Agr. Foo. Nat. Res. J. Volume 3, Issue 2, Page 275 - 281

e-ISSN: 1597-7153 | p-ISSN: 3043-5420

Agriculture, Food and Natural Resources Journal

The Official Journal of the Faculty of Agriculture, Nnamdi Azikiwe University, Awka, Nigeria

Journal homepage: https://journals.unizik.edu.ng/afnrj

Original Article

Chemical composition and sensory characteristics of cookies produced from wheat and African yam bean flours

OPEN ACCESS

Oladotun Olakanmi OGUNTOYINBO*, Iniobong Gloria UDOH & Isaiah Babatunde ADEYEMI

Department of Food Science and Technology, Lagos State University of Science and Technology, Ikorodu, Lagos State, Nigeria.

DOI: https://www.doi.org/10.5281/zenodo.14179858

Editor: *Dr Onyekachi Chukwu, Nnamdi Azikiwe University, NIGERIA*

Received: *June 17, 2024*
Accepted: *August 26, 2024*
Available online: *September 30, 2024*

Peer-review: *Externally peer-reviewed*

Copyright: © 2024 Author(s)
This is an open access article under the licensed under Creative Commons Attribution 4.0 International License (https://creativecommons.org/licenses/by/4.0/) which permits unrestricted use distribution, and reproduction in any medium, provided the original author and source are credited.

Conflict of Interest: The authors have no conflicts of interest to declare

Financial Disclosure: *The authors declared that this study has received no financial support*

ABSTRACT

This study was conducted to evaluate the nutritional quality of composite cookies produced from blends of wheat and African yam bean flours. The proportion of wheat and African yam bean flours was varied to obtain five (5) samples, which include 100:0, 90:10, 80:20, 70:30, and 60:40%, respectively. The proximate and mineral composition of the cookies were determined using standard methods. The sensory characteristics of the composite cookies were also determined. The proximate composition of the composite flour showed that the moisture content, crude protein, crude fat, crude fibre, total ash, and carbohydrate ranged from 1.33-3.50%, 6.44 to 13.56%, 8.33 to 14.33%, 0.42-0.88%, 1.32-2.77% and 71.37-81.38%, respectively. The mineral elements of the composite cookies significantly ($p < 0.05$) increased with an increase in African yam bean flour inclusion. The sensory attributes such as colour, appearance, aroma, taste, crispiness, and overall acceptability of cookies were rated high between like moderately and like extremely with the control sample being rated as the best sample, followed closely by the sample with 10 and 30% African yam bean flour, respectively. Conclusively, the present study showed that substitution of wheat flour with African yam bean flour in cookie production significantly ($p < 0.05$) increased the total ash, crude fibre, crude fat, protein contents, and mineral elements of the composite cookies. The production of acceptable cookies by substituting wheat flour with African yam bean can therefore be harnessed because of its contribution to the nutritional properties of the cookies produced.

K E Y W O R D S : *African Yam Bean Flour, Composite Cookies, Mineral Elements, Nutrition, Proximate*

INTRODUCTION

Cookies are ready-to-eat and convenient food that forms part of the bakery products that are consumed extensively all over the world by all ages (Sengev *et al*., 2015). According to Data Bridge Market Research, (2024) the cookies market is expected to grow by USD 28.36 billion at a compound annual growth rate (CAGR) of 6.82% between 2023 and 2028. Cookies have a longer shelf life and are more resistant to microbial spoilage due to their less content moisture than baked goods like bread and cakes (George *et al*., 2023). They often contain flour, sugar, and some sort of oil or fat and are typically larger and softer than other types of biscuits (Ani and Okoye, 2021). These quick, nutritious snacks are frequently prepared using a range of techniques, some of which require using unappetizing dough that is baked to produce a delicious end product (Adelakun *et al*., 2021).

