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Acceptability of *Fufu* Produced Using Residue from Maize, Millet and Sorghum: Strategy for Sustainable Food Security

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Abstract

Cereal grains are important staples annual plant of the grass family used as food wheat, rice, maize, sorghum, millet, barley and rye. Cereal is not limited to these grains, but also to foodstuff prepared from the starchy grains of cereal like flours, breads and pasta. Cereals like Maize, Millet, and Sorghum are processed into starch which are consumed as pap while the residue (fibre) is discarded or used to feed livestock. This study, therefore, processed the residues of some cereals: sorghum, maize and millet into *fufu* and determined its nutrient composition and general acceptability to ensure food security. The cereals were processed into four samples and coded thus: Ma (Maize), SO (Sorghum), MI (Millet) and MMS (Mixture of Maize, Millet and sorghum) and made into *fufu*. The samples were analyzed using AOAC (2005) methods for proximate composition, dietary fiber and some mineral-potassium, phosphorus, calcium, zinc and iron. The general acceptability was determined through sensory evaluation using nine-point hedonic scale. The result shows that sample Ma had the highest (14.01±0.17) dietary fibre while sample So had highest value of the minerals assessed; Zinc (1.93±0.09), Potassium (280.66±11.6), Calcium (3.73±0.29), Iron (1.36±0.08) and Phosphorus (298.09±1.86). Protein was highest (7.99±0.38) in sample Mi. The *fufu* samples were accepted with maize *fufu* having the highest level of acceptability. It, therefore, recommended that instead of discarding these residues as waste, they can be used to prepare *fufu* to help improve bowel movement and fight against food insecurity.

Keywords: *Cereal residues, Fufu, Acceptability, Food security.*

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Background to the Study

The cereals are annual plant of the grass family (a monocot family Poaceae also known as Gramineae), which usually have long thin stalks. Cereals include wheat, rice, maize, sorghum, millet, barley and rye, whose starchy grains are used as food. The term cereal is not limited to these grains, but also to foodstuff prepared from the starchy grains of cereal flours, breads and pasta. As observed by Afzal et al [2009], cereal grains have been the principal component of human diet and have played a major role in shaping human civilization for thousands of years. Around the world, such cereals like rice, wheat, maize, and to a lesser extent, sorghum and millet are important staples and critical to daily survival of billions of people. Cereal grains are grown in greater quantities and provide more food energy worldwide than any other type of crops and are called staple food its production in 2014 was estimated at 25,829,680 metric tons [Ukwuru et al 2018].

Cereals in general are a good source of dietary fibre which do not necessary add any important chemical nutrients to the diet but plays important role of adding bulk to the diet for easy movement of the bowels (large intestines) [Rui 2004]. Whole grains contain a wide variety of antioxidant compounds (phytochemicals), such as phenolics and carotenoids, and may help protect cellular systems from oxidative damage and also may lower the risk of chronic diseases [Awika and Rooney 2004]. Most of the grains used for human food are milled to remove the bran (pericarp) and germ primarily to meet sensory expectations of consumers. The milling process strips the grains of important nutrients including dietary fiber, phenolic, vitamins and minerals which are beneficial to health (Enyisi et al 2014). Cellulose (insoluble non-starch polysaccharides) which are the major components of dietary fiber is effective laxative which reduces transit time and good in the prevention of colorectal cancer and other inflammatory bowel diseases [Rui 2004]. The soluble non-starch polysaccharides (especially mixed-link β-glucans) have lower plasma cholesterol and so can reduce the risk of cardiovascular diseases [Franko and Albertson 2010], although according to Enyisi et al [2014] the effect is inconsistent.

All cereals are plant seeds and as such contain a large centrally located starchy endosperm which is also rich in protein, a protective outer coat consisting of two or three layers of fibrous tissue, and an embryo or germ usually located near the bottom of the seed [Ihekoronye and Ngoddy 1985]. Cereals have the ability to dry to a safe moisture level naturally in the field than other plant crops thereby making it easy to preserve. They are utilized in many different ways for the preparation of various dishes such as *Ogi* (pap, akamu or koko), *Pito* (traditional alcoholic drink in Nigeria), popcorn (*guguru*), *egbo* (boiled corn), *agidi*, *moi-moi oka* (*moi-moi oka* or corn pudding), *tuwo* (maize fufu), *burukutu* (a local alcoholic beverage in Nigeria). *Kunun zaki* (non-alcoholic drink), *Ndaleyi* (millet *ogi*), *fura* and the rest of it [Ukwuru et al 2018].

