PHYSICO-CHEMICAL, FUNCTIONAL AND PASTING PROPERTIES OF COMPOSITE FLOUR MADE FROM WHEAT, PLANTAIN AND BAMBARA FOR BISCUIT PRODUCTION

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Abstract
The feasibility of producing quality biscuit from composite flour consisting of plantain flour, Bambara flour and wheat flour was investigated. The formulation was grouped into eight in ratio 70:30, 70:25:5, 70:20:10, 70:15:15, 70:10:20, 70:5:25, 70:0:30 for wheat-plantain-Bambara respectively and 100% wheat was used as control. The blends were analyzed for proximate compositions, water absorption capacity, bulk density, swelling capacity, and pasting properties. Functional properties of the flour blends revealed that the blend with highest inclusion of plantain (70% wheat + 30% plantain) had the highest values among the flour blends. Pasting properties showed that peak viscosity and final viscosity of the flour blends decreases with increase in level of Bambara flour incorporated to the blend. However, the pasting temperature of the composite flours were higher than that of the wheat flour. The proximate composition revealed that blend of 70%wheat; 0% plantain; 30% Bambara had the highest protein content of 25%. Physical properties conducted on the biscuit indicated that the diameter and weight of the biscuit produced from composite flour increases with increase in level of Bambara flour present in the composite flour. Sensory analysis showed that biscuit produced from flour blend 70:5:25 (wheat: plantain: Bambara) was the most acceptable. The study has demonstrated the feasibility of producing quality biscuits from wheat, plantain and Bambara flour blends.

Keywords: Bambara, plantain, composite flour, functional properties, sensory properties, pasting properties

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1. INTRODUCTION

Biscuits are convenient food products and the most popular bakery items consumed nearly by all levels of society in Nigeria. Some of the reasons for such wide popularity are low cost among other processed foods (affordable cost), good nutritional quality and availability in different varieties, varied taste, easy availability and longer shelf-life. (Eissa et al., 2007). Majorly biscuit is produced from wheat flour, fat, sugar, water and other ingredients to improve the sensory qualities of the biscuits (Oyeyinka et al., 2014). Wheat flour which is use for production of pastry and bakery products is rarely grown in Nigeria and its importation increases the cost of production of biscuits and has also render our tropical crop useless (Oyeyinka et al., 2014). Research is going on with the use of composite flour for the production of biscuit and other bakery products. Composite flour has been defined as a mixture of several flours obtained from roots, tubers, cereals and legumes with or without the addition of wheat flour (Julianti et al., 2015). Composite flour has been successfully used in production of baked product. For instance Oyeyinka et al. (2014), reported that biscuit made from 50% composite flour of plantain and wheat is comparable to biscuit made from 100%. Composite flour had a few advantages for developing countries such as Nigeria as it reduces the importation of wheat flour and encourages the use of domestic agricultural products as flour. This suggestion has brought about the use of cassava, plantain, Bambara and other underutilized crops that are good source of flour. The adoption of this locally produced flour has improved the utilization of indigenous crops through value addition (Arise et al., 2016).

Bambara groundnut is an under-utilized and neglected crop of African origin. It is the third most important legume seed after groundnut

(*Arachis hypogeal*) and cowpea (*Vigna unguiculata*) in Africa (Arise et al., 2015). It is a drought-tolerant legume and as a result has great potentials as an alternative legume to peanut and soya bean, which cannot withstand harsh agronomic conditions (Arise et al., 2017).

Bambara contain18-27% protein which has been reported to contain more methionine than those found in other legume (Arise et al., 2015, Ijarotimi and Esho, 2009). This high protein content of Bambara may enhance its addition to wheat flour which is low in protein. Plantain (*Musa paradisiaca*) is a giant perennial herb cultivated in many tropics and subtropic countries.

Nutritionally, plantain as a fruit is a good source of energy having carbohydrate of about 32% of the total fruit weight; it is also rich in iron, dietary fiber, calcium, vitamin A, B_6 and C (Adegunwa et al., 2014).

Plantain flour has a good potential for use as a functional agent in bakery industries on account of its high water absorption capacity (Oyeyinka, *et al.* 2014).

In Nigeria, wheat flour is the major flour used in the baking industries, neglecting other sources of flour like plantain flour and Bambara flour which are common and rich in nutrients.

