NUTRITIONAL AND SENSORY EVALUATION OF LOCALLY PRODUCED ACHA (*DIGITARIA EXILIS*) FLAKES FORTIFIED WITH BAMBARA NUT AND CRAYFISH

ABSTRACT

Aim: To evaluate the nutritional, anti-nutritional and sensory characteristics of Acha flakes, fortified with Bambara nut and crayfish powder.
Methodology: Moistened Acha grains were steamed, oven-dried, milled and sieved to obtain Pregelatinized Acha Flour (PAF). Bambara nut seeds were soaked, dehulled, washed, steamed, dried, milled and sieved as Steamed Bambara nut Flour (SBF). PAF, SBF and crayfish powder were mixed in the ratio of 70:20:10, 60:30:10 and 50:40:10 and baked on foil lined oven tray to produce Flakes A, B and C. Chemical (proximate, minerals, Vitamin A, phytate and tannin) and sensory analysis were undertaken using standard methods. ANOVA was used to detect significant differences.
Results: Protein, ash and carbohydrate contents of products ranged from 16.68 – 17.98%, 2.96-3.12% and 63.89-64.16%, respectively. Flake C had the highest ($p<0.05$) protein (17.98%) and fat (4.11%) contents while flake A had the lowest (16.68%, 3.75%) values. Calcium (141 mg/100g) and iron (2.82 mg/100g) contents were significantly highest in Flake B while Flake C had the highest beta-carotene (269.86µg/100g) content. All products recorded low phytate (15.25-19.03 mg/100g) and tannin (5.90-8.65 mg/100g) values. Addition of Bambara nut (40%) and crayfish (10%) to Acha flour increased the protein and beta-carotene by 8% and 10%, respectively. Flake C was rated highest in taste (8.04), flavour (7.80) and overall acceptability (8.40).
Conclusion: Acha based flakes produced from 50% Acha flour fortified with 40% Bambara nut and 10% crayfish was the best in terms of nutritional and sensory attributes. This locally produced breakfast cereal when offered to children may contribute to reductions in child undernutrition.

Keywords: Breakfast cereal, Fonio, Bambara nut, Nutrient

1.0 INTRODUCTION

The burden of hunger fueled by food shortage and food insecurity is much larger in Africa compared to other regions of the world [1]. Post Covid 19 pandemic effects, conflicts in Ukraine/Russia, climate change and insurgencies in some African countries aggravated the situation. Women and children as well as the elderly are the worst hit by food insecurity and the consequence is undernutrition. It is projected that almost 600 million people will be chronically undernourished in 2030, making the chances of SDG 2 achievement very low [1]. Under-nutrition during childhood results in shorter adult stature, poor academic achievement and reduced productivity in adulthood [2]. Low energy and nutrient intake due to poor food intake is a major cause of under-nutrition.

Breakfast is the most skipped meal among children, adolescents and adults due to lack of time, unaffordability and unavailability [3]. Breakfast skipping and poor quality breakfast meals are major contributors to childhood undernutrition and poor academic performance [4,5]. Eating of breakfast is considered as one of the important meal of the day since it helps to start nutrient metabolism and replenishes the body [6]. Reduction of the risk of some chronic disease and weight gain has been cited as one of the benefits of breakfast consumption [7]. Flavia et al reported that breakfast skippers had lower dietary fibre and micronutient but higher saturated fat intake than breakfast cereal consumers [8] Thus, improved breakfast consumption would contribute to reducing the burden of both under-nutrition and over nutrition among children.

Breakfast cereals are the most common type of breakfast meal among children. They are generally defined as foods obtained by soaking, grinding, rolling, shredding before puffing or roasting of cereals [9]. They often include a carbohydrate rich source such as maize, wheat, rice among others [10]. Locally produced breakfast meals include gruels made from cereals and other family meals. Ready-to-eat cereals are generally preferred because they are more convenient.

