



Functional, Sensory and Cooking Qualities of Acha-Tigernut Noodles

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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 DMA 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 functional, sensory and cooking characteristics of noodles from blends of Acha-tigernut composite flour were investigated. The flour blends and noodles produced were analyzed for functional properties and cooking characteristics. The tiger nut flour was substituted into acha flour at 5, 10, 15 and 20% to produce Acha-tigernut composite flour which was used with other ingredients (salt and powdered ginger) to produce acha-tigernut based noodles. The functional properties of the flour, sensory and cooking characteristics of the noodles produced were determined. The water absorption capacity and swelling capacity increased from 210.59 to 215.53 (g/g) and 524.43 to 586.57, respectively with increase in tigernut flour. While oil absorption, solubility and bulk density decreases from 209.80 to 192.72 (g/g), 10.17 to 5.19 and 0.79 to 0.61 (g/ml) respectively. The swelling capacity ranged from 524.43 to 586.57 (%) with an increase in tigernut flour. The final viscosity of the samples was found to range from 2833.00 to 2201.00 (m²/s). The peak properties decreased from 2680.67 to 1580.33 (RVU). The pasting temperature increases from 82.47 to 87.57°C. The addition of tigernut decreased the trough, breakdown and peak time from 1730.67 to 1205.67, 985.67 to 434.67, and 5.84 to 5.71 RVU, respectively. The

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average mean scores for colour decreased from 6.95 to 6.30(%) While that of taste, flavor, texture and general acceptability increased from 5.55 to 6.60, 5.95 to 6.85 (%), 5.95 to 6.44 (%) and 6.70 to 6.83 (%), respectively, as the percentage of tigernut increased.

Keywords: Cooking qualities; noodles; tigernut; composite flour.

1. INTRODUCTION

Noodles are unleavened dough which is stretched, extruded, or rolled flat and cut into one of a variety of shapes which is usually made as long, thin strips, or waves, helices, tubes, strings, or shells, or folded over, or cut into other shapes [1]. Noodles are a popular convenience food eaten all over the world. Noodles are generally inexpensive and easy to prepare and are enjoyed as fast foods across many countries. It has maintained their popularity over the centuries and owe their longevity to a combination of being relatively cheap yet nutritious and filling, quick to prepare, could be eaten hot or cold, can be stored for years and can be transported easily. Although noodles are basically low in calories, fibre and protein, it is higher in fat, carbohydrates, sodium and select micronutrients [2]. Noodles are mainly consumed by school children that need adequate protein for growth. The use of composite flour has been encouraged since it reduces the importation of wheat [3]. Utilization of locally available inexpensive cereals like acha, millet, sorghum and tigernut tubers could substitute a part of wheat flour without adversely affecting the acceptability of the products and could be a welcome development. Total or Partial replacement of wheat flour with acha and tigernut flour will increase the overall nutrient, encourage the agricultural sector, increase the noodle variety, reduce dependence on wheat flour for manufacturing of noodles and lower the cost of production.

Tigernut (*Cyperus esculentum*) is a perennial grass-like plant with spheroid tubers, pale yellow cream kernel surrounded by a fibrous sheath. It is also known as yellow nut sedge, earth or ground almonds, "souchet" in French, "ermandeln" in German and "chufa" in Spanish [4]. It is locally called "aya" in Hausa; "akiawusa" in Igbo; "ofio" in Yoruba and "isipaccara" in Effik. Tigernuts are edible, sweet, nutty, flavored tubers which contain protein, carbohydrate, sugars, and lots of oil and fiber [5]. Unfortunately, despite these potentials in tigernuts, it has been a neglected crop in Nigeria. This probably may be due to inadequate knowledge on its

production, utilization and nutritional value. Tigernut can be eaten raw, roasted, dried, baked or be made into a refreshing beverage called tigernut milk. Tigernut milk is a very nutritive and energetic drink, both for young and old. It is tremendously high in starch, glucose and proteins. Also rich in minerals like Potassium, Phosphorous, Vitamins E and C. Acha (*Digitaria exilis* and *Digitaria iburua*) is an annual cereal crop indigenous to West Africa where it is cultivated for its straw and edible grains. It is probably the oldest African cereal. It is either the staple food or a major part of the diet. Each year West African farmers devote approximately 300,000 ha to acha cultivation and yields of 600-700 kg /ha are recorded which translate to 180,000- 210,000 tonnes of grains annually. The crop supplies food to 3-4 million people [6,7].

