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Effect of Soybean, Sorghum and African Breadfruit Flours on the Proximate Composition and Sensory Properties of Chin-Chin

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Authors' contributions

This work was carried out in collaboration among all authors. Author JIE designed the study. Author RGU performed the statistical analysis and managed the analyses of the study as well as the literature searches. Author ECO wrote the manuscript, edited and wrote the protocol. All authors read and approved the final manuscript.

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ABSTRACT

This work investigated the proximate and sensory properties of chin-chin from the flour blends of wheat, African breadfruit, soybean, and sorghum. Chin-chin was produced from the blends of wheat: African breadfruit (BWF), wheat: soybean (SWF) and wheat: sorghum (SGW) in the ratios of 80:20, 70:30 and 60:40 for each blend and coded as BWF1, BWF2, BWF3 and SWF1, SWF2, SWF3 and SGW1, SGW2, SGW3 respectively. The control was 100% wheat flour (100:0) coded as WF. The proximate composition and sensory properties were determined. The results obtained show that partial substitution of wheat flour with breadfruit, soybean and sorghum flours caused a significant ($p < 0.05$) increase in the proximate composition of the samples. The crude protein content of samples BWF, SWF and SGW ranged from 15.73 to 19.34%, 19.2 to 24.62% and 9.11 to 10.73% respectively. The ash content of the samples ranged from 0.68 to 1.27%, 0.95 to 2.16% and 1.06 to 1.26% respectively and the crude fiber content ranged from 0.42 to 0.91%, 0.25 to 0.91% and 0.43 to 3.73% respectively. While the control sample (WF) had 13.08% of protein, 1.96% of ash and 0.80% of crude fiber. In terms of the overall acceptability, the control sample

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(WF) had the highest score (8.10) when compared with fortified samples followed by BWF3 (7.00). Although the control sample (WF) had the least nutrient contents compared to the fortified samples, yet, it was the most preferred by the panelists.

Keywords: African breadfruit; chin-chin; sensory properties; sorghum; soybean; wheat.

1. INTRODUCTION

Snacks contribute an important part of many consumers' daily nutrient and caloric intake [1]. The most widely consumed snacks are cereal-based products, which generally are low in nutrient density [2]. They are generally regarded as convenience food and have been part of the human diet for a long time and have contributed tremendously to the economy of every nation [3]. Snacks foods are easy to eat products, cheap and readily available on the streets, shops, high-ways (carried about by vendors) schools, churches, and among others. The demand for snacks is attributed to the rapid population and urbanization of both developed and developing countries. Fried products are the center of attraction for many consumers due to the aroma, feel and taste. The modern-day snacks involve the use of frying, baking and customary ingredients for the manipulation of cereal-based products, after which different products of related properties emerge.

Chin-chin is a fried snack popular in West African countries especially Nigeria. It is a sweet hard donut-like fried product which is sometimes baked dough of wheat flour, with eggs and other ingredients [4]. The flour is mixed to form an elastic dough that is properly kneaded, rolled and cut into desired shapes. The shaped flat dough is then deep-fried in hot vegetable oil and when it is slightly golden brown, it is scooped out to let oil drain [5].

Wheat flour has been the basic raw material in the bakery industry. In the past, wheat has been used for snack products such as bread, cakes, chin-chin, cakes and biscuits [6]. Nigerian climate is not favorable to produce wheat. Between 2012 and 2013, 100,000 tones were produced [7] which is not enough to meet demand. Thus, wheat importation is imminent as it is the only way to match the demand for wheat for baking and other purposes which is not favorable for the country's foreign exchange. As a result, a lot of research has been ongoing on the incorporation of non-wheat flour for baking and other purposes such as in bread and snack products [8].

Soybean (*Glycine max*) is a rich source of protein, fat, carbohydrate, vitamins, minerals, and water. It is regarded as a poor man's meat in developing countries where animal products are costly. It is used as the right substitute to mitigate the challenge of protein-energy malnutrition [9]. Soybean is an important inexpensive food crop containing several useful nutrients including prot ein, carbohydrate, vitamins, and minerals. Dry soybean contains 36% protein, 19% oil, 35% carbohydrate (17% of which dietary fiber), 5% minerals and several other components including vitamins [10]. Many leguminous crops provide some protein, but soybean is the only an available crop that provides an inexpensive and high-quality source of protein comparable to meat, poultry, and eggs [11].

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 [12]. Close to 50% of the land is devoted to sorghum and this makes the crop to be extensively grown in the country [13]. In Northern Nigeria, sorghum is widely processed into several food products [6]. Some are used as a snack, while others are used for alcoholic and non-alcoholic beverages such as burukutu and kunu. Sorghum grain is an important source of complex vitamins and some minerals like phosphorus, magnesium, calcium, and iron [14]. The protein content of sorghum is like that of wheat and maize, with lysine as the most limiting essential amino acid [15].

African breadfruit (*Trecullia africana*) belongs to the mulberry family *Moraceae* which is of African origin, but now being grown in the most tropical and subtropical countries [16]. African breadfruit is a wide jack fruit in some areas neglected and underexploited tropical tree [17]. It is a common forest tree in Nigeria used as a low-cost meat substitute for animal protein for poor families [18]. The seeds can be baked, toasted, boiled or fried before consumption. They can also be ground into flour which can be used as a substitute for wheat flour in bakery products [19]. The seeds are highly nutritious and constitute a cheap source of vitamins, minerals, proteins, carbohydrates, and fats. Proximate analysis showed that the seeds contain 17-23% crude protein, 11% crude fat and other essential vitamins and minerals [20].

2. MATERIALS

2.1 Source of Raw Materials

The wheat, soybean, sorghum, African breadfruit, and the ingredients were purchased from Ogige market in Nsukka, Enugu state.

2.2 Sample Preparation

2.2.1 Preparation of sorghum flour

Sorghum flour was produced according to the method of Ndife et al. [21] as shown in Fig. 1. The sorghum grains were weighed, sorted, cleaned to remove extraneous materials, washed, soaked (in water for six hours to reduce the anti-nutrient content) oven-dried (60°C for 12 h), milled and sieved (60 µm mesh size) to get fine flour.