Bambara groundnut is gradually going into extinction because many people see it as a poor man's food, while others avoid it due to its hard to cook effect. Therefore, this work is aimed at evaluating the physical, chemical and sensory qualities of biscuits made from wheat, plantain and Bambara groundnut composite flour with a view to increasing the utilization of Bambara groundnut.

2. MATERIALS AND METHODS

2.1. Materials

Bambara groundnuts were obtained from a local market in Ilorin and plantain fruits were obtained from Ilesanmi farm Ilorin. Other ingredient for production of biscuit were gotten from local market in Ilorin, Kwara state, Nigeria.

2.2. Preparation of plantain flour

The fingers were carefully detached from the bunch and sorted, cleaned, peeled and sliced to about 5 mm thickness. The slices were blanched at 80°C for 5 min to prevent browning. The drained samples were dried in oven at 60°C for 24 hours (Oyeyinka et al., 2014). The dried chips were milled using a hammer mill and sieved through a 300-400 µm sieve size. It was then stored in airtight polythene bag before use.

2.3. Preparation of Bambara groundnut flour

Bambara flour was produced using the method of Arise et al. (2015) with some modifications. Briefly, Bambara groundnut were sorted to remove foreign materials, washed and soaked in water for 2 days. Nuts were dehulled and dried at 37°C for 48 hours using cabinet drier. After which, it was milled into flour using hammer mill and then sieved through a 212 µm sieve size and stored in airtight polythene bag before use.

2.4. Composite flour preparation

The eight different blends of wheat, plantain and Bambara flour (Table 1) are used in composite flours. Wheat, plantain and Bambara flour were blended together using a mixer. The composite flour were stored in airtight container until required.

Table 1: Blend formulation for biscuit

Samples	Wheat flour (%)	Plantain flour (%)	Bambara flour (%)
WTF	100	-	-
WTPF	70	30	-
WPBA	70	25	5
WPBB	70	20	10
WPBC	70	15	15
WPBD	70	10	20
WPBE	70	5	25
WTBF	70	-	30

2.5. Functional properties of composite flours

The functional properties of individual and composite flour such as water absorption capacity (WAC), bulk density and swelling power were determined. WAC was determined according to the methods of Julianti et al. (2015). Flour samples (1 g) were suspended in 5 ml of water in a centrifugal tube. The slurry was shaken on a platform tube rocker for 1 min at room temperature and centrifuged at 3000 rpm for 10 min. The supernatant was decanted and discarded. The adhering drops of water were removed and reweighed. WAC expressed as the weight of sediment/ initial weight of flour sample (g/g). The Bulk Density of the flour sample was determined by the method of Oyeyinka et al. (2014). A measuring cylinder (100 mL) was filled with flour to mark (100 mL), and the content weighed. The tapped bulk density was also obtained by following the same procedure but tapping for 50 times prior to weighing. Bulk density was calculated as the ratio of the bulk weight and the volume of the container (g/mL). The swelling power of flour was determined based on a modified method of Julianti et al. (2015). Approximately 0.1 g of sample was transferred into a weighed graduated 50 ml centrifuge tube. Distilled water was added to give a total volume of 10 ml. The sample in the tube was stirred gently by hand for 30 seconds at room temperature, and then heated at 60^{o}C for 30 min. After cooling to room temperature, the samples were centrifuged for 30 min at 3000 rpm. The weight of sediment was recorded.

2.6. Pasting properties of the composite flours
The pasting properties of flour samples were determined using RVA (Starch master 2, Newport Scientific Pty. Ltd., Warriewood, Australia). Sample of flour (3.5 g, 14 g/100 g moisture basis) was weighed directly in the RVA canister and distilled water was added to obtain a sample weight of 25 g. The prepared slurry in the canister was heated to 50^{o}C and stirred at 160 rpm for 10 seconds to enable complete dispersion. The slurry was held at 50^{o}C for 1 min and temperature was raised to 95^{o}C over 7.5 min, and then held at 95^{o}C for 5 min. Following this, the slurry was cooled to 50^{o}C in 7.5 min, and then held at 50^{o}C for 2 min. Parameters including peak viscosity (PV), viscosity at the end of hold time at 95^{o}C or hot-paste viscosity (HPV), final viscosity (FV) at the end of cooling, breakdown (BD = PV - HPV), setback (SB = FV - HPV) and pasting temperature were recorded

