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EVALUATION OF THE NUTRITIONAL AND SENSORY PROPERTIES OF LACTIC ACID FERMENTED MAIZE FLOUR FORTIFIED WITH BAMBARA GROUNDNUT

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ABSTRACT

The aim of this research is to evaluate the nutritional and sensory properties of Lactic acid fermented maize flour fortified with Bambara groundnut. Maize and Bambara groundnut were obtained from Birnin Kebbi Central market, prepared and fermented. Various analytical methods were employee to evaluate the nutritional and sensory properties of the fortified maize flour. Proximate analysis was used to determine the levels of moisture, protein, fat, ash, and carbohydrates. Also sensory properties of the gumba produced was assessed based on colour, texture, aroma (flavor), taste and overall acceptability. The maize was analyzed peeled and fried bambara groundnut separately. Also the starter cultures of the mixtures were analyzed separately from spontaneous mixture with varied proportion. The result shows that all the samples have moderate moisture contents ranging from 7.66% to 13.62% with spontaneous sample containing maize and groundnut (60:40) having the highest among all. The protein content of the eight samples revealed that Maize with Peeled Bambara groundnut Starter Based MAPBSB (60:40), possesses the highest protein (14.82%), while the same culture produces the highest crude fibre 3.5% with proportion of (70:30). This result indicates that all the samples have high level of carbohydrate and the presence of high carbohydrate content in these samples suggested that it may serve as a source of energy. It may also aid digestion and assimilation of other nutrients. The fibre contents recorded in this study are also lower than those recorded in the study by Hillocks *et al*. (2012). Dietary fibre helps to maintain the health of gastrointestinal track but, in excess, may bind trace elements, leading to deficiencies of some of these micro nutrients in the body. This result indicates that all the samples have high level of carbohydrate and the presence of high carbohydrate content in these samples suggested that it may serve as a source of energy. It may also aid digestion and assimilation of other nutrients. Both the fried and peeled bambara groundnut maize flours fermented spontaneously and with Lactic Acid Bacteria have both excellent eating and nutritional qualities. Results of this study revealed that the nutritional contents also depend on the concentration of the millet and bambara ground nut.

Keys: nutritional, sensory, Lactic acid, fermented maize flour, bambara groundnut,

1.1 INTRODUCTION

Cereal grain crops are grown in greater quantities and provide more food energy worldwide than any other type of crop and are therefore staple crops (Hancock, 2012). In their natural, unprocessed, whole grain form, cereals are a rich source of vitamins, minerals, carbohydrates, fats, oils, and protein. When processed by the removal of the bran, and germ, the remaining endosperm is mostly carbohydrate. In some developing countries, grain in the form of rice, wheat, millet, or maize constitutes a majority of daily sustenance. In developed countries, cereal consumption is moderate and varied but still substantial, primarily in the form of refined and processed grains (Sands *et al*., 2009). Maize has become a staple food in many parts of the world, with the total production of maize surpassing that of wheat or rice. In addition to being consumed directly by humans (often in the form of masa), maize is also used for corn ethanol, animal feed and other maize products, such as corn starch and corn syrup. Sugar-rich varieties called sweet corn are usually grown for human consumption as kernels, while field corn varieties are used for animal feed, various corn-based human food uses (including grinding into cornmeal or masa, pressing into corn oil, and fermentation and distillation into alcoholic beverages like bourbon whiskey), and as chemical feed stocks. Maize is also used in making ethanol and other biofuels (Sands *et al*., 2009). Traditional cereal foods (e.g maize) play an important role in the diet of the people of African particularly in cereal producing zones. Flour from various cereals is one of the main raw materials used in the production of popular food products with high acceptability, good storage characteristics and affordable cost (Mbata *et al*., 2007). Many brands of low - cost proprietary weaning foods have been developed from locally available high calorie cereals and legumes in tropical Africa (Sanni *et al.*, 2001). Despite the reported improvement in the nutrient status of fermented cereal based diets in sub-Saharan Africa, the nutrient needs of infants and sick adults are still not being met. Evidence indicates that it is quite possible to improve the nutrient quality and acceptability of these cereals and legumes and exploit their potentials as human foods by adopting newer scientific processing methods (Edema and Sanni, 2006).