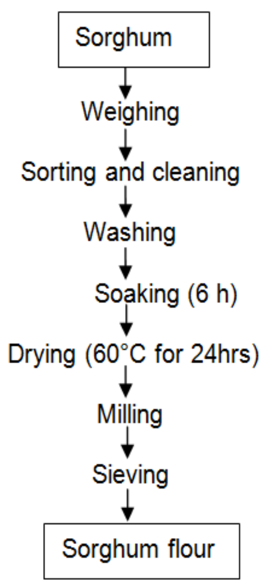

Fig. 1. Production of sorghum flour

2.2.2 Preparation of soybean flour

Fig. 2 shows the production of soybean flour according to the method of Okoye et al. [22]. The soybean seeds were cleaned, sorted, soaked (for 6 h to remove anti-nutrients content), dehulled, oven-dried (60°C for 12 h), milled and sieved (60 µm mesh size) fine flour.

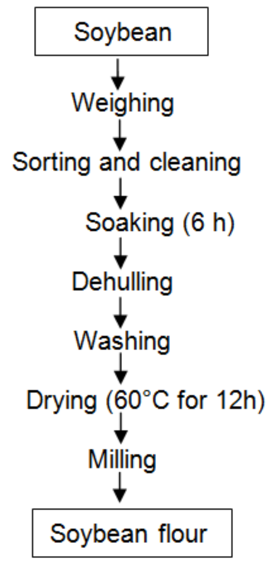

Fig. 2. Production of soybean flour

2.2.3 Preparation of breadfruit fruit flour

Breadfruit flour was prepared according to the method described by Ojoko et al. [23]. Fresh mature breadfruit was sorted, peeled and manually diced into a smaller size which was blanched (at 80°C for 10 min), oven-dried (65°C for 24 h), milled and sieved to obtain fine flour as shown in Fig. 3.

The formulation of flour blends from wheat, soybean, sorghum, and breadfruit is shown in Table 1 while the recipe to produce chin-chin is shown in Table 2.

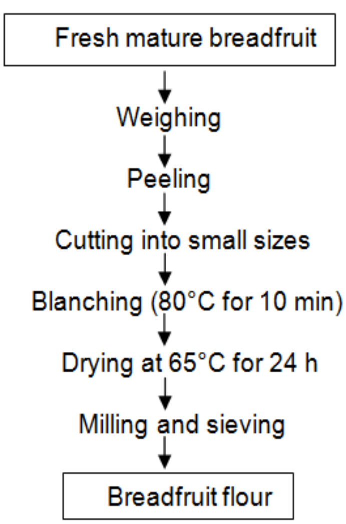

Fig. 3. Production of soybean flour

Table 1. Proportion of composite flour from the blends of wheat, soybean, sorghum and breadfruit flours

Sample codes	Blending ratio (%)
WF	100
BWF1	20:80
BWF2	30:70
BWF3	40:60
SWF1	20:80
SWF2	30:70
SWF3	40:60
SGWF1	20:80
SGWF2	30:70
SGWF3	40:60

Note: WF= 100% wheat flour, BWF1= 20% breadfruit flour + 80% wheat flour, BWF2= 30% breadfruit flour + 70% wheat flour, BWF3= 40% breadfruit flour + 60% wheat flour, SWF1= 20% Soybean flour + 80% wheat flour, SWF2= 30% Soybean flour + 70% wheat flour, SWF3= 40% Soybean flour + 60% wheat flour, SGWF1= 20% Sorghum flour + 80% wheat flour, SGWF2= 30% Sorghum flour + 70% wheat flour, SGWF3= 40% Sorghum flour + 60% wheat flour

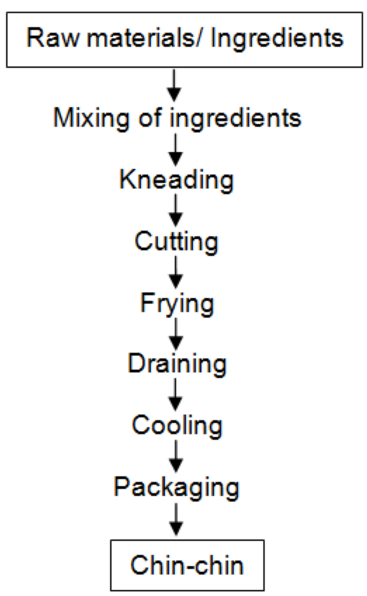

Fig. 4. Production of chin-chin

2.3 Preparation of Chin-chin

Flour, salt and nutmeg were first sieved into a bowl. Then margarine was mixed with flour evenly. Egg, sugar and other ingredients were added to make a stiff dough. The stiff dough was rolled tightly to a 1 (one) cm thickness on a board and cut into cubes. The cut dough was fried in deep hot vegetable oil at 180 Table °C for 8 mins until golden brown. The chin-chin was then drained, cooled and packaged in an airtight container as shown in Fig. 4.

Table 2. Recipes to produce chin-chin

Ingredients	Quantity
Flour	500 g
Egg	3
Nutmeg	10 g
Water	100 mL
Salt	10 g
Sugar	125 g
Milk	3 tablespoons
Pineapple	50 mL
Baking powder	2 tablespoons
Vegetable oil	500 mL
Butter	125 kg
Vanilla oil	5 mL

3. METHODS

3.1 Analyses

3.1.1 Proximate analysis of the samples

The crude protein, moisture, ash, fat and crude fiber contents of the products and flour samples were determined according to the standard method of AOAC [24]. The carbohydrate content of the sample was determined by difference as follows: % Carbohydrate= 100 - (% moisture + % ash + % protein + % fat + % crude fiber).

3.2 Sensory Evaluation of the Samples

Sensory evaluation of the samples was carried out using a 9-point Hedonic scale as described by AOAC [25]. Twenty (20) semi-trained panelists from the Department of Food Science and Technology, University of Nigeria, Nsukka did the evaluation. The 9-point Hedonic scale ranges from extremely like (9) to extremely dislike (1). Samples were presented in identical coded plates. Each sample was evaluated for flavor, color, taste, after taste, texture and overall acceptability.

3.3 Experimental Design and Statistical Analysis

The experimental design was Completely Randomized Design (CRD). The results obtained were analyzed using one-way analysis of variance (ANOVA). The means were separated using Duncan's New Multiple Range Test. Significance difference was accepted at $p < 0.05$ using Statistical Product for Service Solution (SPSS) version 20.0.

4. RESULTS AND DISCUSSION

4.1 Effect of Soybean, Sorghum and African Breadfruit Flours on the Proximate Composition of the Chin-chin Samples

The results of the proximate composition of chin-chin from the blends of wheat, soybean, sorghum and breadfruit flours are shown in the figures below.