Development of breakfast cereals from locally available ingredients has attracted a lot of attention. Nutritionists, food scientists and researchers have employed several traditional and industrial based technologies to produce various breakfast meals from cereals such as maize, millet, wheat and rice among others [11]. These cereal based breakfast meals have also been enriched with plant and animal protein food sources including milk, soybean among others [12, 13, 14]. However, there are many cereals and legumes that are underutilized. The commercial ready-to-eat breakfast cereals are becoming too expensive. Locally Ready-to-eat breakfast meals can be produced from these underutilized crops to reduce the dependence on common ones as well as improve the utilization of underutilized foods [15].

Acha and bambara nut are among the underutilized crops locally produced in Nigeria. They can be combined with plant and sea based animal source food to make nutritious meals. Use of traditional methods and sea based animal sourced food would contribute to sustainability as well as efforts to reducing carbon emissions. Fonio (*Digitariaexilis*) commonly called ‘acha’ is rich in amino acid; methionine and cysteine [16].Acha (*Digitariaexilis*) is an indispensable source of antioxidant phenolics, dietary fiber and cholesterol-lowering waxes. It is less receptive to denaturation while its starch is made of 43.6%, 2.1% and 41.4% total, resistant and digestible starch, respectively with low glycemic index [17]. Bambara nut (*Vigna subterranea*) known as Gurjiya or Kwaruru (Hausa), Okpa (Ibo) and Eparoro (Yoruba) is an important legume that is rich in proteins and minerals [18]. The nut has anti-nutritional factors and does not de-hull easily [18]. Crayfish is a sea food high in protein, B vitamins and minerals [19]. Crayfish, also known as crawfish, crawdads, freshwater lobsters, mountain lobsters, mud bugs or yabbies, are actually freshwater crustaceans that look like a smaller version of a lobster. Taxonomically, they are members of the super families, Astacoidea and Parastacoidea [20]. The use of acha and bambara nut in breakfast meal production would improve their utilization as well as nutritional quality of the product.

Thus, this study aimed at assessing the nutritional, anti-nutritional and sensory characteristics of breakfast cereal flakes produced from acha flour fortified with bambara nut flour and crayfish powder using simple household processes.

2.0 METHODS

2.1 Sample collection

Acha (*Digitariaexilis)*, Bambara nut (*Vigna subterranea*), and Crayfish (*Procambarusclarkii*) were purchased from a local market (Bodija market Ibadan), Oyo State Nigeria.

2.2 Production of Pregelatinized Acha Flour

The acha grains were pregelatinized by a modification of the method described by Edema et al. (2004) [21]. The grains were cleaned by sorting to remove the dirts, husks and stones. It was then washed under running clean tap water five times for 20 minutes. The moistened acha grains were steamed over boiling water for 10 minutes. The pregelatinized seeds were dried at 50°C for 24 hours to a constant weight and milled in a hammer mill. The samples were sieved through a 450 micrometer pore-sized sieve, stored in polythene bags and designated as Pregelatinized Acha Flour (PAF).

Sorting
↓
Winnowing
↓
Washing
↓
Conditioning
↓
Steaming (10 minutes)
↓
Drying at 50^{o}C for 24 hours
↓
Dry milling
↓
Sieving
↓
Packaging
↓
Pregelatinized Acha flour

Figure 1: Flow chart for the production of Pregelatinized Acha Flour (PAF) [21].

2.3 Production of Steamed Bambara Nut Flour

Bambara nut was sorted to remove stones and other extraneous materials. Using the method of Ikujenlola and Adurotoye [22], the seeds were soaked, dehulled, washed and steamed for 20 minutes. The seeds were dried in the oven (60^{o}C for 9 hours). During drying, the dehulled seeds were stirred at interval for 20 minutes to ensure uniform drying. The dried seeds were milled using hammer mill and sieved before being packaged in a polythene bag and labelled steamed Bambara nut flour (SBF).