2.7. Biscuit preparation and evaluation
The biscuits were produced using the method described by Uchenna and Omolayo (2017), with slight modifications. The flour (250 g), sugar (100 g), baking fat (100 g) and salt (1 g) were mixed together manually for 5 minutes to get a creamy dough. The baking powder (2.5 g) and vanilla (5 g) were then added. The measured amount of water (125 ml) was gradually added using continuous mixing until good textured, slightly firm dough was obtained. The dough was kneaded on a clean flat surface for four minutes. It was manually rolled into sheets and cut into shapes using the stamp cutting method.
The cut dough pieces were transferred into fluid fat greased pans and baked in an oven at 180ºC for 20 minutes, cooled and packaged for further analysis.
The physical properties of biscuits were measured using the method of Kiin-Kabari and Giami (2015). Physical characteristics such as weight, height, and the diameter were calculated. The determination of the proximate composition of the biscuit samples ; moisture content, ash, protein, fat and crude fibre were determined with the method of AOAC (2000), while carbohydrate was calculated by difference.
The biscuits were evaluated by a panel of fifty untrained judges drawn from the University of Ilorin, Nigeria for attributes of colour, texture, flavor, crispiness and general acceptability on a hedonic scale of 1-9, where 1 = dislike extremely and 9 = like extremely. Scores were collated and analyzed statistically.

2.8 Statistical analysis
Experiments were conducted in triplicate. Mean scores of some of the results and their standard deviation were reported.
Data were subjected to analysis of variances, and Duncan multiple range (Duncan, 1955) test was used to separate the mens.

3. RESULTS AND DISCUSSION

3.1. Functional properties of composite flours and wheat flour
The result of functional properties of the composite flour were presented in figure 1. 3.2. Pasting properties of composite flours and wheat flour
A peak viscosity of 3250.5 RVU which was significantly different from other flour blends was observed in sample WTPF (70% wheat, 30% plantain flour), while the least peak viscosity of 2226.0 RVU was recorded in sample WTBF (70%wheat + 35% Bambara flour) as shown in Table 2. However, peak viscosity of the samples decreased with increase in Bambara flour. Peak viscosity which is the maximum viscosity developed during or soon after the heating portion of the pasting test was higher than the values reported for wheat flour and blended plantain flour by Arisa et al. (2013). This difference may be attributed to differences in plantain cultivars, or differences in analytical procedures and experimental conditions used. Peak viscosity is often correlated with the final product quality and also provides an indication of the viscous loads likely to be encountered during mixing (D.B. and Banigo, 2015). The hot paste viscosity ranged from 1232.00 RVU in sample WTBF to 1767.50 RVU (sample WTPF). The break down viscosities of the composite flour ranged from 148.30 RVU (sample WTPF) to 1244.20 RVU (sample WPBA). It is an indication of breakdown or of the starch gel during cooking. The breakdown is regarded as a measure of paste stability. Arisa et al. (2013), reported similar breakdown viscosities for blanched unripe plantain flour. High setback viscosity indicates lower potential for retrogradation in food products and gives an idea about retrogradation tendency of starch (D.B. and Banigo, 2015). It shows the viscosity of cooked paste after cooling to 50^{o}C. High setback value is associated with cohesiveness. This study showed a setback viscosity range of 1053.00 to 1474.00 RVU. Arisa et al. (2013), reported a setback value of plantain flour treated with sodium metabisulphide to be 35.83 RVU which is very lower than the values reported in this study. The final viscosity (FV) indicated the re-association of starch granules especially amylose during cooling time after gelatinization (Julianti et al., 2015).