Acha is considered as one of the nutritious of all grains; with its seeds containing 8.79% protein and may be up to 11.89% in some black acha sample [8,7,9]. The grains are rich in amino acids; leucine (9.8%), methionine (5.6%) and valine (5.8%) [8] and cysteine which are vital to human health but deficient in today's major cereals. According to Ayo et al. [10] 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 [9], and could be mixed with other cereal flours to make cookies, as candy and fermented beverages [11,12].

Composite flour is a mixture of different flours from cereals, legumes or root crops that is created to satisfy specific functional characteristics and nutrients composition. It refers to the process of mixing different flours from cereals and legumes for making baked and fried products like bread, biscuit, pie crust, buns, chin-chin and noodles [5]. However, the term may mean mixing of different flours from roots and tubers, legumes, cereals or other raw materials into a composite with wheat for many purposes. FAO [13], reported that replacing wheat with 20% non-wheat flour for the manufacture of baked products would result in

estimated savings in foreign exchange of US \$20 million for developing countries.

Tigernut and Acha grains are underutilized food crops in Nigeria. Both products are unidentified as very important food crops of great potential in managing particularly to health of the consumer.

In recent years, the need to increase the production and utilization of locally available food resources has been highlighted at different national and international fora. Tigernuts and acha are some of the under-utilized food crops locally available in Nigeria and could be used in solving major nutritional problems through the exploitation of its nutritional and economic potentials.

The results of this study would provide a baseline data on the functional and sensory qualities of tiger nut-acha based noodles. This would go a long way to diversify their uses and in turn, lead to their increased production both at household and national levels ultimately to ensure food security. Furthermore, it is expected that through the knowledge of its composition, tiger nut and acha may be exploited for use in the prevention and treatment of some non-communicable diseases for example cancers, diabetes, hemorrhoids and cardiovascular diseases.

The objective of this study was to determine the functional, sensory and cooking qualities of tigernut-acha noodles.

2. MATERIALS AND METHODS

Tigernuts tubers were gotten from Kaduna central market, Kaduna State, while the Acha was obtained from Terminus in Jos, Plateau State, Nigeria. The tigernuts were sorted, cleaned and washed with portable water, drained and dried in an oven at 70°C for 72 hours, milled (using attrition mill), sieved (using 0.4 mm sieve aperture) to obtain tiger nut flour and packed hermetically in polythene bags at room temperature in a cool dry place till usage.

2.1 Preparation of Acha Flour

The acha grain obtained was washed with the use of clean water to remove stones and other contaminants (using sedimentation method), dried (50°C for 72 hours) and milled (using attrition mill) and then sieved (0.4 mm sieve

aperture) to obtain acha flour of uniform size, the flour was then hermetically packed using polythene bags and stored at room temperature for further use.

2.2 Preparation of Tigernut-acha Composite Flour

The tiger nut flour was substituted in to acha flour (5, 10, 20 and 25%) and mixed thoroughly using blender then packaged (in high density polyethylene bags) prior to use.

2.3 Production of Tigernut-acha Based Noodles

Noodles were produced by blending separately acha and tigernut flour samples with warm water. The mixtures were thoroughly worked to form dough. The dough was kneaded (for even distribution of the ingredients and hydration of the particles in the dough), form into sheets, was extruded and oven dried (using hot air oven).

2.4 Determination of Functional Properties

2.4.1 Determination of water absorption capacity

The water absorption capacity was determined using the method described by Onwuka [14]. Ten millilitres (10 ml) of distilled water was added to 1 g of acha-tigernut composite flour sample in a weighed centrifuge tube. The tube was agitated on a vortex 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.

