QUALITY CHARACTERISTICS OF COOKIES PRODUCED FROM WHEAT, ACHA AND PIGEON PEA FLOUR BLENDS

James Abiodun **Adeyanju**[1]*, Grace Oluwakemi **Babarinde**[1], Akinfemiwa Ayobami **Adekunle**[2]
Ajekigbe Sola **Olajire**[1], Adeola Abimbola **Adegboye**[1]
[1]Department of Food Science and Engineering, Ladoke Akintola University of Technology, Ogbomoso, Nigeria
[2]National Biotechnology Development Agency, Bioresource Development Centre, Ogbomoso, Nigeria
*Email: jaadeyanju@lautech.edu.ng

Abstract
Cookies were produced from blends of wheat (Triticum aestivum), acha (Digitaria exilis) and pigeon pea (Cajanus cajan) flours at different proportions. The flours were analyzed for functional properties, pasting properties, anti-nutrient. Cookies produced from the flour blends sample were evaluated for proximate composition and sensory attributes. The oil absorption capacity, water absorption capacity, swelling capacity and solubility for the wheat-acha and pigeon pea flour blends ranged from 125 to 141%, 158 to 185%, 15.55 to 18.80%, and 40.25 to 41.88% respectively. The peak viscosity, breakdown value, final viscosity, setback value, peak time and pasting temperature of the flour blends ranged from 94.37 to 102, 19.43 to 19.65, 95.88 to 124, 26.93 to 33.75, 5.13 minutes to 5.25 minutes, 60.47 ℃ to 60.93 ℃ respectively. The tannin, trypsin inhibitor and phytate of the flour blends ranged from 8.17 to 8.58 mg/100g, 2.97 to 4.93 mg/100g and 0.35 to 0.43 mg/ 100g respectively. The protein, fat, ash, moisture, fiber and carbohydrate values for the cookies ranged from 14.23 to 15.03%, 15.14 to 15.43%, 0.38 to 0.89%, 2.56 to 2.74%, 5.10 to 5.33% and 61.38 to 61.81% respectively. Sensory evaluation of the cookies by the panelists showed that the products were well accepted in terms of colour, flavour, taste, crispiness, and mouthfeel as none of the products was rejected. However, the (20% wheat, 50% acha and 30% pigeon pea) sample was the most acceptable. Thus, the inclusion of pigeon pea in wheat-acha flour improved both the nutritional and sensory properties.

Keywords: Acha, pigeon pea, wheat, composite flour and cookies

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1. INTRODUCTION

Increasing trends in the level of protein deficiency have been occurring in the diets of people who eat carbohydrate based foods. Carbohydrate-based snacks such as cookies, doughnuts and potato chips have relatively low nutritional value (Lasekan and Akintola, 2002). The protein-calorie sources of vegetable origin have been proposed as a solution to this problem (Abioye *et al*., 2011), because legume proteins are high in lysine, an essential amino acid limited in most cereals (Alain *et al*., 2007). Cookies are commonly eaten by adult and children at an equal rate. Cookies is a product that has been dried to a relatively low moisture content (Okaka, 2009), and soften than biscuits. Cookies comprise of more composite flour than bread because it is ready to eat, wide consumption, longer shelf-life and good eating quality (McWatters *et al*., 2003).

Wheat (*Triticum aestivum*) the most important staple food crop for more than half of the entire population and supply energy and proteins to the world diet than all other cereal crops (Adams *et al*., 2002; Shewry, 2009). It contains more essential nutrients, easy to store and transport and can be further processed into another type of food. Wheat is a good source of protein, minerals, B-group vitamins and fiber (Shewry, 2007).

Acha (*Digitaria exilis*) is an annual cereal crop indigenous to West Africa where it is cultivated for its straw and edible grains. Acha is also known as "grain of life" in communities of West Africa, it matures early in the farming season, when other crops are yet to mature for harvest (Ibrahim; 2001). Acha grains are also considered as the best tasting and nutritious of all grains (Vietmeyer *et al*., 1996), it has 7% crude protein which is high in leucine which is about 9.8%, methionine is about 5.6% and valine is about 5.8% (Temple and Bassa,

1991). The grain contains methionine and cystine, and has low sugar on consumption (Ayo *et al*., 2003).

