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PRODUCTION AND EVALUATION OF COOKIES FROM COMPOSITES OF SPROUTED WHEAT, SORGHUM AND AFRICAN YAM BEAN SEED FLOURS

Arukwe, D. C., Ezeocha, V. C. and Ubbor, S. C.

Department of Food Science and Technology, College of Applied Food Sciences and Tourism, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria
Corresponding Authors' email: dorarukwe@gmail.com

Abstract

This study investigated the production of flours from sprouted wheat, sorghum and African yam bean seeds and evaluation of their proximate composition, blending of the composite flours and determination of the functional properties, and production of cookies from the blends and determination of the proximate composition and sensory properties. Flours were produced from sprouted wheat, sorghum and African yam bean seeds and their proximate composition evaluated. The sprouted wheat, sorghum and African yam bean flours were blended at the ratios of 100:0:0, 50:35:15, 40:35:25, 30:35:35, 20:45:35 and 10:55:35 each, where sample 100:0:0 served as control. The proximate composition of the sprouted seed flours showed significant differences ($p<0.05$) in protein, fat, crude fibre, ash and carbohydrate contents. The functional properties of the blends showed that bulk density decreased, while water absorption, oil absorption, foam, emulsion and swelling capacities increased with increased ratio of incorporation of composite flours to wheat flour. The cookies proximate result depicted increased ash, fat, protein, crude fibre and reduced carbohydrate with increasing addition of composite flours to wheat flour. The sensory result showed that the sensory scores for appearance, taste, flavor, texture and general acceptability of the cookies deceased with increased inclusion of composite flour to wheat flour. However, the composite cookie sample 50:35:15 was more acceptable compared to the other composite cookies. Sorghum and African yam bean flour gave a good flour blend with wheat in cookie production.

Keywords: Sprouted Sorghum, sprouted African yam bean, sprouted Wheat, Blends, Cookies

Introduction

The importation of wheat has impacted greatly on Nigeria's economy and to ameliorate this, composite flours are produced from our local raw materials to supplement the use of wheat flour in production of baked products. FAO (1990) reported that the substitution of wheat flour with 20% non-wheat flour for the manufacture of bakery products would result in an estimated savings in foreign exchange of twenty million US dollars for developing countries of the world. The development of an adequate supplementation for wheat will help to reduce the cost of baked products. Cookies are one of the bakery products which are widely accepted and consumed in many developed and developing countries of the world (Giami *et al*., 2004). In Nigeria, cookies are consumed mostly by school children and the flour of choice for the production of baked products is wheat flour (Iwe *et al*., 2016). It has been reported that wheat flour is low in protein (14.70%) and this implies that food produced from it will be of low protein content and therefore, have poor nutritional quality (Olagunju and Ifesan, 2013). Wheat flour can be supplemented with available and cheap legumes and cereals for production of baked products like cookies, and such composite flours from legumes have high protein content and caloric value (Igbabul *et al*., 2014). Some researchers have reported the production of cookies from composite flours such as wheat, fonio, and cowpea (McWatters *et al*., 2003), lima bean, sorghum and wheat (Adebayo and Okoli, 2017), wheat, cocoyam and pigeon pea (Arukwe, 2020) among others.

Sorghum (*Sorghum bicolor*) is a cereal crop which originated in North Africa and is now cultivated widely in tropical and sub-tropical regions of the world. It is typically an annual crop but some cultivars are perennial, commonly called guinea corn in West Africa. Sorghum contains between 11.30-13.00% proteins, 1-3.30% fat, 3-6.00% dietary fibre, and 70-74.63% carbohydrate. Sorghum flour can substitute wheat flour for baked goods (Adebayo and Okoli, 2017). Sorghum is high in antioxidants which acts as a neutraceutical and helps to lower the risk of cancer, diabetes, heart diseases, among others. The wax surrounding the grain contains policosanols, a compound which may have impact on human cardiac health (Varady *et al*., 2003).

