Current Journal of Applied Science and Technology

25(5): 1-15, 2017; Article no.CJAST.38142
Previously known as British Journal of Applied Science & Technology
ISSN: 2231-0843, NLM ID: 101664541

Physicochemical, Phytochemical and Sensory Evaluation of Acha-Carrot Flours Blend Biscuit

J. A. Ayo[1*] and F. E. Gidado[1]

[1]*Department of Food Science and Technology, Federal University, Wukari, Nigeria.*

Authors' contributions

This work was carried out in collaboration by the two authors. Author JAA designed the study, supervise the production and analysis of samples, wrote the protocol, and approved the final manuscript. Author FEG performed the statistical analysis, wrote the first draft of the manuscript, managed the analyses of the study and the literature searches. Both authors read the manuscript.

Article Information

DOI: 10.9734/CJAST/2017/38142
Editor(s):
(1) Ming-Chih Shih, Professor, Department of Health and Nutrition Science, Chinese Culture University, Taiwan.
Reviewers:
(1) Oluwatoyin Oladeji, Institute of Innovative Technology, Nigeria.
(2) Mohamed Gadallah Elsayed Gadallah, Qassim University, Saudi Arabia.
Complete Peer review History: http://www.sciencedomain.org/review-history/23037

Original Research Article

Received 26th September 2017
Accepted 2nd December 2017
Published 5th February 2018

ABSTRACT

The study investigated physiochemical, phytochemical composition and sensory qualities of acha-carrot flour blend biscuits. Flour blends were produced by substituting carrot flour into acha flour at 5, 10, 15, 20, and 25%. Pasting properties and functional properties of the flour blends were determined. Biscuits were produced from the flour blends and the physicochemical, phytochemical composition and sensory qualities of the biscuits were analysed. The protein and carbohydrate content decreased from 8.35±0.03 – 7.90±0.04 and 70.67±0.39 – 68.74±0.39%, respectively. The moisture content, crude fibre, fat and ash content increased from 5.33±0.10 to 6.39±0.01, 0.85±0.01 to 1.50±0.54, 13.80±0.33 to 14.24±0.06 and 1.85±0.00 to 2.73±0.01% respectively, with increase in the added carrot flour (5-25%). The carotenoids, saponnins, flavonoids, and anthocyannins increased from 4.68±0.04 – 7.87±0.05µg/g, 0.05±0.00 – 0.12±0.00, 0.01±0.00 – 0.03±0.00, and 0.05±0.00 – 0.07±0.00 mg/100 g, respectively. The water absorption capacity, oil absorption capacity, and swelling capacity increased from 2.32±0.19 – 3.24±0.08, 1.96±0.20 – 2.24±0.08, and 5.91±0.64 –7.6±00.85 ml/g, respectively, with increase in the added carrot (5-25%). Loosed bulk density, packed bulk density, emulsion activity, and foaming capacity decreased from 0.63±0.05 – 0.55±0.03 glcm^3, 0.86±0.02 – 0.78±0.01 g/cm^3, 56.50±0.71 – 54.50±0.71%, and 6.83±0.82 –

**Corresponding author: E-mail: jeromeayo@gmail.com, jeromeayo@yahoo.com;*

3.33±1.27%, respectively. Peak viscosity, trough viscosity, breakdown, final viscosity, and setback decreased from 216.83±0.06 – 143.21±0.05, 142.17±0.04 – 105.46±0.02, 74.67±2.60 – 37.75±2.72, 351.58±0.09 – 207.71±0.07, and 209.42±0.06 102.25±0.05RVU, respectively. The 85:15% acha-carrot biscuit sample was the most preferred with a corresponding increment of 2.5, 9.4, 25.4, 21.6 and 20% of protein, crude fibre, ash content, carotenoids, and anthocyanins, respectively. Addition of carrot to acha could be said to have greatly improve the quality of acha.

Keywords: Physicochemical; phytochemical; sensory; quality; acha-carrot biscuits.

1. INTRODUCTION

Biscuits are ready-to-eat, convenient and inexpensive food products of digestive and dietary importance consumed by all ages [1]. They are nutritive snacks produced from unpalatable dough that is transformed into appetizing products through the application of heat in the oven [1]. Biscuits generally have been found to be rich in carbohydrate and protein. They contain fat (18.5%), carbohydrate (78.23%), ash (1.0%), and protein (7.1%) and salt (0.85%) as reported by (Okeagu [2]. Biscuits are generally produced from wheat flour; which is imported into Nigeria. Nigeria is finding itself more and more caught up in the "wheat trap" where most of its foods are made from wheat, a foreign cereal [3].

The inability of the country to meet the industrial demand of wheat, has caused incessant rise in the prices of baked products like bread and biscuit which in sequence has resulted into a call for the research into alternative local sources of flour for baking. Most of the common local cereal grains including acha, though having similar structure and composition were left in a state of under development and inadequate processing due to ignorance of the industrialist. 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 has been reported by many researchers [1,4-9].

Acha (*Digitaria exilis*), though potentially rich in nutrients, has been classified among the lost crops with its cultivation and processing at village technology level. 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 [10].

Acha has promising unique nutritional qualities. Nutrition experts have acknowledged it as exceptional. It has relatively low free sugar and low glycemic content(40%) and this makes it adequate as a suggested diet of diabetic patients [11]. *In-vitro* starch digestibility and glycemic property of acha, iburu and maize porridge has been reported [12]. It contains about 91% of carbohydrate. It has a high crude protein content of about 8.7% and in some black acha samples, may be up to 11.8%, which is high in leucine (19.8%), methionine and cysteine (of about 7%) and valine (5.5%) of the essential amino acids. Sometimes considered as "a small seed with a big promise", acha provides food early in the season when other crops are yet to mature for harvest, hence the name hungry rice [13]. It has the potentials for reducing human misery during hungry times, among the over 2000 crops that are native to Africa, which could be effective tools as well in fighting hunger in the continent.

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 [14]. It could be boiled like rice (achajollof) and is also used in the form of "couscous" in some countries in West Africa [14]. 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 [15]. Acha does not contain any glutenin or gladines proteins which are the constituents of gluten, making it suitable for people with gluten intolerance [15,16].

Carrot (*Daucus carota*), cultivated in the Plateau state of Nigeria, have became popular for its freshness and fibre content. Carrot pomace containing about 50% of β-carotene could profitably be utilized for the supplementation of products like cake, bread, biscuits and several types of functional products [17]. Nutritional quality of food supplements based on carrot powder and grits have been reported to be good source of β-carotene, fibre and many essential micronutrients (e.g. amino acids, fatty acids, vitamins, and minerals) and functional ingredients(e.g. carotenoids, dietary fibre, flavonoids, minerals, vitamins, etc.) [18]. The presence of high concentration of carotenoids especially β-carotene in carrot roots, make them to inhibit free radical scavengers, antimutagenic and immune-enhancers. Carrot is also an excellent source of calcium pectate; an extraordinary pectin fibre that has the cholesterol lowering properties [19]. It has a property to reduce the risk of high blood pressure, stroke, heart disease and some type of cancer [19].