Pigeon pea (*Cajanus cajan*) is a nutritionally important food crop of the leguminous family that exist in tropical and subtropical regions of the continent (Rampersad *et al*., 2003). Legumes are usually rich in proteins, essential amino acids and minerals, and are used to supplement other foods (Etonihu *et al*., 2009). Pigeon pea has a fairly high protein, relatively low fiber content and rather small seeds and is drought-resistant. Pigeon pea contains about 5.14% ash, 21.32% protein, 7.29% fiber, 54.25% carbohydrates, 3.8% fat, 10.1% moisture (Onimawo and Akpojovwo, 2006) and it is an important source of food calories and minerals. Pigeon pea flour contains a reasonable amount of protein, due to this reason it can be used as food supplement for cereal food products due to its high level of protein, iron and phosphorus (Harinder *et al*., 1999). Therefore, the aim of this research work was to determine the chemical, nutritional and sensory qualities of the cookies produced from blends of acha, pigeon pea and wheat flour.

2. MATERIALS AND METHODS

Materials

Seeds of pigeon pea were purchased at one market in Ife Odan, Osun state while acha grains were obtained from a local market in Jos, Plateau State. Other ingredients such as wheat flour, sugar, margarine, baking powder, eggs, milk and vegetable oil were purchased from Waso market in Ogbomoso, Oyo State, Nigeria.

Processing of Acha

Acha grains were processed into flour according to the method of Olapade *et al*. (2010). Acha grain was cleaned to remove some extraneous material by handpicking. Acha grains was washed with water and dried at a temperature of 50 ºC for four hours. The grains were dry milled using a hammer mill and sieved to pass through 0.2 mm mesh to produce acha flour. The flour was packaged in a container to prevent the flour from absorbing the moisture.

Processing of Pigeon Pea

Pigeon pea seed was cleaned to remove the damaged insect and other extraneous material from the seed and was soaked in hot water for 1 hour. The seeds were manually dehulled by means of mortar and pestle to separate the seed coats from the cotyledon; the dehulled seeds were dried for 12 hours before milling. The sample was sieved using 0.5 mm sieve to obtain flour sample and was stored in a container to prevent the flour from absorbing the moisture according to the method of Enwere *et al*. (2003).

Composite Flour Formulation

Composite flour formulation was prepared from a blend of wheat, acha and pigeon pea in the ratio of 100:0:0, 35:55:10; 20:60:20; 35:45:20 and 20:50:30.

Preparation of Cookies

The cookies were produced from 100 g of composite flour, 1 g of salt, 1g baking powder, 31 g of egg, 40 g of margarine, 25 g of sugar, 7.8 g of milk and 5 ml vanilla flavour. Margarine and sugar were creamed to homogeneity using an electric mixer at a medium speed for 5 minutes. Egg and milk were added and then mixed for 30 minutes. Other ingredients such as vanilla flavour, composite flour, baking powder and salt were properly mixed before added to mixed cream before it was mixed together to form a dough. The dough was kneaded to a uniform slice thickness of 0.5 cm and a circular cut of 5cm diameter. It was allowed to bake at 150 ^{o}C for 30 minutes and then cooled (Okpala, 2012).

Analyses

Functional Properties Determination

Oil Absorption Capacity was determined according to the method of Giami *et al*. (2002). Swelling capacity and solubility were determined using the method of Ukpabi and Ndimele (1990). Water holding capacity was obtained according to the method of Giami *et al*. (2002).

Pasting characteristics Determination

A modified method of the Brabender Amylograph procedure known as the Rapid

Visco-Analyser (RVA) procedure as contained in the operation manual for the series 3 Rapid Visco-Analyser was adopted.

Anti-nutrients Determination

Tannin content was obtained by the method of Folin-Denis (AOAC, 1990); trypsin inhibitor activity was obtained by a spectrophotometric method described by Arntifield *et al*. (1985), while phytate was obtained by the method described by Pearson (1976).

