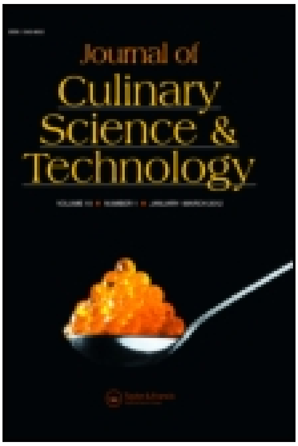

Journal of Culinary Science & Technology
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/wcsc20

Quality Assessment of Biscuits from Green Plantain (Musa paradisiaca) and African Breadfruit (Treculia africana) Flours

Olalekan J. Adebowale [a] , Adebola Ajayi [a] & Titilayo A. Ibikunle [a]
[a] Department of Food Technology , Federal Polytechnic , Ilaro , Ogun State , Nigeria

Journal of Culinary Science & Technology, 11:336–345, 2013

ISSN: 1542-8052 print/1542-8044 online
DOI: 10.1080/15428052.2013.798604

Quality Assessment of Biscuits from Green Plantain (*Musa paradisiaca*) and African Breadfruit (*Treculia africana*) Flours

OLALEKAN J. ADEBOWALE, ADEBOLA AJAYI, and TITILAYO A. IBIKUNLE
Department of Food Technology, Federal Polytechnic, Ilaro, Ogun State, Nigeria

A study was carried out on the utilization of matured green plantain and African breadfruit flour blends in biscuit production. The purpose of this study was to increase the dietary fiber content and enhance the nutritional value of the biscuits. The effects of substituting African breadfruit flour (ABF) with green plantain flour (GPF) on the physical, chemical, and sensory quality of the composite biscuits were evaluated. The protein, fat, moisture, ash, and breaking strength increased from 7.0% to 9.3%, 8.0% to 10.4%, 7.2% to 7.9% and 2150.2 g to 2220.5 g, respectively, with an increase in the percentage of added GPF, while there was decrease in the fracture or breaking strength of the biscuits. However, the average means of the sensory properties decreased from 2.6 to 2.2, 2.4 to 2.1, 3.0 to 2.4, and 3.0 to 2.4 for color, appearance, taste, and general acceptability, respectively, at $p = 0.05$ level of acceptance. Conversely, the mean score for texture increased from 2.5 to 3.4. The addition of GPF above 15% has a significant negative effect on the acceptance of the biscuit.

KEYWORDS *Biscuit, sensory quality, dietary fiber*

INTRODUCTION

Biscuits are ready-to-eat snacks whose nutritive value varies with the type of flour used. They possess several attractive features including wider consumption base, relatively long shelf life, more convenience, and good

Received 4 September 2012; accepted 22 January 2013.
Address correspondence to Olalekan J. Adebowale, Department of Food Technology, Federal Polytechnic, P.M.B. 50, Oja-Odan road, Ilaro, Ogun State, Nigeria. E-mail: jimiolalekan@yahoo.com

eating quality (Akubor, 2003). Owing to their long shelf life, biscuits are considered for many nutritional programs in different countries (Gandhi & Taimini, 2009). Snack foods including biscuits have received criticism due to their high levels of salt, sugar, and fat, which render them nutritionally damaging when eaten regularly in place of nutritional food (Fellows, 1997; Fernando, 1981). However, they can be made very nutritious when made from fruits, pulses, or cereals.

Economic development is normally accompanied by improvement in country food supply, which gradually eliminates the problem of nutrient deficiency. Therefore, the world is seeing a dramatic increase in the problem of over-nutrition, especially among children in many Western and Asian countries (Li Choo, 2007). According to WHO (2005), 300 million people all over the world are obese (BMI > 30) while 1 billion of the people are over-weight (BMI > 25). In Nigeria, however, the prevalence of obesity and chronic energy deficiency may not be properly documented but is clearly and regularly visible on the streets in major towns and cities.

