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EFFECT OF FERMENTATION TIME ON SOME ATTRIBUTES OF SORGHUM CHINCHIN

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ABSTRACT

Fermentation is a cheap method of food preservation and processing. Cereals can be fermented to provide commercially available snacks, meals, and alcoholic beverages. This research examined at how the length of the fermenting time affects some sorghum chinchin quality attributes (in hours). The sorghum grains were subjected to natural fermentation for 0, 12, 24, 36, 48, and 60 hours. They were then dried and processed into flour, and the dough was fried in oil to form Chinchin. Analyses of proximate composition, colour, texture profile, functional and sensory properties were carried out on the samples. The data obtained were further analyzed using ANOVA. Analysis of proximate composition showed an increase in the fat, crude fibre and crude protein contentsbuta decrease in the carbohydrate content as the fermentation period progresses; 19.12±0.01% to 19.44±0.02%, 3.27±0.01% to 4.4±0.00%, 3.85±0.01% to 4.19±0.01%, 64.48±0.01% to 61.05±0.01% respectively, while the values obtained from the control were 17.33±0.01%, 3.31±0.01%, 3.72±0.01%, 65.68±0.08% respectively. Oil uptake for the control sample was 18.64±0.69% and a decrease from 17.71±0.03% to 12.42±0.08% was noted for the fermented samples as the fermentation period increased. 36-hour fermented sample had the lowest value at 7.0±1.08, whereas the control samples and the 60-hour fermented sample had the highest overall acceptability. Implementing the consumption of snacks produced from 100% fermented sorghum as part of the diet can help prevent diet-related diseases and improve nutrition. Also, the commercial production of the snacks could provide additional socioeconomic benefits and increase the economic value of sorghum.

Keywords: Sorghum; Wheat; Fermentation; Chinchin; Proximate; Sensory Evaluation

INTRODUCTION

Sorghum is the fifth most important cereal crop in the world after rice, wheat, corn and barley. It is the main cereal food for over 750 million people living in semi-arid tropical regions of Africa, Asia and Latin America. Sorghum locally called guinea corn and "*dawa*" in Nigeria is a gluten-free grain that has the potential to be used as an alternative to wheat flour (Li et al. 2011). Sorghum grain is a rich source of various phytochemicals such as tannins, phenolic acids etc., which have health-promoting activities, anti-cancer, anti–tumor, antidiabetic and anti-obesity properties (**Awika & Rooney, 2004**). Sorghum grain is a rich source of macronutrients (carbohydrates, proteins, and fat) and micronutrients (mineral and vitamins). It is rich in magnesium, iron, manganese and phosphorus (Rajeshet al. 2014). Sorghum grains contain resistant starch, which makes it interesting for obese and diabetic people, as the digestibility of whole sorghum is slower than other major cereals, leading the slow release of glucose into the blood. Therefore, the energy released is fully utilized and prevents accumulation of fat. It is also recommended as gluten-free food for celiac patients (Dicko et al. 2006). Although cereal grains constitute a major source of dietary nutrients worldwide, they are deficient in some basic components (e.g. Essential amino acids). Fermentation may be the simplest and most economical way of improving their nutritional value and functional qualities (Taylor et al.2010).

Fermentation is well-known to improve the sensory properties of food by imparting unique flavours, textures and aromas (Chaves-Lopez et al. 2014). It is also used to improve the bioavailability and bio-accessibility of nutrients, reduce antinutritional factors (such as lectins, phytic acid, proteinase inhibitors, oxalic and tannins acids) and pathogenic microorganisms, preserve food products as well as to enhance the economic value (Hlangwani et al. 2020). As a result, fermented foods have become a very important part of the human diet worldwide. Fermented food products have been in existence since the arrival of human civilization and are likely to be with us far into the future. Fermentation is, thus, an age-long food processing technique used to transform food products (Adebo, 2020), with different food crops (cereals, legumes, as well as fruits and vegetables) used as starting raw materials.

Increasing fermentation period results in a decrease in tannin content, starch, amylopectin, and water and oil absorption and an in increase in the value of whiteness, dietary fiber, amylose, and viscosity of sorghum flour (Adebo et al. 2018). Also, in a study done by Osungbaro (1990), It was noted that increased fermentation time and temperature led to an increase in mean levels of some phenolic compounds of Ting obtained from whole grain sorghum.

