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Improving The Quality And Nutritional Status Of Maize Fermented Meal By Fortification With Bambara Nut

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Abstract

Studies were conducted to develop an appropriate household/small scale enterprise level technique for the production of bambara groundnut-fortified fermented maize dough or meal by comparing different treatments, processing methods and fortification levels. The effect of fortification of maize based traditional foods with legume protein, bambara nut at 0%. 10% and 20% replacement levels, on the rate of fermentation and product quality were investigated. Sensory characteristics, amino acid pattern, proximate composition (moisture, protein, fat, ash) pH, titratable acidity and theological properties (pasting temperature, peak viscosity, viscosity at 95°C and 95°C hold and viscosity at 50°C) were used as the indices of quality. The results obtained showed that Bambara nut addition caused only minimal changes in the proximate composition with the exception of protein content which increased remarkably from 10.1% to 16.4% and 10.1% to 16.2% with 20% bambara nut addition respectively for boiled bambara nut fortified fermented maize dough and raw bambara nut fortified fermented maize dough. The product pH decreased with concomitant increase in moisture, fat, ash and titratable acidity with increasing bambara addition. A significant improvement was also achieved in the lysine and tryptophan pattern of the fortified dough compared to the unfortified. However, boiling bambara nut for 20mins before incorporation into the maize for milling and fermentation imparted a desirable flavour. This results showed that the most appropriate technique for the production of bambara- fortified high protein fermented maize dough has been suggested to involve incorporation of boiled whole bambara nut in soaked maize before milling and fermentation for improved sensory characteristics, enhanced nutritive valve and optimal functional properties. Little or no changes in the pasting viscosity characteristic occurred in sample containing raw bambara nut. Organoleptic evaluation revealed that the foods were well accepted. Based on the findings of the study, the application of Bambara nut fortification to traditional foods suggests a viable option of promoting the nutritional quality of African maize-based traditional foods with acceptable rheological and cooking qualities.

INTRODUCTION

Maize processing in West Africa is based on traditional indigenous technology, which utilizes local raw materials, and in most cases, local equipment. These technologies are simple, with most of them having been developed through experience in the production of products of desirable quality. Common unit operation have been describe in previous studies [1,2,3,4,5]

Maize is processed into a wide range of foods and beverages ranging from weaning and children's break fast porridge to adult main meals and snack foods [2]

Traditional foods are formulated based on local staple usually cereal grains such as maize, sorghum, millet and rice and roots and tubers such as yam and cassava [6]. To be suitable for the feeding of young children, the cereals are prepared in liquid form by diluting with a large quantity of water, thereby resulting in a large volume with low energy and nutrient density [7,8].

Many brands of low – cost proprietary weaning foods have been developed from locally available high calorie cereals and legumes in tropical Africa [6,7,9]. This has been suggested by the integrated child development scheme (ICDS) and FAO to combat malnutrition among mothers and children of low socio-economic groups. 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 [10].

In Nigeria and other parts of West Africa, cereal grains lack two essential amino acid lysine and tryptophan [11,12,13], thus making their protein quality poorer compared to that of animals [14].

Germination of fermentation has been reported as ways of improving cereal-protein quality [15]. Earlier study has documented increase lysine and tryptophan of germinated corn [16], improved vitamin content of germinated soghum and maize [17] increased amino acid and vitamins of fermented blends of cereals and soybeans [7].

Despite the reported improvement in the nutrient status of germinated and fermented cereal based diets in sub-Saharan Africa, the nutrient needs of infants and sick adults are still not being met.

Earlier studies have documented the need for fortification of traditional fermented maize porridge with legume [18,19,20, 21]. Despite the various reports, information on the effect of bambara nut fortification on the nutritive value of some maize based traditional foods is scarce. Based on these facts, the study was undertaken to formulate and improve the quality and nutritional status of maize fermented meal by fortification with bambara nut.

MATERIALS AND METHODS

Maize (Zea mays L) and Bambara nut (Vigna subterranean L) were purchased from Ota farms in Ogun state and Eke Awka market in Anambra State, respectively all in Nigeria and used for the study. They were all transported to the laboratory in clean polyethylene bags for later use.

PREPARATION OF BAMBARA NUT-FORTIFIED WEANING FOODS

Maize dough were prepared using the traditional method of cleaning, washing and steeping in water for 24 hours: Soak (in water for I hour) in one stage and boiled (20 mins) in another stage to dehulled bambara nut and add separating to the maize at 10% and 20% concentration. The maize-bambara nut blend milled using a Disc Attrition mill mixed into a dough with water (3:1 meal: Water – ratio) and allowed to ferment spontaneously at ambient temperature (24 – 30°C) for three days.