The annual production of maize according to Ndukwe et al [2015] as indicated by Central Bank of Nigeria in 1992 was estimated about 5.6million tones and is the most important cereal crop in Nigeria next to sorghum with the nutrient content of 72% starch, 10% protein, 4.8% oil, 8.5% fibre, 3.0% sugar and 1% ash [Keshinro 2002]. Maize can be eaten

boiled, roasted, fried/popped or processed into starch and used for porridge (pap). Maize starch is made up of two important glucose polymers; amylose (an essentially linear molecule) which accounts for 25-30% and amylopectin (a branched form) accounts for 70-75%. This starch composition of maize is genetically controlled [Ajayi and Korede 2005]. In common maize, the proportion is between 8 - 11% of the kernel weight which is mostly found in the endosperm [Akinere and Bassr 2013]. Maize proteins is said to be incomplete because it is low in lysine but rather have adequate levels of Sulphur containing amino acids. Maize contains an appreciable level of oil and fatty acids which are located in the germ. Adesiya [2013] indicated that, an entire whole grain contains 4.3% fat which is dependent on variety.

Sorghum also known as guinea corn in Nigeria is a cereal grain that originated in Africa and eaten throughout the world. It is drought resistant and especially valuable in arid. Sorghum is a nutrient-rich grain, often ground into flour to make bread, porridge and pancakes. The composition of sorghum grain is similar to maize in many respects. Typical analytical figures for the grain are starch 68-80%, protein 10- 15%, moisture 11-12%, fat 3%, fibre 2%, ash 2% food energy 394 calories. It ranks second to maize in total available energy among the cereal grains [Enyisi et al 2014].

Millet is a principal food cereal cultivated in drought prone semi-arid regions of Africa. Millet is another cereal of importance in this study. The term "Millet" is used loosely to refer to several types of small seeded annual grasses [FAO 2011). Millet is one of the most extensively cultivated cereals in the world, after rice, wheat and sorghum, particularly in arid and semi-arid regions [Maidala and Abdullahi, 2016]. Although different varieties of millet are grown worldwide, pearl millet, finger millet and prove millet accounts for a large proportion of the world production. About 78% of millet produced is utilized as food to supply energy and protein for about 130 million people in sub-Saharan Africa (SSA) (Issoufou et al 2013). As one of the most important drought-resistant crops, millets serves as a major food component in various traditional foods and beverages such as bread, porridges and snack foods, specifically during food scarcity and nutrition and health interventions among the non-affluent in such regions. Nutritionally too, it is an important food crop and contributes around 10-12 % protein, 351 kcal energy, 2.29-2.7 % lysine, 0.59 mg thiamine, 2-3% fat and 3-4% of dietary fiber [Meherunnahar et al. 2018].

Maize, sorghum and millet which are cereals of importance in this study are processed into starch in some recipes while the residue is discarded or used as feed for livestock. These residues contain the non-starch polysaccharide which is needed especially in the diet of adult. This study therefore converted this residues to *fufu* for human consumption which was served as accompaniment to okro soup to ascertain their organoleptic attribute. Their proximate content and some minerals (calcium, phosphorus and zinc) were also determined.

Purpose of the Study

The general objective of the study was to determine the acceptability of *fufu* produced from the residues of maize, millet and sorghum. Specifically the study to;

1. Prepare *fufu* using residue of maize, millet and sorghum,
2. Determine the proximate composition of *fufu* samples produced from the residues,
3. Determine the dietary fiber composition of the *fufu* samples produced from the residue of maize, millet and sorghum,
4. Determine the content of some minerals (calcium, phosphorus, zinc,),
5. Determine their organoleptic attribute and general acceptability.

Materials and Method

Procurement

Maize, Millet and Sorghum were bought from Relief Market in Owerri Municipal Council, Imo State, Nigeria.

Area of the Study

The study was carried out in the food laboratory of the Department of Home Economics, Alvan Ikoku Federal College of Education Owerri, Imo State Nigeria.