Proximate Composition Determination

The moisture, crude protein, fats, fiber and ash contents of the composite cookies samples were determined using AOAC (2005). The total carbohydrate was obtained using Equation (1) Carbohydrate = 100% - (moisture + protein + fat + ash + crude fiber) % (1)

Sensory Evaluation

The sensory evaluation was determined using a fifteen-member panelist consisting of students from the Department of Food Science and Engineering, Ladoke Akintola University of Technology, Ogbomoso, Nigeria. Cookies samples were coded and served to panelists in a white plastic plate using a 9 point hedonic scale where 1 implies dislike extremely and 9 implies like extremely. Table water was used to rinse the mouth between evaluations. The panelists were instructed to evaluate the coded samples for crispiness, colour, taste, flavour, aroma and overall acceptability.

Statistical Analysis

Data obtained were subjected to statistical analysis using one-way analysis of variance (ANOVA). Mean separation was done by Duncan's multiple range test using the Statistical Package for the Social Sciences (SPSS) 20.0 (SPSS Inc., Chicago, IL, USA).

3. RESULTS AND DISCUSSION

Functional Properties of Wheat, Acha and Pigeon Pea Flours

The results of the functional properties of wheat, acha and pigeon pea flour blends are presented in Table 1. The oil absorption capacity, water absorption capacity, swelling capacity and solubility index ranged from 125 to 141%, 158 – 185%, 15.55 g/g to 18.80 g/g and 40.25% to 41.88%, respectively. The OAC of the flour blends were generally high. Oil absorption capacity is the ability of flour to absorb oil which is important as oil act as flavour retainer and improves mouthfeel (Aremu *et al*., 2007). Water absorption capacity is the ability of a product to associate with water under limiting conditions. Flours with such high WAC as seen in this research work are very good in bakery products, because this will prevent staling by reducing moisture loss (Singh, 2001). High swelling capacity has been reported as part of the criteria for a good quality product (Nlba *et al*., 2001). The swelling capacity of the flour samples can be compared with results reported by Abulude *et al*. (2006). Swelling power provides evidence of the magnitude of interaction between starch chains. The solubility index of sample 35/55/10 has the highest solubility and sample 20/60/20 gave the lowest value for solubility and this is as a result of it low swelling power which results from high amylose content.

Pasting Properties of Wheat, Acha and Pigeon Pea Flours

The results of the pasting properties of the flour blends sample are shown in Table 2. Peak viscosity of the flour samples ranged from 94.37 to 102 RVU. Peak viscosity is an index of the capacity of starch-based food to swell freely before their physical breakdown (Sanni *et al*., 2006; Adebowale *et al*., 2008). The breakdown value ranged from 19.43 to 19.65 RVU. Adebowale *et al*. (2005) suggested that as breakdown in viscosity increased, the ability of the sample to withstand heating and shear stress during cooking decreased. The final viscosity is a measure of the stability of granules. The final viscosity ranged from 95.88 to 124 RVU. Shimels *et al*. (2006) reported that final viscosity is necessary to indicate the ability of starch to form various paste after cooling and that less stability of starch paste is commonly accompanied with the high value of breakdown. The setback viscosity ranged from 26.93 to 35.61 RVU.

Table 1: Functional properties of wheat-acha and pigeon pea flours

Sample	OAC (%)	WAC (%)	SWC (g/g)	Solubility (%)
100/0/0	134±1.41^{bc}	178±1.41^{b}	17.05±0.21^{c}	40.61±0.04^{c}
35/55/10	125±1.41^{a}	158±1.41^{a}	18.80±0.14^{d}	41.88±0.22^{e}
20/60/20	141±1.41^{d}	185±1.41^{c}	15.55±0.35^{a}	40.25±0.02^{a}
35/45/20	130±1.41^{b}	174±1.41^{b}	16.45±0.21^{b}	40.96±0.01^{d}
20/50/30	138±2.12^{cd}	183±2.83^{c}	16.20±0.14^{b}	40.37±0.01^{b}

Means with different superscript in the same column are significantly different ($p<0.05$)

Legend
100/0/0: 100% wheat
35/55/10: 35% wheat + 55% acha + 10% pigeon pea
20/60/20: 20% wheat + 60% acha + 20% pigeon pea
35/45/20: 35% wheat + 45% acha + 20% pigeon pea
20/50/30: 20% wheat + 50% acha + 30% pigeon pea
OAC: Oil Absorption Capacity, WAC: Water Absorption Capacity, SWC: Swelling Capacity