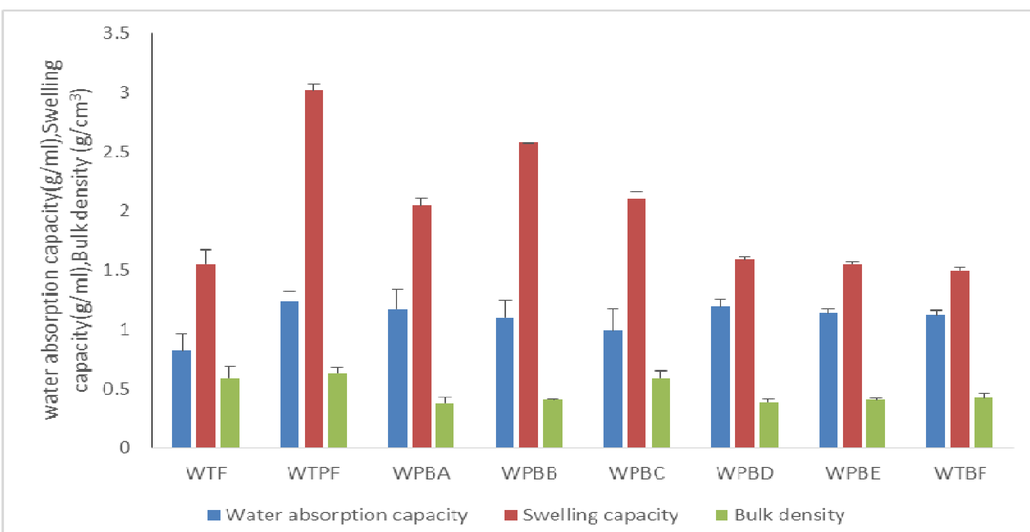

Figure 1: Water absorption capacity, swelling capacity and bulk density of composite flour from wheat-plantain-Bambara flour

WTF= 100% Wheat flour; WTPF= 70% wheat flour + 30% plantain flour; WPBA= 70% wheat+ 25% plantain flour+ 5% Bambara flour; WPBB= 70% wheat flour + 20% plantain+ 10% Bambara; WPBC= 70% wheat flour +15% plantain flour +15% Bambara flour; WPBD= 70% wheat flour + 10% plantain flour + 20% Bambara flour; WPBE= 70% wheat flour+ 5% plantain flour+ 25% Bambara flour, WTBF=70% wheat flour + 30% Bambara flour

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Table 2: Pasting properties of composite flour from wheat, plantain and Bambara groundnut flour

Samples	*PV (RVU)*	*HPV (RVU)*	*BD (RVU)*	*FV (RVU)*	*SBV (RVU)*	*P_{temp} (^0C)*	*CT (Min)*
WTF	2606.0^b	1552.0^b	1054.0^{bc}	3026.0^b	1474.0^a	59.78^a	6.20^a
WTPF	3250.5^a	1767.5^a	1483.0^a	3232.0^a	1464.5^a	80.65^a	5.45^c
WPBA	2873.5^b	1629.2^b	1244.2^b	3053.0^c	1423.7^b	77.80^a	5.56^{bc}
WPBB	2559.0^b	1564.0^b	995.0^c	2719.0^c	1155.0^{bc}	68.13^a	5.60^{bc}
WPBC	2484.0^{bc}	1419.5^{bc}	1064.5^{bc}	2710.0^c	1290.5^b	83.20^a	5.87^b
WPBD	2419.5^{bc}	1301.5^{cd}	1118.0^{bc}	2490.5^d	1189.0^{bc}	83.53^a	5.80^b
WPBE	2228.0^c	1234.0^d	994.0^c	2287.0^e	1053.0^c	84.04^a	5.70^{bc}
WTBF	2226.0^c	1232.0^d	995.0^c	2290.0^e	1055.0^c	84.08^a	5.80^b

PV= Peak viscosity, HPV= Hot paste viscosity, BD= Breakdown viscosity, SBV = Set back viscosity, Ptemp = Pasting temperature, CT = Cooking temperature**.** WTF= 100% Wheat flour; WTPF= 70% wheat flour + 30% plantain flour; WPBA= 70% wheat+ 25% plantain flour+ 5% Bambara flour; WPBB= 70% wheat flour + 20% plantain+ 10% Bambara; WPBC= 70% wheat flour +15% plantain flour +15% Bambara flour; WPBD= 70% wheat flour + 10% plantain flour + 20% Bambara flour; WPBE= 70% wheat flour+ 5% plantain flour+ 25% Bambara flour, WTBF=70% wheat flour + 30% Bambara flour. The values are expressed as the mean of three replicate samples. Values with similar superscripts in a column do not differ significantly (P <0.05).

