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Proximate, Mineral and Sensory Properties of Cookies Produced from Cassava-bambara Groundnut Flour Blends

Eke-Ejiofor J.[1], Beleya E.A.[2,*], Allen J.E.[2]

[1]Department of Food Science and Technology, Rivers State University, Port Harcourt
[2]Department of Home Science and Management, Rivers State University, Port Harcourt
*Corresponding author: ellen.beleya@ust.edu.ng

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Abstract The aim of the study was to determine the proximate, mineral and sensory properties of cookies produced from cassava-bambara groundnut composite flour blends. Cassava tubers and bambara groundnut seeds were processed separately into flours The flours were blended in different ratios from 0 to 50% and used for the production of cookies which were evaluated for proximate, mineral and sensory properties using standard methods. The moisture, protein, fat, ash, crude fibre and carbohydrate contents of the cookies ranged from 5.35 to 7.00%, 3.45 to 15.30%, 17.53 to 19.36%, 1.23 to 3.39%, 1.60 to 11.93%, and 54.91 to 64.41% respectively. The mineral composition of cookies showed significant ($p < 0.05$) variations among the samples. Calcium ranged from 13.47 to 22.07 mg, iron ranged from 9.43 to 20.73 mg and sodium 18.46 to 65.54 mg. The sensory properties of the cookies varied significantly ($p < 0.05$). Colour ranged from (6.45 to 7.80), texture (6.65 to 7.40), aroma (5.95 to 7.20), crispness (6.00 to 7.20), taste (6.10 to 7.35) and overall acceptability (6.38 to 7.29). Cookies produced from cassava/bambara flour blends had improved nutrient contents and were acceptable to the consumers.

Keywords: *cookies, wheat flour, flour blends, cassava, bambara groundnut*

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1. Introduction

Cookies are ready-to-eat baked food products consumed as snack by people of all ages. They are convenient, inexpensive and are among the extensively consumed bakery products worldwide. Cookies are produced basically from wheat flour, sugar, fat and other minor ingredients. They are considered to be of low nutritional value due to their high content of sugar and fat [1]. However, their low moisture content increases shelf life and makes them less susceptible to microbial spoilage [2]. The consumption of baked products such as cookies is in high demand due to changes in the food habits of consumers [3].

Wheat flour is the major ingredient used in cookies production. It is obtained from the wheat grain which is not grown in Nigeria due to unfavourable climatic conditions [4]. The importation of wheat therefore increases the cost of wheat based products and could lead to economic drain. Wheat like other cereals is limiting in certain essential amino acids. Thus, sustaining the production of affordable and nutritious cookies requires the development of an adequate substitute for wheat flour from locally available and inexpensive food crops.

The use of flour blends from locally grown crops would not only reduce the high cost of importation of wheat but could also be a means of addressing the problem of food insecurity and malnutrition [5]. Composite flours from tubers, cereals and legumes have better nutritional value than flour milled from single crops alone [6]. The use of composite flour in food product development is increasing due to their high nutritional value.

Cassava is a crop widely cultivated in Nigeria. It is an important staple food and a major source of carbohydrate for millions of people globally [7]. Cassava flour has high starch content but deficient in protein, vitamins and minerals; this affects its nutritional quality and extended use [8]. However its utilization in food product development could be increased when used as a blend with protein rich legumes.

Bambara groundnut is one of the locally available legumes with nutritional composition that make it suitable for use in composite flour production. It is rich in protein, vitamins and minerals with iron content higher than most other legumes [5]. The production of flour blend from cassava and bambara groundnut could complement for the nutrients deficient in cassava flour and increase its utilization. Flour blend from cassava and bambara groundnut could be used as substitute for wheat flour in bakery products that does not require volume increase and

extensive gluten development such as cookies. Therefore the main objective of the study is to determine the nutrient and sensory characteristics of cookies produced from cassava and bambara groundnut flour blends.

2. Material and Methods

2.1. Materials

Bambara groundnut seeds (*Vigna Subterrenea*), were purchased from Mile 3 Market Port-Harcourt, Rivers State. The seeds were stored at room temperature 32°C until used. Cassava (*Manihot esculenta*) tubers (TMS 30572) were obtained from the Rivers State University Farm in Port-Harcourt. All the chemicals used for analysis were of analytical grade.

2.2. Methods

2.2.1. Preparation of Cassava Flour

Cassava tubers were processed using the high-grade processing method as described by Eke-Ejiofor *et* al., [5]. Freshly harvested cassava tubers were sorted, peeled, washed and grated into a wet mesh and then dewatered using a muslin cloth and the cake pulverized. The pulverized cake was oven dried at 60°C for 12 h, milled with a bender, sieved with a 250 µm mesh size. The flour obtained was packed in air tight plastic containers and stored at 28±2°C.

