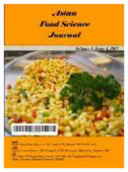

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Production and Quality Evaluation of Acha-tigernut Composite Flour and Biscuits

J. A. Ayo[1,2*], M. O. Ojo[2], C. A. Popoola[1], V. A. Ayo[1] and A. Okpasu[1]

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

Authors' contributions

This work was carried out in collaboration between all authors. Author JAA designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors MOO and AO managed the analyses of the study. Authors VAA and CAP managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The research is aimed at adding value to acha based biscuits using less known and underutilized crops such as tigernuts. The objective of the study was to add value to acha based biscuits Tiger(brown) seeds were sorted, washed and oven dried(45^{0}C for 12hrs), milled(Attrition Mill) and sieved.Acha grains were washed, destoned, dried(45^{0}C), milled and sieved. The tigernut flour was substituted at 2, 4, 6, 8 and 10% into acha flour to produce tigernut-acha composite flour and 100% acha as the control sample, used for production of biscuits with the addition of other ingredients (baking fat, baking powder, salt and water). Powdered date palm was used instead of sucrose (sugar). Functional and pasting properties of the composite flour and chemical, physical and sensory properties of composite biscuits were determined. Bulk density, oil absorption capacity, swelling power, swelling index, and foaming capacity increased from 0.772 to 0.91, 0.64 to 0.68, 235 to 370%, 3 to 9, 5.56 to 10.53 and 5.566 to 10.105, respectively with an increase in

**Corresponding author: Email: jeromeayo@yahoo.com, jeromeayo@gmail.com;*

the added tigernut flour. Peak, tough. Break down, final viscosity and set back values decreased from 1322 to-925, 1049 to 803,270 to 122, 2677 to 2158 and 1628 to 1356RVA, respectively, with an increase in the added tigernut flour. The spread ratio and break strength increased (5.2-5.9) and decreased (0.515 to 0.315kg), respectively with an increase in the added tigernut flour. The protein, ash, moisture and carbohydrate contents of the composite biscuits decreased from 6.04 to 5.22, 2.12 to 1.96, 9.42 to 8.81 and 68.84 to 66.46% respectively, while the fat, crude fibre and energy content increased from 13.58 to -17.57, 2.06 to 4.01% and 421.72 to 444.77cal/g, respectively, with increase in added tigernut flour. The average means scores for taste, aroma, colour, and general acceptability decreased, while an increase were observed for other assessed attributes. Addition of tigernut flour improved the fibre, fat and energy content as well as the crispness and texture of acha-tigernut- biscuit .

Keywords: Tigernut-acha composite flour; biscuits.

1. INTRODUCTION

The search for lesser known and underutilized crops, many of which are potentially valuable as human and animal food has been intensified to maintain a balance between population growth and agricultural productivity, particularly in the tropical and sub-tropical areas of the world. The worsening food crisis and the consequent widespread prevalence of malnutrition in developing and underdeveloped countries have resulted in high mortality and morbidity rates, especially among infants and children in low income groups [1].

The 'wheat trap', a general phenomenon in which most food products are principally made from wheat is one major constraint in biscuit production. This has greatly increased the unit cost of biscuits. The low production of high-quality wheat flour in Nigeria and the banning of importation of same by the Nigerian Government have called for research into alternative local sources of flour baking e.g. cassava, acha, millet, sorghum etc. [2]

Acha, one of the cereals belongs to the family *Graminae* and the sub – family *Poaceae* [3]. Acha (*Digitaria exilis*) originated in West Africa. The plant acha, belongs to the monocotyledonous family the graminae family. As an annual grass, it is about 45cm height with tiny, slightly elongated, yellow grains. It grows on poor sandy soil, which often will not support the growth of some of the more popular cereals [4]. It is an important crop in Southern Mali, Western Burkina Faso, Eastern Senegal North East Nigeria and Southern Niger [5,6]. D. exilis is commonly called acha, hungry rice or fonio [7,8,9]. It was adopted by growers as a marginal grain and forage crop due to its tolerance to soil stress and seasonal droughts [3,6].

