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QUALITY CHARACTERISTICS OF ACHA-WALNUT FLOUR BLENDS AND BISCUITS

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ABSTRACT
The study investigated chemical composition and functional properties of acha-walnut blends and quality assessment of biscuits produced from the blends. The walnut flour was substituted into acha flour at 0, 5, 10, 15 and 20% to produce walnut-acha flour blends. The flour blends were mixed with other ingredients (fat, sugar, salt, baking powder) and baked at 160^{o}C to produce biscuits. The moisture, ash, crude protein, fat, and fibre content increased from 8.16 to 10.68, 0.23 to 1.67, 8.35 to 13.23, 1.33 to 8.85 and 0.23 to 0.87%, respectively, with increase in the added walnut flour (0 to 20%). The Vitamin A, Vitamin B, calcium and the phosphorous content of the flour blends increased from 0.86 to 1.91, 7.91 to 10.34, 103.03 to 535.41 and 115.00 to 1879.30, respectively, with increase in the added walnut flour. The addition of the walnut(0 – 20%) increased the alkaloid(1.87 to 11.72 mg/100 g) and flavonoid (0.083 to 0.45mg/100g) but decreased the phenol(0.25 – 0.10mg/100g) of the flours blends The bulk density, water absorption, oil absorption capacity, forming capacity and swelling capacity results increased from 0.10 to 0.79 g/cm^3, 3.4 to 4.35, 2.35 to 3.00, 4.18 to 7.65 and 5.74 to 7.74 cm^3 /g, respectively, with increase(0 – 20 %) in the added walnut flour. The peak viscosity, trough viscosity and breakdown viscosity decreased from 2324.5 to 1131.5 RVU, 1975.5 to 844.5 RVU and 802.0 to 287.0 RVU, respectively, while the final viscosity, setback viscosity, and pasting temperature increased from 3409.5 to 4573.5, 2186.0 to 3329.5 RVU and 81.6 to 85.5^{o}C, respectively. The addition of walnut flour increased the break strength (0.42 to 1.78 kg) and decreased the spread ratio (5.70 to 4.90) of the blend biscuits. The average means scores of the appearance, texture, taste, flavour and general acceptability of the blend biscuits decreased from 8.0 to 6.85, 6.95 to 6.35, 6.65 to 4.05, 6.30 to 4.95 and 7.15 to 5.05, respectively, with addition of walnut. However, blend biscuits were acceptable up to 15 % walnut flour. Walnut flour incorporation had significant effects and contributed to the improvement of the flour blend and biscuits properties.
Keywords: Functional, chemical, properties, acha, walnut

INTRODUCTION
The inability of Nigeria as a country to meet her industrial demand of wheat had caused incessant rise in the prices of baked products like bread and biscuit which has resulted into a call for the research into alternative local sources of flour for baking. Left in a state of under development and inadequate processing due to ignorance of the industrialist, most of the common local cereal grains including acha, though having similar structure and composition, have not being utilized. The recent efforts by indigenous food researchers to improve the nutritional value of indigenous plant sources are timely and appropriate. The use of composite flours in bread and biscuits making by many researchers has been reported (Ayo *et al*., 2016; Agu *et al*., 2014; Olapade *et al*., 2011; Okoye *et al*., 2008; Olaoye *et al*., 2007).
The quality of the most underutilised cereals needed to be enriched or fortified to further improve their potentials. The quality of nutrients, particularly proteins, fibres and phytochemicals, calls for attention. Plant proteins play significant roles in human nutrition, particularly in developing countries where average protein intake is less than that required. Plant protein products are gaining interest as ingredients in food systems throughout many parts of the world and the final success of utilizing plant proteins as additives depends greatly upon the flavour characteristics that they impart to foods (Ayo *et al*., 2010).
Acha (*D. exilis*), though potentially rich in nutrients, has been classified among the lost crops (Ayo *et al*., 2010) with its cultivation and processing using village technology. The use of acha as substitute to wheat flour could have been advantageous with reference to baking qualities (high pentosan), unique protein (methionine and cysteine), high sulphur, which are deficient in other cereals and its relative lower influence on blood glucose level and then subsequently reducing diabetes (Ayo *et al*., 2010). Acha has been researched in different areas (Ayo *et al.,* 2014, Agu *et al.,* 2014; Jideani, 2012, Jideani *et al.,* 2011; Ayo *et al.,* 2010).
The major traditional foods from acha include: thick (Tuwo) and thin (Gwete and kunu) porridge (eaten with different kinds of stew and vegetables), steamed product (burabusko) and alcoholic beverages (Aloba, 2001). It could be boiled like rice (achajollof) and is also used in the form of "couscous" in some countries in West Africa (Aloba, 2001). Acha is known to be easy to digest, and is traditionally recommended for children, old people and for people suffering from diabetes or stomach diseases (Ayo *et al*., 2007). Acha does not contain any glutenin or gladines proteins which are the constituents of gluten, making it suitable for people with gluten intolerance (Ayo *et al*., 2007).
Walnuts can be utilized as ingredients of many foodstuffs such as bakery products to enhance the nutrition value and sensory properties of the final product (Mexis *et al*., 2009). Walnut oil is a major product of walnut and is one of the important special oils (Oliveira *et al*., 2002). Other proposed benefits of walnuts include their high content of protein, magnesium, copper, folic acid, potassium, fibre and vitamin E (Anderson, *et al*., 2001). Walnuts are a good source of high quality protein (18-24% protein on dwb) (Sze-Tao *et al*., 2000). Walnuts nutrient composition has been fairly investigated by several investigators (Sze-Tao*et al*., 2000 and Amaral, *et al*., 2003). African walnuts are

