Biscuit making potentials of flours from wheat and plantain at different stages of ripeness

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Summary

The biscuit making potentials of wheat and plantain (stages 1 and 3 ripeness) flour blends were evaluated. Composite flours were formulated using wheat (white) and plantain flour in ratio $90/10^1$, $80/20^1$, $50/50^{1,}$ 100/0, $90/10^3$, $80/20^3$ and $50/50^3$ at stages 1 and 3 respectively with the superscripts representing the stage of ripeness. The functional properties of the flours, proximate composition, mineral composition and sensory attributes of the biscuit were evaluated. The loose bulk density (LBD) of flours ranged from 0.46-0.53 g/mL, the packed bulk density (PBD) ranged from 0.64-0.76 g/mL. The water absorption capacity (WAC) ranged from 1.19-2.02 g water/g flour and oil adsorption capacity (OAC) ranged from 0.50-1.00 g oil/g flour. The LBD and PBD values of the composite blends were higher than the control (100 % white wheat flour-sample D). The proximate composition ranged from 11.00 %-9.96 % for moisture, 1.21 %-1.27 % for ash, 2.98 %-4.30 % for fat, 11.82 %-12.64 % for protein, 0.97 %-1.52 % for fibre and 69.56 %-71.21 % for carbohydrate. The protein and carbohydrate value of biscuit produced from composite flour $80/20^3$ (sample F) was significantly ($P \leq 0.05$) lower than other biscuits. Composite flour $50/50^3$ had the highest protein content (12.64 %). The observed mineral composition varied among the samples. The content of calcium, iron and phosphorus ranged from 5.89-6.14, 0.48-0.78 and 21.97-23.46 mg/100g respectively. The calcium and iron contents of biscuit produced from flour blends F was significantly ($P \leq 0.05$) higher than other biscuits, while the phosphorus content of biscuit produced from composite flour $90/10^1$ (sample C) was higher than other biscuit samples. Sensory evaluation of the formulated biscuit samples showed similar sensory attributes with the control.

Keywords: Biscuit, wheat-plantain flours, quality, stage of ripeness

Introduction

Biscuits are one of the confectionary food product consumed in Nigeria especially among children. They are ready to eat, convenient and inexpensive food products, containing digestive and dietary principles of vital importance (Kulkarni, 1997). The major ingredients in biscuit production include flour, fat, sugar and water. Other ingredients added are either optional or added to give a desired sensory attribute. Wheat flour has been the major ingredient used in the production of biscuit and other pastry products. In Nigeria, reliance on wheat flour in the pastry and bakery industries has over the years restricted the use of other cereals and tuber crops available to domestic use. In recent years, government has through intensive collaboration with research institutes encouraged the use of composite flours in the production of bread and related food products such as biscuit. This initiative has enhanced the use of flours from cassava, sweet potato bread fruit, plantains and other underutilized crops that are good sources of flour. The adoption of these locally produced flours in the bakery industry will increase the utilization of indigenous crops cultivated in Nigeria and also lower the cost of bakery products (Ayo and Gaffa, 2002).

Nutritionally, plantain (*Musa paradisca*) constitute a rich energy source with carbohydrate accounting for 22 and 32 % of the fruit weight for banana and plantain respectively and also rich in vitamins A, B_6, C, dietary fibre, iron potassium and calcium (Adeniji et al., 2006). The use of plantain at different stages of ripeness in the production of biscuit could be one of several ways of increasing the utilization of plantain. Plantain has been reported to be a good source of dietary fibre which has several health benefits. Food processors are faced with the challenge of producing food products containing functional ingredients in order to meet the nutritional requirement of individuals. Therefore, biscuit can serve as a vehicle for delivery of important nutrients if made readily

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available to the population (Chinma and Gernah, 2007). This partly stimulated the research work into production of biscuit using varied ratios of wheat and plantain flour containing functional ingredients. Dietary fibre in human diets has been reported to lower serum cholesterol, reduces the risk of heart attack, colon cancer, obesity, blood pressure and many other disease (Rehinan et al., 2004).

The consumption of pastry products made from solely wheat flour has been linked to the prevalence of celiac disease caused by a reaction to gliadin, a protein in wheat and some other cereals. Considering the health benefit of plantain, its incorporation with wheat flour as composite blends, in the preparation of biscuits may enhance the nutritional and health status of consumers. This will help reduce total dependence on wheat flour and the incidence of celiac disease. The use of plantain in the production of composite flours for application in pastry and bakery has been well documented (Abioye et al., 2011; Akubor, 2003; Mepba et al., 2007; Olaoye et al., 2006; Yadav et al., 2012). Mepba et al. (2007) prepared composite breads and biscuits from mixed flours of wheat and plantain. Organoleptically most acceptable breads and biscuits were formulated from wheat-plantain composite flours using up to 80:20 (w/w) % and 60:40 (w/w) ratios of wheat: plantain flours for breads and biscuits respectively. On the account of high water absorption capacity of plantain flours, Akubor (2003) reported that they can be used as functional ingredient in bakery products.