The effect of the addition of soybean, sorghum and African breadfruit flours on the crude protein content of the samples is shown in Fig. 5.

The crude protein content of the chin-chin samples produced from blends of wheat, African breadfruit, and soybean and sorghum flours ranged from 9.11-24.62%. The protein content of sample BWF1 ranged from 15.73-19.34%. Among the breadfruit samples, sample BWF1 had the least mean value of 15.73% which agrees with the findings of [26]. Furthermore, Samples SWF1 and SGWF1 had protein contents ranging from 19.28-24.62% and 9.11-10.73%, respectively. Sample SGWF1 had the least protein content (9.11%), agreeing with 9.17% reported in the findings of Fasasi et al. [27], where the author compared the proximate composition of maize and sorghum, while it was higher than the 6.9% as reported by Sheorain et al. [28] on the production of bread from wheat and sorghum flour blends. Sample WF (control) had a protein content of 13.08%. This value is in line with 13.04% of protein from 100 % wheat as reported by Adegbola et al. [29] in his findings on the production of bread supplemented with soybean. Sample SWF3 had the highest protein content (24.62%) which is higher than 8 and 12% on the blends of whole wheat and soybean flour [21] but lower than 40% value reported by Oluwamukomi et al. [30]. Samples SWF (which contained soybean flour + wheat flour) had the highest protein contents while the samples containing sorghum flour had the least protein content. The relatively high protein content in the SWF samples could be attributed to the high protein content of soybean. Soybean is known as a rich protein source and it has been reported that soybean has up to 40% protein [30]. Also, 43% was earlier reported [31] on the pasting properties of African breadfruit. Of all the samples, samples BWF (samples containing breadfruit: wheat flours) and SWF (samples containing soybean: wheat flours) had higher protein content than WF (control sample containing 100% wheat flour), indicating that breadfruit and soybean flours have higher protein content than wheat flour and can be used in food formulations where high protein is desirable. The present study confirmed that the inclusion of legumes increased the protein content of the food product(s) as previously observed [32,33], which enriched the protein content of cookies and ''Ojojo'' (water yam fried ball) using African yam bean seed flour and rice bean flour respectively. There was a significant ($p < 0.05$) increase in the protein content of the fortified samples with an increase in the level of inclusion of the sorghum, soybean and breadfruit flours. However, the protein content of sample WF (control) was significantly ($p > 0.05$) lower than the fortified samples except for SGWF samples.

The effect of the addition of soybean, sorghum and African breadfruit flours on the ash content of the samples is shown in Fig. 6. The ash content of the samples ranged from 0.68-2.16%. Sample BWF1 had the least ash content (0.68%), this is lower than 3.4% [31] reported in his findings on 30% substitution of African breadfruit and soybean flour blends, while SWF3 had the highest ash content (2.16 %) which is in line with 2.55% from the findings of Akubor et al. [21]. The ash content of BWF samples ranged from 0.68-1.27%, sample BWF1 had the least value (0.68%) while BWF3 had the highest value (1.27%) which was lower than 5.5 reported by Endres et al. [31] on the 30% substitute on of breadfruit soybean flour. More so, samples SWF and SGWF had ash content that ranged from 0.95-2.16% and 1.06-1.26% respectively. It was observed that samples SWF and SGWF had relatively higher ash contents higher than that of sample WF (control). This is an indication that samples SWF and SGWF contained higher ash than sample WF, hence, higher mineral content. Ash content is an index of the mineral content of food products [34]. Samples BWF had lower ash content (0.68-1.27%) than sample WF (1.96%) indicating that the ash content of wheat is higher than that of the breadfruit which means that wheat has higher mineral content than breadfruit. There was a significant ($p < 0.05$) increase in the ash content of the fortified samples with an increase in the level of inclusion of the sorghum, soybean and breadfruit flours. However, the ash content of sample WF (control) was significantly ($p < 0.05$) higher than all the fortified samples except for sample SWF3.

The effect of the addition of soybean, sorghum and African breadfruit flours on the crude fiber content of the samples is shown in Fig. 7. The crude fiber contents of samples BWF, SWF, and SGWF ranged from 0.43-0.91%, 0.25-0.83%, and 0.43-3.73% respectively, while sample WF had the fiber content of 0.80%. Among the BWF samples, BWF1 had the lowest crude fiber content (0.42%) while sample BWF3 had the highest value (0.91%). Among the SWF samples, sample SWF1 had the lowest value (0.25%) of crude fiber content while sample SWF3 had the highest value (0.83%). Sample SGWF1 had the lowest value (0.43%) of fiber content while sample SGWF3 had the highest value (0.92%) among the SGWF samples. It was observed that the crude fiber contents of all the fortified samples were lower than the control sample (WF), except for samples BWF3, SWF3, and SGWF3. This may be as a result of the fiber content of the soybean, sorghum and African breadfruit flours with which the wheat flour was blended with before the production of the chin-chin samples. There was no significant ($p < 0.05$) difference between the crude fiber content of the control sample, WF and that of the chin-chin samples from the composites t a 20% level of wheat substitution. It was observed that the increase in the addition of soybean, sorghum, and African breadfruit flours caused an increase

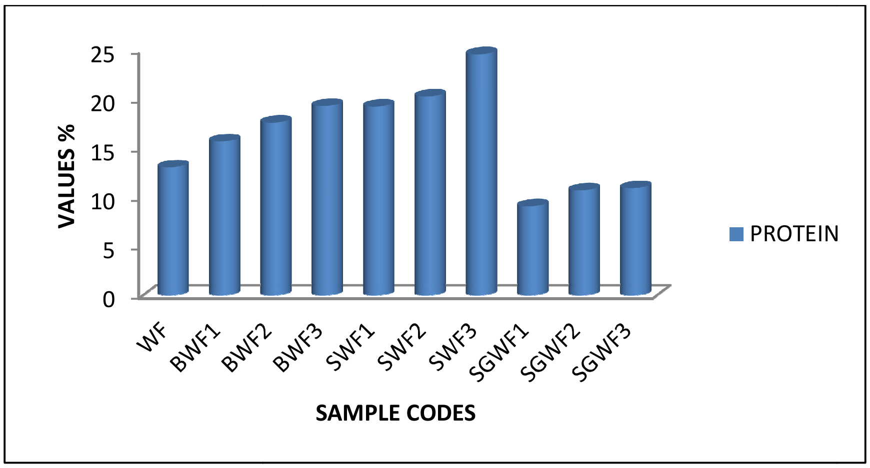

Fig. 5. Effect of soybean, sorghum and African breadfruit flours on the crude protein content of the samples