African yam bean (*Sphenostylis stenocarpa*) belongs to the family Leguminosae and sub-family Papilionoideae or Faboideae; the pea family which originated in Africa (Baudoin and Mergeai, 2001). It is a perennial herbaceous plant, treated mostly as an annual crop and used for both its seed and tubers (NRC, 2006). It is an underutilized crop produced mostly in South-East, Nigeria, where the seed is consumed in different forms such as roasting and eating with palm kernel as snacks or boiling and eating as main meals with local seasonings, starchy roots and fruits (Eneche, 2006; Arukwe and Arukwe, 2021). In Nigeria it is commonly called *okpo dudu* or *odudu* or *azam* (Igbo), *girigiri* (Hausa), *sese* (Yoruba) and *nsama* (Ibibio) (Ogbo, 2002). The nutritional content show that African yam bean is rich in protein, carbohydrate, vitamins and minerals (Iwuoha and Eke, 1996) and its protein contains equal or better levels of lysine and methionine than those of soybeans (Obatolu *et al*., 2001). According to Uguru and Madukaife (2001), the seeds of African yam bean are well balanced in essential amino acids and have higher amino acid levels than pigeon pea, cowpea and bambara groundnut. Although African yam bean has been used as a household food security crop during famine (Klu *et al*., 2001; Maziya-Dixon, 2004), there is still apathy to its consumption due to the inherent constraints in the seed. These include; the hard to cook syndrome, tedious manual removal of seed coat (Wokoma and Aziagba, 2001) and antinutritional factors. Sprouting processing method has been used to improve the nutritional composition of legumes and eliminate the antinutritional factors (Arukwe *et al*., 2017).

Sorghum and African yam bean contain a lot of nutrients but their utilization is hindered by their content of antinutrients. These antinutrients can be removed by sprouting. Sprouting is widely used in legumes and cereals processing to increase their palatability and nutritional value, particularly through the breakdown of certain antinutrients, such as phytate and protease inhibitors (ElMaki *et al*., 2007; Liang *et al*., 2008). The supplementation of African yam bean and sorghum flours into wheat flour would help to improve the protein content and quality of cookies and other baked products. This would also lead to increased utilization and cultivation of African yam bean crop in developing countries where protein-calorie malnutrition is prevalent. The objectives of this study was to produce flours from sprouted wheat, sorghum and African yam bean seeds and evaluate their proximate composition, blend the flours and evaluate the functional properties and thereafter, produce cookies from the blends of sprouted wheat, sorghum and African yam bean flours, and evaluate their proximate composition and sensory properties.

Materials and Methods

Materials collection

The seeds of wheat, sorghum and African yam bean used for this research were purchased at *Ahia ohuu*, a market in Aba, Abia State, Nigeria. Other ingredients used for the production of the cookies were also purchased from the same market.

Sample preparation

Two kilograms (2kg) each of wheat, sorghum (*Sorghum bicolor*) seeds and African yam bean (*Sphenostylis stenocarpa*) seeds were sorted to remove dirt and other foreign particles after which they were washed.

Production of sprouted wheat flour: Sprouted wheat was prepared according to the method described by Ariahu *et al.* (1999) with slight modification. The 2kg washed wheat seeds were spread in a single layer on a moistened jute bag and allowed to germinate (sprout) at room temperature for 3 days. During this time, the seeds were sprayed with water at intervals of 12 hours until the last day of sprouting. After sprouting, the shoots and rootlets of the germinated seeds were removed. The seeds were then dried in an oven at $60^{o}C$ for 7 hours and milled into flour using a disc attrition mill (Asiko AII, Addis Nigeria) and sieved with 1.0mm mesh before packaging into polyethylene bag for further studies.

Production of sprouted sorghum flour: Sprouted sorghum was prepared according to the method described by Ariahu *et al*. (1999) with slight modification. The 2kg washed sorghum seeds were spread in a single layer on a moistened jute bag and allowed to germinate (sprout) at room temperature for 3 days. During this time, the seeds were sprayed with water at intervals of 12 hours until the last day of sprouting. After sprouting, the shoots and rootlets of the germinated seeds were removed. The seeds were then dried in an oven at $60^{0}C$ for 7 hours and milled into flour using a disc attrition mill (Asiko AII, Addis Nigeria) and sieved with 1.0mm mesh before packaging into polyethylene bag for further studies.