*Corresponding author: obalomo2016@gmail.com; +2347035081157

African Yam Beans (*Sphenostylis stenocarpa*) are underutilized food legumes that are often grown in most Sub-Saharan African countries for their edible seeds and tubers (Udo *et al*., 2024). The seed's protein content ranges from 19 to 30%, making it a nutritious food (Ade-Omowaye *et al*., 2015; Duodu and Apea-Bah, 2017; Anya and Ozung, 2019). The protein content of AYB is comparable to that of common beans, chickpeas, pigeon peas, and Bambara. In addition, the bean has higher or equivalent levels of dietary fiber (Baiyeri *et al*., 2018; Anya and Ozung, 2019), carbohydrates (Ndidi *et al*., 2014; Ajibola and Olapade, 2016), and vital minerals like calcium, iron, zinc, and magnesium than soy and common beans (Adamu *et al*., 2015). According to Ade-Omowaye *et al*., (2015) and Chinonyerem *et al*., (2017) essential amino acids can be found in abundance in the beans.

Nigeria spends more than $2 billion a year on the importation of more than five million metric tonnes of wheat, making it the second largest contributor to the country's food import bill and placing strain on its foreign reserve (CBN, 2021). As a result of population growth, shifting dietary preferences, and a strong urbanization trend, wheat consumption has been steadily rising in all African countries over the past 20 years, creating a growing "food gap" that is mostly filled by imports, according to Abah and Ochoche (2021). 90–95% of the wheat consumed is imported from the United States of America, according to Abah *et al*., (2023). Due to the high expense of baked goods made from wheat, more Nigerian households than ever before are turning to wheat derivative meals to meet their nutritional demands (Falola *et al*., 2017; Umar and Muhammad, 2021). This research work therefore aimed at producing healthy and more nutritional beneficial composite cookies from African yam bean and wheat composite flour.

MATERIALS AND METHODS

The raw materials (African yam bean, (*Sphenostylis stenocarpa*), wheat flour, margarine, sugar, milk powder, were purchased from Sabo market in Ikorodu Local Government Area of Lagos State, Nigeria. The raw materials were selected with absolute care to ensure wholesomeness and freedom from diseases, and defects. The equipment used were oven (tom bake oven), weighing balance (TCS model), bowls, baking pans, biscuit cutter, nylon (polythene bags) and rolling pin.

Processing Method of African Yam Bean (*Sphenostylis stenocarpa*) Flour

The cultivars of African yam bean (*Sphenostylis stenocarpa*) were processed into flour using modified method described by Okoye *et al.* (2015). The bean were sorted to remove defective portions and then soaked in clean water for 24 h after which they were dehulled manually by rubbing rigorously between the palms. The dehulled beans were then dried at 72°C for 4 hrs. The dried dehulled beans were milled using the hammer mill machine (Tigerextruda 6.5 hp, UK) which was sieved into fine flour with 250 micron sieve. The processed flour was packaged in polyvinyl chloride bag and stored at room temperature (27 ^{0}C) until use.

Formulation of the Composite Flour Blends

Five different samples of cookies were produced and coded as EF4, IJ5, KT9, GH7 and KL2. Sample EF4 served as the control and contained 100% wheat flour. Sample IJ5, KT9, GH7 and KL2 consisted of wheat and African yam bean flour at the ratio of 90:10, 80:20, 70:30 and 60:40 respectively.

Preparation of Wheat-African Yam Bean Cookies

Cookies were produced using a modified method of George *et al.* (2023). The recipe used for the preparation of cookies contained 100g flour, 40g sugar, 50g fat, 2g milk powder, 2g salt and 5g beaten egg. During preparation, the flours, margarine and sugar were manually mixed in a bowl until a good texture was obtained. Other ingredients (salt, milk powder, beaten egg) were added and mixed thoroughly with spiral mixer (CM. 120) to form a dough. The dough was placed in a clean table, rolled and cut out into required shapes, baked in an oven (tom bake TCS) at 180°C for 30 minutes. After which the cookies were cooled at room temperature (30±20C) and divided into two (2) lots. The first lot was subjected to sensory evaluation after 24 h. The second lot was milled and used for chemical analyses. In addition, the cookies made with 100% wheat flour were similarly prepared and used as control.