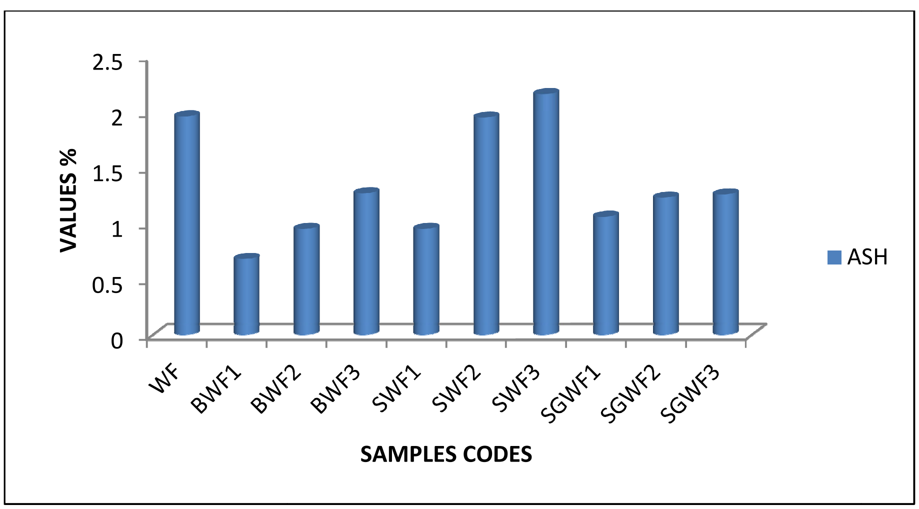

Fig. 6. Effect of soybean, sorghum and African breadfruit flours on the ash content of the samples

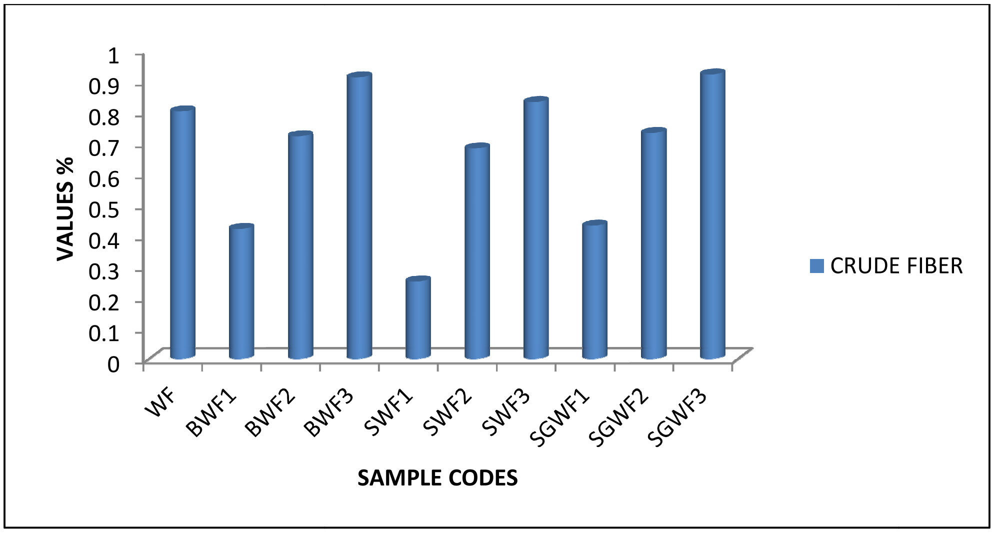

Fig. 7. Effect of soybean, sorghum and African breadfruit flours on the crude fiber content of the samples

in the crude fiber content of the fortified samples. This agrees with the work done by Okoye et al. [33,35], who enriched the protein content of ‘‘Ojojo’’ (water yam ball) and water flour with rice bean flour. It was observed that there was a significant ($p < 0.05$) increase in the crude fiber content of the fortified samples with an increase in the level of inclusion of the sorghum, soybean and breadfruit flours. But the crude fiber content of sample WF (control) was significantly ($p > 0.05$) lower than the fortified samples except for samples BWF3, SWF3, and SGWF3.

The effect of the addition of soybean, sorghum and African breadfruit flours on the fat content of the samples is shown in Fig. 8. The fat content of samples BWF ranged from 22.15-28.14%, SWF samples from 22.60-26.56% and SGWF samples from 17.56-22.56% while the control sample (WF) had 22.27%. Among all the samples, sample BWF3 had the highest fat content (28.14%) while SGWF3 had the least fat content (17.56%). It was observed that the fat content of samples BWF and SWF was higher than that of the control sample (WF), thus, there was an increase in the fat content of the samples with an increase in the inclusion of breadfruit and soybean flours. The relatively higher fat contents of samples BWF and SWF indicated that breadfruit and soybean have higher fat than wheat. African breadfruit and soybean have been reported to have fat content ranging from 13.5-24.3% [36] and 45% [37] respectively, and this could explain the reason for the relatively high-fat content of the chin-chin samples produced from their composite with wheat. The relatively high-fat content of the samples BWF and SWF would contribute to their palatability. However, samples BWF had the least fat content (17.56-22.56%), and this was found to decrease with increase in wheat flour substitution at 20, 30 and 40% and were lower than the 100% wheat chin-chin (22.27%) at 30 and 40% substitution (18.63 and 17.56% respectively). The lower fat content of samples SGWF is an indication that sorghum has a relatively low-fat content when compared to wheat, breadfruit, and soybean. The implication is that samples SGWF produced from sorghum-wheat composite will be less susceptible to rancidity than the chin-chin samples breadfruit and soybean counterparts. There was a significant ($p < 0.05$) increase in the fat content of the fortified samples with an increase in the level of inclusion of the sorghum, soybean and breadfruit flours except for SGWF samples which did not follow the same trend. The fat content of sample WF (control) was significantly ($p > 0.05$) lower than the fortified samples except for samples BWF1, SGWF2, and SGWF3.