Digitaria is a large genus and includes two cultivated West African species, which include *Digitari exilis* and *Digitaria Ibura*, the former being very close to the Wild West African specie *Digitaria Longiflora* [10]. White fonio is the most widely used and can be found in farmer field from Senegal to Chad. It is grown particularly on the upland plateau of Central Nigeria as well as neighbouring regions, which include Togo and Benin Republic [11].

Acha is considered as one of the nutritious of all grains; its seeds contain 8.79% protein and may be up to 11.89% in some black fonio sample [12,7,4]. The grains are rich in amino acids; leucine (9.8%), methionine (5.6%) and valine (5.8%) [12] and cysteine which are vital to human health but deficient in today's major cereals [11]. Acha grains contain substantial minerals (mostly iron, calcium and phosphorus) about 5% dry matter. The grains are commonly used in the production of local foods('Caoscaus', 'gwate' or 'Tuwo') in some countries in West Africa [4], and could be mixed with other cereal flours to make cookies, as candy and fermented beverages [3,13,14]. Acha grain could be a substitute for semovita and other wheat products such as spaghetti and other pastas [11,6].

Tigernut (*Cyperus esculentus*) is an underutilized sedge of the family *Cyperaceae* which produces rhizomes from the base and tubers that are somewhat spherical [15]. The plant is not really a nut but a tuber first discovered some 4000 years ago [16]. It has other names like yellow nutsedge, chufa, flatsedge, rush nut, water grass, earth almond, and Northern nut grass [16]. It is known in Nigeria as *aya* in Hausa, *ofio* in Yoruba and *akihausa* in Igbo [17].

Cyperus esculentus was reported as healthy and helps in preventing heart attack, thrombosis and activates blood circulation. It helps in reducing the risk colon cancer, due to the high content of soluble glucose [18]. The nut is rich in energy content (starch, fat, sugars and protein), mineral (phosphorus, potassium) and vitamins E and C [18]. *Cyperus esculentus* is suitable for diabetic persons and also helps in checking weight [19]. Tigernut contain fairly high content of fibre and arginine(2-Amino-5-guanidinopentanoic Acid) a precursor of nitric oxide which causes blood vessels to open wider for improved blood flow, liberation of the hormones that produce the insulin that could help in immediate decomposition of sugar in the system, hence making it a good meal for diabetes [20] and prevention and treatment of many including colon cancer, coronary heart diseases, obesity, diabetic patient and gastrointestinal disorders [21].

Tigernut flour could be a good alternative to many other flours like wheat flour, as it is gluten free and good for people who cannot take gluten in their diets. It is also used in the confectionery industry [18]. It is considered a good flour or additive for the bakery industry, since its natural sugar content is fairly high, avoiding the necessity of adding too much extra sugar [20].

The research is aimed at adding value to acha based biscuits.

2. MATERIALS AND METHODS

2.1 Preparation of Materials

Tigernut seed used (brown) was obtained from a local market in Wukari, Taraba State, while acha grain(cream coloured) was purchased from Jos Central Market, Jos, Nigeria. The acha grain was washed using bowls to remove stones, adhering dust and destoned using local calabash by sedimentation. The grain was sun-dried, milled (attrition mill), sieved (45 µm mesh size) to produce acha flour, hermetically packed (using polyethene bag) and stored at 6ºC. The tigernuts were cleaned, sorted, washed, drained, dried in an oven and grounded into flour. The flour samples were passed through a 45 µm mesh size sieve and stored at 4ºC until required for use. Date palm was purchased from Wukari Old Market, Wuakari. The seeds were removed, dried (45ºC for 12hrs), milled, sieved and packed in polyethylene bag.

2.2 Production of Tigernut-acha Composite Flour

The tigernut flour was substituted (2, 4, 6, 8, 10%) into acha flour and mixed using kenwood blender to produce acha-tigernut composite flour.

2.3 Production of Biscuits

The recipe (Table 1) was used. The Oyewole et al. [22,9] method of biscuit production was slightly modified and adopted (Fig. 1). The date palm flour was beaten into fat using a Kenwood mixer at medium speed until it becomes fluffy. The acha-tigernut composite flour, baking powder and salt with liquid milk were slowly added into the fluffy date palm-fat mixture and mixed until a uniform smooth paste was obtained. The paste was rolled on a flat oiled rolling board forming a uniform thickness of 0.4 cm using a wooden rolling pin. Circular biscuits of 4.0 cm diameter were cut (using a biscuit-cutter), placed on a greased baking tray and baked at 160°C for 15 min (BCH- Rotary oven, Great Britain). The biscuit was allowed to cool down (to about 32°C) and hermetically sealed in polyethylene bag.

