Production and Quality of Biscuits from Composite Flours

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Abstract: Biscuits were produced from bambara nut, cowpea and wheat flour blends. This study was carried out to evaluate the effects of varying the proportions of these flours on the nutritional quality and general acceptability of the biscuits. Five blends of composite flours were prepared by mixing wheat, bambara nut and cowpea (WBC) flours in the proportions: T₁ (90:5:5), T₂ (80:10:10), T₃ (70:15:15), T₄ (60:20:20), T₅ (50:25:25) and 100% whole wheat flour was used as the control (T₀). Composite flours produced were subjected to functional and proximate analysis while the biscuits made from the flour blends were also subjected to sensory evaluation and proximate analysis. The use of composite flour for the production of biscuits from cowpea and bambara nut flours as supplement for the wheat flour has improved the nutritional contents of the biscuits with protein value being highest at mixing ratio T₅. The functional properties of the biscuits showed some significant differences ($p < 0.05$) when compared with whole wheat biscuits. The results showed that biscuits produced from T₅ formulation with proximate composition of 11.87% moisture, 2.90% ash, 18.61% protein and 75.62% carbohydrate was selected as the best product.

Key words: Biscuits formulation, composite flour, wheat, cowpea, bambara nut.

1. Introduction

Biscuit is an important edible confectionary crisp product of wheat majorly consumed with tea by human especially children and used as weaning food for infants [1]. The primary ingredients used for the production of biscuit (wheat flour, butter, salt, baking powder, fortified milk, whole eggs, sugar and vanilla) are deficient in protein which could be enhanced by supplementing the wheat flour with more nutritional pods and other leguminous crops [2].

Biscuit is an essential food material usually sold in ready to serve form contributing valuable quantities of 20 ppm iron, 12 ppm calcium, 100 ppm protein, 20 ppm calories, 40 ppm fibre and some of the

B-vitamins to our diet and daily food requirement [3].

Wheat flour used for the production of biscuits is insufficient in many regions of the world resulting in importation of the flour by regions with limit supplies [4]. There is therefore, a compelling need to develop an adequate substitute for wheat flour. This substitute should be readily available, cheap and capable of replacing wheat in functionality.

Bambara nut (*Vigna subterranean* L.) has been used by researchers as composite flour for baking because of its nutritional value. Bambara nut is high in protein that plays important role in human nutrition. Study shows that it contains 20-26% crude protein (high in lysine; 6.6%); and makes an excellent source of supplementing proteins in the diet [5].

Bambara nut is consumed in many ways: in many West African Countries, the fresh pods are boiled with salt and pepper, roasted seed can be boiled, crushed

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and eaten as relish and eaten as a snack while in Cote d'Ivoire, the seed is used to make flour, which makes it more digestible. In East African, the beans are roasted, then pulverised, and used to make soup, with or without condiments while in Zambia used for the production of bread [6]. Other common uses of bambara nut are for the production of various fried or steamed products such as "akara" and "moimoi" in Nigeria. Bambara nut milk was examined along side with cowpea, pigeon pea and soybean and was ranked first while all other milks were found to be acceptable [6]. Adu-Dapaah and Sangwan [7] reported that the seed is regarded as a balanced food because when compared to most legumes, it is rich in iron and the protein contents high lysine and methionine and in addition it is known to contain 63% carbohydrate, 18% oil and fatty acid content is predominantly linoleic, palmitic and linolenic acids [8].

Cowpea is one of the most drought tolerant crops and has big potential as food security crop for many poor African subsistence farmers. Cowpea also has high quality proteins that could compete favourably with soyabean protein when substituted in diets at equivalent protein content [9, 10]. A limited number of studies have also demonstrated that cowpeas have high antioxidant capacity [11] and that the antioxidant properties may be improved by heat processing or fermentation [12]. Research evidence also suggests that whole cowpea is effective at binding cholesterol and lowering blood cholesterol in hamsters [13].

Cowpeas (*Vigna unguiculata*) are grown extensively in 16 African countries. Nigeria and Niger put together produced 49% of the world crop. Available data of Food and Agricultural Organisation [14] indicated that cowpea is a cash crop in Burkina Faso, Ghana, Nigeria, Mali, Mauritania, Niger and Senegal. Among these, Nigeria is the largest producer both in the West African sub-region and in the world at large. More than 2.5 million metric tonnes of cowpea are produced annually. Nigeria has unfavourable climate condition for wheat cultivation,

but suitable for other cereals (sorghum, maize, millet and acha); legumes (soybean, groundnut, bambara nut, cowpeas) and vegetable [1]. Reports from International Institute for Tropical Agriculture (IITA) revealed that importation of wheat into the Country (Nigeria) amount to the tune of ₦40.7 billion in recent time. This research however, aimed at improving the quality of biscuit based products by the addition of bambara nut and cowpea as supplement to wheat flour at varying ratio.