Table 3: Proximate composition of Biscuit produced from wheat and composite flour

Samples	Moisture (%)	Protein (%)	Fats (%)	Crude fibre (%)	Carbohydrates (%)	Ash (%)
WTF	4.77±0.82^{b}	18.22±0.23^{c}	10.74±0.12^{bc}	2.35±0.14^{a}	61.42± 1.57^{b}	2.92±0.04^{a}
WTPF	7.52±0.76^{a}	18.68±0.56^{c}	12.60±1.83^{ab}	2.34±0.04^{a}	56.75± 1.58^{c}	2.92±0.01^{a}
WPBA	4.68±0.64^{b}	18.80±0.52^{c}	12.91±1.24^{ab}	2.40±0.01^{a}	59.77±1.30^{b}	2.84±0.16^{a}
WPBB	5.92±0.39^{b}	18.95±1.38^{c}	11.83±0.27^{ab}	2.27±0.10^{a}	61.37±1.19^{b}	2.91±0.03^{a}
WPBC	5.32±0.77^{b}	19.38±0.33^{bc}	9.12±0.89^{c}	2.30±0.18^{a}	60.99±1.20^{a}	2.89±0.04^{a}
WPBD	5.77±0.12^{b}	20.96±0.13^{b}	12.23 ±1.77^{a}	2.37±0.00^{a}	56.94±1.69^{c}	2.73±0.19^{a}
WPBE	6.25±0.64^{ab}	22.34±0.02^{b}	10.68±0.96^{bc}	2.40±0.01^{a}	59.86±0.04^{ab}	2.90±0.01^{a}
WTBF	6.30±0.01^{ab}	25.00±0.04^{a}	9.14±0.66^{c}	2.30±0.01^{a}	54.37±0.03^{d}	2.89±0.02^{a}

WTF= 100% Wheat flour; WTPF= 70% wheat flour + 30% plantain flour; WPBA= 70% wheat+ 25% plantain flour+ 5% Bambara flour; WPBB= 70% wheat flour + 20% plantain+ 10% Bambara; WPBC= 70% wheat flour +15% plantain flour +15% Bambara flour; WPBD= 70% wheat flour + 10% plantain flour + 20% Bambara flour; WPBE= 70% wheat flour+ 5% plantain flour+ 25% Bambara flour, WTBF=70% wheat flour + 30% Bambara flour. The values are expressed as the mean of three replicate samples. Values with similar superscripts in a column do not differ significantly (P <0.05).

Table 4: The physical characteristics of biscuits from wheat, plantain and Bambara flour

Sample	Weight (g)	Height (cm)	Diameter (cm)
WTF	6.17 ±0.11^{e}	3.93 ±0.11^{c}	5.54 ±0.06^{c}
WTPF	9.64 ±0.02^{a}	4.33 ±0.04^{ab}	6.09 ±0.01^{ab}
WPBA	8.61 ±0.02^{d}	4.15 ±0.02^{b}	5.68 ±0.03^{c}
WPBB	8.60 ±0.02^{d}	4.17 ±0.04^{b}	5.91 ±0.04^{b}
WPBC	8.93 ±0.05^{c}	4.44 ±0.05^{b}	6.26 ±0.05^{a}
WPBD	9.25 ±0.04^{b}	4.29 ±0.01^{ab}	6.12 ±0.05^{ab}
WPBE	9.55 ±0.04^{a}	4.14 ±0.57^{b}	5.96 ±0.02^{b}
WTBF	9.60 ± 0.05^{a}	4.20 ± 0.02a^{b}	6.10 ± 0.01^{ab}

WTF= 100% Wheat flour; WTPF= 70% wheat flour + 30% plantain flour; WPBA= 70% wheat+ 25% plantain flour+ 5% Bambara flour; WPBB= 70% wheat flour + 20% plantain+ 10% Bambara; WPBC= 70% wheat flour +15% plantain flour +15% Bambara flour; WPBD= 70% wheat flour + 10% plantain flour + 20% Bambara flour; WPBE= 70% wheat flour+ 5% plantain flour+ 25% Bambara flour, WTBF=70% wheat flour + 30% Bambara flour.
The values are expressed as the mean of three replicate samples. Values with similar superscripts in a column do not differ significantly (P <0.05).

