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Research Article

Nutritional Quality and Physical Characteristics of Biscuit Produced from Fermented Bambara Nut and Wheat Flour Blends

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Abstract

Bambara nut (*Vigna subterrenean*) is a cheap source of leguminous protein that can be used as a good substitute for relatively expensive animal protein to reduce malnutrition in developing countries. Biscuit was produced from blends of wheat flour and fermented bambara nut flour at different ratios of 100:0, 90:10, 80:20, 70:30, 60:40 and 50:50 (wheat flour; fermented bambara nut flour) respectively. Based on the proximate composition of the biscuit, the protein content of biscuit made from the flour mixes was higher than protein content of biscuit made with 100% wheat flour. The moisture content of the biscuit ranged from 2.87 - 5.40%. The initial moisture content in all samples were within the acceptable level. Also the other components of starch and reducing sugar were in the ranges of 60.29 and 63.93%, and 2.74 and 4.43%. Sensory data indicated that the fermented bambara nut biscuit with up to 30% was acceptable, while additional fermented bambara nut resulted in a decreased mean score for overall acceptability. Thickness, diameter and spread ratio of the biscuit ranged from 230.33 - 285.67mm, 29.00 - 36.00 mm and 61.70 - 89.19%, respectively. The potentials of fermented bambara nut in biscuit production was established thereby reducing the pressure in using only wheat for baking biscuit.

Keywords: Fermented Bambara Nut; Biscuit; Nutritional Quality; Composite Flours

Introduction

Biscuit is defined as a small thin crisp cake made from dough [1]. It can be distinguished from other baked products due to its low moisture content of less than 5%, which makes them have a low risk of microbial spoilage and long shelf life [2]. Wheat flour which is the main ingredient used to produce biscuit cannot be grown commercially in many regions of the world due to various climatic condition. Therefore, the industry can only survive by utilizing available local grains which can be substituted with wheat in food product without adversely altering the quality of the product. Composite flour technology has been used as a means for extending scarce supplies of wheat or corn used in the production baked products [3]. In selecting the components to be used in composite flour blends, the materials should preferably be readily available, culturally acceptable and provide increased nutritional potential. Composite flour has the added advantage of improving the nutrient value of biscuits and other bakery products especially when cereals are blended with legumes e.g bambara nut. In countries where malnutrition poses a serious problem especially among children, Composite flours are advantageous because it supplement the deficiencies thereby reducing malnutrition in infants and adults.

Bambara nuts are edible seed from the Leguminosae family [4]. It is a promising crop which needs more awareness as a food. As a legume, bambara nut is high in protein that play important role in human nutrition which makes the crop an excellent source of supplementing proteins in the diet. Bambara nut is highly nutritive in vitamin and mineral contents like iron, phosphorous and calcium. It also has a high content of crude fibre and high level of sulphur containing amino acids which are limited in cereals [3]. Bambara nut are grossly underutilized. Therefore, with the ban on importation of wheat used for baking in confectionery industries. It is hoped that indigenous crop such as bambara nut will be used as substitutes for imported ones.

Fermentation is an age long process of processing cereals and legumes which not only modifies some physical characteristics of the grains but also increases the levels of nutrients, digestibility and bioavailability as well as decreases the level of antinutrients in food [5]. Fermentation process has helped in the development of several food products including biscuits with an improvement in flavours, textures and nutritive properties of the foods.

This work therefore seeks to produce biscuit from flour blends of wheat-fermented bambara nut with the aim of producing products of high nutritional quality and the optimum level of bambara nut flour substitution that would give an acceptable biscuit using sensory parameters

Materials and Methods

Materials used for cookie preparation

Bambara nuts (*Vigna subterrenean*), Golden penny wheat flour and other ingredients used in preparation of biscuits were obtained from a local market in Abeokuta, Ogun State, Nigeria.

