Nutritional analysis of african yam bean and bambara nut pudding

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Abstract

This study was to analyze and compare the nutritional contents of African yam bean pudding and Bambara nut pudding. Many important crop plants native to Africa with the potential to alleviate and reduce food insecurity in the continent are severally neglected, unimproved and under-utilized. It is of great importance to examine the nutrient, toxic substance, and anti-physiological substance composition of locally available foods in a community or country. The result of the proximate analysis showed that BNP had higher moisture content, crude fat, and protein compared to AYBP, and its statistically not significant $P \geq 0.05$, BNP showed a significantly higher carbohydrate compared to AYBP $P \leq 0.05$. The ash and fiber content of AYBP was shown to be statistically higher than that of BNP with $P \leq 0.05$. The result of the vitamin analysis showed that AYBP had significantly higher vitamin C compared with BNP, and vitamin A though not significant. The vitamin E content of both puddings was shown to be equal. The outcome of the analysis showed that AYBP is rich in fiber and low in carbohydrates as such could be a meal for diabetic patients. The vitamins contained in AYBP make it a requirement for school children and could be a source of a cheap source of vitamins to the rural and low-income earners in our society. AYBP has longer shelf life compared with the BNP because of its low moisture content.

Keywords: African yam bean, Bambara nut, Pudding, Proximate, and Vitamins.

Introduction

The alarming increase in the world's population has a direct effect on food security and sustainability which has increased the demands for food production to feed the

teeming human population (Abdulkareem et al., 2015). Although science has made enormous strides in improving the world's ability to feed itself over the past decades, a large proportion of the world's population is still suffering from hunger and malnutrition. Nearly 800 million people in the developing world do not have enough to eat (Abdulkareem et al., 2015). Many important crop plants native to Africa with the potential to alleviate and reduce food insecurity in the continent are severally neglected, unimproved and under-utilized. It is of great importance to examine the nutrient, toxic substance, anti-physiological substance composition, and organoleptic properties of locally available foods in a community or country. Knowledge and use of locally available foods can help ameliorate malnutrition. Some of the problems faced with planning therapeutic diets with local food are limited information on their nutrient composition (Standing Committee on Nutrition (SCN), 2006). It has been proposed that the fight against malnutrition in developing countries should be on the use of mixtures of tubers, cereals, and legumes indigenous to them (Nnam and Obiakor, 2003). The surge of urbanization has made people forget their traditional foods and focus more on convenient foods which are mostly nutritionally inadequate and expensive. The most dietary deficit is protein and this was attributed to the high cost of animal protein (SCN, 2006). Vegetable proteins complement each other if well chosen and will have a nutritive value as good as animal protein (Nnam and Obiakor, 2003). Nutrition has been at the forefront as a major modifiable determinant of chronic diseases, with scientific evidence increasingly supporting the view that alterations in diet have strong effects (both positive and negative) on health throughout life. Dietary adjustments may not only influence a person's health but may determine whether or not an individual will develop such diseases as diabetes, obesity, hypertension, certain cancer, and cardiovascular disease much later in life (WHO/FAO, 2003). The rapid change in disease pattern had occurred as a result of shifts in diet and lifestyle. The urban-based Nigerian is shifting from exercise, and intense agrarian life to a more sedentary urban life, with resultant obesity, diabetes, and hypertension. Cheap imported foods, global markets, and socio-cultural changes are placing African traditional diets at distinct disadvantages. Indigenous diets are being replaced with more refined carbohydrate fast foods (Emile et al. 2006). In tackling the multiple problems of food