Acha has been researched in different areas including: Chemical composition of "acha" flour [20]; physical, chemical properties of acha (D. *exilis*) and iburu (D. *iburua*) [21]; Effect of acha (*Digitaria exilis)* grain flour on the physical and sensory quality of wheat biscuit [22]; Effect of "acha" (D. *exilis*) on the body weight, glucose blood level, haemoglobin and packaged column cell of Rabbit [22]; Effect of "acha" (*Digitaria exilis staph*) grain flour on the physiochemical, and sensory quality of bread [23]; Production and evaluation of malted soybean-acha composite flour bread and biscuits [6]; Physiochemical, in-vitro digestibility and organoleptic evaluation of "acha" wheat biscuit supplemented with soybean flour [15]; Effect of improvers on the quality of acha bread [24]; In-vitro starch digestibility and glycemic property of acha, iburu and maize porridge [12]; Effects of added defatted beniseed on the quality of acha-based biscuit [10], (acha/fonio), *Digitaria iburua,*(iburu/fonio) and *Eluesine corcana* (tamba/finger millet)- Non-convectional cereal grains with potentials [25]; Developments on the cereal grains *Digitaria exilis* (acha) and *Digitaria iburua*(iburu) [26]; Quality assessment of acha-based biscuit improved with bambara nut and unripe plantain [5]; Production and evaluation of malted soybean-acha composite flour bread and biscuits [6] and cereal breakfast [27].

The recent research findings as to the potentials of acha, an under-utilized crop, in alleviating the crises of diabetes, have called for its fortification to improve its nutrient content. The abundance and perishability of carrot with its high nutrient content calls for it's processing to reduce its wastage and could be used as a fortify or enriched food product with relatively low nutrient.

Fortification of acha biscuits with carrot could improve the carotenoids, fibre and mineral content and add value to the sensory qualities of food products. Also, the use of carrot will reduce its wastage and create more market for the same.

The objective of this study was to investigate the of using acha and carrot flours blends on physicochemical, phytochemical and sensory quality parameters of biscuits.

2. MATERIALS AND METHODS

2.1 Materials

Acha grains (D. *exilis*) were purchased from Bauchi central market, Bauchi State; carrots (*Daucus carota*) were purchased from Jos central market, Plateau state Nigeria. Other ingredients such as sweet potatoes (*Ipomoea batatas*), baking fat (Simas), baking powder (Omega), liquid milk (Three crowns), eggs, and salt(Dangote table salt) were purchased from Wukari New market, Taraba state.

2.2 Methods

2.2.1 Preparation of acha flour

Acha grains were sorted manually and then washed (using tap water) to remove tiny stones and dust as well as foreign materials (by decanting them as they float on top of the water), drained, oven dried (at 40°C for 5 hrs), milled (Attrition mill-model no. 0712098, Britain) and sieved using a sieve of 0.3 µm aperture size. The flour was packaged in polyethylene bag and stored at 5°C as acha flour [8].

2.2.2 Preparation of carrot flour

The carrots were selected, washed with clean water by rubbing off with hands and peeled manually (using a knife), sliced (into thin pieces), steam blanched for 3minutes, oven-dried (40°C for 4hrs), milled (Attrition mill-model no. 0712098, Britain and sieved (0.3 mm aperture size sieve). The carrot powder was packaged in a polyethylene bag and stored at low temperature (5°C).

2.2.3 Production of Acha-Carrot composite biscuit

The carrot powder was substituted into acha flour at 5, 10, 15, 20 and 25%. The sweet potatoes flour (30%) was beacon into the fat until fluffy and acha-carrot composite flour and other ingredients (0.6% salt, 1.5%baking powder, 5 g powder peak milk and 15% egg emulsion) added, while mixing at a medium speed of Kenwood blender. The use of sweet patotoes(pink colored) was to reduce the glycemic index of the product(glycemic index of sugar =100 while that of sweet potatoes =53%). Sweet potatoes improves the anti-oxidants activities [28]. The mixing was done properly (using Kenwood mixer) and the method of [29] was used to produce the biscuits.

2.3 Analytical Methods

2.3.1 Determination of physical properties

Spread ratio determination: Spread ratio of acha-carrot composite biscuit was determined using the method described by Gomez et al. [30]. Five well-formed biscuits were arranged in column and the height 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.

Break strength determination: Break strength of acha-carrot composite biscuit was determined using the method described by Okaka and ISieh, [31]. 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.

2.3.2 Determination of pasting properties

Pasting properties of the acha-carrot composite flour were determined using the Rapid Visco Analyzer (RVA-4, Newport Scientific, Australia and Thermocline for Windows programme (version 1.10); viscosity was expressed in RVU (Rapid Visco Units), as described by AACC, (2001). Acha – carrot flour blend (2.5 g, 14 g/100 g moisture basis) was weighed directly in Can RVA canister and 25 ml of distilled water was added. The sample was held at 50°C for 1min, 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 sec and then maintained at 160 rpm for the duration of the process. To prevent the activity of α-amylases, 100 µmol of $AgNO_3$/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.

2.3.3 Determination of proximate composition

The moisture, protein, fat, ash and crude fibre contents of acha-carrot blend biscuit samples were determined on wet basis according to AOAC [32] method. The total carbohydrate was determined by difference:

Carbohydrate =100 − (moisture % + protein % + fat % + ash %)

2.3.4 Determination of functional properties

Water absorption capacity: The water absorption capacity was determined using the method described by Onwuka, [33]. Ten millilitres (10 ml) of distilled water was added to 1g of cha-carrot composite flour sample in a weighed centrifuge tube. The tube was agitated on a vertex mixer for 2 min 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 [33]. One gram (1 g) of acha-carrot composite flour sample was mixed with 10ml of refined vegetable oil and allowed to stand at ambient temperature for 30 min. it was then centrifuged for 30 min at 2000 rpm. 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 of the acah-carrot flour blend was determined using the method described by Onwuka [33]. The acah-carrot flour blend sample (5 g) was poured into a (10 ml) dry measuring and the volume was recorded for the loose bulk density. The bottom of the cylinder was tapped 50 times on the laboratory table and the volume was recorded for packed bulk density.

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 [33]. Two grams (2 g) of acha-carrot composite flour sample was added to 50ml of distilled water at 30 ± 2°C in a 100 ml 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.

Emulsion activity and stability: The emulsion activity and stability were determined using the method described by Olapade et al. [34]. The emulsion, 1 g of acha-carrot composite flour sample, 10 ml distilled water and 10 ml refined vegetable oil was prepared in a calibrated tube. The emulsion was centrifuged at 2000 rpm for 15 min. The ratio of the height of the emulsion layer to the total height of the mixture was calculated as the emulsion activity expressed in percentage. The emulsion stability was estimated after heating the emulsion contained in a calibrated centrifuge tube at 80°C for 30 min in a water bath, cooling for 15 min under running tap water and centrifuging at 2000 rpm for 15 min. The emulsion stability, expressed as a percentage was calculated as the ratio of the height of the emulsified layer to the total height of the mixture.

Swelling capacity: The swelling capacity was determined using the method described by Olapade et al. [34]. One gram (1 g) of acha-carrot composite flour sample was mixed with 10 ml of water in a weighed centrifuge tube. The tube was heated in water bath at 85°c for 15 min and then centrifuged at 2000 rpm for 30 min. 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.