2.2.2. Preparation of Bambara Groundnut Flour

Bambara groundnut flour was produced using the method described by Eke-Ejiofor *et* al., [5]. Bambara groundnut seed were sorted, washed and soaked in water for 24 h at room temperature (28±2°C) with the water changed every 12 h. The seeds were dehulled by manually rubbing in between the palms and fingers and then dried at 60°C for 12 h. The dried seeds were then milled in a blender and sieved with a 250 µm mesh size to obtain the flour which was packed in air tight plastic containers and stored at 28±2°C.

2.2.3. Formulation of Cassava /Bambara Groundnut Flour Blends

Cassava flour was substituted with Bambara groundnut flour at different levels from 0 -50 %. The flour was thoroughly mixed in a blender to obtain a homogenous flour blend.

2.2.4. Production of Cookies

The method described by Bivan and Eke-Ejiofor [3] was used for the production of cookies using Cassava and Bambara groundnut flour blends. The sugar (100 g) and baking fat (100 g) were creamed together until light and fluffy. Egg (1 large size whisked) and flour (200 g), milk powder (30 g), salt (1 g) and baking powder (1 g) were added and thoroughly mixed to obtain slightly firm dough. The dough was rolled out on a clean flat surface, cut into shape with a cookie cutter, arranged in greased baking trays and baked in a preheated oven at 180°C for 15 min. The cookies were allowed to cool to room temperature before packaging in air tight Ziploc bags and stored for sensory evaluation and analysis.

2.2.5. Determination of Proximate Composition of Cookies

The moisture, crude protein, fat, ash and crude fibre contents of the cookies were determined according to the methods of AOAC [9]. The carbohydrate content was calculated by difference.

2.2.6. Determination of Mineral Content

Mineral content of the samples were determined by the method of Allen [10] as described by Eke-Ejiofor *et al.*, [11]. The samples were digested with a mixture of perchloric ($HClO_4$), nitric (HNO_3) and sulfuric (H_2SO_4) acids. The digest was used for the estimation of the mineral content of the samples at different wavelengths and standards appropriate for each of the elements determined. The concentration of minerals in the cookie samples were determined using an Atomic Absorption Spectrophotometer (AAS) (model 5100 PCAAS, Perkin Elmer, USA).

2.2.7. Sensory Evaluation

The procedure described by Iwe [12] was slightly modified and used to evaluate the sensory attributes of the cookies. Cookies were evaluated for their sensory characteristics within 24 h of production by a twenty member semi trained panel made up of Staff and students of the Department of Food Science and Technology, Rivers State University, Port Harcourt. The evaluators were regular consumers of cookies or related products and who were neither sick nor allergic to any of the raw materials used for the production of the cookies. The samples were coded and presented in identical containers. A questionnaire was used to assess the degree of likeness of the cookies using a 9-point hedonic scale ranging from 9= like extremely to 1= dislike extremely. The samples were assessed for appearance/colour, texture, aroma, crispiness and taste while overall acceptability was calculated as the mean responses of all other attributes. Portable water was used for rinsing the mouth between each tasting to avoid after taste.

2.3. Statistical Analysis

Data were analyzed using a one-way analysis of variance (ANOVA) with Statistical Package for Social Sciences (SPSS) version 20.0 software 2011. Duncan Multiple Range Test was used to separate means where significant differences existed. Significance was accepted at $P< 0.05$.

3. Results

The proximate composition of the cookies produced from cassava-bambara groundnut flour blends shown in Table 1 revealed that the moisture content ranged from 5.35% in sample G (100% bambara flour cookies) to 7.00% in sample A (100% cassava flour cookies). Crude protein ranged between 3.45 and 15.40% with sample A (100% cassava flour cookies) having the least and sample G (100% bambara flour cookies) having the highest. The

fat content ranged from 17.53% in sample D (70% cassava: 30% bambara flour cookies) to 19.36% in sample F (50% cassava 50% bambara flour cookies). Ash content ranged from 1.23% in sample B (90% cassava: 10% bambara flour cookies) to 3.39% in sample G (100% bambara flour cookies). Crude fibre ranged from 1.60% in sample F (50% cassava 50% bambara flour cookies) to 11.93% in sample A (100% cassava flour cookies) while carbohydrate was between 54.91% and 64.41% with sample A (100% cassava flour cookies) having the least and sample F (50% cassava 50% bambara flour cookies) having the highest.