The effect of the addition of soybean, sorghum and African breadfruit flours on the moisture content of the samples is shown in Fig. 9. The moisture content of the samples ranged from 3.02-6.12% where SWF1 had the least value (3.02%) of moisture content and sample SGWF1 had the highest moisture content (6.12%). The relatively high moisture content of SGWF1 (6.12%) could be attributed to its relatively high fiber content (3.73%) as fibrous foods can trap in more moisture than the less fibrous counterparts. However, the moisture content of the chin-chin samples was below 10% which normally would enhance the storage stability of the products as moisture enhances biochemical reactions that lead to food spoilage, thus, food products with low moisture content indicate better storage stability and keeping the quality. This high moisture content may also be attributed to the fact that sample SGWF1 was not properly packaged thus absorbed moisture which caused an increase in its moisture level. The moisture content of the samples conformed to the standard of Opara et al. [38], which stated that the moisture content of flour samples should not be higher than 14%. It was observed that the moisture content of sample WF (control) was significantly ($p > 0.05$) lower than that of the fortified samples except for sample SWF1.

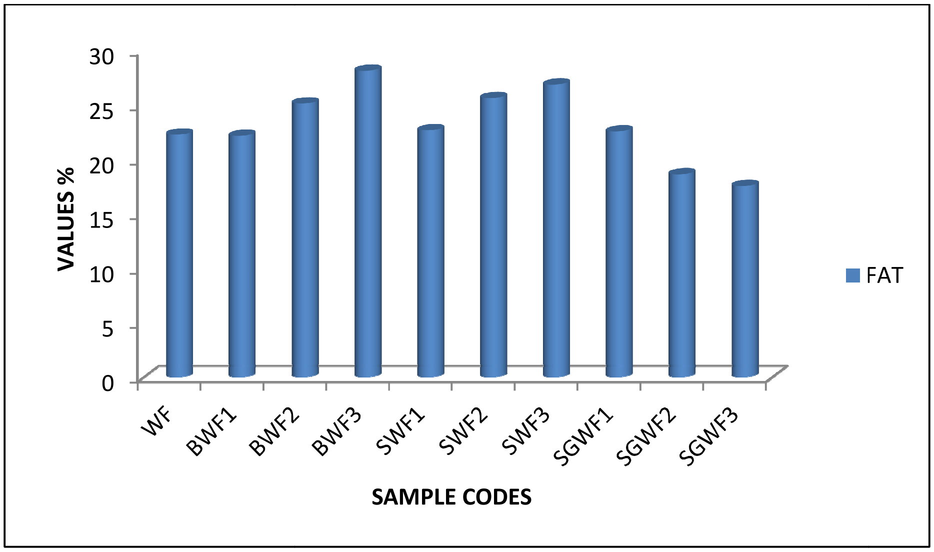

Fig. 8. Effect of soybean, sorghum and African breadfruit flours on the fat content of the samples

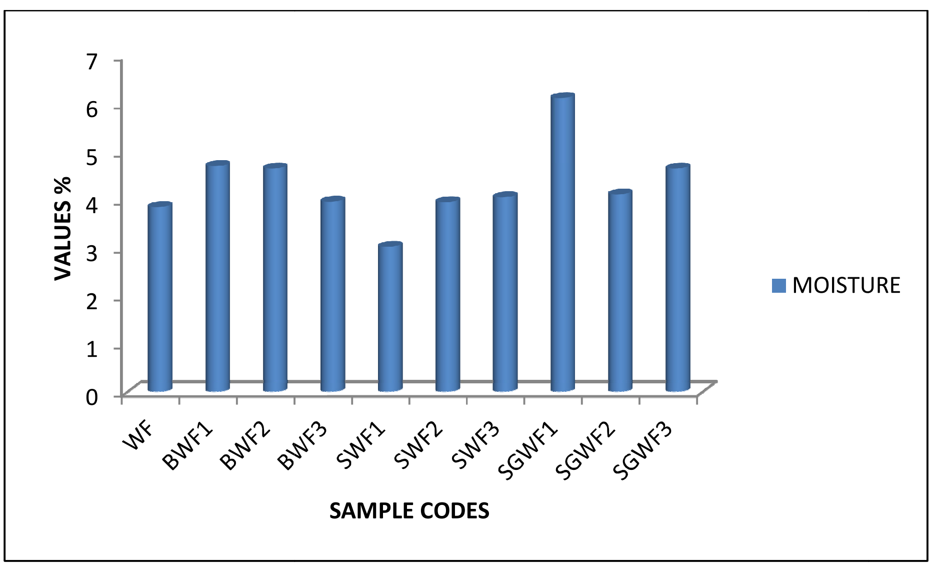

Fig. 9. Effect of soybean, sorghum and African breadfruit flours on the moisture content of the samples

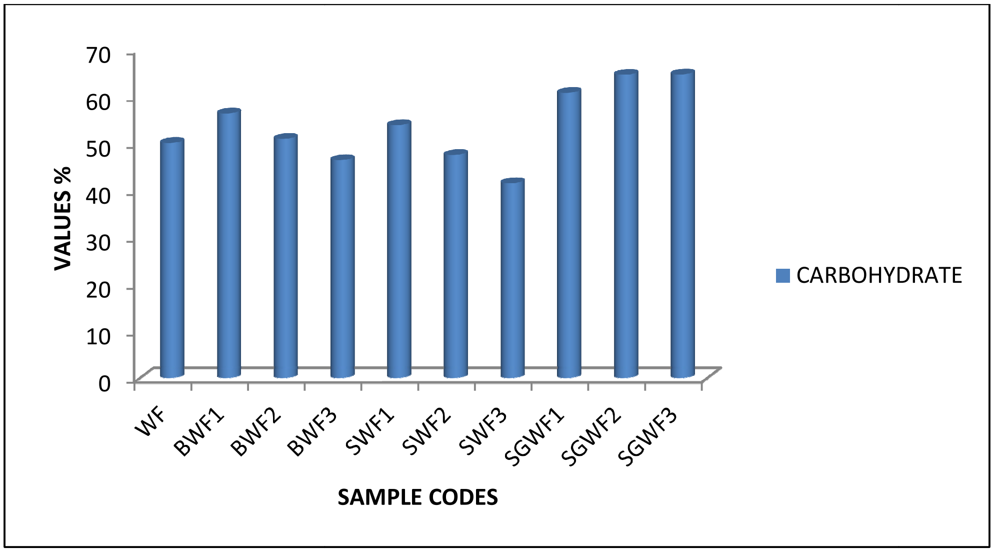

Fig. 10. Effect of soybean, sorghum and African breadfruit flours on the carbohydrate content of the samples

