International Food Research Journal 26(3): 959-967 (June 2019)

Journal homepage: *http://www.ifrj.upm.edu.my*

Effect of incorporation of unripe plantain and mung bean malt flours on wheat flour on the chemical, physical and sensory properties of cookies

[1,2*]Onwurafor, E. U., [2]Uzodinma, E. O., [1,3]Chikwendu, J. N. and [2]Nwankwor, O. F.

[1]Centre for Entrepreneurship and Development Research, University of Nigeria, Nsukka, Enugu State, Nigeria
[2]Department of Food Science and Technology, University of Nigeria, Nsukka, Enugu State, Nigeria
[3]Department of Home Science and Nutrition, University of Nigeria, Nsukka, Enugu State, Nigeria

Article history

Received: 21 April, 2017
Received in revised form: 20 December, 2018
Accepted: 20 February, 2019

Keywords

Mung bean-malt
Unripe-plantain
Cookies
Chemical properties

Abstract

The effect of incorporation of unripe plantain and mung bean malt flours on wheat flour on the chemical, physical and sensory properties of cookies was studied to address the challenge of micronutrients deficiency and increase the food application of indigenous crops. Mung bean seeds and mature unripe plantain fingers were procured from 'Ogige' market, Nsukka town, Enugu State, Nigeria. Mung bean seeds were malted for 72 h, dried and dehulled. Unripe plantain fingers were washed with clean water, peeled, sliced, soaked in sodium metabisulphite solution for 3 min, rinsed, drained and dried. Both samples were milled and sieved to obtain flours. Wheat, plantain and mung bean malt flours were blended at 70:15:15, 40:30:30, 10:45:45, 25:60:15, 10:90:0, 10:0:90, 55:45:0, 55:0:45 and 25:15:60 ratios, and used for cookies preparation. The chemical compositions, physical and sensory properties of the cookies were analysed using standard techniques. The protein, ash, fibre and carbohydrate contents of the cookies varied from 7.28-14.36, 1.44-3.99, 2.16-3.49 and 62.92-70.05 mg/100 g, respectively. The protein and ash contents were higher in the cookies with higher proportions of mung bean malt flour than the plantain flour or control cookies.The increase in mung bean malt and unripe plantain flour resulted in cookies with high contents of calcium, iron and zinc, and their values varied from 22.02-32.34, 1.41-3.98 and 2.60-3.74 mg/100 g, respectively. The diameter and thickness of the cookies from different blends increased while the spread ratio, weight and break strength decreased when compared to control. The cookies from the 70:15:15 were preferred to others in the overall acceptability. The cookies from flour blends containing up to 30% mung bean malt were not significantly different from control in overall acceptability.

Introduction

Cookies are a unique snack food that, in past years, was a homemade item for most people. It represents the largest category of snack item among baked food products throughout the world (Pratima and Yadava, 2000). Studies have shown that snack food consumption has been on the rise as a result of urbanisation. Cookies are popular due to their low manufacturing cost, convenience, long shelf-life and ability to serve as a vehicle for important nutrients (Akubor, 2003; Hooda and Jood, 2005). Cookies are prepared from wheat flour, water, shortenings, baking powder and sugar, and are consumed by all demographic groups. Cookies can also be prepared by combining wheat flour with other ingredients.

Food and Agriculture Organization (FAO) reported that the application of composite flour in various food products would be economically advantageous as well as minimising the problems associated with wheat gluten and meeting the demand for pastry products (Jisha *et al*., 2008). Though nutritionists are more interested in nutritional value, consumers rely heavily on good sensory attributes of finished products as the most important guiding principle for making choice of food products. Fortification of baked products such as cookies among others with legume flour for improving nutritional value without adversely altering the sensory properties has been advocated due to their positive health benefits to humans (Giami *et al*., 2004). This can be achieved through supplementation of wheat flour with modified flours from indigenous food crops in the production of snack foods. This

*Corresponding author.
Email: eucharia.onwurafor@unn.edu.ng

would lead to increased utilisation of such crops and improvement of the nutrient density of the products. Previous studies have evaluated the incorporation of non-wheat flours in the production of cookies (Yusufu *et al*., 2015). Cookies with high sensory scores have been produced from blends of wheat and fonio (McWatters *et al*., 2003), millet and pigeon pea (Eneche, 1999), wheat and plantain (Mepba *et al*., 2007) and maize and pigeon pea (Echendu *et al*., 2004). Gonzalez-Galan *et al*. (1991) reported that cookies prepared from composite flour had higher nutritive value.

"*Orarudi*" in "Igbo" is a species of mung bean (Vigna radiata L. Wilczek) consumed mostly by Nsukka people of Enugu state in Nigeria, and has been reported to be an excellent source of plant protein (Onwurafor *et al*., 2013). Khalil (2006) reported that the consumers of mung bean would meet the essential amino acid requirement except for sulphur-containing amino acids. Mung bean is rich in lysine but deficient in methionine (Anderson, 2007). Kollárová *et al*. (2010) reported that mung bean is rich in essential fatty acids, antioxidants and folate. Mung bean flour attracted considerable attention due to its ability to prevent some of the most common diseases in contemporary western society including, overweight, obesity and diabetes. Despite the advantages of mung bean flour, antinutrients inherent in the beans lower the functionality of the seeds. Modification of flours by malting has been reported to reduce the antinutrient contents and improved both the nutrients and functionality of legumes flours. Mung bean malt has enhanced protein and vitamin contents, but low in fats (Onwurafor *et al*., 2013) which lends it as irresistible new food staple for the evolving spectrum of health diets. Mung bean malt is also rich in iron, magnesium, calcium, phosphorous and potassium (Onwurafor *et al*., 2013).