METHODS

2.1 COLLECTION OF SAMPLES

Maize and Bambara groundnut were obtained from Birnin Kebbi Central market and transferred to the Microbiology Laboratory of the Department of Science Technology, Waziri Umaru Federal Polytechnic Birnin Kebbi, Kebbi State in polythene bags. The Microorganism (*Lactobacillus plantarium*) was collected from the microbiology laboratory of the Department of Science Technology, Waziri Umaru Federal Polytechnic Birnin Kebbi, Kebbi State.

2.2 PREPARATION OF SAMPLE

The freshly collected maize and Bambara groundnut were thoroughly cleaned by picking all the stones and other foreign particles present in them while sorting out the good ones (Adeleke *et al*., 2017). The cleaned bambara groundnut was then soaked in water for 1h and boiled at a temperature of 100°C for 20 min after which it was hand-washed to remove the seed coat and then sundried for 2 - 3 days. The dried seeds were milled into flour to an average particle size of less than 0.3 mm and the milled grain was sieved through a fine mesh sieve to obtain the bambara groundnut flour. Another portion of the Bambara groundnut was fried and then grinded into fine powder after which it was also sieved (Azman *et al*., 2019). The cleaned maize sample was soaked in plastic containing clean water and allowed to steep for 24 h at room temperature (28 ± 2°C). The steep water was then discarded by decantation and the steeped grains were sun dried for 2 - 3 days by putting it in a sterilized tray pan after which it was milled and then sieved. The sieved maize flower was divided into two portions one of which was not mixed with the bambara groundnut flour while the other was mixed with the bambara groundnut at 70:30 and 60:40 concentrations (Luo *et al*., 2011).

2.3 FERMENTATION OF FLOUR

Thirty gram (30g) and 40g of the peeled bambara groundnut flour were weighed and mixed with 70g and 60g of maize flour to produce two different blends of the bambara groundnut fortified maize flour and the blends were poured into two different containers with 100ml of clean water which were then fermented with *Lactobacillus planetarium* collected at room temperature (28°C) for 72h. The same procedure was repeated for the fried bambara groundnut fortified maize flour (Shah *et al*., 2015; Alain *et al*., 2007).

Another 30g and 40g of the peeled bambara groundnut flour were weighed and mixed with 70g and 60g of maize flour to produce two different blends of the bambara groundnut fortified maize flour and the blends of the sample were poured into two different containers with 100ml of clean water which was then left to ferment spontaneously at room temperature (28^0C) for 72h. The same procedure was repeated for the fried bambara groundnut fortified maize flour.

About 600g of the maize flour was also weighed and then divided into two containers (each holding 300g). 100ml of distilled water was added to both flour and mixed thoroughly. One of the maize flour dough was left to ferment spontaneously at room temperature for 72h while the other was fermented by the addition of the collected Lactic acid bacteria and left at 28^0C for 72h (Ijarotimi and Esho, 2009).

After fermentation, eight different paps (gumba) were prepared using both the peeled (spontaneous and starter based) and the fried(spontaneous and starter based) bambara groundnut fortified fermented maize flours. Water was boiled at 100^0C after which the bambara groundnut fortified fermented maize flour was poured in it and stirred until its completely done. It was then brought down from fire and left to cool. Some of the prepared pap was given to people for evaluation while others was used for the nutritional analysis (Ndidi *et al*., 2014).

2.4 SENSORY EVALUATION

All the gumba produced with the peeled bambara groundnut fortified fermented maize flour and the fried bambara groundnut fortified fermented maize flour were given to people for sensory evaluation (Nyau *et al*., 2015). The sensory characteristics of both bambara groundnut fortified fermented maize flour product was assessed by 40 students of the department of Microbiology Waziri Umaru Federal Polytechnic Birnin Kebbi Kebbi State. The gumba was assessed based on colour, texture, aroma (flavor), taste and overall acceptability.

2.5 NUTRITIONAL ANALYSIS

The standard methods of the Association of Official Analytical Chemists (AOAC, 2000) were used to determine moisture, ash, crude protein, and carbohydrate contents of the bambara groundnut fortified fermented maize flour. Moisture content was estimated by heating 6.0g of the gumbato a constant weight in a crucible at 100-110^0C. Ash content was determined gravimetrically by incineration at 550^oC for 8 hours. The kjeldahl method was used to determine the crude protein (protein factor used was 6.25). The carbohydrate was calculated by difference.

