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Chemical, Functional, Physical and Microbial Properties of Snack from Blends of Rice, Bambara Groundnut Incorporated with African Egg Plant Leaves (Anara)

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ABSTRACT

This study was conducted to assess the chemical, physical, and sensory qualities of snacks made from mixtures of rice, bambara nut, and powdered African eggplant leaf. Rice was processed into flour by sorting, washing, drying, milling, and sieving it. While African eggplant leaves were destalked, rinsed, and dried at room temperature before milling, Bambara groundnut was sorted, washed, soaked, dehulled, dried, milled, and sieved. African eggplant, rice, and bambara groundnut flours were combined in varying ratios to make biscuits, with 100% wheat biscuits acting as the control. The biscuits' sensory attributes were identified. The most favoured samples, RBU, RUB, URB, UUB, and UBR, which scored 6.80, 7.40, 7.40, 6.00, and 7.70 correspondingly for sensory overall acceptability, were put through routine tests for chemical, physical, microbiological, and functional qualities. The range of the biscuits' physical characteristics, including weight, diameter, thickness, and breath, was 5.36 to 18.81g, 56.40 to 58.52 mm, 4.53 mm to 8.83 mm, and 53.52 mm to 56.56 mm, respectively. The biscuit's concentration of vitamins A (0.52 mg/100g - 0.94 mg/100g), B1 (0.01 mg/100g - 0.07 mg/100g), and B3 (0.23 mg/100g - 0.36 mg/100g) slightly increased. The samples' bulk densities, ability to absorb water and oil, and ability to swell ranged from 0.47 g/ml to 0.71 g/ml, 72.85% to 199.16%, 48.23% to 115.125%, and 17.51% to 36.00%, respectively. The sample biscuits had no mold growth, and the viable counts were satisfactory in general. The study concludes that items with additional value, such as biscuits, can be manufactured using composite flours made of rice, bambara groundnut, and African eggplant leaves.

KEYWORDS

Rice; Bambara nut; African eggplant leaf; Biscuit; Chemical properties

INTRODUCTION

According to Benton et al. [1], snacks are defined as foods and beverages consumed in between meals, such as milk drinks, ordinary soft drinks, sports drinks, and energy drinks. Snacks often only have a shelf life of one to two days because they are intended for rapid consumption [2]. However, with the right packaging, this shelf life can be

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increased. Despite their negative reputation among dietitians, snacks are becoming more and more popular because people are changing their eating patterns and enjoying them more. The creation of wholesome and health-promoting snacks is the newest trend [3]. Biscuits are a popular baked snack that can be consumed immediately. Because composite flour increases the nutritional value of the baked good, it is justifiable to use it in the preparation of biscuits [4]. A biscuit is a tiny, flat, crisp cake made primarily of flour as a basic ingredient, since they stay fresh for a longer period of time, as it has become the perfect travel food. Biscuits are dried to a low moisture level, which prolongs their storage shelf life and lowers the risk of microbiological deterioration [5]. According to Ashaye et al. [6], the features of biscuits that make them so popular include their great palatability, rich nutritional content, rapid release of energy, availability in handy quantities, and variety of shapes. Additionally, the formulation of the biscuits can be simply changed to satisfy the dietary requirements of the intended consumers. To make it, a variety of ingredients are combined, including water, fat, egg, sugar, and flour [6]. Biscuits have actually been suggested as a better application for composite flour than bread due to their ready-to-eat form, broad consumption, relatively long shelf life, and acceptable eating quality [7,8]. Rice is a wholesome cereal grain that is mostly consumed by humans. It is the primary source of energy and a significant source of protein, supplying sizeable amounts of the nutrients zinc and niacin that are advised for ingestion. Worldwide, biscuits are a significant and widely used staple food made of grain [9]. Its low protein content and lack of other macronutrients make it a risk factor for obesity, diabetes, and biliary-tract cancer [9]. However, it is high in carbohydrates and has a low glycemic index. Therefore, efforts are being made to increase the nutrient content of biscuits while also lowering their price so that the bulk of the population, who are low-income earners, can buy them. This study evaluated the chemical, physical, functional microbiological, and sensory qualities of biscuits prepared from a mixture of rice, African eggplant leaf, and bambara groundnut.