Plantain (Musa paradisica) belongs to the family of banana, and is popularly called "cooking banana" since it is seldom eaten raw (Rodriguez-Ambriz *et al*., 2008). Plantain is an excellent source of nutrients such as vitamins A and C, potassium and fibre (Obo and Eremu, 2010; Adetuyi *et al*., 2012). Furthermore, plantain has high carbohydrate content, but low in fat and sodium contents. Plantain is also a good source of iron, calcium, and vitamins B1, B2 and B3 (Oboh and Erema, 2010). The use of plantain flour in combination with wheat flour for production of baked goods has been practiced (Chinma *et al*., 2012). The incorporation of unripe plantain and mung bean malt flours into cookies formulation could improve the nutrient contents and modify the functionality of flours and the final cookies. Both mung bean malt and plantain flours are low in fats, and consumers' demand for healthier bakery foods with low fat contents has significantly grown. The incorporation of mung bean malt and plantain flours into wheat flour for cookies production would lessen the overdependence on importation of wheat flour, address the challenge of micronutrient deficiency and create varieties for health-conscious individuals. The objective of the present work was therefore to evaluate the effect of plantain and mung bean malt flour blends on wheat flour on the chemical, physical and sensory properties of cookies.

Materials and methods

Collection of raw materials

Mung bean '*orarudi*' seeds, unripe plantain fingers "*agbagba*", Golden Penny wheat flour, shortenings, honey, baking powder and sodium chloride were purchased from 'Ogige' market in Nsukka town, Enugu State, Nigeria.

Preparation of mung bean seed flour

Mung bean seeds (1 kg) were sorted and weighed. A lot of 200 g of the seeds was put into each of the malting bags, and steeped in water (1:3 w/v) for 3 h, air rested for 90 min, re-steeped in water for 3 h, spread in a dark room and then germinate for 72 h. Thereafter, the germinated seeds were sun dried (32 ± 0.25°C) for 24 h. The dried mung bean malts were de-hulled by abrasion in-between the palm, winnowed, milled in a hammer mill (H. Jurgens and Co., Bremen, Germany), and sieved through a 200 μm sieve to obtain the mung bean malt flour.

Preparation of unripe plantain fruit flour

The flour was processed following the method of Dadzie and Orchard (1997). The plantains were washed, peeled and sliced to 5 mm diameter using a stainless-steel knife. Sodium metabisulphite solution was prepared by dissolving 2 g of the salt in 100 mL of distilled water. The pulp slices were soaked in 2.0% sodium metabisulphite for 3 min, rinsed with water, and oven-dried at 50°C for 72 h to obtain dry chips. The chips were then milled in a hammer mill and sieved through 200 μm sieve to obtain the dry flour. The flour was packed in high density polyethylene (HDPE) bags until use.

Formulation of composite flour

The wheat, unripe plantain and mung bean malt flours were mixed as shown in Table 1. The flour blends were packed in HDPE bags prior to use.

Table 1. Formulation of the composite flours.

Samples WH:MB:PF	Wheat flour (WH) (%)	Mung bean malt flour (MB) (%)	Unripe plantain flour (PF) (%)
100:0:0	100	-	-
70:15:15	70	15	15
40:30:30	40	30	30
10:45:45	10	45	45
25:15:60	25	15	60
10:0:90	10	0	90
10:90:0	10	90	0
55:0:45	55	0	45
55:45:0	55	45	0
25:60:15	25	60	15

Preparation of cookies

Cookies were prepared with the composite flours following the method described by AACC (2000). The basic formulation for the cookie was composite flour (900 g), shortening (90 g), honey (45 mL), sodium chloride (1.0 g), sodium bicarbonate (1.0 g), water (62 mL) and whole egg (3). The honey and the shortening were thoroughly mixed together for 5 min and gradually mixed with flour, sodium chloride and sodium bicarbonate (dry ingredients). A required quantity of water was added and mixed until dough was formed. The dough was then kneaded for 4 min and rested for another 30 min. The dough was flattened and rolled into sheet of uniform thickness of 7 mm. The sheet was stamped out in the desired shapes of 5.8 mm diameter using a cookie cutter and arranged on lightly greased baking trays. The cookies prepared from the 100% wheat flour served as control. The dough samples were baked at 180°C for 15 min in a convention oven (Eurosonic, Model No. ES9022, Hong Kong), de-paned, and cooled for 30 min prior to sensory evaluation and other analyses.

Analytical methods

Determination of proximate composition

The composite flours and their cookie samples in three replicates were analysed for moisture, protein, ash, fat and crude fibre contents following the AOAC (2010) methods. Carbohydrate content was calculated by difference as:

% carbohydrate = 100 – (% moisture + % protein + % fat + % crude fibre + % ash)

The energy values were calculated by adding up the carbohydrate × 17 kJ, crude protein × 17 kJ and crude fat × 37 kJ for each sample (Kilgour, 1987).

Determination of minerals contents

The mineral contents of the samples were analysed following the AOAC (2010) methods for calcium, iron and zinc contents using atomic absorption spectrophotometer (Pekin-Elmer, Model 300AA, Perkin-Elmer, USA).

Evaluation of physical properties

The thickness of the cookies was determined using Hounsfield Tensometre (Model No. 888, England). The spread ratio was determined following the AACC (2000) method. The break strength of the cookie was determined following the method described by Okaka and Isieh (1990). The weight of cookies was determined using a weighing balance (Mettler PE160 Balance, Switzerland).