According to Aurore et al. (2009) ripening classification defines 8 stages by colour index for banana (Fig. 1) At stages 1-3, banana is not usually eaten like fruit, because it is green, very hard, astringent, and rich in starch. At stage 8, banana is overripe and muddy. Bunches are usually harvested mature-green and then ripened either naturally at ambient temperature, or artificially in a controlled atmosphere chamber. During ripening, a number of changes take place which can affect the quality of banana and plantain as reported by (Dadzie and Orchard, 1997). Such changes like pH, soluble solids, pulp firmness, pulp to peel ratio, peel and pulp colour are indices for checking maturity in these fruits. The substitution of wheat flour with unripe plantain and banana flour in the production of cookies (Fasolin et al., 2007; Idoko and Nwajiaku, 2013) and their digestibility study (Aparicio-Saguila`n et al., 2007), have also been reported. There is no information on the use of wheat and plantain at different stages of ripeness or maturity in the production of biscuits. Therefore the aim of this work was to investigate the quality of biscuit produced from varied ratios of plantain at stages 1 and 3 of ripeness and wheat (white) flour.

Materials and methods

Fresh, matured green plantain was obtained from a farm in Ilorin. The fruits were utilized at stages 1 and 3 of ripeness using colour index chart according to Aurore et al. (2009) (Fig. 1). Polyethylene bags, knife (for peeling), wheat (white) flour, sugar, salt, fat, sodium bicarbonate (baking powder) and whole milk powder were purchased from Ipata market Ilorin, Nigeria. All reagents used were obtained from the Departmental Laboratory of Home Economics and Food Science, University of Ilorin, Nigeria.

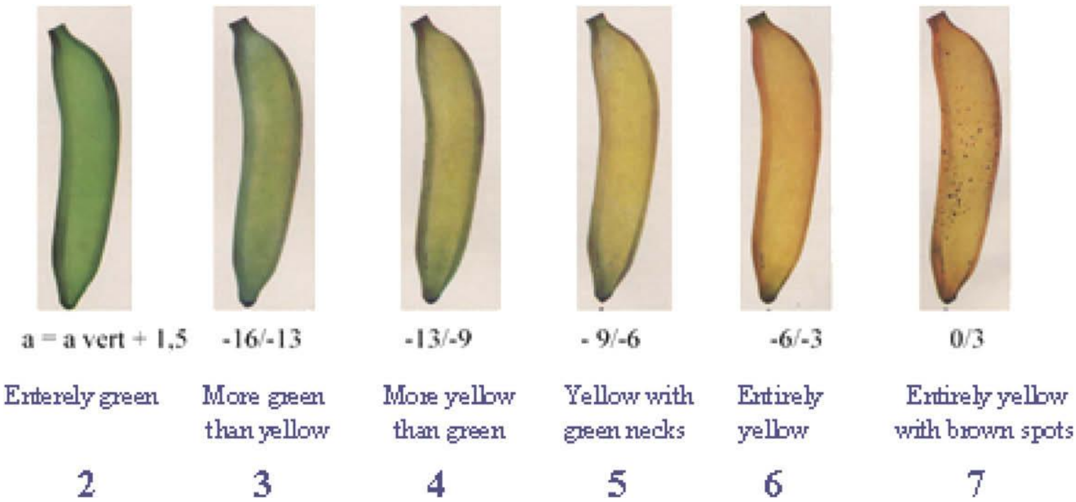

Fig. 1. Colour index according to the commercial peel colour scale

Above pictures are adapted from the work of Aurore et al. (2009).

Production of plantain flour

Plantain was oven dried using methods described by Falade and Olugbuyi (2010). The fingers were carefully detached from the bunch at the stage of ripeness (1 and 3) under consideration, sorted, cleaned, peeled and sliced to about 5 mm thickness. The slices were blanched at 80^{o}C for 5 min to prevent browning. The drained samples were dried (Model OV-160 size two BS, Gallenkamp, UK) in a cross flow oven at 60 ºC for 24 hours (Olaoye et al., 2006). The dried chips were milled using a hammer mill (8 Lab Mill, Christy and Norris Ltd, Process Engineers, Chelmsford, England) sieved (300-400 µm) and sealed in polythene bags (100 µm) until needed for baking.

