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Nigerian Food Journal 33 (2015) 8–11
www.elsevier.com/locate/nifoj

Utilisation of broken rice and cocoyam flour blends in the production of biscuits

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Available online 23 May 2015

Abstract

Biscuits were produced from five broken rice and cocoyam flour blends which were: (1) 100% cocoyam flour, (2) 25% cocoyam flour:75% broken rice flour, (3) 50% cocoyam flour: 50% broken rice flour, (4) 75% cocoyam flour: 25% broken rice flour and (5) 100% broken rice flour. Biscuits made with 100% wheat served as the control. Functional properties of the flour blends were analysed while proximate composition, physical properties and sensory quality of the biscuits produced were also determined. Significant differences ($p < 0.05$) in the functional properties existed among the flour blends. Proximate content ranged as follows: protein: 7.18–10.54%; ash: 1.46–1.75%; fat: 11.17–18.52%; moisture: 6.56–7.89%; fibre: 1.15–1.23% and carbohydrates: 58.71–65.97%. Biscuits made with wheat flour did not differ significantly ($p > 0.05$) from those made with 50% cocoyam and 50% broken rice flour blend with respect to the physical properties and sensory quality.

Keywords: Wheat; Physical properties; Sensory quality

1. Introduction

Biscuits are one of the most popular bakery products made from cereals that are consumed by nearly all people in the world. They are snacks produced from palatable dough that is transformed into an appetising product through the application of heat in the oven (Kure et al., 1998). They are made from flour, sugar, milk, fat, flavouring agents and other chemical additives. Sometimes bakery products are used as vehicles for the incorporation of different nutritionally rich ingredients (Sudha et al., 2007).

Wheat flour, the main ingredient for biscuit production is imported by countries with unfavourable climates for growing wheat. This importation has placed a considerable burden on the foreign exchange reserves of the economies of such importing countries. This has led to the development and use of composite flours for production of biscuits, bread and pastry products. Composite flour has been defined as a mixture of several flours obtained from roots and tubers, cereals, legumes etc. with or without the addition of wheat flour (Adeyemi and Ogazi, 1985).

Rice is a cereal which is used mainly for human food. The milling process of rice causes some loss of nutrients and breakage of some rice resulting in “broken rice.” Little attention has been paid to the use of broken rice in Nigeria. Indeed, it is underutilised and often referred to as “poor man's food” in some societies because it is cheaper than unbroken rice and purchased mainly by those who cannot afford unbroken rice. Bean et al. (1983) reported that rice is free from allergens and is widely used in baby foods and other products. The use of flour from broken rice in products could significantly increase the utilisation of broken rice grains; thereby reducing losses that are normally incurred with the locally processed rice grains in Nigeria.

Cocoyam is an edible root crop grown in the tropics of which Nigeria is a major producer. The flour has been used in baking and its fine granular starch improves binding and reduces breakage of

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Peer review under responsibility of Association of Vice-Chancellors of Nigerian Universities.

http://dx.doi.org/10.1016/j.nifoj.2015.04.010
0189-7241/

snack products (Huang, 2005). *Xanthosoma* sp of cocoyam, like broken rice grains is underutilised in Nigeria.

This work seeks to use flour blends produced from *Xanthosoma* spp of cocoyam and broken rice to produce biscuits with the aim of reducing complete dependence on the importation of wheat.

2. Materials and methods

Cocoyam (*Xanthosoma* sp.), wheat flour and other ingredients used for baking were purchased from a retail outlet in Abakaliki, Ebonyi State, Nigeria. Broken rice grains were procured from Ebony Agro Industries, Ikwo L.G.A., Ebonyi State, Nigeria.

2.1. Sample preparation

2.1.1. Cocoyam flour (CF) preparation

Cocoyam flour was produced as described by Okpala et al. (2013). The corms were washed, peeled, sliced and blanched at 80 °C. They were sun dried and milled in a hammer mill (Stedman, Model 20×12) to pass through a 40-mesh sieve (British standard). Flour was stored in airtight plastic containers at room temperature (28 °C; 24% R.H.) until needed.