MATERIALS AND METHOD

Source of Material

Bambara groundnut, rice, African eggplant leaf (anara), and other baking ingredients like “King's butter”, Dangote granulated sugar, baking powder, Dano full cream milk powder, and Dangote salt were purchased from Eke Aka market in Awka, Anambra State. Biscuits are a significant and widely consumed staple cereal.

Experimental Design

The experiment was a completely randomized design, with a total of 8 runs (Table 1).

Sample Code	Rice (%)	Bambara Groundnut (%)	Concentration of Leaf (%)
UBR (100% wheat)	0	0	0
RIC	100	0	0
RBU	0	100	0
CUB	80	15	5
RUB	20	75	5
BRU	55	40	5
URB	40	55	5
UUB	45	50	5

Table 1: Design key.

Sample Preparation

Rice flour

The paddy rice was obtained from the market and sifted to eliminate debris such as mud, textiles, stones, and other undesired items. Sands and other lighter debris were then removed from the seeds by winnowing. After the dirt was removed, the rice sample was ground to produce a finer, smaller particle and sieved to produce rice flour that was much finer. Until it was required for the creation of biscuits, the flour was stored in an airtight container.

Bambara groundnut flour

Market-purchased Bambara groundnut seeds were sifted to separate the immature and inferior seeds from the mature and superior ones. It was milled after it had been winnowed. The ground seeds were sieved after milling to produce fine

flour, which was then packaged until it was required for manufacturing.

African egg plant leaf

After the leaf was purchased from the market, it was plucked to separate the leaf from the stem. The leaf was then carefully washed with portable water and salt to get rid of the presence of microbes, sand, and other unwanted particles in the leaf. The leaf was then sun dried for days before being shred into the desired form and packaged until it was required for production (Figure 1 - Figure 3).

Figure 1: Rice flour production.

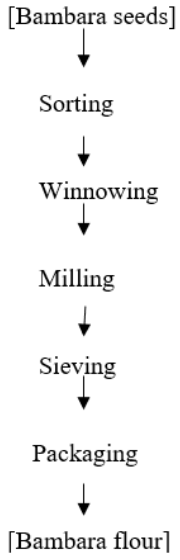

Figure 2: Bambara flour production.

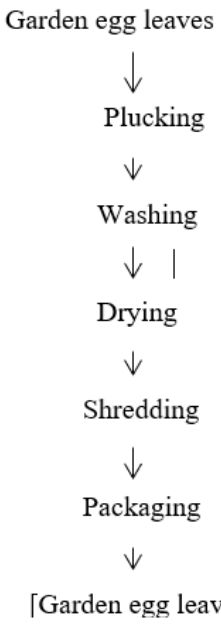

Figure 3: Garden egg leaves flour production.

Production of biscuit

Using technique as described by Ohizua et al. [10], the biscuit sample was made by combining Bambara groundnut, rice flour, and African eggplant leaf.

Composition of blends

In accordance with their composition, Bambara groundnut flour, rice flour, and African eggplant leaves were weighed and combined in a ratio of 8:5:2, and additional ingredients like sugar, salt, water, flavor, and wheat flour were also added in the proper proportions, as shown in the table 2 (Figure 4).

Ingredients	RBU 1	RBU 2	RBU 3	RBU 4	RBU 5	RBU 6
Bambara Groundnut	26.7	33.3	26.7	33.3	26.7	26.7
Rice Flour	10	-	10	-	10	10
African Eggplant Leaf	-	20	10	20	-	-
Flour	13.3	16.7	13.3	16.7	13.3	13.3
Salt	0.3	0.3	0.3	0.3	0.3	0/3
Sugar	3.3	3.3	3.3	3.3	3.3	3.3
Flavor	1.4	1.4	1.4	1.4	1.4	1.4
Water	20	25	20	25	20	20
Vitamin Premix	-	-	-	-	-	0.25
Total	100	100	100	100	100	100

Table 2: Composition of the extruded snack feed blends.

