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Quality Evaluation of Noodles Produced from Fermented Bambara Groundnut (Vigna Subterranean (L) Verdc.) Flour

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Abstract
The quality evaluation of noodle samples from fermented bambara groundnut produced in blend proportions of wheat (*Triticum eastrum)* flour was analyzed to determine its suitability for use in noodle production. Pure cultures of *Lactobacillus plantarum* [NRRL B-4306] and *Lactobacillus fermentum* [NRRL B-1932] was used to initiate a 72 hours fermentation of the bambara groundnut after which it was dried, finely milled and sieved. The result of crude protein content of the noodle samples ranged from 16.70 (50:50) to 19.28% (100:0) bambara: wheat; indicating increase in protein content with increase in bambara groundnut flour. Similar increment trend were also observed for fat, fiber and ash content with increase in the proportions of the fermented flour; while carbohydrate content had a decreasing status which ranged from 60.03 (50:50) to 53.60% (100:0) bambara: wheat. To determine the product quality; the cooking quality, cooking time, cooking yield and cooking loss of the noodles were analyzed and results showed that the control sample (0:100) recorded longest cooking time of 7.2 minutes than the experimental samples. Hence, increase in wheat flour replacement led to decrease in cooking time and increase in both cooking yield and cooking loss of the experimental samples. Sensorial data was used to access for consumer acceptance of the products and results showed that appearance was not significantly ($p < 0.05$) affected up to 70% substitution; while aroma, taste and texture was significantly ($p > 0.05$) affected as the proportion of fermented bambara groundnut flour increased.
Keywords: Noodles, Fermentation, Bambara Groundnut, Quality Evaluation

INTRODUCTION

The need for the development and effective utilizations of bambara groundnut cannot be overemphasized. Apart from its plausible role in food security, bambara groundnut has veritable industrial uses that cut across many industries. The development of industrial potentials of bambara groundnut in a country like Nigeria will save more than 2 billion naira on annual basis from over dependence on wheat and as well create employment and export opportunities. While commercial canning of bambara groundnut gravy is a successful industry in Ghana (GFAR, 1999) and Zimbabwe (DFID, 2012), little or no industrial activity is taking place on this crop in Nigeria. Bambara groundnut is an important source of dietary protein, particularly when intake from animal sources is low or not available (Mune *et al*., 2007). When compared to other food legumes, bambara groundnut is rich in iron and the protein contains high lysine and methionine (Mbata *et al.,* 2009) and can thus complement cereals in making foods such as noodles. Food products like noodles have existed for long and the consumption of these products has been increasing at global level. Producing a widely consumed food such as noodle with bambara groundnut or in blends with other cereals will enhance food security.

One of the major problems militating against the successful industrial application of this legume is the long time it takes to cook and the anti-nutritional factors such as tannins and trypsin – inhibitors coupled with its poor milling characteristics due to its poor dehulling potentials (Barimalaa and Anoghalu, 1997). In the present study, the bioprocess of fermentation was used to reduce cooking time and reduce these anti-nutritional factors to tolerable levels and its use in noodle production explored.

MATERIALS AND METHODS

Collection and Preparation of Samples: Bambara groundnut was purchased from Ogbete Main Market, Enugu State of Nigeria. The bamabara groundnuts were carefully cleaned and freed of all extraneous materials as well as damaged nuts prior to use. The nuts was washed twice with ordinary water, rinsed with distilled water, and cooked to softness as a pretreatment measure and to eliminate existing microflora. Pure cultures of freeze dried *Lactobacillus plantarum* [NRRL B-4306] and *Lactobacillus fermentum* [NRRL B-1932] preserved in a dormant state by drying a heavy suspension of cells in sterile bovine serum was obtained from Agricultural Research Services Culture Collection, Bacterial Foodborne Pathogens and Mycology Research Unit; National Center for Agricultural Utilization Research of the United States Department of Agriculture, Peoria Illinois USA. The freeze dried cells was brought to active state by growing in 25 ml sterile M.R.S. broth, and incubated in CO_2 enriched jars for 24 h and centrifuged at 3600-x g for 15 min. The recovered cells were rinsed using 10 ml sterile distilled water and spine twice at 3600-x g for 15 min. After this, a 9 ml suspension of the cells was made using sterile distilled water. The suspensions was serially diluted and plated out on plate count agar using the pour plate method. After 24 h incubation period in CO_2 enriched jars, the colonies on each plate of dilution factor was counted and the plate with approximately 10^6 cfu/ ml was noted and used at every inoculation of the fermentation process.