2.1.2. Broken rice flour (BRF) preparation

The broken rice grains were cleaned by manually removing extraneous materials. The rice grains were washed with potable water; sun dried and milled using a hammer mill to pass through a 40-mesh sieve. Flour was stored in airtight plastic containers at room temperature until needed.

2.1.3. Formulation of flour blends

Five blends were prepared by mixing CF with BRF in the percentage proportions of 100:0, 75:25, 50:50, 25:75 and 0:100 respectively. Hundred per cent (100%) wheat flour formulation was served as the control.

2.1.4. Biscuit preparation

The ingredients used were: flour: 46.7%; vegetable fat: 18.7%; sugar: 11.7%; egg: 14.6%; milk: 7.0%; nutmeg: 0.1%; vanilla: 0.2%; salt: 0.5% and baking powder: 0.5%. Fat and sugar were creamed using an electric hand mixer (Kenwood HM 220) at medium speed for 5 min. Eggs and milk were added while mixing and then mixed for a total of about 30 min. Vanilla, nutmeg, flour, baking powder and salt were mixed thoroughly and added to the cream mixture where they were all mixed together to form a dough. The dough was rolled and cut using a circular shaped cookie cutter of 5 cm diameter. Baking was carried out in an electric oven (Gallenkamp oven 300 plus series) at 185 °C for 20 ± 5 min. Biscuit samples were cooled and stored in airtight containers until needed. Biscuits were made from wheat to serve as a control.

2.2. Proximate analysis

Protein, fat, moisture, fibre and ash were determined using methods described by AOAC (2000). Carbohydrate content was determined by difference.

2.3. Functional properties of flour blends

Water and oil absorption capacities were determined according to the methods described by Beauchat (1977). Bulk density and emulsion capacity were determined using methods described by Onwuka (2005).

2.4. Physical properties

Weight of biscuits was determined using an analytical weighing balance (Mettler MS 104S). Spread ratio was expressed as diameter/thickness (McWatters et al., 2003). Break strength of the biscuits was determined as described by Okaka and Isieh (1990) with slight modifications. Biscuit from each formulation was placed centrally between two parallel wooden bars. Another wooden bar was placed on the biscuit. Weights were then placed incrementally on the bar until the biscuit fractured. Break strength of the biscuit was regarded as the least weight that caused the breaking of the biscuit.

2.5. Sensory evaluation

Sensory evaluation was carried out using twenty semi-trained panellists (students of the Ebonyi State University, Abakaliki) who were regular consumers of biscuits and were not allergic to any food. Samples were scored for appearance, taste, texture, crispness and general acceptability on a 9-point hedonic scale with 1 representing dislike extremely, 5, neither like nor dislike and 9 like extremely (Ihekoronye and Ngoddy, 1985).

2.6. Statistical analysis

The data collected were subjected to analysis of variance (ANOVA). Means were separated using Duncan's new multiple range test (DNMRT) using the Statistical Package for the Social Sciences (SPSS) version 17.0 (SPSS Inc., Chicago, IL, USA).

3. Results and discussion

3.1. Functional properties of flour blends

Functional properties of the flour samples are presented in Table 1. Bulk density of the flour samples ranged from 0.66 to 0.91 g/cm^3. Sample from 100% wheat (100W) had the highest value of 0.91 g/cm^3 while the blend of 75% cocoyam: 25% broken rice flour (75CF:25BRF) had the least value of 0.66 g/cm^3. There was no significant difference ($p > 0.05$) in the bulk density of the blends. Bulk density gives an indication of the relative volume and type of packaging material required (Udensi and Okoronkwo, 2006). Oil absorption capacity of the samples were high and ranged from 2.24 to 2.96 g/g with the control having the highest value of 2.96 g/g while 100CF and 25CF:75BRF both had the least value of 2.24 g/g. Adeleke and Odedeji (2010) observed that the oil absorption capacity of wheat flour was 2.15 g/g. This value was close to the value reported in this work. Oil absorption capacity is of great importance since fat as a flavour retainer and increases the mouth feel of foods (Aremu et al., 2007). Water absorption capacity values of the samples were equally high with values ranging from 1.4 to 2.8 g/g. Obasi et al., (2012) reported that the water absorption capacity of wheat flour was 2.04 g/g while Adeleke and Odedeji (2010) reported a value of 2.45 g/g. The value for wheat flour in this work fell between these reported values. The high values obtained in this work for the flour blends suggest that the flours would be useful functional ingredients in bakery products. Emulsion capacity of the samples ranged from 52.63% to 60.00%. The sample from 100CF had the lowest value and it was the only sample that was significantly different ($p < 0.05$) from wheat flour. Brandt (1996) reported that emulsifiers help retard staling in baked goods, thereby prolonging the shelf life.