Production of sprouted African yam bean flour: Sprouted African yam bean was prepared according to the method described by Ariahu *et al*. (1999) with slight modification. The 2kg washed African yam bean seeds were spread in a single layer on a moistened jute bag and allowed to germinate (sprout) at room temperature for 3 days. During this time, the seeds were sprayed with water at intervals of 12 hours until the last day of sprouting. After sprouting, the seeds were de-hulled and shoots and rootlets of the germinated seeds removed. The seeds were then dried in an oven at $60^{o}C$ for 7 hours and milled into flour using a disc attrition mill (Asiko AII, Addis Nigeria) and sieved with 1.0mm mesh before packaging into polyethylene bag for further studies.

Proximate analysis

The AOAC (2010) methods were used to determine the protein, moisture, crude fibre, fat, ash and carbohydrate content of the samples and the analysis was done in triplicates.

Determination of functional properties

Bulk density was determined using Okaka and Potter (1977) method. Water absorption capacity and oil absorption capacity were determined by the method **as** described by Onwuka (2018). Foam capacity was determined by the method of Akpata and Miachi (2001).

Emulsion capacity was determined by method of Okezie and Bello (1988) and swelling capacity determined by method of Takashi and Sieb (1988).

Formulation of wheat-sorghum-African yam bean flour blend

The sprouted wheat, sorghum and African yam bean flours were blended at the ratios of 100:0:0, 50:35:15, 40:35:25, 30:35:35, 20:45:35 and 10:55:35 reach, where the sample 100:0:0 served as control.

Production of wheat-sorghum-African yam bean cookies

The wheat-sorghum-African yam bean cookies were prepared according to the method described by AACC (2000) with slight modification. The recipes used were flour (500g), fat (250g), sugar (250g), eggs (2) and baking powder (5g). The ingredients were accurately weighed with a weighing balance (Mettler, PC 400, Switzerland). Then creaming of fat and sugar was done followed by addition of eggs and then the flour and baking powder were added to the creamy mass and mixed to a homogenous mass using Kenwood electronic mixer for 30min. The batter was then rolled out with a rolling pin to a thickness of 3 inches and 1inch diameter using a biscuit cutter. The cut cookies were placed on a baking tray and baked at 175 °C in an oven for 10-15min. The cookies were then brought out from the oven and left to cool at room temperature before packaging in polyethylene bag for subsequent proximate and sensory analyses.

Sensory evaluation of wheat-sorghum-African yam bean cookies

The sensory evaluation of the wheat-sorghum-African yam bean cookies was done using 20 staff and students of the Michael Okpara University of Agriculture, Umudike. The panelists were asked to evaluate the cookie samples on the basis of the 7-point Hedonic test described by Macfie *et al*. (1989), ranging from 1 (extremely dislike) to 7 (like extremely). The cookie samples were evaluated for appearance, taste, flavor, texture and overall acceptability.

Statistical analysis

All data obtained were statistically analyzed with one-way analysis of variance (ANOVA) to determine significant difference at 5% level of acceptance using SPSS version 17. All data were expressed as mean $\pm$ standard deviation of triplicate values.

Results and Discussion

Proximate composition of sprouted wheat, sorghum and African yam bean seed flours

Table 1 shows the proximate composition of the sprouted seed flours for this study. There was no variation in the moisture content of wheat, sorghum and African yam bean flour samples. The moisture content of the flours (7.00-7.02%) was within the recommended level for safe flour storage of not higher than 10% by SON (2007). The low moisture content of the flours is beneficial for its storage stability, because it will curb the growth of spoilage microorganisms and lead to increased shelf life when properly packaged (Nnam, 2002).nAfrican yam bean flour showed higher protein content which was expected since legumes have more protein content then cereals. The fat, crude fibre and ash content of sprouted African yam bean flour were significantly ($p<0.05$) higher than those of sprouted wheat and sprouted sorghum flours. Sprouted African yam bean flour has crude fibre content of 6.25%, while sprouted wheat and sorghum had 1.82% and 2.15% respectively. This result shows that sprouted African yam bean is a rich source of fibre compared to the other flours. Fibre in the diet is useful in the prevention of obesity, atherosclerosis, coronary heart disease, diabetes, increasing faecal bulk and lowering serum cholesterol (Truswell, 1995; Michael *et al*., 2013). The carbohydrate content of African yam bean flour (57.78%) was lower than those of wheat (78.68%) and sorghum (75.55%).