The main reason for a higher-density diet is due to the increasing consumption of added sugar, fats, oils, and animal products, especially with increased fast food outlets and eateries in towns and cities and with the reduction in the intake of complex carbohydrates and dietary fiber. This over-nutrition diet is associated with diet-related chronic diseases, which account for more than half of the world's diseases like obesity, cardio-vascular disease, type-2 diabetes, and even constipation. In fact, WHO (2005) reported that 35 million people died from chronic disease and an estimated 388 million people might die from these diseases by 2025. As a result, an increase in the dietary fiber content in human diets is encouraged and advocated. This is because dietary fiber plays a major role in determining health and disease conditions by preventing colon cancer, coronary heart disease, obesity (weight management), diabetes (improving blood sugar control), and gastro-intestinal disorder (keeping the bowels regular).

The dependence on the use of wheat flour is one major constraint in biscuit production. The high demand of wheat flour, and the ability of the country to meet this demand, calls for research into alternative local sources of flour baking (Ayo et al., 2010) such as cassava, African breadfruit, plantain, acha, millet, sorghum, and many others. Composite flour from plantain, cassava, soybean, and other indigenous crops has been exploited in baking as well as snacks and complementary food formulations (Sanni & Eniola, 2004).

In Nigeria, the African breadfruit tree is widely distributed in the southern states, especially Imo, Enugu, Abraham, Edo, Delta, Cross-river, and Rivers. In such areas, it is either found growing wild or planted in home gardens. The tree is evergreen, grows up to 40 m high and produces 30–50 fruits annually with the weight of the fruit varying between 30 and 40 kg (Akubor et al., 2000).

Matured green bananas, especially plantains, are very rich in starch and are one of the promising substitutes for the starch industry. Bananas and plantains are an important staple in Central and West Africa, and they provide 60 million people with 25% of their calories (Mepba et al., 2007). Raw plantain starch is resistant to α-amylase and glucoamylase due to its high degree of crystalline intrinsic structure. Green plantain is also high in fiber content (18%), especially in hemicellulose (6.08%), which is higher than in most fruits and vegetables. The high fiber content, particularly insoluble fiber, can lower glycemic response by forming a physical barrier to enzymatic hydrolysis of starch. Apart from dietary fiber, plantains contain high amounts of essential minerals such as potassium, sodium, and various vitamins like A, B1, B2 and C. Bananas and plantains, when processed to flour or chips, could be possible food options for obese individuals. Due to this nutritional contribution by the green plantain, the application of plantain starch and flour in bakery and snack food products have been explored by many researchers (Mepba et al., 2007; Olaoye, Onilude, & Idowu, 2006; Olaoye, Onilude, & Oladoye, 2007; Giami, 2004). Many other researchers have conducted investigations using combinations of wheat with others materials and/or materials other than wheat flours: buckwheat (Baljeet et al., 2010); acha-beniseed (Ayo et al., 2010); sesame (Gandhi & Taimini, 2009); wheat-cashew (Aroyeun, 2009); acha-wheat-soy (Ayo et al., 2007); acha (Ayo & Nkama, 2003); cassava (Oyewole, Sanni, & Ogunjobi, 1996); wheat-African breadfruit (Agu et al., 2007) and wheat-cocoyam (Idowu et al., 1996).

The present study examines the physical properties, chemical composition, and acceptability of the composite biscuits produced from African breadfruit and matured green plantain flour mixtures. Hence, this work is aimed at improving the dietary intake of the populace, particularly the dietary fiber content, by supplementing the matured green plantain flour into the African bread ruit flour to produce the composite biscuits.

MATERIALS AND METHODS

Materials

Matured green plantain, African breadfruit, and eggs were purchased from Kuto market, Abeokuta, Ogun state, Nigeria. Salt (Dangote), sugar (Dangote), shortening (Blue Band margarine, Unilever, Nigeria), baking powder, and milk (Our Milk, Promasidor, Nigeria) used for this work were purchased from a supermarket in Ota, Ogun state.

Methods

Sample preparation

The plantain head was cut into separate bunches, which were subsequently de-fingered. The fingers were washed, peeled, cut into thin slices, and dipped in a 1.25% potassium metabisulphite solution (Mepba et al., 2007) for 3 minutes. The dipped slices were drained and dried in an aluminium foil oven (Gallenkamp hot box oven) with fan size 1 at 50°C for 15 hours. Dried plantain slices were milled (Attrition mill, Yamaha, Japan) into flour (GPF). The African breadfruit was equally sorted, washed, peeled, cut into thin slices, and washed with alum to remove the mucilage (slime), re-washed with clean water, drained and oven-dried (50°C for 15 hours). Dried African breadfruit chips were milled into flour (ABF). Both GPF and ABF were equally sieved through 60 mm size screen to obtain flour of uniform particle size and stored in an air-tight container until needed.

