

Fermentation of Bambara Groundnut (Vigna Subterranean (L) Verdc.) to Complement Infant Foods

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Abstract
The potential of bambara groundnut (*Vigna subterranean* (L) *Verdc.*) to be used as food in complementing infant formulations was studied by blending in proportions with Ogi (a traditional weaning food) and the physical, chemical and sensory qualities was compared to samples made from 100 percent Ogi and Nutrend (commercial weaning diet). The formulated diet containing 50% Ogi and 50% fermented bambara groundnut (Formula 1) had the highest energy value of 384.4 kcal and comparable to 383.5 kcal and 397.1 kcal for Ogi and Nutrend respectively. The high energy value of the formulated diets when compared to Recommended Daily Allowance (RDA) of infants (≤ 1 year) was above requirement. The protein content of formula 1 (13.8 g) was significantly higher than ogi (5.60 g) and other formulated foods, but significantly lower than Nutrend (16.00 g). Carbohydrate content (78.8) was significantly higher than Nutrend (64.0) while fat content for Formula 1 (8.1) showed no significant difference to Nutrend (8.5). For all the minerals studied, Formula 1 showed higher content to Nutrend and Ogi with exception to sodium, this was observed to be slightly higher in Ogi. The functional properties of the formulated diets decreased as the proportion of bambara groundnut increased but not to the extent that affected the sensory attributes of the food. However, all the sensory attributes of the formulated diets were significantly low when compared to Nutrend and Ogi and this could be attributed to the familiarity of the panelist to these foods.
Keywords: Fermentation, Infant Foods, Proximate Composition, Sensory Evaluation

INTRODUCTION

Malnutrition contributes directly or indirectly to over 60% of ten million child deaths each year (UNICEF, 1998). Infant malnutrition is common in developing countries (FAO, 1995); and this is because infants at early stage of development require higher energy and proteins in their diet as to meet increasing demand for metabolism. Thus, bambara groundnut (*Vigna subterranean* (L) *Verdc.*) is a highly nutritive but underutilized grain legume indigenous to West and Central Africa. A high carbohydrate and relatively high protein content as well as sufficient quantities of fat makes the legume rank highly as a complete food. The bambara groundnut is commonly grown by subsistence farmers and little attempts has been made towards its commercialization; hence, the potentials of this legume crop are not only in its commendable nutritional composition but it also has outstanding traits such as drought tolerance, nitrogen fixation and an ability to produce yields in marginal soils, among others.

However, lack of adequate processing techniques to overcome the hard-to-cook effect has limited its utilization and hence reduced its production. According to farmers, the decline in bambara groundnut production is due to lack of adequate processing techniques to promote utilization (Mkandawire, 2007). This study is intended to use the bioprocess of fermentation as an adequate technique to effectively use bambara groundnut in new food product designs to solve infant malnutrition in developing countries.

MATERIALS AND METHODS

Sample Collection and Preparation: The Bambara groundnuts, Nutrend (a commercial weaning food) and Ogi (a traditional weaning food) was purchased from Ogbete Main Market, Enugu State of Nigeria. The nuts were carefully cleaned and freed of all extraneous materials as well as damaged nuts prior to use and was washed twice with ordinary water, rinsed with distilled water; then cooked to softness as a pretreatment measure and to eliminate existing microflora before inoculation with starter cultures. Pure cultures of freeze dried *Lactobacillus plantarum* and *fermentum* 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 CO2 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 CO2 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: The nuts was first cooked and then rinsed with distilled water. A total of 10 kg of the cooked nut was poured into a basin and 10 ml inoculum suspension of *L. plantarum* and *L. fermentum* containing approximately 10^6 cfu/ml was then inoculated aseptically into the 10 kg of bambara nuts used for this study and 15 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. At the end of the fermentation period, the water was drained and the nuts spread on a tray and dried in a cabinet dryer at 60^oC for 14 h. To obtain the whole bambara groundnut flour; the cooked, fermented and dried bambara groundnuts was finely milled using commercial attrition grinder and sieved 3 times using a laboratory test sieve (Sethi Standard Test Sieve 100 BSS) to obtain the flour. The flour was stored in an airtight nylon bags at 4°C until it was used for further experiments.

Food Application: The flour used for bambara-ogi diet formulation was obtained by blending in the ratio of [50:50; 60:40; 70:30, 80:20 and 90:10] (Ogi: Bambara). The samples were first reconstituted with cold water to form a paste and later with hot water boiling at 100^0C. The chemical, functional and sensory properties of these foods were evaluated to determine their acceptability and suitability for consumption and for use as infant formula.