2.3.5 Determination of phytochemicals

Determination of Carotenoids content: Carotenoids content was determined according to the method described by Krishnaiah et al. [35]. A measured weight of acha-carrot composite biscuit sample was homogenized in methanol using a laboratory blender. A 1:10 (1%) mixture was used. The homogenate was filtered to obtain the initial crude extract, 20 ml of ether was added to the filtrate and mixed well and then treated with 20 ml of distilled water in a separating funnel. The ether layer was recovered and evaporated to dryness at low temperature (35-50^{o}C) in a vacuum dessicator. The dry extract was then saponified with 20 ml of ethanolic potassium hydroxide and left over in a dark cupboard. The next day, the carotenoid was taken up in 20 ml of ether and the washed with two portions of 20 ml distilled water. The carotenoid extract (ether layer) was dried in a dessicator and then treated with light petroleum (petroleum spirit) and allowed to stand overnight in a freezer (-10°c). The precipitated steroid was removed by centrifugation after 12hours and the carotenoid extract was evaporated to dryness in a weighed evaporation dish, cooled in a dessicator and weighed. The weight of carotenoid was determined and expressed as a percentage of the sample weight.

Percentage carotenoid content =

$$\frac{weight\ of\ sample}{weight\ of\ sample\ taken} \times 100$$

Determination of Saponnins content: Saponnins content was determined according to the method described by Obadoni and Ochuko, [36]. Twenty grams (20 g) of acha-carrot composite biscuit sample was dispersed into 200 ml of 20% ethanol. The suspension is heated over hot water bath for 4hours with continuous stirring at about 55°C. The mixture is filtered and the residue re-extracted with 200 ml of diethyl either is added and shaken vigorously. The aqueous layer is recovered while the either layer is discarded. The purification process is repeated. 60 ml of n-butanol is added. The combined n-butanol extracts are washed twice with 10 ml of 5% aqueous sodium chloride. The remaining solution is heated in a water bath. After evaporation, the samples are dried in the oven to a constant weight. The saponnin content is calculated in percentage.

Percentage saponnin content =

$$\frac{weight\ of\ residue}{weight\ of\ sample\ taken} \times 100$$

Determination of Flavonoids content: Flavonoids content was determined using the method described by Bohm and Kocipal [37]. Five grams (5 g) of acha-carrot composite biscuit sample was boiled for 30 min under reflux. It was allowed to cool and then filtered through a

Whatman No. 42 grade filter paper. A measured volume of the extract was treated with equal volume of ethyl acetate starting with drop. The flavonoid precipitate was recovered by filtration using a weighed filter paper. The resulting weight difference was recorded as the weight of flavonoid in the sample.

Percentage flavonoid content =

$$\frac{weight\ of\ residue}{weight\ of\ sample\ taken} \times 100$$

Determination of Anthocyanins content: Anthocyanins content were determined using the method described by Krishnaiah et al. [35]. Five grams (5 g) of acha-carrot composite biscuit sample was hydrolysed by boiling in 100 ml of 2MHcl solution for 30 minutes. The filtrate is transferred into a separation funnel and equal volume of ethyl acetate is added to it, mixed well and allowed to separate into two layers. The ethyl acetate layer {extract} is recorded while the aqueous layer is discarded. The extract is separated to dryness in the crucible over a steam bath. The dried extract is then treated with concentrated amyl alcohol to extract the anthocynins. After filtration, the alcohol extract and the filtrate are transferred to a weighed evaporating dish and evaporated to dryness. It is then dried in the oven at 30°C for 30 minutes and cooled in desiccators. The weight of anthocyanins is determined and expressed as percentage of the original sample.

2.3.6 Sensory evaluation

The sensory quality of the acha-carrot biscuits was evaluated using twenty untrained panellists, randomly selected from Federal University Wukari, Nigeria based on their familiarity with the biscuit. The biscuits, appropriately coded (ACH, BSA, CAU, DON, EFU and FDA) and of the same size and temperature (29 ± 3°C) were placed in white plastic plates. The panellists rinsed their mouths with bottled water after tasting each sample and were not allowed to make comment during evaluation to prevent influencing other panellist. A nine-point Hedonic scale with one (1) representing “extremely dislike” and nine (9) “extremely like” was used, presented as a questionnaire. The qualities assessed were color, texture, taste, flavor and general acceptability [38].

2.4 Statistical Analysis

All the analyses were conducted in duplicates in completely randomized design. The data were subjected to analysis of variance using Statistical Package for Social Science (SPSS) software version 15, 2007. Means averages that where significantly different were separated by the least significant difference (LSD) test. Significance was accepted at $p<0.05$.

3. RESULTS AND DISCUSSION

3.1 Functional Properties of Acha-Carrot Flour Blends

The results of functional properties are shown in Table 1. The water absorption capacity, oil absorption capacity, and swelling capacity increased from 2.32±0.19 – 3.24±0.08, 1.96±0.20 – 2.24±0.08, and 5.91±0.64 – 7.6±00.85 ml/g, respectively, with increase in added carrot flour(5-25%). Loosed bulk density, packed bulk density, emulsion activity, and foaming capacity decreased from 0.63±0.05 – 0.55±0.03 ml/g, 0.86±0.02 – 0.78±0.01 ml/g, 56.50±0.71 – 54.50±0.71%, and 6.83±0.82 – 3.33±1.27%, respectively. The 75:25% acha-carrot sample had the highest value for water absorption, oil absorption and swelling capacities and lowest value for bulk density, emulsion activity and foaming capacity. The effect are not significant different, $p>0.05$ for oil absorption capacity, swelling capacity, and emulsification. The results agreed with the reported values for starch foodstuff by Onuh and Abdulsalam [39]. Bulk density is significant in package design, storage and transport of foodstuff [40]. This revealed that bulk density depends on the particle size and moisture content of flours. The high bulk density of flour could suggest their suitability for use in food preparations. On contrast, low bulk density would be an advantage in the formulation of complementary foods [40].

Water absorption capacity defines the ability of a product to associate with water under conditions where water is limited [41]. The highest water absorption capacity of the 100:0% acha-carrot samples could be attributed to the presence of higher amount of carbohydrates (starch) and fibre in this flour. Water absorption capacity is a critical function of protein in various food products like soups, dough and baked products [42].

The water and oil binding capacity of protein depend upon the intrinsic factors like amino acid composition, protein conformation and surface polarity or hydrophobicity [41].

The ability of the proteins of these flours to bind with oil could makes it useful in food system where optimum oil absorption is desired. The acha-carrot composite flour could be said to have potential functional uses in foods such as sausage production. High oil absorption capacity could make flours suitable in facilitating enhancement in flavor and mouth feel when used in food preparation.

The acha-carrot (75:25%) sample had the highest swelling capacity (7.60±0.85ml/g). The swelling capacity of flours depends on size of particles, types of variety and types of processing methods or unit operations. Highest emulsion activity (56.50%) was observed in 95:5% acha-carrot sample. Difference in the emulsion activity of the flours may be related to their solubility exhibited by the lowest emulsifying activity and highest emulsion stability. Hydrophobicity of protein has been found to influence their emulsifying properties [43]. These properties are influenced by many factors among which are solubility, pH and concentration. The capacity of protein to enhance the formation and stabilization of emulsions is important for many applications in food products like cake, coffee whiteners and frozen desserts. In these products, varying emulsifying and stabilizing capacity are required because of their various compositions and processes [44].

