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QUALITY EVALUATION OF HARD DOUGH BISCUIT PRODUCED FROM FERMENTED BAMBARA GROUNDNUT TEMPEH AND WHEAT FLOUR MIXES

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Abstract

There is growing interest in fortifying wheat flour with high lysine material, such as bambara groundnut flour, to improve the essential amino acid balance of baked food products. Bambara groundnut is not adequately utilized in Nigeria. In this study, wheat flour in a standard biscuit formulation was partially or fully substituted with fermented bambara groundnut tempeh flour at six levels: 0%, 5%, 10%, 25%, 40% and 100%. The composite flours were analyzed for physico-chemical properties such as pH, water absorption capacity, bulk density, pasting characteristics and reconstitution index. Biscuit samples were then evaluated for chemical composition, texture, microbial characteristics and sensory properties. Increasing levels of fermented bambara tempeh flour in the mix resulted in changed flour characteristics. Incorporation of fermented bambara tempeh flour exerted positive influence on the nutritional status of the resultant biscuit products based on the level of substitution. Sensory evaluation tests revealed that biscuit sample prepared from wheat flour substituted with 5% fermented bambara groundnut tempeh flour consistently had the highest rating in terms of all the quality attributes assessed. Biscuit that closely followed this was that from pure wheat flour while rating for other samples gradually decreased with increasing level of substitution with bambara groundnut tempeh flour. All the biscuit samples were however acceptable though at varying degrees depending on the level of bambara flour incorporation.

Introduction

Biscuit is one of the most popularly consumed snacks in Nigeria as in most other countries of the world. Because of the long shelf life of biscuits, they are considered useful for nutritional enrichment or fortification in feeding programmes. Considerable research attention is being given to the fortifying of wheat flour with high lysine material, such as legume flour, to enhance the essential amino acid balance of baked food products (Hallen et al., 2004). Acceptable doughnut and biscuit were produced from flour blends of wheat, maize and pigeon pea (Echendu et al., 2004). Another recent study by Hallen et al. (2004) demonstrated the feasibility of incorporating pretreated cowpea flour into bread-making. Acceptable results have been reported for biscuit supplemented with roasted cowpea (Okafor et al., 2005). Besides, FAO (1970) reported that replacing wheat with 20 percent non-wheat flour for the manufacture of baked goods would save money for poor countries. Wheat substitution with locally available raw materials such as legumes would definitely encourage agriculture, widen the utilization of local raw materials, reduce heavy dependency on wheat importation and consequently conserve the foreign reserves of poor countries. Recently the Nigerian Federal Government approved the inclusion of 10–20% cassava flour into baking flour by industry.

Bambara groundnut, a starch-protein seed with low fat content, because of its availability, low cost and high protein quality can be used to enrich wheat and derivative products such as biscuits. Earlier reports have established the potential of bambara in baked products. Studies have also shown that pretreatments such as germination and/or fermentation enhance the nutritional quality of such raw materials (Whyte, 1973; Svanberg, 1999; Ade-Omowaye et al., 2003). Fermentation being a relatively efficient and low energy preservation method, which increases the shelf life and decreases the need for refrigeration or other forms of cost-intensive food preservation methods, is highly appropriate for application in developing countries such as Nigeria. Ample evidence abounds to the effect that fermented foods play an important role in providing food security, enhancing livelihood and improving the nutritional and social well-being of millions of people around the developing world particularly for the marginalized and highly vulnerable groups. As a food source, bambara groundnut has not been adequately utilized in Nigeria. Hence, this promising indigenous crop if fermented could find wide application as an enrichment ingredient in various food formulations such as in baked goods. Fermented bambara groundnut has been demonstrated to result in nutritional enhancement of products upon its incorporation (Nwanna et al., 2005). For these reasons, the potential of incorporating fermented bambara groundnut tempeh as an ingredient in biscuit- making is examined in this study by partially or fully substituting wheat flour in a standard biscuit formulation with fermented bambara groundnut tempeh flour at six levels.