Table 1. Reciepe of tigernut-date palm-acha composite biscuits

Material	Samples					
	A	B	C	D	E	F
Acha flour (%)	100	98	96	94	92	90
Tigernut flour (%)	0	2	4	6	8	10
Date palm flour (%)	30	30	30	30	30	30
Baking fat (%)	50	50	50	50	50	50
Baking powder (%)	1.5	1.5	1.5	1.5	1.5	1.5
Salt (%)	1.5	1.5	1.5	1.5	1.5	1.5
Water(ml)	10	10	10	10	10	10

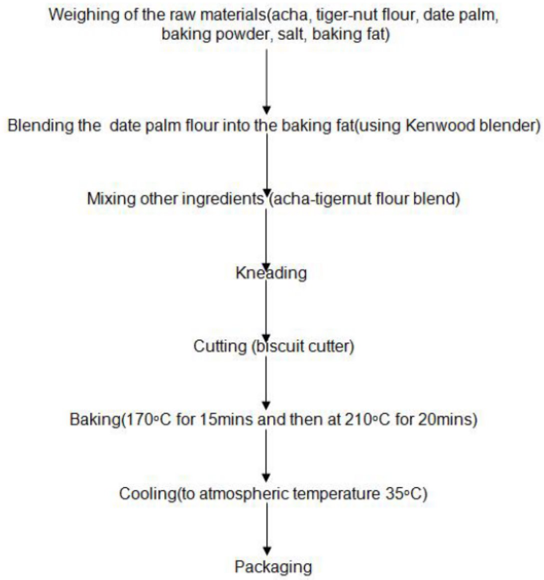

Fig. 1. Production of Acha-tigernut biscuits (modified Oyewole et al. [22,9] method)

2.4 Determination of Functional Properties of Acha-tigernut Composite Flour

2.4.1 Water and oil absorption capacities

Water and oil absorption capacities of the flour samples were determined by Beuchat [23,24] methods. One gram of the flour was mixed with 10 ml of water/oil in a centrifuge tube and allowed to stand at room temperature ($30 \pm 2^{\circ}$C) for 1 h. It was then centrifuged at 200 x g for 30 min. The volume of water or oil on the sediment water measured. Water and oil absorption capacities were calculated as ml of water or oil absorbed per gram of flour.

2.4.2 Foam capacity and foam stability

The method described by Narayana and Narasinga [25] was used for the determination of foam capacity (FC) and foam stability (FS). Two grams of flour sample was added to 50 ml distilled water at $30 \pm 2^{\circ}$C in a 100 ml measuring cylinder. The suspension was mixed using glass rod and properly shaken to foam and the volume of the foam after 30 s was recorded. The FC was expressed as a percentage increase in volume.

2.4.3 Bulk density

A 50 g flour sample was put into a 100 ml measuring cylinder. The cylinder was tapped continuously until a constant volume was obtained. The bulk density (g cm-3) was calculated as weight of flour (g) divided by flour volume (cm^3) [26].

2.4.4 Swelling capacity

This was determined by the method described by Narayana and Narasinga [25] with modification for small samples. One gram of the flour sample was mixed with 10 ml distilled water in a centrifuge tube and heated at 80ºC for 30 min. This was continually shaken during the heating period. After heating, the suspension was centrifuged at 10,000 rpm, decanted and the paste weighed. The swelling power was calculated as indicated below. : swelling power = weight of the paste/weight of dry flour.

2.4.5 Pasting property

The pasting properties were determined using Rapid Visco Analyser (RVA) [27]. 3.5 g of the flour sample was weighed and dispensed into the test canister,25 ml of distilled water was added, mixed thoroughly and was analysed using the RVA using the manufacturer recommended parameters.

2.5 Analysis of Biscuit

2.5.1 Physical

The weight and the diameter of the baked biscuit were determined using weighing balance (Santual electronic weighing balance) and measurement with a calibrated ruler, respectively. The spread ratio was determined using the method of Gomez et al. [28]. A column of five well-formed biscuits were made and the height was measured. Also the same was arranged horizontally edge to edge and the sum diameter was measured. The spread ratio was calculated as diameter/height.