2.5.1 ASH CONTENT

The ash content of thegumba was determined according to the method described by AOAC (2000). According to the method, 6.0g of the sample was weighed in a silica crucible. The crucible was heated in a muffle furnace for about 7-8 hours at 550°C. It was cooled in desiccators and weighed. To ensure completion of ashing, it was reheated again in the furnace for half an hour more, cooled and weighed. This was repeated consequently till the weight became constant (ash became white or grayish white). Weight of ash give the ash content and was calculated by the following formula.

$$\text{Ash (\%)} = \frac{\text{Weight of sample after ashing}}{\text{Weight of fresh sample taken}} \times 100$$

2.5.2 MOISTURE CONTENT

The moisture content of the gumbawas determined according to the method described by AOAC (2000). 6.0g of the sample was taken in a flat-bottom dish (pre-weighed); keep overnight in an oven at 100 to 110°C and weighed. The loss in weight was regarded as a measure of moisture content, and was calculated by the following formula:

$$\text{Moisture (\%)} = \frac{\text{Weight of fresh sample} - \text{weight of dry sample}}{\text{Weight of fresh sample}} \times 100$$

2.5.3 CRUDE PROTEIN

Total nitrogen of the gumba samples was determined by micro-KJELDAHI method according to AOAC method. 1g of the sample was weighed and transferred to a digestion tube, two Kjeldehl tablets and 25ml of concentrated Sulphuric acid was added from an automatic dispenser. The tube was placed in the preheated digester at 420^0C for about 30 minutes until a clear solution is obtained. After digestion, the tubes were removed from the digester, cooled and diluted with water. The tube was placed with the digester and diluted sample in the distillation and a conical flask containing 25ml of boric acid (indicator) was placed under the condenser outlet. The alkali (25ml of 40% NaOH) was dispensed and distilled for 4 minutes after which the ammonium borate solution formed with 0.1ml Sulphuric acid was titrated to a purplish – grey end- point.

2.5.4 CRUDE FIBRE CONTENT

The crude fiber content of the gumba samples was analyzed as described in AOAC method. About 2g sample was transferred to 600 ml beaker. After digestion with 1.25 % sulfuric acid it was washed with distilled water and then digested by 1.25 % sodium hydroxide. It was then filtered in coarse porosity 75-76 μm crucible in an apparatus at a vacuum of about 25 mm. The residue left after refluxing was washed again with 1.25% sulfuric acid near boiling point. This residue was then dried at 110^0C for one hour, cooled in desiccators and then it was weighed (*W1*). After ashing at 550℃, it was cooled in desiccators and weight again (*W2*). The total crude fiber was expressed in percentage as follows:

$$\text{Crude fibre (\%)} = \frac{W1 - W2}{W3} \times 100$$

2.5.5 CARBOHYDRATE

Carbohydrate content of the gumba samples was determined by subtracting the above proximate composition values from 100 using the following formula:

C (%) = 100 – (%M + %A + %F + %FB + %P)

Where: C (%), % M, % P, % F, % Fb and % A are percentage of carbohydrate, moisture content, protein, fat, fiber and ash content respectively.

2.6 STATISTICAL ANALYSIS

The results of this research was analysed using mean and standard deviation.

4.0 RESULTS AND DISCUSSION

This research is carried out to evaluate the nutritional composition of Lactic acid and spontaneously fermented maize flours fortified with Bambara groundnut. The results of the Nutritional analysis and sensory evaluations carried on roasted and peeled Bambara groundnut fortified fermented maize flours are presented on Tables.

Figure 1 and 2 presented above showed that *Lactobacillus planetarium* was able to survive in the fermentation medium (maize flour) over a period of 24 hours with the counts from 1.00 at 0 hours to 11.4×10^4after 24 hours.

Also, there was a decline in the population of the *Lactobacillus plantarium* in the fermented maize flour one part of which is refrigerated and the other kept at room temperature. The decline in the count of the organism was observed over a period of 14 days. It was noticed that as the days goes by the *Lactobacillus* count reduces. This may be as a result of limited sugar in the fermented maize flour which the organism can utilize for its growth in the flour thereby leading to the reduction in the activities of the organism. Also, the decline in the count of the *Lactobacillus* was higher in the fermented flour kept at room temperature when compared to the one kept in the fridge.