Materials and Methods

Bambara groundnuts were procured locally while soft wheat flour and the mould *Rhizopus Oligosporus* were, respectively, obtained from Nigerian Flour Mills and Indonesian embassy in Lagos. Other ingredients for biscuit-making were procured from a supermarket in Ogbomoso in Nigeria.

Preparation of Fermented Bambara Groundnut

Fermented bambara groundnut tempeh meal was prepared by a slight modification of the method reported by Frazier & Westhoff (1991) for tempeh production. Cleaned bambara groundnuts (1500g) were steeped in water at room temperature (30°C) for 24hr at a ratio of 1:6 (w/v). The steeped nuts were boiled in the steep water for 1hr, drained and cooled to room temperature. The cooled bambara nuts were then transferred into sterile perforated polythene bag and an inoculum of *Rhizopus Oligosporus* sprinkled and thoroughly admixed with them. The plastic bag was sealed before incubation at 30°C for 28hr. At the end of incubation the matted sample was blanched for 20min and then sliced into smaller slices. The slices were drained and dried in an oven at a temperature of 55°C for 24hr, cooled before milling in a plate mill to obtain fermented bambara groundnut tempeh flour. The flour was packed in sealed polythene bags, sealed and kept in the freezer until required for analysis and use.

Formulation of Wheat Flour and Fermented Bambara Groundnut Tempeh Flour Mixes and Biscuit Production.

Wheat flour was partially or fully substituted with fermented bambara groundnut tempeh flour at six levels as flows: 0%, 5%, 10%, 25%, 40% and 100% to obtain corresponding composite flour mixes. For biscuit-making, all other ingredients such as fat, egg, sugar, milk and water were added to the composite flour mixes according to the formulation of Peter (1971), mixed, moulded into desired shapes and sizes and baked at 230°C for 15min (AACC, 1971).

Evaluation of Physico-Chemical Properties of the Flour Mixes

The composite flour samples were evaluated for pH, titratable acidity, water absorption capacity, reconstitution index and pasting viscosity according to standard methods (AOAC, 1990; Quinn and Paton, 1979; Egounlety, 1994; Akanbi et al., 2003).

Quality Evaluation of Biscuit Samples

Proximate composition, phosphorus, calcium, iron, thiamine, riboflavin and niacin contents were determined for the biscuit samples according to standard analytical methods (AOAC, 1990). The method described by Ade-Omowaye et al. (2003) was adapted for the measurement of biscuit strength using a cone penetrometer (Stanhope and Sepa U.K.). By this method, biscuit strength is recorded as the penetration depth of the cone head with a time-span of 12s.

Microbial Analysis

Total viable coliform, yeast and mould counts were determined according to the procedure reported by James (1992).

Sensory Evaluation

Biscuit samples were presented to 10 panelists who were randomly selected. The biscuit samples were assessed for appearance, colour, flavour, texture, taste and overall acceptability using a 7 point hedonic scale where 7 = like extremely and 1= dislike extremely. The scores obtained were subjected to analysis of variance at 5% level of significance using Duncan method (1955).

Results and Discussion

Physico-Chemical Properties of the Composite Flour Mixes

The result of the physico-chemical properties of the various composite flour mixes are presented in Table 1. The pH of the mixes was found to range from 5.65 to 6.26 with unsubstituted wheat flour having the least value and 100% fermented bambara tempeh flour having the highest value. The titratable acidity mimicked the pH pattern observed with values ranging from 0.28 to 0.22% lactic acid. The result suggests that the fermented bambara groundnut flour was less acidic in character. A similar observation was reported by Amadi et al. (1999) in which fermentation of bambara nuts with *Rhizopus* strains resulted in increased pH.