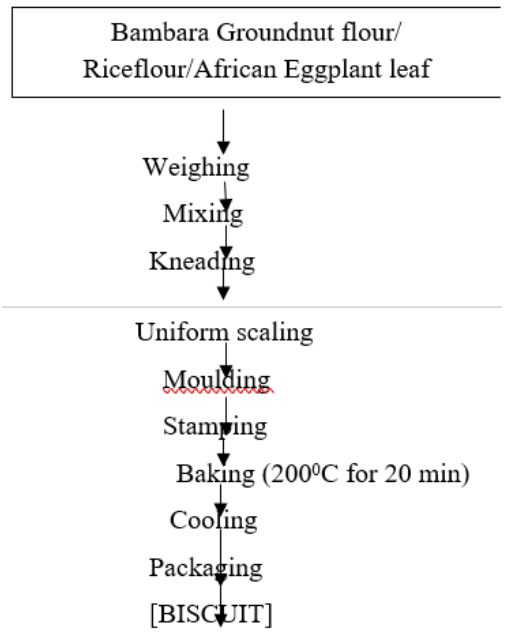

Figure 4: Biscuit production.

Methods of Analysis

Determination of physical properties of the biscuit sample

With a small modification, the method described by Bala et al. [11], was used to assess the biscuit for the following characteristics:

Thickness

The diameter of biscuit samples placed edge to edge was measured using a digital vernier caliper to determine the biscuits' thickness. For each set of samples, the mean of six values was taken. The millimeters of the average thickness value were recorded.

Diameter

By aligning four biscuit samples side by side and measuring using a digital vernier caliper, the diameter of the biscuits was ascertained. For each set of samples, an average of six values was taken. The millimeter average diameter value was given.

Weight

The weight of the biscuits was determined by averaging the weights of six distinct biscuits using an analytical weighing scale. The average weight was specified in grams.

By dividing diameter by thickness, spread ratio was calculated.

Vitamins

Vitamin B1 determination using a scalar analyzer was determined according to AOAC, [12] method.

The procedure devised by Jakutowicz et al. [13] was used to determine vitamin A. AOVC [14] described the method that was used to determine vitamin B3.

Sensory evaluation and analysis

The panel was composed of 20 semi-trained judges from the Department of Food Science and Technology at Nnamdi Azikiwe University in Awka. The panelists were given instructions on the various descriptive words of the sensory scales and asked to rate the different biscuit samples for taste, color, texture, scent, and overall acceptability on a 9-point Hedonic scale, where 9 equaled strongly like and 1 equaled extremely dislike. Random presentations of coded samples and commercial samples were made, and potable water was made available for mouth washing in between each evaluation [14].

Microbial analysis

Total viable count and mould analysis were carried out as described by AOAC [12].

Statistical analysis

The three duplicated experiments' data were examined to see if the variances were statistically homogeneous, and the results were presented as means standard deviation. Using the SPSS 25 software, one-way analysis of variance (ANOVA) will be used to make statistical comparisons, which will be followed by a Tukey's test. At $p > 0.05$, a mean difference was deemed significant.

RESULTS AND DISCUSSION

Sensory Qualities of Biscuits produced from Blends of Rice, Bambara Groundnut and African Eggplant Leaves Flours

Since consumers seek food with particular sensory qualities, sensory quality is seen as a crucial aspect in food acceptance [15]. Table 3 displays average evaluations for the sensory assessment of biscuits made from a combination of rice, bambara groundnut, and African eggplant leaves. The findings showed that the samples' quality features varied across them in some significant ways ($p < 0.05$).

Due to the Millard reaction that took place during baking, color is a crucial characteristic that customers should take into account when assessing the acceptability of biscuits [16]. According to Table 3, the mean color rating ranged from 5.64 to 7.20, with sample CUB receiving the lowest rating and sample RBU receiving the highest. The findings demonstrated that adding African eggplant leaf powder to the designed items had no negative effects on their color. This is consistent with the finding of Thorat et al. [17], who noted that adding lemon grass powder to cookies up to 5% did not change their acceptability for color. It was found that samples with higher percentages of bambara groundnut flour-particularly samples RBU, RUB, and UUB-had colors that were rated higher than the control, with mean scores of 7.20, 6.80, and 6.40, respectively, while samples with higher percentages of rice flour had colors that were rated below the control. Given that rice contains a high amount of starch, and that heating can also cause starch dextrinization and caramelization, Chung et al. [18] hypothesized that the samples with higher percentages of rice flour had lower color preferences.