Table 1: Proximate composition of sprouted wheat, sorghum and African yam bean seed flours

Flour Samples	Moisture (%)	Protein (%)	Fat (%)	Crude fibre (%)	Ash (%)	Carbohydrate (%)
Wheat	7.00 ± 0.0^{a}	9.65 ± 0.0^{b}	1.72 ± 0.1^{c}	1.82 ± 0.0^{c}	1.55 ± 0.02^{c}	78.68 ± 0.0^{a}
Sorghum	7.01 ± 0.02^{a}	8.50 ± 0.01^{c}	2.80 ± 0.0^{b}	2.15 ± 0.1^{b}	2.50 ± 0.0^{b}	75.55 ± 0.0^{b}
AYB	7.02 ± 0.01^{a}	22.30 ± 0.01^{a}	3.00 ± 0.1^{a}	6.25 ± 0.02^{a}	4.05 ± 0.1^{a}	57.78 ± 0.1^{c}
LSD	0.00	0.00238	0.00168	0.00153	0.00245	0.00531

Means with different letter within a column are significantly different (p<0.05). LSD= least significant difference. AYB= African yam bean flour

Functional properties of wheat-sorghum-African yam bean composite flours

The functional properties of the blended wheat-sorghum-African yam bean flours are shown in Table 2. The bulk density indicated significant ($p<0.05$) decrease as the ratio of wheat flour in the blends reduced and the composite blends increased. The low bulk density of the blends could be beneficial in baby food formulation where high nutrient density to low bulk is desired. The bulk density obtained in this study is within the range 0.586 - 0.693g/ml reported by Arukwe (2021) for wheat-pigeon pea flour blends. The water absorption capacity significantly ($p<0.05$) increased as the ratio of the composite flours incorporated into the wheat flour increased. This result implies that the composite blends would be useful in baked products where hydration for easy handling is required. The same trend of increase was observed in the oil absorption capacity and the values ranged from 84.70 – 86.15%. The blends can also find use in ground meat, doughnuts and pancakes formulation where oil absorption property is of great importance.

The foam capacity indicated increased as the ratio of inclusion of sorghum/African yam bean flours to wheat flour increased, and these ranged from 15.20-27.50%. The increase in foam capacity may be due to the high protein content of the composite flour blends (African yam bean and sorghum flour blends). Foam capacity is a measure of the foamability of flour which is dependent on the presence of flexible protein molecules which decrease the surface tension of water (Fennama, 1996). The blends which exhibited increased foam capacity could be used in production of baked and confectionary products. The emulsion capacity result also depicted increase as the level of addition of the composite blends increased, and these ranged from 26.80-29.68%. The increased emulsion capacity may be because the composite flour blends have higher protein than the wheat flour. Emulsion capacity is a measure of the maximum amount of oil emulsified by protein in a given amount of flour. Increased emulsion capacity is important in production of comminuted meat products, salad dressings, frozen desserts and mayonnaise. The swelling capacity also recorded increase in values as the level of incorporation of the composite blends increased. The swelling capacity obtained in this study (11.15 – 15.50%) is within the range reported for blends of wheat and combined sprouted/fermented pigeon pea flours (13.00 – 16.50%) by Arukwe (2021). Swelling capacity is an increase in volume of dry starch when it is exposed to moisture and a very significant index in baking.

Table 2: Functional properties of wheat-sorghum-African yam bean composite flours