widely distributed in southern part of Nigeria (Aviara and Ajikashile, 2011). Non- conventional flours, such as, African walnut flour can present an alternative means of diversifying the use of non-wheat flour as it has the potential to increase farmer's income by adding value to products, extend marketing, support food diversification and security and reduce wheat importation.

The recent research findings have confirmed acha as good alternative flour. Walnut has been identified with high protein content and underutilised. Therefore, the use of walnut as substitute in acha could be investigated. The aim of the work is to determine the effect of adding walnut on the quality of acha based biscuits.

MATERIALS AND METHODS

Materials

2 kg of fresh African walnuts were purchased from Oshogbo market, Osun State, while the acha was obtained from Terminus in Jos, Plateau state, Nigeria.

Methods

Production of acha and African walnut flour

The acha grain was washed, de-stoned (manually using sedimentation method), dried (oven dried at 50^0C for 72 h); milled (using attrition mill), and sieved (using 0.4mm sieve aperture) to obtain acha flour, packed hermetically in polythene bags and at room temperature in cool dry place till usage.

The fresh African walnut seeds were washed, boiled for 30 – 45 min, de-shelled (using knife) and cut into slices to facilitate drying. The slices were then drained and oven dried at 70°C to a constant weight. The dried slices were milled (using attrition mill) into flour and sieved (using 0.4 mm sieve aperture) to obtain flour of uniform size. The flour was packaged and stored at room temperature.

Production of acha-walnut flour blend biscuits

Biscuits were prepared using the traditional creaming method described by Chinma *et al*., (2011). The walnut flour is substituted (0, 5,10, 15, 20 %) into the acha flour to produce flour blend. The fat(55%) and sugar(45%) were mixed in a Kenwood mixer (HM 430) until the mixture was fluffy. Baking powder(0.9%), flour blend(100 – 75%), and salt(1.0%) were introduced into the mixture to form soft dough. The dough was kneaded, rolled out into sheets (using a rolling pin), cut (into desired shape using a cutter), transferred to a greased baking tray and baked (at 180°C for 17 min), cool(room temperature) and packaged for further analysis.

Analytical Methods

Proximate analysis

The proximate composition: moisture, ash, fat, protein, crude fiber and carbohydrate content were determined by AOAC(2012) method

Phytochemical Analysis*:*

The alkaloids, tannins, flavonoids were determined as described by Oku *et al*. (2007) while the phenol was determined by AOAC (2012) method.

Determination of minerals and vitamins content of the acha-walnut flour blends

The minerals (calcium, phosphorous) and Vitamins (*A* -β-Carotene, C) were determined as described by Okwu (2004).