Methods

Preparation of the flour samples

Bambara nut were fermented using the method of Frazier and Westholf [6]. Bambara nut was cleaned and washed. It was steeped in water for 24 h and dehulled. The steeped beans was boiled in the steeped water for 15 mins, drained and spread out to dry a little at room temperature. Dehulled Bambara nut were poured into the perforated polythene bag and an appropriate volume of 2 ml of spore suspension of *R. oligosporous* was carefully added, thoroughly mixed and tightly sealed. They were incubated at 32^0C for periods of time ranging between 0 and 48 h at regular intervals of 24 h. The seeds were dried in an oven maintained at 55^0C for 24 h, cooled and finely ground using hammer mill to obtain a fine particle flour. The flour samples were kept in airtight containers for further analysis.

Biscuit preparation

The flour used for biscuit production were from blends of fermented bambara nut flour and wheat flour using 0, 10, 20, 30, 40 and 50% bambara nut flour respectively. The 100% wheat flour biscuit was used as the control sample. The method used for the preparation of dough was the creaming method where fat and sugar were creamed together using electric mixer at medium speed for 5 min. Baking powder and milk were added and mixed until dough was well mixed. The dough was manually kneaded to ensure uniformity. The dough was rolled using a roller and cut into round shapes using a cutter. Shaped dough pieces were placed into a greased pan and baked in the oven at 200^0C for 15min. The baked biscuits were placed on a rack for 30 min to cool before packaging.

Analyses

Chemical analyses of biscuit

Protein content was determined using the micro – Kjeldahl method as described AOAC methods [7]. Starch, reducing sugar and moisture contents were also determined according to the methods described by AOAC methods [7]. Analyses were performed in triplicates.

Sensory evaluation

Sensory evaluation of biscuit samples from various flour blends was conducted using a 25 member semi-trained panellists drawn from the staff of Babock University, Ilisan, Ogun State, Nigeria. Biscuits were evaluated for colour, crispiness, crumbliness, hardness, aroma, taste and overall acceptability using a nine-point hedonic scale of 9 = liked extremely down to I = disliked extremely as described by [8].

Physical analysis

Diameter and thickness were measured with a vernier calliper at two different places in each biscuit and the average was calculated. The spread ratio was calculated using the formula: diameter of biscuit divided by height of biscuit [9].

Statistical analysis

The data obtained from study and sensory evaluation was subjected to descriptive and inferential statistics and significance established at $p < 0.05$.

Result and Discussion

Chemical components of wheat/fermented bambara nut biscuit

The result of the chemical analysis of the biscuit samples is shown in table 1. The biscuit produced from flour mixes ranged from 4.61 - 8.00%. Sample B5 had the highest while sample A had the lowest protein content. It was observed that the protein content of the biscuit produced from the flour mixes was higher than that of wheat flour (4.61%). The result of the product reveals that protein increased due to fermentation process. The high protein content of food legumes generally constitutes the natural protein supplements to staple diet. The moisture content of the biscuit samples ranged from 2.95 - 5.71% on dry basis. Sample A had the highest moisture content. Even though there was a significant difference between moisture content of the samples ($p < 0.05$), the initial moisture contents in all samples were within the acceptable level. The reducing sugar content of the biscuit ranged from 2.74 - 4.43%. Sample B2 had the highest while sample C3 had the lowest. There is a slightly increase in reducing sugar during fermentation. The increased level of reducing sugar is a reflection of the activities of amylase and sucrose in the fermenting seeds [10]. Starch content varies from 60.29 - 64.99%. Biscuits are high in sugar and low in moisture. These factors inhibit starch gelatinization which has little contribution to the structure of the finished product.