WF:SF:AYBF	Bulk Density (g/ml)	Water Absorption Capacity (%)	Oil Absorption Capacity (%)	Foam capacity (%)	Emulsion Capacity (%)	Swelling Capacity (%)
100:0:0	0.70 ± 0.0^{a}	85.00 ± 0.10^{f}	84.70 ± 0.1^{f}	15.20 ± 0.01^{f}	26.80 ± 0.01^{f}	11.15 ± 0.0^{f}
50:35:15	0.67 ± 0.01^{b}	85.20 ± 0.0^{e}	84.80 ± 0.0^{e}	25.50 ± 0.0^{e}	27.50 ± 0.0^{e}	12.80 ± 0.01^{e}
40:35:25	0.65 ± 0.0^{c}	85.50 ± 0.0^{d}	84.96 ± 0.10^{d}	25.65 ± 0.10^{d}	27.73 ± 0.0^{d}	13.12 ± 0.0^{d}
30:35:35	0.60 ± 0.02^{d}	85.92 ± 0.0^{c}	85.00 ± 0.0^{c}	27.02 ± 0.0^{c}	28.20 ± 0.10^{c}	14.00 ± 0.0^{c}
20:45:35	0.57 ± 0.01^{e}	86.36 ± 0.01^{b}	85.65 ± 0.01^{b}	27.25 ± 0.10^{b}	28.90 ± 0.0^{b}	14.21 ± 0.0^{b}
10:55:35	0.55 ± 0.10^{f}	87.02 ± 0.0^{a}	86.15 ± 0.0^{a}	27.50 ± 0.01^{a}	29.68 ± 0.0^{a}	15.50 ± 0.0^{a}
LSD	0.00168	0.00599	0.00224	0.00229	0.00206	0.00202

Mean values with different letters within the same column are significantly different ($p<0.05$). LSD= Least significant difference. WF = Wheat flour, SF = Sorghum flour and AYB = African yam bean flour

Proximate composition of wheat-sorghum-African yam bean blend cookies

Table 3 shows the proximate composition of the cookies produced from blends of wheat-sorghum-African yam bean flours. There were significant differences ($p<0.05$) in the moisture content of the cookies which ranged from 7.25-7.60%. The low moisture content of the cookies will enhance the storage stability. The ash content ranged from 1.83-3.95%, with the ash content increasing as the level of inclusion of the composite flours to wheat flour increases. The increase in ash content may be due to the high ash content of African yam bean flour (Table 1). The fat content ranged from 2.38-5.01% and increased as the ratio of inclusion of sprouted sorghum and African yam bean flours to with flour increased. The increase in fat content is advantageous, because high oil retention enhances mouthfeel and flavor retention in baked products (Fagbemi, 1999; Appiah *et al*., 2011). The protein content ranged from 12.15-20.82% with 100% wheat flour (control) recording the lowest value. The protein content increased as the ratio of composite flour inclusion increased. This is in agreement with the findings of Arukwe (2020) during the production of biscuits from wheat-cocoyam-pigeon pea flour blends. The increased protein content of the blended flours is an advantageous effect of blending food in food product development. Crude fibre content followed the same trend of increase as the level of incorporation of the composite flours to wheat flour increased and ranged from 2.00-4.90%. The values obtained for crude fibre in this study are within the FAO/WHO (1994) recommended level of not more than 5% for both children and adults. This implies that the composite cookies will be good for digestive health. The carbohydrate content was higher in the control sample (100% wheat flour) cookie and decreased as the level of supplementation of wheat flour with the composite flours increased, meaning that that the carbohydrate content of all the composite cookies were lower than that of the control. Arukwe (2020) reported a reduction in carbohydrate content of biscuits with increased inclusion of cocoyam-pigeon pea flour blends.

Table 3: Proximate composition of wheat-sorghum-African yam bean blend cookies

WF:SF:AYBF	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Crude Fibre (%)	Carbohydrate (%)
100:0:0	7.40$\pm$0.0[c]	1.83$\pm$0.10[f]	2.38$\pm$0.1[f]	12.15$\pm$0.01[f]	2.00$\pm$0.01[f]	73.89$\pm$0.0[a]
50:35:15	7.40$\pm$0.01[c]	2.20$\pm$0.0[e]	3.10$\pm$0.0[e]	17.10$\pm$0.0[e]	3.65$\pm$0.0[e]	66.55$\pm$0.01[b]
40:35:25	7.35$\pm$0.0[d]	2.68$\pm$0.0[d]	3.55$\pm$0.10[d]	18.50$\pm$0.10[d]	4.10$\pm$0.0[d]	63.82$\pm$0.0[c]
30:35:35	7.55$\pm$0.02[b]	3.30$\pm$0.0[c]	3.80$\pm$0.0[c]	20.58$\pm$0.0[c]	4.32$\pm$0.10[c]	60.45$\pm$0.0[d]
20:45:35	7.60$\pm$0.01[a]	3.75$\pm$0.01[b]	4.62$\pm$0.01[b]	20.75$\pm$0.10[b]	4.50$\pm$0.0[b]	58.78$\pm$0.0[e]
10:55:35	7.25$\pm$0.10[e]	3.95$\pm$0.0[a]	5.01$\pm$0.0[a]	20.92$\pm$0.01[a]	4.90$\pm$0.0[a]	57.97$\pm$0.0[f]
LSD	0.00168	0.00135	0.00144	0.00173	0.00196	0.00206