Table 2 shows the mineral composition of the cookies produced with cassava/bambara groundnut flour blends. The calcium content ranged from 13.47 to 22.07mg with Sample G (100% bambara flour cookies) having the lowest value and sample D (70% cassava: 30% bambara flour cookies) having the highest value. Iron content ranged from 9.43 mg in sample G (100% bambara flour cookies) to 20.73 mg in sample D (70% cassava: 30% bambara flour cookies) having the highest value, while sodium ranged from 18.46 mg in sample G (100% bambara flour cookies) to 65.54 mg in sample A (100% cassava flour cookies).

Table 1. Proximate composition of cookies produced from Cassava-Bambara groundnut flour blends (%)

Sample	Moisture Content	Crude Protein	Fat	Ash	Crude fibre	Carbohydrate
A	7.00^{a}±0.42	3.45^{f}±0.01	18.49^{ab}±0.51	1.73^{ab}±0.46	11.93^{a}±1.38	57.40^{bc}±5.5
B	6.70^{ab}±0.00	3.54^{f}±0.00	18.87^{ab}±0.13	1.23^{b}±0.18	8.93^{ab}±1.06	60.73^{ab}±0.75
C	5.95^{ab}±0.07	3.85^{e}±0.01	18.70^{ab}±0.29	1.61^{ab}±0.51	6.43^{bc}±1.21	63.46^{a}±2.06
D	5.85^{ab}±0.07	5.44^{d}±0.01	17.53^{b}±0.01	2.41^{ab}±1.00	7.38^{bc}±0.14	61.39^{ab}±1.09
E	6.65^{ab}±1.34	5.59^{c}±0.01	18.03^{ab}±1.22	2.97^{ab}±1.22	5.38^{cd}±3.11	61.38^{ab}±1.77
F	6.05^{ab}±0.78	6.14^{b}±0.01	19.36^{a}±0.85	2.44^{ab}±1.05	1.60^{e}±0.28	64.41^{a}±0.88
G	5.35^{b}±0.21	15.30^{a}±0.01	18.39^{ab}±0.16	3.39^{a}±1.19	2.66^{e}±0.71	54.91^{c}±0.10

Means with the same superscript along the same column are not significantly different ($p<0.05$)
A= 100% Cassava flour cookies, B=90% Cassava flour: 10% Bambara flour cookies
C=80% Cassava flour: 20% Bambara flour cookies, D= 70% Cassava flour: 30% Bambara flour cookies
E=60% Cassava flour: 40% Bambara flour cookies, F=50% Cassava flour: 50% Bambara flour cookies
G= 100% Bambara flourcookies

Table 2. Mineral composition (mg/100g) of cookies produced from Cassava/Bambara groundnut composite flour blend

Sample	Calcium	Iron	Sodium
A	16.03^{c} ± 0.04	19.05^{b} ± 0.07	65.54^{a} ± 0.01
B	19.83^{b} ± 0.01	18.33^{c} ± 0.01	35.31^{b} ± 0.01
C	21.24^{a} ± 0.00	17.53^{d} ± 0.01	31.71^{d} ± 0.01
D	22.07^{a} ± 0.00	20.73^{a} ± 0.01	30.63^{e} ± 0.01
E	17.32^{c} ± 0.01	13.99^{e} ± 0.01	32.28^{c} ± 0.07
F	15.77^{d} ± 0.00	14.96^{e} ± 0.01	33.75^{c} ± 0.01
G	13.47^{e} ± 0.01	9.43^{f} ± 0.02	18.46^{f} ± 0.01

Means with the same superscript along the same column are not significantly different ($p<0.05$)
Key:
A= 100% Cassava flour cookies, B=90% Cassava flour: 10% Bambara flour cookies
C=80% Cassava flour: 20% Bambara flour cookies, D= 70% Cassava flour: 30% Bambara flour cookies
E=60% Cassava flour: 40% Bambara flour cookies, F=50% Cassava flour: 50% Bambara flour cookies
G= 100% Bambara flour cookies

Table 3. Mean scores for the sensory attribute of Cookies produced from Cassava/Bambara groundnut composite flour blends