Sensory evaluation

Sensory evaluation was carried out using twenty panellists recruited from staff and students of Department of Food Science, University of Nigeria, Nsukka. The selection criteria were that panellists were regular consumers of cookies and were not allergic to any food products. The panellists consisting of 10 males and 10 females were instructed to evaluate the colour, flavour, taste, texture, crispiness and general acceptability of the cookies. A 9-point Hedonic scale with 1 = extremely dislike, 5 = neither like nor dislike and 9 = extremely like, was used. Samples were coded with three digits number and presented in a random sequence to the panellists.

Statistical analysis

The analysis was carried out in three replicates. The data were subjected to analysis of variance (ANOVA) in complete randomised design according to the methods of Steel and Torrie (1980). The means where significantly different were separated using Duncan's new multiple range test using SPSS version 16.00 (SPSS Inc., Chicago, USA). Significance level was set at $p < 0.05$.

Results

The proximate composition of cookies prepared from the blends of wheat, unripe plantain and mung bean malt flours are presented in Table 2. The moisture content of the cookies from the blends varied from 7.41-8.95 g, and was influenced by the addition of mung bean malt and plantain flours. The moisture content of the cookies from blends was significantly ($p < 0.05$) lower than the moisture content of the control (9.51 g) and decreased with increased level of substitution. The protein contents of the cookies

Table 2. Proximate composition (g/100 g) of cookies from blends of wheat, unripe plantain and mung bean malt flours.

Cookies WH:MB:PF	Moisture	Protein	Fat	Fibre	Ash	Carbohydrate	Energy (KJ)
100:0:0	9.51 ± 0.07[e]	8.07 ± 0.02[b]	8.77 ± 0.10[bc]	2.16 ± 0.03[a]	1.44 ± 0.08[a]	70.05 ± 0.28[g]	1652.53
70:15:15	7.91 ± 0.20[c]	11.84 ± 0.0[d]	8.43 ± 0.10[b]	3.96 ± 0.06[b]	2.79 ± 0.06[b]	65.07 ± 0.09[e]	1663.41
40:30:30	8.15 ± 0.01[c]	13.32 ± 0.07[f]	8.30 ± 0.23[b]	3.97 ± 0.13[b]	3.32 ± 0.01[d]	62.94 ± 0.07[cd]	1620.01
10:45:45	8.76 ± 0.01[d]	12.71 ± 0.01[e]	8.42 ± 0.21[b]	3.27 ± 0.12[a]	2.43 ± 0.00[b]	64.41 ± 0.37[cd]	1610.34
25:15:60	7.48 ± 0.01[a]	11.38 ± 0.01[c]	7.38 ± 0.10[a]	3.17 ± 0.25[a]	3.85 ± 0.00[de]	66.74 ± 0.19[e]	1601.10
10:0:90	8.95 ± 0.00[d]	7.28 ± 0.01[a]	8.10 ± 0.45[b]	4.04 ± 0.05[b]	3.73 ± 0.02[d]	67.90 ± 1.42[e]	1577.76
10:90:0	7.41 ± 1.01[a]	14.36 ± 0.01[h]	8.25 ± 0.18[b]	4.07 ± 0.08[b]	3.99 ± 0.00[e]	61.92 ± 0.10[a]	1602.01
55:0:45	7.59 ± 0.40[a]	7.39 ± 0.01[a]	8.71 ± 0.03[bc]	4.49 ± 0.01[c]	3.06 ± 0.05[c]	68.76 ± 0.18[f]	1616.82
55:45:0	7.70 ± 0.06 [b]	13.38 ± 0.06[f]	8.57 ± 0.02[b]	3.17 ± 0.03[a]	3.89 ± 0.00[de]	63.29 ± 1.27[c]	1620.48
25:60:15	7.92 ± 0.01[c]	13.42 ± 0.00[g]	8.53 ± 2.16[b]	3.81 ± 0.05[b]	3.58 ± 0.00[d]	62.74 ± 0.10[b]	1610.33

Data are means of three replications (n = 3) ± SD. Means within a column with the same superscript were not significantly ($p > 0.05$) different. WH = wheat flour; MB = mung bean malt flour; PF = unripe plantain flour.

varied from 7.28-14.36 g with the sample containing 10% wheat, 0% plantain flour and 90% mung bean malt flour yielding the highest value. Cookies from the blends with no mung bean malt flour (10:90:0 and 55:45:0) (WH:PF:MB) had low protein contents as compared to other blends. The fat contents of the cookies ranged between 7.38 and 8.77 g. The cookies from the blends of wheat, unripe plantain and mung bean malt flour had lower fat contents than the control and the variations were significant ($p < 0.05$) except for the cookies containing 55% wheat flour, 45% unripe plantain flour and 0% mung bean malt flour. The ash contents of the cookies from the blends varied from 2.43-3.99 g with the control having the lowest (1.44 g). The incorporation of mung bean malt and unripe plantain flours into the cookies significantly ($p < 0.05$) increased the ash content. The fibre contents of the cookies ranged between 2.16 and 4.49 g, and significantly ($p < 0.05$) increased with increasing level of plantain and mung bean malt flours. The carbohydrate contents of the cookies varied from 61.92-70.05 g. Control had the highest carbohydrate contents. The cookies containing higher amount of mung bean malt flour had significantly ($p < 0.05$) lower carbohydrate contents than the others. The energy values of the cookies varied from 1577.76-1663.41 kJ. The cookie containing 70% wheat flour, 15% plantain flour and 15% mung bean malt flour had the highest energy value.