2.4.2 Determination of oil absorption capacity

The oil absorption capacity was determined using the method described by Onwuka [14]. One gram (1 g) of acha-tigernut composite flour sample was mixed with 10 ml 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.

2.4.3 Determination of bulk density

The bulk density was determined using the method described by Onwuka [14]. Fifty grams (50 g) of acha-tigernut composite flour sample was poured into a 100 ml measuring cylinder. The cylinder was tapped fifty (50) times on a laboratory bench to constant volume. The volume of sample was recorded.

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

2.4.4 Determination of foaming capacity and stability

The foaming capacity and stability were determined using the method described by Onwuka [14]. Two grams (2 g) of acha-tigernut composite flour sample was added to 50 ml of distilled water at $30 \pm 2^\circ\text{C}$ in a 100 ml graduated cylinder. The suspension was mixed and shaken manually for 5 min to foam. The volume of foam at second after whipping was expressed as foaming capacity using the formula;

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

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.

2.4.5 Determination of emulsion activity and stability

The emulsion activity and stability were determined using the method described by Olapade et al. [15]. The emulsion, (1 g of acha-tigernut 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.

2.4.6 Determination of swelling capacity

The swelling capacity was determined using the method described by Olapade et al. [15]. One gram (1 g) of acha-tigernut 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.

2.4.7 Determination of pasting properties

Pasting properties of flour was characterised using Rapid ViscoAnalyser (RVA) Model 3C, Newport Scientific PTY Ltd., Sydney) as described by Delcour et al. [16] and Sanni et al. [17]. Five gram (5 g) of sample was accurately weighed into a weighing vessel, 25 ml of distilled water was dispensed into a new test canister. Sample was transferred onto the water surface in the canister, after which the paddle was placed into the canister. The blade was vigorously joggled up and down through the sample ten times or more until no flour lumps remained neither on the water surface nor on the paddle. The paddle was placed into the canister and both were inserted firmly into the paddle coupling so that the paddle is properly centred. The measurement cycle was initiated by depressing the motor tower of the instrument. The test was then allowed to proceed and terminate automatically.

2.5 Determination of Cooking Properties

2.5.1 Determination of cooking time

Cooking quality of a noodle were analysed according to the American Association of cereal chemists [18] method. The time required for the noodle for the noodle core to disappear, when pressed softly between two glass plates after cooking, is the optimum cooking time (OCT). The cooking period began as the noodles were put into boiling water. 300 ml tap water was taken in a beaker and then 25 grams of noodle was cooked to optimum time. After this, they were rinsed for 15 minutes in cold water before weighed.

2.5.2 Determination of cooking loss

The cooking loss was determined by measuring the amount of solid substance lost to cooking

water. A 10 g of noodles were placed into 300 ml of boiling distilled water in a 500 ml beaker. Cooking water was collected in an aluminium vessel which was placed in an air placed in an oven at 105°C and evaporated to dryness. The residue was weighed and reported as a percentage of the starting material. For the cooking loss value, five determinations were performed to obtain the mean value.

2.5.3 Weight increase

The weight increase of noodle was determined by calculating the difference in weight of the uncooked and cooked noodles. 10 g of the noodles samples were weighed before and after cooking. The weight increase (%) was calculated as;

Weight increase (%) = (weight of cooked noodles-weight of raw noodles)/ (weight of raw noodles)

2.5.4 Volume increase

The volume increase of noodle was determined by calculating the difference in the amount of water displaced by the uncooked noodle. 40g of raw noodles samples was tied in a polythene lather dropped into a cylinder containing 200 ml of deionized water the volume increase was recorded and the same process was repeated after cooking the sample. The volume increase (%) was calculated as;

Volume increase (%) = (the volume increase by cooked noodles-the volume increase by raw noodles) /the volume increase by raw noodles).

