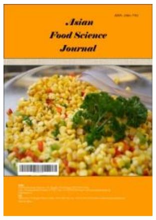

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Quality Evaluation of Sweet Potato - Acha Flour Blend Biscuits

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Authors' contributions

This work was carried out in collaboration between both authors. Author JAA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author EA managed the analyses of the study and managed the literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

The study investigates the chemical, physical and sensory properties of sweet potato and acha flour based biscuits. The work was aimed at ameliorating the quality of acha-based biscuit with addition of sweet potato flour. Flour blends were produced by substituting sweet potato into acha flour at 20, 40 and 60%. Proximate, physical and sensory properties of the biscuit were analyzed. The carbohydrate, moisture content, fat content, fibre and ash increased from 67.21 to 75.94, 5.69 to 6.74, 13.81 to14.87, 1.4 to 1.68, and 2.48 to 3.45 respectively with an increase in added sweet potato flour (20-60), while the protein decreased from 8.14 to 3.73. The relative decrease could be due to the low inherent protein of sweet potato. Magnesium, phosphorus and potassium increased from 220.33 to 375.22, 0.438 to 0.632 and 218 to 252.33mg/100g respectively with added sweet potato flour. There was an increase in break strength and spread ratio from 1.35 to 2.95 kg 4.80 to 5.13, respectively, with an increase in the level of sweet potato flour substitution. The reverse was observed for thickness and diameter of the biscuit which decreased from 0.70 to 0.60 and 4.28 to 4.13 cm, respectively. The average mean score of texture, colour, taste, flavour and general acceptability ranges from 6.05 to 7.65, 6.55 to 6.40, 5.55 to 6,25, 6.70 to 5.75 and 6.10 to 6.95,

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respectively. The sample 40:60 sweet potato-acha flour blend biscuit with average means scores of 6.95 was most preferred and acceptable with the corresponding increment of 3.45, 14.87, 8.14, and 1.68 of ash content, fat content, protein and crude fibre, respectively.

Keywords: Evaluation; quality; sweet potato; acha; 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 are 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 [2]. Nigeria is finding itself more and more caught up in the "wheat trap" where most of its foods are made from wheat (including biscuit and bread) a foreign cereal [3].

The inability of the country to meet the industrial demand of wheat had caused an 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 [4,5].

Most of the common local cereal grains including acha, though having similar structure and composition were left in a state of underdevelopment 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 [1,6,7,8,9].

Acha (*D. exilis*), though potentially rich in nutrients, has been classified among the lost crops [10] with its cultivation and processing at village technology level. The use of acha as substitute to wheat flour have been advantageous concerning 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].

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 [10]. It could be boiled like rice (acha joll of) and is also used in the form of "couscous" in some countries in West Africa [11]. 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 [10]. Acha does not contain any glutenin or gliadin proteins which are the constituents of gluten, making it suitable for people with gluten intolerance [12].

Sweet potato (*Iomea batatas* L), has the nutritional advantage for the rural and urban dwellers [13]. Laurie et al. [14] reported that sweet potato is an excellent source of energy. It also contains sugar, vitamin C, β-carotene, iron, and several other minerals [14,15]. Despite its high carbohydrate content, it has a low glycemic index due to low digestibility of the starch making it suitable for diabetic or overweighed people [16,17,18]. Oloo et al. [18] reported that sweet potato has higher protein content than other roots and tubers, such as cassava and yams. Maloney et al. [19] pointed out that potentially valuable proteins can be extracted from the peel during the processing of sweet potatoes. Sweet potato's tubers have anti-oxidant and anti-proliferative properties due to the presence of valuable nutritional and mineral component [10]. Also, some varieties of sweet potatoes contain colored pigments, such as β-carotene, anthocyanin, and phenolic compounds. These pigments form the basis for classifying the food as nutraceuticals [15].

Sweet potato can easily complement cereal-based diets [20,15]. Moreover, it is reported that sweet potato can be used for various products, such as drinks (wine, liquor, vinegar), sugar production, biscuit, flour, pasta, alcohol among others [16].

Poor research information on acha has resulted to its underutilization. Diabetic crises have been identified with increase in sucrose level therefore calling for alternative food material particularly locally available such as sweet potato. The high level of sweet potato production in Nigeria is still under-utilized.