The calcium, iron and zinc contents of the cookies from blends of wheat, unripe plantain and mung bean malt flour are presented in Table 3. The calcium content of the cookies varied from 20.38 mg (control) to 32.34 mg for the cookies containing 40% wheat flour, 30% unripe plantain and 30% mung bean malt flours. The combination of the wheat, mung bean malt and plantain flours significantly ($p < 0.05$) increased the calcium contents of the cookies as compared to control. The iron contents of the cookies varied from 1.34-3.98 mg. Increasing the quantity of mung bean malt and unripe plantain flours significantly ($p < 0.05$) increased the iron content of the cookies relative to control. There were significant ($p < 0.05$) differences in the zinc contents of the cookies from the blends and that of control which ranged between 1.43 and 3.74 mg. The zinc content increased as the level of substitution of mung bean malt and plantain flour was increased.

Table 3. Calcium, iron and zinc content (mg/100 g) of cookies from blends of wheat, unripe plantain and mung bean malt flours.

Cookies WH:MB:PF	Calcium	Iron	Zinc
100:0:0	20.38 ± 1.42[a]	1.34 ± 0.87[a]	1.43 ± 0.00 [a]
70:15:15	24.60 ± 2.62[d]	1.41 ± 0.14[a]	3.51 ± 0.01[f]
40:30:30	32.34 ± 0.40[h]	3.98 ± 0.00[g]	3.24 ± 0.01[d]
10:45:45	30.13 ± 1.10[g]	2.58 ± 0.05[c]	3.74 ± 0.00[g]
25:15:60	26.60 ± 1.02[ef]	1.48 ± 0.14[a]	3.55 ± 0.01[f]
10:0:90	22.20 ± 2.43[b]	2.19 ± 0.15[bc]	2.60 ± 0.00[c]
10:90:0	25.95 ± 0.40[e]	3.84 ± 0.17[f]	3.26 ± 0.01[d]
55:0:45	22.03 ± 0.40[b]	2.07 ± 0.01[b]	2.36 ± 0.00[b]
55:45:0	23.15 ± 0.02[c]	2.67 ± 0.01[d]	2.86 ± 0.00[c]
25:60:15	28.60 ± 1.02[f]	2.91 ± 0.24[e]	3.61 ± 0.01[g]

Data are means of three replications ($n = 3$) ± SD. Means within a column with the same superscript were not significantly ($p > 0.05$) different. WH = wheat flour; MB = mung bean malt flour; PF = unripe plantain flour.

The physical properties of the cookies from the blends of wheat, unripe plantain and mung bean malt flours are presented in Table 4. The thickness of the cookies from the blends of wheat, unripe plantain, mung bean malt flours varied from 3.93 mm (control) to 4.95 mm (cookies containing 10% wheat flour, 45% unripe plantain and 45% mung bean malt flour, 25% wheat flour, 15% unripe plantain and 60%

Table 4. Physical properties of cookies from blends of wheat, unripe plantain and mung bean malt flours.

Samples WH:MB:PF	Thickness (mm)	Diameter (mm)	Spread ratio	Weight (g)	Break strength (N)
100:0:0	3.93 ± 0.08^{a}	3.32 ± 0.03^{a}	1.23 ± 0.02^{b}	7.13 ± 0.47^{c}	44.69 ± 3.45^{h}
70:15:15	4.80 ± 0.08^{cd}	4.05 ± 0.07^{bc}	1.19 ± 0.04^{b}	6.93 ± 1.25^{bc}	28.44 ± 1.15^{d}
40:30:30	4.63 ± 0.25^{b}	4.25 ± 0.07^{c}	1.09 ± 0.08^{a}	6.47 ± 0.87^{b}	28.63 ± 1.94^{d}
10:45:45	4.95 ± 0.04^{d}	3.90 ± 0.00^{bc}	1.27 ± 0.01^{bc}	6.67 ± 1.53^{b}	21.95 ± 1.17^{b}
25:15:60	4.75 ± 0.06^{c}	4.30 ± 0.18^{c}	1.10 ± 0.04^{a}	7.45 ± 0.87^{d}	38.57 ± 2.19^{f}
10:0:90	4.64 ± 0.22^{bc}	4.28 ± 0.05^{c}	1.09 ± 0.04^{a}	7.35 ± 1.01^{d}	42.25 ± 1.71^{g}
10:90:0	4.26 ± 0.10^{b}	4.31 ± 0.00^{c}	1.12 ± 0.03^{a}	6.96 ± 1.10^{bc}	19.57 ± 2.05^{a}
55:0:45	4.70 ± 0.14^{c}	4.08 ± 0.19^{bc}	1.16 ± 0.02^{ab}	5.86 ± 0.22^{a}	34.13 ± 2.30^{e}
55:45:0	4.66 ± 0.37^{bc}	3.73 ± 0.07^{b}	1.25 ± 0.07^{b}	6.82 ± 0.80^{bc}	38.69 ± 3.65^{f}
25:60:15	4.95 ± 0.00^{d}	3.93 ± 0.10^{bc}	1.25 ± 0.00^{b}	6.71 ± 0.85^{bc}	24.18 ± 1.56^{c}

Data are means of three replications (n = 3) ± SD. Means within a column with the same superscript were not significantly ($p > 0.05$) different. WH = wheat flour; MB = mung bean malt flour; PF = unripe plantain flour.

mung bean malt flour). The substitution of wheat flour in the formulation with varying ratios of mung bean malt and unripe plantain flours significantly ($p < 0.05$) increased the thickness of the cookies. The diameter of the cookies from blends of wheat flour, unripe plantain flour and mung bean malt flour varied from 3.73-4.31 mm. The diameter of control cookies was significantly ($p < 0.05$) lower than the other cookies. The spread ratio for the cookies ranged from 1.09-1.27. The spread ratios for 10:45:45, 55:0:45, 25:15:60 (wheat flour:mung bean malt flour:plantain flour) were 1.27, 1.25 and 1.25, respectively, and did not significantly differ ($p > 0.05$) from control. However, significant ($p < 0.05$) differences occurred among the cookies of 70:15:15, 40:30:30, 10:45:45, 25:60:15, 10:90:0, 10:0:90 and 55:45:0 (WF:MB:PF). The breaking strength of the cookies from the blends varied from 19.57-44.69 N. Control had higher break strength than the cookies from the blends. The weight of the cookies from the composite flour varied from 5.86-7.45 g while weight of the control sample was 7.13 g. The cookies containing 25% wheat flour, 60% unripe plantain flour and 15% mung bean malt flour had the highest weight.