Product development

The GPF was supplemented (at 0, 5, 10, 15, and 20%) into the ABF to produce composite flour. Fat (shortening) and ground sugar were creamed in a mixer with a flat beater for 2 minutes at slow speed, and added to different proportions of composite flour, and mixed for 8 minutes with condiments (salt, baking powder, egg, and milk) to form the batter. The batter was rolled (on a stainless steel table), cut into shape (with a biscuit cutter) to desired diameter of 50 mm, and transferred to lightly greased aluminium baking trays. The biscuits were baked at 160°C for 20 minutes in a baking oven. The baked samples were cooled and stored in air-tight film for further analysis.

Physical analysis

The spread ration was determined by measuring the length and height of rows and columns, respectively, of five well-formed biscuits. Weight of biscuits was measured as the average value of three individual biscuit with digital weighing balance. The spread ratio was calculated as the average diameter divided by height or thickness (Gomez et al., 1997). Percentage spread was calculated by dividing the spread ratio of the supplemented biscuits with the spread ratio of the control biscuits and multiplying by 100.

The breaking strength was determined by adapting the procedure described by Ayo et al. (2010). A biscuit of known thickness was placed centrally between two parallel metal bars (3 cm apart). Weights were added to the biscuit until the biscuit snapped. The least weight that caused the breaking of the biscuit was regarded as the break strength of the biscuit.

Chemical analysis

The protein, fat, ash, and moisture contents of the samples were determined (AOAC, 1990). The digestible carbohydrate content was determined by simple difference [100 – (%protein + %fat + %ash + %moisture + %fiber)] and calorie value was estimated by multiplying the proportions of protein, fat, and digestible carbohydrates by their respective physiological values of 4, 9, and 4 kcal/g respectively and taking the sums of the products.

Sensory evaluation of the composite biscuits

Biscuit samples were analyzed for consumer acceptance and preference using 25 judges (students from the Federal Polytechnic, Ilaro community) randomly selected using a 9-point Hedonic scale (1 and 9 representing "extremely dislike" and "extremely like," respectively). Coded samples of the same size and temperature (25 ± 2°C) were served on a white plate of the same size to judges in each panel booth under fluorescent light. Quality characteristics assessed include color, texture, appearance, flavor, shape (symmetry), taste, and overall/general acceptance.

Statistical Analysis

The mean scores of duplicate data were differentiated using analysis of variance methods with the statistical package for social science (SPSS version 16.0, SPSS Inc., Chicago, IL, USA). Significance of the sensory scores was accepted at $p < 0.05$ level and means were separated using Duncan multiple range test.

RESULTS AND DISCUSSION

Results

Physical characteristics of composite biscuits

The physical properties of the composite biscuit samples from the ABF and GPF are shown in Table 1. The diameter of biscuits made from 5, 10, 15, and 20% GPF was found to be significantly lower than that of the control, 100% ABF ($p \leq 0.05$). The thickness of the biscuits ranged from 0.91 to 0.98 cm.

TABLE 1 Physical Properties of Composite Biscuits

Biscuit (% flour) ABF: GPF	Diameter (cm)	Thickness (cm)	Weight (g)	Spread ratio	% Spread	Fracture strength (g)
100: 0	5.30	0.91	12.6	5.82	100	2150.2
95: 5	4.90	0.95	14.2	5.16	88.7	2155.6
90: 10	4.90	0.96	15.2	5.10	87.6	2170.0
85: 15	4.80	0.96	16.1	5.00	85.9	2195.4
80: 20	4.40	0.98	17.1	4.49	77.1	2220.5

Mean values of triplicate sample ($p \leq 0.05$).
ABF = African breadfruit flour; GPF = Green plantain flour.