Sorting

↓

Cleaning

↓

Soaked

↓

Dehulled

↓

Washing of seeds

↓

Steaming (20 minutes)

↓

Draining

↓

Drying at 60^{o}C for 15 hours

↓

Dry milling

↓

Packaging

↓

Steamed bambara nut flour

Figure 2. Production of Steamed Bambara nut Flour (SBF) [22]

2.3 Production of Crayfish Powder

Crayfish was cleaned and extraneous materials removed. The crayfish was washed, oven dried at 50^{o}C for 1 hour and milled into flour. It was packaged in a polythene bag and labelled as crayfish powder.

2.4 Formulation of flour composite

Table 1 : Blending ratios of Acha, Bambara nut and Crayfish

Sample code	Acha	Bambara nut	Crayfish
FLAKE A	70	20	10
FLAKE B	60	30	10
FLAKE C	50	40	10

2.5 Production of Acha flakes

Pregelatinized acha and steamed bambara nut composite flours were mixed with crayfish powder in a bowl in their powdery form. Water was added little at a time, stirring until batter is smooth and thin to get a watery consistency similar to that of pancake batter. The mixture was precooked (heat treated) by steaming for 10 minutes and then allowed to age at a temperature of 4°C in a refrigerator for about 6 hours. The oven was preheated to 70°C and the baking tray was lined with foil and greased lightly with oil. The mixture was poured into the prepared pan and spread out evenly. It was baked on the centre rack for 5 hours until the dough has dried out and cracked. The tray was then removed from the oven and allowed to cool, and then a clean glove was worn on the hand and snack shaping used to crack the dough into small flakes. The heat of the oven was lowered to 70°C and the cracked flakes were returned and allowed to bake on the centre rack for 70 minutes when pieces were toasted, crisp, and golden. It was left to cool completely under room temperature and stored in a packaging material (ziploc bag) in a cool dry place.

Composite Flours
↓
Mixing with water
↓
Batter
↓
Conditioning (heat treated) for 10 minutes
↓
Ageing (for 6 hours)
↓
Flaking (temperature of 70^{o}C for 5 hours)
↓
Baked cracked flakes (temperature of 70^{o}C for 70 minutes)
↓
Cooling (28^{o}C)
↓
Packaging
↓
Acha flakes

Figure 3:Flow chart for production of Acha Flakes [23]

Figure 4: Produced Acha-based flakes

2.6 CHEMICAL ANALYSIS

2.6.1 Determination of nutrient and anti-nutrient composition

The AOAC method was used to determine the protein (Kjedahl method), moisture (hot air oven method), fat, ash and fibrecontent [24] Carbohydrate was calculated as the difference between 100 and values of other macronutrients. Calcium was determined by flame photometric. Iron and Zinc were determined by atomic absorption spectrometer (AAS). Phytate and tannin contents of the formulated flakes were determined using standard methods as described in AOAC [24].

2.7Sensory Evaluation

Ready-to-eat fortified acha flakes was served to a 30-member semi-trained panelists comprising of mothers. The panelists were presented with the three samples of acha flakes and told to indicate their preferences based on taste, colour, flavour, texture and overall acceptability. The panelists were instructed to rinse mouth with water before and after the assessment of each product. Scoring was done on 9-point Hedonic scale where 9 and 1 represented liked extremely and disliked extremely, respectively [25].

2.8 Statistical Analysis

Data analysis was performed using SPSS version 20. Descriptive statistics was used to describe and summarize data. Data was expressed as means and standard deviations where applicable. Differences for continuous variable were evaluated using a one-way analysis of variance(ANOVA) and Duncan's multiple range test was used to compare differences when the ANOVA was significant ($p < 0.05$).

3.0 RESULTS

3.1 Nutrient and anti-nutrient properties of Acha, Bambara nut and Crayfish

Table 2 shows the proximate composition of the food samples (Crayfish, Bambara nut and Acha). Proximate parameters of the three food samples varied significantly. Crayfish is low in moisture, crude fiber and carbohydrate contents. However, crayfish is highest in protein content than bambara nut and acha, respectively having 54.56% protein. Acha flour is richer in carbohydrate contents compared to Bambara nut flour and crayfish blend.