The sensory scores of the cookies from the blends of wheat, unripe plantain and mung bean malt flours are shown in Table 5. The scores for colour of the cookies varied from 5.25-7.78. Increasing the mung bean malt and plantain flour above 30% resulted in decrease in colour preference by the panellists. The sensory score for flavour varied from 6.30-7.95 for the cookies from the blends. The results showed that increasing the quantity of mung bean malt above 15% and unripe plantain flour above 45% resulted in significant ($p < 0.05$) decrease in the flavour preference among the panellists. The sensory score for taste for the cookies from the blends varied from 5.55-7.95 with the cookies containing 25% wheat flour, 15% unripe plantain and 60% mung bean malt flour having the least score. The cookies containing 70% wheat flour, 15% unripe plantain and 15% mung bean malt flour scored the highest (7.95) which was

Table 5. Sensory scores of cookies from blends of wheat, unripe plantain and mung bean malt flour.

Samples WH:MB:PF	Colour	Flavour	Taste	Texture	Crispiness	Overall Acceptability
100:0:0	7.80 ± 1.44^{d}	7.90 ± 0.88^{de}	8.05 ± 1.15^{c}	7.90 ± 1.02^{c}	7.90 ± 0.85^{f}	8.45 ± 0.76^{e}
70:15:15	7.78 ± 1.31^{d}	7.88 ± 0.88^{de}	7.95 ± 1.12^{c}	7.85 ± 1.28^{c}	7.70 ± 0.98^{f}	8.20 ± 1.11^{d}
40:30:30	7.78 ± 1.45^{d}	7.87 ± 1.71^{d}	7.80 ± 1.54^{c}	5.35 ± 1.35^{a}	7.20 ± 1.85^{cd}	8.15 ± 0.94^{d}
10:45:45	6.05 ± 1.47^{ab}	7.10 ± 1.52^{bc}	6.85 ± 1.31^{b}	5.45 ± 1.35^{a}	6.30 ± 1.42^{cd}	5.45 ± 1.15^{b}
25:15:60	6.80 ± 1.44^{bcd}	7.60 ± 1.47^{c}	6.70 ± 1.84^{b}	5.00 ± 1.89^{a}	5.30 ± 1.89^{bc}	5.70 ± 1.63^{b}
10:0:90	6.10 ± 1.55^{ab}	7.05 ± 1.79^{bc}	6.30 ± 2.25^{b}	5.30 ± 2.18^{a}	5.50 ± 1.93^{bc}	5.55 ± 2.21^{b}
10:90:0	5.75 ± 2.02^{ab}	6.30 ± 1.95^{a}	6.25 ± 1.86^{a}	4.75 ± 1.97^{bc}	5.40 ± 2.30^{bc}	4.15 ± 2.13^{a}
55:0:45	7.75 ± 0.72^{d}	7.95 ± 1.39 ^{e}	7.25 ± 1.21^{c}	7.65 ± 1.14^{c}	6.70 ± 1.69^{de}	7.80 ± 1.01^{cd}
55:45:0	6.70 ± 1.63^{bc}	6.90 ± 1.92^{ab}	6.60 ± 1.47^{a}	5.45 ± 1.32^{a}	4.95 ± 2.01^{ab}	5.05 ± 1.47^{ab}
25:60:15	5.25 ± 1.99^{a}	6.90 ± 1.71^{ab}	5.55 ± 1.36^{a}	4.55 ± 1.39^{a}	4.05 ± 2.11^{a}	4.20 ± 1.15^{a}

Data are means ± SD. Means within a column with the same superscript were not significantly ($p > 0.05$) different. WH = wheat flour; MB = mung bean malt flour; PF = unripe plantain flour.

however not significantly ($p > 0.05$) different from the cookies containing 40% wheat flour, 30% mung bean malt flour and 30% unripe plantain flour (8.15) and control (8.05). Variation in the preference for the texture of the cookies also existed among the panellists. Cookies with high contents of mung bean malt above 15% and unripe plantain flour above 45% had significantly ($p < 0.05$) lower scores for texture. Variation in the scores for crispiness existed between control and the cookies from the composite flours, and the differences were significant ($p < 0.05$) except for the cookies containing 70% wheat, 15% mung bean malt and 15% unripe plantain flours (7.70). The scores for overall acceptability decreased with increasing level of mung bean malt and plantain flours. The scores of 8.20 and 8.15 were given to the cookies containing 70:15:15 and 40:30:30 (WF:MB:PF) for overall acceptability, respectively. These scores were lower than that of the control; however, the differences were not significant ($p > 0.05$).

Discussion

The moisture content of the cookies was influenced by the addition of mung bean malt and plantain flours. The inclusion of mung bean malt and plantain flours in the cookies' formulation decreased the moisture content of the cookies. This may be due to the high protein content of the sample with high mung bean malt flour. Yusufu *et al*. (2015) made similar observation when wheat flour was substituted with green bean and attributed it to protein in bean flour. The moisture contents in these cookies were similar to that reported by other researchers (Yusufu *et al*., 2015). The level of moisture reported in the cookies is advantageous as it will enhance the keeping quality of the cookies and prolong its shelf life. Onyeike *et al*. (1995) noted that high moisture content could lead to food spoilage through increasing microbial action.

