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Physical, Chemical and Sensory Properties of Cakes Produced From Wheat Flour Enriched With Bambara Groundnut Flour

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Abstract

Cakes were produced from the substitution levels of wheat flour at 50 - 100 % and enriched with 10 - 50 % level of Bambara groundnut flour and 100 % wheat flour as a control. The flour blends were evaluated for functional properties. The proximate composition of wheat flour and Bambara groundnut flour was carried out. Protein content of cake produced from 100 % wheat flour (18.37 %) was significantly ($p > 0.05$) lower than that of composite flour cakes. There was, however reduction in the values of ash in cakes enriched with Bambara groundnut flour at different substitution. Cakes from 50 % wheat and 50 % Bambara groundnut flour blends had the highest batter density, weight and volume of 1.04 g/cm3, 26.59 g and 78.7 % respectively. Acceptable cakes were produced from 50 % wheat flour and 50 % Bambara groundnut flour blends with regards to the crumb texture which compared favourably with the control (100 % wheat flour) except 70 % wheat and 30 % Bambara groundnut flour blends which differs significantly with other samples. The crumb colour and crust colour were not significantly different at all levels of Bambara groundnut flour enrichment compare with the control, except for sample 312 and 811 with values of 6.50, 6.40 and 6.05, 6.45 respectively. The flavour, taste and mouth feel of the cakes were also acceptable but sample 312, 630 and 811 respectively shows significant difference ($p > 0.05$) compared to others. The overall acceptability of the cakes were significantly different at 20 % and 30 % level of enrichment with Bambara groundnut flour. Wheat flour enriched with Bambara groundnut flour have improved nutritional qualities with fair acceptability.

Keywords: Cakes; Bambara groundnut flour; Wheat flour

Introduction

Increasing urbanization in African countries is changing the food habit and preference of the population towards convenience foods. Change in consumption pattern towards cake and similar foods made from wheat flour has become very popular in Nigeria. This has led to nutritional disorders and socio-economic implications such as high cost of wheat importation as it cannot be grown here in Nigeria [1]. Research efforts in developing countries have been focused on the improvement of protein quality of cereal products and other tuber crops [2]. Enrichment of cereal-based products (cakes) with other protein sources such as oil seeds and legumes (Bambara groundnut) has received considerable attention to fight malnutrition [3].

Bambara groundnut (BGN) is an underutilised crop predominantly grown in African countries [4]. Legume seeds such as BGN are good sources of dietary fibre and a cheap source of protein and BGN fibre has potential for both food and non-food applications [5]. An increase in consumer awareness of the health benefits of dietary fibre has led to the investigation of alternative sources by a number of researchers [6]. These health benefits include reduced risk of diseases of lifestyle, such as obesity, diabetes, coronary heart disease, some cancers and haemorrhoids [7]. Bambara groundnut has high vitamin and mineral contents like iron, phosphorous and calcium. It also has a high content of crude fibre and high level of sulphur containing amino acids which are limited in cereals. These compositions gave Bambara its high nutritive and health valueBambara groundnut (BGN) is an underutilised crop predominantly grown in African countries [8]. Legume seeds such as BGN are good sources of dietary fibre and a cheap source of protein and BGN fibre has potential for both food and non-food applications. An increase in consumer awareness of the health benefits of dietary fibre has led to the investigation of alternative sources by a number of researchers. These health benefits include reduced risk of diseases of lifestyle, such as obesity, diabetes, coronary heart disease, some cancers and haemorrhoids. Bambara groundnut is an indigenous African legume and is one of the common crops found on the continent [9].The seeds have high nutritional value and detailed compositional studies showed high protein content of 17 – 24 %, 6.8 % lysine and 1.3 % of methionine [10]. It is necessary to use Bambara groundnut flour as composite flour with wheat in baked product to take care of the widespread protein deficiency which is a global problem especially in developing countries. In fact, Bambara Groundnut has the potential in addressing the energy-protein malnutrition problem in developing countries because it is a proteinous food with a high amount of carbohydrate [11]. However, one set back of Bambara Groundnut flour in baked product is the beany flour associated with it [12]. Therefore, the purpose of this work is to prepare cakes from wheat composite flour blends enriched with Bambara groundnut flour and to analyse the quality characteristics of the produced cakes which included the physical, chemical, microbial and sensory properties of the product.