The break strength of the biscuit was determined using the method of Okaka and Isieh [29]. Biscuit of known thickness (0.4 cm) was placed between two parallel wooden bars (3 cm apart). Weights were added on the biscuit until the biscuit snapped. The least weight that caused the breaking of the biscuit was regarded as the break strength of the biscuit.

2.5.2 Chemical properties

The moisture content (hot air oven method), fat (soxhlet extraction method), ash, and protein were determined using the methods of AOAC [30]. The carbohydrate content was determined by simple difference while calorie value was estimated using Atwater factors by multiplying the proportion of protein, fat, and carbohydrate by their respective physiological fuel values of 4,9 and 4 kcal/g, respectively, and taking the sum of the products [31].

2.5.3 Organoleptic properties

The sensory evaluation of the samples was carried out for consumer acceptance and preference using 20 randomly selected untrained judges (students and staff of the Department of Food Science and Technology, Federal University Wukari Nigeria). Nine points Hedonic scale (1 and 9 representing " extremely dislike" and " extremely like", respectively was used for the preference test. Qualities assessed include colour (crust and crumb), odour, taste, texture (crumb and crust) and general acceptance. Coded samples of the same size and temperature (30°C) were served in a coloured (white) plate of the same size to judges in each panel cupboard under the fluorescent light; only one sensory attribute was tested at one sitting. Unless otherwise maintained all the measurement were made in triplicate and the values represented the average of the three measurements.

2.6 Statistical Analysis

All data obtained from various analyses were subjected to Analysis of Variance (ANOVA) using Statistical Package for Social Sciences (SPSS) version 16.0. Means were separated with Duncan Multiple Range Test (DMRT) at 95% confidence level (p=0.05).

3. RESULTS AND DISCUSSION

3.1 Functional Property of Tigernut–acha composite Flour

The effect of the added tigernut flour on the functional property of tigernut-acha composite flour is shown in Table 2. The bulk density and water absorption capacity decreased from 0.475±00 to 0.433±00 g/100 g and 1.06±.03 to 0.98±00 g/cm3, respectively with an increase in the added tigernut flour. The decrease in the bulk density with added tigernut flour which could be related to its high fibre content could reduce the heaviness of the composite flour and that of the products and consequently the transportation costs and post handling of the same. The loose density, oil absorption capacity, swelling power, swelling index and foaming capacity increased from 0.722±.01 -0.791±.00, 0.64±.06 – 0.68±.00, 235.33± 2.52 – 271.60±.00%, 3±.00 – 9.33±.58, and 5.566±.3 – 10.53±.01%, respectively with an increase in the added tigernut flour. Foam stability (Fig. 2), showed a relative stability at 4% added tigernut flour and decrease on further addition (4 – 1 min) with an increase in whipping duration(10-60 sec).

Water absorption capacity describes flour-water association ability under limited water supply. The result suggests that added tigernut could increase the baking application of the tigernut-acha composite flour e.g cookies [32]. The relatively low increase in the oil absorption capacity could be due to low hydrophobic proteins which shows superior binding of lipids [33]. The increase in the oil absorption capacity could improve flavour retainer in tigernut-acha composite products. The increase in the forming capacity with added tigernut flour could be due to the soluble protein content [25] and the amount of polar and non-polar lipids in a sample [34]. The increase in the foaming capacity could improve the composite flour application in ice cream and foam mat biscuits industries.

3.2 Pasting Properties of Acha-tigernut Composite Flour

The peak, tough, break down, final viscosity and set back of the tigernut-acha composite flour decreased from 1322.33±58 to 925.33±58, 1050.33±1.53 to 803.33±58, 272.00±1.73 to 122.00±00, 2677.67±58 to 2158.33±29 and 1628.33±58 to 1357.57±38RVA, respectively, with an increase in the percentage of added tigernut (Table 3). The decrease in the peak viscosity could be due to the high level of fibre and low carbohydrate level of the added tigernut.

The added tigernut flour decrease the hold-period (trough) of the samples. It is an indication of breakdown or stability of starch gel during cooking [35]. The hold-period sometimes called holding strength, hot paste viscosity or trough due to the accompanied breakdown in viscosity is a period when the sample was subjected to constant temperature and mechanical shear stress. It is a minimum viscosity value in the constant temperature phase of the RVA profile and measures the ability of paste to withstand breakdown during cooling [27].