insecurity, nutrition transition, and the double burden of diseases, it is essential to mobilize and employ indigenous foods like legumes as part of the solution (SCN, 2006). This is because several studies have reported immense nutritional and health-protecting properties of African indigenous foods such as legumes (Okeke et al. 2009). African yam bean (AYB) is a herbaceous leguminous plant occurring throughout tropical Africa (United States Department of Agriculture (USDA), 2007). It is grown as a minor crop in association with yam and cassava. AYB serves as a security crop; it has the potential to meet year-round protein requirements if grown on a large scale. Previous work done on the AYB seeds showed that the dry matter is approximately (90.50%), which comprises protein (24-28%), fat (1.5- 2.0%), total carbohydrate (74.10%), fiber (5.2-5.7%) and ash (2.80-3.20) (Frank et al., 2016; Nwokeke et al., 2013; Osuagwu and Nwofia, 2014; Olisa et al., 2010). The amino acid content of the protein depicted a similar value to that of soya bean but richer and higher in histidine and iso-leucine (Frank et al., 2016; Nwokeke et al., 2013; Osuagwu and Nwofia, 2014; Olisa et al., 2010). The energy content of the seeds per 100 g dry matter was reported to be 1.640 kJ. It was reported that the seeds can be eaten without harm, are non-toxic to humans, suitable for consumption but must be soaked in water for about 12 h before being cooked or processed (Olasoji et al., 2011; Ajayi et al., 2010). It has a higher water absorption capacity when compared to cowpea (Achinewhu and Akah, 2003). The potential role of AYB in the management of many aging and chronic noncommunicable diseases has been reported (Enwere, 1998). African yam bean (Sphenostylis stenocarpa) pudding is known and called different names by different tribes in Nigeria, some of the names are Igba- Azama, Igba- Ijiriji, igba-Azam, and igba-Uzaaki in Igbo. Bambara nuts "Okpa" is a well-cherished food, especially among the inhabitants of the eastern part of Nigeria. However, it is derived from Bambara nuts. Bambara nut (vigna Subterranean) belongs to the plantea of the family of fabaceae and subfamily of fabiodea. It is a legume, indigenous to tropical Africa. Bambara is grown extensively in Nigeria (Enwere, 1998) but it is one of the lesser utilized legumes in Nigeria.

Nutritional analysis and comparison is an indispensable working tool for nutritionists in the country for dietary counseling and the planning of therapeutic diets. Although, these traditional dishes are available, affordable, and accessible, though lack of information on

their nutritional contents has made their incorporation into meal planning and dietary advice for the prevention and management of chronic diseases (such as diabetes) a very challenging task for dieticians and nutritionists (Davidson 1972).

This study aimed to analyze and compare the nutritional contents of African yam bean pudding and Bambara nut pudding.

Materials and Methods

Materials: The African Yam Bean pudding (AYBP) and Bambara Nut pudding (BNP) were prepared by a vendor at Afor Awkunanaw market, Garriki Awkunanaw, Enugu South LGA. Enugu State, Nigeria. It was transferred to the Biochemical Laboratory of the Renaissance University Ugbawka Enugu State Nigeria for nutritional analysis.

Method

Moisture contents: This was done by the gravimetric method described by the AOAC (1995). A measured weight of the sample (5.0 g) was weighed into a previously weighed crucible. The sample in the crucible was dried in the oven at 105°C for 3 h. It was cooled in a desiccator and weighed. It was then returned to the oven for further drying. Drying, cooling, and weighing was done repeatedly at hourly intervals until there were no further diminutions in the weight (that is, constant weight was obtained). The weight of moisture lost was calculated and expressed as a percentage of the weight of the sample analyzed. It was given by the expression below: W2- W3 ÷ 5 × 100

Where:

W1 = Weight of empty moisture crucible

W2 = Weight of empty crucible + Sample before drying

W3 = Weight of crucible + Sample dried to constant weight

Crud protein: This was done by Kjeldahl method described by Chang (2003). The total nitrogen was determined and multiplied with a factor 6.25 to obtain protein content. The sample (0.5 g) was mixed with 10 mL of concentrated H2SO4 in the digestion flask. A tablet of selenium catalyst was added to it before it was heated under a fume cupboard until a clear solution was obtained (the digest). The digest was diluted to 100 mL in a volumetric flask and used for the analysis. The 10 mL of the digest was mixed with an equal volume of 45% NaOH solution in a Kjeldahl distillation apparatus. The mixture was distilled into 10 mL of 40% boric acid

containing 3 drops of mixed indicator (bromo cressol green/methyl red). A total of 50 mL of distillates was collected and titrated against 0.02 N EDTA from green to a deep red endpoint. A reagent blank was also digested, distilled and titrated. The nitrogen content and hence the protein content were calculated using the formula below:

1 mL of 1 N H2SO4 = 14 mg, Protein (%) = N2 (%) x6.25

W = Weight of sample (0.5 g)

N = Normality of titrant (0.02 N H2SO4)

Vt = Total digest volume (100 mL)

Va = Volume of digest analyzed (10 mL)