2. Materials and Methods

The wheat, cowpea and bambara nut seeds used for this study were purchased at Muda-Lawan market in Bauchi, Bauchi State, Nigeria. Other ingredients: granulated sugar (1.25 g), fortified milk (15 mL), baking powder (2.0 g), whole eggs (1.25 g), butter (33 g), salt (0.2 g) and vanilla (1.0 g) used in the production of the biscuits formulation were also obtained from the same market.

2.1 Flour Preparation

Bambara nut flour was prepared using the method described by Nwosu [5]. Bambara nut seeds were cleaned manually to remove all foreign materials such as dust, dirt, small branches and immature seeds. The cleaned sample were sorted and steeped in water for 12 hrs; it was then dehulled and oven dried using Genlab oven, at 60 °C for 3 hrs and finely ground to powder (0.60 mm) form with a high speed grinding machine and sieved using 500 µm sieve to obtain fine flour (Fig. 1).

Cowpea seeds were manually cleaned and sorted to remove the foreign materials. Totally, 1,304 g was measured. In preparing the flour, samples were soaked in water for 5 minutes after which it was dehulled manually to remove the coat, then water was decanted alongside the coats. It was allowed to drain off and then dried in the oven dryer at 40 °C for 3 hrs. The dried seeds were finely ground using milling machine and sieved to obtain the flour (Fig. 1).

2.2 Biscuit Making

The mixing ratios of the biscuit formulations were as presented in Table 1 while the biscuit was prepared

Fig. 1 Bambara nut and cowpea flour preparation [5].

Table 1 Composite flour compositions of wheat, bambara nut and cowpea.

Treatment	Wheat flour	Bambara nut flour	Cowpea flour
T ₀ (Whole wheat flour as control)	100	0	0
T ₁ (5% bambara nut flour, 5% cowpea flour)	90	5	5
T ₂ (10% bambara nut flour, 10% cowpea flour)	80	10	10
T ₃ (15% bambara nut flour, 15% cowpea flour)	70	15	15
T ₄ (20% bambara nut flour, 20% cowpea flour)	60	20	20
T ₅ (25% bambara nut flour, 25% cowpea flour)	50	25	25

using the method described by AOAC [15]. The flours (200 g), butter (33 g) and salt (0.2 g) were mixed together manually for 5 min to get a creamy dough. The baking powder (2.0 g), fortified milk (15 mL), whole eggs (1.25 mL), sugar (1.25 g), vanilla (1.0 g) were mixed thoroughly. And 65 mL of water was gradually added using continuous mixing until good texture, slightly firm dough is obtained. The dough was kneaded on a clean flat surface for 4 mins. It was

manually rolled into sheets and cut into shapes using the stamp cutting method. The cut dough pieces were transferred into fluid fat grease pans and baked in an oven at 180 °C for 20 min, cooled and packed for further analysis.

2.3 Proximate Analyses of Wheat, Bambara Nut and Cowpea Flours.

The wheat, bambara nut and cowpea flours were

analyzed for moisture content, ash content, crude fibre, crude fat and crude protein as prescribed by the standard setup in Ref. [16]. Total carbohydrate was determined by simple difference method. Initial nutritional compositions of the three composite flours were determined in triplicates to evaluate effect of the treatment on the end product.

2.4 Physical Analysis of Biscuits

The diameter (width), thickness and spread factor of the biscuit product for each blend was determined as prescribed by Ayo et al. [17].

Spread factor is the ratio that depends on the values of the thickness and diameter of the biscuits. Spread factor (SF) was determined from the diameter and thickness using the formula:

$$SF = \frac{D \times CF \times 10}{T}$$

where, *CF* is a correction factor at constant atmospheric pressure, *T* = Thickness of biscuits (mm), *D* = Diameter of biscuits (mm) as its value was 1.0 in this case [17].

2.5 Sensory Evaluation of Biscuits

The biscuit formulations at the specified mixing ratios described in Table 5 were evaluated for quality and overall acceptability using 10 panelists; the sensory evaluation was carried out for colour, flavour, crispness, texture and overall acceptability (Table 5).

2.6 Statistical Analysis

The data obtained from this study were statistically evaluated using IBM SPSS 21.0 statistical tool while the mean significant differences of triplicate values were separated by Duncan Multiple range method using analysis of variance (ANOVA) at $p < 0.05$.

3. Results and Discussion

The mean initial proximate compositions of bambara nut, cowpea and wheat flour are presented in Table 2. The results indicate that total carbohydrate contents of the flours at raw stage were significantly higher in wheat flour than bambara nut and cowpea flour with 52.50%, 21.06% and 15.82% respectively; while bambara and cowpea flour were statistically higher in protein contents than wheat flour which are 43.40%, 57.02% and 21.4%, respectively. Crude fat contents were higher in cowpea than bambara nut and wheat flour (Table 2).