The decrease in the breakdown value could be attributed to the relatively high fibre content, which could decrease the stability of the food product when stored at high temperature. The higher the breakdown value the higher the ability to remain undisrupted when subjected to long period of constant high temperature and ability to withstand beak down during cooking [36].

The decrease in the set back value due to the higher fibre content could be an advantage in the improvement of the digestibility and lower tendency for retrogradation of tigernut composite food products. Higher set back values are synonymous with reduced dough digestibility [37] while lower setback during the cooling of the paste indicates a lower tendency for retrogradation [28]'.

The decrease in the final viscosity could be due to the relatively high fibre value of the added tigernut with subsequent negative effect on the quality of starch [38].

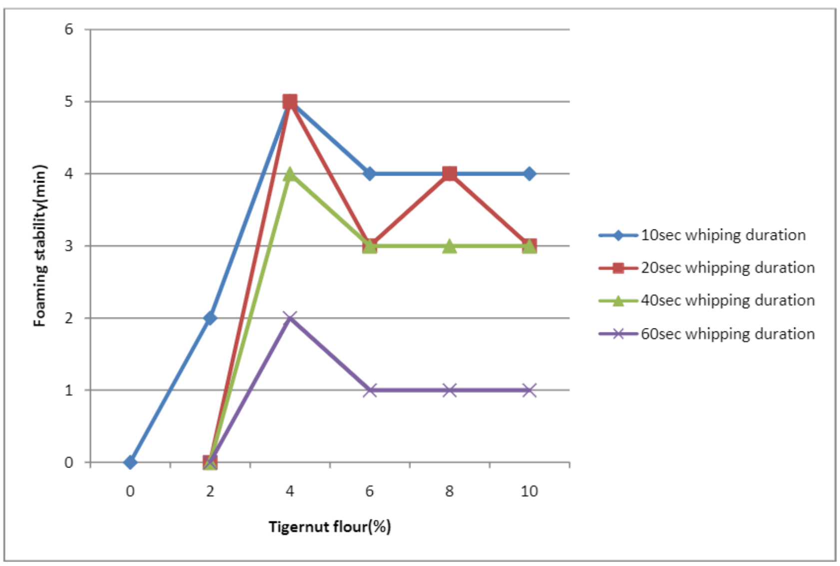

Fig. 2. Effect of added tigernut flour on the foam stability

Table 2. Effect of added tiger-nut flour on the functional property of acha based biscuits

Acha flour (%)	Tiger-nut flour (%)	Bulk density	Loose density	Oil absorption capacity	Water absorption capacity	Swelling index	Least conc. for gelatination	Foaming capacity	Swelling power
100	0	0.47±.00a	0.71±01d	0.59±.06b	1.03±.03b	3.00±.00c	19.67±.58a	5.54±.03e	232.33±2.52e
98	2	0.47±.00a	0.72± 02d	0.65±.01a	1.05±.01a	3.67±.58c	18.33±.58b	6.26±.00d	251.67± .58d
96	4	0.46±.00b	0.74±.00c	0.64±.01a	1.05±.01a	4.67±.58bc	18.33±.58b	7.27±.01c	262.67 ±.58c
94	6	0.46±.00c	0.74±.00c	0.65±.01a	1.01±.01bc	6.00±.00b	18.00±.00b	8.94±.04b	266.33±.58b
92	8	0.44±.00d	0.77±.00b	0.66±.01a	1.00±.00c	7.00±.00b	18.00±.00b	8.93±.58b	269.33±.58a
90	10	0.43±.00e	0.79±.00a	0.68±.00a	.98±.00d	9.33±.58a	16.33±.58c	10.53±.01a	271.00 ±.00a

Average means scores with the same alphabet in the same column are not significantly different, p=0.05

Table 3. Effect of added tiger-nut on the pasting properties of acha based biscuits