Table 2: Proximate composition of Acha, bambara nut and crayfish (% dry matter)

Food Sample	Moisture	Crude Fat	Ash	Crude fiber	CHO	Protein
Acha flour	11.21 ± 0.08^{a}	1.32 ± 0.08^{a}	2.71 ± 0.03^{a}	1.86 ± 0.02^{a}	76.09 ± 0.08^{a}	6.82 ± 0.09^{a}
Bambara nut flour	$9.88\pm0,06^{b}$	5.22 ± 0.06^{b}	4.10 ± 0.04^{b}	3.29 ± 0.04^{b}	59.76 ± 0.27^{b}	17.75 ± 0.23^{b}
Crayfish blend	6.22 ± 0.04^{c}	6.17 ± 0.03^{c}	13.43 ± 0.65^{c}	0.82 ± 0.08^{c}	18.81 ± 1.48^{c}	54.56 ± 0.83^{c}

Values in the column followed by the same superscript are not significantly different ($p>0.05$).
Values are means and standard deviations of duplicate samples determinations.
A= 70:20:10 (acha flour, bambara nut flour and crayfish)
B= 60:30:10 (acha flour, bambara nut flour and crayfish)
C= 50:40:10 (acha flour, bambara nut flour and crayfish)

Table 3 shows that crayfish is rich in vitamin A, calcium, iron and zinc compared to Bambara nut and acha flours. It is also low in phytate. High Ash content of crayfish shown in Table 3.1a is indicative that crayfish is rich in other minerals compared to Bambara nut and Acha flours.

Table 3: Mineral and anti-nutrient composition of Acha, bambara nut and crayfish (mg/100g)

Food sample	Vitamin A	Iron	Zinc	Calcium	Phytate	Tannin
Acha	175.07 ± 3.14^{a}	1.02 ± 0.01^{a}	0.59 ± 0.03^{a}	79.5 ± 0.71^{a}	27.6 ± 0.35^{a}	16.5 ± 2.12^{a}
Bambara nut	182.28 ± 3.39^{b}	4.26 ± 0.01^{b}	0.75 ± 0.02^{b}	64.5 ± 0.71^{b}	19.8 ± 0.42^{b}	60.5 ± 3.53^{b}
Crayfish	431.98 ± 4.50^{c}	8.56 ± 0.02^{c}	1.32 ± 0.01^{c}	1448.0 ± 1.41^{c}	9.1 ± 0.28^{c}	23.5 ± 3.53^{c}

Values in the column followed by the same superscript are not significantly different (p>0.05).
Values are means and standard deviations of duplicate samples determinations.
A= 70:20:10 (acha flour, bambara nut flour and crayfish)
B= 60:30:10 (acha flour, bambara nut flour and crayfish)
C= 50:40:10 (acha flour, bambara nut flour and crayfish)

3.2Proximate composition of breakfast cereal flakes produced from Acha, bambara nut and crayfish blend

As shown in Table 4 below, significant differences (p<0.05) were observed among all samples for moisture, crude fat, crude fiber and protein except for ash and carbohydrate contents. The moisture content of the formulated Acha flake samples ranged from 9.72-10.73% and was highest in 70% Achaflour based flakes. Flake C (50:40:10) had the highest protein content.