PREPARATION OF TRADITIONAL UNFORTIFIED FERMENTED MAIZE DOUGH

This was prepared by soaking clean selected maize grains in water for 24 hours, washing and milling in a local corn mill (Disc Attrition Mill, Hunt No. 2A Premier Mill, Hunt and Co, UK) to an average particle size of less than 3mm. The meal was mixed with water and kneaded into a smooth dough of about 50% moisture content. The dough samples were allowed to ferment spontaneously at ambient temperature (24 – 30°C) for three days.

FERMENTATION STUDIES

Samples of dough were taken during fermentation and analysed for titratable acidity and pH to determine the effect of method and level of fortification on the fermentation characteristic.

P AND TITRATABLE ACIDITY

Ten grams of sample was mixed in 100mls of CO_2 – free distilled water. The mixture was allowed to stand for 15 minutes, shaken at 5 minutes interval and filtered with Whatman No. 14 filter paper. The pH of the filterate was measured using a pH meter (Model HM-305, Tokyo, Japan). Ten millitres aliquots (Triplicates) were pipetted and titrated against O.1 M NaoH to phenolphthalein end-point and the acidity was calculated as g lactic acid/100.

VISCOSITY MEASUREMENT

The cooked paste viscosity of the slurries were determined with a brabender viscoamylograph (Brabender, Duisburg Germany) equipped with a 700 cm – g sensitivity cartridge. A 10% slurry (dry matter basis) of each flour was prepared with 500ml distilled water and the slurry was heated uniformly from 25°C at a rate of 1.5°C per minute to 95°C and held for 15 minutes, and cooled at the same rate to 50°C [22]. The brabender viscoamylogrpahy reheological indices (Gelatinization temperature, peak viscosity, viscosity at 95°C and 95°C Hold, viscosity on cooling to 50°C, the index of gelatinization, and starch stability were all determined from obtained values.

PROXIMATE COMPOSITION

Samples of the fermented doughs were analyzed by standard procedure [23] for moisture, protein, fat and ash.

AMINO ACID ANALYSIS

Lysine and Tryptophan composition of sample was determine in triplicate by digestion under vacuum with 6N HCL in sealed ampules at 110°C for 22hours. The hydrolysates were derivatized and analyzed for amino-acids on a water HPLC system controlled by Millenium 2010 software (Water DIV, Millipore Corp, Milford, MA, USA) Tryptophan was determined according to the AOAC [24] method.

SENSORY EVALUATION

Sensory characteristic of the fortified fermented maize dough products were assessed by 10 trained members of the Department Applied Biochemistry and Food Technology. Fresh samples of cooked porridge prepared with each of the products by boiling a 10% (w/v) slurry of the dough for 15 minutes were assessed for their colour, texture, flavour (aroma), taste and overall acceptability. The judges were instructed to sip water before and after each product. The judges recorded quality characteristics of each sample on a 8 – point hedonic scale where:

8 = like extremely
7 = like very much
6 = like moderately
5 = like slightly
4 = dislike slightly
3 = dislike moderately
2 = dislike very much and
1 = dislike extremely

Each treatment was evaluated three times by each panelist.

STATISTICAL ANALYSIS

The data were subjected to analysis of variance in a completely randomized design using the method of Snedecor and Cochran [25]. Significance was accepted at P ? 0.05 level.

RESULTS

The effect of bambara nut treatment and fortification method the rate of fermentation of traditional maize dough are shown in Table 1. In Generally addition of raw bambara-nut or heat treatment to the dough accelerated acid production also the steeping of maize grains generally encourages higher lactic acid production by the prevailing microorganism. The rate of acid production increased with increase in the level of fortification. Also, for the different periods of fermentation studied, boiled bambara-nut blend with the maize resulted in greater TA than the blend of raw bambara-nut to the maize meal before fermentation The P^H of the formulated food drops as fermentation lasted.

Table 2 showed the proximate composition (ash, crude protein, total fat and moisture) of unfortified and fortified dough. It is clear that the superior quality of bambara-nut over maize in terms of fat, protein, minerals etc is reflected in the higher values of those components determined in the bambara –nut fortified samples.

Table 3 showed the brabender amylography pasting viscosities of fermented maize dough fortified with bambara nut before milling and fermentation.It is also clear that addition of raw bambara nut to maize before milling and fermentation had relatively minimal effect on the hot paste viscosity characteristics of traditional fermented maize dough.

Table 4 showed the amount of available lysine and tryptophan after fortification. The result showed that bambara-nut contained lysine in concentration that can contribute significantly to improving the amino acid pattern of the blend before milling and fermentation.

The over all acceptability scores of the various attributes as shown in Table 5 indicated that the panelists liked the products.