T = Sample titre value

B = Blank titre value

Total ash content: This was done by the furnaces incineration gravimetric method described by James (1995) and AOAC (1995). Accurately 5.0 g of the processed sample was measured into a previously weighed porcelain crucible. The sample was burnt to ashes in a muffle furnace at 550°C. When it has become completely ashed, it was cooled in a desiccator and weighed. The weight of ash obtained was determined by difference and calculated as a percentage of the weight of the sample analyzed thus: W2-W3/5 × 100

Where:

W1 = Weight (g) of empty crucible

W2 = Weight of crucible + sample

W3 = Weight of Crucible + Ash

Crude fibre: Crude fibre was determined by the method of James (1995). The sample (5.0 g) processed sample was boiled in 150 mL of 1.25% H2SO4 solution for 30 min under reflux. The boiled sample was washed in several portions of hot water using a two-fold cloth to trap the particles. It was returned to the flask and boiled again in 150 mL of 1.25% NaOH for another 30 min under the same condition. After washing in several portions of hot water the sample was allowed to drain dry before being transferred quantitatively to a weighed crucible where it was dried in the oven at 105°C to a constant weight. It was thereafter taken to a muffle furnace where it was burnt, only ash was left of it. The weight of the fibre was determined by difference and calculated as a percentage of the weight of the sample analyzed thus:

W2- W3/5 × 100

Where:

W1 = Weight of crucible

W2 = Weight of crucible + sample after washing, boiling and drying

W3 = Weight of crucible + sample of ash

Crude Fat: This was determined by solvent extraction gravimetric method described by Kirk and Sawyer (1980). Five grams of the sample were wrapped in porous paper (Whatman filter paper) and put in a thimble. The thimble was put in a soxhlet reflux flask and mounted into a weighted extraction flask containing 200 mL of petroleum ether. The upper of the reflux flask was connected to a water condenser. The solvent (petroleum ether) was heated, boiled vaporized and condensed into the reflux flask filled. Soon the sample in the thimble was covered with the solvent until the reflux flask filled up and siphoned over, carrying its oil extract down to the boiling flask. This process was allowed to go on repeatedly for 4 h before the defatted sample was removed, the solvent recovered and the oil extract was left in the flask. The flask (containing the oil extract) was dried in the oven at 60°C for 30 min to remove any residual solvent. It was cooled in a desiccator and weighed. The weight of oil (fat) extract was determined by difference and calculated as a percentage of the weight of the sample analyzed thus: W2- W1/ 5×100

Where:

W1 = Weight (g) of empty extraction flask

W2 = Weight of flask+oil (fat) extract

Carbohydrate content: This was determined by difference. The determined percentages of protein, fat, crude fibre and moisture were summed up and subtracted from 100%.

Vitamin A Determination: This is determined as described by (AOAC, 1995). One gram of the material is mixed with 20mls of petroleum ether in a beaker for 5mins and filtered, the filtrate was evaporated to dryness. Thereafter 0.2ml chloroform and acetic anhydride (1:1) were added to dissolve it and letter 2ml (trichloroacetic acid and chloroform in the ratio of 1:1) were added. The absorbance of the resultant solution will be measured within 15mins at 620nm.

The calculation was done using the standard calibration graph, stating the graph equation as; y=0.112x + 0.014.

Vitamin E Determination: This is determined as described by (AOAC, 1995).

One gram of the sample was weighed into a 100ml flask and 10ml of absolute alcohol (ethanol) was added, 20ml of 1M alcoholic sulphuric acid was added and reflux for 45mins cooled in a reflux condenser (for oil) 10mls of the clear solution were pipetted into a test tube and heated in a water bath at 90˚c for 30mins and allowed to cool. A standard and blank were prepared and the absorbance was read at 470nm.

The calculation was done using the standard calibration graph, stating the graph equation as; Y = 0.027X +0.003

Vitamin C Determination

Vitamin C was determined using the titratable method (AOAC, 1995).

0.3gram of the plant sample was weighed and 10mls of extracting solvent (metal sulfuric acid and acetic acid) in the ratio of 2:1, were added and centrifuged for 10mins at 3000rpm, the supernatant was made up to 10ml with the extracting solvent, thereafter two (2ml) of the filtrate were titrated with dyes solutions to a pink color that lasts for at least 30seconds. And the titer value was noted.