Determination of Functional Properties

Water absorption capacity: The water absorption capacity was determined using the method described by Onwuka, (2005). Ten millilitres (10 ml) of distilled water was added to 1g of acha-walnut composite flour sample in a weighed centrifuge tube. The tube was agitated on a vertex mixer for 2min and then centrifuged at 4000 rpm for 20 min. The clear supernatant was decanted and discarded. The adhering drops of water was removed and then weighed. Water absorption capacity was expressed as the weight of water bound by 100 g of dried flour.

Oil absorption capacity: The oil absorption capacity was determined using the method described by Onwuka, (2005). One gram (1g) of acha-walnut composite flour sample was mixed with 10ml of refined vegetable oil and allowed to stand at ambient temperature for 30min. it was then centrifuged for 30min at 2000rpm. The oil and adhering drops of oil was decanted and discarded. Oil absorption capacity was expressed as percent oil bound per gram flour.

Bulk density: The bulk density was determined using the method described by Onwuka, (2005). Fifty grams (50g) of ach-walnut composite flour sample was poured into a 100ml measuring cylinder. The cylinder was tapped fifty (50) times on a laboratory bench to constant volume. The volume of sample was recorded.

$$\text{Bulk density (g/cm}^3) = \frac{weight\ of\ sample}{volume\ of\ sample\ after\ tapping}$$

Foaming capacity and stability: The foaming capacity and stability were determined using the method described by Onwuka, (2005). Two grams (2g) of acha-walnut composite flour sample was added to 50ml of distilled water at 30 ± 2°C in a 100ml graduated cylinder. The suspension was mixed and shaken manually for 5min to foam. The volume of foam at 0second after whipping was expressed as foaming capacity using the formula;

$$\text{Foam capacity} = \frac{volume\ of\ foam\ after\ whipping}{volume\ of\ mixture} \times 100$$

The volume of foam was recorded at different time intervals (5, 10, 15 and 20 seconds) after whipping to determine the foam stability as percent of the initial foam volume.

Swelling capacity: The swelling capacity was determined using the method described by Olapade *et al.* (2003). One gram (1g) of acha-walnut composite flour sample was mixed with 10ml of water in a weighed centrifuge tube. The tube was heated in water bath at 85°c for 15min and then centrifuged at 2000rpm for 30min. The clear supernatant was decanted and discarded. The adhering drops of water was removed and then weighed. Swelling capacity was expressed as percent swelled per gram flour.

Determination of pasting properties

Pasting properties of the sample were determined using the Rapid ViscoAnalyzer (RVA-4, Newport Scientific, Australia and Thermocline for Windows programme (version 1.10); viscosity was expressed in RVU (Rapid Visco Units), as described by AOAC, (2012). The flour blend (2.5 g) was weighed directly in can RVA canister and 25 ml of distilled water was added. The sample was held at 50°C for 1 min, heated to 95°C within 3.5 min, held at 95°C for 2.5 min, then cooled to 50°C within 4 min and finally held at 50°C for 2 min. the rotating speed was held constant at 960 rpm for 10 s and then maintained at 160 rpm for the duration of the process. To prevent the activity of α- amylases, 100 µmol of AgNO3/g starch (dry basis) was added to the sample. Recorded parameters included peak viscosity, trough viscosity, breakdown, final viscosity, setback, peak time and pasting temperature.

Determination of Physical Properties

Breaking Strength: Break strength of acha-walnut composite biscuit was determined using the method described by Appiah *et al.*, (2011). Biscuit sample of 0.4cm thickness was placed centrally between two parallel metal bars 2cm apart and weights were applied until the biscuit snapped. The least weight that caused the breaking of the biscuit was regarded as the break strength of the biscuit.

Weight: The weight of the acha-walnut composite biscuit was determined by weighing on an electronic weighing balance (Mettler PF160 Balance, Switzerland) (Ayo *et al.* 2007).

Diameter and Thickness: The acha-walnut composite biscuit diameter and thickness were determined using venire calipers (Ayo *et al.* 2007).