2.6 Evaluation of Sensory Properties

The cooked noodles samples were evaluated for colour, taste, odour and texture by twenty (20) trained panelists who were randomly selected from staff and students of the Department of Food Science and Technology, Faculty of Agriculture and Life sciences, Federal University Wukari, Taraba state, Nigeria based on their familiarity with noodles. The noodle samples were presented on 3 digit coded white plastic plates at 29±3°C. The samples were evaluated on 9 point Hedonic scale where 1 = disliked extremely and 9= like extremely. The order of presentation of the sample to the panelist was randomized. The panelists were provided with bottle water to rains their mouths in between evaluation. The sensory evaluation was carried

out at mid-morning (10 am) in the sensory evaluation laboratory under adequate lighting and ventilation.

2.7 Statistical Analysis

Data were analyzed in 3 replications by one-way analysis of variance (ANOVA) in completely randomized design using Statistical Package for Social Science (SPSS) version 23.00. The statistically significant differences ($p < 0.05$) were separated using the Duncan's Multiple Range Test (DMRT).

3. RESULTS AND DISCUSSION

3.1 Functional Properties of Acha-tigernut Flour Blend

The functional properties of acha-tigernut flour is shown in Table 1. The relative bulk density ranged from 0.61-0.79 (g/ml). The range showed that there was a decrease in bulk density with a corresponding increase in added tigernut flour. The decrease in the bulk density with added tigernut flour which could be related to its high fibre content which could reduce the heaviness of the composite flour and that of the products and consequently the transportation costs. However, this results was higher than that of the findings of Ayo et al. [10]. The increase could be as a result of the higher amount of tigernut added to the samples. Bulk density is a function of flour wettability which influences packaging design and could be used in determining the required type of packaging material [19]. The water absorption capacity and swelling capacity increased from 210.59 – 215.53 and 524.43 – 586.57(g/g) respectively with an increase in tigernut flour while oil absorption, solubility and bulk density decreased from 209.80 - 192.72, 10.17 - 5.19 and 0.79 - 0.61 (g/m) respectively, with increase in the addition of tigernut flour. 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 [20]. Although the value obtained for water absorption capacity (210.59 – 215.53) was higher than the findings of Eke-Ejiofor et al. [21] which could be due to other factors such as species of grain and the resulting efficiency.

Water absorption capacity is an important functional property required in food formulations especially those involving dough handling

(Lorenz and Collins 1980). The ability of protein in flours to physically bind with water is a determinant of its water absorption capacity [22]. The swelling capacity of the flour blend increased from 524.43 – 586.57(g/ml). The results showed that an increase in tigernut leads to decrease in the swelling capacity of the flour samples. Although this results was higher than that of the findings of Akoma et al., [23] in wheat- cassava composite flour. The 100% Acha (601.36 g/g) have the highest value which could be due to the presence of high gluten content present in the wheat sample.

Table 2 shows the pasting properties of composite flours. Pasting properties are the most commonly assessed set of quality characteristics probably because the methods are well established and have been proven to be a reliable predictor of flour quality. The pasting properties are important as it is used in predicting the pasting behavior and ability of the flour samples. The final viscosity of the samples were found to range from 2833.00 to 2201.00 (m²/s). The peak properties decreases from 2680.67 to 1580.33 (RVU) from sample 100% acha to sample 75% acha and sample 100% wheat having 1368.00. The pasting temperature increases from 82.47 to 87.57. The effect of tigernut was significantly difference ($p \leq 0.05$) in the acha-tigernut flour blends as shown in the Table 2.

The addition of tigernut decreased the trough, breakdown and peak time from 1730.67 to 1205.67, 985.67 to 434.67, and 5.84 to 5.71 (RVU) respectively. The observed decrease of each agreed with the findings of Ndie et al. [24]. The higher the breakdown in viscosity, the lower the ability of the starch in the flour samples to withstand heating and shear stress [25]. Chinma et al. [26] reported that high break-down value indicates relative weakness of the swollen starch granules against hot shearing while low breakdown values indicate that the starch in question possesses cross-linking properties. Higher pasting temperature of these flours showed higher water binding capacity, with low gelatinization and low swelling property. The ability of starch to imbibe water and swell is primarily dependent on the pasting temperature. Pasting properties indicate the tendency to form paste. The higher the pasting temperature, the faster the tendency for paste to be formed.