Table 2: Pasting properties of wheat-acha and pigeon pea flours

Sample	Peak viscosity (RVU)	Break down value (RVU)	Final viscosity (RVU)	Set back value (RVU)	Peak time (min)	Pasting temperature (°C)
100/0/0	98.70±0.00^{c}	19.61±0.01^{bc}	110±0.01^{c}	28.32±0.00^{b}	5.25±0.01^{c}	60.79±0.01^{a}
35/55/10	96.56±0.01^{b}	19.58±0.01^{b}	98.83±0.01^{b}	29.28±0.00^{c}	5.23±0.02^{c}	60.89±0.01^{d}
20/60/20	94.37±0.01^{a}	19.43±0.01^{a}	95.88±0.00^{a}	26.93±0.01^{a}	5.20±0.01^{b}	60.93±0.01^{e}
35/45/20	101±0.00^{d}	19.63±0.01^{cd}	118±0.01^{d}	35.61±0.01^{e}	5.18±0.00^{b}	60.83±0.01^{c}
20/50/30	102±0.01^{e}	19.65±0.01^{d}	124±0.01^{e}	33.75±0.01^{d}	5.13±0.01^{a}	60.47±0.01^{a}

Means with different superscript in the same column are significantly different ($p<0.05$)

The higher the setback, the lesser the retrogradation of the flour paste during cooling and the lower the stalling rate of the product made from the flour (Adeyemi and Idowu, 1990). The peak time of the flour blends ranged from 5.13 to 5.25 min. Peak time is the time at which the peak viscosity occurred in minutes and this is a measure of the cooking time of the flour (Adebowale *et al*., 2005). The pasting temperature of the flour blends ranged from 60.47 to 60.93 °C. The pasting temperatures for the samples were quite lower than values obtained for wheat-flour cassava starch blend (Zaidul *et al*., 2007) and for dried moringa leaf-wheat flour blends (Dachana *et al*., 2010).

Anti-nutrient Content of Wheat, Acha and Pigeon Pea Flours

The anti-nutrient contents of the flour blends sample are presented in Table 3. Tannin contents values ranged from 8.17 to 8.59 mg/100g. These levels of tannin were higher than 0.98% reported by Anuoye *et al*. (2012) for pigeon pea and unripe plantain blend. Trypsin inhibitors values ranged from 2.97 to 4.93 mg/100g. Trypsin inhibition was increased with increasing amounts of pigeon pea flour in the blends. The result obtained was in agreement with that of Iwe and Ngoddy (1998) and Iwe (2000) which state that protein and Trypsin inhibition activity increased with an increase in the amount of soybean flour. The phytate content of the products ranged from 0.30 to 0.43mg /100g. Bushway *et al*. (1984) suggested that the maximum tolerable dose of phytate in the body is from 250 - 500 mg/100g. Therefore, the flour produced from the blend of wheat, acha and pigeon pea is safe.

Proximate Composition of Wheat-Acha-Pigeon Pea Cookies

The results proximate composition of the cookies prepared from 100% wheat flour and flour blends are presented in Table 4. The protein, fat, fiber, ash, moisture and carbohydrate contents ranged from 12.61 to 15.03%. The results show that sample E had the highest protein content of 15.03% while sample A had the lowest value of 14.23%. There was a significant difference ($p<0.05$) in protein content between the samples. The result is higher than 10.91% recorded for cashew nut-wheat cookies (Ojinnaka and Agubolum, 2013). The increase in protein of the cookies was as a result of the higher value of protein in pigeon pea (Tiwari *et al*., 2008). The fat content of cookies ranged from 15.14 to 15.43%. The samples are significantly ($p<0.05$) different from each other. A similar non-significant increase has been noted in using defatted legumes such as pigeon and groundnut (Ayo *et al*., 2003).