Mean values with different letters within the same column are significantly different (p<0.05). LSD= Least significant difference. WF = Wheat flour, SF = Sorghum flour and AYB = African yam bean flour

Sensory characteristics of wheat-sorghum-African yam bean blend cookies

The sensory characteristics of the cookies are shown in Table 4. The cookie with 100% sprouted wheat flour (control sample) was more preferred to the test samples in terms of appearance, taste, flavor, texture and overall acceptability, followed by cookie sample 50:35:15 (containing 50% sprouted wheat flour, 35% sprouted sorghum flour and 15% sprouted African yam bean flour). The cookie sample 10:55:35 (containing 10% sprouted wheat flour, 55% sprouted sorghum flour and 35% sprouted African yam bean flour) was rated the lowest compared to the other cookie samples for all the sensory properties assessed. The scores for all the attributes decreased as the level of inclusion of the composite flours to wheat flour increased in the cookies. However, the cookie sample 50:35:15 was more acceptable than the other composite blend cookies for all the parameters evaluated.

Table 4: Sensory properties of wheat-sorghum-African yam bean blend cookies

WF:SF:AYBF	Appearance	Taste	Flavour	Texture	Overall Acceptability
100:0:0	5.60$\pm$0.0[a]	6.10$\pm$0.0[a]	5.70$\pm$0.0[a]	5.60$\pm$0.0[a]	5.70$\pm$0.0[a]
50:35:15	4.50$\pm$0.0[b]	5.80$\pm$0.0[b]	5.00$\pm$0.0[b]	5.00$\pm$0.0[b]	5.10$\pm$0.0[b]
40:35:25	4.00$\pm$0.0[c]	5.60$\pm$0.0[c]	4.30$\pm$0.0[c]	4.80$\pm$0.0[c]	4.50$\pm$0.0[c]
30:35:35	3.50$\pm$0.0[d]	5.20$\pm$0.0[d]	3.60$\pm$0.0[d]	3.60$\pm$0.0[d]	3.50$\pm$0.0[d]
20:45:35	3.00$\pm$0.0[e]	4.50$\pm$0.0[e]	3.20$\pm$0.0[e]	3.20$\pm$0.0[e]	3.50$\pm$0.0[d]
10:55:35	2.50$\pm$0.0[f]	3.00$\pm$0.0[f]	2.30$\pm$0.0[f]	2.30$\pm$0.0[f]	3.00$\pm$0.0[e]
LSD	0.00206	0.00189	0.00212	0.00189	0.00196

Mean values with different letters within the same column are significantly different (p<0.05). LSD= Least significant difference. WF = Wheat flour, SF = Sorghum flour a nd AYB = African yam bean flour

Conclusion

This study has revealed the potential of production of cookies from composite blends of sprouted wheat-sorghum-African yam bean flours. The sensory studies showed that 15% substitution of African yam bean was more acceptable by the panelists. African yam bean substitution of 35% gave the highest protein content and this has significant nutritional implications for the poor people of developing countries such as Nigeria, who find protein rich foods expensive and out of their reach. The supplementation of African yam bean to sorghum and wheat flour produced highly nutritious and acceptable cookies. Therefore, the utilization of African yam bean in this way will increase its value and lead to its increased production.

References

AACC (2000). Approved Methods of the American Association of Cereal Chemists. American Association of cereal Chemists Inc., St. Paul, Minnesota.

Adebayo, S. F. and Okoli, E. C. (2017). Production and evaluation of biscuits from lima bean (*Phaseolus lunatus*), sorghum and wheat flours. *IOSR-Journal of Environmental Science, Toxicology and Food Technology*, 2(7): 44-48.