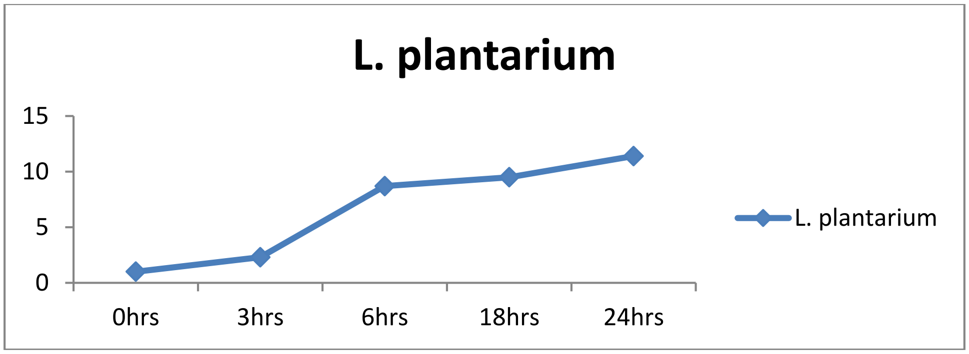

Figure 1: Chart showing the survival of *Lactobacillus planetarium* in the fermentation of Maize flour.

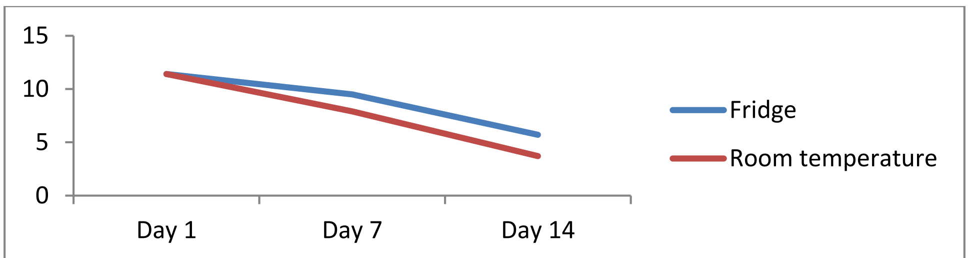

Figure 2 showing the *Lactobacillus* count in the fermented maize flour (In fridge and at room temperature) after 14 days

The result of the nutritional analysis of the 8 samples of gumba is presented on Table 1. The analysis of the proximate composition gives the basic chemical composition of the eight samples and the composites analysed include ash, moisture, fat, protein, fibre and carbohydrates which are known to be essential for the assessment of the nutritive quality of foods. The moisture content of 8.96, 10.82, 13.41, 10.00, 7.66, 11.64, 10.49, and 13.62, were observed for MASB, MAFBSB (70:30), MAFBSB (60:40), MASP, MAPBSB (70:30), MAPBSB (60:40), MAPBSP (70:30), and MAPBSP (60:40) respectively. The result shows that all the samples have moderate moisture contents ranging from 7.66% to 13.62% with sample MAPBSP (60:40) having the highest among all. All the moisture contents observed in this research are within the American Association of Cereal Chemists (AACC) recommended moisture content limit of 14% to 20% for cereal based flours and dough. This is in line with the findings of Hillocks *et al*. (2012) where they found the moisture contents of maize, millet and sorghum fortified with Bambara groundnut to be 14%, 12% and 10% respectively.

The ash content of the eight samples are 0.5%, 1.5%, 2.5%, 0.5%, 2.5%, 2.5%, 0.5%, and 0.5%for MASB, MAFBSB (70:30), MAFBSB (60:40), MASP, MAPBSB (70:30), MAPBSB (60:40), MAPBSP (70:30), and MAPBSP (60:40). Determination of ash content in food samples has no nutritional significance per se, but the value for ash is a useful check in summing up the nutritional composition of food and a measure of its mineral content. The importance of the ash content is that it gives an idea of the amount of mineral elements present in the sample. No specific amount of ash intake has been recommended for different age groups; however, ash content is an important nutritional indicator of mineral content and an important quality parameter for contamination, particularly with the foreign matters.