Sensory evaluation of biscuits prepared from composite flour

The result of the sensory evaluation is shown in table 2. Mean quality score of the colour of the biscuits ranged from 3.00 - 6.60. It is evident from the results that biscuits prepared from sample A

	Sample Protein (%)	Reducing sugar (%)	Starch (%)	Moisture (%)
A	4.61 ± 1.00^{a}	2.93 ± 1.00^{c}	60.50 ± 1.00^{b}	5.71 ± 1.00^{j}
B_1	5.96 ± 1.00^{d}	3.72 ± 1.00^{g}	62.62 ± 1.00^{g}	3.44 ± 1.00^{e}
B_2	6.30 ± 0.10^{f}	4.43 ± 0.84^{i}	63.91 ± 1.00^{i}	3.09 ± 1.00^{c}
B_3	7.17 ± 1.00^{j}	4.43 ± 0.84^{i}	62.07 ± 1.00^{f}	4.02 ± 1.00^{f}
B_4	6.63 ± 1.00^{i}	3.33 ± 1.00^{e}	61.99 ± 1.00^{e}	4.60 ± 1.00^{h}
B_5	8.00 ± 1.00^{k}	3.22 ± 0.68^{d}	61.24 ± 1.00^{d}	4.96 ± 1.00^{i}
C_1	5.51 ± 1.00^{b}	3.53 ± 1.00^{f}	63.15 ± 1.00^{h}	3.01 ± 1.00^{b}
C_2	6.57 ± 1.00^{h}	3.23 ± 0.68^{d}	64.99 ± 1.00^{k}	2.95 ± 1.00^{a}
C_3	6.21 ± 0.10^{e}	2.74 ± 1.00^{a}	60.29 ± 1.00^{a}	3.44 ± 1.00^{e}
C_4	5.70 ± 0.75^{c}	2.81 ± 1.00^{b}	60.74 ± 1.00^{c}	4.09 ± 1.00^{g}
C_5	6.44 ± 1.00^{g}	3.79 ± 1.00^{h}	63.93 ± 1.00^{j}	3.19 ± 1.00^{d}

Table 1: Chemical Components of Wheat/Fermented Bambara nut Biscuit.

All values are means of triplicate determinations ± standard deviation (SD). All values with different superscripts in the same column are significantly different at $p< 0.05$.

Key: Sample A = 100% wheat flour

Sample B_1 = 90:10%, wheat flour + 24h fermented bambara nut flour

Sample B_2 = 80:20%, wheat flour + 24h fermented bambara nut flour

Sample B_3= 70:30%, wheat flour + 24h fermented bambara nut flour

Sample B_4 = 60:40%, wheat flour + 24h fermented bambara nut flour

Sample B_5 = 50:50%, wheat flour + 24h fermented bambara nut flour

Sample C_1 = 90:10%, wheat flour + 48h fermented bambara nut flour

Sample C_2 = 80:20%, wheat flour + 48h fermented bambara nut flour

Sample C_3 = 70:30%, wheat flour + 48h fermented bambara nut flour

Sample C_4 = 60:40%, wheat flour + 48h fermented bambara nut flour

Sample C_5 = 50:50%, wheat flour + 48h fermented bambara nut flour

Sample	Colour	Crispiness	Crumbliness	Aroma	Taste Acceptability	Overall
A	6.60 ± 1.00^{k}	6.80 ± 1.00^{i}	6.90 ± 1.00^{i}	6.60 ± 1.00^{j}	6.70 ± 1.00^{i}	6.70 ± 1.00^{h}
B_1	5.30 ± 1.00^{g}	6.30 ± 1.00^{h}	6.20 ± 1.00^{h}	5.90 ± 1.00^{i}	6.10 ± 1.00^{h}	5.60 ± 0.39^{g}
B_2	5.20 ± 1.00^{g}	5.20 ± 1.00^{f}	5.70 ± 1.00^{f}	5.70 ± 1.00^{h}	5.80 ± 1.00^{g}	5.60 ± 0.39^{g}
B_3	4.90 ± 1.00^{f}	4.70 ± 1.00^{e}	4.80 ± 1.00^{d}	5.30 ± 1.00^{e}	5.10 ± 1.00^{e}	5.50 ± 1.00^{f}
B_4	6.50 ± 1.00^{j}	5.70 ± 1.00^{g}	5.40 ± 1.00^{e}	5.00 ± 1.00^{b}	4.90 ± 1.00^{c}	5.40 ± 1.00^{e}
B_5	5.50 ± 1.00^{i}	5.20 ± 1.00^{f}	5.80 ± 1.00^{g}	5.50 ± 1.00^{g}	5.40 ± 1.00^{f}	5.40 ± 1.00^{e}
C_1	3.80 ± 1.00^{c}	4.10 ± 1.00^{c}	3.50 ± 0.41^{a}	5.00 ± 1.00^{b}	5.00 ± 1.00^{d}	4.80 ± 1.00^{d}
C_2	3.10 ± 1.00^{b}	4.70 ± 1.00^{c}	3.50 ± 0.41^{a}	5.40 ± 1.00^{f}	4.00 ± 0.42^{a}	4.20 ± 1.00^{b}
C_3	4.80 ± 1.00^{e}	4.40 ± 1.00^{d}	4.40 ± 1.00^{c}	5.20 ± 1.00^{d}	4.90 ± 1.00^{c}	4.80 ± 1.00^{d}
C_4	4.00 ± 1.00^{d}	3.40 ± 1.00^{b}	4.00 ± 1.00^{b}	5.10 ± 1.00^{c}	4.20 ± 1.00^{b}	4.30 ± 1.00^{c}
C_5	3.00 ± 1.00^{a}	2.90 ± 1.00^{a}	3.50 ± 0.41^{a}	2.20 ± 1.00^{a}	4.00 ± 0.42^{a}	4.00 ± 1.00^{a}