Production of Biscuits

Seven blends were prepared by mixing wheat flour and plantain flours at stages 1 and 3 of ripeness in the percentages, as shown in Table 1 below. Biscuit were produced from the seven formulations using the method of Ihekoronye (1999). Ingredients used were 8 g sugar, 20 g fat, 2 g sodium bicarbonate, 4 g salt, 8 g milk and 76-80 ml of water. Sugar and fat (margarine) were mixed together. Sieved wheat-plantain flour, common salt, sodium-bicarbonate and water were added to prepare the dough. The dough was mixed using a B8 universal mixer (model IPX1, 7076) at 550 rpm for 15 min until uniform smooth dough was obtained. The dough was kneaded on a flat board sprinkled with the some flour to a uniform thickness using a wooden rolling pin. Circular biscuits were cut (using a circular biscuit-cuter of diameter 4 cm), placed on a greased baking tray and kept at ambient temperature for 2 hours to allow proper dough leaving. The samples were baked at once in an oven at a temperature of 200 ºC for between 15-20 min. until a very light brown colour was formed. Biscuits were removed from the oven and cooled. Samples used for sensory evaluation was used immediately after cooling while other samples were packed in air tight polyethylene bags (100 µm) and stored (24 hours) at ambient temperature (25 ± 2 ºC) until analysis.

Table 1. Samples of flour blends for biscuit production

Symbols	Wheat (white) flour (%)	Plantain flour (%)	
		Stage 1 of ripeness	Stage 3 of ripeness
A	50	50[1]	-
B	80	20[1]	-
C	90	10[1]	-
D	100	-	-
E	50	-	50[3]
F	80	-	20[3]
G	90	-	10[3]

Quality Evaluation

Determination of Water and oil Absorption Capacity

Water and oil absorption capacity of the flour was determined following methods adopted by Oyeyinka et al., (2013). One gram of flour sample mixed with 10 mL distilled water and 10 mL of refined soybean oil (sp. gravity 0.9092) for water and oil absorption capacity respectively. The mixture was allowed to stand at room temperature for 30 mins and then centrifuged (Philips Drucker, Oregon, USA) at 2000 g for 30 mins. Water absorption capacity was expressed as gram of water bound per gram flour and oil absorption capacity as gram of oil bound per gram flour.

Determination of bulk density

The method described by Mpotokwane et al. (2008) was adopted for the determination of bulk density with slight modification. 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).

Determination of proximate composition of biscuits

Proximate composition (moisture content, protein, fat, fibre, ash, carbohydrate) of biscuits were determined using methods described by AOAC, (1990).

Sensory Evaluation

The biscuits were evaluated by a panel of twenty 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 (Ihekoronye and Ngoddy, 1985). Scores were collated and analysed statistically.

Determination of mineral composition of biscuits

Mineral composition (iron, calcium and phosphorus) of the biscuit were determined using methods described by AOAC, (1990).

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 means.

Results and discussion

Functional properties of flour blends

The functional properties of the flour blends used for the biscuits is presented in Table 2. The loose bulk density (LBD) of flours ranged from 0.46-0.53 g/mL for samples D and A (50/50[1]) respectively. All the composite flours had relatively higher LBD than 100 % wheat (white) flour (sample D). This observation demonstrates greater compactness of the starch molecules in the composite flours (Falade and Olugbuyi, 2010) and thus, will allow the use of economical package for the flours (Osundahunsi and Aworh, 2002).

Similarly, sample D had the lowest packed bulk density (PBD) of 0.64 g/mL compared with the composite flours. The PBD varied significantly among the samples. The PBD of the composite flours with plantain at stage 1 of ripeness was higher than those formulated with plantain at stage 3 (Table 2). The relatively low densities could be attributed to the difference in particle size and to total or partial gelatinization of the flours, resulting from thermal effect during drying (Falade and Olugbuyi, 2010). Bulk density is related to the particle size and thus determines the extent of compactness of the flours (Perez, 1997). Although the bulk densities reported in this study are lower than those reported (0.83-0.85 g/mL) by Akubor (2003) for cowpea-plantain-wheat flour blends, the bulk density for the wheat flour is similar.

Both water absorption capacity (WAC) and oil absorption capacity (OAC) varied significantly ($p \leq 0.05$) in all examined samples. The WAC was higher for samples A, B, C than E, F and G. The difference in WAC could be due to difference in the granule size of the various formulations which may enhance the ability of the flours to absorb water. OAC varied from 0.50-1.00 g oil/g flour for sample B (80/20[1]) and A (50/50[1]) respectively. Oil absorption in starch relies predominantly on the physical entrapment of oil within the starch structure as starch does not possess nonpolar sites compared to those found in proteins (Abu et al., 2006).