The crude fiber values of cookies ranged from 0.38 to 0.89%. The fiber contents of all the cookies were within the Recommended Daily Allowance which should not exceed 5 g dietary fiber per 100 g dry matter (FAO/WHO 1994). The ash content of cookies ranged from 2.56% to 2.74%. There was a significant difference between the samples ($p<0.05$). Increase in ash content could make the product sources of minerals as observed by previous work reported by De Lemen *et al*. (2003). The moisture content of cookies ranged from 5.33 to 5.10%. This was in line with the report of Obasi *et al*. (2012) and Igbabul *et al*. (2015) who reported that a reduction in moisture content was observed in flour obtained from cereals and legumes. Due to this low moisture content in cookies (less than 10%) the self- life will be increased because the high moisture content is responsible for the microbial deterioration in the food product. The carbohydrate content of cookies ranged from 61.38 to 61.81%. The carbohydrate content of the sample is favourably compared with the Dabel *et al.* (2016) value implying that the cookies are the source of energy needed for body metabolism.

Table 3: Anti-nutrient content of wheat-acha and pigeon pea flours

Sample	Tannin (mg/100g)	Trypsin (mg/100g)	Phytate (mg/100g)
100/0/0	8.27 ± 0.01^{b}	3.25 ± 0.01^{c}	0.30 ± 0.00^{a}
35/55/10	8.57 ± 0.01^{c}	3.13 ± 0.00^{b}	0.39 ± 0.01^{c}
20/60/20	8.59 ± 0.01^{c}	2.97 ± 0.01^{a}	0.43 ± 0.01^{d}
35/45/20	8.25 ± 0.01^{b}	4.75 ± 0.01^{d}	0.35 ± 0.01^{b}
20/50/30	8.17 ± 0.01^{a}	4.93 ± 0.01^{e}	0.37 ± 0.01^{bc}

Means with different superscript in the same column are significantly different ($p<0.05$)

Table 4: Proximate composition of cookies from wheat, acha and pigeon pea flour blends

Sample	Protein (%)	Fat (%)	Fiber (%)	Ash (%)	Moisture (%)	Carbohydrate (%)
100/0/0	12.61 ± 0.09^{d}	13.57 ± 0.02^{d}	0.44 ± 0.02^{d}	2.98 ± 0.01^{a}	5.33 ± 0.02^{a}	69.78 ± 0.01^{a}
35/55/10	14.33 ± 0.06^{c}	15.40 ± 0.02^{a}	0.85 ± 0.02^{c}	2.73 ± 0.02^{b}	5.27 ± 0.02^{a}	61.44 ± 0.02^{c}
20/60/20	14.47 ± 0.06^{c}	15.28 ± 0.01^{b}	0.57 ± 0.02^{c}	2.66 ± 0.02^{b}	5.18 ± 0.02^{b}	61.59 ± 0.04^{c}
35/45/20	14.84 ± 0.05^{b}	15.20 ± 0.02^{b}	0.44 ± 0.02^{b}	2.57 ± 0.01^{c}	5.13 ± 0.02^{b}	61.75 ± 0.01^{b}
20/50/30	15.03 ± 0.05^{a}	15.14 ± 0.02^{c}	0.38 ± 0.02^{a}	2.56 ± 0.02^{c}	5.10 ± 0.01^{b}	61.81 ± 0.03^{b}

Means with different superscript in the same column are significantly different ($p<0.05$)

Table 5: Sensory Evaluation of wheat-acha and pigeon pea cookies

Sample	Colour	Aroma	Taste	Crispness	Overall acceptability
100/0/0	6.33±1.40^{a}	6.53±1.19^{a}	6.00±1.13^{a}	6.53±0.83^{a}	6.60±1.06^{ab}
35/55/10	7.80±1.21^{bc}	6.93±0.70^{a}	6.93±1.53^{bc}	6.60±1.50^{ab}	7.13±1.25^{ab}
20/60/20	7.53±0.74^{b}	7.27±1.10^{a}	7.20±1.26^{b}	7.00±1.41^{a}	7.33±1.11^{b}
35/45/20	7.47±0.74^{b}	7.20±1.14^{a}	6.40±0.74^{a}	6.40±1.68^{a}	6.40±1.24^{a}
20/50/30	8.40±0.74^{c}	7.80±0.86	7.53±1.25^{c}	7.60±1.12^{b}	8.20±0.77^{c}