Spread Ratio: The spread ratio was calculated by method described by McWatters *et al*. (2003). Five well-formed biscuits were arranged in column and the height was measured. The same pieces were also arranged in row, edge to edge and the sum of the diameters measured. The spread ratio was calculated as diameter divided by height.

RESULTS AND DISCUSSION

Proximate composition of walnut-acha flour blend

The result of proximate composition is given in Table 1. The moisture, ash, crude protein, fat, and fibre content ranged from 8.16 to 10.68, 0.23 to 1.67, 8.35 to 13.23, 1.33 to 8.85, and 0.23 to 0.87%, with increasing acha substitution using walnut of up to 20%.The carbohydrate ranged from 64.84 to 81.88% and decreased with increasing walnut flour addition.

The moisture content increased with increase in walnut flour addition to the walnut flour blend which could be due to the increasing fiber content of the flour blend brought about by walnut flour. The increase in moisture content of the flour blend biscuits with increase in the added walnut flour could also be due to the presence of polar amino acids and the positive influence of increasing levels of protein on water holding capacity (Chinma *et al.,* 2011).The moisture content of the flour blend biscuits is higher than the maximum level(6%) recommended by the Nigerian Industrial Standard(NIS) requirement for biscuits by SON(2007) which could negatively affect the stability and shelf life quality of the product.. The ash contents increased from 0.23 to 1.67%with increase in the added walnut flour (5 to 20%). The increase in the ash content of the flour blend biscuits with increase in the added walnut flour could be attributed to the relatively higher ash contents of the former. The findings in this work agreed with that of Chinma *et al.* (2011) .

Increase in crude protein content (with increase in walnut flour addition) were found to be similar to the report of Tapsell *et al.*(2005) and can be attributed to the high protein supply of walnut flour as reported in the USDA National Nutrient database (Tapsell *et al.,* 2005; Crews *et al.,* 2005). The 100% acha flour yielded the least protein content (8.35%) compared to others while the 20% walnut acha flour blend had the highest protein content of 13.23% and conforms to the earlier stated reports by Tapsell *et al.* (2005).

The increase in protein contents of the flour blend biscuits may be attributed to the addition of effect caused by walnut flour due to the complementation of acha flour with walnut flour that contains higher amount of protein. Based on the results of the protein values of the flour blend when compared to the 100% acha flour biscuits and that of wheat flour biscuits(10.86%) as observed by Chinma *et al* (2011), it can be inferred that the flour blend biscuits are nutritious. This is because about 100 g of each product of the flour blend biscuits would provide more than 50% of the recommended daily requirement for protein (25 to 30 g/day) as recommended by FAO/WHO(1985) for children aged between 5 and 19 years. This findings suggest that biscuits prepared from flour blends made up of acha and walnut could be usefully be included in school feeding programm for children (Chinma *et al* 2011).

The fat content increased from 1.33 to 8.85% with increasing (0 – 20%) added walnut flour. The increase in the fat content with addition of walnut agreed with finding of Sen (2013). Acha-walnut flour blends could therefore be a perfect source of Omega 3 and a source of arachidonic acid which are inherent in walnut (Sen 2013).

Crude fibre content increased from 0.23 - 0.87% with increase in walnut flour addition. The increase in the crude fibre content could be due to the inherent high content of the same in nuts (Chinma *et al.,* 2011) which also agreed with findings of Cruz *et al*. (2011). The carbohydrate content on the other hand decreased (81.88 to 64.84 %) with increase in addition of walnut flour. Increasing walnut levels lowered the carbohydrate content of the resulting flour blends (73.17 to 65.37%) which could be due to relatively low carbohydrate content of walnut as reported by Sen (2011).