Studies have shown that snacks can be used to increase the nutritional status of consumers by incorporating nutrients such as protein and fibre from plant sources with significant health benefits (Zazueta-Morales et al. 2001). Use of sorghum grains as composite flour have previously been studied in the production of bread, extruded snacks, biscuits among others. But, the utilization of 100% sorghum flour in food production and its acceptability is not yet widely examined and information on its use as snacks is insufficient.

Chin-chin is a fried snack popular in West African countries especially Nigeria. It is a sweet hard doughnut-like fried product which is sometimes a baked dough of wheat flour, with eggs and other ingredients (Akubor, 2004). The flour is mixed to form an elastic dough which is properly kneaded, rolled and cut into desired shapes. The shaped flat dough is then deep fried in hot oil until slightly golden brown then scooped out to let the oil drain (Mepba et al. 2007).

The objective of this research work is to evaluate the effect of fermentation periods on the proximate composition, sensory characteristics, moisture loss, oil uptake and textural properties of a chinchin snack produced from 100 % sorghum flour using 100% wheat chinchin as control.

MATERIALS AND METHODS

MATERIALS

Materials used (*Sorghumbicolour* grains, margarine, sugar, nutmeg, salt and baking powder) were purchased at Osiele Market, Abeokuta. The production was carried out in the food processing laboratory in the Department of Food Science and Technology, Federal University of Agriculture Abeokuta, Ogun State, Nigeria.

FERMENTATION OF SORGHUM GRAINS

Fermentation of sorghum grains was done as described by Ojokoh et al. (2020) with a little modification. 1.3kg of whole sorghum grains were sorted manually to remove stones, damaged grains and foreign particles. The grains were put in a plastic container, steeped in 1 litre of distilled water and covered tightly. The grains were subsequently subjected to naturalfermentationat37^{0}C. This was repeated separately for different periods of time (12hr, 24hr, 36hr, 48hr, and 60hr).

250g of unfermented whole sorghum grain was also sorted manually to remove damaged grains and all foreign particles. The grains were rinsed thoroughly with distilled water without allowing fermentation to take place (0hr).

Afterwards, the unfermented (0hr) and fermented grains (12hr, 24hr, 36hr, 48hr, and 60hr) were dried at 70^{o}C for 4hrs in hot air oven, exposed to air to cool and the samples were labelled according to the fermentation period.

SORGHUM FLOUR PRODUCTION

A slight modification was done to the flour production process outlined by Ingbian & Akpapunam (2005). The dried, cooled fermented grains was milled using a single flour milling machine into flour (to be used in the chinchin production). The flour was sieved, packaged in airtight polyethylene bags and stored at 37^{0}C in covered plastic buckets for storage (4 days before the chinchin snacks production).

CHINCHIN PREPARATION

Using a reviewed method described by Akubor (2004) for chinchin production, 100g of fermented sorghum flour was poured in a bowl, then mixed with 30g of sugar, 20g of margarine, 1.42g of baking powder, 2.7g of salt and 1g of nutmeg. Another 100g of fermented flour was poured in a separate bowl and a well was made at the center; 118ml of water was heated to a temperature of 32^{0}C and poured in the center; the flour was gently folded in with a turning stick 3 times and poured immediately to the first flour mixture. The lumps formed were separated with fingertips till all ingredients were well combined and resembled breadcrumbs. Eggs whisked until light, was added to the mixture, mixed with finger tips into smooth dough leaving the side of the bowl clean. It was rolled evenly on a floured board and cut into desired shape and size; length and thickness. Deep-fried in oil until attractively brown. Excess oil was drained. The product was then cooled and packaged in high density polyethylene bag for storage until the chinchin was evaluated. This was repeated for all samples.