Acha flour (%)	Tigernut flour (%)	Peak viscosity	Trough I	Break dowm viscosity	Final viscosity	Set back viscosity	Peak time (Min)	Pasting temperature(°C)
100	0	1322.33±.58a	1050.33±1.53a	272.00±1.73a	2677.67±.58a	1628.33±.58a	5.57±.06ab	83.13±.06bc
98	2	1242.33±.58b	1012.33±.58b	230.33±.58b	2677.33±.58a	1665.33±.58b	5.61±.06a	83.18±.02b
96	4	1159.33±.58c	952.67±.58c	207.33±.58c	2571.33±.58b	1619.33±.58c	5.55±..06b	83.13±.06bc
94	6	1100.16±.29d	925.33±.58d	180.33±.58d	2506.00±.00c	1580.57±.38d	5.57±00ab	82.83±.06d
92	8	980.33±.58e	837.33±.58e	144.00±.00e	2281.33±.58d	1445.33±.58e	5.55±.06b	83.09±.08c
90	10	925.33±.58f	803.33±.58f	122.00±.00f	2158.33±.29e	1356.57±.38f	5.53±.00b	83.51±.01a

Average means scores with the same alphabet in the same column are not significantly different, p=0.05

3.3 Physical Property of Tigernut–acha Composite Flour

The spread ratio increased (5.20 ± .00 to 5.93 ±.06) while the break strength decreased (0.57 ±.00 to 0.32±.00 kg) with increase in the added tigernut flour (0-10%) (Table 4). The increase in the spread ratio could be due to high fibre content of the tigernut, which could decrease the viscosity of the paste prior to baking. The decrease in the break strength could be caused by the increase in the fibre content resulting in weakening of the bond between the carbohydrates-carbohydrates and carbohydrate-protein molecules [39].

3.4 Chemical Composition of Tigernut – acha Composite Biscuit

The effect of the added tigernut flour on the chemical composition of tigernut-acha composite biscuit is shown in Table 5. The protein, ash, moisture and carbohydrate contents decreased from 6.04±.01 to 5.20±.01, 2.12±.01 to 1.97±.02, 9.41±.01 to 8.82±.02, 68.84±.01 to 66.46±.00% respectively while the fat, crude fibre and the energy calorie content increased from 13.57±.01 to 17.54±.05%, 2.06±.01 to 4.01±.00% and 421.71±.01 to 444.78±.01cal/g, respectively with an increase in the added tigernut flour.

The decrease in moisture content with increase in the added tigernut could have a positive effect on the shelf life stability, as moisture could lead to product spoilage due to oxidation reaction [24]. There was a progressive increase in the fat content with increase in added tigernut. This may be due to the higher level of fat (32.88%) in tigernut flour [40]. A fat content of 7.7 – 17.3% was reported by Ade-Omowaye et al. [41]. The fat content (13.57±.01- 17.54±.05%) of the samples were higher than the recommended value Protein Advisory Group (PAG) weaning food [41,42]. Hence, partial defatting of the tigernut flour before utilization might yield a better result, though fat is important in the infant diet because it contains essential fatty acids which promote good health. It is also a carrier of fat-soluble vitamins promoting the absorption of vitamin A and carotene [19].

Fiber content increased with increase in the addition of tigernut flour. The value of fiber obtained was within the recommended Protein Advisory Group (PAG) of 5%. Ade-Omowaye et al. [41] reported a fiber value of 0.8-3.2% for wheat and tigernut composite bread. The fiber content of the samples was higher than reported by Akapo et al. [43,44,45,46,47]. Dietary fiber is reported to have some beneficial effects on the muscles of the large and small intestine [48]. It is well known that soluble fibres generally increase transit time through the gut, slow emptying of the stomach and slow glucose absorption [49,50]. Tigernut tubers have high dietary fibre content [51], so they may play a major role in lowering blood glucose level. This observation supports an earlier hypothesis that the tuber may be important for diabetics and those seeking to reduce weight [52]. However, a higher fibre diet is believed to have some adverse effect on mineral elements in the body [53].

3.5 Sensory Quality of Acha-tigernut Composite Biscuit

The average means scores for taste, aroma, colour, mouthfeel and general acceptability decreased from 5.89 ± .04 - 5.22± .31, 6.06 ± .10 - 5.05±.07 , 6.83± .04 - 6.08± .11, 5.95± .07 - 5.03± .04 and 5.98 ± .74 - 6.00±.00 while the crispness and appearance increased from 6.35 ±.07 - 6.75 ± .07 and 5.60 ±.00 - 6.05 ± .07, respectively, with the increase in the percentage of added tigernut flour(Table 6). The increase in the crispness could be due to the increase in the fibre content which agrees with the finding of Ayo et al. [54]. The decrease in taste and aroma are not significant, p=0.05, however at 8% and above of added tigernut, a significant effect was observed for other assessed parameters. Generally, the products were fairly acceptable (5.98 ± .74 - 6.00±.00).