The protein contents of the cookies were influenced by the quantity of mung bean malt flour in the cookies. The high protein content of the cookies containing higher levels of mung bean malt was not surprising as it has been documented that mung bean flour and its malt are rich source of protein (Onwurafor *et al*., 2013). The values suggest that the cookies containing 10:0:90 (WF:MB:PF) can contribute to daily protein need of 14.36 g for children and teenagers. The low protein content of the cookies from flour blends with higher quantity of unripe plantain flour could be due to dilution caused by low protein content of unripe plantain (Agunbiade *et al*., 2006). Similar dilution effects were observed by Yusufu *et al*. (2014) during production of fura with firm ripe plantain flour. Mepba *et al*. (2007) reported that increasing the levels of unripe plantain flour caused decrease in moisture, protein, fat content of bread made from the composite. Complementation of cereals with legume has been reported to significantly improve the protein content of cereals. Research findings recommended the fortification of cereal-based diets with legume products to complement the limited essential amino acids, lysine and tryptophan which are high in legumes with the sulphur-containing amino acids, methionine and cysteine which are high in cereals and are indispensable for growth (Ijarotimi and Aroge, 2005). The nutrient levels in cereals are better utilised when they are complemented with legumes (Yusufu *et al*., 2015). The high protein contents of the cookies from blends with higher quantity of legumes further confirmed the reports of Yusufu *et al*. (2015). Wardlaw *et al*. (2004) noted that protein is essential as a building block for body and it is necessary for growth and repair of damaged tissues.

Low fat content of the sample with higher quantity of unripe plantain may be attributed to low fat content of unripe plantain and mung bean malt flours (Obo and Eremu, 2010; Onwurafor *et al*., 2013). High fat content could be undesirable in baked food products as it promotes rancidity which could reduce the shelf life of food products (Ihekoronye and Ngoddy, 1985). Okpala and Chinyelu (2011) noted that diet high in fat predispose consumers to different illnesses such as obesity, coronary heart disease among others. The incorporation of mung bean malt and unripe plantain flours in cookies significantly increased the ash content. This indicates high mineral content of the cookies since ash content is an index of mineral content of products. The level of ash in the cookies suggests that the cookies could supply mineral to the consumers of the products. Fibre content significantly increased with the increase in plantain and mung bean malt flour. Plantain flour is rich in fibre and could have contributed to the increase in the value of fibre of the cookies. The fibre in the cookies suggests its ability to provide moderate fibre. The levels of fibre in the blends were of significance as fibre is essential in food as roughage for the bowels, assisting intestinal transit. Fibre also helps maintain the health of the gastrointestinal tract but in excess may form complex with trace elements leading to deficiency of iron and zinc (Siddhuraju *et al*., 1996). The low carbohydrate contents of the cookies from the blends with high content of mung bean malt flour was an indication that mung bean malt flour was rich in other nutrients and/or due to modification of starch by malting (Onwurafor *et al*., 2013). The fibre and low carbohydrate contents of the cookies could aid digestion, reduce constipation associated with products from refined wheat alone (Elleuch *et al*., 2011).

Mung bean malt and unripe plantain have been reported to be excellent sources of calcium (Oboh and Eremu, 2010; Onwurafor *et al*., 2013). Calcium aids in bone formation and has been noted to play role in keeping the heart and muscle working. The result suggests that consumption of these cookies could help in reduction of calcium deficiency. Increasing the quantity of mung bean malt and unripe plantain flours significantly increased the iron contents of the cookies relative to control. It was evident that increasing the level of substitution of mung bean malt and plantain flour increased the zinc content. The results suggest that consumption of these cookies could help in reduction of zinc deficiency and contribute significantly to recommended dietary allowance (RDA) for calcium, iron and zinc.

The thickness of the samples was influenced by product composition. The substitution of wheat flour in the formulation with varying ratios of mung bean malt and unripe plantain significantly increased the thickness of the cookies contrary to the report of Yusufu *et al*. (2015) that increasing the level of substitution of wheat flour with green bean flour decreased the cookies thickness. The values of the cookies thickness in these studies were higher than the values reported for the biscuit made from wheat and brewer's spent grain (Gernah *et al*., 2010). Cookies from the blends had higher diameter contrary to the observation of Okpala and Chinyelu (2011) for wheat-pigeon pea-cocoyam blends. The lower diameter of the cookies in control as compared to other blends indicated greater expansion of the cookies from the blends. The spread ratio observed in these studies was lower than the values reported for the cookies made from wheat-brewers spent grain (Gernah *et al*., 2010). The increase in the level of unripe plantain and mung bean malt flour resulted in the decrease of the spread ratio, similar to the observation of Maridula *et al*. (2007) that spread ratio decreased significantly with increasing proportion of sorghum flour in wheat-sorghum composite biscuit and attributed it to the decrease in dough strength as the quantity of sorghum flour increased. Yahya (2004) reported that hydrophilic starches had a negative relation with the spread ratio of cookies which suggests that the starches from unripe plantain and mung bean malt flours could be more hydrophilic in nature than those of wheat flour. Matz (1993) noted that controlling cookie spread is one of challenges encountered in cookie production; a cookie spread ratio should not be so much or too little that it cannot be filled in a package, cause slack fill or excess height for the package thus creating havoc on the packaging line (Okpala and Chinyelu, 2011). The decrease in break strength had been reported when cookies were substituted with cocoyam flour (Idowu *et al*., 1996). The decrease in break strength could be attributed to cookies' starch granules which are responsible for gel formation in baked goods. Increasing the substitution of wheat flour with mung bean malt and unripe plantain flours decreased the break strength values thereby making the cookies more fragile. The decrease could be due to the decrease in cookies carbohydrates granule which is responsible for structure formation in baked goods. This report agrees with the report of Idowu *et al*. (1996) and Okpala and Egwu (2015) who noted that break strength of cookies made from wheat and cocoyam and broken rice and cocoyam, respectively was lower than that of 100% wheat flour blends and attributed the effects to dilution of wheat flour with cocoyam and broken rice flour, respectively.