PROXIMATE COMPOSITION

The protein, fat, crude fibre, moisture and ash content of the samples were analyzed after fermentation using the methods described by the Association of Official Analytical Chemists (AOAC, 2005). the Total carbohydrate content was obtained by difference (subtracting sum of %moisture, crude protein, crude fat and ash from 100%). The crude protein contents were determined by micro-kjeldahl method to obtain the Nitrogen content. The crude protein was then calculated as "gN x 6.25" while the crude fat was obtained using Soxhlet apparatus. Dry ashing method was used in ash content determination. The samples were analyzed using a muffle furnace at a temperature of 500-600^{o}C for 24 hours. For the crude fibre determination, the samples were digested in sulphuric acid and sodium hydroxide solution and the residues calcined. The difference in weight after calcination was used to indicate the quantity of fibre present.

FUNCTIONAL PROPERTIES OF THE CHINCHIN

Moisture content of the chinchin was determined using methods of Analysis of the Association of Official Analytical Chemists (AOAC, 2005).

Moisture Loss: (Moisture content of fried chinchin) - (Moisture content of the dough). Oil content of the chinchin was determined using methods of Analysis of the Association of Official Analytical Chemists (AOAC, 2005) method.

Oil Uptake: (Oil content of fried chinchin) – (Oil content of dough)

Colour Analysis

Each sample of the chinchin was analyzed using a colorimeter to determine their brightness, redness and yellowness by the application of Beer-Lambert's law. The instrument was standardized and the samples placed in the sample holder. The measurement was taken in triplicates for analysis.

Texture Analysis

The instrumental texture measurements of the sorghum chinchin was analyzed with a TA.XT. plus Texture Analyzer (Stable Microsystems, Godalming, UK) provided with Texture expert software. The chinchin (with a thickness of 2mm) was placed horizontally directly under the probe. A double compression test (texture profile analysis) was performed with a 75 mm diameter fiat-ended cylindrical probe (P/75) and compression to 50% of the initial height at a speed of 1 mm/s with 5s waiting time between the two cycles.

Sensory Evaluation

The sensory attributes of the *chinchin* was determined by using simple hedonic tests as described by (Larmond, 1991). This was done using a 20-member panel comprising of students of the department of Food science and technology, Federal University of Agriculture, Abeokuta, who were familiar with the sensory attributes of chin-chin. Each panelist was asked to score each attribute on a 9-point hedonic scale where 1 and 9 represent dislike extremely and like extremely, respectively. The attributes that were evaluated includes appearance, colour, taste, texture, aroma and overall acceptability.

Data Analysis

All data obtained was subjected to analysis of variance (ANOVA). Means was separated using Duncan's multiple range test (DMRT) using the Statistical package for social sciences (SPSS) version 21.0 (SPSS Inc., Chicago, IL).

RESULTS AND DISCUSSION

Proximate Composition of the Fermented Sorghum Chinchin Sample

The proximate composition of the chinchin samples is shown in Table I. The moisture content increased from 6.22 to 6.37 % as the fermentation period increased and was significantly different ($p<0.05$) from each other. The values were within the range reported to have no adverse effect on quality attribute of the product (Zazueta-Morales et al. 2001). The low moisture content could reduce the growth of micro-organism thereby increasing the shelf life of the product.

Dietary fat functions in the increase of palatability of food by absorbing and retaining flavours (Anita et al. 2006). The fat content increased from 19.12 to 19.44 % with a significant difference ($p<0.05$) from each other, There was an increase in the fat content as the fermentation period is increased due to an increase in the activity of the lipolytic enzymes in hydrolyzing fat to glycerol and fatty acids (Achinewhu, 1986).

Ash content is an indication of the mineral content of a food (Ndife et al. 2013). The ash content ranged between 3.07 to 4.59 % with sample F^{48} having the highest. The ash content has been reported to increase with fermentation according to Apena et al.(2015).

The values for crude fibre ranged between 3.12 to 4.40 %, sample G^{60}had the highest while sample C^{12} had the least. Crude fibre content increases with an increase in the fermentation period. Sorghum contains high level of fibre and this was further increased by fermentation (Achinewhu, 1986). Crude fibre helps in the prevention of heart diseases, colon cancer and diabetes (Slavin & Marlett, 1997).

The protein value ranged from 3.85 to 4.19%, sample G^{60} had the highest and sample B^{0} had the lowest value with a significant difference ($p<0.05$) for all samples. The protein content increased with an increase in the fermentation period, which could be due to synthesis of protein by micro-organisms. Fermentation increases protein value (Apena et al. 2015).