Table 4. Effect of added tiger-nut flour on the physical properties of acha based biscuits

Acha flour (%)	Tigernut flour (%)	Spread ratio	Break strength(kg)
100	0	5.20 ± .00f	0.57 ±.00a
98	2	5.25 ± .00e	0.52±.00b
96	4	5.30±.00d	0.47±.00c
T94	6	5.43 ±.06c	0.37±.002d
92	8	5.70 ±.006b	0.34±.00e
90	10	5.93 ±.06a	0.32±.00f

Average means scores with the same alphabet in the same column are not significantly different, p=0.05

Table 5. Effect of added tigernut on the proximate composition acha based biscuits

Acha flour (%)	Tiger nut flour (%)	Protein (%)	Fat (%)	Ash (%)	Moisture (%)	Carbohydrate (%)	Energy cal/g	Fibre (%)
100	0	6.04±.01a	13.57±.01f	2.12±.01a	9.41±.01a	68.84±.01a	421.71±.01f	2.06±.01f
.98	2	5.87±.00b	14.21±.01e	2.08±.00b	9.02±.01	68.83±.00b	426.83±.16e	2.62e±.01d
.96	4	5.45±.00c	15.06±.00d	2.06±.00c	8.88±.01	68.55±.01c	431.89±.60d	3.22±.00c
.94	6	5.36±.00d	16.22±.01c	2.01±.01d	8.88±.01	67.53±.00d	437.55±.01c	3.17±.01d
92	8	5.21±.00e	17.49±.01b	2.00±.00d	8.84±.00	66.46±.00e	444.09±.00b	3.63±.00e
90	10	5.20±.01f	17.54±.05a	1.97±.02e	8.82±.02	66.46±.00e	444.78±.01a	4.01±.00f

Average means scores with the same alphabet in the same column are not significantly different, p=0.05

Table 6. Effect o f added tigernut flour on the sensory quality of acha-tigernut biscuits

Acha flour (%)	Tigernut Flour (%)	Taste	Aroma	Colour	Crispness	Appearance	Mouth feel	Gen accept
100	0	5.89 ± .04ab	6.06 ± .10a	6.83± .04a	5.95± .07bc	6.35 ±.07b	5.60 ±.00d	5.98 ± .74a
98	2	6.02 ± .03a	6.22± .18a	6.65 ±.07a	6.15± .07ab	6.43 ± .04b	6.02 ± .04c	6.42 ±.04a
96	4	5.95 ±.04ab	6.23± .04a	6.43±b .04b	6.35 ± .07a	6.38 ± .11b	5.73 ± .04b	6.32 ±.04a
94	6	5.73± .04ab	5.50± .14b	6.38 ±.11b	5.88± .18bc	6.30 ± .07b	5.98 ± .04a	6.28 ± .04a
98	8	5.63± .01b	5.33 ± .04b	5.90 ±.14c	5.68± .18c	6.90± .14a	5.48 ± .04a	6.03 ± .04a
90	10	5.22± .31c	5.05±.07c	6.08± .11c	5.03± .04c	6.75 ± .07a	6.05 ± .07a	6.00± .00a

Average means scores with the same alphabet in the same column are not significantly different, p=0.05

4. CONCLUSION

The use of acha and tigernut composite flour in the production of biscuits with improved nutritional and sensory quality without adversely affecting most properties or characteristics is possible. The fat, fibre and energy content of the acha(13.57± 0.01, 2.06 ±.01% and 421.71±.01cal/g respectively) was relatively improved to 17.54± .05, 4.0± .00% and 444.75± .01cal/g on addition of 10% tigernut flour. Biscuits prepared from such composite flour could help in combating protein-energy malnutrition; have the potential as a functional food especially for celiac, diabetic and obese patients considering the relatively slow digestibility of acha starch and high crude fiber contents of the blend than 100% acha flour biscuits.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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