Table 2: Sensory Attributes of Biscuits with Bambara nut Flour Blend.

All values are means of triplicate determinations ± standard deviation (SD). All values with different superscripts in the same column are significantly different at $p< 0.05$.

Key: Sample A = 100% wheat flour

Sample B_1 = 90:10%, wheat flour + 24h fermented bambara nut flour

Sample B_2 = 80:20%, wheat flour + 24h fermented bambara nut flour

Sample B_3= 70:30%, wheat flour + 24h fermented bambara nut flour

Sample B_4 = 60:40%, wheat flour + 24h fermented bambara nut flour

Sample B_5 = 50:50%, wheat flour + 24h fermented bambara nut flour

Sample C_1 = 90:10%, wheat flour + 48h fermented bambara nut flour

Sample C_2 = 80:20%, wheat flour + 48h fermented bambara nut flour

Sample C_3 = 70:30%, wheat flour + 48h fermented bambara nut flour

Sample C_4 = 60:40%, wheat flour + 48h fermented bambara nut flour

Sample C_5 = 50:50%, wheat flour + 48h fermented bambara nut flour

had the highest value of 6.60 while biscuits prepared from C_5 had the lowest value of 3.00. Judges disliked the biscuits prepared from C_5 with respect to colour because the seed used for the production of flour were fermented for a longer period of time. Darkness in colour of the biscuits was observed as the level of the supplementation of the bambara nut flour increased in the wheat flour. From the result, Sample A (control) had the highest value (6.80) for the quality score of the biscuits compared to the biscuit produced from flour mixes. This could be attributed to the lower gluten content of bambara nut since gluten is responsible for the extensibility of the dough. Based on Aroma, the judges accepted biscuits from all the treatments of the composite flour containing bambara nut flour except sample C_5. This effect could be as a result of longer fermentation period slight aroma of the beamy off flavour that was noticed. Since aroma is the main criterion for determining factor in consumers' acceptance of biscuit it can be deduced that the biscuit is accepted up to 70% substitution with bambara nut. The results show that supplementation significantly affected the overall acceptability of the biscuits. Maximum score (6.70) by biscuits prepared from sample A (control) while minimum scores (4.00) were recorded from the biscuits prepared from C_5. Biscuits prepared from C_5 were rejected by judges with respect to overall acceptability. It could be recommended that up to 24 h fermentation period and 70% bambara nut flour be used in the substitution of wheat flour in the production of biscuits.