The carbohydrate content of the chinchin ranged between 64.48 to 61.05 % with a significant difference ($p<0.05$). The carbohydrate value decreased as fermentation period increased. This agrees with (Odunfa & Adeyele, 1985), who reported that carbohydrate content was reduced with fermentation due to the increase of alpha-amylase activity which hydrolyses starch to simple sugars.

Table I: Proximate analysis for the fermented sorghum chinchin sample

Sample	Moisture Content (%)	Fat (%)	Ash (%)	Crude Fibre (%)	Crude Protein (%)	Carbohydrate (%)
A	6.46 ± 0.02^{e}	17.33 ± 0.01^{a}	3.52 ± 0.01^{d}	3.31 ± 0.01^{c}	3.72 ± 0.01^{a}	65.68 ± 0.08^{g}
B^0	6.22 ± 0.01^{d}	19.12 ± 0.01^{f}	3.07 ± 0.01^{f}	3.27 ± 0.01^{g}	3.85 ± 0.01^{d}	64.48 ± 0.01^{a}
C^{12}	6.24 ± 0.01^{a}	19.15 ± 0.01^{b}	3.11 ± 0.01^{a}	3.12 ± 0.01^{b}	3.85 ± 0.01^{b}	64.57 ± 0.00^{e}
D^{24}	6.31 ± 0.01^{a}	19.17 ± 0.01^{bc}	3.48 ± 0.01^{b}	3.51 ± 0.01^{a}	4.09 ± 0.01^{b}	63.46 ± 0.02^{f}
E^{36}	6.34 ± 0.01^{b}	19.31 ± 0.01^{c}	3.98 ± 0.01^{c}	4.08 ± 0.01^{d}	4.11 ± 0.01^{c}	62.2 ± 0.05^{d}
F^{48}	6.36 ± 0.01^{c}	19.36 ± 0.01^{d}	4.59 ± 0.01^{e}	4.32 ± 0.01^{e}	4.17 ± 0.01^{c}	61.22 ± 0.02^{c}
G^{60}	6.37 ± 0.01^{cd}	19.44 ± 0.02^{e}	4.56 ± 0.01^{f}	4.4 ± 0.00^{f}	4.19 ± 0.01^{d}	61.05 ± 0.01^{b}

Mean values with different superscripts within the same column are significantly different **($p<0.05$)**
A: Chinchin from 100% wheat flour **(Control)**
B^0: Chinchin from 100% sorghum flour (No fermentation)
C^{12}: Chinchin from 100% sorghum flour (12hours Fermentation)
D^{24}: Chinchin from 100% sorghum flour (24hours Fermentation)
E^{36}: Chinchin from 100% sorghum flour (36hours Fermentation)
F^{48}: Chinchin from 100% sorghum flour (48hours Fermentation)
G^{60}: Chinchin from 100% sorghum flour (60hours Fermentation)

Oil uptake for the Fermented Sorghum Chinchin after frying

Evaluation of the oil uptake for each of the Sample was carried out as shown in Table III. Oil absorption capacity is important since oil acts as flavor retainer and increases mouth feel of foods (Aremu et al. 2007).

The values for the oil content of the fried snack ranged from 21.14 to 16.28 with sample B^0 having the highest value and sample G^{60} having the lowest values. The values were significantly different from each other ($p<0.05$). The values decreased with increase in fermentation period.

The values for the oil content of the dough ranged from 6.43 to 3.87 with sample B^0 having the highest value and sample G^{60} having the lowest values. The values were significantly different from each other ($p<0.05$).

The values for the oil uptake of the fried snack ranged from 17.71 to 12.42 with sample B^0 having the highest value and sample G^{60} having the lowest values. The values were significantly different from each other ($p<0.05$). in line with study done by Elkhalifa & Bernhardt (2013), the values of the oil uptake by the fried snack decreased with an increase in fermentation period which could be as a result of decrease in water binding capacity of sorghum flour during fermentation.