Table 4: Proximate composition of Acha based flakes (% dry matter)

Product Sample	Moisture	Crude Fat	Ash	Crude Fiber	CHO	Protein
A	10.73^{a}	3.75^{a}	3.12^{a}	1.56^{a}	64.16^{a}	16.68^{a}
B	10.21^{b}	3.89^{b}	3.03^{a}	1.40^{b}	64.41^{a}	17.07^{b}
C	9.72^{c}	4.11^{c}	2.96^{a}	1.35^{c}	63.89^{a}	17.98^{c}

Values in the column followed by the same superscript are not significantly different (p>0.05)
A= 70:20:10 (acha flour, bambara nut flour and crayfish)
B= 60:30:10 (acha flour, bambara nut flour and crayfish)
C= 50:40:10 (acha flour, bambara nut flour and crayfish)

3.3 Mineral, Vitamin A and anti-nutrient contents of acha-based flakes (mg/100g)

Table 5 below indicates the vitamin A, iron, zinc and calcium contents of the produced flakes. Vitamin A and mineral contents in the three sample products differed significantly (p>0.05) except for Zinc with range of 0.18-0.22mg/100g. The three sample products were low in phytate and tannin.

Table 5: Mineral, Vitamin A and anti-nutrient content of acha-based flakes (mg/100g)

Product Sample	Vitamin A	Iron	Zinc	Calcium	Phytate	Tannin
A	246.42^{c}	1.02^{b}	0.18^{a}	124.5^{b}	19.00^{a}	5.90^{c}
B	254.08^{b}	1.23^{b}	0.18^{a}	141.0^{a}	16.70^{b}	7.60^{b}
C	269.86^{a}	2.82^{a}	0.22^{a}	93.8^{c}	15.35^{c}	8.65^{a}

Values in the column followed by the same superscript are not significantly different (p>0.05)
A= 70:20:10 (acha flour, bambara nut flour and crayfish)
B= 60:30:10 (acha flour, bambara nut flour and crayfish)
C= 50:40:10 (acha flour, bambara nut flour and crayfish)

3.4 Sensory Properties of the produced flakes

Table 4 below shows the sensory evaluation of ready-to-eat Acha flakes enriched with Bambara nut and crayfish which was served to a 30-member panel comprising of school-aged children and their mothers. Sample C (50% Acha flour, 40% Bambara nut flour and 10% crayfish) scored highest in all the sensory parameters compared to Sample A and B.