Table 2. Functional properties of wheat and wheat-plantain composite flours

Sample*	Loose bulk density (g/mL)	Packed bulk density (g/mL)	Water absorption capacity (g water/g flour)	Oil absorption capacity (g oil/g four)
A	0.53^{a}	0.76^{a}	1.86^{b}	1.00^{a}
B	0.47^{d}	0.73^{b}	1.49^{d}	0.53^{c}
C	0.50^{c}	0.76^{a}	2.20^{a}	0.50^{c}
D	0.46^{e}	0.64^{d}	1.59^{c}	0.70^{b}
E	0.47^{d}	0.68^{c}	1.40^{e}	0.66^{b}
F	0.52^{b}	0.74^{b}	1.19^{f}	0.96^{a}
G	0.52^{b}	0.69^{c}	1.00^{g}	0.53^{c}

Means with the same superscripts along a column are not significantly different ($p \leq 0.05$)
*Symbols A, B, C, D, E, F and G are as defined in Table 1

Proximate composition of wheat plantain biscuit

The proximate composition of biscuits made from wheat and plantain flour blends are shown in Table 3.

The moisture content of the biscuit samples ranged from 9.96 %-11.00 % for biscuit produced from composite flour C and F respectively. The moisture content of sample F was significantly different from

other biscuit samples ($p \leq 0.05$). Similar values were reported by Akpapunam and Darbe (1994) in production of cookies from maize-bambara flour blends.
The protein content of the biscuit samples ranged from 11.82-12.64 % for biscuit made from sample F and E respectively. The protein content was not significantly different ($P \leq 0.05$) except for biscuit made from flour F. The biscuits produced from blend E contained higher protein than other biscuit samples. This may be attributed to the increase in the protein composition of plantain that increases as ripening progresses (INIBAP, 1999). Akubor, (2003) reported higher protein content (15.2-18.9 %) for biscuits made from wheat-cowpea-plantain flour blends. The higher values reported in this study could be attributed to the cowpea used, since cowpea is a good source of protein in the diet.
The carbohydrate content of the biscuits sample was different except biscuit made from sample F. Values observed for the carbohydrate content of the biscuits in this study, are similar to those reported for cookies produced from defatted sesame flour and plantain flour blends at a ratio of at 90:10 (Chinma et al., 2012). The ash content of the biscuits samples were similar to those previously reported for biscuits (Akpapunam and Darbe, 1994). The fat content of the biscuit samples prepared from the composite flours were higher than biscuits made from sample D. The crude fibre content of the biscuit varied significantly. Sample E and A had the lowest (0.97 %) and highest (1.49 %) crude fibre content respectively.

Table 3. Proximate composition of biscuits produced from wheat and wheat-plantain composite flours

Sample*	Moisture (%)	Protein (%)	Carbohydrate (%)	Ash (%)	Fat (%)	Crude Fibre (%)
A	10.40 ± 0.02^{bc}	12.49 ± 0.08^{a}	70.08 ± 1.00^{abc}	1.26 ± 0.03^{ab}	3.49 ± 1.0^{e}	1.49 ± 0.01^{ab}
B	9.99 ± 0.30^{c}	12.61 ± 0.10^{a}	70.04 ± 0.10^{abc}	1.27 ± 0.02^{ab}	4.30 ± 0.43^{b}	1.39 ± 0.2^{ab}
C	9.96 ± 0.47^{c}	12.50 ± 0.42^{a}	71.12 ± 0.40^{bc}	1.29 ± 0.02^{a}	3.72 ± 0.2^{a}	1.52 ± 0.1^{a}
D	10.04 ± 0.86^{b}	12.44 ± 0.15^{a}	71.15 ± 0.07^{ab}	1.21 ± 0.01^{d}	2.98 ± 0.3^{f}	1.44 ± 0.2^{ab}
E	9.97 ± 0.10^{c}	12.64 ± 0.30^{a}	71.16 ± 0.20^{ab}	1.25 ± 0.02^{c}	3.54 ± 0.2^{c}	0.97 ± 0.02^{c}
F	11.00 ± 0.20^{a}	11.82 ± 0.50^{b}	69.56 ± 1.9^{d}	1.27 ± 0.01^{ab}	3.46 ± 0.2^{f}	1.03 ± 0.03^{c}
G	10.44 ± 0.64^{bc}	12.21 ± 0.11^{ab}	71.21 ± 0.38^{a}	1.23 ± 0.01^{ab}	2.52 ± 0.1^{d}	1.27 ± 0.07^{b}