Proximate analysis

The method of AOAC method (AOAC, 2019) was used for the determination of moisture content, crude protein, crude fat, total ash and crude fibre contents of the samples. The carbohydrate content was calculated by difference. % Carbohydrate = 100% - (%Protein + % Ash + % Crude fibre + % Fat + % Moisture).

Mineral Analysis

Determination of calcium, zinc and sodium was by Atomic Absorption Spectrophotometer (AAS), while potassium and phosphorus was determined by flame photometry method following AOAC procedures (2005).

Sensory Evaluation

The sensory evaluation was carried out according to the method described by Adeyanju *et al*., (2021). Thirty (30) untrained panelists randomly selected from the staff and students of Lagos State Polytechnic, Ikorodu campus, Lagos State, Nigeria. Water was provided for rinsing between the samples. The organoleptic attributes assessed include colour, taste, aroma, crispiness, appearance and overall acceptability of the cookies using the 9-point hedonic scale with 1 dislike extremely and 9 like extremely.

Statistical Analysis

Results from the proximate analysis, mineral analysis and sensory evaluation were subjected to analysis of variance (ANOVA). The results were presented as means standard deviation using SPSS windows version 21. Duncan multiple range test was used to separate the means and significant difference was judged at $P< 0.05$.

RESULTS AND DISCUSSION

Proximate Composition of Cookies Produced from Wheat and African Yam Beans Composite Flour

The proximate composition of cookies produced from wheat and African yam beans composite flour is shown in Table 1. These analyses are important for determination of food quality, microbial stability and can be used for nutritional labeling. It also determines the storage ability and quality of flour and susceptibility to microbial contamination (Al-Marazeeq, and Angor, 2017). The moisture content ranged from 1.33-3.50%. The highest moisture content was observed in sample KL2 (60:40 wheat:African yam bean flours) while the lowest value was recorded in sample EF4 (control). It was observed that moisture content increased with inclusion of African yam beans flour. However, the moisture contents recorded in this study were relatively lower to the range 7.85 to 9.71% reported by Adeyanju *et al*., (2021) for cookies from wheat, African yam bean and acha flours. The moisture contents were also lower than the range 10.83% to 12.63% reported by Jimoh (2021) for cookies produced from wheat flour fortified with tiger nut and palm date. The low moisture content recorded in this study will therefore increase the stability and shelf life of the cookies. Significant difference ($p< 0.05$) existed among the samples. The protein content of the composite cookies significantly ($p < 0.05$) increase from 6.44 to 13.56% with increase in African yam bean. The increase in protein content established the fact that African yam bean is a rich source of protein as reported by George *et al*., (2023). The protein content reported in this study corroborates with the range 9.4 - 15.1% reported by Aluge *et al*. (2016) for confectionaries produced from wheat, malted sorghum and soybean composite flour. The range 8.33 to 14.33% recorded for fat in this study is relatively higher than the range of 1.25 to 2.36% reported by Jimoh (2021), for cookies made from wheat flour fortified with tiger nut flour and date palm fruit. The significant increase in the fat content of the cookies with the inclusion of African yam beans flour could be as a result of the contribution of ingredients added in the production of the cookies such margarine and powder milk. The range reported in this study is lower than the range 18.73 – 22.67% reported by Bello *et al*. (2020) for cookies made from wheat, unripe plantain and fluted pumpkin seeds flour blends. However, it is imperative to note that the high fat content observed in the cookies will most likely affect the shelf stability. The crude fibre ranged from 0.42-0.88%. The highest value was observed in sample KL2 (60:40% wheat:African yam bean flours) while the lowest value was observed in sample EF4 (100% wheat flour). It was observed that the fiber content of the cookies increased with increase in African yam bean inclusion. According to Awuchi (2019), the crude fiber aids in the prevention of diabetes, colon cancer, and heart disease.