The water absorption capacity (WAC) was observed to show an increasing trend with increase in the level of wheat flour substitution (Table 1). The WAC values ranged from 58.04 to 75.20% with pure wheat flour having the least value and 100% fermented bambara tempeh flour having the highest value. This result suggests that the yield of biscuits from the composite flours may be significantly higher than that of pure wheat flour. This observation agrees with earlier studies that indicated enhanced WAC patterns for fermented soybean composite flour (Olanipekun, 2004).

There was approximately 2 to 18% increase in bulk density with 5 to 100% wheat flour substitution. Reconstitution index also followed the same trend with approximately 1 to 13% improvement as the level of substitution increased.

Pasting Characteristics

The pasting characteristics, which include peak viscosity, breakdown viscosity and final viscosity, were observed to exhibit decreasing trend with increase in the level of wheat flour substitution (Table 2). The peak viscosity decreased from 311.58 to 221.17 RVU (Rapid Visco-Analyzer Unit) with unsubstituted wheat flour having the highest value and 100% fermented bambara flour having the least value. The pasting temperature varied between 65.10 and 64.00°C while the time taken to reach peak viscosity was between 5.54 and 4.27min. This finding suggests reduced starch content in the composite flour as the level of wheat flour substitution increased. The result further shows that increasing levels of fermented bambara tempeh flour in a mix altered flour characteristics in significant way.

Chemical Composition of Biscuits from the Various Mixes

The summary of the chemical composition of biscuit produced from wheat and fermented bambara groundnut composite flour mixes is presented in Table 3. Increasing levels of fermented bambara groundnut resulted in enhanced quality characteristics such as the proximate composition, mineral and vitamin contents of the biscuit. The moisture content of the biscuit samples from the various mixes was generally low (3.81 to 6.06%) which is typical of biscuit. Starch content of the various samples showed a reducing pattern depending on the level of wheat flour substitution. However, the information in Table 3 revealed approximately 2 to 40%, 2 to 18%, 4 to 42% and 8 to 20% enhancement in protein, fat, ash and crude fiber contents, respectively, of the biscuit samples as compared to the control; i.e. biscuit produced from pure wheat flour, depending on the level of fermented bambara groundnut flour in the formulation. The same trend was observed with mineral and vitamin status of biscuits produced from the composite flours. Analysis of the data showed about 7 to 74%, 8 to 43% and 4 to 60% increases in phosphorus, calcium and iron contents, respectively, depending on the substitution level. The highest improvement (25 to 225%) was recorded in the level of riboflavin content of the produced biscuit. Improvements recorded in respect of other vitamins were: thiamin with 5 to 21% and niacin with 2 to 9% enhancement over biscuit without the fermented bambara groundnut. These observations are not unexpected as bambara groundnut has been reported to be a rich source of essential nutrients. The result of this study is consistent with the earlier report of Steinkraus (1992), which demonstrated enhanced vitamin content after fermentation of pulses. It may therefore be suggested from these findings that inclusion of fermented bambara groundnut in the biscuit formulation resulted in enhanced nutritional status and the extent of enhancement depends on the substitution level.

A reducing trend (16.00 – 30.00mm) in the strength of the biscuit samples was noticed with increasing level of substitution. Information in Table 3 shows that biscuit from 100% fermented bambara groundnut had the greatest penetration depth (30.00 mm) among the samples indicating the lowest strength. Its low strength may be attributed to lack of gluten and presence of relatively high content of protein. Biscuit from pure wheat flour had a penetration depth of 16.00 mm.