Design of the Study

This experimental research design was adopted in carrying out the study. The treatment level produced four samples coded thus; Ma (Maize), Mi (Millet), So (Sorghum) and MMS (Maize, Millet & Sorghum).

Method of Processing

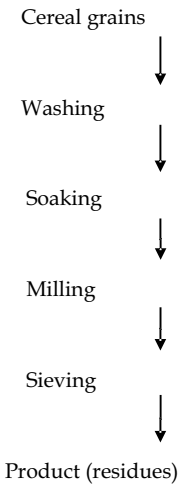

Figure 1: Flow diagram on method of processing the cereals to obtain residue

Preparation of *fufu*

Fifty centiliters (50cl) of water were put, boil in a source pan.

One kilogram (1kg) of the sample was measured into the boiling water and stirred continuously until a smooth desired dough like consistency is achieved.

Sample of the dough was packed in a Ziploc bag for chemical analysis.

Chemical Analysis
The proximate composition, total dietary fibre and some minerals (calcium, phosphorous, iron and potassium) of the samples were analyzed using AOAC (2005), method while carbohydrate was determined by difference.

Sensory Evaluation
The sensory evaluation was be carried out using a ten-man trained panel to determine the organoleptic attributes such as texture, appearance (colour,) taste, aroma, mouth feel and general acceptability. The panelists comprised staff and students of the Department of Home Economics, Alvan Ikoku Federal College of Education Owerri. The *fufu* residue samples were served with soup to accompany it. A nine point hedonic scale form with the options of; like extremely (9 points), like very much (8) like moderately (7 points), like slightly (6 points), neither like nor dislike (5 points), dislike slightly (4 points), dislike moderately (3 points), dislike very much (2 points) and dislike extremely (1 point) [Ihiekoronye and Ngoddy 1985] was provided as the instrument of the organoleptic evaluation. The data was collected for statistical analysis.

Exclusion Criteria: People who have cold and cough were excluded. Also, smokers were not legible and were not selected.

Informed consent: An informed consent was obtained from all volunteer subjects prior to the test.

Statistical Analysis
The data obtained from this study were analyzed using conventional one -way analysis of variance (ANOVA) to check the differences in the varieties of cereal. Statistical Product for Service Solution (SPSS) version 22 was used as a tool to test the significance difference between means at 5% probability ($P < 0.5$).

Results
The result in table 1 shows that sample SO was highest (2.09±0.88) in Ash but least (13.18±0.11) in fiber while sample MI had the least value (1.53±0.09) for ash. Sample MA had the highest fibre content (14.01±0.17) while sample MI was highest in Fat (1.75 ±0.16) and Protein (7.99±0.38) and sample MMS had the least (6.95±0.06) protein. Sample MI has the highest fat content (1.75±0.16), followed by sample MA (1.63±0.06) while sample SO had the least fat content (0.88±0.04). Sample MA has the highest carbohydrate (54.61±0.92) followed by sample MMS (52.57±1.37) while sample MI (49.87±1.18) and sample SO (46.28±0.91) has the least. Sample SO had the highest (30.06±0.99) moisture content followed by sample MI (25.39±1.39) while sample MA had the least (21.39±0.88).

Table 1: Results of proximate composition of *fufu* samples produced from the residues of maize, millet and sorghum

Samples	Moisture	Ash	Dietary Fibre	Fat	Protein	Gly CHO
MA	21.39±0.88^{c}	1.85±0.08^{b}	14.01±0.17^{a}	1.63±0.06^{a}	6.50±0.36^{bc}	54.61±0.92^{a}
MI	25.39±1.39^{b}	1.53±0.09^{c}	13.45±0.08^{c}	1.75±0.16^{a}	7.99±0.38^{a}	49.87±1.18^{b}
SO	30.06±0.99^{a}	2.09±0.08^{a}	13.18±0.11^{d}	0.88±0.04^{b}	7.52±0.42^{ab}	46.28±0.91^{c}
MMS	23.64±1.31^{b}	1.72±0.03^{b}	13.69±0.09^{b}	1.43±0.11^{a}	6.95±0.06^{b}	52.57±1.37^{a}
LSD	**2.19**	**0.14**	**0.22**	**0.2**	**0.63**	**2.09**

Key: MA=Maize, MI=Millet, SO=Sorghum, MMS=Mixed meal from the three cereals.
Mean values with the same superscript within the same column are not significantly different (P > 0.05).