The results of proximate compositions of biscuit products at varying mixing ratios of bambara nut, cowpea and wheat flour indicate that there are statistical significant differences in the output ($p < 0.05$). However, crude protein contents were observed with high significant value of $18.61 \pm 0.01\%$ at mixing ratio T_5 (25% bambara nut flour, 25% cowpea flour and 50% wheat flour) as compared with the control (T_0) and other treatments (Table 3).

Table 2 Initial nutrient values of samples (bambara nut, cowpea and wheat) flour.

Parameter	Bambara nut	Cowpea	Wheat
Moisture (%)	3.68 ± 0.14	3.84 ± 0.29	12.3 ± 0.24
Ash (%)	8.41 ± 0.37	7.93 ± 0.17	3.68 ± 0.43
Crude protein (%)	43.40 ± 0.35	57.02 ± 0.43	21.4 ± 0.55
Crude fibre (%)	5.86 ± 0.18	6.08 ± 0.21	6.18 ± 0.27
Crude lipid (%)	4.40 ± 0.811	4.820 ± 0.19	0.18 ± 0.57
Carbohydrate value (%)	21.06 ± 0.53	15.82 ± 0.21	52.5 ± 0.60
Calorific value (kcal)	$5,784.55 \pm 0.12$	$6,260.10 \pm 0.52$	$1,704 \pm 0.45$
Ether extract (%)	17.59 ± 0.23	19.27 ± 0.11	15.01 ± 0.63
Nitrogen	6.94 ± 0.51	9.12 ± 0.76	3.43 ± 0.42
Phosphorus	14.62 ± 0.34	17.89 ± 0.61	0.146 ± 0.71
Calcium	2.63 ± 0.62	1.09 ± 0.51	0.104 ± 0.51

Table 3 Chemical composition of biscuit products.

Treatments	Moisture content (%)	Crude ash (%)	Crude protein (%)	Crude fat (%)	Crude fibre (%)	Carbohydrate (%)	Ca	Na
T ₀	8.57 ± 0.06 ^a	1.97 ± 0.00 ^a	13.11 ± 0.00 ^a	1.89 ± 0.00 ^a	2.98 ± 0.01 ^f	81.03 ± 0.03 ^e	0.04 ± 0.00 ^a	0.04 ± 0.00 ^a
T ₁	10.26 ± 0.01 ^b	2.10 ± 0.00 ^b	13.46 ± 0.00 ^b	0.97 ± 0.01 ^b	2.24 ± 0.01 ^e	81.24 ± 0.01 ^f	0.05 ± 0.00 ^a	0.04 ± 0.00 ^a
T ₂	10.83 ± 0.01 ^c	2.14 ± 0.01 ^c	13.94 ± 0.00 ^c	1.05 ± 0.01 ^c	2.02 ± 0.01 ^d	80.86 ± 0.21 ^d	0.05 ± 0.00 ^a	0.04 ± 0.00 ^b
T ₃	11.16 ± 0.01 ^d	2.23 ± 0.00 ^d	14.64 ± 0.01 ^d	1.10 ± 0.01 ^d	1.95 ± 0.01 ^c	80.09 ± 0.01 ^c	0.06 ± 0.00 ^a	0.05 ± 0.00 ^d
T ₄	11.59 ± 0.01 ^e	2.55 ± 0.00 ^e	15.20 ± 0.01 ^e	1.43 ± 0.01 ^e	1.81 ± 0.01 ^b	79.02 ± 0.01 ^b	0.24 ± 0.18 ^a	0.05 ± 0.00 ^d
T ₅	11.87 ± 0.01 ^f	2.90 ± 0.00 ^f	18.61 ± 0.01 ^f	1.96 ± 0.01 ^f	1.44 ± 0.01 ^a	75.62 ± 0.03 ^a	0.07 ± 0.00 ^a	0.06 ± 0.00 ^e

Values are mean ± SEM; T₀ = 100% of whole wheat; T₁ = 90% of wheat, 5% of bambara nut and 5% of cowpea; T₂ = 80% of wheat, 10% of bambara nut and 10% of cowpea; T₃ = 70% of wheat, 15% of bambara nut and 15% of cowpea; T₄ = 60% of wheat, 20% of bambara nut and 20% of cowpea; T₅ = 50% of wheat, 25% of bambara nut and 25% of cowpea.

High crude protein value experienced in the sample could be a result of increase in bambara nut and cowpea flour proportion which concurs with previous finding of Ref. [18].