The foam capacity (FC) decreased from 6.83±0.82 to 3.33±1.27. The effect was most significant, $p>0.05$ at 15% and above of added carrot powder. 100:0% acha-carrot sample obtained the highest foam capacity due to higher protein content. The foaming stability (Fig. 1) decreased with increase in time. Protein in the dispersion may cause a lowering of the surface tension at the water air interface, thus always been due to protein which forms a continuous cohesive film around the air bubbles in the foam [43].

3.2 Pasting Properties of Acha-Carrot Flour Blends

The results of the pasting properties are shown in Table 2. The peak viscosity, trough viscosity, breakdown, final viscosity, and setback decreased from 216.83±0.06 – 143.21±0.05, 142.17±0.04 – 105.46±0.02, 74.67±2.60 – 37.75±2.72, 351.58±0.09 – 207.71±0.07, and 209.42±0.06 102.25±0.05RVU, respectively. The effect of adding carrot powder are not significant, $p>0.05$. The 100:0% acha-carrot Sample had the highest values for all the properties. Pasting properties are dependent on the rigidity of starch granules, with consequent effect on the granule swelling potential and the amount of amylose leaching out in the solution [45]. The high content of starch in the 100:0% acha-carrot sample, compared to other samples may contribute to some extent, to the higher pasting viscosity observed, which could be the resultant effect of decrease in viscosities with decrease in the acha flour proportion.

High values of breakdown, associated with high peak viscosities could be related to the degree of swelling of the starch granules during heating. The peak viscosity often correlates with the quality of end-product and also provides an indication of the viscous load likely to be encountered by a mixing cooker [46]. The lower setback viscosities of acha starches could make the suitable for preparing gels with tendencies to synerese [21].

Pasting time of fonio grains reported by Jideani et al. [47] was significantly higher than that obtained in this study which could be due to climatic and soil factors. A higher pasting temperature indicates high water-binding capacity, higher gelatinization tendency and lower swelling property of starch-based flour due to high degree of associative forces between starch granules [44]. Pasting temperature is one of the properties which provide an indication of the minimum temperature required for sample cooking, energy costs involved and other components stability. Therefore, from the results obtained, 75:25% acha-carrot samples could be said to cook faster with less energy consumption, thereby saving time and cost.

3.3 Physical Properties of Acha-Carrot Blend Biscuits

The physical properties of the acha-carrot flour blend biscuits is shown in Fig. 2a&b. The spread ratio of the biscuits decreased from 8.08±0.15 – 7.64±0.21, while breaking strength increased from 0.5±0.00 – 3.0±0.00 kg. The 100:0% acha-carrot sample had the highest and lowest values for spread ratio (8.08±0.15) and breaking strength (0.5±0.00 kg), respectively. The effect of adding carrot powder are significant, $p>0.05$. Decrease in spread ratio could be due to the dilution effect of the carrot flour on the acha flour carbohydrate/protein, weaking the binding properties of the flour and the texture of the biscuits, which agreed with the findings of [48].

Okaka and Isieh [31] reported similar trend in biscuits for wheat and cowpea flours. A value of 70.5% was reported for all wheat flour biscuit which is much higher than the value obtained for all acha flour biscuits in this study. The difference may be due to the absence of gluten protein, responsible for visco-elastic behavior of wheat flour. Increase in break strength could be due to the strong binding force of the carrot fibre, diluting the protein and carbohydrate which are the principal compounds responsible for spread in biscuits [31]. Addition of carrot flour with relatively higher fiber content could have been responsible for the increase in the break strength of the biscuits with the 75:25%,acha-carrot having the highest break strength.

3.4 Proximate Composition of Acha-Carrot Flour Blend Biscuits

The proximate composition of the acha-carrot composite biscuit evaluated is presented in Table 3. The protein and carbohydrate content decreased from 8.35±0.03 – 7.90±0.04 and 70.67±0.39 – 68.74±0.39 %, respectively. The moisture content, crude fibre, fat and ash content increased from 5.33±0.10 – 6.39±0.01, 0.85±0.01 – 1.50±0.54, 13.80±0.33 – 14.24±0.06 and 1.85±0.00 – 2.73±0.01 % respectively. The effect of adding carrot to acha are significant, $p>0.05$. The 75:25% acha-carrot sample had the highest value for moisture (6.39±0.01%), ash (2.73±0.01%) and crude fibre (1.50±0.54%), while the 100:0% acha-carrot sample had the highest value for protein (8.35±0.03%) and carbohydrate (70.67±0.39%). The increase in moisture content could be due to the relative increase in the fibre content of the added carrot. Fibres have the ability of absorbing moisture.

The crude fibre increased with increase in added carrot powder. This could be due to the presence of high dietary fibre content in carrot vegetables [49]. Accurately measuring the fibre content of foods is critical to making a sound benefit claim, whether it is a nutient claim, structure-function claim, or health claim [50].