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Table II: Moisture loss for the Fermented Sorghum Chinchin (FSC)

Sample	Dough Moisture content (%)	Fried Snack Moisture content (%)	Moisture loss (%)
A	**25.68±0.01 ^{a}**	**10.21±0.01 ^{a}**	**15.47±0.02 ^{a}**
B^{0}	28.32±0.01 ^{c}	12.57±0.00 ^{b}	15.75±0.01 ^{b}
C^{12}	29.93±0.01e	12.77±0.01 ^{d}	17.17±0.02 ^{d}
D^{24}	31.44±0.02 ^{g}	12.51±0.01 ^{f}	18.93±0.03 ^{f}
E^{36}	30.11±0.01 ^{f}	12.38±0.01e	17.74±0.02e
F^{48}	28.86±0.00 ^{d}	12.34±0 .01 ^{c}	16.53±0.01 ^{c}
G^{60}	26.72±0.01 ^{b}	10.21±0.01 ^{c}	16.51±0.02 ^{c}

Mean values with different superscripts within the same column are significantly different **($p < 0.05$)**

A: Chinchin from 100% wheat flour (Control)

B^{0}: Chinchin from 100% sorghum flour (No fermentation)

C^{12}: Chinchin from 100% sorghum flour (12hours Fermentation)

D^{24}: Chinchin from 100% sorghum flour (24hours Fermentation)

E^{36}: Chinchin from 100% sorghum flour (36hours Fermentation)

F^{48}: Chinchin from 100% sorghum flour (48hours Fermentation)

G^{60}: Chinchin from 100% sorghum flour (60hours Fermentation)

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The values for the oil uptake of the fried snack ranged from 17.71 to 12.42 with sample $\mathbf{B^{0}}$ having the highest value and sample $\mathbf{G^{60}}$ having the lowest values. The values were significantly different from each other ($p<0.05$). In line with study done by Elkhalifa & Bernhardt (2013), the values of the oil uptake by the fried snack decreased with an increase in fermentation period which could be as a result of decrease in water binding capacity of sorghum flour during fermentation.

Table III: Oil uptake for the Fermented Sorghum Chinchin (FSC)

Sample	Oil Content (Fried) (%)	Oil Content (Dough) (%)	Oil uptake (%)
A	**25.15±0.67**	**6.51±0.01g**	**18.64±0.69^{f}**
B^0	24.14±0.04	6.43±0.01^{f}	17.71±0.03^{ef}
C^{12}	22.65±0.04^{d}	5.19±0.01^{e}	17.46±0.06^{d}
D^{24}	21.02±0.94^{c}	5.05±0.04^{d}	15.97±0.98^{c}
E^{36}	20.14±0.04^{c}	4.92±0.02^{c}	15.22±0.01^{c}
F^{48}	18.24±0.01^{b}	4.66±0.06^{b}	13.58±0.07^{b}
G^{60}	16.28±0.04^{a}	3.87±0.04^{a}	12.42±0.08^{a}

Mean values with different superscripts within the same column are significantly different **(p <0.05)**

A: Chinchin from 100% wheat flour (Control)

B^0: Chinchin from 100% sorghum flour (No fermentation)

C^{12}: Chinchin from 100% sorghum flour (12hours Fermentation)

D^{24}: Chinchin from 100% sorghum flour (24hours Fermentation)

E^{36}: Chinchin from 100% sorghum flour (36hours Fermentation)

F^{48}: Chinchin from 100% sorghum flour (48hours Fermentation)

G^{60}: Chinchin from 100% sorghum flour (60hours Fermentation)

Colour analysis for Fermented Sorghum Chinchin (FSC)

Colour is an important aspect in the market. Consumer perceptions about some products are based on color and many foods are associated with a specific color. The surface color values of the chinchin were analyzed using a CIE lab color system L value. According to the L, a, b type of scales: L (lightness) axis—0 is black, 100 is white; a (red-green) axis—positive values are red; negative values are green and 0 is neutral; and b (yellow-blue) axis—positive values are yellow; negative values are blue and 0 is neutral.

Since lightness is a very important colour quality parameter, lower frying temperatures with lower boiling point of water are preferable to preserve the lightness and hence the attractiveness of fried products and so its adequate control is of utmost importance (**Mariscal & Bouchon, 2008**). Table IV shows the result of the colour analysis done for the chinchin samples.