Determination of Chemical Composition and Total Energy: The nutrient composition of the food samples were determined using the standard procedures of Association of Official Analytical Chemists (1990). 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. 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. 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. The gross energy was determined with a ballistic bomb calorimeter and the caloric value estimation will be done according to Antia *et al.* (2006) by summing the multiplied values for crude protein, oil, and carbohydrate by their respective factors. Total minerals from the samples were determined using the dry ashing method described by Chapman and Pratt (1982). About 2.0 gm of sample was acid-digested with diacid mixture (HNO3:HClO4, 5:1, v/v) in a digestion chamber. The digested samples were dissolved in double-distilled water and filtered (Whatman No. 42). The filtrate was made to 50 ml with double-distilled water and used for the determinations. Calcium was determined by a titration method. Iron was determined by atomic absorption spectrophotometer. Phosphorus and other minerals were determined spectrophotometrically using molybdovanadate method.

Determination of Functional property: Water absorption capacity was determined using the method modified by Adebowale *et al.* (2002); where 10 ml of distilled and deionized water were added to 1.0 g of the sample in a beaker. The suspension was stirred using magnetic stirrer for 5 min. The suspension obtained was then centrifuged at 3500 rpm for 30 min and the supernatant measured into a 10 ml graduated cylinder. Water absorbed was calculated as the difference between the initial volume of water added to the sample and the volume of the supernatant.

Swelling capacity was determined by weighing 20 g of the flour or food sample into a cleaned, dried graduated cylinder. The cylinder was tapped 3 times on the table and then 80ml of distilled water was poured into the cylinder. The cylinder was then allowed to stand for 1 h after which the final volume of the sample was noted. The ratio of the final volume to initial volume gave the swelling capacity on volume basis. The supernatant was decanted and the weight of food sample and the cylinder obtained and the ratio of final weight to initial weight of sample gave the swelling capacity on weight basis (Coffman and Garcia, 1977).

Determination of Sensory Attributes: Sensory evaluation of the food products were conducted 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 sterile distilled before tasting another sample/product. The products was analyzed based on the following parameters of appearance, aroma, texture, crispness, and overall quality using a nine-point hedonic scale of 9 = liked extremely down to I = disliked extremely.

RESULTS

The proximate composition and mineral content of the formulated food samples in comparism with Ogi (traditional weaning food) and Nutrend (commercial weaning diet) are shown in Table 1. The formulated diet containing 50% ogi and 50% fermented bambara groundnut flour (Formula 1) had the highest energy value (384.4 kcal.), while the sample containing 90% Ogi and 10% fermented bambara groundnut flour (Formula 5) had the least energy value (361.5 kcal.). The energy value of formula 5 was insignificantly high when compared with other formulated diets and ogi ($p \geq 0.05$), but significantly lower when compared with the nutrend (commercial weaning diet) ($p < 0.05$).

The protein content of formula 1 (13.8 g) was significantly higher than ogi (5.60 g) and other formulated foods, but also significantly lower than nutrend (16.00 g). The analysis showed that the protein content of the formulated diet increases progressively as the percentage of fermented bambara groundnut increases (Table 1).

The mineral composition of the formulated diets showed that formula 1 sample contained the highest mineral content, while formula 5 contained the least in virtually all the minerals determined. The study also observed that the mineral content of the food samples increases as the percentage of fermented bambara groundnut increases.

The functional properties of the formulated food samples are shown in Table 2. The water absorption capacity of food materials is an index of the maximum amount of water that it can take up and retain; hence determine the energy and nutrient dense of a food. However, the food formulations decrease in reconstitution ability as percentage of substitution with fermented bambara groundnut increases. This means that formula 1 sample which had a ratio of 50:50 (Bambara: Ogi) had the lowest water absorption ability. The swelling capacity decreased with the % increase of bambara groundnut flour. However, the swelling capacities of the formulated diets were significantly lower than ogi and nutrend ($p \geq 0.05$) but not to the extent that affected the sensory attributes of the food (Table 2).

Table 3 shows the results of sensory attributes of the formulated diets, ogi and nutrend. All the sensory attributes of the formulated diets samples were significantly low compared to the nutrend (a commercial weaning food) and ogi (a traditional weaning food) ($p \leq 0.05$).

Table 1: Comparism of Bambara-Ogi Formulation, Ogi and Nutrend Food Samples to meet Recommended Daily Allowance (RDA) of Infants