Means with the same superscripts along a column are not significantly different ($p\leq0.05$)
*Symbols A, B, C, D, E, F and G are as defined in Table 1

Mean Sensory Scores

The mean sensory scores of the biscuits produced from wheat-plantain flour blends at different proportion (Table 1) are shown in Table 4. Biscuit produced from sample D (control) were better accepted by panel members. However, sample A compares favourably well with the control in aroma crispiness and overall acceptability. Biscuits produced from composite flours using plantain at stage 3 of ripeness had low ratings for colour, crispiness and overall acceptability. The low ratings recorded could be due to the presence of higher amounts of sugar in the flours and the possible formation of dark coloured compounds during baking. Chemical changes that occur during post harvest ripening of fruits leads to the conversion of starch into simple sugars (Palmer, 1971). This is usually responsible for the sweetening of the fruit at it ripens. Although, the unique baking property of wheat flour has been well known (Ihekoronye and Ngoddy, 1985), the substitution of wheat flour up to 50 % with plantain flour in this study produced good results. Above this level, the organoleptic attributes of the biscuits were unacceptable from preliminary studies. Sample A, C and D had similar ratings for overall acceptability.

Table 4. Sensory evaluation of biscuits produced from wheat and wheat-plantain composite flours

Sample*	Aroma	Colour	Taste	Crispiness	Overall acceptability
A	6.10^{ab}	6.00^{b}	6.00^{b}	6.05^{a}	6.55^{a}
B	6.00^{abc}	5.60^{c}	5.95^{b}	6.45^{a}	5.95^{b}
C	6.50^{ab}	6.20^{b}	6.25^{a}	5.00^{b}	6.55^{a}
D	6.95^{a}	6.75^{a}	6.75^{a}	6.45^{a}	7.15^{a}
E	5.20^{c}	3.80^{d}	5.65^{c}	4.35^{ab}	5.00^{c}
F	6.65^{ab}	5.05^{bcd}	6.75^{a}	5.80^{b}	6.05^{b}
G	5.50^{c}	4.45^{cd}	5.95^{b}	3.20^{c}	4.85^{d}

Means with the same superscripts along a column are not significantly different ($p\leq0.05$)
*Symbols A, B, C, D, E, F and G are as defined in Table 1

Mineral composition of the biscuits

The biscuits produced from wheat-plantain flour blends revealed had significantly ($p \leq 0.05$) higher calcium and iron content than the control (Table 5). This is may be due to the addition of plantain flour which contains higher amount of calcium and iron (INIBAP, 1999). However, the phosphorus content of wheat-plantain biscuit ($90:10^1$) was significantly higher than other biscuits.

Table 5. Mineral composition of biscuits produced from wheat and wheat-plantain composite flours

Sample	Calcium (mg/100g)	Iron (mg/100g)	Phosphorus (mg/100g)
A	6.12 ± 0.10^a	0.58 ± 0.06^c	22.33 ± 0.05^b
B	6.01 ± 0.06^b	0.73 ± 0.10^a	23.46 ± 0.05^a
C	5.99 ± 0.06^c	0.64 ± 0.10^b	23.80 ± 0.10^a
D	5.89 ± 0.06^c	0.48 ± 0.00^d	22.10 ± 0.10^b
E	6.06 ± 0.10^b	0.61 ± 0.10^b	23.20 ± 0.10^a
F	6.14 ± 0.06^a	0.78 ± 0.006^a	21.97 ± 0.05^c
G	6.04 ± 0.00^b	0.76 ± 0.006^a	22.50 ± 0.00^b

Means with the same superscripts along a column are not significantly different ($p \leq 0.05$)
*Symbols A, B, C, D, E, F and G are as defined in Table 1

Conclusions

This study has shown that acceptable biscuit can be produced from wheat flour and flour from plantain at different stages of ripeness. Biscuits made from the composite blends had acceptable quality similar to those made from 100 % wheat flour (white). Biscuits made from wheat-plantain flour at stage 1 of ripeness up to 50 % addition compared favourably with the control. Substitution of wheat flour with plantain flour beyond 50 % did not produce good results. Therefore, substitution beyond this level is not encouraged. From the study, it was observed that the biscuits produced from the composite flour blend had better mineral quality than those produced from 100 % wheat flour because of their high calcium and iron content. Digestibility studies and energy value of biscuit obtained from wheat-plantain flour blends may be required in further studies.

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