Sample	Colour	Texture	Aroma	Crispness	Taste	Overall Acceptability
A	7.20^{ab}±1.14	6.65^{a}±1.35	6.75^{ab}±1.55	6.00^{b}±1.52	6.35^{c}±1.63	6.59^{ab}±1.14
B	7.30^{ab}±1.07	6.65^{a}±1.60	6.60^{ab}±1.19	6.50^{ab}±1.10	6.25^{c}±1.55	6.66^{ab}±1.07
C	7.55^{a}±1.29	7.30^{a}±1.38	7.20^{a}±1.32	6.90^{ab}±1.55	7.35^{ab}±1.39	7.26^{a}±1.29
D	7.80^{a}±0.83	7.40^{a}±0.94	6.95^{a}±1.32	7.05^{a}±1.43	7.25^{ab}±1.07	7.29^{a}±0.83
E	7.30^{ab}±1.30	6.60^{a}±1.54	5.95^{b}±1.61	6.90^{ab}±1.68	6.25^{c}±1.48	6.60^{ab}±1.30
F	7.25^{ab}±1.13	7.15^{a}±1.46	7.00^{a}±1.34	7.20^{a}±1.51	7.45^{a}±1.28	7.21^{a}±1.13
G	6.45^{b}±1.33	6.70^{a}±1.59	6.35^{ab}±1.31	6.30^{ab}±1.81	6.10^{c}±1.97	6.38^{b}±1.33

Means with the same means with the same superscript along the same column are not significantly difference ($p<0.05$)
Key:
A= 100% Cassava flour cookies, B=90% Cassava flour: 10% Bambara flour cookies
C=80% Cassava flour: 20% Bambara flour cookies, D= 70% Cassava flour: 30% Bambara flour cookies
E=60% Cassava flour: 40% Bambara flour cookies, F=50% Cassava flour: 50% Bambara flour cookies
G= 100% Bambara flour cookies.

Table 3 shows the mean sensory scores for cookies produced from cassava/bambara groundnut composite flour blends. Colour ranged from 6.45 in sample G (100% bambara flour cookies) to 7.80 in sample D (70% cassava: 30% bambara flour cookies). The texture ranged from 6.60 in sample E (60% cassava: 40% bambara flour cookies) to 7.40 in sample D (70% cassava: 30% bambara flour cookies). The aroma of the cookies ranged between 5.95 and 7.20 with sample E (60% cassava: 40% bambara flour cookies) having the least and sample C (80% cassava: 20% bambara flour cookies) having the highest mean score. The mean values for crispness ranged from 6.00 in sample A to 7.20 in sample F while the taste ranged between 6.10 and 7.45 with sample G (100% bambara flour cookies) having the least mean score and sample F (50% cassava: 50% bambara flour cookies) having the highest mean score. The values for taste ranged from 6.10 in sample G (100% bambara flour cookies) to 7.45 in sample F (50% cassava: 50% bambara flour cookies). Sample G (100% bambara flour cookies) had the least mean score of 6.38 for overall acceptability while sample D (70% cassava: 30% bambara flour cookies) had the highest mean score of 7.29 for overall acceptability.

4. Discussion

The result of the proximate composition of the cookies revealed that cookies produced from the flour blends had lower moisture content and were significantly different from those produced from single flours (cassava and bambara groundnut) respectively. The lower moisture content of the cookies produced from the flour blends would have a longer shelf-life. Foods with low moisture content have higher storage stability and are less susceptible to microbial proliferation and spoilage [13]. Laelago *et al*., [14] reported a reduction in moisture content of cookies with increased substitution of orange-fleshed sweet potato flour for wheat flour.

Protein content of the cookies increased with increasing level of bambara groundnut substitution. This is due to the high protein content of bambara groundnut flour. Bambara groundnut flour has a protein content ranging between 19 and 20% [5,15]. The findings of this study corroborate that of Abioye *et al.*, [4] who reported higher protein content in cookies produced from wheat flour substituted with germinated finger millet and African yam bean flours.

Fat plays an important role in confectionary products especially cookies because it contributes to the flavour, texture and mouth-feel [16]. Significant difference was observed in the fat content of cookies produced from flour substituted with 30% (sample D) and 50% (sample F) bambara groundnut flour.

The ash content of the cookies increased with increase in the level of bambara groundnut flour substitution. A similar trend was reported for the ash content of cassava-bambara groundnut composite flour blends by Ejiofor *et al*., [5]. The findings of this study are in agreement with that of Abioye *et al*., [4] who also reported an increase in ash content of cookies with increased substitution of finger millet and African yam bean flours.

A significant reduction was observed in the crude fibre content of the cookies from 11. 93 to 1.60% as the level of substitution with bambara groundnut flour increased. Bambara groundnut flour has been reported to have a lower fibre content (0.02 to 3.60%) compared to cassava flour (0.14 to 5.78%) [5,15]. The values obtained for the crude fibre content of the cookies in this study are higher than the range of 1.25 -1.70% reported by Omah and Okafor [17] for cookies produced from wheat, millet-pigeon pea and cassava cortex composite flour blends.