The use of acha in the production of biscuits could reduce the importation of wheat and the cost of production. The acceptance of substituted sweet potato flour could reduce the diabetes crises of consumers and create a market for its underutilization. Added sweet potato flour could also improve the fibre and mineral content of the food product. The objective of this study was to evaluate the chemical composition, physical and sensory properties of the sweet potato-acha flour blend biscuits.

2. MATERIALS AND METHODS

2.1 Materials

Sweet potatoes (Ipomoea batatas) were purchased from Zaki-Biam central market, Benue State, Nigeria while acha grains (D. exilis) were purchased from Jos central market, Plateau State, Nigeria. Other ingredients such as baking fat (Simas), baking powder (Omega), and salt (Dangote table salt) were purchased from Zaki-Biam central market, Benue State, Nigeria.

2.2 Processing of Acha Flour

Acha grains were sorted manually, washed (using tap water), drained, sun-dried, milled (Attrition mill-model no. 0712098) and sieved (0.3 µm aperture size). The acha flour was packaged in polyethylene bag and stored at 5°C.

2.3 Sweet Potato Flour Production

Sweet potatos (*Ipomoea batatas*) were sorted manually to remove the damaged ones, (peeled using knives), washed (using potable water) and sliced into 2 mm thickness, blanched (using steam for 5 minutes), sun dried, milled (using Attrition mill) and sieved (0.3 µm aperture), packaged in polyethylene bags, and stored at room temperature until further analysis.

2.4 Production of Sweet Potato-acha Composite Flour

Sweet potato flour was substituted into *acha* 20, 40 and 60% and sweet potato-acha composite flour and other ingredients were added, while mixing at medium speed of Kenwood blender. The mixing was done properly and the method of Okaka [21] was followed to produce the biscuits.

2.5 Analytical Methods

2.5.1 Determination of proximate composition

Determination of moisture content: The moisture content was determined using the procedure described by AOAC [22]. The five grams of the sample was weighed into an aluminium moisture can. The sample was then dried to constant weight at 105±2°C. The moisture content was calculated as:

% Moisture content = (weight of can + sample)-(weight of empty can)/ Weight of sample x 100

Determination of crude protein content: The macro Kjeldhal method as described by the AOAC [22] method was used. Ten gram of the sample was weighed into a conical flask (250 ml), 0.8 g of the catalyst (potassium sulphate) was poured into the conical flask and 5 ml of sulphuric acid and three glass beads (anti bumps) were dropped inside the conical flask and swirled. The mixture was heated on the Kjeldhal apparatus for 2-3 hours at 100°C, until it turned bluish white.

The digest was allowed to cool in the air and diluted with 10 ml distilled water. This was distilled using Markham distillation apparatus where 100 ml conical flask containing 5 ml of boric and 2-3 drops of mixed indicator was attached. The 5 ml of the digest was introduced into the body of the apparatus and followed by 10 ml of 40-45% sodium hydroxide solution. The distillate collected as ammonium sulphate which was titrated against 0.1 M hydrochloric acid. A blank titration was carried out using distilled Water instead of the distilled. Percentage nitrogen was calculated.

Determination of crude fat content: Fat was extracted using Soxhlet extractor with hexane and quantified gravimetrically. One gram of sample was weighed into an extraction thimble and then put on hold with grease-free cotton. Before extraction commenced the round bottom cans was dried, cooled and weighed. The thimble was placed in the extraction chamber and 80 ml hexane was added to extract the fat. The extraction was carried out at 135°C for 1 hour 40 minutes after which the fat collected at the bottom of the cans cooled in a desiccators [22].

Determination of ash content: The ash content was determined by the AOAC [22] method. Two grams of the sample was weighed into a dried pre-weighed porcelain crucible. The sample was transferred into a preheated muffle furnace (carbolite Bamford S30 2AU) and heated at 550°C for 2 h. The ash was removed and cooled in a desiccators and weighed.

Determination of crude fibre content: Crude fibre was determined using the method described by the AOAC [22] method. 2 g of the samples were weighted into 500 ml beaker and in 200 ml (WI t) 1 & 30 minutes. 11 weight suspension was filtered using a white filter pipa and rinsed with hot water to obtain filtrate. The residue obtained was transferred into a crucible and placed in an oven for 40 other 30 minutes. The dried residue was cooled in a desiccators and weighed. Percentage crude fibre was calculated using the formula:

Determination of carbohydrates content: Carbohydrate was calculated by difference as described by AOAC [22]. %Carbohydrate=100 - (%Moisture + %Fat + %Protein + %Ash + % Cruder fibre.