Cake is a baked product widely consumed from wheat flour. Wheat cultivation thrive best in temperate regions but susceptible to disease in warm humid tropics. Due to recent economic meltdown and certain health risk associated with wheat, substitution of wheat flour with locally cultivated crops in baked foods now has a focused attention [13]. Cakes are soft bakery products produced by baking a batter containing flour, baking powders and beaten eggs with or without shortenings. According to the final products desired, other ingredients such as flavourings, nuts, chocolate and dried fruits are also included [14]. Cakes are a major snack in the fast food industry and highlight of many celebrations. They are highly cherished by women and children. It is a complete food, rich in fat and proteins. There are literally millions of cake recipes and can be classified based on their accompaniment such as coffee cakes, occasion cakes or based, primarily on ingredients and cooking techniques. Cake may be small and intended for individual consumption such as queen cake while longer cakes are cut, sliced and served as part of a meal or social functions. Zambrano reported the development of low fat of light cakes by substituting the fat with either quar or xanthan gums. Jyotsna et al., [15] reported the effect of substitution of wheat flour with whey protein concentrate (WPC) at the level of 10, 20 and 30 % an egg replacer on the physical properties of the cake. Akubor [16] reported the protein content, physical and sensory qualities of some Nigerian snack foods particularly cakes, chin-chi and puff-puff prepared from blends of cowpea and wheat flours. Adegbanke et al., [17] also produced cookies from wheat flour which was enchriced with bambara groundnut flour at different levels of substitution. Plant proteins are gradually gaining acceptance as food ingredients. These are often used to enhance nutritional value of foods formulated from carbohydrate based ingredients such as wheat and plantain. Cakes have been produced from composite flours of wheat and plantain by Kiin-Kabari and Eke-Ejiofor. Kiin-Kabari and Eke-Ejiofor observed that plantain flour can be used in substituting wheat flour in cake production up to 30 %.

Materials and Method

Material Procurement

The Bambara groundnut seeds and wheat flour were purchased at Erekesan market in Akure, Ondo State, Nigeria. The equipment and chemicals were obtained from the Department of Food Science and Technology, Federal University of Technology Akure, Ondo State, Nigeria. The chemicals and reagents used were of analytical grade.

Preparation of the Flour Samples

Bambara groundnut flour was prepared by modifying the method described by Barimalaa et al., [18]. The Bambara groundnut was sorted to remove extraneous materials and damaged seeds. The seeds were then soaked in tap water at a ratio of 1:2 for 24 hours at room temperature. It was manually dehulled and dried in the hot air oven at a temperature of 50 oC for 19 hours. The dried samples were then milled using the attrition mill in the food processing laboratory to obtain the flour and was sieved into flour using 0.25 mm sieves and then the flour was packaged in an air tight container.

Preparation of Flour Blends

The flour to be used for cake production was from blends of Bambara groundnut flour and wheat flour. The flour was obtained by blending in the ratio of (100:0, 80:20, 70:30, 60:40, and 50:50, (wheat flour: Bambara groundnut flour). The 100 % wheat flour cake was used as the control sample and the manual method was used for the preparation of the dough.