Starch granules swell and form paste by imbibing water in the presence of water and heat. Peak time of the composite flour samples ranged from 5.84 min (100%) acha to 5.71 min (75%) acha. However, the product with higher peak time showed low peak viscosity (Table 2). This is to be expected as high peak times characterize low swelling starch granules in the flour.

3.2 Sensory Quality of Acha-tigernut Noodle

The quality of a product and its appearance are important factors to consumers. Quality and appearance can be described by color, flavor and taste in addition to physical attributes such as texture. The average mean scores for acha-tigernut noodles are shown in Table 3, The average mean scores for colour decreased from 6.95±0.31-6.30±0.29, While that of taste, flavor, texture and general acceptability increased from 5.55- 6.60, 5.95 – 6.85, 5.95-6.44 and 6.70-6.83.

Respectively, with sample (100%) acha having the least results (6.70). The addition of tigernut flour had a significant effect on the blend. This results was higher than the finding of Ayo et al. [10]. The increase must have been as a result of increase in quantity of tiger nut added for the production of the noodles. Colour is an important attribute that enables the acceptability of a product by consumers. The colour of the samples decreased as the percentage of tiger nut increased. Taste is an important attribute in acceptance of food product. The taste of the samples increased with the increasing inclusion of Tiger nut flour. Though, the increase in taste are not significant $p=0.05$. Texture plays an important role in how consumers evaluate a product, this refers to the feel, appearance or consistency of a product. The texture of the noodles increased as the percentage of tigernut increase, and could be due to the high fiber content in tigernut, which agrees with the feedings of [27]. The result of the sensory evaluation revealed that noodles made from 100% wheat flour and those produced from composite flour with 10 and 20% acha-tigernut flour were rated closely in almost all the quality attributes evaluated. This showed the acceptability of tigernut in noodles. This result suggests the potential application of tigernut flour either as full flour or substituted flour in food industry.

Table 1. Functional properties of composite flour

Acha flour (%)	Tigernut flour (%)	Wheat (%)	OAC (g/100 g)	WAC (g/100 g)	Bulk density (g/m)	Swelling capacity (%)	Solubility (%)
100	0	0	183.15 ^a ±0.50	190.09 ^a ±0.48	0.66 ^b ±0.00	601.36 ^a ±2.00	8.85 ^b ±0.04
0	0	100	209.80 ^d ±0.26	210.59 ^d ±0.41	0.79 ^d ±0.01	524.43 ^c ±0.18	10.17 ^c ±0.12
85	10	5	203.66 ^d ±0.43	211.81 ^c ±0.33	0.76 ^c ±0.13	544.31 ^b ±0.13	8.83 ^a ±0.13
80	15	5	198.99 ^b ±0.56	213.39 ^c ±0.47	0.68 ^a ±0.01	584.10 ^b ±0.00	6.54 ^a ±0.01
75	20	5	192.72 ^c ±0.53	215.53 ^b ±0.26	0.61 ^c ±0.00	586.57 ^a ±0.65	5.19 ^b ±0.01

Values are mean± standard deviation of replications. Means with the same superscripts within a column are not significantly different (0.05); OAC – Oil Absorption Capacity; WAC- Water Absorption Capacity