Samples	Colour	Taste	Aroma	Flavour	Mouthfeel	Texture	Overall Acceptability
RIC	$5.76^{ab} \pm 1.16$	$4.60^{b} \pm 1.38$	$4.28^{b} \pm 1.31$	$4.16^{bc} \pm 1.25$	$3.96^{bc} \pm 1.14$	$4.24^{bc} \pm 1.23$	$4.40^{c} \pm 1.32$
RBU	$7.20^{a} \pm 1.64$	$5.80^{a} \pm 2.17$	$6.80^{a} \pm 1.64$	$5.80^{b} \pm 1.92$	$7.40^{a} \pm 0.54$	$6.80^{a} \pm 0.84$	$6.80^{a} \pm 1.79$
CUB	$5.64^{ab} \pm 1.38$	$5.72^{ab} \pm 1.43$	$4.80^{ab} \pm 1.61$	$3.64^{c} \pm 1.50$	$4.24^{b} \pm 1.59$	$4.32^{b} \pm 1.63$	$4.80^{bc} \pm 1.32$
RUB	$6.80^{a} \pm 1.10$	$6.60^{a} \pm 0.55$	$6.00^{a} \pm 0.71$	$5.00^{b} \pm 1.41$	$6.60^{a} \pm 0.55$	$6.40^{a} \pm 0.84$	$7.40^{a} \pm 0.89$
URB	$5.60^{ab} \pm 1.14$	$6.40^{a} \pm 2.51$	$6.20^{a} \pm 1.64$	$5.40^{b} \pm 2.51$	$1.80^{c} \pm 0.84$	$3.60^{c} \pm 0.55$	$7.40^{a} \pm 1.52$
UUB	$6.40^{a} \pm 1.14$	$5.00^{ab} \pm 3.08$	$4.80^{ab} \pm 2.59$	$4.80^{bc} \pm 2.87$	$3.40^{bc} \pm 0.55$	$2.40^{d} \pm 0.55$	$6.00^{ab} \pm 2.35$
BRU	$5.96^{ab} \pm 1.24$	$5.68^{ab} \pm 1.49$	$5.52^{ab} \pm 1.23$	$4.72^{bc} \pm 1.65$	$5.56^{ab} \pm 1.75$	$4.16^{bc} \pm 1.46$	$5.60^{bc} \pm 1.63$
UBR	$6.12^{a} \pm 1.12$	$7.00^{a} \pm 2.01$	$3.01^{b} \pm 0.21$	$7.01^{a} \pm 0.23$	$5.01^{ab} \pm 0.11$	$5.80^{ab} \pm 0.11$	$7.70^{a} \pm 3.21$

Table 3: Sensory evaluation of biscuits produced from blends of rice, bambara groundnut and African eggplant leaves.
*Values are means ± standard deviation of sensory evaluation. Means with the same superscript in the same column are not significantly different ($p > 0.05$). Key: RIC -100:0:0 Rice-Bambara groundnut-African Eggplant leaf, RBU - 0:100:0 Rice-Bambara groundnut-African Eggplant leaf, CUB - 80:15:5 Rice-Bambara groundnut-African Eggplant leaf, RUB- 20:75:5 Rice-Bambara groundnut-African Eggplant leaf, URB - 40:55:5 Rice-Bambara groundnut-African Eggplant leaf, UUB - 45:50:5 Rice-Bambara groundnut-African Eggplant leaf, BRU -55:40:5 Rice-Bambara groundnut-African Eggplant leaf, UBR – 100 wheat (control).