Production of Cake

The cakes were produced from wheat flour and Bambara groundnut flour blends according to the creaming method described by Okorie and Oyeneke with slight modification. A measure of wheat flour and Bambara groundnut flour were blended in different proportion and the samples were mixed together in a mixer until a uniform flour was achieved. 250 g of wheat flour was measured to make the control, 12.5 g of baking powder, 10 g of vanilla flavour was added to the flour mixtures. 4 medium sized eggs, 125 g of granulated sugar and 125 g of butter were mixed thoroughly to form a cream. The cream was then mixed with the flour thoroughly until a slight firm mixture known as batter is achieved. Round shaped cup cake pans was prepared by putting cupcake paper into each pan. The cake batter was then poured in the greased pans. Due to the rising nature of the batter, it was not filled to the brim. Space was left on top of the pan. It was then baked in an oven at 150 oC for 20 minutes.

Physical characteristics of the cakes

The physical characteristics of the enriched cakes were measured using the method reported by Kiin-Kabari and Banigo. Physical parameters measured included height, weight, volume, specific volume. The queen's cake volume was calculated using the cone equation below.

Volume of cake (cm^3) = πh $(d^2 + db + b^2)$ where d and b are upper and lower diameters of cake. The specific volume was determined by dividing the cake volume by the weight.

Sensory evaluation of the enriched cakes

The cakes prepared from wheat flour and the composite flour were subjected to sensory evaluation and this was done by coding all the samples and serving them to twenty panelists that were familiar with assessment of bakery products. The cake samples were evaluated for sensory parameters which are crumb texture, taste, crust colour, flavour, crumb colour, mouth feel and general acceptability using the scoring text as described by Akinjayeju. The responses were scored on a nine point hedonic scale ranging from 1 (dislike extremely) to 9 (like extremely).

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Chemical Analysis

Crude protein, moisture content, fat, ash and crude fiber content of the cakes were determined according to the AOAC (2005) methods. The carbohydrate content was calculated by difference as described by AOAC (2005). Carbohydrate (%) = 100 – (% moisture + % protein + % crude fat + % crude fibre + % ash).

Statistical Analysis

All analysis was carried out in triplicates for all determinations and the results were expressed as mean of the triplicate determination. The SPSS 21.0 for windows computer software package was used for one way analysis of variance (ANOVA) and the Pearson correlation coefficients significance of the differences was ascribed at p > 0.05 for ANOVA. The difference in means was compared by using the Duncan's multiple range tests.

Results and Discussion

Physical characteristics of the cakes

The physical properties of cake prepared from wheat- Bambara groundnut flour are presented in Table 1. Batter density ranged from 0.94 % - 1.04 g/cm3 with 50 % wheat flour and 50 % Bambara groundnut flour cake having the highest. There was however no significant different between cakes prepared from 100 % wheat flour, 80 % wheat flour and 20 % Bambara groundnut flour blends and 70 % wheat flour and 30 % Bambara groundnut flour blends while there was significant different between cakes prepared from 60 % wheat flour and 40 % Bambara groundnut flour blends, 50 % wheat flour and 50 % Bambara groundnut flour blends and the rest of the formulations whose values were higher than the rest of the formulation. The increase in batter density due to substitution of Bambara groundnut flour could be responsible for the addition in cake

volume. The weights of the cakes from different proportion flour blends were significantly different and were found in the descending order of control < 312 < 630 < 811 < 322. The values of control, sample 312, 630, 811 and 322 were 25.73 g, 25.98 g, 25.80 g, 26.41 g and 26.59 g respectively. The significantly higher weight of wheat Bambara groundnut flour cakes may not be unconnected with high gluten content in wheat flour which enhance the moisture huddling capacity of the cake within its crumbs thus constitute to its weight (David et al., 2015). However the least weight was observed for the control

(25.73 g) which shows that the rest of the samples that were substituted Bambara groundnut flour were heavier and increase in further improved the cake volume to 787 cm3 (Sample 322). The specific volume of cake followed the same pattern. Although, the values obtained in this research are higher than those reported by Kiin-Kabari and Banigo), for cakes enriched with unripe plantain flour and Bambara groundnut protein concentrate. The differences involves may be due to difference in cake sizes and types which also affect the recipe formulation.