For all the frying treatments in this study, L* values ranged from 43.12 to 34.64%. sample $\mathbf{B^0}$ had the highest and sample $\mathbf{G^{60}}$ had the lowest value. However, there was a significant difference between all the samples at (p<0.05) level of significance. There was a decrease in the lightness of the chinchin samples as a result of loss of lightness as the fermentation period increased. The a* values of the chinchin ranged from 9.94 to 9.19; sample $\mathbf{B^0}$ had the highest and sample $\mathbf{G^{60}}$ had the lowest value and there was a significant difference between all the samples at (p<0.05) level of significance. This shows that there is a decrease in the redness of the chinchin sample as fermentation is increased. The b* values ranged from 21.33 to 17.11 with sample **B⁰** having the highest and sample **G⁶⁰** having the lowest value and there was a significant difference between all the samples at ($p<0.05$) level of significance as fermentation is increased.

The colour values (a/b) ranged from 0.55 - 0.69 with sample **B⁰** having the lowest value and sample **G⁶⁰** having the highest value and there was a significant difference between all the samples at ($p<0.05$) level of significance and this shows that there is an decrease in the colour value with increased fermentation period and this is similar to the observation made by Hart et al. (1970), in which a darker colour was observed in the bread made by fermented sorghum flour. The dark colour could be as a result of higher reducing sugar content which undergoes non-enzymatic browning and the frying process. This showed that reducing sugars increased during fermentation as observed by Taur et al. (1984).

Table IV: Colour analysis for Fermented Sorghum Chinchin (FSC)

Sample	L*[1]	a*[2]	b*[3]	(a/b)[4]
A	**45.83±0.35[d]**	**14.43±0.16[c]**	**31.13±0.28[e]**	**0.67±0.01[c]**
B^0	43.12±0.37[c]	9.94±0.14[b]	24.3±0.35[d]	0.55±0.01[a]
C^{12}	38.4±0.05[b]	9.3±0.00[a]	20.15±0.01[c]	0.60±0.0[b]
D^{24}	37.40±0.2[b]	9.33±0.06[a]	17.89±0.44[b]	0.67±0.01[c]
E^{36}	37.29±1.04[b]	9.33±0.12[a]	17.16±0.06[a]	0.68±0.00[c]
F^{48}	37.11±1.67[b]	9.15±0.01[a]	17.18±0.04[a]	0.60±0.0[b]
G^{60}	34.64±0.45[a]	9.19±0.08[a]	17.11±0.08[a]	0.69±0.01[c]

[1] Lightness axis: 0 is black, 100 is white
[2] A red-green axis: positive values are red; negative values are green and 0 is neutral
[3] A yellow-blue axis: positive values are yellow; negative values are blue and 0 is neutral.
[4] Colour values

Mean values with different superscripts within the same column are significantly different **($p<0.05$)**

A: Chinchin from 100% wheat flour (Control)

B^0: Chinchin from 100% sorghum flour (No fermentation)

C^{12}: Chinchin from 100% sorghum flour (12hours Fermentation)

D^{24}: Chinchin from 100% sorghum flour (24hours Fermentation)

E^{36}: Chinchin from 100% sorghum flour (36hours Fermentation)

F^{48}: Chinchin from 100% sorghum flour (48hours Fermentation)

G^{60}: Chinchin from 100% sorghum flour (60hours Fermentation)

Texture profile analysis of Fermented Sorghum Chinchin (FSC)

Texture analysis is primarily concerned with measurement of the mechanical properties of a product, often a food product, as they relate to its sensory properties detected by human while applying controlled forces to the product and recording its response in the form of force, deformation and time. Texture measurements can be very valuable for the quality control and process optimization as well as for the development of new products with desirable properties and characteristics (Aly & Seleem, 2015).

The mechanical characteristics parameters are the hardness, springiness, adhesiveness and cohesiveness (Rosenthal, 2010). Texture analysis is an objective physical examination of baked products and gives explicit information on the product's quality (Szczesniak, 2002).

Table V shows the textural parameters assessed from texture profile analysis (TPA) test curves results of the chin-chin samples. Although hardness in snacks such as chin-chin is dependent on moisture content, moisture migration and redistribution of water, gluten-starch interactions (Pillar et al. 2005), the fermentation period has no much effect on the hardness of the chinchin samples. Sample **B⁰** has the lowest value for hardness and sample **E³⁶** has the highest values for hardness.