3.3 Proximate composition of biscuit made from composite flours and wheat flour

The major components in the biscuit samples were carbohydrate (54.37-61.42%) and protein (18.22-25.00%) (Table 3). Ash (2.73-2.92%), fats (9.12-12.91%) and fibre (2.30-2.40%) contents were generally low. In general, protein increased, while fat, fibre, ash and carbohydrate content decreased with increasing levels of Bambara groundnut flour. Previous research suggested that protein contents of cereals can be improved by adding legumes such as groundnut, soya bean, cowpea and Bambara groundnut which are better sources of protein (Arise et al., 2015). The increase in protein contents of the biscuit samples is expected since Bambara groundnut is known to be a good source of protein. According to the literature, the protein content of Bambara groundnut may vary between 15 and 27% (Arise et al., 2015, Oyeyinka et al., 2015, Onimawo et al., 1998). Thus, the enriched biscuit samples can be potentially used to increase the protein intakes of the populace.

3.4 Physical Characteristics of biscuit from composite flours and wheat flour

The result of physical characteristics of biscuits prepared from the flour blends are presented in Table 4. There were significant differences in biscuit weight among the biscuit samples (P < 0.05). The highest weight was observed in the sample that contain wheat and plantain without bambara. However, the weight of composite biscuit sample increases with increasing level of bambara in the composite flour. This same trend was observed when composite flour made of soybean, maize, sweet potato and xanthan gum was used for bread production (Kiin-Kabari and Giami, 2015). The height ranged from 3.95 to 4.44cm. Sample WTF (100% wheat) had the lowest value while sample WPBC (70%wheat, 15% plantain, 15% Bambara) had the highest value. The height and diameter of the biscuit samples were also observed to increase gradually with increase in the level of Bambara, up to sample WPBD. Therefore, biscuits prepared from Bambara and plantain flour compared favorably in height and diameter with the control (100% wheat flour). This observation is similar to the report of Kiin-Kabari and Giami (2015) for cookies made from a blend of plantain and bambara protein concentrates.

3.5 Sensory properties of the biscuit made from composite flours and wheat flour

Sensory evaluation of composite biscuit samples as compared to the control (100% wheat flour) is presented in table 5. Interestingly, all the biscuits were accepted according to the panelists. Appearance is very significant parameter in judging well baked biscuits. It does not only reflect the suitable raw material used for the preparation but also provides information about the formulation and quality of the product (Giami et al., 2005). In terms of appearance, Sample WPBA(70% wheat + 25% plantain + 5% bambara flour) is the most preferred with the score of 7.45 while sample WTPF (70% wheat + 30% plantain flour) is the least preferred with a score of 6.45. The scores for aroma ranged from 6.73 to 6.36. Sample WPBC (70% wheat +15% plantain +15% Bambara flour) had the highest value (6.73) while sample WTPF (70% wheat + 30% plantain flour) had the least value (6.36). There was a significant different ($p<0.05$) among samples. In term of taste, sample WTF (100% wheat) is the most preferred with a score of 7.32 while sample WPBD (70% wheat + 10% plantain + 20% Bambara) is the least preferred with a score of 6.23. This variation may be due to the natural taste of the flour samples used for the biscuit production. This may have contributed to the choice of the panelist. There were significant differences ($P<0.05$) between the samples in terms of crispness. However, there was no significant difference between WTPF (70% wheat + 30% plantain) and WPBB (70% wheat+10% plantain + 20% bambara) In general acceptability, sample WTF (100% wheat flour) was most preferred but among the biscuits produced from the composite flour, sample WPBE (70% wheat+5% plantain + 25% bambara flour) is the most acceptable. However, all the biscuit samples were all generally accepted. The overall result showed that the substitutions had minimal impact on the sensory properties at the levels used. Partial substitutions of wheat flour with non-wheat flours have been suggested by other authors (Julianti et al., 2015, Uchenna and Omolayo, Oyeyinka et al., 2014).