Samples	Batter density (g/cm3)	Height (cm)	Weight (g)	Volume (cm3)	Specific volume (g/cm3)
214	0.95 ± 0.01cd	3.46 ± 0.02bc	25.73 ± 0.02e	737.66 ± 6.35b	28.67 ± 0.21b
312	0.94 ± 0.02d	3.20 ± 0.00d	25.98 ± 0.01c	681.00 ± 0.00d	26.20 ± 0.01e
630	0.96 ± 0.00c	3.40 ± 0.00cd	25.80 ± 0.00d	723.00 ± 0.00c	28.01 ± 0.00c
811	0.99 ± 0.01b	3.39 ± 0.00a	26.41 ± 0.00b	721.66 ± 1.15c	27.31 ± 0.05d
322	1.04 ± 0.01a	3.70 ± 0.00ab	26.59 ± 0.02a	787.00 ± 0.00a	29.59 ± 0.01a
Means of triplicate determinations ± S.D					

Table 1: Physical properties of cakes prepared from wheat and Bambara groundnut flour blends.

Means with different superscripts on the same column are significantly different (p > 0.05) Key: Samples: 214 = Wheat Flour/Bambara groundnut flour (100:0), 312 = (80:20), 630 = (70:30), 811 = (60:40), 322 = (50:50).

Sensory evaluation of the cakes

Acceptable cupcakes were prepared from 50 % wheat flour and 50 % Bambara groundnut flour blends with regard to crumb texture which compared favourably with cakes prepared from 100 % wheat flour as shown in table 2. Although sample 630 differ significantly with sample 214 (control), the panellist found it acceptable. The crust colour and crumb colour of cake prepared from 70 % wheat flour and 30 % Bambara groundnut flour blends and 50 % wheat flour and 50 % Bambara groundnut flour blends compared favourably with cake prepared from 100 % wheat flour. Although sample 312 and 811 differs significantly with control, the panellist still found them acceptable the slight changes in colour is due to thermal effect

or reactions between amino acids and sugars. (Be-miller and Whistler 1996; Alobo, 2001). Acceptable cupcakes were prepared from 50 % wheat flour and 50 % Bambara groundnut four blends with regards to taste, flavour and mouth feel which compared favourably with cakes prepared from 100 % wheat flour. Although sample 312, 630 and 811 differ significantly with the control, the Panelists still found them acceptable. Also the overall acceptability of the cakes were not significantly different at the level of enrichment of 50 % wheat flour and 50 % Bambara groundnut flour when compared with the cakes prepared from 100 % wheat flour.

Samples Crumb	Taste	Crust	Flavour	Crumb	Mouth feel Overall	Texture colour	Colour acceptability
214	7.00±1.77ab	7.50±1.39a	7.35±1.08ab	7.75±1.07a	7.50±1.27ab	7.85±1.42a	7.75±1.16a
312	6.55±1.23abc	6.05±1.05b	6.40±1.39c	6.20±1.19bd	6.50±1.00c	6.25±1.41b	6.40±0.97c
630	6.90±1.58c	6.00±1.45b	6.75±1.20bc	6.20±1.02b	6.95±0.68bc	6.65±1.75b	6.80±1.47bc
811	6.35±1.26bc	6.45±1.23b	6.45±1.35c	6.25±1.02b	6.40±0.88c	6.85±1.34b	6.95±1.23abc
322	7.45±1.42a	7.40±1.27a	7.70±1.21a	7.25±1.51a	7.70±1.03a	7.25±1.37ab	7.60±1.56ab

Table 2: Sensory score of cake prepared from wheat and Bambara groundnut flour blends.

Means of triplicate determinations ± S.D

Means with different superscripts on the same column are significantly different (p > 0.05) Key:

Samples: 214 = Wheat Flour/Bambara groundnut flour (100:0), 312 = (80:20), 630 = (70:30), 811= (60:40), 322 = (50:50).

