuits prepared from different blends of wheat and African walnut flours are presented in Table 4. These findings were in agreement with the observation of Awan et al. (1995), who found that the diameter of the biscuits was affected positively by increase in the diameter of biscuits with increasing level of Moth bean flour supplementation. The thickness showed some variations in the values observed with the least value being 1.03 cm for 50:50 blend.

Table 3. Pasting properties of the blends of African walnut-wheat flour

Sample Walnut: Wheat (%)	Peak (RVU)	Trough (RVU)	Breakdown viscosity (RVU)	Final viscosity (RVU)	Setback viscosity (RVU)	Peak time (minutes)	Pasting temperature (ºC)
0:100	301.08^{a}	240.33^{a}	60.75^{b}	413.83^{a}	173.50^{b}	5.18^{ab}	82.5^{a}
10:90	191.17^{d}	156.00^{d}	35.17^{d}	224.33^{e}	68.33^{f}	5.27^{a}	82.1^{a}
20:80	278.67^{b}	199.83^{c}	78.83^{a}	391.58^{b}	191.75^{a}	5.35^{a}	83.6^{a}
30:70	197.37^{d}	158.92^{d}	38.45^{c}	249.25^{d}	98.33^{d}	5.12^{ab}	83.4^{a}
40:60	251.83^{c}	220.08^{b}	31.75^{d}	300.25^{c}	80.17^{e}	5.09^{b}	84.2^{a}
50:50	128.50^{e}	106.42^{e}	22.08^{e}	229.33^{e}	122.92^{c}	5.18^{ab}	82.6^{a}

Means of three replicate analysis; Means within the same column not followed by the same superscripts are significantly ($p \leq 0.05$) different.

Table 4. Physical properties of biscuits

Sample Walnut: Wheat (%)	Weight (g)	Diameter (cm)	Thickness (cm)	Spread ratio
0:100	17.7[d]±0.15	4.97[d]±0.15	1.41[b]±0.08	3.52[c]±0.10
10:90	17.9[d]±0.06	5.73[c]±0.25	1.63[a]±0.06	3.53[c]±0.24
20:80	21.7[c]±0.25	5.87[c]±0.11	1.43[b]±0.06	4.10[bc]±0.21
30:70	23.5[b]±0.64	6.03[bc]±0.21	1.27[b]±0.15	4.82[b]±0.71
40:60	24.0[b]±1.00	6.37[b]±0.12	1.07[c]±0.12	6.02[a]±0.67
50:50	25.3[a]±0.58	6.76[a]±0.25	1.03[d]±0.06	6.56[a]±0.41

Means of three replicate analysis; Means within the same column not followed by the same superscripts are significantly ($p\leq0.05$) different.

Table 5. Sensory attributes of the biscuits

Sample Walnut: Wheat (%)	Appearance	Taste	Texture	Aroma	General acceptability
0:100	7.10[a]	6.45[ab]	6.70[a]	6.50[ab]	6.80[a]
10:90	6.25[bc]	6.20[a]	6.20[a]	6.60[a]	6.50[ab]
20:80	6.90[a]	6.30[a]	6.35[a]	6.55[a]	6.55[ab]
30:70	6.80[ab]	6.70[a]	6.40[a]	6.95[a]	6.70[a]
40:60	6.10[bc]	5.00[b]	5.80[b]	5.10[b]	5.50[b]
50:50	5.65[c]	5.25[b]	5.50[b]	5.40[b]	5.75[b]

Means within the same column not followed by the same superscripts are significantly ($p\leq0.05$) different

Sensory evaluation

The sensory attributes of the biscuits produced from the blends are shown in Table 5. The results showed that there were significant differences ($p\leq0.05$) among appearance, taste, texture, aroma and general acceptability of the samples when compared with the control biscuit. Nevertheless, up to 30% substitution of wheat flour with walnut flour did not significantly affected the appearance, taste, texture, aroma and general acceptability of the samples when compared to the control sample.

Conclusion

The study revealed that biscuits from blends of African walnut and wheat flours compared favourably with the all wheat biscuits in all sensory attributes examined. Biscuit consumption is high in Nigeria among various groups. Therefore, African walnut supplemented biscuits would serve as a way of increasing intake of protein, fat and calories among these groups.

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