At the 48hr fermentation period (sample **F⁴⁸**), lowest value for springiness was recorded as shown in table V, this could be as a result of absence of gluten in the sorghum flour. Springiness refers to the rate at which a deformed product goes back to its un-deformed state, when the deforming force is removed while chewiness is the energy needed to masticate solid food to a state of readiness for mastication.

Table V: Texture profile analysis (TPA) of Fermented Sorghum Chinchin (FSC)

Sample	Hardness (N)	Springiness	Adhesiveness (N.s)	Cohesiveness	Chewiness (N)	Fracturability (N)	Gumminess (N)	Stringiness (mm)
A	**163.55 ± 0.21^{a}**	**0.02 ± 0.00^{a}**	**0.02 ± 0.01^{a}**	**0.04 ± 0.01^{a}**	**0.08 ± 0.00^{a}**	**23.45 ± 0.04^{a}**	**7.22 ± 0.01^{a}**	**4.53 ± 0.00^{f}**
B^{0}	297.4 ± 412.25^{ab}	0.12 ± 0.00^{d}	2.28 ± 0.06^{c}	0.13 ± 0.01^{d}	3.82 ± 0.00^{f}	34.64 ± 0.01^{c}	34.22 ± 0.01^{e}	4.37 ± 0.01^{e}
C^{12}	477.49 ± 1.03^{ab}	0.12 ± 0.00^{d}	0.03 ± 0.00^{a}	0.05 ± 0.00^{b}	3.49 ± 0.01^{e}	31.04 ± 0.01^{b}	31.66 ± 0.04^{d}	4.37 ± 0.01^{e}
D^{24}	585.65 ± 0.07^{b}	0.08 ± 0.01^{c}	0.23 ± 0.01^{b}	0.05 ± 0.00^{b}	1.12 ± 0.00^{c}	50.83 ± 0.01^{e}	31.38 ± 0.06^{c}	3.58 ± 0.01^{a}
E^{36}	585.91 ± 0.34^{b}	0.09 ± 0.00^{c}	0.01 ± 0.00^{a}	0.16 ± 0.00^{e}	2.16 ± 0.00^{d}	57.51 ± 0.11^{d}	46.14 ± 0.14^{g}	3.83 ± 0.00^{c}
F^{48}	332.2 ± 0.46^{ab}	0.06 ± 0.00^{b}	0.01 ± 0.00^{a}	0.08 ± 0.00^{c}	0.84 ± 0.00^{b}	41.9 ± 0.00^{e}	23.47 ± 0.07^{b}	3.76 ± 0.01^{b}
G^{60}	566.85 ± 0.92^{b}	0.08 ± 0.00^{c}	0.02 ± 0.00^{a}	0.15 ± 0.00^{e}	3.82 ± 0.01^{f}	76.4 ± 0.47^{g}	44.64 ± 0.01^{f}	3.92 ± 0.00^{d}

Mean values with different superscripts within the same column are significantly different **($p<0.05$)**. Values are means and standard deviations of two determination.

A: Chinchin from 100% wheat flour (Control)
B^{0}: Chinchin from 100% sorghum flour (No fermentation)
C^{12}: Chinchin from 100% sorghum flour (12hours Fermentation)
D^{24}: Chinchin from 100% sorghum flour (24hours Fermentation)
E^{36}: Chinchin from 100% sorghum flour (36hours Fermentation)
F^{48}: Chinchin from 100% sorghum flour (48hours Fermentation)
G^{60}: Chinchin from 100% sorghum flour (60hours Fermentation)

Sensory Characteristic of Fermented Sorghum Chinchin (FSC)

The result of the sensory evaluation of sorghum chin-chin are shown in Table VI. The colour, taste, texture, texture, aroma and overall acceptability of the composite chin-chin were not statistically different ($p>0.05$).

The result showed that the snack was liked for all the levels. In terms of colour, the values ranged from 7.65 to 6.25 with the control sample having the highest score and sample $\mathbf{B^{0}}$ having the lowest. In terms of texture, the values ranged between 7.20 and 6.40 with sample $\mathbf{F^{48}}$ having the highest score and sample $\mathbf{B^{0}}$ having the least score. The high score rating for sample $\mathbf{F^{48}}$ could be as a result of the hardness caused by increased fibre content due to fermentation which provides a crunchy sensation during mastication.