Physical evaluation of biscuits produced from wheat-bambara nut flour mixes

The result obtained from the physical evaluation of the biscuit samples showed that the thickness, diameter and spread ratio of the biscuits prepared from the composite flour varied significantly ($p < 0.05$) between the treatments. The thickness and diameter of the biscuits showed gradual increase as the level of bambara nut flour replacement from sample B_1- B_5 and C_1 - C_5. The increase in diameter could be due to the reduction in gluten content (elasticity) with increase in bambara nut flour. The results showed that the spread factor gradually decrease as the level of bambara nut flour replacement increased. This can be attributed probably to the effects of composite flours that form aggregates with increased numbers of hydrophilic sites found within the oligosaccharides, polysaccharides and protein which compete for the limited free water in cookies dough (Hallen., *et al.* 2004). These results obtained for the spread factor were in close agreement with Awan., *et al.* (1995) who reported that spread factor, like that of width, decreased with increasing level of Mothbean flour supplementation.

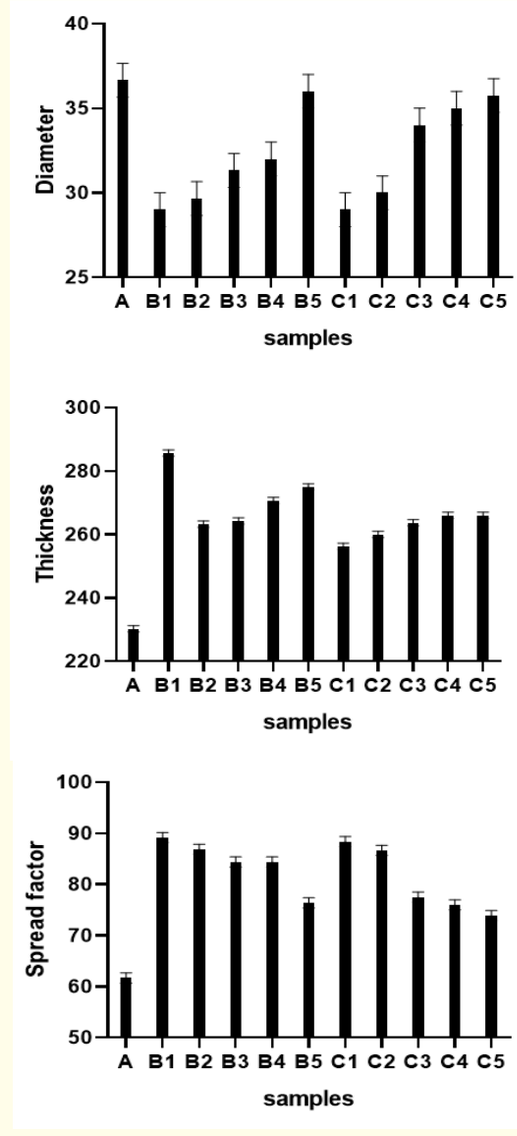

Figure 1:

Key: Sample A = 100% wheat flour

Sample B_1= 0:10%, wheat flour+24h fermented bambara nut flour

Sample B_2=80:20%, wheat flour+24h fermented bambara nut flour

Sample B_3=70:30%, wheat flour+24h fermented bambara nut flour

Sample B_4=60:40%, wheat flour+24h fermented bambara nut flour

Sample B_5=50:50%, wheat flour+24h fermented bambara nut flour

Sample C_1=90:10%, wheat flour+48h fermented bambara nut flour

Sample C_2=80:20%, wheat flour+48h fermented bambara nut flour

Sample C_3=70:30%, wheat flour+48h fermented bambara nut flour

Sample C_4=60:40%, wheat flour+48h fermented bambara nut flour

Sample C_5=50:50%, wheat flour+48h fermented bambara nut flour

Conclusion

This study has shown that fermentation process generally improved the nutritional quality of biscuit produced from the composite flour. The increasing trend in the protein content of the produced biscuits as the level of substitution increases could be used in eradicating malnutrition problem among the children. This study has also opened new possibilities of incorporating fermented bambara nut flour into starchy diets which invariably will lead to expansion in the utilization of fermented bambara nut flour which could reduce the importation rate of wheat flour thereby increasing savings in foreign exchange for countries that rely heavily on the importation of wheat.

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