The effect of the addition of soybean, sorghum and African breadfruit flours on the carbohydrate content of the samples is shown in Fig. 10. The breadfruit: wheat (BWF), soybean: wheat (SWF) and sorghum: wheat (SGWF) chin-chin samples had carbohydrate contents that ranged from 46.38-56.32%, 42.14-53.41%, and 57.41-64.88% respectively, while the 100% wheat chin-chin (WF) had carbohydrate content of 58.04%. Sample SWF3 had the lowest value (42.14%) of carbohydrate while sample SCWF3 had the highest value (64.66%). It was observed that the carbohydrate content of sample WF (control) was significantly ($p < 0.05$) higher than the fortified samples except for SGWF samples. The lower carbohydrate contents of chin-chins from breadfruit: wheat and soybean: wheat composites could be as a result of their relatively high protein and fat contents from the added soybean and breadfruit flours which reduced the carbohydrate level of the samples. This could also be attributed to the fact that soybean and breadfruit flour added had higher bulk density than the sorghum flour which made to occupy more spaces during weighing and blending of the flours prior to the production of the chin-chin samples. It was observed that there was a significant ($p > 0.05$) decrease in the carbohydrate content of the fortified samples with an increase in the level of inclusion of the sorghum, soybean and breadfruit flours except for SGWF samples where significant ($p < 0.05$) increase occurred. However, the carbohydrate content of sample WF (control) was significantly ($p < 0.05$) higher than all the fortified samples except for samples from SGWF.

4.2 Sensory Scores of the Chin-chin Samples from the Blends of Wheat, Sorghum, Soybean and Breadfruit Flours

The sensory scores of the samples from the blends of African breadfruit, soybean, sorghum and wheat flour are shown in Table 3.

4.2.1 Color

The sensory scores for the color of the samples ranged from 6.10-7.95. Sample WF (control) had the highest score (7.95) which depicts that in terms of color it was the most preferred among all the samples, while SGWF2 had the least score (6.10) as shown in Table 3. Among all the fortified samples, SWF samples had the highest scores which ranged from 6.80 - 6.95 and increased with increase in the addition of soybean. This implies that the color of the samples was accepted by the panelists as the addition of soybean increased. The higher sensory scores observed in SWF samples could be attributed to the golden brown color of soybean flour which resulted to golden brown color of the chin-chin crust which the consumers found desirable as shown in Plate 1. There was a significant ($p < 0.05$) difference between sample WF (control) and other fortified samples.

4.2.2 Texture

The sensory scores for the texture of the samples ranged from 5.65-7.70 with the 100% wheat chin-chin (WF) having the highest score (7.70), while SGWF2 had the least score (5.65). It was observed that there was a significant ($p < 0.05$) increase in the scores as the increase in the level of inclusion of sorghum, African breadfruit and soybean flours increased. There was a significant ($p < 0.05$) difference between sample WF (control) and other fortified samples.

4.2.3 Flavor

The sensory scores for the flavor of the samples ranged from 5.70-7.85. Sample WF (control) had the highest score (7.85), while samples BWF1 and SGWF2 had the least scores. Among the fortified samples, sample SWF2 had the highest score (6.80), this could be as a result of the characteristic aroma of soybean flour which consumers are familiar with. There was a significant ($p < 0.05$) difference between sample WF (control) and other fortified samples.

Table 3. Sensory scores of chin-chin produced from wheat, breadfruit, soybean and sorghum flours

Sample	Color	Texture	Flavor	Taste	After taste	Overall acceptability
WF	$7.95^{a}\pm1.23$	$7.70^{a}\pm1.34$	$7.85^{a}\pm1.09$	$7.95^{a}\pm1.19$	$7.50^{a}\pm1.24$	$8.10^{a}\pm0.91$
BWF1	$6.75^{b}\pm0.97$	$6.35^{bc}\pm1.23$	$5.70^{c}\pm1.49$	$5.70^{b}\pm1.53$	$5.50^{bc}\pm1.50$	$5.75^{c}\pm1.07$
BWF2	$6.85^{b}\pm1.14$	$6.60^{bc}\pm1.39$	$6.20^{bc}\pm1.61$	$6.40^{b}\pm1.54$	$6.05^{bc}\pm1.23$	$6.55^{bc}\pm1.05$
BWF3	$6.70^{b}\pm1.66$	$6.65^{b}\pm1.53$	$6.80^{b}\pm1.28$	$6.70^{b}\pm1.45$	$6.20^{bc}\pm1.47$	$7.00^{b}\pm1.41$
SWF1	$6.80^{b}\pm1.15$	$6.50^{bc}\pm1.05$	$6.30^{bc}\pm1.30$	$6.50^{b}\pm1.47$	$6.25^{bc}\pm1.74$	$6.35^{bc}\pm1.60$
SWF2	$6.90^{b}\pm1.25$	$6.40^{bc}\pm1.50$	$6.80^{b}\pm1.40$	$6.20^{b}\pm1.64$	$5.75^{bc}\pm1.65$	$6.50^{bc}\pm1.57$
SWF3	$6.95^{b}\pm1.36$	$6.40^{bc}\pm1.31$	$6.15^{bc}\pm1.93$	$5.70^{b}\pm1.87$	$5.85^{bc}\pm1.73$	$6.10^{bc}\pm1.59$
SGWF1	$6.70^{b}\pm1.45$	$6.60^{bc}\pm1.19$	$6.55^{bc}\pm1.00$	$6.85^{b}\pm1.14$	$6.50^{b}\pm1.10$	$6.90^{b}\pm1.12$
SGWF2	$6.10^{b}\pm1.33$	$5.65^{c}\pm1.84$	$5.70^{c}\pm1.22$	$5.75^{b}\pm1.80$	$5.35^{c}\pm1.14$	$5.70^{c}\pm1.98$
SGWF3	$6.40^{b}\pm1.19$	$6.75^{b}\pm1.21$	$6.15^{bc}\pm1.76$	$6.70^{b}\pm1.95$	$6.40^{bc}\pm1.96$	$6.30^{bc}\pm2.08$