The designed biscuits' tastes differed widely ($p > 0.05$). The UBR group's average score was 7, whereas the RIC samples was 4.60. When compared to the control sample, the taste ratings for each of the designed products were lower. The panelist reported that all of the samples that contained African eggplant leaf powder had a mildly bitter flavor. African eggplant leaves contained tannin, a polyphenolic compound linked to the bitter flavoring of food products, according to Ukom and Obi [19]. The samples' rise in polyphenol content could be what caused the taste to be bitter [20]. Amadi [21] reported similar results for cookies made from a mixture of wheat and moringa leaf powder. According to Okache et al. [22], aroma and flavor are key sensory attributes that correspond to the sensations in the nostrils brought on by the rise of food or drink volatile molecules. They are one of the most important elements shoppers take into account before purchasing any item. The biscuit samples' mean ratings for flavor and scent varied from 3.46 to 7.01 and 3.01 to 6.90, respectively. The findings showed that there were some discernible fragrance and flavor differences ($p < 0.05$) between the samples. Sample RBU (100% bambara groundnut) had the most favorable aroma, while sample UBR (the control) had the least favorable aroma. In contrast, sample CUB's flavor was the least liked while the control sample's (UBR) flavor was the most liked. The panelists' comments that the majority of the samples had a beany fragrance and flavor were to be expected. This resulted from the formulation's use of bambara groundnut. Similar observations were made by Eke-Ejiofor and Williams [23] for biscuits manufactured from composite flours made of rice and defatted soybean flour.

The mouthfeel of the biscuit samples, which ranged from 3.96 to 7.40, differed significantly ($p < 0.05$). The mouthfeel of the sample made entirely of rice flour (RIC) was the least well-liked, whereas the sample made entirely of bambara groundnut was well-liked. The panelists stated that the majority of the samples with a high concentration of rice flour had a gritty mouthfeel, which is likely why people didn't enjoy them. The findings of Awolu et al. [24], who found a mouthfeel score of 7.37 for biscuit made from 95% rice and 5% sweet potato flour, are not in agreement with this. These findings could differ depending on the raw material and formulation employed.

The samples of biscuits received mean scores for texture ranging from 2.40 to 6.80. Sample RBU received the highest score, while Sample UUB received the lowest. The outcome showed that there were a few significant changes ($p > 0.05$) in the texture of the created biscuits.

All of the samples' textures (including the control) were scored by the panelists as being below average (5.00), with the exception of samples RBU and RUB, whose mean scores were 6.80 and 6.40, respectively. The graininess of the rice flour used in the product formulation may be the cause of the low acceptance of the texture of the items. Salem et al. [25] reported a greater and more acceptable score of 8.19 for the same formulation in comparison to the 4.24 obtained as the score of texture of 100% rice biscuit (RIC). This could be caused by different varieties or different production and processing techniques used. Similar to this, Bolarinwa et al. [18] revealed that panelists generally preferred the texture of cookies made from mixtures of sprouted rice and sweet potato starch. According to a study by Ufot et al. [28] on rice, unripe banana, and sprouted soybean composite biscuits, the formulations had no negative effects on the texture of the biscuits. These observations from other studies do not match the findings of the current investigation, most likely as a result of the different raw materials employed. According to Dueik et al. [29], texture is one of the most important characteristics of dry snack goods, signifying great quality and freshness. Therefore, the acceptance of the manufactured biscuits as a whole may be negatively impacted by the scores given to their texture. The overall acceptability scores for the biscuit products ranged from 4.40 to 7.70, with sample RIC obtaining the lowest mean value (4.40), which on the hedonic scale denotes "dislike slightly," and sample UBR recording the highest mean value (7.70), which denotes "like very much." The overall acceptability ratings of the control (URB) and samples RUB, RBU, and URB did not differ significantly ($p > 0.05$). They did, however, significantly deviate ($p > 0.05$) from the other samples. When compared to samples with a larger proportion of bambara groundnut, it was found that all samples with a higher percentage of rice flour proved to be unpopular. The inferior color, texture, mouthfeel, and flavor of the biscuits may be to blame for their poor evaluations. The findings of the sensory test also demonstrated that adding African eggplant leaf powder to the biscuits had no negative effects on the products' acceptance. Nasser et al. [30] claim that additional elements, such as physiological, behavioral, and cognitive aspects relating to the consumer, may also play a role in determining acceptance in addition to sensory features of the product. The five most well-liked samples, RUB, RBU, URB, UUB, and UBR (control), with overall acceptability scores of 7.40, 7.40, 6.80, 6.00, and 7.70, respectively, were chosen for physical, chemical, and microbiological examination based on these findings.