Figure 1

Table 1: Effect of bambara nut treatment and fortification method on the rate of fermentation of traditional maize dough.

Bambara nut fortification (level and Treatment)	P^H				Titratable acidity mg NaOH/g sample[1]			
	0 h	24h	48h	72h	0h	24h	48h	72h
Control Traditional dough (0% Bambara nut)	6.55^a	4.5^{ab}	4.0^a	3.6^c	1.3^d	5.3^c	6.2^c	6.5^e
Fortification before fermentation								
10% raw bambara nut	6.30^a	4.25^a	3.90^a	3.60^c	2.6^c	7.1^b	80^b	8.6^c
20% raw bambara nut	6.42^a	4.01^b	3.80^a	3.62^c	2.8^c	7.5^b	7.9^b	9.7^b
10% boiled bambara nut	5.50^b	4.01^b	3.70^a	3.50^c	4.2^b	7.5^b	8.2^b	9.8^b
20% boiled bambara nut	5.40^b	3.90^b	3.75^a	3.62^c	5.0^a	8.0^a	8.4^b	10.6^a

[1] Titratable acidity values are means of triplicate determinations expressed on day weight basis. Mean values in the same column with different superscripts differ significantly ($P < 0.05$). Stated values are means of triplicate trails

Figure 2

Table 2: Proximate composition of weaning food formulations of fermented maize dough sample fortified with bambara – nut using different method and treatment1.

Bambara-nut fortification (Level and Treatment)	Moisture (%)	Protein (%)	Fat (%)	Ash (%)
Control Traditional dough (0% bambara-nut)	50.2 ± 1.3^b	10.1 ± 0.4^c	4.0 ± 0.3^c	1.0 ± 0.1^c
Fortification before fermentation				
10% raw Bambara-nut	50.6 ± 0.7^b	12.5 ± 0.3^b	5.1 ± 2^b	1.5 ± 0.2^b
20% raw Bambara-nut	51.9 ± 1.0^{ab}	16.2 ± 1.0^a	6.3 ± 0.7^a	2.4 ± 0.1^a
10% boiled Bambara-nut	52.7 ± 1.1^a	12.6 ± 0.7^b	5.1 ± 0.5^b	-
20% boiled Bambara-nut	52.9 ± 0.5^a	16.4 ± 1.1^a	6.5 ± 0.5^a	2.4 ± 0.3^a

[1] Values are means ± SD of three independent determination, expressed on dry weigh basis except for moisture.
Mean values in the same column with different superscripts differ significantly ($P < 0.05$).

Figure 3

Table 3: Brabender amylography pasting viscosities of fermented maize dough samples fortified with Bambara-nut before milling and fermentation.

Pasting characteristics	Traditional unfortified maize dough	Boiled whole bambara-nut		Raw whole bambara-nut	
		10 %	20%	10 %	20%
Gelatinization Temp. (°C)	80.1±0.7^{a}	73.2±0.8^{c}	73.8±0.5^{b}	76.0±0.8^{a}	73.2±0.6^{c}
Peak Viscosity (BU)	320±5^{b}	300±5^{c}	250±10^{d}	380±5^{a}	350±5^{b}
Viscosity at 95°C (BU)	310±10^{a}	300±10^{b}	250±5^{c}	350±20^{a}	325±5^{a}
Viscosity after 15 minutes at 95°C	280±5^{a}	300±5^{b}	235±0^{c}	290±10^{a}	300±0^{a}
Starch stability (BU)	40±7^{bc}	0±7^{c}	15±5^{d}	90±11^{a}	50±5^{b}
Viscosity on cooling to 50°C (BU)	440±10^{a}	370±10^{c}	320±5^{d}	430±15^{a}	410±10^{b}
Index of gelatinization	160	70	85	140	110

Values are means of three replicates of ± SD. Means within a row with different superscripts are significantly different ($P < 0.05$)

Figure 4

Table 4: Amino acid content (g/16N) of fortified food made with Bambara nut

	Traditional unfortified Maize dough	Fortified maize
Lysine	0.5	4.2
Tryptophan	0.1	0.86

Values are means of three replicates ± SD.

Figure 5

Table 5: Organoleptic characteristic and acceptability of fortified maize dough from bambara-nut

	Means scores ^{a,b}				
Supplement No.	Color	Texture	Flavor	Taste	Overall
1	6.8	6.8	6.8	7.0	6.9
2	6.6	7.0	7.0	6.8	6.9
3	6.3	6.1	6.6	7.0	6.5
4	6.5	6.1	6.1	6.4	6.3
5	6.5	6.3	6.0	6.3	6.3
6	6.3	6.0	5.5	6.1	6.0
7	6.2	6.1	6.3	6.3	6.3
8	6.3	6.0	6.1	5.5	6.0

^{a}Means are scores of 10 Judges and not significantly ($p > 0.05$) different between supplementary foods.