Table 1 Proximate Composition of Cookies Produced from Wheat and African Yam Beans Composite Flour

SAMPLE	Moisture Content (%)	Crude Protein (%)	Crude Fat (%)	Crude Fibre (%)	Total Ash (%)	Carbohydrate (%)
EF4	1.33±0.29^{ab}	6.44±0.16^{a}	8.33±0.58^{a}	0.42±0.01^{a}	2.10±0.36^{bc}	81.38±0.47^{b}
IJ5	2.50±0.00^{c}	9.59±0.04^{b}	5.00±0.50^{a}	0.62±0.00^{b}	2.77±0.25^{d}	79.52±0.64^{b}
KT9	1.17±0.29^{a}	9.89±0.01^{c}	14.33±0.58^{b}	0.64±0.00^{c}	2.60±0.17^{c}	71.37±0.80^{a}
GH7	1.83±0.29^{b}	10.27±0.02^{d}	12.67±3.79^{b}	0.67±0.00^{d}	1.43±1.12^{a}	73.13±3.59^{a}
KL2	3.50±0.50^{d}	13.56±0.07^{e}	6.67±0.58^{a}	0.88±0.00^{e}	2.00±0.50^{ab}	73.39±0.80^{a}

**Mean± standard deviation with same superscripts along the column are not significantly different at (p>0.05)*

KEY: Sample EF4: *100% wheat flour (control);* ***Sample IJ5:*** *90% wheat flour and 10% African yam bean flour;* ***Sample KT9****: 80% wheat flour and 20% African yam bean flour;* ***Sample GH7****: 70% wheat flour and 30% African yam bean flour;* ***Sample KL2:*** *60% wheat flour and 40% African yam bean flour*

Significant difference ($p<0.05$) existed among the samples. The carbohydrate content ranged from 71.37-81.38%. The highest value was recorded in sample EF4 (100% wheat flour) while the lowest content value was recorded in sample KT9 (80:20% wheat:African yam bean flours). There was no significant difference ($p>0.05$) among the samples. The range observed in this study is similar to the range 68.48 to 70.89% reported by Jimoh (2021) for cookies produced from wheat flour fortified with tiger nut and palm date and similar to the range 59.83-70.23% reported by Akujobi (2018) for cookies produced from cocoyam (*Xanthosoma sagittifolium*) and tiger nut (*Cyperus esculentus*) flour blends. This implies that the cookies are good sources of energy needed for normal body metabolism. The significant variation ($p<0.05$) in carbohydrate content may be attributed to alterations in other constituents. This result indicates that substituting wheat with and African yam beans flour can be used to improve the nutritional properties of the cookies especially protein, fat and crude fibre which offers health benefits to consumers because protein is needed for physiological functioning and reducing protein-energy malnutrition; crude fibre is anti- diabetic while vegetable fat is a good source of energy and helps in absorption of most fat-soluble vitamins and minerals (Vong and Liu, 2016).

Mineral Composition of Cookies Produced from Wheat and African Yam Beans Composite Flour

The mineral composition of cookies produced from wheat and African yam beans composite flour is shown in Table 2. Minerals whether macro or micro-minerals are required in the body for the maintenance of physiochemical processes essential to life. The calcium content of the cookies ranged from 309.47-314.60 mg/100g. The highest value was recorded in sample KT9 (80:20% wheat:African yam bean flours) while the lowest content value was recorded in sample EF4 (100% wheat flour). Apart from keeping bones and teeth strong, calcium ensures the proper functioning of muscles and nerves (Panhwar *et al.*, 2014). The inclusion of the African yam beans flour therefore increases the calcium content of the cookies. Significant difference ($p>0.05$) exists among the samples. It was observed in this study that the sodium content of the cookies increased with increase in substitution level. Sodium helps in maintaining healthy fluid balance (Bello *et al.,* 2019). The potassium content ranged from 215.19-278.15 mg/100g. Sample KT9 (80:20% wheat:African yam bean flours) had the highest value while sample KL2 (60:40% wheat:African yam bean flours) had the lowest value. There was no significant difference ($p>0.05$) between the samples except for sample KT9 with 80:20 – wheat:African yam bean flours.