Note: Mean ± SD of triplicate determinations. Mean values along the same column with the same super scripts are not significantly (p < 0.05) different. WF= 100 % wheat flour, BWF1= 20 % breadfruit flour + 80 % wheat flour, BWF2= 30% breadfruit flour + 70% wheat flour, BWF3= 40% breadfruit flour + 60 % wheat flour, SWF1= 20% Soybean flour + 80 % wheat flour, SWF2= 30 % Soybean flour + 70% wheat flour, SWF3= 40% Soybean flour + 60% wheat flour, SGWF1= 20% Sorghum flour + 80% wheat flour, SGWF2= 30% Sorghum flour + 70% wheat flour, SGWF3= 40% Sorghum flour + 60% wheat flour

Plate 1. Chin-chin samples from the blends of wheat, soybean, sorghum and breadfruits
Note: WF= 100% wheat flour, BWF1= 20% breadfruit flour + 80% wheat flour, BWF2= 30% breadfruit flour + 70% wheat flour, BWF3= 40% breadfruit flour + 60% wheat flour, SWF1= 20% Soybean flour + 80% wheat flour, SWF2= 30% Soybean flour + 70% wheat flour, SWF3= 40% Soybean flour + 60% wheat flour, SGWF1= 20% Sorghum flour + 80% wheat flour, SGWF2= 30% Sorghum flour + 70% wheat flour, SGWF3= 40% Sorghum flour + 60% wheat flour

4.2.4 Taste

The sensory scores for the taste of all the samples ranged from 5.70-7.95 with the sample WF (control) having the highest score (7.95) while sample BWF1 had the least score (5.70). The scores for taste for samples BWF ranged from 5.70-6.70, and it increased with increase in the addition of breadfruit flour. This could be attributed to the taste of breadfruit which was found out to be higher and better at higher concentration. Samples SWF had sensory scores for taste ranging from 5.70-6.50 and this decreased with increase in soybean addition. It could be that, at higher concentrations of soybean, the consumers no longer found the taste of the samples' desirable. Scores for the taste of samples SGWF ranged from 5.75-6.85. There was a significant ($p < 0.05$) difference between sample WF (control) and other fortified samples.

4.2.5 After-taste

The chin-chin samples had sensory scores ranging from 5.35-7.50 with SGWF2 having the least score (5.35) and sample WF (control) the highest score. The sensory scores for after-taste of samples BWF increased (5.50-6.20) with an increase in the addition of breadfruit flour, while in samples SWF, the scores of the after-taste decreased as the inclusion of soybean flour increased. There was a significant ($p < 0.05$) difference between sample WF (control) and other fortified samples.

4.2.6 Overall acceptability

Scores for overall acceptability of the chin-chin samples ranged from 5.70-8.10. Sample WF (control) had the highest score (8.10) while BWF1 (20:80 breadfruit: wheat chin-chin) had the least score (5.70). Samples BWF had the overall acceptability scores ranging from 5.75-7.00 and this increased with increase in the addition of breadfruit flour. This means that the consumers preferred the samples BWF at higher concentration of the breadfruit. For samples SWF, the overall acceptability scores ranged from 6.10-6.50 and were highest at 30% soybean addition and lowest at 40% soybean addition. This means that beyond 30% soybean addition, the consumers found the chin-chin samples less appreciable. Overall acceptability scores for samples SGWF ranged from 5.70-6.90 and were highest at 10% sorghum addition and lowest at 30% sorghum addition. There was a significant ($p < 0.05$) difference between sample WF (control) and other fortified samples. It was observed from the sensory scores of all the samples that sample WF (control) scored the highest, this was the most preferred of all the samples by the panelists, followed by sample BWF3 (30% breadfruit: wheat chin-chin). The preference for sample WF may be since the panelists are most conversant with the chin-chin produce from wheat flour.

5. CONCLUSION AND RECOMMENDATIONS

Incorporation of breadfruit, soybean, and sorghum in the composites for chin-chin production affected the proximate composition and sensory properties of the chin-chin samples. The use of African breadfruit, soybean, and sorghum improved the nutritional content of the chin-chin samples with respect to their proximate composition. The chin-chin samples containing breadfruit and soybean recorded high protein contents which were higher than the 100% wheat chin-chin and the chin-chin samples containing sorghum recorded high ash content higher than the 100% wheat chin-chin. This means that African breadfruit, soybean, and sorghum can be used in a composite with wheat for chin-chin production in order to improve the nutritional adequacy of chin-chin and snack foods in general. Sensory scores showed that the chin-chin samples were acceptable as none of the samples had a sensory score less than 5.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Rodriguez-Miranda J, Ruiz-López II, Herman-Lara E, Martínez-Sánchez CE, Delgado-Licon E, Vivar-Vera MA. Development of extruded snacks using taro (*Colocasia esculenta*) and nixtamalized maize (*Zea mays*) flour blends. LWT-Food Science and Technology; 2011.
2. Da Silva MC, De Carvalho CWP and Andrade CT. The effects of water and sucrose contents on the physicochemical properties of non-directly expanded rice flour extrudates. Cienc Tecnol. Aliment. 2009;29:3.
3. Lasekan OO and Akintola AM. Production and nutritional evaluation of puffed soy maize snacks. J. Cereal Sci. 2002;24:79-85.
4. Akubor PI. Protein content, physical and sensory properties of soybean/maize flour blends for food preparation. Proceeding of the 28th Annual Conference/AGM Nigeria Institute of Food Science and Technology, Ibadan, October, 2004;21–14:46–47.
5. Mepba HD, Ebon L, Nwaojigwa SU. Chemical composition, functional and baking properties of wheat plantain composite flours. African J. Food Agric. Nutr. Dev. 2007;7(1):1-22.
6. Opara CC, Edem UB, Anierobi BU. Deep fat frying properties of malted sorghum buns with cassava and rice flour as binders. Greener J. Agric. Sci. 2013;3(2): 185-192.
7. USDA. USDA Foreign Agricultural Service, Gain Report, Global Agricultural Information Network; 2012. Available:https://gain.fas.usda.gov/Pages/Default.aspx
8. Gomez MI, House LR, Rooney L, Dendy D. Proceedings of International Symposium on Utilization of Sorghum and Millets. ICRISAT. 1992;4:1-22.
9. Nath A, Chattopadhyay KP. Effect of process parameters and soil flow concentration in quality attribute and microstructure changes in ready-to-eat potato soy snacks using high temperature short time air puffing. Agricultural and Food Engineering Department, Indian Institute of Technology; KharangPur, India. 2007;721-302. Liu K.S. Chemistry and Nutritional Value of Soybean Components. In: Soybean: Chemistry, Technology, and Utilization. New York: Chapman & Hall. 1997;25-113.
10. Food and Agriculture Organization (FAO). Oilseeds. Washington D.C; 2007.
11. Riaz MN. Soy Applications in Food. Boca Raton, FL: CRC Press. 2006;39.
12. Liu L, Herald TJ, Wang D, Wilson JD, Bean SP, Aramuni FM. Characterization of Sorghum grain and evaluation of sorghum flour in a Chinese egg noodle system. J. Cereal Sci. 2012;55:31-36.
13. Aba DA, Idem, NUA, Marley, PS, Maigida DA. Sorghum. In Cereal Crops in Nigeria: Principles of Production and Utilization, 38-73. Idem, N. U. A. and Showemimo, F. A.