Chemical analysis of the cakes

The proximate composition of wheat flour and Bambara groundnut flour is shown in Table 3. The results are expressed on the wet matter basis per 100 g of material. The moisture content of wheat flour was 8.94 % and Bambara groundnut flour was 11.18 %. The results obtained were lower than the values reported by Nwosu (2013) in the production and evaluation of biscuits from Bambara groundnut and wheat flour.

The fat content for wheat flour was 14.89 % above the value reported by Belderok (2000) in the development in bread making processes plant foods for human nutrition. While the fat content for Bambara groundnut flour was 12.48 % higher than the range reported by Okafor (2010) in the production and evaluation of extruded snacks from composite flour of Bambara groundnut.

The ash content of the wheat flour was 4.85 %. The ash content was higher than the values reported by Belderok (2000) in the development in bread making processes plant foods for human nutrition. While the ash content of Bambara groundnut was 0.99 %.

The fiber content of wheat flour as shown in table 3 was 0.44 %. The result obtained was similar to the value reported by Belderok (2000) in the development in bread making processes plant foods for human nutrition. While the fiber content of Bambara groundnut flour was 0.40 %. The result obtained was lower than the values reported by Belderok (2000) and Nwosu (2013) in the production and evaluation of biscuits from Bambara groundnut and wheat flour.

Protein content of wheat flour was 11.15 %. The result obtained was lower than the value reported by Nwosu (2013) and this may be as a result of the wheat type. While the protein content of the Bambara groundnut flour was 22.75 %. The result was in agreement with values reported by Okafor (2010) in the Production and evaluation of extruded snacks from composite flour of Bambara groundnut and was also higher than the values reported by Nwosu (2013). The difference in value may be attributed to the specie of Bambara groundnut seed used in the flour production.

The carbohydrate content of wheat flour was 61.31 % while the carbohydrate content of Bambara groundnut was 52.18 %. The result obtained in this research study was in agreement to the values reported by Nwosu (2013) in the production and evaluation of biscuits from Bambara groundnut and wheat flour and Okafor (2010) in the production and evaluation of extruded snacks from composite flour of Bambara groundnut.

Samples	Moisture	Fat	Ash	Fibre	Protein	CHO
214	15.82±0.37c	35.85±0.27d	2.93±0.01a	0.36±0.01c	18.37±0.87c	26.65±0.26a
312	19.53±0.10a	38.34±0.26a	0.88±0.01d	0.56±0.01b	20.25±0.75b	20.48±0.38d
630	18.02±0.66b	36.56±0.08c	2.17±0.01b	0.25±0.00d	21.00±0.00ab	21.98±0.70c
811	17.36±0.28b	36.91±0.27c	1.91±0.01c	1.67±0.02a	18.81±0.44c	23.33±0.46b
322	17.86±0.21b	37.80±0.30b	1.91±0.03c	0.24±0.00d	21.87±0.87a 20.28±1.03d	
Means of triplicate determinations ± S.D						

Table 3: Proximate Composition of the Cakes Produced from

Wheat and Bambara Groundnut Flour Blends (100%).

Means with different superscripts on the same column are significantly different (p > 0.05)

Key: Samples: 214 = Wheat Flour/Bambara groundnut flour (100:0), 312 = (80:20), 630 = (70:30), 811 = (60:40), 322 = (50:50).

CHO – Carbohydrate

Conclusion

Acceptable cup-cakes were prepared from flour blends of 50 % wheat flour enriched with 50 % Bambara groundnut flour (Sample 322) as shown in table 2 with regards to crumb colour, taste, crumb texture, crust colour, flavour, mouth feel and overall acceptability which compared favourably with the control. Sensory evaluation shows that composite cake has higher acceptability. The physical and chemical properties of the cakes produced from blends of wheat flour and Bambara groundnut flour were enhanced. It was clearly evident that Bambara groundnut has a significant nutritional impact on wheat flour.