Means with different superscript in the same column are significantly different ($p<0.05$)

Sensory Evaluation

The sensory scores of the cookies made from wheat flour, acha flour and pigeon pea flour blend are shown in Table 5. The result shows that all the samples had very high sensory ratings in all the attributes considered such as colour, taste, aroma, crispness and overall acceptability. The colour of samples 20/60/20 and 35/45/20 was moderately liked with no significant difference in how much their colour was liked. Sample 20/50/30 was accepted by respondents when it comes to flavour, taste, crispness and mouth feel followed by sample 20/60/20 and 35/45/20, while sample 10/0/0 and 35/55/10 have the lowest preference. Test for overall acceptability of sample 100/0/0 and sample 35/45/20 was slightly liked. Samples 35/55/10 and sample 20/60/20 was moderately liked. Sample 20/50/30 was accepted most of all the samples with the mean of acceptability (8.20).

4. CONCLUSION

The finding has shown that acceptable cookies can be produced from flour blends of wheat, acha and pigeon pea. These cookies were found to be good nutritional products. This study shows that enrichment of wheat-acha with pigeon pea resulted in a notable increase in protein content, which could be of great nutritional benefits to Nigeria, where many can hardly afford to buy high protein foods due to high cost.

5. REFERENCES

[1]. ABIOYE, V. F., ADE-OMOWAYE, B. I. O., BABARINDE, G. O. and ADESIGBIN, M. K. (2011). Chemical, physico-chemical and sensory properties of soy plantain flour. *African Journal of Food Science*, 5: 176-180.

[2]. ABULUDE, O., OLAWALE, L. L. and OLALEYE, M. F. (2006).Effects of processing on physical and functional properties of groundnut (*Arachis hypogea*) flour. Electronic Journal of Environmental, *Agricultural and Food Chemistry*, 5(4): 1457-1491.

[3]. ADAMS, M. L., LOMBI E., ZHAO F. J. and MCGRATH S. P. (2002). Evidence of low selenium concentrations in UK bread-making wheat grain. *Journal of the Science of Food and Agriculture*, 82: 1160-1165.

[4]. ADEBOWALE, A. A., SANNI, L. O. and AWONORIN, S. O. (2005). Effect of texture modifies on the physiochemical and sensory properties of dried fufu. *Journal of Food Science and Technology International*, 11: 373-385.

[5]. ADEBOWALE, A.A., SANNI L.O. and ONITILO, M.O. (2008). Chemical composition and pasting properties of tapioca grit from different cassava varieties and roasting method. *African Journal of Food Science*, 2: 77-82.

[6]. ADEYEMI, I. A. and IDOWU, M. A. (1990). Evaluation of pregelatinized maize in the development of maissa baked product. *Nigerian Food Journal*, 8: 63–73.

[7]. ALAIN, M. M. M., ISRAEL, M. P. and RENE, M. S. (2007). Improving the nutritional quality of cowpea and bambara bean flours use in infant feeding. *Pakistan Journal of Nutrition*, 6: 660-664.

[8]. ANUOYE, J. C., JIGAM, A. A. and NDACEKO, G. M. (2012). Effects of extrusion–cooking on the nutrient and antinutrient composition of pigeon pea and unripe plantain blends. *Journal of Applied Pharmaceutical Sciences*, 2 (5): 158-162.

[9]. AOAC (2005) Official Methods of Analysis of the association of Analytical chemist AOAC, Airlington, Virgina.

[10]. AREMU, M. O.,OLAOFE, O. AND AKINTAYO. E. T. (2007). Functional properties of some Nigerian varieties of legume seed flours and flour concentration effect on foaming and gelation properties. *Journal of Food Technology*, 5:109–115.

[11]. ARNTIFIELD, S. S., ISMOND, M. A. AND MURRAY, E. D. (1985). Fate of antinutritional factors during miscellization technique. *Canadian Institution Food Science Technology Journal*, (18): 137-140.