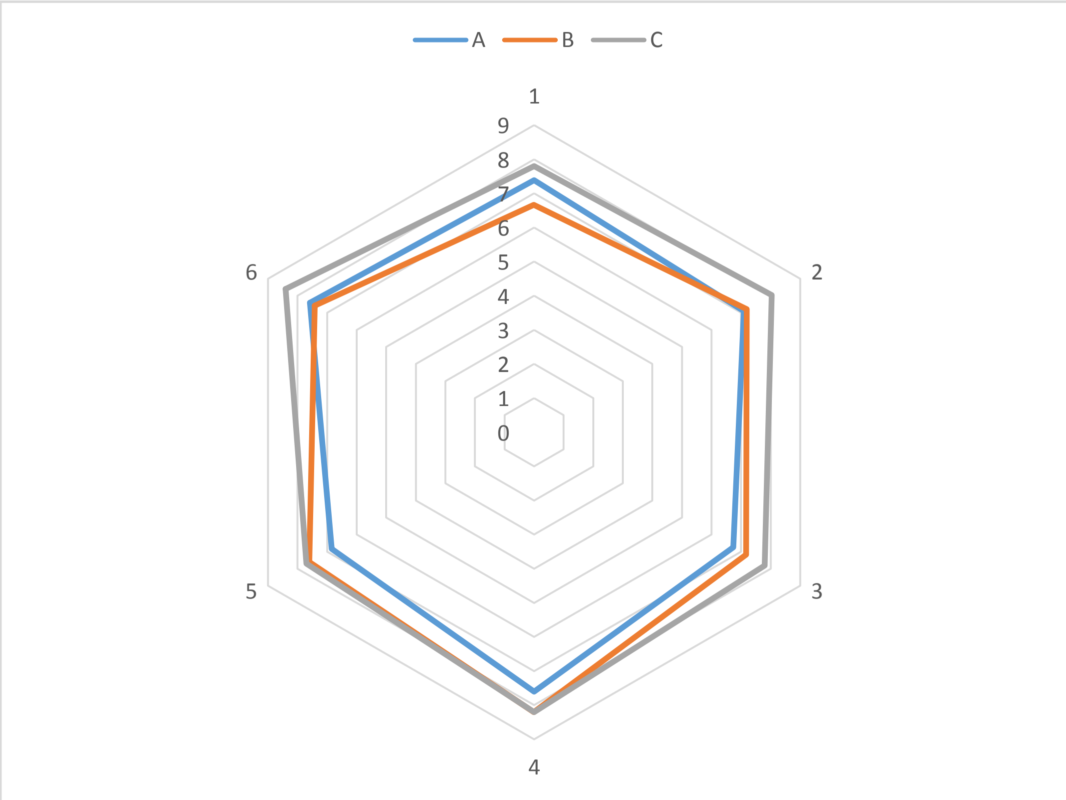

Figure 5: Sensory attributes of the produced flakes

A= 70:20:10 (acha flour, bambara nut flour and crayfish)
B= 60:30:10 (acha flour, bambara nut flour and crayfish)
C= 50:40:10 (acha flour, bambara nut flour and crayfish)

3.5 Contribution of produced flakes to the daily energy requirement for ages 1-18 years

Contributions of serving portions (50-100g) of the acha flakes to the daily energy requirements for children, adolescents and teens are displayed in Table 6. Serving portions of the flakes provide about 15-26% of the daily energy requirements as displayed in the table.

Table 6. Contribution of serving portions of Acha-based flakes to daily energy and nutrient recommendations (Dietary reference intake*)

Age groups	1-3 years			4-8 years			9-18 years		
Flake samples	A	B	C	A	B	C	A	B	C
Serving portions (g)	50	50	50	100	100	100	100	100	100
Energy (kcal)/day	1200			1400			1800		
Energy/100g of Flakes	357	361	365	357	361	365	357	361	365
Energy/serving	179	181	183	357	361	365	357	361	365
% of DRI	15%	15%	15%	26%	26%	26%	20%	20%	20%

*Dietary Reference Intake (DRI) (Source:Judith Brown, Nutriton during Life Cycle, Cengage Learning, USA, 2017)

4.0 DISCUSSION

The moisture content of the samples was fairly low and thus gives an indication of their safety and microbial stability. Low moisture content is desirable because high moisture content may predispose the product(s) to microbial growth due to high water activity. In addition, the observed moisture content in this study was lower than the values reported for rice-based Masa (40 - 70%) [20]. Also moisture content of wheat and pawpaw puree bread was about two times higher than what was observed in this study [26]. In other studies, the moisture contents of ready-to-eat breakfast cereal produced from blend of rice, maize, African yam bean and defatted coconut were lower than what was found in this present study [27, 28, 29].

Addition of Bambara nut and crayfish flour toAcha flour increased crude fat, ash, and protein composition of Acha-based flakes by 2%, 1% and 10%, respectively. Crayfish is high in protein, ash content and fat compared to Acha flour and Bambara nut. Acha flour and Bambara nut are rich in carbohydrate and other nutrients. Thus, the combination of these food ingredients resulted to improved nutritional quality of the produced flakes.

Values obtained for carbohydrate and protein for all Acha-based flake products were within the values reported for breakfast cereal from maize, African yam bean and defatted coconut blend [29] and rice, African yam and defatted coconut blend [27]. Fat contents of all the sample products were comparable to that of the blend produced by Edima-nyah*et al.* [14]. However, variation existed in the ash and fiber contents observed in this study and those reported by other researchers [14, 20, 26, 29].

The iron and Vitamin A values of the produced flakes increased as the quantity of bambara nut flour rose from 20-40%. Edima-nyah et al., [14] (42-68 mg/100g) and Usman [13] (9.81-14.1 mg/100g) reported higher iron values for breakfast cereals produced from blends of yellow maize/soyabean/unripe banana flour and african yam bean/maize/deffated coconut, respectively. The low iron values found in this study might be atrributed to the difference in ingredients used and processes employed.