Akpata, M. I. and Miachi, O. E. (2001). Proximate composition and selected functional properties of *Detarium microcarpum. Plant Foods for Human Nutrition*, 56: 297-302.

Appiah, F., Oduro, I. and Ellis, W. O. (2011). Functional properties of *Artocarpus altilis* pulp flour as affected by fermentation. *Agriculture and Biology Journal of North America*, 2(5): 773-779.

Ariahu, C.C., Ukpabi, U. and Mbajunwa, K.O. (1999). Production of African breadfruit (*Treculia africana*) and soyabean (*Glycine max*) seed based food formulations. I: Effects of germination and fermentation on nutritional and organoleptic quality. *Plant Foods for Human Nutrition*, 54: 123-266.

AOAC (2010). Official Methods of Analysis International, 18th Edition. Association of Official Analytical Chemists, USA.

Arukwe, D. C. (2020). Proximate composition, physical properties and sensory evaluation of wheat-cocoyam-pigeon pea biscuits. *IOSR-Journal of Environmental Science, Toxicology and Food Technology*, 14(7): 47-51.

Arukwe, D. C. (2021). Proximate composition, functional and pasting properties of wheat flour supplemented with combined processed pigeon pea flour. *International Journal of Food Science and Nutrition*, 6(4): 59-64.

Arukwe, D. C. and Arukwe, J. A. (2021). Quality assessment of azama – a toasted African yam bean (*Sphenostylis stenocarpa*) seed snack in Abia State, Nigeria. *International Journal of Theoretical & Applied Sciences*, 13(1): 26-31.

Arukwe, D. C., Nwanekezi, E. C. and Agomuo, J. K. (2017). Effect of combined processing methods on the functional and pasting properties of pigeon pea (*Cajanus cajan*) flour. *International Journal of Food Engineering and Technology*, 3(3): 28-35.

Baudoin, J. P. and Mergeai, G. (2001). Yambean – *Sphenostylis stenocarpa* Hochst. ExA Rich Harms. In: Crop Production in Tropical Africa. R. H. Raemaekers (ed)., Pp. 372-374.

El Maki, H. B., Abdel Rahaman, S. M., Idris, W. H., Hassan, A. B., Babiker, E. E. and El Tinay, A. h. (2007). Content of antinutritional factors and HCl-extractability of minerals from white bean (*Phaseolus vulgaris*) cultivars: Influence of soaking and/or cooking. *Food Chemistry*, 100: 362-368.

Eneche, H. E. (2006). Production and evaluation of cakes from African yam bean and wheat flour blends. *Proceedings of the Nigerian Institute of Food Science and Technology*, Pp. 46-47.

Fagbemi, T. N. (1999). Effect of blanching and ripening on functional properties of plantain (*Musa abb*) flour. ***Plant** Foods for Human Nutrition*, 54: 261-269.

FAO (1990). Roots, Tubers, Plantains and Banana in Human Nutrition. Food and Agricultural Organization of the United Nations. Food and Nutrition Series No. 2, Rome.

FAO/WHO (1994). Codex Alimentarius: foods for special dietary uses (including foods for infants and children). Food and Agricultural Organization of the United Nations, World Health Organization, Rome.

Fennama, R. O. (1996). Food Chemistry. (3rd edn.) Basel, Hong Kong: Marcel Dekker Inc. New York, Pp. 36-39.

Giami, S. Y., Amasisi, T. and Ekiyo, G. (2004). Comparison of bread making properties of composite flour from kernel of roasted and boiled African breadfruit (*Treculia africana*). *Journal of Raw Materials Research*, 1(1): 16-25.

Igbabul, B. D., Amove, J. and Twadue, I. (2014). Effect of fermentation on the proximate composition, antinutritional factors and functional properties of cocoyam (*Colocasia esculenta*) flour. *African Journal of Food Science*, 5(3): 67-74.

Iwe, M. O., Onyeukwu, U. and Agiriga, A. N. (2016). Proximate, functional and pasting properties of FARO 44 rice, African yam bean and brown cowpea seeds composite flour. *Cogent Food and Agriculture*, 2: 1142409.