It increased with the incorporation of GPF. The weight of the composite biscuits increased as the concentration of GPF increased in the blends. The range of biscuit weight was 14.2 to 17.1 g, with a maximum value in 20% GPF biscuit. The fracture strength of control biscuit was found to be lowest (2150.2 g), and the highest value was observed in the 20% GPF biscuit (2220.5 g).

Chemical composition of composite biscuits

The chemical analysis of the five biscuit samples made from the blends of ABF and GPF shown in Table 2 indicated that the ash content decreased with increasing levels of GPF substitution 2.8 to 2.3%. Conversely, the moisture protein, fat, and fiber contents were on the increasing side as the proportions of GPF substitution increased. The moisture content of the biscuits increased from 7.3 to 7.9% with increasing GPF (0–20%). The protein content increased from 7.2 to 9.3% with the increase in the proportion (0–20%) addition of GPF. The calorific intake value shows a steady increase with increasing GPF, from 392.0 to 401.2 kcal with the 80:20 blend having the highest value.

Sensory evaluation of composite biscuits

The influence of the GPF addition to ABF on the sensory qualities and characteristics of the biscuits are shown in Table 3. The effect of incorporating GPF into ABF on the sensory qualities showed that with the addition of AGF there were significant differences ($p = 0.05$) in terms shape and flavor of the biscuits. The mean scores for taste, color, and appearance show no wide variation among their mean. However, acceptability of biscuit color was best for the 15% GPF addition; conversely it was poor with the 20% addition of GPF. The score for taste reduced marginally with the higher concentration of GPF addition. The biscuit formed with the addition of 15% GPF got the overall acceptability score of 3.0. Generally, the sample at 20% GPF addition was lowest in most of the evaluated attributes. The panelists also had their reservations for the fruity flavor of the biscuits, which could be improved upon.

TABLE 2 Proximate Composition of Composite Biscuits

Biscuit (% flour) ABF: GPF	moisture (%)	protein (%)	fat (%)	ash (%)	fibre (%)	carbohydrate (%)	calorific intake (Kcal)
100: 0	7.2	7.0	8.0	2.8	2.0	73.0	392.0
95: 5	7.5	7.2	9.2	2.7	2.1	71.3	396.8
90: 10	7.7	8.4	9.7	2.6	2.3	69.3	398.1
85: 15	7.8	8.5	9.8	2.5	2.4	69.0	398.2
80: 20	7.9	9.3	10.4	2.3	2.5	67.6	401.2

ABF = African bread fruit flour; GPF = Green plantain flour

TABLE 3 Sensory Qualities of African Breadfruit—Green Plantain Biscuits

Biscuit (% flour) ABF: GPF	color	texture	appearance	flavor	shape	taste	overall acceptability
100: 0	2.6[a]	2.5[c]	2.4[b]	2.6[b]	2.2[a]	3.0[a]	2.9[b]
95: 5	2.4[c]	2.9[a]	2.1[a]	2.1[a]	2.2[a]	3.1[ba]	2.4[a]
90: 10	2.7[ba]	2.9[a]	2.5[b]	2.6[b]	3.0[c]	3.1[ba]	2.8[b]
85: 15	2.6[a]	2.8[ba]	2.7[c]	3.2[c]	2.5[b]	3.0[a]	3.0[cb]
80: 20	2.2[c]	3.4[d]	2.1[a]	2.0[a]	1.7[d]	2.4[c]	2.4[a]

Scores are means of duplicate determinations.
Scores with the same superscript are not significantly different at 5% level of acceptance.
ABF = African bread fruit flour; GPF = Green plantain flour.