The protein content of the eight samples reported in this study are 10.68%, 9.15%, 11.23%, 8.54%, 9.75%, 14.82%, 11.56%, and 8.56% for MASB, MAFBSB (70:30), MAFBSB (60:40), MASP, MAPBSB (70:30), MAPBSB (60:40), MAPBSP (70:30), and MAPBSP (60:40) respectively with sample MAPBSB (60:40) having the highest protein content. The results obtained were higher than the findings of Gwala *et al.* (2020) with percentage value ranging from 4.11% - 5.23% but lower than the findings of Daykin (2006) with maximum protein of 15.28% for spiced maize ogi. The protein contents of all the samples is higher than the EU/WHO (2000) recommended limits of 5g/100g for cereal groups. The difference in the protein content of these studies could have arisen from environmental factors, cultural practices and the fortification. Earlier reports by Alain *et al.* (2007) indicate that diet is nutritionally satisfactory, if it contains high calorific value and a sufficient amount of protein. It has been shown that any plant foods that provide about 12% of their calorific value from protein are considered good sources of protein an observation which is similar to the recommendations of the National Agency for Food and drug Administration and Control (NAFDAC), 2010 in Nigeria.

The Crude fibre content of the eight samples observed are 2.0%, 3.5%, 1.5%, 2.5%, 1.5%, 2.0%, 1.5%, and 1.5%, for MASB, MAFBSB (70:30), MAFBSB (60:40), MASP, MAPBSB (70:30), MAPBSB (60:40), MAPBSP (70:30), and MAPBSP (60:40) respectively. The fibre contents of all the samples except sample MAFBSB (70:30) are relatively low in comparison to NAFDAC minimum requirement of 3g/100g for source of fibre in cereals. The fibre contents recorded in this study are also lower than those recorded in the study by Hillocks *et al*. (2012). Dietary fibre helps to maintain the health of gastrointestinal track but, in excess, may bind trace elements, leading to deficiencies of some of these micro nutrients in the body.

The carbohydrate content of the samples observed in this study are 73.46%, 70.01%, 68.01%, 75.25%, 76.37%, 68.04%, 72.53%, and 71.45%for MASB, MAFBSB (70:30), MAFBSB (60:40), MASP, MAPBSB (70:30), MAPBSB (60:40), MAPBSP (70:30), and MAPBSP (60:40) respectively. This result indicates that all the samples have high level of carbohydrate and the presence of high carbohydrate content in these samples suggested that it may serve as a source of energy. It may also aid digestion and assimilation of other nutrients. This result is in line with the findings of Bamshaiye *et al.* (2011) in which bambara groundnut fortified millet was found to have good nutritive value, particularly high carbohydrates and recommended to be suitable for children and younger people. This result is also within the limit of the Recommended Dietary Allowance (RDA) for carbohydrate of 130g/d for adults.

The values of fat (lipid) contents obtained in this research are 4.40%, 5.02%, 3.35%, 3.21%, 2.22%, 1.00%, 3.42%, and 4.37%for MASB, MAFBSB (70:30), MAFBSB (60:40), MASP, MAPBSB (70:30), MAPBSB (60:40), MAPBSP (70:30), and MAPBSP (60:40) respectively. The fat contents obtained are higher than the 0.5g/100g maximum limit recommended by NAFDAC for fat free foods.

Table 1: Shows result of the nutritional value of fried and peeled bambara groundnut fortified fermented maize flours.

			Parameters Analyzed (%)			
Samples	**Ash**	**Moisture**	**Protein**	**Fibre**	**Carbohydrate**	**Fat**
MASB	0.5	8.96	10.68	2.0	73.46	4.40
MAFBSB (70:30)	1.5	10.82	9.15	3.5	70.01	5.02
MAFBSB (60:40)	2.5	13.41	11.23	1.5	68.01	3.35
MASP	0.5	10.00	8.54	2.5	75.25	3.21
MAPBSB (70:30)	2.5	7.66	9.75	1.5	76.37	2.22
MAPBSB (60:40)	2.5	11.64	14.82	2.0	68.04	1.00
MAPBSP (70:30)	0.5	10.49	11.56	1.5	72.53	3.42
MAPBSP (60:40)	0.5	13.62	8.56	1.5	71.45	4.37