[12]. AYO, J. A., IBRAHIM, A. and NKAMA, I. (2003).Effect of acha (*Digitaria exilis*) on the body weight, glucose blood level haemoglobin and packed column cell of rabbit. Proceedings, National Conference of the application of Science for National Development, Mubi, Adamawa state. 25–28

[13]. BUSHWAY, R. J., BUREAU, J. L. and MCGANN, D. P. (1984). Determination of organic acid in potatoes by high performance liquid chromatography. *Journal of Food Science*, 49:75-77.

[14]. DABEL, N., IGBABUL, B. D., AMOVE J. and IORLIAM B. (2016). Nutritional composition, physical and sensory properties of cookies from wheat, acha and mung bean composite flours. *International Journal of Nutrition and Food Science*, 5: 6, 401-406.

[15]. DACHANA, K., RAJIV, J., INDRANI, D. and PRAKASH, J. (2010). Effect of dried moringa (*Moringa oleifera Lam.*) leaves on rheological, microstructural, nutritional, textural and organoleptic characteristics of cookies. *Journal of Food Quality*, 33, 660–677.

[16]. DE LUMEN B. O., THOMPSON, S. and ODEGAARD, J. W. (2003). Sulphuramino-acid rich proteins in acha (*Digitaria exilis*) a promising underutilized African cereal. *Journal of Agricultural Food Chemistry*, 41:1045 – 1047.

[17]. ENWERE, N. J., OYARIEME, H. C. and OSHO, S. M. (2003). Characteristics of porridge-type breakfast cereal prepared from soybean and maize. A paper presented at the 14th Annual conference of the Nigerian Soybean Association at NCRI Ibadan April, 20-22, 1993, Events and Book of Abstract, pp 12.

[18]. ETONIHU, A. C., AYODELE, J. T. and IBRAHIM, M. (2009). Proximate and amino acid composition of wheat species of pigeon pea grown in Kogi State, Nigeria. *Nigerian Journal of Biochemistry and Molecular Biology*, 24(2): 32-36.

[19]. FAO/WHO. 1994. Codex Alimentarius: foods for special dietary uses (including foods for infants and children). 2nd edn. FAO, Rome, pp 23.

[20]. GIAMI, S. Y., MEPBA, H. D., KIIN-KABARI, D. B. and ACHINEWU, S. C., (2002). Evaluation of the nutritional quality of breads prepared from wheat-fluted pumpkin (*Telfairia occidentalis*) seed flour blends. *Plant Foods for Nutrition*, 58: 1–8.

[21]. HARINDER, K. and SHARMA, B. (1999). Studies on the baking properties of wheat: Pigeon pea flour blends. *Plant Foods for Human Nutrition*, 54: 217–226.

[22]. IBRAHIM, A. (2001). Hungry rice (Fonio): A neglected cereal crop. NAQAS Newsletter (1) 4: 4–5.

[23]. IGBABUL, B., ADOLE, D. and SULE, S. (2013). Proximate composition, functional and sensory properties of bambara nut (*Voandzeia subterranean*), cassava (*Manihot esculentus*) and soybean (*Glycine max*) flour blends for "Akpekpa" production. *Current Research in Nutrition and Food Science*, 1(2): 147-155.

[24]. IWE, M .O. and NGODDY, P. O. (1998). Proximate composition and some functional properties of extrusion cooked soybean and sweet potato blends. *Plant Foods for Human Nutrition*, 53: 121-132.

[25]. IWE, M. O. (2002). Handbook of sensory methods and analysis. PROJOINT Communications Services Ltd, Enugu, pp. 70-72.

[26]. LASEKAN, O. O. and AKINTOLA, A. M. (2002). Production and nutritional evaluation of puffed soy-maize snack. *Nigerian Food Journal*, 20(1): 15-19.

[27]. MCWATTERS, K. H., OUEDRAOGO, J. B. A., RESURRECCION, 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 Food Science and Technology*, 38: 403–410.

[28]. Niba, L. L., BOKANGA, M. M., JACKSON, F .L. SCHLIMME, D. S. and LI, B.W. (2001). Physicochemical properties and starch granular characteristics of flour from various *Manihot Esculenta* (Cassava) Genotypes, *JFS: Food Chemistry and Toxicology*, 67: 1701 – 1705.