Increasing the mung bean malt and plantain flour above 30% resulted in slight decrease in colour preference by the panellists. The lower scores could be due to colour of cookies which may have been influenced by the reaction between reducing sugars and protein during baking (Maillard reaction) of the sample. The results showed that increasing the quantity of mung bean malt above 15% and unripe plantain flour above 45% resulted in significant decrease in flavour preference among the panellists.

The texture of the cookies was greatly influenced by the level of mung bean malt and unripe plantain flour substitution, which is similar to observation of other researchers (Eneche, 1999). Only the cookies containing 10:90:0 and 25:15:60 (WF:MB:PF) had sensory score below 5 for texture, indicating that the panellists appreciated the texture of the products. The highest rating for crispiness for cookies containing 70:15:15 (WF:MB:PF) could be due to low level of mung bean malt (15%) and unripe plantain flour (15%) in the cookies. Cookies with high sensory rating have been produced from composite of fonio (McWatters *et al*., 2003); millet and pigeon pea (Eneche, 1999), and also wheat and plantain (Mepba *et al*., 2007).

Conclusion

The present work demonstrated that nutrient-rich and acceptable cookies could be produced from blends of wheat, unripe plantain and mung bean malt flours. The incorporation of unripe plantain and mung bean malt flour improved the protein, ash, calcium, iron and zinc contents of the cookies. The cookies from 70% wheat flour, 15% unripe plantain and 15% mung bean malt flour and 40% wheat flour, 30% unripe plantain and 30% mung bean malt flour and control were not significantly different in the panellists assessment of the sensory attributes of colour, taste, flavour, texture and crispiness. The incorporation of mung bean malt flour up to 30% and unripe plantain flour up to 45% led to the production of cookies rich in nutrients with high level of acceptance. The commercialisation and consumption of these products could aid in reducing the nutrient deficiency and aid the health-conscious individuals to consume cookies. These results suggest that wheat flour could be supplemented with other staple foods to produce cookies and other snack foods.

Acknowledgement

The present work did not receive any research grant from funding agencies, but the authors deeply appreciate the financial support received from their families.

References

Adetuyi, F., Ajala, L. and Ibrahim, T. 2012. Effect of the addition of defatted okra seed (*Abelmoschu esculentus*) flour on the chemical composition, functional properties and Zn bioavailability of plantain (Musa paradisiacal Linn.) flour. Journal of Microbiology, Biotechnology and Food Sciences 2(1): 69-82.

Agunbiade, S. O., Olanlokun, J. O. and Olaofe, O. A. 2006. Quality of chips produced from rehydrated dehydrated plantain and banana. Pakistan Journal of Nutrition 5(5): 471- 473.

Akubor, P. I. 2003. Functional properties and performance of cowpea/plantain/wheat flour blends in biscuits. Plants Foods for Human Nutrition 58(3): 1-8.

American Association of Cereal Chemists (AACC). 2000. Approved Methods of the American Association of Cereal Chemists (10th ed). United States: AACC.

Anderson, P. 2007. Food Security through Ricebean Research in India and Nepal (FOSRIN), Report 3: Nutritive value of ricebean. Received from Ricebean Network website: http://www.ricebean.org/deliverables/deliverable%203%20-%20nutrient%20content.pdf

Association of Analytical Chemists (AOAC). 2010. Official methods of analysis of AOAC International (18th ed). United States: AOAC.

Chinma, C. E., Igbanul, B. D. and Omotayo, O. O. 2012. Quality characteristics of cookies prepared from unripe plantain and defatted sesame flour blend. American Journal of Food Technology 7(7): 395-408.

Dadzie, B. K. and Orchard, J. E. 1997. Routine post harvest screening of banana/plantain hybrids: criteria and methods. INIBAP Technical Guidelines 2. Received from Bioversity International website: https://www.bioversityinternational.org/fileadmin/_migrated/uploads/tx_news/Routine_post-harvest_screening_of_banana_plantain_hybrids__Criteria_and_methods_235.pdf

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(1): 147-153.

Elleuch, M., Bedigian, D., Roiseux, O., Besbes, S., Blecker, C. and Attia, H. 2011. Dietary fibre and fibre-rich by-products of food processing: characterisation, technological functionality and commercial applications: a review. Food Chemistry 124(2): 411-421.

Eneche, E. H. 1999. Biscuit making potentials of millet/pigeon pea flour blends. Plant Foods for Human Nutrition 54(1): 21-27.

Gernah, D. I., Senger, I. A. and Audu, J. O. 2010. Physicochemical and sensory evaluation of cookies produced from wheat and brewers spent grain composite flour. Nigerian Food Journal 28(2): 440-447.

Giami, S. Y., Amasisi, T. and Ekiyor, G. 2004. Comparison of bread making properties of composite flour from kernel of roasted and boiled African breadfruit (*Treculia africana*) seeds. Journal of Raw Material Research 1: 16-25.