TABLE 1: PROXIMATE PROPERTIES OF WALNUT-ACHA FLOUR BLEND

FLOUR	**BLENDS**	**MOISTURE**	**ASH**	**CRUDE PROTEIN**	**CRUDE FAT**	**CRUDE FIBRE**	**CHO**	
Acha (%):	Walnut (%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
100:	0	8.16^{c}±0.04	0.23^{d}±0.04	8.35^{d}±0.04	1.33^{d}±0.04	0.23^{c}±0.04	81.88^{a}±0.04	81.88^{a}±0.04
95:	5	10.61^{a}±0.06	0.87^{c}±0.04	9.94^{c}±0.04	2.04^{c}±0.04	0.76^{a}±0.04	73.17^{c}±0.02	73.17^{c}±0.02
90:	10	10.68^{a}±0.04	1.25^{b}±0.04	11.36^{b}±0.04	4.27^{b}±0.04	0.60^{b}±0.03	74.47^{b}±0.04	74.47^{b}±0.04
85:	15	10.32^{b}±0.04	1.65^{a}±0.04	13.18^{a}±0.04	8.69^{a}±0.04	0.81^{a}±0.04	65.37^{d}±0.04	65.37^{d}±0.04
80:	20	10.68^{a}±0.04	1.67^{a}±0.04	13.23^{a}±0.04	8.85^{a}±0.04	0.87^{a}±0.04	0.87^{a}±0.04	64.84^{d}±0.04

*Average mean score with the same letter(s) on the same column are not significantly different if p=0.05

Table 2 Phytochemical Contents of Walnut-Acha Flour Blend

Acha (%):	Walnut (%)	Total Phenols	Tannins	Alkaloids	Flavonoids
100:	0	0.25±0.02[c]	2.04±0.09[a]	1.87±0.04[d]	0.083±1.26[b]
95	:5	0.14±0.01[bc]	0.18±0.00[b]	9.21±0.00[c]	0.09±0.21[b]
90	:10	0.06±0.01[b]	0.18±0.07[b]	9.93±0.07[b]	0.11±0.01[b]
85	:15	0.02±0.01[a]	0.02±0.02[b]	10.78±0.01[a]	0.38±0.04[a]
80	:20	0.01±0.01[a]	0.02±0.02[b]	11.72±0.01[a]	0.45±0.04[a]

*Average mean score with the same letter(s) on the same column are not significantly different if P=0.05

Phytochemicals Walnut-Acha Flour Blend

The result of phytochemical composition is shown in Table 2 . The Phenolic, tannin and flavonoid contents decreased from 0.25 to 0.01, 2.04 to 0.02 and 137.83 to 0.45 mg/100g, respectively, with increase in added walnut flour. However, the alkaloids content increased 1.87 to 11.7mg/100g with increase in added walnut-acha flour blends.

The addition of walnut flour had a significant effect (p=0.05) on the level of the alkaloid content of the flour blends. The increasing alkaloids content could be due to the addition of walnut which agreed with the findings of Okwu (2005), Anderson *et. al.* (2001) and Morgan *et al.* (2002). The flavonoid content of 100% acha was highest at 137.83±1.26mg/100g and conforms to the reports of Ayo *et al*. (2010). Decrease in amount of tannins and phenols correspond to the reports of Awika and Rooney (2004). This decline could be attributed to the heat treatment and handling conditions of the acha and walnut flour.

Vitamin composition of walnut-acha flour blends

The vitamin content of the walnut-acha flour blend is given in Table 3. The vitamin A and Vitamin C content of the flour blends increased from 0.84 to 1.91 and 7.91 to 10.34 mg/100g, respectively, with increase (0 -25%) of walnut flour. The increase in these vitamins agreed with finding of Sen (2011).

Mineral composition of walnut-acha flour blends

The result of mineral values for the walnut acha flour blend is given in Table 4. The calcium and phosphorous content of walnut-acha blends increased from 103.03 to 535.41mg/100g and 1115.60 to 1879.26mg/100g, respectively, with increase in addition of walnut flour.

The 100% acha flour had the least amounts of calcium (103.03) and Phosphorous (1115.60). The increasing effects of walnut flour which is significant, p = 0.05, on the calcium and phosphorous content of the flour blends agreed with findings of Cruz *et al*(2011) and Sen(2011).