Discussion

Physical characteristics of composite biscuits

These increases in thickness have been attributed to the decrease in diameter (Baljeet et al., 2010). The changes in diameter and thickness were, however, reflected in the spread ratio as well as the percent spread of the biscuits. This decrease in spread ratio may be an indication of good cohesions of the network of proteins and carbohydrates. The good cohesion could, thus, prevent the outflow of some ingredients like sugar that could melt at the high temperature of baking, hence increasing the spreadibilty of the material (Ayo et al., 2010). Some researchers have also reported a reduction in the spread ratio when soy flour and fenugreek flour were substituted for wheat flour (Singh et al., 1996; Hooda & Jood, 2005); buckwheat flour for wheat flour (Baljeet et al., 2010). However, the range of biscuit weight obtained by Baljeet et al. (2010) was 10.73 to 12.00 g with a maximum value with a 40% buckwheat flour addition. The increase in weight of the biscuits was probably due to the ability of the flour to retain oil during the baking process (Rufeng et al., 1995). The values obtained from this study for fracture, however, imply that the fracture strength of the biscuit samples increased with increasing GPF addition. Values obtained here were, however, lower than those obtained by Baljeet et al. (2010) in buckwheat biscuits but higher than the values reported by Ayo et al. (2010) for acha-beniseed composite biscuit samples.

Chemical composition of composite biscuits

The increased moisture content associated with composite biscuits. however, could be due to the increase in protein content. Because protein have been reported to have high affinity for moisture, it may be attributed for the increased moisture content (Jideani & Akingbala, 1993; Alobo, 2006) as the levels of additional GPF increase. The protein content increased from

7.2 to 9.3% with an increase in the proportion (0–20%) addition of GPF. The significant ($p \leq 0.05$) increase in the fiber content was due to the reason that GPF had better fiber content (about 18%) compared to the ABF. Crude fiber contributes to the health of the gastrointestinal system and metabolic system in humans. Because crude fiber consists of cellulose and lignin, its estimation affords an index for evaluation of dietary fiber whose efficiency has been implicated in a variety of gastrointestinal disorders (Schneeman, 2002). By increasing intestinal mobility, fiber causes increased transit time for bile salt derivatives such as deoxycholate, which are effective chemical carcinogens, hence reducing incidence of carcinoma of the colon (Eddy et al., 2007). Moreover, the observed significant decrease in carbohydrates with the increase in GPF substitution may be attributed to the lower content of carbohydrates in GPF.

Sensory evaluation of composite biscuits

The panelists also had their reservations about the fruity flavor of the biscuits, which could be improved upon. Despite the improved nutritional qualities of the composite biscuits, practically all of the panelists seem to dislike the biscuits, going by the mean average scores of the sensory scores. A 9-point hedonic scale was used and the highest overall acceptability identified was 3.0 for the 85:25 blends (ABF:GPF).

CONCLUSION

Our results show that an acceptable composite biscuit can be made from ABF up until 85 and 15% blending of ABF and GPF respectively without affecting consumer preference. This will increase the utilization of these food materials, boost the income generation of the producers of theses food crops, and ensure adequate food security, especially in developing countries where these crops are highly abundant. From a practical point of view, the testers disliked the biscuits, going by the mean scores from the sensory results. However, biscuit blends (ABF:GPF) at 90:10 and 85:15 were rated almost similarly.

LIMITATIONS

Using large judge-panels for the organoleptic assessment may enhance the quality of the test with a stronger post-hoc test. Also, by optimizing the formulation and other processing parameters, a product of better and more practically acceptable composite biscuits could be achieved.

REFERENCES

Agu, H. O., Ayo, J. A, Paul, A. M. & Folorunsho, F. (2007). Quality characteristics of biscuits made from wheat and African breadfruit (Treculia africana). *Nigerian Food Journal*, *25*(2), 19–27.

Alobo, A. P. (2006). Effect of Sesame seed on millet biscuit. *Plant Food for Human Nutrition*, 64, 21–27.

Association of Analytical Chemists (AOAC). (1990). *Official Methods of Analysis*. Washington DC: Author.

Akubor, P. I. (2003). Functional properties and performance of cowpea/plantain/ wheat flour blends in biscuits. *Plant Food for Human Nutrition*, 58, 1–8.

Akubor, P. I., Isolokwu, P. C., Ugbane, O., & Onimawo, I. A. (2000). Proximate composition and functional properties of African breadfruit kernel and flour blends. *Food Research International*, 33, 707–712.

Aroyeun, S. O. (2009). Utilization of cashew kernel meals in the nutritional enrichment of biscuit. *African Journal of Food Science*, *3*(10), 316–319.

Ayo, J. A., Ikuomola, D. S., Esan, Y. O., Onuoha, O. G., Ayo, V. A. & Eleke, V. (2010). Effect of added defatted Beniseed on the quality of Acha-based biscuits. *Continental Journal Food Science and Technology*, 4, 7–13.