Microbial Analysis

The observations from the microbial enumeration of the biscuits are presented in Table 4. Biscuit produced from pure fermented bambara groundnut had the highest total viable count (1.20×10^2 cfu/ml) while samples from pure wheat flour had the least count (0.18×10^2 cfu/ml). It is obvious that as the level of substitution increased the total viable counts also increased which might be an indication of the prevailing environmental condition during fermented bambara flour preparation and the indigenous microflora of the nuts which might have survived the processing conditions applied. No coliform bacteria was detected in all the samples indicating absence of feacal contamination, hence the samples were adjudged fit for human consumption. Biscuit from pure wheat flour had the least yeast count (0.07×10^2 cfu/ml) while samples prepared from composite flours had yeast counts ranging from 0.09 to 0.18×10^2 cfu/ml. No mould growth was discovered in all the samples signifying that the starter culture (*Rhizopus Oligosporus*) used in the preparation of fermented bambara groundnut was completely destroyed during processing

Sensory Evaluation of the Biscuit Samples

The result of sensory evaluation of the biscuit is presented in Table 5. Sensory evaluation tests revealed that biscuit samples prepared from wheat flour substituted with 5% fermented bambara groundnut flour consistently had the highest rating in terms of all the quality attributes assessed. Biscuits from pure wheat flour closely followed while ratings for other samples gradually decreased with increasing levels of substitution. There were no significant differences in the sensory mean scores recorded for biscuits from pure wheat flour and that substituted with 5 % fermented bambara groundnut flour. It could be deduced from this observation that wheat substitution with fermented bambara flour above 10% resulted in noticeable reduction in sensory properties although all the biscuit samples were acceptable but at varying degrees depending on the level of substitution.

Conclusion

The results of this study show that acceptable biscuit can be produced from wheat flour substituted with fermented bambara groundnut flour. Hence it can be concluded that addition of 10% fermented bambara groundnut flour into biscuit formulation would result in a product with enhanced nutritional value and satisfactory acceptability. In addition, biscuits produced from wheat and fermented bambara groundnut flour mixes could serve as a good alternative to those prepared from wheat and cassava flour mixes thus widening utilization the horizons of bambara nuts in Nigeria.

Table 1: Physico-chemical properties of wheat-fermented bambara groundnut mixes

Parameters	A	B	C	D	E	F
PH	5.65±0.00	5.68±0.00	5.76±0.00	5.95±0.00	6.00±0.00	6.26±0.00
Water absorption capacity (WAC) (%)	58.04±0.27	61.04±0.89	63.43±1.87	65.60±2.17	68.44±0.81	75.20±0.91
Titratable acidity (% lactic acid)	0.28±0.01	0.27±0.01	0.26±0.00	0.24±0.01	0.23±0.01	0.22±0.01
Bulk density (g/ml)	0.51±0.01	0.52±0.00	0.54±0.02	0.56±0.01	0.57±0.01	0.60±0.02
Reconstitution index	26.75±0.35	27.00±0.00	27.75±0.35	29.50±0.71	30.00±0.00	30.25±0.35

A – 100% WF; B – 95% WF, 5% FF; C – 90% WF, 10% FF; D – 75% WF, 25% FF; E – 60% WF, 40% FF; F – 100% FF. (WF – Wheat flour and FF- Fermented flour)

Table 2: Pasting characteristics of wheat-fermented bambara groundnut mixes

Parameters	A	B	C	D	E	F
Vp (RVU)	311.58	281.38	281.08	257.33	257.25	221.17
Tp (°C)	64.30	64.55	65.10	64.20	64.50	64.00
Mn (min)	5.34	5.54	5.51	5.28	5.08	4.27
Vr (RVU)	177.50	150.83	150.92	138.17	139.58	144.33
Vc (RVU)	302.75	276.26	273.50	270.00	267.50	241.58
Vp-Vr	134.08	130.50	130.17	119.17	117.67	76.83
Vc-Vr	98.75	119.17	151.83	103.42	127.92	151.83
Vc-Vp	-194.08	-162.18	-129.29	153.91	129.33	69.34

A – 100% WF; B – 95% WF, 5% FF; C – 90% WF, 10% FF; D – 75% WF, 25% FF; E – 60% WF, 40% FF; F – 100% FF. (WF – Wheat flour and FF- Fermented flour)

[Vp – Peak Viscosity, Tp – Pasting Temperature, Mn – Time to reach Peak Viscosity, Vr – Viscosity after 30 min holding at 95°C, Vc – Viscosity on cooling or Final Viscosity Vp-Vr = Breakdown or Stability of Starch, Vc-Vr = Gelatinization index or setback from trough, Vc-Vp = Setback from Peak].