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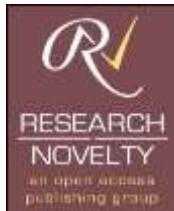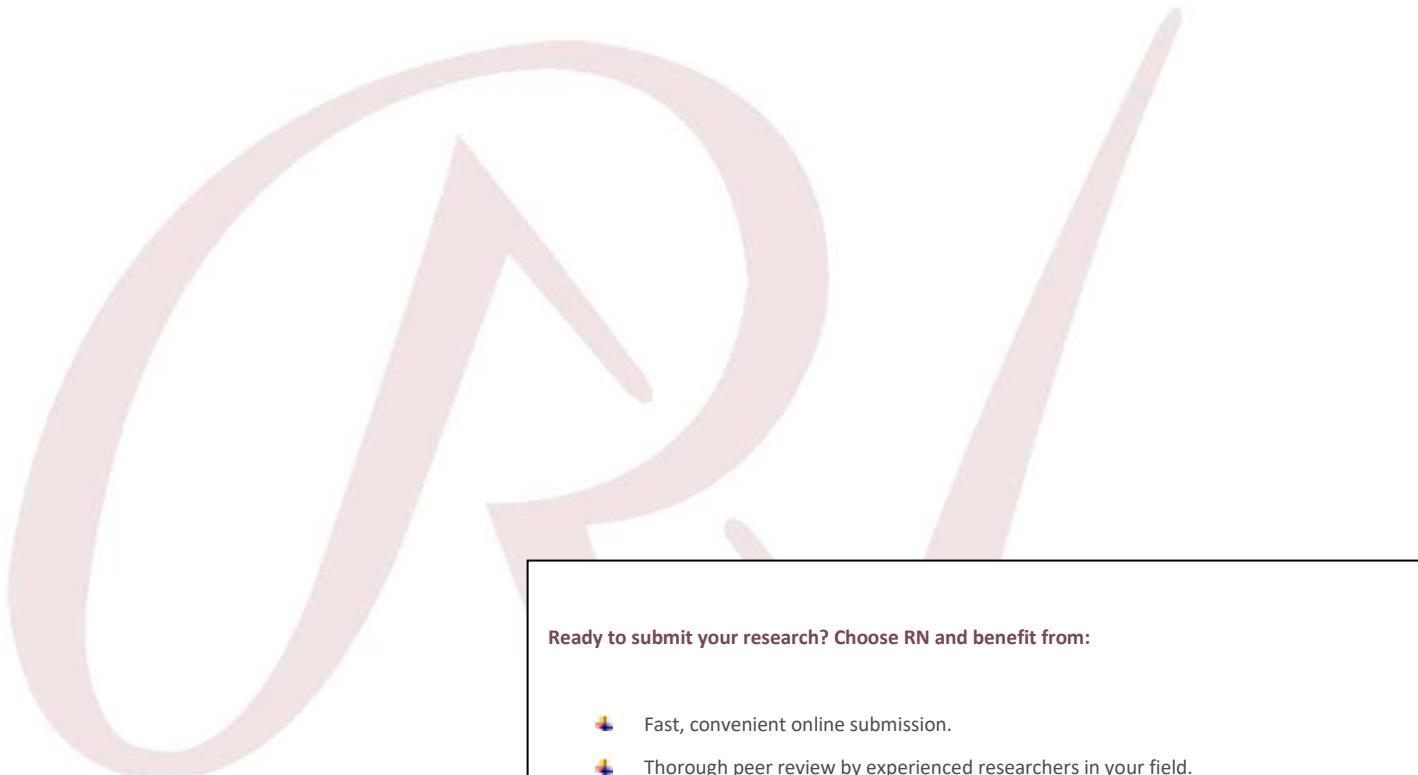
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