The calculation was done using the standard Ascorbic Acid content formular

C x V x df/W.T

C = concentration of the ascorbic acid (0.5mg/g)

V = volume of the sample used (20mls)

DF = dilution factor (1)

W.T = weight of the sample (3 grams)

Statistical analysis

Statistical Package for Social Sciences (SPSS) computer software version 20 was used to analyze the data. Means and standard deviation were calculated where appropriate. Analysis of variance (ANOVA) was used to determine the treatment that was different from others in the various parameters tested.

Results

Table 1: Result of the analysis of the comparative proximate composition of AYBP and BNP

Parameter	AFBP	BNP	Variance
Moisture	18	22	0.063
Ash	21	18	0.049*
Fiber	14	4	0.036*
Crude fat	10	14	0.105
Protein	8	9	0.137
Carbohydrate	29	33	0.041*

* Significant at P ≤ 0.05; Key: AFBP (African yam bean pudding), BNP (Bambara nut pudding).

The result of the proximate analysis showed that BNP had higher moisture content, crude fat and protein compared to AYBP and its statistically not significant P ≥ 0.05, BNP showed a significantly higher carbohydrate compared to AYBP P≤ 0.05. The ash and fiber content of AYBP was shown to be statistically higher than that of BNP with P≤ 0.05.

Table2: The Result of the Vitamins A, C and E

Vitamins	AYBP	BNP	Variance
Vit. A	2.73	1.42	0.052
Vit. C	1.33	1.17	0.041*
Vit. E	6.38	6.38	1

* Significant at P ≤ 0.05

The result of the vitamin analysis showed that AYBP had significant higher vitamins C compared with BNP, and vitamin A though not significant. The vitamin E content of the both pudding was shown to be equal.

Discussion

Malnutrition is widespread in the entire country and rural areas are especially vulnerable to chronic food shortages, malnutrition, unbalanced nutrition, erratic food supply, poor quality foods, high food costs, and even a total lack of food. African yam bean pudding and Bambara nut pudding have been a source of succor to most rural dwellers. An attempt to compare the nutritional constituents of both puddings in other to make recommendation becomes inevitable. The moisture content of AYBP was shown to be lower than that of BNP Table 4.1. This moisture concentration is lower than that obtained from the analysis done by Adumanya et al (2012) on BNP. The moisture content of this study also was lower than that obtained by China et al (2019). The variance in the moisture content of both puddings is a function of the amount of water added during the pudding preparation. Food needs to be preserved and avoid microbial growth, and the moisture content and water activity must be kept below approximately 10% and 0.60–0.65, respectively (Mercer, 2008), depending on the type of food. AYBP was shown to have a longer shelf life compared to BNP because the degree of moisture in food determines the shelf life of the food.

The ash content is the function of the mineral elements present. The result of the analysis showed that AYBP had higher ash content compared to BNP Table 4.1. The ash content of BNP was shown to be higher than that obtained by Adumanya et al on BNP (Ademuanya et al. 2012). The ash content of other pudding mixtures of Maize flour and

AYB flour pudding was shown to be lower than that of this study (Anosike et al. 2019). Most of the minerals in human diets come from eating animals and plants or from drinking water (Corvallis, 2016). A total mineral in food is referred to as ash (Awuchi, 2019). The high content of ash in AYBP inferred that it contains a large number of minerals that can help in ameliorating micronutrient deficiencies in the rural regions of Africa and can be given to children as snacks.

Dietary fiber is the edible parts of plants or analogous carbohydrates that are resistant to digestion and absorption in the human small intestine (Park et al. 2011). The result of the analysis showed that AYBP had higher fiber content compared with BNP Table 4.1. The fiber content of BNP was shown to be the same as that obtained by Adumuanya et al (2012). The dietary fiber in AYBP was shown to be higher than the mixture of African yam bean and maize pudding (Anosike et al. 2019). Dietary fibers function in the body to slow down the rate of glucose absorption into the blood. Dietary fiber is also believed to be a key component of a healthy diet as recommended by several nutritional guidelines (Lichtenstein et al. 2006). Therefore a high intake of fibers is associated with a reduced risk of several chronic diseases, including cardiovascular diseases (CVDs), cancer, type 2 diabetes, and obesity (Anderson et al 2009). Experiments in animal models indicate that dietary fiber intake is associated with lower concentrations of inflammatory and oxidative stress markers (Miller et al. 2016), which, in turn, are associated with several health outcomes including several cancers and CVD (Madeddu et al. 2014). The costs of managing these ailments are high, especially in Africa therefore AYBP can be a dietary supplement against these diseases.