2.5.2 Determination of mineral composition

Determination of potassium: The Potassium content in the sample was determined by flame photometry method using an instrument called flame photometer as described by AOAC [22]. The instrument was set up according to the manufactures' instruction. The equipment was switched on and allowed to stay for 10 minutes. The gas and air lets were opened as the knob was turned on. The equipment being self-igniting and the flame was adjusted to a non-luminous level (that is blue colour). The concentration of the test mineral in the sample was calculated with reference to the graph and obtained by galvanometric reading.

Determination of Magnesium: Magnesium (Mg) contents of the sample was determined by the Versanale Ethylene diamine tetraacetic acid (EDTA) complexometric titration method as described by AOAC [22]. 20 ml of distilled water was mixed with 5 g of the sample and was dispersed into a conical flask. Pinches of the masking agent's hydroxyl tannin, hydrochlorate and potassium cyanide were added and 20 ml ammonia indicator, Erichrome black T. The mixture was shaken very well and titrated against 0.02N EDTA solution. The titration changed from mauve colour to a permanent blue colouration. A reagent blank consisting of 20 ml distilled water was also treated as described above. The titration gave a reading from combined calcium and magnesium complexes in sample. A separate titration was then conducted for calcium alone. Titration for calcium alone was a repeat of the previous one with slight change. 10% NaOH solution at pH 12.0 was used in placed of the ammonia buffer while solechiome dark blue (calcon) was used as an indicator in place of Erichrome black. Calcium and Magnesium contents were calculated.

Determination of Phosphorus: Phosphorus in the sample was determined by the vanado molybdate (yellow) spectrometry as described by AOAC [22]. The sample was dispensed into a test tube. Similarly, the same volumes of standard phosphorus solution, as well as water, were put into another test tube to serve as standard blank respectively. The content of each tube was mixed with equal volume of the vanadomohbdate colour reagent. They were left to stand for 15 minutes at room temperature (28°C) before their absorbance was measured in Jenway electronic spectrophotometer at a wavelength of 420 nm. Measurement was given with the blank at zero.

2.5.3 Determination of physical properties

Spread ratio determination: Spread ratio of sweet potato-acha composite biscuit was determined using the method described by Gomez et al. [23]. 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 sweet potato-acha composite biscuit was determined using the method described by Okaka and Isieh, [24]. Biscuit sample of 0.4 cm thickness was placed centrally between two parallel metal bars 2 cm 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.

Determination of Thickness and Diameter of Biscuits: According to method of Gomez et al. [23]. Two rows of five well-formed biscuits were made and the height was measured. They were also arranged horizontally edge to edge and the sum of the diameter was measured.

2.5.4 Sensory evaluation

Sensory quality characteristics of the sweet potato-acha blend biscuit such as colour, taste, texture, flavour, crispiness as well as overall acceptability were evaluated using a 20 member semi-trained panel, made up of staff and students of the Federal University Wukari. A 9-point hedonic scale system such as like extremely, like very much, like moderately, like slightly, neither like nor dislike, dislike slightly, dislike moderately, dislike very much and dislike extremely as carried out by Nguyen [25].

2.6 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. Means 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 Proximate Composition of Sweet Potato-acha Blend Biscuit

The result of the proximate composition of sweet potato-acha blend biscuit is presented in Table 1. The moisture, ash, fat, protein fibre and carbohydrates increase from 4.59-6.74, 2.46-3.45, 8.48-14.87, 3.73-8.14, 1.49-1.68 and 67.-75, respectively. The increase in the moisture content could be due to the high water-binding capacity of sweet potato which retained higher moisture content in ultimate products. Kalpana [24] reported a similar range for wheat-sweet potato biscuit.

The ash content of the biscuit samples increased significantly due to the high ash content of the sweet potato. The finding agreed with that of Van Hal [26]. The result revealed that biscuit produced from ratio 40:60% sweet potato-acha has the lowest protein content, with the amount of protein decreasing as the quantity of sweet potato flour increases. The relative decrease in the protein percentage could be due to the low inherent protein content of sweet potato added as observed by works of Morgan [27]. The highest value of crude fibre was seen in biscuit produced from ratio 40:60% sweet potato-acha flour. The effect of adding sweet potato flour to acha is significant, $p>0.05$.