Serving portions of 50-100g of the developed flakes would provide about 18-26% of the daily energy allowance for children and teens. In addition to desired physical attributes, ready-to-eat cereals are expected to contribute substantially to the daily nutritional needs of the growing and active child.

5.0 CONCLUSION

Addition of Bambara nut and crayfish to acha grain increased the protein, Vitamin A, calcium and reduced the antinutrient contents of the Acha flakes. However, iron and zinc values were not increased. Acha flake C (50% acha, 40% bambara nut and 10% crayfish) was rated highest in all the examined sensory attributes. Consumption of the bambara nut and crayfish fortified acha breakfast cereal would contribute greatly towards reducing child undernutrition.

REFERENCES

1. UNICEF. Children, food and Nutrition: Growing well in a changing world. The state of the world's children. United Nations Children's Fund. 2019.
2. De Onis, M. and Branca, F. Childhood stunting: a global perspective and maternal child nutrition. 2016; 12:12-26.
3. Tin S, Ho S, Mak K, Wan K, Lam T. Lifestyle and socioeconomic correlates of breakfast skipping in Hong Kong primary 4 school children. J. Prev.Med. 2011:2;250-253. doi:10.1016/j.ypmed.2010.12.012.
4. Hoyland A, Dye L, Lawton CL. A systematic review of the effect of breakfast on the cognitive performance of children and adolescents. Nutr Res Rev. 2009; 2:220-43.
5. Mwaniki EW, Makokha AN. Nutrition status and associated factors among children in public primary schools in Dagoretti, Nairobi, Kenya. African Health Sciences. 2013;13(1): 39 – 46.
6. Al-Hazzaa HM, Alhowikan AM, Alhussain MH, Obeid OA. Breakfast consumption among Saudi primary school children relative to sex and socio-demographic factors. BMC Public Health. 2020;20(1)1-14. https://doi.org/10.1186/s12889-020-8418-1.
7. Bi H, Gan Y, Yang C, Chen Y, Tong X, Lu Z. Breakfast skipping and the risk of type 2 diabetes: A meta-analysis pf observational studies. Public Health Nutrition. 2015;18, 3013-3019
8. Flavia F, Andrew M, Kate T, Peter P. Breakfast and breakfast cereal choice and its impact on nutrient and sugar intakes and anthropometric measures among a nationally representative sample of Australian children and adolescent. Nutrients. 2017:9;1045-1046.

9. Nkiru EO, Chigozie EO, Gloria CO, Munachiso CU, Peace OO. Production and evaluation of breakfast cereal from flour blends of maize (Zea mays) and jackfruits seeds. Article in Archives of Current Research International. 2019;16(3)1-16
10. Rampersaud GC, Pereira MA, Girard BL, Adams J, Metzl DL. Breakfast habits, nutritional status, body weight and academic performance in children and adolescents. Journal of American Dietetic Association. 2005; 105:743-60; quiz 761-2.
11. Awika JM, Piironen V, Bean S. Advances in Cereal Science: Implications to Food Processing and Health Promotion, ACS Symposium Series, American Chemical Society, Washington DC. 2011;1-13.
12. Ofuya, Z. M. and Akhidue, V. (2005). The Role of Pulses in Human Nutrition: A Review. *J. Applied Sci and Env Mgt*., 9(3): 99-104
13. Usman GO. Production and Evaluation of Breakfast Cereals from Blends of African Yam Bean (Sphenostylisstenocarpa), Maize (Zea mays) and Defatted Coconut (Cocos nucifera). 2012. A Dissertation Submitted to the Department of Food Science and Technology, Faculty of Agriculture, University of Nigeria, Nsukka
14. Edima-Nyah AP, Ntukidem VE, James E.I. Development and Quality Assessment of Breakfast Cereals from Blends of Whole Yellow Maize (Zea mays), Soybean (Glycine max) and Unripe Banana (Musa sapientum). Asian Journal of Agriculture and Food Sciences. 2019; 7(3):85
15. Jaenicke H, Pasiecznik N. Underutilized crops and invasive species -Understanding the links. *International Society for Horticulture Science.* 2009; 806:587-594.
16. Mbaeyi-Nwaoha I. Uchendu NO. Production and evaluation of breakfast cereals from blends of acha and fermented soybean paste. J. Food Sci.Technol. 2016;53(1):50-70