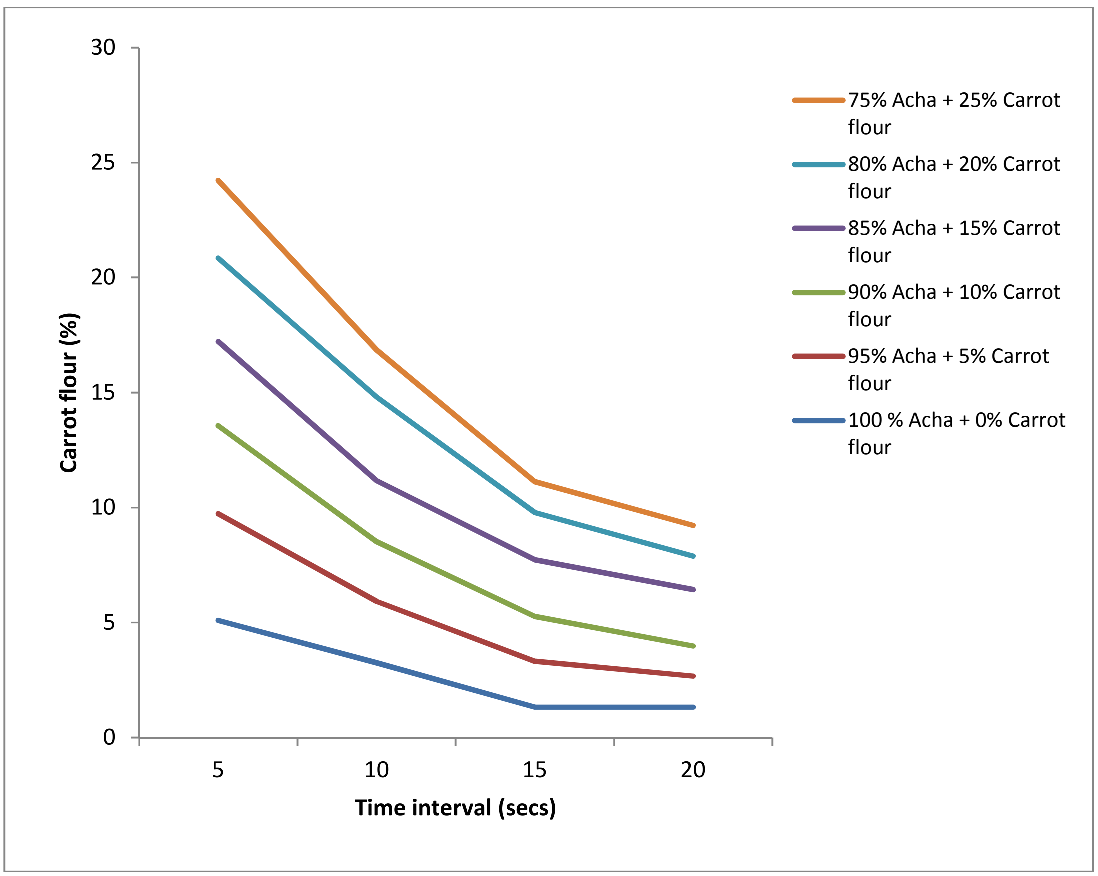

Fig. 1. Foaming stability (%) of acha-carrot flour blends

Table 1. Functional properties of acha-carrot flour blends

Acha flour (%)	Carrot powder (%)	LBD(g/cm^{3})	PBD(g/cm^{3})	WAC(ml/g)	OAC(ml/g)	SC(ml/g)	EA(%)	ES(%)	FC(%)
100	0	0.63^{a}±0.05	0.86^{a}±0.02	2.32^{d}±0.19	1.96^{a}±0.20	5.91^{a}±0.64	56.50^{a}±0.71	57.00^{a}±1.41	6.83^{a}±0.82
95	5	0.57^{ab}±0.01	0.85^{a}±0.03	2.40^{d}±0.00	2.10^{a}±0.01	6.50^{a}±0.71	56.00^{a}±0.00	56.50^{a}±0.71	6.75^{a}±0.81
90	10	0.57^{ab}±0.01	0.84^{ab}±0.01	2.55 ^{d}±0.13	2.14^{a}±0.06	6.77^{a}±0.83	56.00^{a}±1.41	56.00^{a}±1.41	6.06^{ab}±0.61
85	15	0.56^{b}±0.01	0.81^{abc}±0.04	2.82^{bc}±0.00	2.14^{a}±0.06	6.96^{a}±0.20	56.00^{a}±1.41	56.00^{a}±1.41	4.62^{bc}±0.20
80	20	0.55^{b}±0.01	0.79^{bc}±0.02	2.96 ^{b}±0.19	2.23^{a}±0.19	7.18^{a}±1.16	55.00^{a}±1.41	53.50^{a}±2.12	3.93^{c}±0.51
75	25	0.55^{b}±0.03	0.78^{c}±0.01	3.24^{a}±0.08	2.24^{a}±0.08	7.60^{a}±0.85	54.50^{a}±0.71	53.50^{a}±2.12	3.33^{c}±1.27

Values are mean ±standard deviation of 2 replicates. Means within each column not followed by the same superscript are significantly different (P>0.05) from each other using Duncan multiple range test. LBD=loosed bulk density, PBD=packed bulk density, WAC=water absorption capacity, OAC=oil absorption capacity, SC=swelling capacity, EA=emulsion activity, ES=emulsion stability, FC=foaming capacity

Table 2. Pasting properties of acha-carrot flour blends

Acha flour (%)	Carrot powder (%)	Peak1 (RVU)	Trough1 (RVU)	Breakdown(RVU)	Final viscosity (RVU)	Setback (RVU)	Peak time (mins)	Pasting temp(^{o}c)
100	0	216.83^{a}±0.06	142.17^{a}±0.04	74.67^{a}±2.60	351.58^{a}±0.09	209.42^{a}±0.06	5.27^{a}±0.00	94.05^{ab}±0.57
95	5	208.33^{a}±1.53	136.12^{b}±0.01	72.21^{a}±0.06	333.16^{b}±0.01	197.04^{b}±0.01	5.20^{a}±0.00	93.63 ^{b}±0.04
90	10	186.29^{b}±0.04	125.75^{c}±0.02	60.54^{b}±1.71	300.00^{c}±0.03	174.33^{c}±0.01	5.27^{a}±0.00	94.45^{b}±0.00
85	15	172.67^{c}±0.00	122.46^{c}±0.01	50.21^{c}±1.24	268.28^{d}±0.07	145.83^{d}±0.02	5.27^{a}±0.00	94.35^{a}±0.00
80	20	159.75^{d}±0.00	114.59^{d}±0.00	45.15^{d}±0.15	242.83^{e}±0.06	28.25^{e}±0.01	5.20^{a}±0.00	94.08^{a}±0.60
75	25	143.21^{e}±0.05	105.46^{e}±0.02	37.75^{e}±2.72	207.71^{f}±0.07	102.25^{f}±0.05	5.20^{a}±0.00	93.45^{b}±0.00

Values are mean± standard deviation of 2 replicates. Means within each column not followed by the same superscript are significantly different (P>0.05) from each other using Duncan multiple range test

Table 3. Proximate composition of acha-carrot flour blend biscuits(wet weight basis)

Acha flour (%)	Carrot powder (%)	Moisture content (%)	Crude protein (%)	Ash content (%)	Crude fibre (%)	Fat content (%)	Carbohydrate(%
100	0	5.33^{d} ±0.10	8.35^{a} ±0.03	1.85^{f} ±0.00	0.85^{c} ±0.01	13.80^{a} ±0.33	70.67 ^{a} ±0.39
95	5	5.74^{c} ±0.03	8.30^{a} ±0.05	1.93^{e} ±0.01	0.88^{b} ±0.02	13.90^{a} ±0.37	70.83 ^{a} ±0.05
90	10	5.77^{c} ±0.10	8.15^{a} ±0.01	2.18^{d} ±0.02	0.92^{b} ±0.03	14.00^{a} ±0.01	69.90 ^{a} ±0.26
85	15	6.17^{b} ±0.02	8.10^{a} ±0.01	2.32^{c} ±0.03	0.93^{b} ±0.01	14.10^{a} ±0.08	69.31^{b} ±0.12
80	20	6.27^{ab} ±0.04	7.95^{a} ±0.03	2.43^{b} ±0.00	1.03^{a} ±0.01	14.15^{a} ±0.25	69.20^{b} ±0.71
75	25	6.39^{a} ±0.01	7.90^{a} ±0.04	2.73^{a} ±0.01	1.50^{a} ±0.54	14.24^{a} ±0.06	68.74^{b} ±0.39

Values are mean ± standard deviation of 2 replicates. Means within each column not followed by the same superscript are significantly different (P>0.05) from each other using Duncan multiple range test

Table 4. Phytochemical composition of acha-carrot flour blend biscuits

Acha flour (%)	Carrot powder (%)	Carotenoids (ug/g)	Saponnins (mg/100g)	Flavonoids (mg/100 g)	Anthocyanins (mg/100g)
100	0	4.68 [f] ±0.04	0.05 [d] ±0.00	0.01 [e] ±0.00	0.05 [e] ±0.00
95	5	4.81 [e] ±0.04	0.06 [e] ±0.00	0.02 [c] ±0.00	0.06 [d] ±0.00
90	10	5.44 [d] ±0.03	0.08 [b] ±0.00	0.02 [d] ±0.00	0.06 [a] ±0.00
85	15	5.69 [c] ±0.01	0.08 [c] ±0.00	0.03 [a] ±0.00	0.08 [c] ±0.00
80	20	6.82 [b] ±0.03	0.10 [a] ±0.00	0.03 [a] ±0.00	0.07 [b] ±0.00
75	25	7.87 [a] ±0.05	0.12 [c] ±0.00	0.03 [b] ±0.00	0.08 [a] ±0.00

Values are mean± standard deviation of 2 replicates. Means within each column not followed by the same superscript are significantly different (P>0.05) from each other using Duncan multiple range test.