Table 3: Chemical composition of biscuits produced from wheat and fermented bambara groundnut mixes

Nutrients	A	B	C	D	E	F
M.C (%)	3.81±0.02	4.81±0.02	5.76±0.02	6.02±0.08	6.04±0.07	6.06±0.08
Protein (%)	13.12±0.01	13.29±0.01	14.09±0.01	14.11±0.01	14.81±0.01	18.32±0.01
Fat (%)	16.41±0.01	16.67±0.01	16.68±0.01	16.80±0.01	18.18±0.01	19.40±0.01
Ash (%)	1.46±0.01	1.52±0.01	1.61±0.03	1.62±0.01	1.82±0.01	2.07±0.01
Crude Fiber (%)	0.81±0.01	0.87±0.01	0.91±0.02	0.93±0.01	0.94±0.01	0.96±0.01
Sugar (%)	22.37±0.08	18.43±0.01	18.37±0.05	18.38±0.03	17.45±0.06	13.13±0.03
Starch (%)	39.79±0.16	38.77±0.21	37.82±0.21	36.69±0.09	35.90±0.09	32.24±0.12
P (%)	0.15±0.00	0.16±0.00	0.19±0.00	0.21±0.00	0.23±0.00	0.26±0.00
Ca (%)	0.38±0.00	0.41±0.00	0.42±0.00	0.46±0.00	0.48±0.00	0.54±0.00
Fe (%)	0.054±0.00	0.056±0.00	0.069±0.00	0.071±0.00	0.073±0.00	0.086±0.00
Vit. B1 (mg/100g)	0.108±0.00	0.113±0.00	0.119±0.00	0.120±0.00	0.125±0.00	0.130±0.00
Vit. B2 (mg/100g)	0.08±0.01	0.10±0.02	0.17±0.03	0.20±0.01	0.23±0.03	0.26±0.05
Niacin (mg/100g)	1.37±0.00	1.39±0.00	1.42±0.00	1.43±0.00	1.45±0.00	1.49±0.00
Biscuit strength (mm)	16.00±0.04	19.25±0.05	20.15±0.05	23.10±0.06	26.75±0.05	30.00±0.04

A – 100% WF; B – 95% WF, 5% FF; C – 90% WF, 10% FF; D – 75% WF, 25% FF; E – 60% WF, 40% FF; F – 100% FF. (WF – Wheat flour and FF- Fermented flour)

Table 4: Microbial analysis of biscuit produced from wheat-fermented bambara groundnut mixes

Microbial growth	A	B	C	D	E	F
Total viable count (cfu/ml)	$0.18x10^2$	$0.32x10^2$	$0.36x10^2$	$0.42x10^2$	$0.59x10^2$	$1.20x10^2$
Coliform count (cfu/ml)	NIL	NIL	NIL	NIL	NIL	NIL
Yeast count (cfu/ml)	$0.18x10^2$	$0.18x10^2$	$0.18x10^2$	$0.18x10^2$	$0.18x10^2$	$0.18x10^2$
Mould count (cfu/ml)	NIL	NIL	NIL	NIL	NIL	NIL

A 100% WF; B – 95% WF, 5% FF; C – 90% WF, 10% FF; D – 75% WF, 25% FF; E – 60% WF, 40% FF; F – 100% FF. (WF – Wheat flour and FF- Fermented flour)

Table 5: Mean sensory scores for biscuit produced from wheat-fermented bambara groundnut mixes

Quality attributes	A	B	C	D	E	F
Taste	6.3a	6.4a	6.1a	5.9ab	5.5b	4.2c
Flavour	6.0a	6.3a	5.9ab	5.5bc	4.9cd	4.1d
Appearance	6.3a	6.4a	5.9b	6.0ab	6.0ab	5.0c
Colour	6.5a	6.5a	6.1a	6.1a	6.2a	5.3b
Texture	6.2a	6.5a	5.9ab	5.8ab	5.0bc	4.8c
Overall acceptability	6.1a	6.5a	6.0ab	5.7b	5.7b	4.3c

A – 100% WF; B – 95% WF, 5% FF; C – 90% WF, 10% FF; D – 75% WF, 25% FF; E – 60% WF, 40% FF; F – 100% FF. (WF Wheat flour and FF- Fermented flour).