3.2. Proximate composition of biscuits

The proximate composition of biscuits produced is shown in Table 2. Moisture contents of the biscuits were all below 10% which suggests reduced chances of spoilage by microorganisms and consequently increased shelf life (Kure et al., 1998). Protein content ranged from 7.18% to 10.24%. Yadav et al. (2011) reported that biscuits produced with plantain and chickpea flour blends had protein contents which ranged between 7.1% and 9.2%. Values obtained in this work were not too different those values. Biscuits made with 100CF had the lowest protein content while the control had the highest value. It was observed that as the level of CF increased in the blends, the level of protein reduced in the biscuits. This could be due to the high level of carbohydrates present in cocoyam. Enwere (1998) reported that of the solid nutrients present in roots and tubers, carbohydrates predominate. Therefore the addition of CF may have had a "dilution effect" on the protein content of this biscuits. Even though biscuits from the blends had lower protein content than the control, the protein quality of the blends could be better than that of the control because roots and cereals complement each other with respect to essential amino acids. The protein quality of roots and tubers is sufficiently improved by cereal flours (FAO, 1990). Values for fibre ranged between 1.15% and 1.23%. There was no significant difference ($p > 0.05$) in the values obtained. The highest fat content was obtained from biscuits made with 50CF:50BRF (18.52%) while the control had the least value of 11.17%. Values obtained in this study were moderate. High levels of fat are undesirable in food products because they could lead to rancidity in foods leading to the development of unpleasant and odorous compounds (Ihekoronye and Ngoddy, 1985). Ash content of food materials is an indication of the minerals present in the food. It was observed that the control had the least ash content of 1.46% while biscuits made with 50CF:50BRF had the highest value of 1.75%. This suggests that biscuits from cocoyam and broken rice flour blends will provide more minerals to the consumer than the control.

Table 1
Functional properties of cocoyam and broken rice flour blends.

Blends (CF:BRF)	Bulk density (g/cm^3)	Oil absorption capacity (g/g)	Water absorption capacity (g/g)	Emulsion capacity (%)
100:0	0.67^b	2.24^b	1.40^d	52.36^b
75:25	0.66^b	2.42^b	2.4^{ab}	57.89^{ab}
50:50	0.68^b	2.51^{ab}	1.8^{cd}	57.50^{ab}
25:75	0.74^b	2.24^b	1.6^d	60.00^a
0:100	0.69^b	2.60^{ab}	2.8^a	59.30^a
100% Wheat flour	0.91^a	2.96^a	2.2^a	54.52^{ab}

Mean values within the same column with the same superscript are not significantly different ($p > 0.05$).

Table 2
Proximate composition of the biscuits.

Blends (CF:BRF)	Protein (%)	Moisture (%)	Fat (%)	Fibre (%)	Ash (%)	Carbohydrates (%)
100:0	7.18^c	6.78^e	17.24^c	1.18^a	1.65^b	65.97^a
75:25	7.24^d	7.86^a	18.37^b	1.20^a	1.68^b	63.67^b
50:50	8.24^b	7.89^a	18.52^a	1.23^a	1.75^a	62.38^c
25:75	8.36^b	6.56^d	18.36^b	1.22^a	1.70^{ab}	63.83^b
0:100	8.86^c	7.36^b	16.34^d	1.21^a	1.74^a	64.50^{ab}
100% Wheat flour	10.54^a	6.98^c	11.17^e	1.15^a	1.46^c	58.71^d

Mean values within the same column with the same superscript are not significantly different ($p > 0.05$).