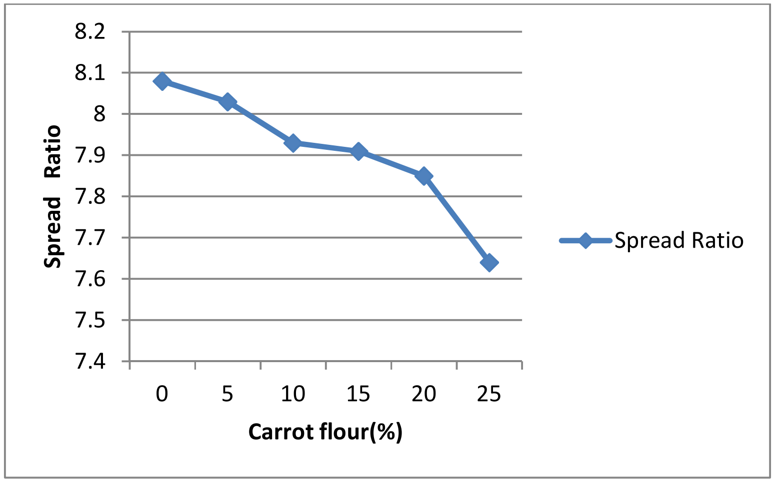

Fig. 2a. Physical properties (Spread ratio) of acha-carrot flour blend biscuits

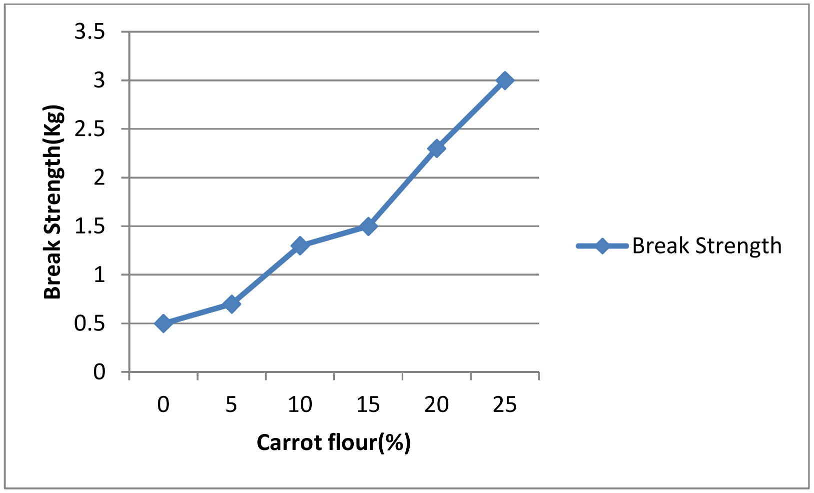

Fig. 2b. Physical properties (Break strength) of acha-carrot flour blend biscuits

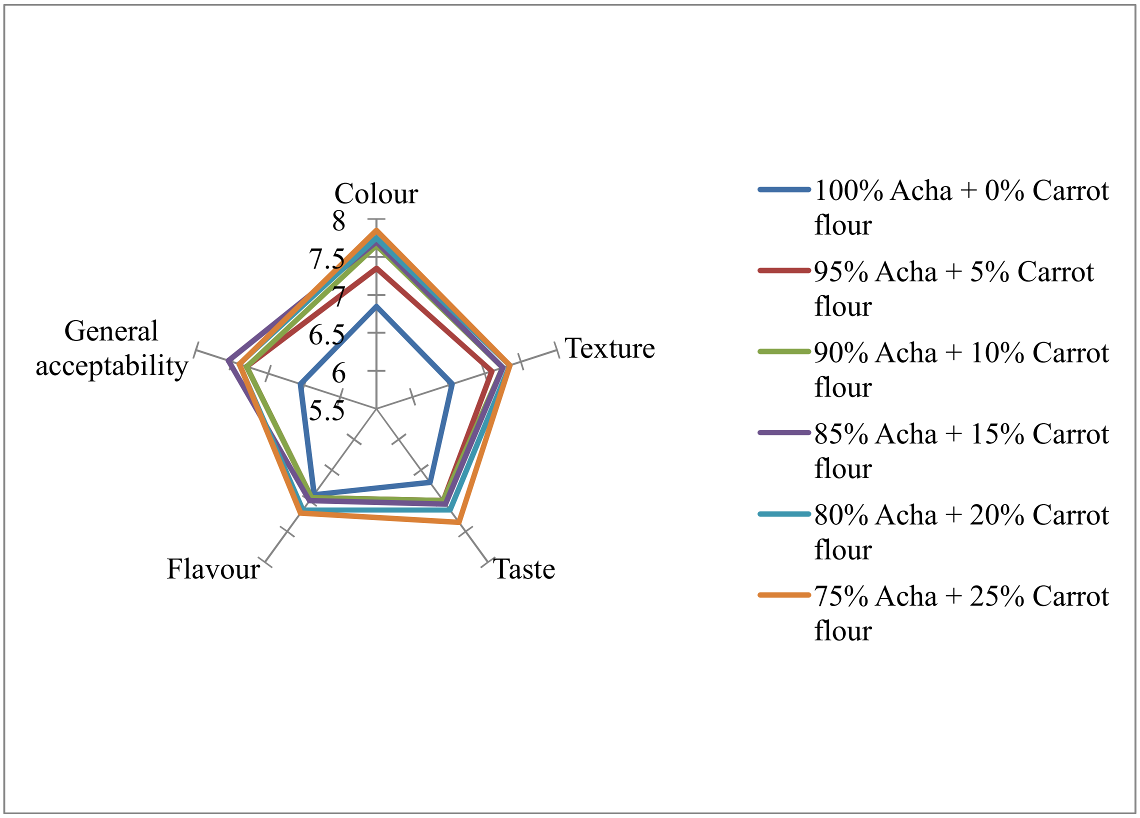

Fig. 3. Spider web graph showing the sensory qualities of acha-carrot flour blend biscuits

Ash content indicates the presence of mineral matter in food. Increase in ash content indicates that samples with high percentage of ash will be good sources of minerals. The carbohydrate decreased with increase in carrot powder addition. The results obtained in this study are within the ranges earlier reported for acha [51]. Olapade et al. [31] also reported a similar range for biscuits from acha and cowpea flour. The carbohydrate contents of these samples are an indication that the products are good sources of energy.