Table 2: Mineral Composition of Cookies Produced from Wheat and African Yam Beans Composite Flour

SAMPLE	Calcium (mg/100g)	Zinc (mg/100g)	Sodium (mg/100g)	Potassium (mg/100g)	Phosphorus (mg/100g)
EF4	309.47±0.00^{e}	0.03±0.00^{c}	414.80±20.58^{a}	250.35±3.05^{b}	458.33±15.28$_{a}$
KL2	310.32±0.00^{b}	0.03±0.00^{b}	381.84±20.58^{a}	215.19±0.00^{a}	470.00±5.00^{a}
GH7	311.65±0.00^{c}	0.04±0.00^{d}	497.19±77.22^{b}	222.22±6.09^{a}	529.00±7.81^{b}
IJ5	312.65±0.00^{d}	0.04±0.00^{e}	516.96±19.78^{b}	243.32±3.05^{b}	478.33±17.56^{a}
KT9	314.60±0.00^{a}	0.02±0.00^{a}	520.26±54.46^{b}	278.48±9.14^{c}	560.00±5.00^{c}

**Mean± standard deviation with same superscripts along the column are not significantly different at (p>0.05)*
Sample EF4: *100% wheat flour (control);* ***Sample IJ5:*** *90% wheat flour and 10% African yam bean flour;* ***Sample KT9****: 80% wheat flour and 20% African yam bean flour;* ***Sample GH7****: 70% wheat flour and 30% African yam bean flour;* ***Sample KL2:*** *60% wheat flour and 40% African yam bean flour*

Potassium is an important component of cell and body fluids that helps control heart rate and blood pressure by countering negative effects of sodium (Bamigbola *et al.,* 2016). The phosphorus content of the cookies ranged from 458.33-560.00 mg/100g. The values obtained in this study are higher than the range 140.00 – 212.00 mg/100 reported by Bello *et al.* (2019). Phosphorus contributes to the formation and solidification of bones (Awedem *et al.,* 2015). Lack of phosphorus will therefore result in impaired bone mineralization, reduced bone strength and poor growth (Eleazu *et al,* 2015). The mineral composition of the cookies produced from wheat and African yam bean composite flour increased with increase in African yam bean flour inclusion, this therefore

established the fact that African yam bean greatly influences the mineral composition of the cookies.

Sensory Evaluation of Cookies Produced from Wheat and African Yam Beans Composite Flour

Result for sensory evaluation of cookies produced from wheat and African yam beans composite flour is presented in Table 3. The colour ranged from 6.70-8.10. The most preferred colour was observed in sample EF4 (100% wheat flour) while the least preferred colour was recorded in sample KL2 (60:40% wheat:African yam bean flours). There was no significant different ($p>0.05$) between samples except sample EF4 (100% wheat flour) and KL2 (60:40% wheat:African yam bean flours) among other samples. Taste ranks among the most important attributes to consider. Taste can be influenced by the types and quality of ingredients and may also depend on the formulation of the food material (George *et al*., 2023). The taste of the cookies ranged from 6.50-8.00. The most preferred taste was recorded in sample EF4 (100% wheat flour) while the least preferred taste was observed in sample KL2 (60:40% wheat:African yam bean flours). The taste of the composite cookies was observed to decrease significantly different ($p>0.05$) with increase in African yam bean flour. The aroma, crispiness and appearance ranged from 6.70-7.90, 7.10-8.20 and 6.9-8.10 respectively. There was no significant difference ($p>0.05$) among the samples. The results for colour, taste, aroma, crispiness and appearance show similar score trend. The overall acceptability ranged from 7.50-8.40. The highest value was recorded in sample EF4 (100% wheat flour) while the least value was recorded sample KL2 (60:40% wheat:African yam bean flours). There was no significant difference ($p>0.05$) among the samples. The samples showed no significant difference in terms of aroma, appearance, and overall acceptability. The composite cookies compared favourably with control (100% wheat flour) sample which has already gained popularity for acceptability. Sample IJ5 (90:10% wheat:African yam bean flours) and CH7 (70:30% wheat:African yam bean flours) and the control sample (EF4) was most preferred in terms of overall acceptability while sample KL2 (60:40% wheat:African yam bean flours) was found to have the least value for almost all the sensory parameters. The study therefore illustrates that African yam bean addition has the potential to improve colour, aroma, taste, crispiness, appearance and overall acceptability of composite cookies.