Table .3 Vitamin composition of walnut-acha flour blend

Flour blends (acha %):	Walnut (%)	VITAMIN A(mg/100g)	VITAMIN A(mg/100g)
100:	0	0.86[c]±0.04	7.91[b]±0.04
95:	5	0.93[c]±0.03	7.96[b]±0.03
90:	10	1.38[b]±0.02	7.98[b]±0.05
85:	15	1.84[a]±0.04	10.11[a]±0.15
80:	20	1.91[a]±0.04	10.34[a]±0.15

Score with the same letter(s) on the same column are not significantly different if P=0.05

Table 4 Minerals composition of walnut-acha flour blends

Flour blends (acha %)	Walnut (%)	CALCIUM(mg/100g)	PHOSPHORUS (mg/100g)
100:	0	103.03±7.02[e]	1115.60±7.71[d]
95:	5	155.98±0.03[d]	1339.00±2.91[c]
90:	10	231.04±0.06[c]	1650.20±3.47[b]
85:	15	435.41±2.26[b]	1794.30±0.75[a]
80:	20	535.41±2.26[a]	1879.30±0.75[a]

*Average mean score with the same letter(s) on the same column are not significantly different if P=0.05

Functional properties of walnut-acha flour blends

The result of functional assessment of the acha walnut flour blend is shown in Table .5. The bulk density, water absorption, oil absorption capacity, forming capacity and swelling capacity results ranged from 0.10 to 0.79 g/cm^3 , 3.4 to 4.35 cm^3/g, 2.35 to 3.00 cm^3/g, 4.18 to 7.65 cm^3/g and 5.74 to 7.74 cm^3/g , respectively, with increasing added walnut flour. The effect of the added walnut flour on the functional properties were significant at 20% and above. The effects observed on the functional properties of flour blends agreed with findings as reported by Rehman *et al*. (2007), Lawal *et al*. (2007) and Temple and Bassa (1991).

Table 5: Functional properties of acha-walnut flour blends

Acha Flour (%)	Walnut flour (%)	BD (g/cm^3)	WAC (cm^3/g)	OAC (cm^3/g)	Foaming Capacity (cm^3/g)	Swelling Capacity (cm^3/g)
100	0	0.10[c]±0.02	3.40[b]±0.28	2.35[c]±0.21	4.18[d]±0.66	5.74[b]±0.02
95	5	0.71[b]±0.01	3.35[b]±0.21	2.60[b]±0.28	5.92[c]±0.18	5.87[b]±0.06
90	10	0.79[a] ±0.02	3.50[a]±0.14	2.8[5ab]±0.21	7.07[b]±0.29	6.24[b]±0.05
85	15	0.79[a] ±0.01	3.50[a]±0.57	3.00[a] ±0.71	7.65[a] ±0.13	7.74[a] ±0.13
80	20	0.79[a]±0.01	3.55[a]±0.21	3.00[a]±0.71	7.65[a]±0.13	7.74[a]±0.13

*Average mean score with the same letter(s) on the same column are not significantly different if P=0.05

Pasting Properties Result

The results of pasting properties evaluated are presented in Table 6. The peak viscosity, trough viscosity, breakdown, final viscosity, set back and pasting temperature of the acha-walnut flour blends increased from 1134 to 19925.5, 534.5 to 1975.5, 302.0 to 755.5, 3421.0 to 4573.5, 2186.0 to 3229.5RVU and 81.6 to 85.2^{o}C , respectively, but the peak time decreased from 5.3 to 5.0 min with increase in the added walnut flour.

The increasing setback time and breakdown viscosities of the flour blends could make it unsuitable for jelly products (Ndie *et al*., 2010). However, the high peak viscosity, trough viscosity and pasting temperature of the flour blends suggest more water binding capacity, gelatinization and low swelling property. These properties could be attributed to presence of high fibre and proteins of the added walnut flour (Sen, 2011).

Table 6: **Pasting properties of walnut-acha flour blend**

Acha flour %	Walnut flour%	Peak Viscosity (RVU)	Trough viscosity (RVU)	Breakdown (RVU)	Final Viscosity (RVU)	Setback (RVU)	Peak time (mins)	Pasting temp (°C)
100	0	1134.5^c±2.1	534.5^e±.71	302.0^d±1.4	3421.0^c±1.4	2186.0^c±1.4	5.3^a±.03	81.6^b±1.6
95	5	1131.5^c±.71	844.5^d±.71	287.0^d±1.4	3409.5^c±2.1	2562.5^b±2.1	5.1^b±.00	85.5^a±.04
90	10	1533.5^b±.71	1038.0^c±1.4	495.5^c±.70	4318.0^b±1.4	3276.5^a±2.1	5.1^b±.00	85.3^a±.71
85	15	1829.5^a±.71	1515.5^b±4.4	626.5^b±2.1	4393.5^b±.71	3192.5^a±.71	5.1^b±.01	85.2^a±.04
80	20	1992.5^a±.71	1975.5^a±4.4	755.5^a±2.1	4573.5^a±.71	3229.5^a±.71	5.0^b±.01	85.2^a±.04