References

AACC (1971). Wheat Chemistry and Technology. American Association of Cereal Chemist. Vol. 3, Minnesota, USA.

Ade-Omowaye, B.I.O., Olajide, J.O and Oluyomi, E.O. (2003). Pretreated sorghum cassava flour as a substitute for traditional Nigerian yam flour (elubo). Plant Foods for Human Nutrition, 58: 1-11.

Akanbi, C.T., Ade-Omowaye, B.I., Ojo, A. and Adeyemi, I.A (2003). Effect of processing factors on rheological properties of ogi. International Journal of Food Properties, 6(3): 1-14.

AOAC (1990). Official Method of analysis, 15th Ed., Association of Official Analytical Chemists. Washington D.C., Virginia, USA.

Duncan, D.B (1955). Multiple range and multiple F-test. Biometrics 11: 1-5.

Echendu, C.A, Onimawo, I.A and Adieze, S. (2004). Production and evaluation of doughnuts and biscuits from maize- pigeon pea flour blends. Nigerian Food Journal, 22: 147-153.

Egounlety, M. (1994). Production, properties and utilization of mold fermented food from soybean, cowpea and groundnut. Ph.D Thesis, Department of Food Technology, University of Ibadan, Nigeria.

FAO (1970). Amino acid content of foods and biological data on proteins. Food and Agriculture organisation of the United Nations, Rome, Italy.

Frazier, W.C and Westhoff, D.C. (1991). Food Microbiology. McGraw-Hill Publishing company, New York.

James, M and Jay, W. (1992). Modern Food Microbiology, 4th Edition, Chapman and Hall One, Penn. Plaza, New York.

Nwanna, L.C., Enujiugha, V.N., Oseni, A.O. and Nwanna, E.E. (2005). Possible effects of fungal fermentation on bambara groundnut (Vigna Subterranea (L) Verdc) as a feedstuff resource. Journal of Food Technology 3(4): 576-580.

Okafor, J.N.C., Okafor, G.I., Leelavathi, K., Bhagha, S. and Narashimha, H.V. (2005). Chemical composition of biscuits enriched with roasted cowpea (Vigna unguiculata). Proceedings of the 29th Annual NIFST conference, 11-13th October, Abakaliki. Nigeria.

Olanipekun, B.F. 2004. Studies on selected properties of soybean (*Glycine max.*) during fermentation with *Rhizophus oligosporus*. M.Tech Thesis, Department of Food Science and Engineering, Ladoke Akintola University of Technology, Ogbomoso, Nigeria.

Peter, R.W. (1971). Biscuit manufacture: Fundamentals of On-line Production. Elsevier Publishing Company Ltd., London.

Quinn, J.R and Paton, D (1979). A practical measurement of water hydration capacity of protein materials. Cereal Chemistry, 56: 38-39.

Steinkraus, K.H. (1992). Lactic acid fermentation. In: Applications of biotechnology to traditional fermented foods. Report of an adhoc panel of the board on Science and Technology for

International development, Nation Academy Press, Washington D.C, USA.

Svanberg, U. (1999). Improving nutritional quality and hygienic safety in supplementary foods for young children. Department of Food Science, Chalmers University of Technology, Gothenburg, Sweden.

Whyte, K.C. (1973). Complete Sprouting Cookbook. Troubador Press, San Francisco, CA, pp 14.