Table 3 Sensory Evaluation of Cookies Produced from Wheat and African Yam Beans Composite Flour

Sample	Colour	Taste	Aroma	Crispiness	Appearance	Overall acceptability
EF4	8.10 ± 1.10^{b}	8.00 ± 1.16^{b}	7.60 ± 0.84^{a}	7.20 ± 0.79^{ab}	7.90 ± 1.29^{a}	8.40±1.25a
IJ5	8.00 ± 0.94^{ab}	7.80 ± 0.92^{ab}	7.90 ± 0.99^{a}	7.60 ± 0.84^{ab}	8.00 ± 1.05^{a}	8.30 ± 0.68^{a}
KT9	7.60 ± 1.51^{ab}	7.50 ± 1.35^{ab}	6.70 ± 1.64^{a}	7.10 ± 0.99^{a}	7.80 ± 0.79^{a}	8.10 ± 0.99^{a}
GH7	7.90 ± 1.29^{ab}	7.40 ± 1.43^{ab}	7.60 ± 1.27^{a}	8.20 ± 0.79^{b}	8.10 ± 1.10^{a}	8.00 ± 0.70^{a}
KL2	6.70 ± 1.77^{a}	6.50 ± 1.78^{a}	6.70 ± 1.49^{a}	7.50 ± 1.65^{ab}	6.90 ± 1.73^{a}	7.50 ± 1.72^{a}

**Mean± standard deviation with the same superscripts along the same column are not significantly different ($p>0.05$)*
***Sample EF4:** 100% wheat flour (control); **Sample IJ5:** 90% wheat flour and 10% African yam bean flour; **Sample KT9**: 80% wheat flour and 20% African yam bean flour; **Sample GH7**: 70% wheat flour and 30% African yam bean flour; **Sample KL2:** 60% wheat flour and 40% African yam bean flour*

CONCLUSION AND RECOMMENDATIONS

The present study showed that addition of African yam bean flour to wheat flour in cookies production significantly increased the total ash, crude fibre, crude fat, protein contents and mineral elements of the composite cookies. The moisture content of all the samples are relatively low which guaranteed good quality and long shelf-life of the cookies. The sensory attributes such as colour, appearance, aroma, taste, crispiness and overall acceptability of cookies were rated high between like moderately and like extremely. This is an indication that apart from additional nutritional benefit, the characteristic eating quality and suitability of the food satisfied consumer's perception. The production of acceptable cookies by substituting wheat flour with African yam bean can therefore be harnessed because of its contribution to the nutritional properties of the cookies produced. African yam bean at a right proportion is therefore recommended as a substitute for wheat flour in baking industry.

Acknowledgement

The authors greatly appreciate the constructive contribution of the Lagos State Polytechnic and Federal University of Technology, Akure, Nigeria for giving us

the opportunity to carry out the analysis in their laboratories and other valuable assistance.

Authors' Contributions

OOO: Conceptualization, Supervision, Viewing and Editing. IGU: Methodology and writing of the original draft. IBA: Statistical analysis and interpretation of data results.

Ethical Statement

Not applicable.

REFERENCES

Abah, D. & Ochoche, C. O. (2021). Trend Analysis of Wheat Production in Nigeria (1981- 2018): Impact on Agricultural Output. *International Journal of Advances in Engineering and Management (IJAEM)*, 3(3):871-878.