3.5 Phytochemical Composition of Acha-Carrot Flour Blend Biscuits

The result of the phytochemical composition is as shown in Table 4. The carotenoids, saponnins, flavonoids, and anthocyannins increased from 4.68±0.04 – 7.87±0.05, 0.05±0.00 – 0.12±0.00, 0.01±0.00 – 0.03±0.00, and 0.05±0.00 – 0.07±0.00 mg/100 g, respectively. The 75:25% acha carrot sample had the highest carotenoid content (7.87±0.05 ug/g). Increase in carotenoids could be due to the inherent carotenoid content of carrot. Olson and Kirisky [52] observed that the high levels of carotenoid on addition of carrot flour, and the predominant carotenoid present which is β-carotene constitutes 99% of the colour pigment in carrot, which could be the resultant effect of colour improvement of the biscuits. Carotiniod have been proved to improve the recovery of night blindness and loss of appetite [53], Saponins have beneficial effects on blood cholesterol level; reduce cancer risk, increase bone health, stimulation of the immune system and also an antioxidant [54]. Saponnins have hypolipidemic and anticancer activity, anti-oxidant and anti-mutagenic properties and are also necessary for activity of cardiac glycosides [55]. The effect was significant different at $p<0.05$. Flavonoids level in all samples ranged from 0.01 to 0.03 mg/100 g with an increase in the level of added carrot powder. Flavonoids are anti-oxidants, lower cholesterol, inhibit tumor formation, decrease tumor formation, decrease inflammation and protect against cancer, heart diseases, etc. [56]. Anthocyanins in the acha-carrot biscuits ranged from a value of 0.05 to 0.07 mg/100 g, with an increase in carrot powder.

3.6 Sensory Evaluation of Acha-Carrot Blend Biscuits

The sensory qualities evaluated are presented in Fig. 3. Colour, texture, taste, flavour, and general acceptability ranged from 6.85±1.18 − 7.85±0.93, 6.55±1.15 − 7.35±0.93, 6.70±1.38 – 7.35±1.09, 6.90±1.07 – 7.20±1.11 and 6.55±1.19 – 7.55±1.00, respectively. The effect of carrot was significant, $p>0.05$ for colour, texture and general acceptability. The significant effect on the colour could be due to the corresponding increase of the carotinoid as observed in the work. The relative increase in the average mean scores for texture could be due to the inherent fibre content of the carrot with consequent effect on the crispiness of the biscuit. The increase in the texture could be due to increase in the break strength of the products [57]. The values for taste and flavour of the biscuits were not significantly different from each other ($p>0.05$). Agu et al. [5] and Ayo et al. [58], reported a similar range for sensory qualities of acha biscuits. The samples were generally accepted up to 80:20% acha-carrot blends (with average mean score of 7.55±1.00) but the most preferred sample is 85:18%. This level of acceptance corresponds with an increase of 2.5, 9.4, 25.4, 21.6 and 20% of protein, crude fibre, ash content, carotenoids, and anthocyannins, respectively of the biscuit product.

4. CONCLUSION

The result of research work showed that the addition of carrot powder improved the quality of the carotenoids, anthocyanins, fibre and ash content. The 85:15% acha-carrot blend was the most preferred sample with a corresponding increment of 2.5, 9.4, 25.4, 21.6 and 20% of protein, crude fibre, ash content, carotenoids, and anthocyannins, respectively. The texture (crispiness) and colour of the biscuit were greatly improved.

Addition of carrot to acha could be said to have also added variety to diabetes meals and other individuals that are non-tolerant to gluten protein (people suffering from celiac disease).

ACKNOWLEDGEMENT

The authors expresses their gratitude to the Dept. of Food Science and Technology, Federal University Wukari. Nigeria, for allowing the use of their Processing laboratory, also Mr Omeagu Chizoba of University of Mkar, Nigeria for providing relevant information to enhance quality work.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Olaoye OA, Ondude AA, Oladoye CO. Breadfruit flour in biscuit making. African Journal of Food Science. 2007; 3:20-23.
2. Okeagu NJ. Extraction and comparision of two varieties of beniseed oil. A Project Submitted to the Department of Food Science and Technology; 2001.
3. Ayo JA, Haruna US, Yelmi B, Ayo VA, Onajaife F. Effect of improvers on the quality of Acha bread. Nigerian Food Journal. 2008;26(10):56-63.
4. Okoye JI, Nkwocha AC, Ogbonnaya AE. Production, proximate composition and consumer acceptability of biscuits from wheat soybean flour blends. Continental Journal of Food Science and Technology. 2008;2:6-13.
5. Agu HO, Ezeh GC, Jideani AI. Quality assessment of acha-based biscuit improved with. bambara nut and unripe plantain. African Journal of Food Science. 2014;8(5):278-289.
6. Ayo JA, Ayo VA, Popoola C, Omosebi M, Joseph M. Production and evaluation of malted soybean-acha composite flour bread and biscuits. African Journal of Food Science and Technology. 2014; 5(1):21-28.
7. Olapade AA, Akingbala JO, Oguntunde AO, Falade KO. Effect of processing method on the quality of cowpea (*Vigna unguiculata)* flour for akara preparation. Plant Food for Human Nutrition. 2003; 58:1-10.
8. Ayo JA, Adedeji OA, Ishayo G. Phytochemical composition and Functional properties of flour produced from two varieties of tigernuut FUW Trends in Science & Technology Journal. 2016a; 1(1):261-266.
9. Ayo JA, Kajo N. Effect of soybean hulls supplementation on the quality of acha based biscuits. American Journal of Food Nutrition. 2016b;6(2):49-56.
10. Ayo JA, Ikuomola DS and Esan YO. Effects of added defatted beniseed on the

quality of Acha-based biscuit. Continental Journal of Food Science and Technology. 2010;4:7-13.