[29]. OBASI, N. A., AKUBUGWO, E. I., UGBOGU, O. C. and CHINYERE, G. C. (2012). Heavy metals bioavailability and phyto-accumulation potentials of selected plants on burrow-pit dumpsites in Aba and Ntigha dumpsite in Isiala Ngwa of Abia State, Nigeria. *Nigerian Journal of Biochemistry and Molecular Biology*, 27: 27-45.

[30]. OJINNAKA, M. C. and AGUBOLUM, F. U. (2013). Nutritional and sensory properties of cashew nut-wheat based cookies. *American Journal Food Nutrition*, 3:127–134.

[31]. OKAKA, J. C. (2009). Handling, storage and processing of plant foods. Academy Publishers Enugu, Nigeria, page 132.

[32]. OKPALA, L. C. and OKOLI, E. C. (2011). Nutritional evaluation of cookies produced from pigeon pea, cocoyam and sorghum flour blends. *African Journal of Biotechnology*, 10(3): 433-438.

[33]. OLAPADE, A. A., AWORH, O. C. and OLUWOLE, O. B. (2010). Quality attributes of biscuits from acha (*Digitaria exilis*) flour supplemented with cowpea (*Vigna unguiculata*) flour. *African Journal of Food Science and Technology*, 2(9): 198-203.

[34]. ONIMAWO, I. A. and AKPOJOVWO, A. E. (2006). Toasting (dry heat) and nutrient composition, functional properties and anti-nutritional factors of pigeon pea (*Cajanus cajan*) flour. *Journal of Food Processing and Preservation*, 30(6): 742-753.

[35]. PEARSON, D. M., 1976. The chemical analysis of foods. 6th Edn., AVI Publishers, West Port.

[36]. RAMPERSAD, R., BADRIE, N. and COMISCIONG, E. (2003). Physic-chemical and sensory characteristics of flavoured snacks from extruded cassava/pigeon pea flour. *Journal of Food Science*, 68: 363-367.

[37]. SANNI, L. O., ADEBOWALE A. A. and TAFA, S. O. (2006). Proximate, functional, pasting and sensory qualities of instant yam flour. A Paper presented at the 14 ISTRC symposium, Central Tuber Crops the Research Institute, Trivandrum, Kerala State, India.

[38]. SHEWRY, P. R. (2007). Improving the protein content and composition of cereal grain. *Journal of Cereal Science*, 46: 239–250.

[39]. SHEWRY, P. R. (2009). The health grain programme opens new opportunities for improving wheat for nutrition and health. *Nutrition Bulletin*, 34(2): 225–231.

[40]. SHIMELS, A. E., MEAZA M. and RAKSHIT, S. (2006). Physicochemical properties, pasting behaviour and functional characteristics of flour and starches from improved bean (*Phaseoluus vulgaris L.*).varieties grown in East Africa, *Agricultural Engineering International: the CIGR Ejournal*, 8: 1-18.

[41]. SINGH, U. (2001). Functional properties of grain legume flours. *Journal of Food Science*, 38:191-199.

[42]. TEMPLE, V. J. and BASSA, J. D. (1991). Proximate chemical composition of fonio (*Digitaria exilis*) grain. *Journal Science Food Agriculture*, 56: 561-564.

[43]. TIWARI, B. K.., TIWARI, U., MOHAN, R. J. and ALAGUSUNDARAM, K. (2008). Effects of various pre-treatments on functional, physicochemical and cooking properties of pigeon pea (*Cajanus cajan L.*). *Food Science Technology*, 14:487–495.

[44]. UKPABI, U. J. and NDIMELE (1990). Evaluation of gari production in Imo State Nigeria, *Nigerian Food Journal*, 8: 105- 108.

[45]. VIETAMEYER, N. D. BORLAUGH, N. E., AXTELL, J., BURTON, G. and HARLAN, W. and ACHIE, K. O. (1996). Fonio. In: Lost crops of Africa Vol. 1. Grains BOSTID Publications. National Academy press, New York.

[46]. ZAIDUL I. S. M., YAMAUCHI H., TAKIGAWA S., MATSUURA-ENDO C., SUZUKI T. and NODA, T. (2007) Correlation between the compositional and pasting properties of various potato starches. *Food Chemistry*, 105(1): 164-172.