Abah, D., Umbugadu, G. B. &Ochoche, C. O. (2023) Growth Rate, Trends and Forecast Analysis of Wheat Demand-Supply Gap in Nigeria. *Nigerian Journal of Agriculture and Agricultural Technology (NJAAT)* 3(1): 2811-1885.

Adamu, G., Ezeokoli, O., Dawodu, A., Adebayo-Oyetoro, A. & Ofodile, L. (2015). Macronutrients and micronutrients profile of some underutilized beans in South Western Nigeria. *International Journal of Biochemistry Research Revision*. 7, 80–89.

Adelakun, O.E., Olanipekun, B.F., Oyelade, O.J. & Ogundara, O.A. (2021). Evaluation of Cookies produced from blends of Wheat, Soybean and Corn Flours. *International Journal of Scientific & Engineering Research*, 12(6):846.

Ade-Omowaye, B.I.O., Tucker, G.A. & Smetanska, I., (2015). Nutritional potential of nine underexploited legumes in Southwest Nigeria. *International Food Research Journal*, 22, 798–806.

Adeyanju, J.A., Babarinde, G.O., Olanipekun, B.F., Bolarinwa, I.F. & Oladokun, S.O. (2021). Quality assessment of flour and cookies from wheat, African yam bean and acha flours. *Journal of Food Research*, 5(1): 371 – 379. https://doi.org/10.26656/fr.2017.5(1)

Ajibola, G.O. & Olapade, A.A. (2016). Physical, proximate and anti-nutritional composition of African yam bean (*Sphenostylis stenocarpa*) seeds varieties. *Journal of Food Research*, 5, 67.

Al-Marazeeq K.M. & Angor, M.M. (2017). Chemical characteristic and sensory evaluation of biscuit enriched with wheat germ and the effect of storage time on the sensory properties for this product. *Journal Food Nutrition and Science*. 8(2),189–195. https://doi.org/10.4236/fns.2017.82012

Aluge O.O., Akinola S.A. & Osundahunsi O.F. (2016) Effect of malted sorghum on quality characteristics of wheat-sorghum-soybean flour for potential use in confectionaries. *Food Nutrition*, 7(13):1241–1252.

Ani, E.C. & Okoye, J.I. (2021). Nutrient Composition, Physical and Sensory Properties of Cookies Produced from Millet, African Walnut and Unripe Plantain Composite Flours. *Journal of Food Science and Nutrition*. 7: 108.

Anya, M.I. & Ozung, P.O. (2019). Proximate, mineral and anti-nutritional compositions of raw and processed African Yam bean (*Sphenostylis stenocarpa*) seeds in Cross River State, Nigeria. *Global Journal of Agricultural Science*, 18, 19.

AOAC, Official method of analysis, 18th ed. Washington, DC: Association of Officiating Analytical Chemists, 2005

Awedem, W.F., Achu, M.B., & Happi, E.T. (2015). Nutritive value of three varieties of banana and plantain blossom from Cameroon. *Greener Journal of Agricultural Sciences*, 5 (2):052-061.

Baiyeri, S., Uguru, M., Ogbonna, P., Samuel-Baiyeri, C.C., Okechukwu, R., Kumaga, F. & Amoatey, C. (2018). Evaluation if the nutritional composition of the seeds of some selected African yam bean (*Sphenostylis stenocarpa*). *Agro-Science Journal of Tropical Agricultural and Food Environment Extension* 17, 37–44.

Bamigbola, Y. A., Awolu, O. O. & Oluwalana, I. B. (2016). The effect of plantain and tigernut flours substitution on the antioxidant, physicochemical and pasting properties of wheat based composite flours. *Cogent Food and Agriculture*, 2(1):1245060.

Bello F.A., Akpan M.E. & Sodipo M.A. (2020). Physicochemical and sensory properties of cookies produced from wheat, unripe plantain and germinated fluted pumpkin seed composite flour. *Food Science Quality & Management*, 96:36–43.