Table 2 shows the result of some mineral content of the samples. Sample SO had the highest (298.09±1.86) value of Phosphorus followed by sample MI (283.19±2.18) while sample MA had the lowest values for phosphorus (258.29±2.27). Sample SO has the highest (3.73±0.029) value of Calcium followed by sample MMS (3.23±0.21) while sample MA (2.80±0.21) and sample MI (2.46±0.06) has the least value. Iron was highest in sample SO (1.36±0.08) followed by sample MI (1.22±0.08) while sample MA had the lowest (0.87±0.08) value. Sample SO had the highest (1.93±0.09) value of Zinc while sample MA had the least (0.95±0.08) value while sample MI (1.06 ±0.06), sample SO (1.93±0.09) and sample MMS (1.26±0.02) has the highest Zinc. Sample SO has the highest (280.66±11.6) value of Potassium followed by sample MI (357.54±1.76) while sample MA had the least (265.92±14.95).

Table 2: Mineal content of the *fufu* sample produced from the residues of maize, millet and sorghum

SAMPLES	Ca	P	Fe	Zn	K
MA	2.80±0.21^{c}	258.29±2.27^{c}	0.87±0.08^{c}	0.95±0.08^{d}	265.92±14.95^{d}
MI	2.46±0.06^{c}	283.19±2.18^{b}	1.22±0.08^{b}	1.06±0.06^{c}	357.54±1.76^{b}
SO	3.73±0.29^{a}	298.09±1.86^{a}	1.36±0.08^{a}	1.93±0.09^{a}	380.66±11.06^{a}
MMS	3.23±0.21^{b}	276.59±10.26^{b}	1.10±0.03^{b}	1.26±0.02^{b}	318.50±15.90^{c}
LSD	**0.39**	**10.25**	**0.13**	**0.13**	**23.09**

Key: MA=Maize, MI=Millet, SO=Sorghum, MMS=Mixed meal from the three cereals.
Ca = Calcium, P = Phosphorus, Fe = Iron, Zn = Zinc, K= Potassium. Mean values with the same superscript within the same column is not significantly different (p>0.05).

The result in table 3 on the organoleptic attributes of the samples shows that sample MA was rated highest in all the attributes; Texture (8.70±0.87), Taste (8.30±0.67), Aroma (8.60±0.52), Colour (8.70±0.48), Mouth-feel (8.50±0.71) and General acceptability (8.50±0.97). Sample MI was rated second in all the attribute thus; texture (7.70±1.33), Taste (6.80±2.04), Aroma (7.70±1.05), Colour (6.90±1.45) Mouth-feel and General acceptability (8.20±0.79). Sample SO had the least mean score in all the attributes; Texture (5.40±2.17), Taste (7.10±1.10), Aroma (7.30±1.70), Colour (6.70±1.83), Mouth-feel (6.30±2.06) and General acceptability (6.30±1.83).

Table 3: Results of the organoleptic attribute of the samples eaten as *fufu* with soup

Samples	Sensory Attributes					
	Texture	Taste	Aroma	Colour	Mouth-feel	G. Acceptability
MA	8.70±0.67^{a}	8.30±0.67^{a}	8.60±0.52^{a}	8.70±0.48^{a}	8.50±0.71^{a}	8.50±0.97^{a}
MI	7.70±1.33^{a}	6.80±2.04^{b}	7.70±1.05^{ab}	7.10±1.19^{ab}	6.90±1.45^{b}	8.20±0.79^{ab}
SO	5.40±2.17^{b}	7.10±1.10^{ab}	7.30±1.70^{b}	6.70±1.83^{b}	6.30±2.06^{b}	6.30±1.83^{b}
MMS	5.80±2.15^{b}	7.40±1.78^{ab}	7.20±1.23^{ab}	5.90±1.85^{b}	6.80±1.03^{b}	7.30±1.16^{b}
LSD	**1.54**	**1.36**	**1.09**	**1.32**	**1.27**	**1.13**

Key: MA=Maize, MI=Millet, SO=Sorghum, MMS=Mixed meal from the three cereals. Mean values with the same superscript within the same column are not significantly different ($P > 0.05$)