^{b}Scales used for judging:

8 = like extremely
7 = like very much
6 = like moderately
5 = like slightly
4 = dislike slightly
3 = dislike moderately
2 = dislike very much
1 = dislike extremely

The scores for color, texture, flavour (aroma), taste and overall acceptability of the fortified products are given above

DISCUSSION

The formulated weaning foods had pH values drop from about 6.4 to 3.5 with the titratable acidity (TA) increasing from 2.6 to 10.6 mg NaOH/g sample for both raw and boiled bambara nut. The pH of the unfortified products also decreased from about 6.5 to 3.6 and titratable acidity increased from 1.3 to 6.5 mg NaOH/g sample with 0% bambara-nut addition. The acidic nature of the product could be due to the production of lactic acid produced by microorganism associated with maize dough fermentation. It has also been reported that microorganisms involved in fermentation affect the nutritional level of fermented food [11,26]. In this study bambara-nut fortification increased the acid production. This was also probably due to availability of more nutrients for microbial proliferation and enhanced metabolic activities. This early production of carboxylic acid and the consequent rise in TA is important to avoid proliferation of undesirable organisms resulting in poor fermentation

The nutrient component Fat and Ash content increase with increased level of Bambara-nut fortification. It is also clear from the result that all the fortified foods were nutritious since the products provided one third of the Recommended Dietary Allowance (RDA) with respect to protein (10 to 12%) as recommended by World Health Organization [27] and National Institute of Nutrition [28] for children and rural mothers. The proximate characteristic of all fortified foods were within the range reported for weaning and supplementary food [24,27]. Shulk et al [29] and Chandrasekhara et al [18] reported protein in weaning mixture developed based on soybeans cereals and malted ragi and roasted groundnut. In this study protein content increased from 10.1% to 16.4%. Fermented maize dough samples fortified with processed boiled bambara-nuts were found to contain more protein than samples fortified with whole raw bambara nut.

The brabender viscoamylogrph as presented in Table 3 showed useful information on the hot and cold paste viscosity of starch based food . Valued obtain from gelatinization temperature viscosity at 95°C, Peak Viscocity, Viscosity at 50°C were similar for traditional unfortified maize dough and samples of dough fortified with raw bambara-nut especially at 10% replacement level. Starch stability was slightly reduced in the Bambara nut fortified samples indicating a slightly greater breakdown of the paste during cooking. Little or no viscosity changes were therefore expected when raw bambara-nuts were incorporated in soaked maize before milling and fermentation to obtain a bambara-fortified product. On the contrary, fortification of maize with boiled bambara-nut before milling and fermentation reduced peak viscosity (from 310 to 250 BU, in the case of 20% fortification) and viscosity at 95°C. Starch stability, however was improved with increase in level of fortification.

All the blends produced from fermented raw and boiled bambara-nut-maize dough were found to display desirable starch stability and consistent gelling tendency. However, only the blend boiled bambara-nut-maize dough fall within acceptable limits as observed by similar workers [15]. This blend could be used as a low-cooked viscosity weaning food which could potentially increase the food intake of the child. The others due to its high gelatinization index could be recommended only as food for adults

In Table 4, there was progressive increase in the lysine and tryptophan content in the fortified maize dough. Lysine and tryptophan are very important amino acid the body required for good health, but unfortunately Nigeria cereal grains as earlier reported [21,23] lack these essential amino acids. The incorporation of bambara nut to maize dough increased these amino-acid content (Table 4).

In general bambara-nut fortification improved the protein quality through the mutual complementation of the limiting essential acids in the blends components (Lysine and tryptophan in maize) fortification with boiled bambara-nut produced blends with slight but significantly ($P<0.05$) greater conentration of most of the essential amino acids than raw bambara nut.

The trained panelists accepted all fortified foods as shown in Table 5. Mean scores of all eight supplements for the organoleptic characteristics were not significantly ($P>0.05$) different between supplements. This shows that, although different combinations of cereals/maize and legumes/bambara-nut, were used to prepare the food mixtures all the supplements were liked by the trained panelists. This shows that although there were slight variations in taste, flavour and overall acceptability, all the fortified foods were like very much. None of the panelists developed any side effects like diarrhea and emesis after consuming the preparations.

In conclusion, fortified foods prepared with bambara-nut and maize was nutritious since the products conformed to specifications with respect to protein as recommended. It has special importance for use in weaning foods, catch-up growth and improving birthweights.

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