Bello, F.A., Edeke, J.E. & Sodipo, M.A. (2019). Evaluation of chemical, functional and sensory properties of flour blends from sorghum, African yam bean and soybean for use as complementary feeding. International Journal of Food Science and Biotechnology, 4(3):74–81.

CBN, (2021). Central Bank of Nigeria intervenes in wheat production, multiplies 13,000MT seeds. *Vanguard newspaper on line 20th October 2021*.

Chinonyerem, A., Obioha, O. & Ebere, U. (2017). Amino acid composition, amino acid scores and predicted protein efficiency ratio of raw and cooked African

yam bean (*Sphenostylis sternocarpa*). *Journal of Applied Life Science International*, 13, 1–10.

Data Bridge Market Research, (2024). Cookies Market Analysis North America, APAC, Europe, South America, Middle East and Africa - US, Canada, China, India, Germany - Size and Forecast 2024-2028. Pages: 168. SKU: IRTNTR71785

Duodu, K.G. & Apea-Bah, F.B. (2017). African Legumes: Nutritional and Health-Promoting Attributes. Gluten-free Ancient Grains: Cereals, Pseudocereals, and Legumes: Sustainable, Nutritious, and Health-Promoting Foods for the 21st Century. *Elsevier Ltd.*

Eleazu, C. O., Iroaganachi, M., & Eleazu, K. C. (2013). Ameliorative potentials of cocoyam (Colocasiaeesculenta L.) and unripe plantain (Musa parasidiaca). *Journal of Diabetes Research. Article*, (2), 1-8.

Falola, A., Achem, E.A. Oloyede, W.O. & Olawuyi, G.O. (2017). Determinants of commercial production of wheat in Nigeria: A case study of Bakura Local Government Area, Zamfara State. *Trakia Journal of Sciences*, 4:397-404.

George, I.C., Igwe, E.C., Obiora, C.U., Omologbe, F., Igwe, P.N. & Ubaka, I.T. (2023). Chemical Composition and Sensory Properties of Wheat, African Yam Bean and Tiger Nut Residue Composite Flour Cookies. *Asian Journal of Food Research and Nutrition*, 2(4):536-545.

Jimoh, M.O. (2021). Quality Evaluation of Cookies Made from Wheat Flour Fortified With Tiger Nut Flour and Date Nut Flour and Date Palm Fruit. *European Journal of Food Science and Technology*, 9(1):1-17.

Ndidi, U.S., Ndidi, C.U., Olagunju, A., Muhammad, A., Billy, F.G. & Okpe, O. (2014). Proximate, antinutrients and mineral composition of raw and processed (boiled and roasted) Sphenostylis stenocarpa seeds from Southern Kaduna, Northwest Nigeria. *ISRN Nutrition*. 1–9.

Okoye, J.I, Alugwu, S.U. & Obi, C.D. (2015). Effect of processing methods on the proximate composition and functional properties of African yam bean (Sphenostylius stenocarpa) seed flours. *Journal of Science, Agriculture, Food Technology and Environment.* 14:1– 6.

Panhwar, A. A., Sheikh, S. A., Mirani, B. N., Channa, M. J., & Khanzada, S. (2014). Studies on the nutritional characteristics of some commercial wheat varieties of dry land and wet land grown in Sindh province. *Journal of Pharmacy and Nutrition Sciences*, *4*(4), 263-267.

Udo, M. E., Opara, D. C., Ibokette, M. E., & Archibong, D. E. (2024). Proximate composition and vitamins profile of African yam bean flour used as meals in Akwa Ibom State, Nigeria. International Journal of Health Sciences and Research, 14(5), 168-175. https://doi.org/10.52403/ijhsr.20240519.

Umar, U.A. & Muhammad, M.B. (2021). Challenges and Strategies of Wheat Production in Nigeria Amidst Growing Demands for Wheat and Wheat Products. *Journal of Agriculture and Environment* 17(2): 1-6.