3.3. Physical properties of biscuits

Physical properties of biscuits produced in this study are shown in Table 3. It was observed that biscuits made with 100CF had the highest break strength of 900 g. McWilliams (1974) reported that increase in rigidity is due to increase in carbohydrate starch granules, which is responsible for gel and structure formation in baked goods. Therefore, the hardness of 100CF biscuits could be attributed to the carbohydrate starch granules. Biscuits made with 100BRF had the least break strength of 592 g and it was significantly different ($p < 0.05$) only from 100CF.

Table 3
Physical properties of the biscuits.

Blends (CF:BRF)	Break strength (g)	Spread ratio	Weight (g)
100:0	900.00^a	9.10^b	9.65^a
75:25	832.00^{ab}	8.40^b	8.32^b
50:50	781.00^{ab}	9.21^b	10.44^a
25:75	810.00^{ab}	12.23^a	9.82^a
0:100	592.00^b	12.20^a	10.12^a
100% Wheat flour	682.00^{ab}	10.09^{ab}	10.17^a

Mean values within the same column with the same superscript are not significantly different ($p > 0.05$).

Table 4
Sensory scores of the biscuits.

Blends (CF:BRF)	Taste	Texture	Crispiness	Appearance	Overall acceptability
100:0	6.6[b]	7.0[abc]	5.9[b]	7.1[ab]	6.9[b]
75:25	6.3[b]	6.7[bc]	5.5[b]	6.7[bc]	6.4[bc]
50:50	7.9[a]	7.4[ab]	7.4[a]	7.9[a]	7.9[a]
25:75	5.5[b]	6.5[bc]	4.9[b]	5.7[c]	5.6[c]
0:100	5.8[b]	6.2[c]	5.6[b]	6.5[bc]	6.0[bc]
100% Wheat flour	8.1[a]	7.9[a]	7.7[a]	7.2[ab]	8.1[a]

Mean values within the same column with the same superscript are not significantly different ($p > 0.05$).

Biscuits having higher spread ratios are considered most desirable (Kirssel and Prentice, 1979). Biscuits from 25CF:75BRF had the highest spread ratio and it was not significantly different ($p > 0.05$) from the control and 100BRF. Controlling biscuit spread is one of the most serious problems encountered in biscuit production; a biscuit which spreads so much that it cannot be filled in the package, or one that spreads too little, causing slack fill or excess height for package, can create havoc on the packaging line (Matz, 1992).

3.4. Sensory evaluation of biscuits

Presented in Table 4 are the sensory scores obtained for biscuits made from CF and BRF. There was no significant difference ($p > 0.05$) in the taste between the control and biscuits produced from 50CF:50BRF.The least score was obtained by 25CF:75BRF and it was not significantly different ($p > 0.05$) from 100BRF, 100CF and 75CF:25BRF. With regards the texture, the control, 50CF:50BRF and 100CF were not significantly different ($p > 0.05$) from each other while 100BRF received the least. This could be due to the type of starch present in rice. Crispiness has been reported to be the most important quality attribute in biscuits (Yahya, 2004). The control received the highest ratings for crispiness and it was not significantly different ($p > 0.05$) from 50CF:50BRF. All the other samples received significantly lower ratings ($p < 0.05$). Biscuits made with 50CF:50RF appeared to have the best appearance; however statistically, they were not different from the control and 100CF. With respect to general acceptability, the control and 50CF:50BRF were most preferred and they did not differ significantly ($p > 0.05$) while 25CF:75BRF was least preferred.

4. Conclusion

This study has shown that the blend of 50CF:50BRF has great potentials in biscuit manufacture as biscuits produced from them compared favourably with the control in most of the parameters studied. The use of these locally available crops in biscuit production could help reduce dependence on importation of wheat.

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