Ayo, J. A., & Nkama, I. (2003). Effect of Acha (Digitaria exilis, Staph) grain flour on the physical and sensory quality of biscuit. *Journal of Nutrition and Food Science*, *33*(3), 125–135.

Ayo, J. A., Ayo, V. A., Nkama, I., & Adewori, R. (2007). Physico-chemical, in-vitro digestibility and organoleptic evaluation of Acha-wheat biscuit supplemented with soybean flour. *Nigerian Food Journal*, *25*(1), 77–89.

Baljeet, S. Y., Ritika, B. Y., & Roshan, L. Y. (2010). Studies on functional properties and incorporation of buckwheat flour for biscuit making. *International Food Research Journal*, 17, 1067–1076.

Eddy, N. O., Udofia, P. G., & Eyo, D. (2007). Sensory evaluation of wheat/cassava composite bread and effect of label information on acceptance and preference. *African Journal of Biotechnology*, *6*(20), 2415–2418.

Fellows, P. (1997). *Traditional Food Processing for Profit*. London, UK: Intermediate Technology publication.

Fernando, R. (1981). *Traditional and Non-Traditional Foods*. Rome, Italy: FAO publications.

Gandhi, A. P., & Taimini, V. (2009). Organoleptic and nutritional assessment of sesame (Sesame indicum, L.) biscuits. *Asian Journal of Food and Agro-Industry*, *2*(2), 87–92.

Giami, S. Y. (2004). Effect of fermentation on the seed proteins, nitrogenous constituents, Antinutrients and nutritional quality of fluted pumpkin (Telfaria occidentalis Hook). *Food Chemistry*, 88, 397–404.

Gomez, M. I., Obilance, M. D. F., Madzavanuse, M., & Many, E. S. (1997). *Manual Laboratory for Quality Evaluation of Sorghum and Millet*. New Delhi, India: International Crop Research Institute of the Semi-Arid and Tropics.

Hooda, S., & Jood, S. (2005). Organoleptic and nutritional evaluation of wheat biscuits supplemented with untreated and treated fenugreek flour. *Food Chemistry*, 90, 427–435.

Idowu, M. A., Oni, A., & Amusa, B. M. (1996). Bread and Biscuit potentials of some Nigerian Cocoyam Cultivars. *Nigerian Food Journal*, 14, 1–11.

Jideani, I. A., & Akingbala, J. O. (1993). Some physicochemical properties of Acha (Digitaria exilis Staph) and Ibuns (Digitaria inunia Staph) grains. *Journal of Food Science and Agriculutre*, 63, 369–374.

Li-Choo, C. (2007). *Utilisation of matured green banana (Musa paradisiaca var. Awak) flour and oat beta glucan as fibre ingredients in noodles*. Master of Science Thesis, Universiti Sains Malaysia, Penang, Malaysia.

Mepba, H. D., Eboh, L., & Nwaojigwa, S. U. (2007). Chemical composition, functional and baking properties of wheat-plantain composite flours. *African Journal of Agriculture, Nutrition and Development*, 7(1), 1–22.

Rufeng, N., Enqi, L., Chuangji, C., & Jiangping, Z. (1995). A study on the production of healthy biscuit made with tartary buckwheat grown in North China. *Current Advances in Buckwheat Research*, *4*(1), 861–865.

Sanni, S. A., & Eniola, S. A. (2004). Sensory characteristics of plantain-wheat biscuits. In G. O. Adegoke, L. O. Sanni, K. O. Falade, & P. I. Uzo-Peters (Eds.), Proceeding of 28th Annual Conference/AGM of Nigerian Institute of Food Science and Technology, University of Ibadan, Ibadan, Nigeria. Lagos, Nigeria: Nigerian Institute of Food Science & Technology.

Schneeman, B. O. (2002). Gastrointestinal physiology and functions. *British Journal of Nutrition*, *88*(2), 159–163.

Singh, R., Singh, G., & Chauhan, G. S. (1996). Effect of incorporation of defatted soya flour on the quality of biscuits. *Journal of Food Science and Technology*, 33, 355–357.