Table 5: Mean sensory score of biscuits made from wheat-plantain- Bambara flour

Samples	Aroma	Appearance	Taste	Crunchiness	Overall acceptability
WTF	6.68 ± 0.21^{a}	6.59 ± 0.53^{ab}	7.32 ± 0.17^{a}	6.68 ± 0.08^{a}	7.00 ± 0.51^{a}
WTPF	6.36 ± 0.25^{a}	6.45 ± 0.37^{b}	6.77 ± 0.23^{ab}	5.68 ± 0.49^{a}	6.41 ± 0.43^{ab}
WPBA	6.55 ± 0.40^{a}	7.45 ± 0.05^{a}	6.27 ± 0.08^{b}	6.36 ± 0.01^{a}	6.82 ± 0.40^{a}
WPBB	6.41 ± 0.14^{a}	6.64 ± 0.36^{ab}	6.27 ± 0.06^{b}	5.68 ± 0.04^{b}	6.09 ± 0.37^{b}
WPBC	6.73 ± 0.51^{a}	7.00 ± 0.29^{ab}	6.45 ± 0.53^{ab}	6.23 ± 0.07^{a}	6.73 ± 0.42^{a}
WPBD	6.64 ± 0.39^{a}	6.80 ± 0.33^{ab}	6.23 ± 0.60^{b}	5.95 ± 0.10^{a}	6.75 ± 0.03^{a}
WPBE	6.59 ± 0.01^{a}	6.82 ± 0.33^{ab}	7.09 ± 0.15^{ab}	6.86 ± 0.42^{a}	6.85 ± 0.14^{a}
WTBF	6.65 ± 0.01^{a}	6.65 ± 0.02^{ab}	6.69 ± 0.01^{ab}	6.56 ± 0.05^{a}	6.60 ± 0.12^{a}

WTF= 100% Wheat flour; WTPF= 70% wheat flour + 30% plantain flour; WPBA= 70% wheat+ 25% plantain flour+ 5% Bambara flour; WPBB= 70% wheat flour + 20% plantain+ 10% Bambara; WPBC= 70% wheat flour +15% plantain flour +15% Bambara flour; WPBD= 70% wheat flour + 10% plantain flour + 20% Bambara flour; WPBE= 70% wheat flour+ 5% plantain flour+ 25% Bambara flour, WTBF=70% wheat flour + 30% Bambara flour.
The values are expressed as the mean of three replicate samples. Values with similar superscripts in a column do not differ significantly ($P <0.05$).

4. CONCLUSIONS

This study has shown that acceptable biscuit with high protein content can be produced from wheat, plantain and Bambara flour. Biscuits made from the composite blends had acceptable quality similar to those made from 100 % wheat flour. Biscuits made from 70%wheat+ 5%plantain flour +25% Bambara groundnut compared favorably with the control. Sensory scores showed that sample WPBE (70% wheat +5% plantain + 25% Bambara flour) was preferred with reference to taste, crunchiness and general acceptability. This finding will serve as an alternative for biscuit confectionary industries in Nigeria and other tropical countries in Africa that depends solely on imported and expensive wheat flour for processing. The nutritive value of Bambara groundnut in the biscuit could improve the nutritional status of children who consumes biscuit as snack food.

Conflict of interest

The authors do not have conflict of interest

5. REFERENCES

[1] Abioye, V. F., B.I.O.Ade-Omowaye, Babarinde, G. O. & M.K.Adesigbin, A. (2011): Chemical, physico-chemical and sensory properties of plantain flour. *African Journal of Food Science,* 5**,** 176-180.

[2] Adegunwa, M., Adebowale, A., Bakare, H. & Ovie, S. (2014): Compositional characteristics and functional properties of instant plantain-breadfruit flour. *Int. J. Food Res,* 1**,** 1-7.

[3] Aoac 2000. *Official methods of analysis (17th ed.),* Rockville Maryland.

[4] Arisa, N., Adelekan, A., Alamu, A. & Ogunfowora, E. (2013): The effect of pretreatment of plantain (Musa parasidiaca) flour on the pasting and sensory characteristics of biscuit. *International Journal of Food and Nutrition Science,* 2**,** 10-24.

[5] Arise, A. K., Alashi, A. M., Nwachukwu, I. D., Malomo, S. A., Aluko, R. E. & Amonsou, E. O. (2016): Inhibitory properties of bambara groundnut protein hydrolysate and peptide fractions against angiotensin converting enzymes, renin and free radicals. *Journal of the Science of Food and Agriculture*. DOI: 10.1002/jsfa.8112

[6] Arise, A. K., Amonsou, E. O. & Ijabadeniyi, O. A. (2015): Influence of extraction methods on functional properties of protein concentrates prepared from South African bambara groundnut landraces. *International Journal of Food Science and Technology,* 50**,** 1095-1101.