Fermentation: Twenty (20) kg of bambara groundnuts were cooked to softness and was rinsed with distilled water and poured into a basin. The inoculum suspension of *Lactobacillus plantarum* [NRRL B-4306] and *Lactobacillus fermentum* [NRRL B-1932] containing approximately 10^6 cfu/ml was then inoculated aseptically into the bambara groundnuts used for this study and 20 liters of distilled water added. The basin was covered completely and allowed to stand on the laboratory bench for three days at room temperature for the nuts to ferment. The fermentation was carried out without stirring, in accordance with the usual household practice. After the fermentation period the nuts were drained of water and spread on a tray and dried in a cabinet dryer at 60^{o}C for 14 hours. To obtain the whole bambara groundnut flour; the samples were finely milled using commercial attrition grinder and sieved 3 times using a laboratory test sieve (Sethi Standard Test Sieve 100 BSS). The flour was stored in an airtight nylon bags at 4°C until it was used for experiments. However, wheat (*Triticum eastrum)* flour of commercial grade was bought and used in blend proportions.

Noodle Production: A small-scale standardized laboratory procedure was used for noodle manufacturing using the fermented bambara groundnut flour and commercial wheat flour. Based on the blending proportions of 100:0, 50:50, 60:40, 70:30, 80:20 and 90:10 (Bambara:Wheat) flours, the noodles was prepared according to the procedure adopted by Atowa, (2017). The portions of flour were mixed with warm water to form a paste that was slowly mixed with a dry sample of the same flour until smooth dough is formed. About 0.02 g of alum was dissolved in water and added to the dough for stabilization. The noodles were then extruded through a die of 1.64 mm diameter (locally manufactured at the National Root Crop Research Institute Umudike, Nigeria) into boiling water. The noodles were allowed to remain in the water for about 5 minutes after which the extrudates was transferred into a bowl of cold water and allowed to remain for 15 minutes. Thereafter, the extrudates were spread at room temperature for 4 hours before drying in a conventional oven at 65^{o}C for 2 hours. The dried noodles was allowed to cool to room temperature, packaged in dry labeled plastic bags, sealed and stored for use.

Quality Evaluation

Proximate analysis: The samples were analyzed for crude protein, crude fat, crude fiber and total ash by following their respective procedures described in AACC (2000). Crude protein (N × 6.25) was determined by the Kjeldahl method. Crude fiber was determined after digesting a known weight of fat-free sample in refluxing 1.25% sulfuric acid and 1.25% sodium hydroxide. Ash was determined by incineration (550°C) of known weights of the samples in a muffle furnace. Crude fat was determined by exhaustively extracting a known weight of sample in petroleum ether (boiling point, 40 to 60°C) in a soxhlet extractor. The carbohydrate content was determined by subtracting the total crude protein, crude fiber, ash and fat from the total dry weight (100g) of the sample differences.

Noodle cooking quality: Noodle cooking quality was determined according to the approved method in American Association of Cereal Chemists (AACC), (2000). Optimum cooking time was the time required for the opaque central core of the noodle to disappear when squeezed gently between two glass plates after cooking. Twenty-five grams of noodle was cooked to optimum time in 300 ml tap water in a beaker, rinsed in cold water, and drained for 15 min before weighed. Percentage of increased weight was calculated as a cooking yield. Solids content in the cooking water was determined by drying at 105^{o}C overnight. The cooking loss was expressed as percentage between the solid weight and initial dry matter.