Dietary fats are secondary plant products that yield more energy per gram than carbohydrates. BNP was shown to have higher fat content compared with AYBP Table 4.1. The oil obtained could be attributed to the quantity of oil added to the flour during pudding preparation. China et al observed a low-fat content compared with this study (China et al. 2019). The lower oil content of AYBP could be a result of cooking because it is wrapped with plant leaves that are permeable and so allow oil to leak into the cooking water. Fat content usually plays a role in the shelf life stability of food products because of the rancidity of oil. BNP will supply the needed energy and the fat-soluble vitamins that are needed compared with AYBP.

Proteins are important in the body for the repair of warned out tissues, hormones, enzymes and blood plasma production. BNP had higher protein compared with AYBP. BNP had been reported to contain high Protein (Adumanya et al. 2012). Anosike et al reported an increase in the protein content of maize pudding when mixed with AYB (Anosike et al. 2019). The quantity and quality of protein consumed and the timing of protein intake throughout the day all play a role in determining the health benefits of dietary protein. The primary role of protein in the diet is to provide amino acids required for the synthesis of new proteins. Humans rely on dietary protein to provide the nine essential amino acids, which cannot be synthesized in the body. Protein intake greater than the dietary recommendations may prevent sarcopenia (Morais et al. 2006), help maintain energy balance (Wilson et al. 2002), improve bone health and cardiovascular function, and aid in wound healing (Stratton et al. 2005). Both AYBP and BNP will supply the protein needed for low-income populations in the rural community. The protein content obtained from this study compares well with the study of Ogundele et al. (2015) who reported a protein content of 4.40-11.60% for moi-moi made from cowpea and soybean flour blends. It is also close to the study of Agbara et al. (2018) who reported 4.72-10.32%for differently processed moi-moi samples.

Carbohydrates in plants are the by-products of photosynthesis. They are the major source of energy for the red cells and the brain. The BNP had higher carbohydrate content compared with AYBP. The studies carried out have shown that AYBP is low in carbohydrates (Anosike et al. 2019). The Carbohydrate content of BNP in this study is higher than that obtained by Adumanya et al. (2012) and that of moi-moi (China et al. 2019). These differences in the carbohydrate could be due to the variation in recipes used. High carbohydrate in diets is an advantage as it provides the energy needed to do work (Ijeh et al. 2010). However, low carbohydrate content diets are also of advantage for diabetic patients that need very low carbohydrate content in their diets.

There are significant differences in Vitamin C between AYBP compared to BNP. Legumes contain a high amount of vitamins. The Vitamin of this study was lower than that obtained by raw AYB (Oladejo et al. 2020). Vitamin C is antioxidant which are required by school children and adults for collagen synthesis. AYBP which is a traditional food could be given to school children to enhance

malnutrition due to tissue and brain development.

Vitamin A contents of AYBP are high compared to BNP. This observation was in accord with that observed by Oladejo et al (2020). Vitamin A is required for the immune system and is supplied majorly from the diet. The high-fat content of BNP helps in the assimilation of Vitamin A. the low concentration of vitamin A in this study maybe be a result of heating.

the vitamin E content of BNP and AYBP are the same. This concentration is at variance from other studies, though the recipes that are used for the preparation such as palm oil could have contributed to the value of the Vitamin E in the pudding.

Conclusion: The comparative analysis of the AYBP and BNP was necessary because AYBP are underutilized and their nutritional contents were not known to the public, unlike the BNP. The outcome of the analysis showed that AYBP is rich in fiber and low in carbohydrates as such could be a meal for diabetic patients. The vitamins contained in AYBP make it a requirement for school children and could be a source of a cheap source of vitamins to the rural and low-income earners in our society. AYBP has longer shelf life compared with the BNP because of its low moisture content.

REFERENCE

Abdulkareem, R., Chauhan, A., and Maitama, K. (2015). Relationship between human resource management practices and employee's turnover intention among registered nurses in Nigerian public hospitals: The mediating role of organizational trust. UTM Press;2: 95– 98.

SCN Working Groups on Nutrition (2006), Ethics and Human Rights/Nutrition Throughout the Life CycleJoint statement on the human right of children and adolescents to adequate food and to be free from obesity and related diseases: the responsibilities of food and beverage corporations and related media and marketing industries. (Statement made at the SCN 33rd Session, March)(available at http://www.unsystem.org/scn/publications/Annualmeeting/SCN34/34_humanrights.htm.) accessed on December 15 2020.