11. Cruz JF, Fanio: A small grain with potential. LEISA Magazine. 2004;201:16-17.
12. Jideani VA, Podgorski SC. In-vitro starch digestibility and glycemic property of acha (*Digitaria exilis*) porridge. Cereal Foods World Supplementary. 2009;54:A48.
13. Ibrahim A. Hungry rice (Fanio): A neglected cereal crop. NAQAS Newsletter. 2001;4-5.
14. Aloba A. Effect of sesame seed flour on millet biscuit characteristics. Plant Food Human Nutrition. 2001;195-200.
15. Ayo JA, Nkama I, Ayo VA, Ibrahim A. Effect of acha and other local cereals on the feed intake, body weight, haematological and nutritional quality of Rabbit. Journal of Research in Bioscence. 2007;3(3):76-83.
16. Ayo JA, Andrew E. Effect of added Bambara groundnut on the quality of acha-date palm based biscuit Intern. Journal of Biotechnology and Food Science. 2016c; 493:34-38.
17. Krishan DS, Swati K, Narayan ST, Surekha A. Chemical composition, functional properties and processing of carrot, a review. Journal of Food Science and Technology. 2012;49(1):22-32.
18. Singh P, Raghuvanshi RS. Finger millet for food and nutritional security. Afr J. Food Sci. 2012;6(4):77-84.
19. Kaur M, Sharma HK, Bala J. Kinetic changes in quality attributes of stored carrot-pineapple blended juice. Indian Food Packer. 2012;66(5):32-43.
20. Lasekan DO. Chemical composition of acha (*Digitaria exilis*) flour. Journal of Food Science and Agriculture. 1994; 14:177-179.
21. Jideani IA, Akingbala JO. Some physiochemical properies of acha (*Digitaria exilis* Staph) and iburu (*Digitaria iburua* Staph) grains. Journal of Sciences and Food Agriculture. 1993;63:369-371.
22. Ayo JA, Nkama I. Effect of acha (*Digitaria exilis* Staph) grain flour on the physical and sensory quality of biscuit. Nutrition and Food Science. 2003;33(3):125-130.
23. Ayo JA, Nkama I. Effect of acha (*Digitaria exilis* Staph) grain flour on the physicochemical and sensory properties of bread. International Journal of Food Properties. 2004;7(3):561-569.
24. Ayo JA, Haruna US, Ayo VA, Oyegun TM. Effect of malted acha on the quality of biscuit. Internationl Journal of Food and Agricultural Research. 2008;5(1):196-205.
25. Jideani IA. *Digitaria exilis* (acha/fonio), *Digitaria iburua* (iburu/fonio) and *Eleusine coracana* (tamba/finger millet)-Non-conventional cereal grains with potentials. Scientific Research and Essays. 2012; 7(45):3834-3843.
26. Jideani IA, Jideani VA. Developments on the cereal grains *Digitaria exilis* (acha) and *Digitaria iburua* (iburu). J. Food Sci. Technol. 2011;48(3):251-259.
27. Mbaeyi-Nwaoha IE. Production and evaluation of breakfast cereals from blends of acha and fermented soybean paste (okara). J Food Sci Technol. 2016; 53(1):50-70.
DOI: 10.1007/s13197-015-2032-8
28. MiaoZhang N, Tai-Hua MU. Identification and characterization of antioxidant peptides from sweet potato protein hydrolysates by Alcalase under high hydrostatic pressure. Innoyative Food Science and Emerging Technologies. 2017;I(43):92-101.
29. Okaka JC. Cereal and legumes: Storage and processing technology. Ogui-Enugu Data and Micro Systems Publishers. 1997; 116-131.
30. Gomez M, Obliana AB, Martins DF, Madzavamuse M, Monyo ES. Manual laboratory procedures for quality evaluation of sorghum and pearl millet. Technical Manual No. 2 ICRISAT. India: Pantencheru. 1997;502:324.
31. Okaka JC, Isieh M. Development and quality evaluation of cowpea-wheat biscuit. Nigerian Food Journal. 1990;8:56-60.
32. AOAC. Official method of analysis of the AOAC, (W. Horwitc Ed.) 16th Edition. Washington D.C: Association of Offical Analytical Chemists; 2010.
33. Onwuka GI. Food analysis and instrumentation: Theory and practice. Nigeria: Naphathali Prints. 2005;95-96.
34. Olapade AA, Aworh OC, Oluwole OB. Quality attributes of biscuit from acha (*Digitaria exilis*) flour supplemented with cowpea (*Vigna Unguiculata*) flour. African Journal of Food Science and Technology. 2011;2:198-203.

35. Krishnaiah D, Devi T, Bono A, Sarbatly R. Studies on phytochemical constituents of six Malaysian medicinal plants. Journal of Medicinal Plant Resources. 2009;3(2):67-72.
36. Obadoni BO, Ochuko PO. Phytochemical studies and comparative efficacy of the crude extract of some homeostatic plants in Edo and Delta states of Nigeria. Global Journal of Pure Application Science. 2001; 8:203-208.
37. Bohm BA, Kocipal AR. Flavonoid and condensed tannins from the leaves of *Vaccinum raticulatia* and *Vaccinum caloyimum*. Journal of Pacific Science, 1994;48:458-463.
38. Akinjayeju O. Quality control for the industry: A statistical approach. Lagos: Concept Publications; 2009.
39. Onuh JO, Abdulsalam KO. Production and evaluation of the physiochemical properties of maize-Bambara groundnut "apula". Nigerian Food Journal. 2009; 27:83-92.
40. Akpata MI, Akubor PI. Chemical composition and selected functional properties of sweet Orange (*citrus sinensis*) seed flour. Plant Food Human Nutrition. 1999;54:353-362.
41. Singh KK, Samanta AK, Maity SB. Nutritional evaluation of stylo (*Stylosanthes hamata*) hay in goats. Indian J. Anim. Nutr. 2001;18(1):96-98.
42. Adeyeye EL, Aye PA. The effect of sample preparation on proximate composition and the functional properties of African yam bean flours. Notel La Rivista Italiana Della Sostanze Grasse. 1998;LXXV-Maggio. 253-261.
43. Kaushal P, Kumar V, Sharma HK. Comparative study of physico-chemical, functional, anti-nutritional and pasting properties of taro (*Colocasia esculenta*), rice (*oryza sativa*), pegeon pea (*cajanus cajan*) flour and their blends. LWT. Food Chemistry. 2012;91(3):403–411.
44. Adebowale AA, Sanni LO, Awonarin SO. Effect of texture modifiers on the physicochemical and sensory properties of dried fufu. Food Science and Technology International. 2005;11:373-382.
45. Morris VJ. Starch gelation and retrogradation. Trends in Food Science and Technology. 1990;1:2-6.
46. Sanaa Tel, El-Sayed M. Immobilization, optimization and stability of pepper (*Capsicum annuum*). Research Journal of Pharmaceutical, Biological and Chemical – Sciences, RJPBCS. 2004; 7(2):710-716.
47. Jideani IA, Takeda Y, Hizukuri S. Structures and physico-chemical properties of starches from Acha (*Digitaria exilis*), Iburu (*Digitaria iburua*), and Tamba (*Eleusine coracana*). Cereal Chemistry. 1996;73:677-685.
48. Oluwamukomi MO, Oluwalara IB,d Akinbowale OF. Physicochemical and sensory properties of wheat-cassava composite biscuit enriched with soyflour. African Journal of Food Science. 2001; 5(2):50-56.
49. Villanueva-Suárez AS, Redondo-Cuenca MJ, Rodríguez-Sevilla MD, de las Heras Martínez M. Characterization of nonstarch polysaccharides content from different edible organs of some vegetables, determined by GC and HPLC: comparative study. J. Agric. Food Chem. 2003;51(20):5950–5955.
50. Mermelstein NH. Analyzing for resistant starch. Journal of Food Technology. 2009; 63:80-84.
51. McWatters KH, Phillips RD, Walker SL, Mccullongh SE, Mensa-Wilmot Y, Saalia FK, Hung YC, Petterson SP. Baking performance and consumer acceptability of rew and extruded cowpea flour breads. Journal of Food Quality. 2004;27:337-351.
52. Olson JA, Krisky NI. The colorful, fascinating world of the carotenoids: Important physiological modulators. Federation of American Societies for Experimental Biology Journal. 1995; 9:1547-1550.
53. Food Fortification. Food Advisory consumer service; 2017.
Avaliable:http:foodfacts.org.za/food fortification
(Assessed on 27th November, 2017)
54. Sun AY, Wang Q, Simonyi A, Sun GY. Botanical phenolics and brain health. Neuromolecular Med. 2009;10:259–74.
55. Mattson MP, Cheng A. Neurohormetic phytochemicals: Low-dose toxins that induce adaptive neuronal stress responses. Trends in Neurosciences. 2006;29(11):632-639.
56. Adebowale AA, Sanni SA, Oladapo FO. Chemical, functional and sensory

properties of instant yam-Breadfruit flour. Nigerian Food Journal. 2008;26(1):2-12.

57. Onimawo IA, Akubor PI. Food chemistry (Integrated Approach with Biochemical background) (2nd ed.). Ibadan, Nigeria: Joytal Prints; 2012.

58. Ayo JA, Ojo MO, Popoola C, Chieshe E. Effects of pretreatments on the quality of Acha flour and acha flour based biscuit. Journal of Agriculture and Life Sciences, Fed. University Wukari. 2017;1(1):56-59.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history/23037