This is an indication that the T₅ blending ratio can effectively supplement biscuit production from wheatflour to improve the protein requirement by consumers. General trend of the results of biscuit products in this work also indicated that T₅ consists of higher moisture content, crude ash, crude fat, crude fibre, calcium and sodium content as compared with other blending ratios (Table 3) but has least carbohydrate contents of 75.62 ± 0.03%. High ash content has been attributed to high minerals which invariably could increase the mineral content of the consumers and are good for the bones as reported by Agu et al. [19]. High values of crude fat content agree with the findings of Agu et al. [20] which can be improved on subsequently to serve as added advantage in improving product shelf stability alongside with observed high moisture content (11.87%) although within acceptable limit in terms of

food storage as recommended by USDA [20] which states 13-15% safe moisture contents as optimal range for storage of food and cereal grain. High value of fibre contents could also improve the digestion and aid waste elimination in the body and guide against anthracites [21]. Low value of carbohydrate content could be as result of initial low contents obtained in bambara nut (21.06 ± 0.53) and cowpea flour (15.82 ± 0.21) value which actually increased significantly in the final biscuit product as compared with the initial value of wheat flour (52.5 ± 0.60) (Table 2).

3.1 Physical Characteristics

The effects of biscuit prepared from different mixing ratios of bambara nut, cowpea substituted wheat flour as control (100% wheat flour) are shown in Table 4 while the physical characteristics of the product are shown in Fig. 2.

The spread ratio of the sample ranged from 51.45% in T₁ and T₂ to 76% in T₅ while the control (T₀) has 58%. An increase the spread ratio could be as a result of relatively increase in oil contents contained in the

Fig. 2 Physical appearance of biscuit production from composite flours.

Table 4 Physical characteristics of biscuits.

Sample	Thickness (mm)	Diameter (mm)	Spread factor
T ₀	47.33	274.5	58.00
T ₁	38	195.5	51.45
T ₂	37.67	194	51.45
T ₃	50	315	63.00
T ₄	39.33	244	62.04
T ₅	40	304	76.00

Table 5 Sensory attributes of composite biscuit from bambara nut, cowpea and wheat.

Treatment	Colour	Flavour	Crispness	Texture	Overall acceptability
T ₀	4.93 ± 0.03 ^{cd}	5.00 ± 0.58 ^{abc}	5.00 ± 0.58 ^b	5.33 ± 0.33 ^{ab}	4.97 ± 0.29 ^a
T ₁	4.30 ± 0.35 ^{bc}	5.33 ± 1.20 ^{bc}	3.00 ± 0.58 ^a	5.27 ± 0.54 ^{ab}	4.27 ± 0.45 ^a
T ₂	5.8 ± 0.76 ^d	5.97 ± 0.29 ^c	5.33 ± 0.88 ^{bc}	6.23 ± 0.23 ^b	7.00 ± 0.58 ^b
T ₃	3.33 ± 0.88 ^{ab}	3.20 ± 0.17 ^a	4.00 ± 0.58 ^{ab}	4.80 ± 0.35 ^a	5.00 ± 0.00 ^a
T ₄	3.05 ± 0.03 ^a	3.80 ± 0.15 ^{ab}	4.67 ± 0.33 ^{ab}	4.83 ± 0.17 ^a	4.67 ± 0.17 ^a
T ₅	8.20 ± 0.06 ^e	8.10 ± 0.15 ^d	7.07 ± 0.23 ^{bc}	8.20 ± 0.31 ^c	8.13 ± 0.23 ^c

Values are means ± SD of triplicate determinations. Values in the same column with different superscripts were significantly ($p < 0.05$) different.

mixing ratio of bambara nut and cowpea flour which could enhance the attribute and added advantage as it will prevent breaking during post handling of the biscuit. The mean diameter of the biscuit product as shown in Table 4 indicates varying significant difference ($p < 0.05$). Data revealed that the highest was observed in biscuits prepared from T₅ (304 mm) whereas the lowest was observed in T₂ (194 mm). This is an indication that increase in the mixing formulation contributes to an increase in the size of the product, this conforms with the findings of Ref. [1]. Thickness of biscuit was found highest in the formulation with T₃.

3.2 Sensory Evaluation Results

The results of the sensory evaluation of the biscuits produced from T₅ (25% bambara nut flour, 25% cowpea flour and 50% wheat flour) have overall acceptability while the quality of biscuits from T₃ and T₄ was rejected by the panellists (Table 5).

4. Conclusion

The study demonstrated use of composite flour for the production of biscuits from bambara nut and cowpea flours substituted for wheat flour which

positively improved the nutrient contents of biscuits with high value in protein, crude fat, crude fibre. Increase in the carbohydrate content in T₅ compared with initial value of wheat is also encouraging in term of balancing the vulnerable group diet. Overall acceptability of T₅ is a justification for the recommendation of biscuits production at 25% bambara nut flour, 25% cowpea and 50% wheat flour ratio which will enhance nutritional requirement for consumers and increase economic value of bambara nut and cowpea produce for possible application in the production of biscuit.

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