*Average mean score with the same letter(s) on the same column are not significantly different if P=0.05

Physical properties of acha-walnut flour biscuits

The result of physical analysis of the walnut-acha flour blend biscuits is shown in Table 7. The break strength and the weight of the blend biscuits increased from 0.42 to 1.78 kg and 12.95 to 13.15 g, respectively, while the spread ratio decreased from 5.78 to 4.98 with increase in the added walnut flour. The increase in the break strength could be due to the effect of the inherent protein content of the walnut to form strong bond with the carbohydrate of the acha flour.

Table 7: Physical properties of acha-walnut flour blend biscuits,

Acha:	Walnut (%)	Break Strength (kg)	Spread Ratio	Weight(g)
100:	: 0	0.42^d±0.25	5.78^a±1.27	12.95^a±0.21
95	:5	0.85^c±0.26	5.64^b±0.24	13.25^a±0.35
90	:10	1.40^b±0.22	5.33^c±0.82	12.85^a±0.07
85	:15	1.76^a±0.16	5.10^d±0.72	13.20^a±0.28
80	:20	1.78^a±0.18	4.98^e±0.10	13.15^a±0.16

*Average mean score with the same letter(s) on the same column are not significantly different if P=0.05.

The effect of walnut incorporation is therefore on the break strength and could be attributed to the high binding and pasting properties associated with walnut flour reported by Ndie *et al*. (2010).

Acceptability of acha-walnut biscuits

The result of the sensory evaluation is shown in Table 8.The appearance, texture, taste, flavor and general acceptability ranged from 6.40 to 8.00, 6.35 to 6.95, 4.05 to 7.00, 4.95 to 6.90 and 5.05 to 7.15, respectively. The effect of walnut incorporation into the flour blend to produce biscuits had significant effects on the taste, appearance, flavor and general acceptability at above 15%. There was significant effect on the taste may be attributed to the phenolic components of walnut as well as the effect of thermal treatment on the protein, fats and carbohydrates of the walnut flour based biscuits on the reports of Al-Saqer *et al.* (2004).

Table 8: Acceptability of Walnut-Acha Flour Blend Biscuits

SAMPLE		APPEAR ANCE	TEXTURE	TASTE	FLAVOUR	GEN ACC
(Acha):	(Walnut					
100:	: 0	8.00^a±.97	6.95^a±1.5	6.65^a±1.6	6.50^a±1.9	7.15^a±1.5
95	:5	7.20^{ab}±1.3	6.85^a±1.7	6.65^a±2.1	6.90^a±1.8	7.00^a±1.4
90	:10	6.75^b±1.5	6.85^a±1.2	7.00^a±1.8	6.50^a±1.8	6.75^a±1.3
85	:15	6.40^b±1.2	6.60^{ab}±1.7	5.80^a±1.8	6.05^a±1.4	6.80^a±1.1
80	:20	6.45^b±1.6	6.35^b±1.5	4.05^b±2.3	4.95^b±1.5	5.05^b±1.3

*Average mean score with the same letter(s) on the same column are not significantly different if p=0.05

CONCLUSION

This study has revealed that an acceptable biscuits can be prepared using acha and walnut flour blends up to 15% added walnut flour. The use of acha and walnut flour in the biscuits preparation resulted in significant improvement in protein, fat, vitamin A, calcium and phosphorous content of the acha biscuits. The added walnut did significantly improve the break strength of the acha biscuits and thus could reduce damages during packaging and transportation. The acceptability of the flour blend biscuits could reduce the full dependence on wheat flour for biscuit production and could as well provide an alternative functional food product for the gluten sensitive individual.

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