Nnam, N.M. and Obiakor, P.N. (2003) Effect of Fermentation on the Nutrient and Antinutrient Composition of Baobab (Adansonia digitata) Seeds and Rice (Oryza sativa) Grains. Ecology of Food and Nutrition;42(4-5): 265-77.

WHO and FAO (2003) Report of a joint WHO/FAO expert consultation series 916 geneva (available at https://www.who.int/mediacentre/news/releases/2003/pr32/en/)accssed December 13 2020.

Emile F., Ifeyironwa F. S., Timothy J., Eyzaguirre P. and Jeremy C.(2006).Agricultural Biodiversity, Nutrition, and Health: Making a Difference to Hunger and Nutrition in the Developing World.Food and Nutrition Bulletin; 27(2):167-79

Okeke E.C, Eneobong H.N., Uzuegbunam A., Ozioko A.O., Umeh S. and Kuhnlein H. V. (2009). Nutrient Composition of Traditional Foods and Their Contribution to Energy and Nutrient Intakes of Children and Women in Rural Households in Igbo Culture Area. Pakistan Journal of Nutrition 8(4)

United State Department of Agriculture (USDA), (2010). National Genetic Resources Program. Germplasm Resources Information Network -(GRIN)[Online Database].National Germplasm Resources Laboratory, Beltsville, Maryland.URL: http://www.ars-grin.gov/cgi-bin/npgs/html/taxon.pl.

Frank UE, Rita NO, and Chukwuemeka SA (2016). Effect of African yam bean (Sphenostylis stenocarpa) on serum calcium, inorganic phosphate, uric acid, and alkaline phosphatase concentration of male albino rats. Journal of Agricultural Science 8(1).

Nwokeke B, Adedokun I., Osuji C (2013). Effect of blending on the proximate, pasting and sensory attributes of Cassava-African yam fufu flour. International Journal of Research Publications 3(8):1-7.

Osuagwu AN, and Nwofia GE (2014). Effects of spent engine oil on the germination ability of eleven accessories of Africa yam bean seeds (Sphenostylis stenocarpa Hochst ex A. Rich) Harms. Journal of Agriculture and Veterinary Science;7(1):59-62.

Olisa BS, Ajayi SA, Akande SR (2010). Physiological quality of seeds of promising African yam bean (Sphenostylis stenocarpa (Hochst. Ex A. Rich) Harms) and pigeon pea (Cajanus cajan L. Mill sp.) Landraces. Research Journal of Seed Science 3:93-101.

Olasoji J, Akande S, Owolade O. (2011). Genetic variability in seed quality of African yam bean (Sphenostylis stenocarpa Hoscht. Ex A. Rich Harms). African Journal of Agricultural Resources 6(27):5848- Gbenga-Fabusiwa 47 5853

Ajayi FT, Akande SR, Odejide JO, Idowu B, Udoji IA, Abdulrahman F, Hassan LG,

Maigandi S, Itodo HU, Udoji IA (2010). Nutritive evaluation of some tropical under-utilized grain legume seeds for ruminant's nutrition. Journal of American Science 6(7):1-7.

Achinewhu S.C. and Akah G.N. (2003). Chemical, functional and sensory properties of processed African yam beans (Sphenostylis stenocarpa) and cowpeas (Vigna unguiculata) Plant Foods for Human Nutrition; 58(4):1–6.

Enwere, N.J. (1998). Foods of plant origin. 1st edition. Agro-orbis publications Nsukka. Nigeria.

Davidson, S., J.F. Brock and A.S. Truswell, 1975. Human Nutrition and Dietetics. Churchill Livingstone, Edinburgh, UK., pp: 107-119, 221-224.

Association of Official Analytical Chemists (A.O.A.C) (1995). Official method of analysis. 15th edition, Washington D.C.

Chang, S.K.C., 2003. Protein Analysis. In: Food Analysis, Nielsen, S.S. (Ed.). Kluwer Academic Plenum Publisher, New York

James, C.J., 1995. The Analytical Chemistry of Foods. Chapman and Hall Press, New York, Pages: 86.

Kirk, B. and S. Sawyer, 1980. Pearson's Food Composition and Analysis. Longman Press, England, Pages: 34.