The increase in moisture content could be due to the relative increase in the fibre content of the added sweet potato as it is hygroscopic. Fibres have the ability of absorbing moisture. The crude fibre increases with an increase in added sweet potato flour [28]. Accurately measuring the fibre contents of foods is critical to making a sound benefit claim, whether it is a nutrient claim, structure-function claim, or health claim [29].

Table 1. Proximate composition of sweet potato acha-blend biscuit

Acha flour	SP flour	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Fibre (%)	Carbohydrate (%)
100	0	4.59^d±.006	2.46^d±.003	8.48^d±.008	8.14^a±.008	1.49^d±.003	67.21^e±.002
80	20	5.69^c±.003	2.48^c±.005	13.81^b±.005	7.01^b±.004	1.54^c±.009	68.75^d±.021
60	40	6.25^b±.011	2.63^b±.006	13.82^b±.009	6.35^c±.006	1.58^b±.002	71.19^c±.034
40	60	6.74^a±.006	3.45^a±.004	14.87^a±.005	3.73^e±.010	1.68^a±.002	75.94^b±.013
WHE		4.56^e±.007	1.68^e±.007	9.84^c±.005	5.69^d±.003	1.24^e±.005	76.96^a±.022

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

Table 2. Mineral composition of sweet potato-acha blend biscuit

Mineral	Samples				
(mg/100 g)	A (100:0)	B (80:20)	C (60:40)	D (40:60)	E (100 wheat)
Magnesium	220.19^e±.007	250.18^d±.004	290.21^c±.004	375.22^a±.004	327.84^b±.005
Phosphorus	$.438^e$±.002	$.476^d$±.009	$.583^c$±.009	$.648^a$±.006	$.632^b$±.003
Potassium	218.82^e±.005	221.38^d±.003	245.63^c±.003	252.33^a±.007	247.92^b±.008

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

Ash content of food could indicate the level of mineral matter in food. Increase in ash content indicates that samples with a high percentage of ash will be a good source of minerals. The carbohydrate decreased with increase in sweet potato flour addition. The results obtained in this study are within the ranges biscuit supplemented with sweet potato flour [30]. Laurie et al. [14] reported that sweet potato is an excellent source of energy.

3.2 Mineral Composition of Sweet Potato-acha Blend Biscuit

The result of the mineral composition of sweet potato-acha blend biscuit is presented in Table 1. The magnesium, phosphorus and potassium content of the sweet potato-acha blend biscuit increased from 250.18 to 290.21, 0.476 to 0.583 and 218.82 to 245.63, respectively with an increase in the addition of sweet potato flour. The effect of adding sweet potato flour is significant (p>0.05). The 80:20% sweet potato-acha blend biscuit sample had the highest values for magnesium, phosphorus and potassium. High amount of potassium in the body was reported to increase iron utilization and beneficial to people taking diuretics to control hypertension [31,32]. Phosphorus is very important mineral salt for human health. According to Andzouana and Mombouli, [33], phosphorus in conjunction with calcium, contribute to strengthening the bones and teeth especially in children and lactating mothers. In view of the result obtained, sweet potato is considered as a good source of magnesium which is necessary for the biochemical reactions of the body, to maintain the muscle and improve the functioning of the nerve. The finding agreed with that of Ukom et al. [34] and Ingabire et al., [35]. Sweet potato's tubers have anti-oxidant and anti-proliferative properties due to the presence of valuable nutritional and mineral component [36].

3.3 Physical Properties of Sweet Potato-acha Blend Biscuit

The result of the physical properties of sweet potato-acha blend biscuit is shown in Table 3. There was an increase in break strength and spread ratio from 0.45 to 2.35 kg and 4.84 to 5.13 kg, respectively, as a result of the increase in the level of sweet potato flour substitution. The reverse was observed for thickness and diameter which decreased from 0.70 to 0.06cm and 4.28 to 4.13 cm, respectively. The 40:60% sweet potato-acha blend biscuit sample had the highest breaking strength and spread ratio with the lowest values in thickness and diameter. The effect of adding sweet potato flour is significant, p>0.05 for diameter and break strength. The increase spread ratio observed in sweet potato flour substituted biscuit samples could be due to the difference in particle size characteristics of the constituent flour of sweet potato and acha [37]. Olapade et al. [7] reported a similar trend in biscuit from acha flour supplemented with cowpea flour. The spread ratio could be an indicator of biscuit quality. The physical properties of the flour blend biscuit compared favourably with that of the 100% wheat biscuit.