Sensory analysis: The prepared noodle samples were cooked in stainless steel thick-bottomed sauce pan (5-7 min, salted boiling water at 100°C) and were occasionally stirred to prevent sticking to each other. When soft it was strained from cooking water and allowed to cool. Sensorial data were obtained using a 25 member untrained panelists drawn from the public. The test was conducted while the samples were still fresh and the panelists were required to observe the sample, taste and score. Then rinse their mouth with water before tasting another sample/product. The products was analyzed based on the following parameters of appearance, aroma, texture, taste, and overall quality using a nine-point hedonic scale of 9 = liked extremely down to I = disliked extremely.

Statistical Analysis

Data generated from this study were represented as mean ± standard deviation and statistically analyzed using one-way analysis of variance and mean separation was done by Duncan's new multiple range and Paired T-tests at 95 % level.

RESULTS AND DISCUSSION

The effect of blend proportions on the proximate compositions of noodles produced from fermented bambara groundnut flour and wheat flour is shown in table 1 for crude protein, crude fat, crude fiber, ash and carbohydrate content. The crude protein content of the noodle samples ranged from 16.70 (50:50) to 19.28% (100:0) bambara to wheat. Bambara groundnut however is a high protein food when compared to wheat and the result observed increase in protein as the proportion of the fermented flour increases. Comparable results were seen in pasta produced from wheat and chickpea and deffated soya which had protein content ranging from 13.33% to 17.17% when compared to pasta produced from wheat alone which had protein content of 12.3% (Iqbal *et al.*, 2006).

Result of crude fat content of the noodle samples ranged from 5.86 (50:50) to 7.10% (100:0) bambara to wheat, hence, the sample from wheat alone (control) had low fat content of 1.69%. In the same way, Krishnan (2000) observed an increase in fat content with addition of soybean on wheat for cookie products. Similar increment trend were also observed for fiber and ash content with increase in the proportions of the fermented flour with ranges of 4.92 (50:50) to 7.10% (100:0) and 2.08 (50:50) to 3.08% (100:0) bambara to wheat, for fiber and ash respectively. In contrast, the carbohydrate content had a decreasing status with increase in the proportion of fermented flour and ranged from 60.03 (50:50) to 53.60% (100:0) bambara to wheat. The decrement is owing to the fact that wheat is a high carbohydrate food and as the proportions of bambara supercides that of wheat the carbohydrate content decreases. Hence, the control sample from 100% wheat had carbohydrate content of 72.45% which is high when compared to sample from 100% bambara.

Table 1: Proximate composition of noodles from fermented bambara groundnut and wheat flour blends

	Sample Blends*						
Parameters	**50:50**	**60:40**	**70:30**	**80:20**	**90:10**	**100:0**	**0:100**
Protein (g)	16.70±0.4	17.0±0.1	17.65±0.1	18.10±0.4	18.73±0.6	19.28±0.3	13.08±0.4
Fiber (g)	4.92±0.1	5.12±0.2	5.78±0.5	6.03±0.2	6.88±0.4	7.10±0.2	0.78±0.9
Fat (g)	5.86±0.5	5.94±0.5	6.12±0.1	6.28±0.3	6.69±0.2	7.10±0.2	1.69±0.5
Ash (g)	2.08±0.5	2.27±1.0	2.41±0.7	2.73±0.5	2.94±0.1	3.08±0.8	1.80±0.1
Carbohydrate (g)	60.03±0.8	58.77±0.2	57.28±0.3	56.78±0.1	54.45±0.1	53.60±0.5	72.45±0.1

Values are means ± SD (n = 3)
*Ratio of Bambara: Wheat

Table 2: Cooking quality of noodles from fermented bambara groundnut and wheat flour blends

			Sample Blends*				
Parameter	50:50	60:40	70:30	80:20	90:10	100:0	0:100
Cooking Time (min)	5.4	4.8	4.1	2.2	2.1	1.45	7.2
Cooking Yield (%)	201.74	216.00	222.07	230.32	236.77	248.99	173.31
Cooking Loss (%)	9.71	10.68	11.35	11.92	13.11	14.18	8.40