The texture was not statistically different ($p>0.05$) for all the samples. In a similar way, in terms of aroma, the mean values ranged from 6.9 to 6.40, with sample $\mathbf{D^{24}}$ having the highest and $\mathbf{F^{48}}$ having least score.

The high sensory score observed for aroma may be attributed to the development of flavour cause by the fermentation. No Significant difference ($p>0.05$) was observed for the samples. Taste ranged from 7.60 and 6.80 with sample $\mathbf{B^{0}}$ having the highest while sample $\mathbf{D^{24}}$ had the least. Sample for the control was the most acceptable followed by $\mathbf{G^{60}}$ while sample $\mathbf{E^{36}}$ was the least accepted. Generally, the overall acceptability increased with fermentation.

Table VI: sensory analysis for the Fermented Sorghum Chinchin (FSC)

Sample	Colour	Texture	Aroma	Taste	Overall Acceptability
A	**7.65 ± 1.27^{b}**	**7.1 ± 1.07^{a}**	**6.75 ± 1.12^{a}**	**7.0 ± 1.21^{a}**	**7.45 ± 1.00^{a}**
B^{0}	6.25 ± 1.37^{a}	6.4 ± 1.31^{a}	6.65 ± 1.53^{a}	7.6 ± 1.43^{a}	7.15 ± 1.42^{a}
C^{12}	6.65 ± 0.88^{a}	6.55 ± 1.1^{a}	6.55 ± 1.1^{a}	$6.\ 9\pm1.33^{a}$	7.25 ± 0.91^{a}
D^{24}	6.3 ± 1.53^{a}	6.6 ± 1.43^{a}	6.9 ± 1.33^{a}	6.8 ± 1.32^{a}	6.95 ± 1.23^{a}
E^{36}	6.35 ± 1.18^{a}	6.65 ± 0.93^{a}	6.35 ± 1.09^{a}	7.15 ± 1.18^{a}	7.0 ± 1.08^{a}
F^{48}	6.85 ± 1.23^{a}	7.2 ± 1.15^{a}	6.4 ± 1.05^{a}	7.35 ± 1.5^{a}	7.2 ± 1.15^{a}
G^{60}	6.5 ± 1.15^{a}	6.9 ± 1.37^{a}	6.85 ± 1.27^{a}	6.95 ± 1.28^{a}	7.40 ± 1.00^{a}

Mean values with different superscripts within the same column are significantly different **($p < 0.05$)**

A: Chinchin from 100% wheat flour (Control)

B^0: Chinchin from 100% sorghum flour (No fermentation)

C^{12}: Chinchin from 100% sorghum flour (12hours Fermentation)

D^{24}: Chinchin from 100% sorghum flour (24hours Fermentation)

E^{36}: Chinchin from 100% sorghum flour (36hours Fermentation)

F^{48}: Chinchin from 100% sorghum flour (48hours Fermentation)

G^{60}: Chinchin from 100% sorghum flour (60hours Fermentation)

CONCLUSION

This study examined how some sorghum chinchin properties were affected by the length of the fermentation process. The results obtained showed a notable increase in the protein content, fat content and dietary fibre while the carbohydrate content decreased with the fermentation period. Also, a high overall sensory acceptability was recorded for the fermented sorghum snack.

As the incidence of celiac disease rises, gluten-free cereals like sorghum are being investigated as alternatives to wheat. Snacks are very popular in Nigeria and are consumed by majority of the population. Consumption of Fermented Sorghum Chinchin (FSC) should be promoted as a healthy approach to boost nutrition, improve digestion, and lower dietary-related problems like celiac disease, obesity, and diabetes. In addition, fermentation is a cost-effective technology and this innovative product will provide prospective excellent economic benefits and will greatly improve the economic value of sorghum.

Further research work on the microbial status and anti-nutritional properties of fermented sorghum chinchin is recommended. Also, storage studies should be conducted on the finished product to determine the shelf stability of the snack.

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COMPETING INTERESTS

The authors declare no competing interest.

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