Gonzalez-Galan, A., Wang, S. H., Sgarbieri, V. C. and Moraes, M. A. C. 1991. Sensory and nutritional properties of cookies based on wheat-rice soybean flours baked in a microwave oven. Journal of Food Science 56(6): 1699-1701.

Hooda, S. and Jood, S. 2005. Organoleptic and nutritional evaluation of wheat biscuits supplemented with untreated and treated fenugreek flour. Food Chemistry 90(3): 427-435.

Idowu, M. A, Oni, A. and Amusa, B. M. 1996. Bread and Biscuit making potential of some Nigerian Cocoyam cultivars. Nigerian Food Journal 14: 1-12.

Ihekoronye, A. I. and Ngoddy, P. O. 1985. Integrated Food Science and Technology for the Tropics, p. 296-298. London: Macmillan Publishers.

Ijarotimi, S. O. and Aroge, F. 2005. Evaluation of the nutritional composition, sensory and physical properties of a potential weaning food from locally available food materials-breadfruit (Artocarpus altilis) and soybean (Glycine max). Poland Journal of Food and Nutrition Sciences 55(4): 411-415.

Jisha, S., Padmaja, G., Moorthy, S. N. and Rajeshkumar, K. 2008. Pre-treatment effect on the nutritional and functional properties of selected cassava-based composite flours. Innovative Food Science and Emerging Technologies 9(4): 587-592.

Khalil, A. A. 2006. Nutritional improvement of Egyptian breed of mungbean by probiotic lactobacilli. African Journal of Biotechnology 5(2): 206-212.

Kilgour, O. F. G. 1987. Mastering Nutrition, p. 85-86.

London: Macmillan Education Ltd.

Kollárová, K., Vatehová, Z., Slováková, L. and Lisková, D. 2010. Interaction of galactoglucomnnan oligosaccharides with auxin in mungbean primary root. Plant Physiology and Biochemistry 48(6): 401-406.

Maridula, D., Gupta, R. K. and Manikantan, R. 2007. Effect of incorporation of sorghum flour to wheat flour on quality of biscuits fortified with defatted soy flour. American Journal of Food Technology 2(5): 428-434.

Matz, S. A. 1993. Cookie and Cracker Technology (3rd ed). United States: Springer.

McWatters, K. H., Ouedraogo, J. B., Resurreccion, A. V. A., Hung, Y.-C. and Dixon Phillips, R. 2003. Physical and sensory characteristics of sugar cookies containing mixtures of wheat, fonio (*Digitaria exilis*) and cowpea (*Vigna unguiculata*) flours. International Journal of Food Science and Technology 38(4): 403-410.

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

Oboh, H. A. and Erema, V. G. 2010. Glycemic indices of processed unripe plantain (*Musa paradisiaca*) meals. African Journal of Food Science 4(8): 514-521.

Okaka, J. C. and Isieh, M. I. 1990. Development and quality evaluation of cowpea wheat biscuits. Nigerian Food Journal 8: 56-62.

Okpala, L. C. and Chinyelu, V. A. 2011. Physicochemical, nutritional and organoleptic evaluation of cookies from pigeon pea (*Cajanus cajan*) and cocoyam (*Xanthosoma* sp.) flour blends. African Journal of Food, Agriculture, Nutrition and Development 11(6): 5431-5443.

Onwurafor, E. U., Onweluzo, J. C. and Umunnakwe, I. L. 2013. Effect of malting period on the chemical contents of mung bean '*Orarudi*' (*Vigna radiata*) flour. In Hall, R. and Rudebjer, P. (eds). Proceedings of the 3rd International Conference on Neglected and Underutilized species: for a Food-Secure Africa, p. 175-193. Rome, Italy: Bioversity International.

Onyeike, E. N., Olungwe, T. and Uwakwe, A. A. 1995. Effect of heat treatment and defatting on the proximate composition of some Nigerian local thickeners. Food Chemistry 53(2): 173-175.

Pratima, A. and Yadave, M. C. 2000. Effect of incorporation of liquid dairy by-product on chemical characteristic of soy fortified biscuits. Journal of Food Science and Technology 37(2): 158-161.

Rodriguez-Ambriz, S. L., Islas-Herna´ndez, J. J., Agama-Acevedo, E., Tovar, J. and Bello-Pe´rez, L. A. 2008. Characterization of a fiber-rich powder prepared by liquefaction of unripe banana flour. Food Chemistry 107(4): 1515-1521.

Siddhuraju, P., Vijayakumari, K. and Janardhanan, K. 1996. Chemical composition and protein quality of the little-known legume, velvet bean (*Mucuna pruriens* L.). Journal of Agricultural and Food Chemistry 44(9): 2636-2641.

Steel, R. G. D. and Torrie, J. H. 1980. Principles and Procedures of Statistics: A Biometrical Approach (2nd ed). New York: McGraw-Hill.

Wardlaw, G. M. Hampl, J. S. and Di Sivelstro, R. A. 2004. Perspective in Nutrition (6th ed). USA: McGraw-Hill Book Company.

Yahya, M. N. A. 2004. Physicochemical and shelf life studies on reduced fat legume-based cookies using sago flour as a fat replacer. Malaysia: Universiti Sains Malaysia, MSc. thesis.

Yusufu, M. I., Obiegbuna, J. E. and Yusufu, P. A. 2015. Studies on the utilization of green bean as raw material in cookies produced from wheat flour. Agricultural Science Research Journal 5(6): 92-97.

Yusufu, P. A., Mosiko, T. B. and Ojuko, O. O. 2014. Effects of firm ripe plantain fruit flour addition on the chemical, sensory and microbial quality of *fura* powder. Nigerian Food Journal 32(1): 38-44.