Adumanya, O. C., Uwakwe, A. A., Onuoha, S, C., Odeghe O, B.,Obi-Adumanya, G. A.,Agbara, G. I., Haruna, B., Chibuzo, E. C., & Agbara, H. N. (2012) Proximate Analysis and Sensory Evaluation Of "Okpa" Prepared With Fluted Pumpkin and Scent Leaves.

Canadian Journal on Scientific and Industrial Research; 3(4):175.

China M, Deedam N. J., Mbah P and Pepple C. (2019). Proximate composition and sensory assessment of beans pudding prepared using two different cooking methods. Research Journal of Food Science and Nutrition; 4(2):58-64.

Mercer, D. G. (2008). Solar drying in developing countries: Possibilities and pitfalls. In G.L. Robertson, & J. R. Lupien (Eds.). Using food science and technology to improve nutritionand promote national development. International Union of Food Science & Technology http://www.iufost.org/publications/books/documents/Mercer.pdf, Accessed date: 30 April 2017.

Anosike F C, Nwagu K E, Ekwu F, Nweke F N, Nwoba S T, Onuegbu R N and Enwere E

N, (2019). Proximate Composition and Sensory Properties of Ukpo oka: A Steamed Maize Pudding Formulated from Maize and African Yam Bean Flour. Pakistan Journal of Nutrition, 18: 795-799.

Corvallis, O. R. (2016). "Minerals". Micronutrient Information Center, the Linus Pauling Institute, Oregon State University.

Awuchi, C G and Awuchi, C G (2019). Impacts of Plastic Pollution on the Sustainability of Seafood Value Chain and Human Health. International Journal of Advanced Academic Research, 5 (11); 46 – 138.

Park Y, Subar A. F., Hollenbeck A., Schatzkin A. (2011). Dietary fiber intake and mortality in the NIH-AARP Diet and Health Study. Arch Intern Med;171(12):1061–8.

Lichtenstein A. H Appel L. J, Brands M, Carnethon M, Daniels S, Franch H. A, Franklin B, Kris Etherton P, Harris W. S, Howard B,Karanja N, Lefevre M, Rudel L, Sacks F, Van Horn L, Winston M, Wylie-Rosett J (2006). Summary of American Heart Association diet and lifestyle recommendations: revision 2006.Arterioscler Thromb Vasc Biol;26(10):2186–91.

Anderson J. W, Baird P, Davis R. H, Ferreri S, Knudtson M, Koraym A, Waters V,Williams C. L. (2009). Health benefits of dietary fiber. Nutritional Review;67(4):188–205.

Miller S. J, Batra A. K, Shearrer G. E, House B. T, Cook L.T., Pont S. J., Goran M. I, Davis J. N. (2016). Dietary fibre linked to decreased inflammation in overweight minority youth. Pediatr Obes;11(1):33–9.

Morais J. A., Chevalier S., and Gougeon R (2006). Protein turnover and requirements in the healthy and frail elderly. The Journal of Nutrition, Health & Aging.10:272-283.

Stratton R. J., Ek A. C., Engfer M., Moore Z., Rigby P., Wolfe R. (2005). Enteral nutritional support in prevention and treatment of pressure ulcers: A systematic review and meta-analysis. Ageing Research Reviews;4:422-450.

Ogundele, G., Ojubanire, B., & Bamidele, O. (2015). Proximate composition andorganoleptic evaluation of cowpea (Vignaugu culata) and soybean (Glycine max) blends for the production of Moi-moi and Ekuru (steamed cowpea paste). Journal

of Experimental Biology and Agricultural Sciences, 3(2), 207-212.

IJeh, I. I., Ejike, E. C., Nkwonta, O.M., & Njoku, B. C. (2010). Effect of traditional processing techniques on the nutritional and phytochemical composition of African (Treculia Africana) seeds. Journal of Applied Sciences and Environmental Management, 14(4), 169-173.

Oladejo T. C., Olaniyi O. O.,Ayodeji A.O. and Akinyele B. J. (2020). Protease produced by Lactobacillus brevis enhanced nutritional values of African yam beans and demonstrated improvement in the growth and blood indices of albino rats. Heliyon;6(10):5123.

Appendices



Appendix 1: Wrapped African Yam Bean Pudding.



Appendix 2: Unwrapped African Yam Bean Pudding.



Appendix 3: Wrapped Bambara nut Pudding.



Appendix 4: Unwrapped Bambara nut pudding.