Keys: MASB = Maize Starter Based
MAFBSB = Maize and Fried Bambara groundnut Starter Based
MASP = Maize Spontaneous
MAPBSB = Maize and Peeled Bambara groundnut Starter Based
MAPBSP = Maize and Peeled Bambara groundnut Spontaneous

The result of the sensory evaluation of the eight samples based on colour, texture, flavor, Taste, and General Acceptability showed that 11%, 11%, 9%, 7.5%, 11%, 11.5%, 30.5%, and 8.5% of the respondents agrees to MASB, MAFBSB (70:30), MAFBSB (60:40), MASP, MAPBSB (70:30), MAPBSB (60:40), MAPBSP (70:30), and MAPBSP (60:40) respectively with MAPBSP (70:30) having the highest percentage. This means that peeled Bambara groundnut fortified maize fermented spontaneously of concentration (70:30)is the best among all.

According to FAO (2011), “Ogi” has poor biological value thus; children weaned entirely on “Ogi” are known to suffer from protein-energy malnutrition (PEM). So, a good supplemental relationship thus exists between “Ogi” and

Bambara-groundnut. Addition of 30% bambara-groundnut into Bambara-groundnut supplemented "Ogi' improves the protein content of "Ogi". The organoleptic evaluation showed that, combinations of cereals/maize and legumes/bambara groundnut, to prepare the food mixtures, was liked by the panelists. None of the panelists developed any side effects like diarrhea and vomiting after the sensory evaluation.

The study has revealed that fortification of millet meal(cereal) with bambara groundnut (legume) is able toalleviate problems of protein energy malnutrition (PEM).The fortified foods prepared with bambara-nut and maize was nutritious and conformed to specifications as recommended by national institute of nutrition and foodand agriculture organization (FAO) to combat malnutrition especially in low economic groups. It has special importance for use in weaning foods, catch-up growth and may improve birth weights. Therefore there is a need for research into the isolation, identification and characterization of the microorganisms involved in the fermentation of bambara groundnut-maize fortified meal to enable the selection of most suitable strains for starter culture development. Starter culture developed may be used to scale up the production of the product from households to small scale level. Furthermore, the introduction of appropriate starter culture techniques may constitute one of the major steps towards improving the safety, quality and security of traditional production of bambara groundnut maize fermented meal.

Table 2: Shows result of the sensory evaluation of malted and peeled bambara groundnut fortified fermented maize flours by 40 respondents.

Sample	Colour	Texture	Flavour	Taste	G.A	Total	% acceptance
MASB	4	2	3	5	8	22	11
MAFBSB (70:30)	3	4	7	3	5	22	11
MAFBSB (60:40)	6	3	5	2	2	18	9
MASP	2	3	2	5	3	15	7.5
MAPBSB (70:30)	4	5	4	4	5	22	11
MAPBSB (60:40)	6	7	5	3	2	23	11.5
MAPBSP (70:30)	13	10	11	16	11	61	30.5
MAPBSP (60:40)	2	6	3	2	4	17	8.5
100							

Keys: G.A = General Acceptability
MASB = Maize Starter Based
MAFBSB = Maize and Fried Bambara groundnut Starter Based
MASP = Maize Spontaneous
MAPBSB = Maize Peeled Bambara groundnut Starter Based
MAPBSP = Maize and Peeled Bambara groundnut Spontaneous

4.3 CONCLUSION

The study has shown that both the fried and peeled bambara groundnut maize flours fermented spontaneously and with Lactic Acid Bacteria have both excellent eating and nutritional qualities. Results of this study revealed that the nutritional contents also depend on the concentration of the millet and bambara ground nut. Also, the dietary parameters analysed for the samples in this study; Ash content, moisture content, crude fat, protein content, crude fibre, and carbohydrate content meet local and international requirements recommended.

Finally, based on people's response, the MAPBSP (70:30) fermented spontaneously has the best flavor, taste and most generally accepted. Therefore, the results from this study give strong credence to the utilization of Bambara groundnut in the fortification of cereal-based ogi.

4.4 RECOMMENDATION

Based on the findings of this research, it is recommended that further nutritional analysis such as acids contents and sugar content should be carried out on the samples.

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