Iwuoha, C. I. and Eke, O. S. (1996). Nigerian indigenous fermented foods: their traditional process operations, inherent problems, improvements and current status. *Food Research International*, 29: 527-540.

Klu, G. Y. P., Amoatey, H. M., Bansa, D. and Kumaga, F. K. (2001). Cultivation and use of African yam bean (*Sphenostylis stenocarpa*) seed flour as affected by processing. *Food Chemistry*, 48: 337-340.

Liang, J., Han, B. Z., Nout, M. J. R. and Hamer, R. J. (2008). Effects of soaking, germination and fermentation on phytic acid, total and in vitro soluble zinc in brown rice. *Food Chemistry*, 110: 821-828.

Macfie, H. J., Bratchell, N., Greenhoff, K. and Vallis, L. V. (1989). Designs to balance the effect of order of presentation and first order carry-over effects in hall tests. *Journal of Sensory Studies* 4: 129-148.

Maziya-Dixon, B. (2004). Nigeria Food Consumption and Nutrition Survey 2001 – 2003. International Institute of Tropical Agriculture IITA/National Planning Commission.

McWatters, K. H., Ouedraogo, J. B., Resurreccion, A. V. A., Hung, Y. and Phillips, R. D. (2003). Physical and sensory characteristics of sugar cookies containing mixtures of wheat, fonio (*Digitaria exilis*) and cowpea (*Vigna unguiculata*) flours. *International Journal of Food Science and Technology*, 38: 403-410.

Michael, O. A., Dick, I. G. and Bibiana, D. I. (2013). Physicochemical and sensory evaluation of wheat bread supplemented with stabilized undefatted rice bran. *Food and Nutrition Science*, 4: 43-48.

Nnam, N. M. (2002). Evaluation of complementary foods based on maize, soybean, pawpaw and mango flour blends. *Nigerian Journal of Nutritional Sciences*, 22(23): 8-18.

NRC (2006). Lost Crops of Africa. Volume II: Vegetables. National Academic Press, Washington D. C.

Ogbo, A.I. (2002). Nutritional Values of Some Tropical Foods. Enugu, Computer Edge Publishers Ltd. Enugu, Nigeria, Pp. 49-56.

Okaka, J. C. and Potter, N. N. (1977). Functional and storage properties of cowpea-wheat flour blends in bread making. *Journal of Food Science*, 42: 822-833.

Okezie, B. O. and Bello, A. B. (1988). Physicochemical and functional properties of winged bean flour and isolate compared with soy isolate. *Journal of Food Science*, 53(2): 450-454.

Olagunju, A. I. and Ifesan, B. O. T. (2013). Nutritional composition and acceptability of cookies made from wheat flour and germinated sesame (*Sesamum indicum*) flour blends. *British Journal of Applied Sciences and Technology*, 3: 702-713.

Onwuka, G. I. (2018). Food Analysis and Instrumentation. Theory and Practice. Naphthali Prints, Lagos, Nigeria.

SON (2007). Nigerian Industrial Standards for Pastes. Standard Organization of Nigeria, ICS: 664, 68, pp.25-26.

Takashi, S. and Sieb, P. A. (1988). Paste and gel properties of prime corn and wheat store house with and without native lipids. *Journal of Cereal Chemistry*, 65: 474-480.

Truswell, A. S. (1995). Dietary fibre and plasma lipid. *European Journal of Clinical Nutrition*, 49: 105-

109.

Uguru, M. I. and Madukaife, S. O. (2001). Studies on the variability in agronomic and nutritive characteristics of African yam bean (*Sphenostylis stenocarpa*). *Journal of Plant Protection Research*, 6: 10-16.

Varady, K. A., Wang, Y. and Jones, P. J. (2003). Role of policosanols in the prevention and treatment of cardiovascular disease. *Nutrition Review*, 61(11): 376-383.

Wokoma, E. C. and Aziagba, G. C. (2001). Sensory evaluation of dawa dawa produced bythe traditional fermentation of African yam bean (*Sphenostylis stenocarpa*) seeds. *Journal of Applied Science and Environmental Management*, 5(1): 85-91.