Table 2. Pasting properties of composite flours

Acha (%)	Tigernut (%)	Wheat (%)	Peak	Trough	Breakdown	Final viscosity	Peak time	Pasting temperature (°C)
100	0	0	1368.00±0.14 ^a	717.00±0.25 ^b	586.00±0.20 ^b	882.00±0.23 ^d	5.78±0.30 ^a	86.57±0.23 ^d
0	0	100	2680.67±0.12 ^a	1730.67±0.15 ^d	985.67±0.30 ^a	2833.00±0.21 ^a	5.84±0.21 ^a	82.47±0.32 ^b
85	10	5	1914.0±0.13 ^a	1527±0.35 ^b	666.33±0.21 ^a	2629.00±0.23 ^d	5.78±0.21 ^a	87.14±0.11 ^a
80	15	5	1674.67±0.11 ^a	1314.00±0.11 ^b	530.00±0.23 ^d	2414.33±0.30 ^a	5.74±0.23 ^d	87.47±0.22 ^b
75	20	5	1580.33±0.21 ^b	1205.67±0.35 ^b	434.67±0.13 ^d	2201.00±0.30 ^a	5.71±0.30 ^a	87.57±0.35 ^a

*Values are mean± standard deviation of replications. Means with the same superscripts within a column are not significantly different (0.05)

Table 3. Sensory characteristics of acha- tigernut noodles

Acha (%)	Tigernut (%)	Wheat (%)	Color	Taste	Flavor	Texture	General acceptability
100	0	0	8.15 ^a ±0.18	7.80 ^a ±0.21	6.90 ^a ±0.49	7.85 ^a ±0.22	8.05 ^a ±0.20
0	0	100	6.95 ^b ±0.31	5.55 ^b ±0.23	5.95 ^d ±0.34	5.95 ^e ±0.39	6.70 ^e ±0.34
85	10	5	6.75 ^c ±0.44	6.20 ^d ±0.27	6.50 ^c ±0.35	6.20 ^d ±0.28	6.75 ^d ±0.30
80	15	5	6.50 ^d ±0.39	6.40 ^c ±0.23	6.75 ^b ±0.27	6.35 ^c ±0.36	6.77 ^c ±0.28
75	20	5	6.30 ^e ±0.29	6.60 ^b ±0.24	6.85 ^a ±0.32	6.44 ^b ±0.34	6.83 ^b ±0.28

Values are mean ± SEM of triplicate determination samples with different superscripts within the column were significantly (p≤0.05) different

Table 4. Cooking characteristics of acha-tigernut noodles

Acha (%)	Tigernut(%)	Wheat (%)	Cooking time (%)	Weight increase (%)	Cooking loss (%)	Volume increase (%)
100	0	0	502.00±0.32	11.4±7.04	5.24±0.12	13.59±0.141
0	0	100	890.±0.23	14.26±0.4	0.24±0.12	20.39±0.14
80	15	5	486±0.32	12.23±0.25	2.0c2±0.42	15.89±0.18
75	20	5	546. ±0.10	14.96±0.61	1.64±0.12	17.60±0.13
70	25	5	574.5±.120	15.08±0.46	1.49±0.12	17.92±0.14

3.3 Cooking Characteristics of Acha-tigernut Noodles

The cooking time (sec), weight increase (%), cooking loss (%), and volume increase of acha-tigernut noodles are shown in Table 4. The cooking time, volume and weight increased from 502.00 to 574.5, 1359 to 17.92 and 11.43 to 15.08 (%) respectively, while the cooking loss decreased from 5.24 to 1.49 with addition in tigernut flour. The increment in cooking time could be due to the quantity of tigernut added and also compositional difference, the degree of cooking can be observed either by eye or image analysis [28]. The weight increase after cooking increased upon addition of tiger nut flour to the samples. This could be due to the quality of tigernut used in the production. The cooking loss decreased as tigernut were added, and could be due to the weakening of the of the proteins network in presence of acha grain which allowed more solid to be leached out from the noodles in to cooking water. Volume increased upon addition of tigernut which may be due to the reduction in the cooking loss of the noodles produced, which agrees with the findings of Eke-Ejiofor et al. [21].

4. CONCLUSION

The addition of tigernut had a significant effect on both the functional and sensory properties of acha-tigernut noodles. However, the noodles with 20% tigernut was most preferred and accepted. This result suggests the potential application of tigernut flour either as full flour or substituted flour in food industry.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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