(Eds). Ade Commercial Press, Zaria; 2004.
14. Onabanjo OO, Akinyemi CO, Agbon CA. Characteristics of complementary foods produced from sorghum, sesame, carrot, and crayfish. J. Natural Sci. Engineering, and Technol. 2009;8(1):71–83.
15. FAO. Maize, Rice, and Wheat: Area Harvested, Production Quality and Yield. Food and Agriculture Organization of the United Nations, Rome, Italy. 2009;105–112.
16. Agu HO, Ayo JA, Paul AM, Folorunsho F. Quality characteristics of biscuits made from wheat and African breadfruit (*Treculia africana*). Nig. Food J. 2007;25(2):19-27.
17. Osuji JO, Owei SO. Miotic index studies on Treculia Africana Decne in Nigeria. Australian J. Agric. Engineering. 2010;1(1): 25-28.
18. Badifu GIO, Akubor PI. Influence of pH and sodium chloride on selected functional and physical properties of African breadfruit (*Treculia africanadecne*) kernel flour. Plant Foods for Human Nutri. 2001;56:105-115.
19. Ijeh II, Ejike CE, Nkwonta OM, Njoku BC. Effect of traditional processing techniques on the nutritional and phytochemical composition of African breadfruit (*Treculia africana*) seeds. J. Appl. Sci. Env. Management, 2010;14(4):169-173.
20. Akubor PI, Isolukwu PC, Ugbabe O, Onimawo IA. Proximate composition and functional properties of African breadfruit kernel and wheat flour blends. Food Res. Int. J. 2000;33:707-712.
21. Ndife J, Abdulraheem OL, Zakari MU. Evaluation of the nutritional and sensory quality of functional bread produced from whole wheat and soya bean flour blends. African J. Food Sci. 2011;8:466-472.
22. Okoye JI, Nkwocha AC, Ogbonnaya AE. Production, proximate composition and consumer acceptability of biscuits from wheat/soybean flour blends. Continental J. Food Sci. Technol., 2008;2:6-13.
23. Ojoko AO, Fayemi OE, Ocloo FCK, Alakija O. Proximate composition, antinutritional and physiochemical properties of breadfruit (*Treculia Africana*) and cowpea (*Vigna unguiculata*) flour blends fermented with *Lactobacillus plantarum*. African J. Microbiol. Res., 2014;8(12):1352-1359.
24. AOAC. Official Methods of Analysis of the Association of Official Analytical Chemists, 18th edition. Gaithersburg, Maryland, U.S.A; 2010.
25. Ihekoronye AI, Ngoddy PO. Integrated food science and technology for the tropics. London: Macmillian Education Ltd. 1985;272-273.
26. Fasasi OS, Eleyinmi AR, Fasasi AR, Karim OR. Chemical properties of raw and processed breadfruit (*Treculia africana*) seed flour. Food, Agric. and Env. 2004; 2(1):65-68.
27. Sheorain V, Banka R, Chavan M. Ethanol production from sorghum. Technical and institutional options for sorghum grain MOLD management: Proceedings of an International Consultation, ICRISAT, Patancheru, India. 2000;228–239.
28. Adegbola AJ, Awagu EF, Kamaldeen, OS, Kashetu RQ. Sorghum: Most under-utilized grain of the semi-arid Africa. Scholarly J. Agric. Sci. 2003;3(4):147-153.
29. Oluwamukomi MO, Oluwalana IB, Akinbowale OF. Physiochemical and sensory properties of wheat-cassava composite biscuit enriched with soy flour. African J. Food Sci. 2011;5(2):50-56.
30. Endres JG. Definitions and methods of preparation. In: Endres JG (ed) Soy Protein Products: Characteristics, Nutritional Aspects, and Utilization. AOCS Press, Champaign, IL. 2001;4-8.
31. Appiah F, Oduro I, Ellis WO. Pasting properties of *Treculia africana* seed flour in Ghana and the production of a breakfast meal. Agric. Biol. J. North Am. 2011;2(2): 325-329.
32. Okoye EC, Onyekwelu CN. Production and quality valuation of enriched cookies from wheat, african yam bean, and carrot composite flours. Annals. Food Sci. Technol. 2018;19(1):1-6.
33. Okoye EC, Okoyeuzu CF, Eze CM, Asogwa IS, Njoku EU. Proximate composition of composite flour from the blends of water yam (*Dioscorea alata*) and rice bean (*Vigna umbellata*). Book of Abstracts of the 4th Regional Food Science and Technology Summit (ReFoSTS) of NIFST East Central Chapter, Awka. 2018a;175-176.
34. Ojinaka MC, Emeh TC, Okorie SU. Evaluation of the quality of composite maize-wheat chinchin enriched with Rhynchophorous phoenicis. J. Food Res. 2016;5(4):19-27.
35. Okoye EC, Eze CM, Njoku EU. Effect of rice bran flour on the proximate and

sensory properties of ''Ojojo''- water yam fried ball (Poster presentation). At the 3rd African Conference/ Workshop on the Application of Nanotechnology to Energy, Environment, Agriculture, and Health. Theme- Nanotechnology: Key to National and Industrial Development at Princess Alexandra Auditorium (PAA), University of Nigeria, Nsukka; 2018b.

36. Enwere NJ. Foods of Plant Origin. Nsukka: Afro-orbis Publications Limited; 1998.
37. Opara MN, Sanyigha FT, Ogbuewu IP, Okoli IC. Studies on the production trend and quality characteristics of palm grubs in the tropical rainforest zone of Nigeria. J. Agric. Technol. 2012;8(3):851-86.
38. Food and Agricultural Organization. The standard for Wheat Flour. 1985;2.

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