Values are means ± SD (n = 3)
*Ratio of Bambara: Wheat

Table 2 shows the cooking quality of the noodles; cooking time, cooking yield and cooking loss of the noodles. According to Chung *et al.* (2012), a good quality noodles is that with a short cooking time, higher cooking yield with little loss of solids in the cooking water. Result shows that the control sample (0:100) bambara: wheat, recorded longest cooking time of 7.2 minutes than for the experimental samples. Increasing the replacement level of the wheat flour led to a decrease in cooking time of the noodles. On the other hand, increase in wheat flour replacement led to increase in both cooking yield and cooking loss. The 100% bambara flour sample (100:0) recorded the highest noodle yield (248.99%) and cooking loss (14.18%); while the control sample (0:100) recorded the least for both cooking yield (173.31%) and cooking loss (8.40%). Similar result has also been reported by Mahmoud *et al.* (2012) and Sirichokworrakit *et al.* (2012). The differences in cooking quality of the noodles could be attributed to primarily to the gluten fraction of the different flour blends. This is because, by replacing the wheat flour with bambara flour, the gluten fraction was being diluted, leading to less water retention level of the noodles. Therefore, increasing the amount of bambara flour hindered the functional dough properties and the cooking quality (Li *et al.,* 2012). According to the characteristics, supplementation of wheat flour with fermented bambara flour improved the cooking quality of the noodles.

Hence, the results of the sensory evaluation showed the acceptability rate of the noodles produced from different blends of fermented bambara groundnut flour and wheat flour using sensory attributes like appearance, aroma, texture, taste and overall acceptability and shown in table 3. The appearance of the noodle samples was not significantly ($p < 0.05$) affected up to 70% substitution with fermented bambara groundnut flour. On the contrary, the aroma and taste, generally understood as flavor, was significantly ($p > 0.05$) affected as the proportion of fermented bambara groundnut flour increased. The texture of the noodles was also significantly (p

> 0.05) decreased as the amount of fermented bambara groundnut flour increased in the blends and this could be as a result of high fiber content. Considering that wheat is a low fiber food (0.70%); this increment in the fiber content of the noodle samples could be attributed to higher content of fiber in bambara groundnut. Using the 9 point hedonic scale of rating adopted for this study, the noodle samples up to 70% substitution with fermented bambara groundnut flour scored above average (4.5) out of 9 scale rating.

Table 3: Sensory evaluation of noodles from fermented bambara groundnut and wheat flour blends

Samples*	Appearance	Aroma	Taste	Texture	Overall Acceptability
50:50	6.8±0.4	6.0±0.5	5.0±0.2	5.0±0.1	5.7±0.4
60:40	6.3±0.1	5.7±0.9	4.5±0.5	4.8±0.5	5.3±0.6
70:30	5.7±0.2	5.2±0.2	4.1±0.2	4.3±0.8	4.8±0.1
80:20	5.2±0.2	4.7±0.3	3.5±0.4	3.6±0.3	4.2±0.2
90:10	4.7±0.8	4.0±0.1	3.2±0.8	2.8±0.1	3.5±0.8
100:0	4.0±0.3	3.0±0.1	2.0±0.1	2.2±0.2	2.8±0.1
0:100	9.0±0.1	9.0±0.7	8.5±0.1	8.0±0.2	8.6±0.4

Values are means ± SD (n = 3)

CONCLUSION

With the increasing challenges of food security in many developing countries, it is imperative for research and development to source new innovative ways to optimize indigenous raw materials in food designs, thus reduce dependence and importation of foods or raw materials from other countries. As the food shortage situation is worsening owing to increasing population and restrictions on the importation of food among several other factors. This has resulted in a high incidence of hunger and malnutrition, a situation in which children and women are most vulnerable. Hence, the study observed that bambara groundnut is a good substitute in noodle production and was found to improve the nutrient composition of wheat flour; show good cooking qualities and had good sensorial characteristics.

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