[7] Arise, A. K., Nwachukwu, I. D., Aluko, R. E. & Amonsou, E. O. (2017): Structure, composition and functional properties of storage proteins extracted from bambara groundnut (Vigna subterranea) landraces. *International Journal of Food Science & Technology,* 52**,** 1211-1220.

[8] D.B., K.-K. & Banigo, E. (2015): Quality Characteristics Of Cakes Prepared From Wheat And Unripe Plantain Flour Blends Enriched With Bambara Groundnut Protein Concentrate. *European Journal of Food Science and Technology,* 3**,** 1-10.

[9] Eissa, H. A., Hussein, A. & Mostafa, B. (2007): Rheological properties and quality evaluation on Egyptian balady bread and biscuits supplemented with flours of ungerminated and germinated legume seeds or mushroom. *Polish Journal of Food and Nutrition Sciences,* 57**,** 487-496.

[10] Falade, K. O. & Olugbuyi, A. O. (2010): Effects of maturity and drying method on the physico-chemical and reconstitution properties of plantain flour. *International journal of food science & technology,* 45**,** 170-178.

[11] Giami, S. Y., Achinewhu, S. C. & Ibaakee, C. (2005): The quality and sensory attributes of cookies supplemented with fluted pumpkin (Telfairia occidentalis Hook) seed flour. *International journal of food science & technology,* 40**,** 613-620.

[12] Ijarotimi, O. S. & Esho, T. R. (2009): Comparison of nutritional composition and anti-nutrient status of fermented, germinated and roasted bambara groundnut seeds (*vigna subterranea*). *British Food Journal,* 111**,** 376-386.

[13] Julianti, E., Rusmarilin, H. & Yusraini, E. (2015): Functional and rheological properties of composite flour from sweet potato, maize, soybean and xanthan gum. *Journal of the Saudi Society of Agricultural Sciences*. 16, 171-177

[14] Kiin-Kabari, D. B. & Giami, S. Y. (2015): Physico chemical properties and in-vitro protein digestibility of Non-wheat cookies prepared from plantain flour and bambara groundnut protein concentrate. *Journal of food research,* 4**,** 78.

[15] Lee, J. H., Cho, A.-R., Hong, J. Y., Park, D.-J. & Lim, S.-T. (2012): Physical properties of wheat flour composites dry-coated with microparticulated soybean hulls and rice flour and their use for low-fat doughnut preparation. *Journal of cereal science,* 56**,** 636-643.

[16] Mundi, S. & Aluko, R. (2012): Physicochemical and functional properties of kidney bean albumin and globulin protein fractions. *Food Research International,* 48**,** 299-306.

[17] Onimawo, I., Momoh, A. & Usman, A. (1998): Proximate composition and functional properties of four cultivars of bambara groundnut (Voandezeia

subterranea). *Plant foods for human nutrition,* 53**,** 153-158.
[18] Oyeyinka, S., Oyeyinka, A., Karim, O., Toyeeb, K., Olatunde, S. & Arise, A. (2014): Biscuit making potentials of flours from wheat and plantain at different stages of ripeness. *Croatian journal of food science and technology,* 6**,** 36-42.
[19] Oyeyinka, S. A., Singh, S., Adebola, P. O., Gerrano, A. S. & Amonsou, E. O. (2015): Physicochemical properties of starches with variable amylose contents extracted from bambara groundnut genotypes. *Carbohydrate Polymers,* 133**,** 171-178.
[20] Tiwari, B., Tiwari, U., Jagan Mohan, R. & Alagusundaram, K. (2008): Effect of various pre-treatments on functional, physiochemical, and cooking properties of pigeon pea (Cajanus cajan L). *Revista de Agaroquimica y Tecnologia de Alimentos,* 14**,** 487-495.
[21] Uchenna, C. J. & Omolayo, F. T. Development and quality evaluation of biscuits formulated from flour blends of wheat, bambara nut and aerial yam. Annals. Food Sci. and Tech. 18, 51-56