17. Chinma CE, Anuonye JC, Ocheme OB, Abdullahi S, Oni S, Yakubu CM *et al*. Effect of acha and bambara nut sourdough flour addition on the quality of bread. LWT - Food Science and Technology. 2016; 70:223–228. https://doi.org/10.1016/j.lwt.2016.02.050.
18. Hillocks RJ, Bennett C, Mponda OM, Maritime C. Bambara Nut: A Review OfUtilisation, Market Potential And Crop Improvement. African Crop Science Journal. 2012;20(1):1–16.
19. Iombor TT, Umoh EJ, Olakumi E. Proximate Composition and Organoleptic Properties of Complementary Food Formulated from Millet (Pennisetumpsychostachynum), Soybeans (Glycine max) and Crayfish (Euastacusspp). Pakistan Journal of Nutrition. 2009;8: 1676-1679.
20. Samuel FO, Ishola OR, Otegbayo BO. Nutritional and Sensory Evaluation of Rice-Based Enriched with Soybean and Crayfish. Food and Nutrition Sciences. 2015;6(2) 234–241. https://doi.org/10.4236/fns.2015.62024.
21. Edema MO, Sanni LO, Sanni A. Evaluation plantain flour blends for plantain bread production in Nigeria. Afr. J. Biotecnol. 2004; 4:911-918
22. Ikujenlola AV, Adurotoye EA. Evaluation of Quality Characteristics of High Nutrient Dense Complementary Food from Mixtures of Malted Quality Protein Maize (Zea mays) and Steamed Cowpea (Vigna unguiculata). J Food Process Technol. 2014; 5:291.
23. Odimegwu NE, Ofoedu CE, Omeire GC, Umelo MC. Production and evaluation of breakfast cereals from flour blends of maize and Jack fruit seeds. *Archives of Current Res. Int.* 2019;16(3):1-16.
24. AOAC. *Official Methods of Analysis, Association of Official Analytical Chemist*, 18th Edition Association Maryland USA.2010.

25. Agu HO, Ayo JA, Jideani AIO. Evaluation of the quality of malted acha-soy breakfast cereal flour. *African Journal of Food Agriculture, Nutrition and Development.* 2015:15(5),10542-10588

26. Bolarinwa I, Aruna T, Adejuyitan J, Adeyemo G, Alabi O. Chemical, Physical and Sensory Properties of Pawpaw Fortified Pan Bread. *Journal of Food Chemistry & Nanotechnology*. 2020;6(2), 65–71.

27. Edima-nyah AP, Ntukidem VE, Davies AE. Development and Quality Evaluation of Breakfast Cereals from Blends of Local Rice (Oryza sativa), African Yam Beans (Sphenostylisstenocarpa) and Coconut (Cocosnucifera) Flour. *International Journal of Food Nutrition and Safety*. 2019;10(1)

28. Mostafa AR, Haleem EMA, Gabal SS. Formulation and Evaluation of Some Novel Breakfast Blends Made from Cereals and Legumes. *Alex. JournalofFood.Science.&Technology*. 2017:*14*(2) 25–34.

29. Okafor GI, Usman GO. Production and Evaluation of Breakfast Cereals from Blends of African Yam Bean (*SphenostylisStenocarpa*), Maize (*Zea Mays*) And Defatted Coconut (*CocusNucifera*). *Journal of Food Processing and Preservation*. 2014:38;1037–1043. https://doi.org/10.1111/jfpp.12060.