Discussion

The findings of this study shows that the moisture content of the cereal *fufu* samples were between 21.39±0.88 and 30.06±0.99 which were similar to what was obtained by Femi (2008). The moisture was less than what was reported by Agbon et al [2010] for different cassava *fufu* which were within the range of 65.62±4.08 - 74.42 ±3.71. This may likely be due to the fact that root/tubers are composed of regular starches (made up of about 25 amylose and 75 amylopectin) do not gel whilst cereals which has carbohydrate that are composed of high amylose starches becomes rigid in standing or gel. They are highly water soluble which reduces the amount of water they can absorb and hold during gelatinization [Onyeka, 2015]. Amylose is water soluble and retrogrades faster than amylopectin (which is water insoluble) and retains water more as a thickener. Also the high fibre content of the samples have the ability to absorb more water. Sample MI (millet) with the highest moisture content will most likely contain starches that fall within sample MA (maize) group for birefringence value which are highly crystalline and easily rotate a plain polarized light.

Percent protein content of the samples were found in the range of 6.50±0.36 - 7.99±0.38 with sample SO (Sorghum) having the highest value which was lower than the value obtained by Ndukwe et al, [2015] with varieties of maize having the value range of 10.72±0.04 - 12.33±0.03. This difference could be attributed to the processing of the cereals which must have leached out part of the nutrients still retaining valuable quantity in the residue.

Sample SO (sorghum) had the highest quantity of each mineral - calcium (3.73±0.29), Phosphorous (298.09±1.86), Iron (1.36±0.08), Zinc (1.93±0.09) and Potassium (380.66±11.06) among all the samples while sample MA (maize) had the least in exception of calcium. This suggest that sorghum is a very good source of Calcium, Phosphorus, Iron, Zinc and Potassium even when in combination with maize and millet. Calcium is the major structural element and quantitatively the largest but the high protein content of the cereal meals may decrease the efficacy of dietary calcium uptake. Abdulrahman and Omoniyi (2016), reported mineral composition of whole cereals in this study to be within

the ranges of 9.00±0.0024 - 30.82±0.0015 (calcium), 48.73±0.0007 - 58.35±0.0006 (iron), 10.05±0.0018 - 9.45±0.0009 (zinc), and 300.00±0.001 - 400.00±0.001 (potassium). These values are higher than the values observed in this study which could be attributed to the fact that the samples where produced from residues after leaching in water which must have reduced the nutrients in the cereals. The high dietary fiber of these meals (especially the phytic acid component) may affect their dietary intake of calcium. All the sample have adequate amount of each of the mineral determined in this work.

The organoleptic attribute of the samples showed that sample MA (Maize) *fufu* had the most accepted texture, taste, aroma, colour, mouth-feel as well as overall acceptability as it was seen to be significantly higher than any other cereal even in the combined sample MMS. Its texture is likely to have been influence by its high fibre (14.01±0.17) which agrees with Enyisi et al [2014] who reported crude fibre content of 2.10- 26.70% of different varieties of maize and maize products as studied. Aroma of food is a function of sugar profile of the food. The highest available carbohydrates (high sugar profile) contents of maize seems to promote the production of excellent aroma compared to other samples and this must have also contributed to the desired texture indicating that maize has a high sugar profile than other samples in this study. This corroborates the general observation of Ndukwe et al [2015], that higher sweetness of some maize as responsible to their popularity and preference for direct human consumption at green ear stage. The yellow colour of maize must have made it the most attracting colour to the eyes.

Conclusion

The residue of some cereal which hitherto were discarded or used as animal feed was converted into *fufu* for human consumption. The result showed that the samples had low fat, moderate protein and high dietary fibre. The minerals determined showed high potassium and phosphorus, iron, calcium and zinc were moderately available. The samples were all accepted to serve as accompaniment to soup or stew in a meal, although maize (MA) residue *fufu* was rated highest as the most acceptable even when the three cereals were combined.

Recommendations

1. Residues generated from cereals especially ones used in this study (maize, millet and sorghum) should be converted as food for human consumption.
2. Although *fufu* made from maize had the highest level of acceptability, the high mineral content of sorghum *fufu* and higher protein content of millet *fufu* can be combined to form a more functional food.
3. The high fibre content will help in bowel movement and reduce the incidence of constipation.
4. The low carbohydrate is also desirable for people with health challenges requiring carbohydrate restriction.
5. They can also be fortified with legumes to improve the nutrient content as functional food.

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