The carbohydrate content of the cookies differed significantly among the samples and was higher in cookies produced from the composite blends. This may be due to the high starch content of bambara groundnut flour. Bambara groundnut flour has starch content of 82.5 % and its amylopectin content (79.8 %) is higher than that of cassava (74.1 %) [5].

The mineral composition of the cookies showed that calcium varied significantly ($p<0.05$) among the samples. Cookies produced from the composite blends had higher calcium content than the control. This is in agreement with the findings of Nwatum *et al*., [18] who also reported higher content of calcium in cookies produced from composite blends of wheat, defatted peanut and avocado flours.

Significant differences were observed in the iron content of the cookies and were lower in cookies produced from the composite flour blends than the control except sample D (70% cassava 30% bambara groundnut flour cookies) which was higher than the control. The values obtained are lower than the range of 20.55 to 65.53 mg/100 g iron reported for cookies produced from blends of acha, defatted soybean and defatted groundnut flour by Bivan and Eke-Ejiofor [3].

Sodium content of the cookies varied significantly ($p<0.05$) among the samples. Cookies produced from bambara groundnut flour had the least content of sodium and that of the composite flour blends were also lower than cookies produced from 100% cassava flour. This could be due to the low sodium content of bambara groundnut which was reported to be 0.10 mg/100g by Musah *et al*., [19]. Adeyanju *et al*., [20] reported lower values (14.81 to 20.43 mg/100 g) for sodium content of cookies produced from blends of wheat, acha and African yam bean flours.

The result of the sensory attributes of the cookies showed that the mean values of the cookies varied significantly among the samples in terms of colour, aroma, crispness, taste and overall acceptability while the texture did not vary significantly ($P>0.05$). Colour is an important sensory attribute of foods that affects consumers' acceptance of food products [21] and a criterion for assessing the quality of baked products [22]. The colour of cookies produced from composite flour blends with 20% (sample C) and 30% (sample D) bambara groundnut substitution were the most liked samples as they were rated highest.

The mean scores for the texture of the cookies did not vary significantly among the samples ($P>0.05$). This implies that substitution of cassava flour with bambara groundnut flour had little or no effect on the texture of the cookies. The mean scores for texture of the cookies which ranged from 6.60 to 7.15 indicate that the textures of the cookies were liked moderately by the panelists. Sanni *et al*., [23] reported similarities in the texture of

cookies produced from composite flour of wheat, sorrel seed protein isolate and yellow cassava flour.

Significant variations were observed for the aroma of the cookies. Samples C, (80% cassava: 20% bambara) D (70% cassava: 30% bambara) and F (50% cassava: 50% bambara) had the highest mean scores and were not significantly different. The substitution of cassava flour with bambara groundnut flour may have imparted a pleasant aroma resulting in the higher mean scores of cookies produced from the flour blends.

Crispness of the cookies made from the composite flour blends had higher mean scores and were distinguishable from the control (sample A). This could be due to the higher fat content of the cookies made from the composite blends. Crispness of baked food products is associated with fats which also imparts flavour and tenderness [24].

The taste of the cookies varied significantly ($p<0.05$) among the samples. Most of the cookies produced from composite flours were rated higher and differed significantly from the control (100% cassava) except samples B (90% cassava: 10% bambara) and E (60% cassava: 40% bambara). Sample F (50% cassava: 50% bambara) had the highest mean of 7.45. Previous studies have reported increased likeness for taste of cookies produced from composite flours than single flours [25,26].

Cookies produced from the composite blends had the highest mean ratings for overall acceptability. Samples C (80% cassava: 20% bambara), D (70% cassava: 30% bambara) and F (50% cassava: 50% bambara) with the highest mean scores for color, texture and taste also had the highest means for overall acceptability. This shows the extent to which these factors affect consumers' acceptability of food products.

5. Conclusion

The result of the study revealed that cookies produced from cassava/bambara groundnut composite flour blends had lower moisture and higher contents of protein, ash and carbohydrate. There was an appreciable increase in the calcium and iron contents of the cookies produced from the composite blends. Cookies produced from the composite blends had better acceptance for all the sensory attributes assessed. The utilization of composite flour of 70% cassava and 30% bambara groundnut for large scale cookies production is advocated as it resulted in acceptable cookies with improved nutrient content. The use of the composite flour blend for the development of other food products should also be explored.

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