Table 3. Physical properties of sweet potato-acha blend biscuit

Acha flour	SP flour	Thickness (cm)	Diameter	Break strength (kg)	Spread ratio
100	0	$0.70^a \pm 0.00$	$4.28^a \pm 0.04$	$1.35^e \pm 0.05$	$4.80^b \pm 0.03$
80	20	$0.79^a \pm 0.08$	$4.25^a \pm 0.03$	$1.95^d \pm 0.05$	$4.84^b \pm 0.06$
60	40	$0.73^a \pm 0.05$	$4.19^b \pm 0.02$	$2.29^c \pm 0.05$	$4.97^b \pm 0.04$
40	60	$0.60^b \pm 0.00$	$4.13^b \pm 0.04$	$2.64^b \pm 0.05$	$5.13^a \pm 0.01$
WHE		$0.65^b \pm 0.05$	$4.23^a \pm 0.01$	$2.95^a \pm 0.05$	$4.82^b \pm 0.03$

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

Table 4. Sensory qualities of sweet potato-acha blend biscuit

Acha flour	SP flour	Texture	Colour	Taste	Flavour	General acceptability
100	0	$6.00^c \pm 0.308$	$7.75^a \pm 0.190$	$5.55^c \pm 0.328$	$5.75^b \pm 0.40$	$6.10^b \pm 0.390$
80	20	$6.05^c \pm 0.328$	$6.55^b \pm 0.211$	$6.10^c \pm 0.34$	$6.10^b \pm 0.324$	$6.20^b \pm 0.287$
60	40	$6.75^{bc} \pm 0.298$	$6.50^b \pm 0.344$	$6.25^{bc} \pm 0.3390$	$6.70^{ab} \pm 0.317$	$6.95^{ab} \pm 0.336$
40	60	$7.65^{ab} \pm 0.182$	$6.40^b \pm 0.336$	$7.35^{ab} \pm 0.209$	$6.90^{ab} \pm 0.4223$	$7.50^a \pm 0.267$
WHE		$7.85^a \pm 0.244$	$8.00^a \pm 0.192$	$7.70^a \pm 0.231$	$7.50^a \pm 0.185$	$8.00^a \pm 0.178$

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

3.4 Sensory Evaluation of Sweet Potato-acha Blend Biscuits

The average mean score of the sensory qualities evaluated are presented in Table 4. The average mean score for texture, colour, taste, flavour, and general acceptability range from 6.05-7.85, 6.50 - 8.00, 6.25-7.35, 5.75-6.90, and 6.95-7.50, respectively. The effect of added sweet potato was significant, p>0.05. The relative increase in the average mean scores for texture from sample 80:20% sweet potato-acha blend biscuit could be due to the increased fibre content of sweet potato. The value for flavour was not significantly different (p<0.05) from each other. The sample 40:60% acha-sweet patato blend is the most preferred and acceptable with average score mean of 6.95. This effect on the sensory could be due to inherent flavour compounds in sweet potato. Nguyen [25] reported a similar range for sensory qualities of wheat-sweet potato biscuits and Srivastava et al. [38], reported a similar range for sensory qualities of biscuits from sweet potato. Generally, all the sweet potato-acha flour blend biscuits were acceptable and compared favourably to that of the 100% wheat biscuit.

4. CONCLUSION

The sweet potato-acha flour blend biscuit was found to be nutritionally superior in fat content, fibre, protein, magnesium and potassium when compared to acha flour. The sample with 60% sweet potato was the most preferred corresponding relatively high improvement in the ash, fat, fibre, protein, magnesium and potassium content of the acha based biscuit. The appearance and crispiness of the sweet potato-acha blend biscuit were greatly improved and acceptable.

The use of sweet potato-acha flour blends in biscuit will go a long way in enhancing nutrition, health and wellbeing of consumers and reduce the dependence on wheat flour. The properties of sweet potato-acha also make it a good potential for edible blend and as raw materials for several domestic and industrial purposes and in the medical sector. Acha could also be recommended as a dietary supplement for diabetic patients due to its high fibre content.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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