		Bambara-Ogi Formulations						
Nutrients	**RDA (≤ 1 year)**	**F1**	**F2**	**F3**	**F4**	**F5**	**Ogi**	**Nutrend**
Energy (kcal)	344.4	384.4	380.9	374.8	369.8	361.5	383.5	397.1
Carbohydrate (g)	95	78.8	75.4	71.8	66.5	63.9	88.4	64.0
Protein (g)	14	13.8	11.0	10.3	9.5	8.9	5.6	16.0
Fat (g)	30	8.1	6.5	5.9	4.2	3.4	0.88	8.5
Zinc (mg)	3	3.5	2.9	2.4	1.9	1.6	1.4	0.7
Phosphorus (mg)	275	255.0	238.8	225.0	200.6	193.3	96.7	22.5
Potassium (mg)	700	74.9	69.0	66.8	61.5	54.5	51.9	58.0
Calcium (mg)	270	208.2	196.4	189.8	176.0	165.0	52.0	39.0
Magnesium (mg)	75	17.5	17.0	16.6	15.9	15.2	14.8	12.0
Sodium (mg)	370	38.8	33.6	29.1	27.8	26.0	40.8	22.0
Iron (mg)	1.1	3.2	2.7	2.4	2.1	1.8	0.34	1.0

Values are mean of triplicates. The means with different superscripts in a row differ significantly ($p \leq 0.05$)
Recommended Daily Allowance (RDA) of Infants (UNICEF, 1998)

Table 2: Funtional Properties of the Bambara-Ogi Formulation and the Control Samples

Samples	% Water Absorption Capacity	% Swelling Capacity
F1	202.4	21.6
F2	193.5	18.5
F3	185.5	17.8
F4	170.8	17.2
F5	157.2	16.8
Ogi	135.0	16.8
Nutrend	350.5	30.8

Samples F1 = 50% Fermented Bambara Groundnut Flour and 50% Corn Gruel
F2 = 40% Fermented Bambara Groundnut Flour and 60% Corn Gruel
F3 = 30% Fermented Bambara Groundnut Flour and 70% Corn Gruel
F4 = 20% Fermented Bambara Groundnut Flour and 80% Corn Gruel
F5 = 10% Fermented Bambara Groundnut Flour and 90% Corn Gruel

Table 3: Sensory Evaluation of the Bambara-Ogi Formulation and Control Samples

Samples	Appearance	Aroma	Taste	Mouth Feel	Overall Acceptability
F1	2.0	4.1	4.0	5.0	4.5
F2	5.3	4.5	4.0	5.0	4.7
F3	5.7	4.8	4.4	5.2	5.0
F4	6.4	5.2	5.3	5.5	5.6
F5	6.4	5.8	5.6	5.8	5.9
Ogi	7.8	7.1	7.1	8.3	7.5
Nutrend	9.0	9.0	8.4	8.4	8.7

Values are mean of triplicates. The means with different superscripts down the colum differ significantly ($p \leq 0.05$)

DISCUSSION

Many researchers have worked extensively on cereal-legume combinations in Nigeria. For example, Fashakin *et al.,* (1986) formulated nut-ogi (a mixture of corn gruel and peanut), Akinrele and Edwards (1989) formulated soya-ogi (corn gruel plus soya bean). The traditional weaning foods could be improved by combining locally available foods that complement each other in such a way that new pattern of amino acids created by this combination is similar to that recommended for infants (Fashakin *et al.,* 1986).

The highest energy value and protein value observed in formula 1 (The formulated diet containing 50% ogi and 50% fermented bambara groundnut flour) corresponded with the findings other researchers. Numerous studies have reported that fermentation method improves the nutritive values of food products compared with other processing methods, such as roasting, cooking, etc (Adams, 1990; Obizoba and Atii, 1991).

The mineral composition of the formulated diets showed that formula 1 sample contained the highest mineral content, while formula 5 contained the least in virtually all the minerals determined. The study also observed that the mineral content of the food samples increases as the percentage of fermented bambara groundnut increases. The increase in vital nutrients as supplementation of fermented bambara groundnut increases could be attributed to the fact that bambara groundnut is a good source of protein and minerals. Numerous studies also reported that legumes are good sources of protein and minerals and that these seeds are usually consumed in many parts of the developing countries, particularly, where animal proteins are scarce or very expensive (Brough *et al*., 2003; Lalude and Fashakin, 2006).

The recommended functional properties such as low absorption capacity recorded in the formulated food samples, majorly formula 1 corroborated with the reports from other researchers (Brough *et al*., 2003; Lalude and Fashakin, 2006).

The disparity between the flavor and taste of the formulated diets and the control food samples could be attributed to the characteristics of beany aroma and taste of bambara groundnut flour. The low ratings of the formulated diets in terms of aroma, taste and color compared with the ogi and nutrend could also be attributed to the familiarity of the panelist to these foods.

CONCLUSION

In Nigeria where population is constantly on the increase, food security becomes paramount and there is no better means of ensuring food security than harnessing the potentials of indigenous crops. Bambara groundnut as an indigenous crop has the potentials to be utilized in many forms as food but antinutritional factors hinder these possibilities. The process of fermentation was used in this study to reduce the content of these unwanted substances and the results showed that this crop could effectively be used as food for infants. The traditional weaning foods could be improved by combining locally available foods that complement each other in such a way that new pattern of amino acids created by this combination is similar to that recommended for infants.

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