Physical Properties of Biscuits produced from Blends of Rice, Bambara Groundnut and African Eggplant Leaves Flours

Table 4 displays the physical characteristics of cookies made from a blend of rice, bambara groundnut, and African eggplant leaves. The samples' weights ranged from 5.36 g to 18.81 g, and there were statistically significant differences ($p > 0.05$) between them all except for samples URB and UUB. In terms of weight, sample URB had the highest value while sample RBU had the lowest value. The findings revealed that the samples' weight gradually

decreased as the amount of bambara groundnut flour added rose. This was comparable to the findings of Emojorho et al. [4], which noted a drop in biscuit weight with an increase in orange seed flour. This observation conflicts with those of Adegbanke et al. [31], who found that the weight of cookies increased (10.06 g - 12.01 g) as the percentage of bambara groundnut flour replaced wheat flour increased. The variations in the raw materials employed may be the cause of this. The fact that bambara groundnut flour is a legume and may include more fat than other flours may account for the observed reduced weight of biscuits with increased bambara groundnut flour addition, as fat has been found to weigh less than water [28]. The study's findings exceed the range of value options (6.43 g - 7.67 g) published by Talabi et al. [32] for biscuits made with composite flour made from wheat, groundnuts from the Bambara region of Africa, ground beans, and moringa seeds.

Samples	Weight (g)	Diameter (mm)	Thickness (mm)	Breath (mm)
RBU	$5.36^{d} \pm 0.09$	$57.90^{a} \pm 0.95$	$4.53^{d} \pm 0.19$	$56.56^{a} \pm 0.40$
RUB	$14.09^{c} \pm 0.75$	$56.40^{a} \pm 2.02$	$6.15^{c} \pm 0.38$	$53.52^{b} \pm 1.27$
URB	$18.81^{a} \pm 0.71$	$58.52^{a} \pm 0.69$	$8.24^{a} \pm 1.23$	$54.52^{ab} \pm 1.27$
UUB	$18.63^{a} \pm 0.71$	$56.85^{a} \pm 0.78$	$8.83^{a} \pm 0.36$	$54.31^{ab} \pm 2.50$
UBR	$17.72^{b} \pm 1.47$	$58.19^{a} \pm 2.01$	$7.84^{b} \pm 0.75$	$55.07^{ab} \pm 1.19$

Table 4: Physical properties of biscuits produced from blends of rice, bambara groundnut and African eggplant leaves.

*Values are means ± standard deviation of triplicate determinations. Means with the same superscript in the same column are not significantly different (p >0.05). Key: RBU - 0:100:0 Rice-Bambara groundnut-African Eggplant leaf, RUB- 20:75:5 Rice-Bambara groundnut-African Eggplant leaf, URB - 40:55:5 Rice-Bambara groundnut-African Eggplant leaf, UUB - 45:50:5 Rice-Bambara groundnut-African Eggplant leaf, UBR - 100% biscuits (control).

The range of the biscuit samples' diameters was 56.40 mm to 58.52mm, with sample RUB having the smallest diameter and sample URB having the largest. According to the findings in Table 4, there were no significant changes (p >0.05) among the formulas, indicating that the diameter of the biscuits was unaffected. These numbers are greater than those published by Bolarinwa et al. [18] for biscuits made from rice flour and sweet potato starch, which ranged from 42.00 mm to 49.77mm. The variances in raw materials utilized could be the cause of the disparities in these outcomes.

The thickness of samples URB and UUB did not substantially differ from the other samples (p >0.05), but they did significantly differ from each other (p >0.05). Sample UUB had the highest value, 8.83mm, while Sample RBU had the lowest value, 4.55 mm. The thickness of the biscuit flour with rice flour was seen. These values are greater than the 3.93 mm - 4.95 mm reported by Onwurafor et al. [33] for cookies prepared from wheat, mung bean malt, and unripe plantain composite flours, but lower than the 73.00 mm - 91.00 mm reported by Ufot et al. [28] for rice, unripe banana, and sprouted composite biscuits. The observed discrepancies in these outcomes could be the result of differences in the shape and raw materials employed.

The formulations had a minor impact on the breath of the biscuit samples, as demonstrated in Table 4. The readings were between 53.52 mm and 56.56 mm, with sample RBU scoring the highest and sample RUB scoring the lowest. The breath of samples URB, UUB, and UBR had values of 54.52 mm, 54.31 mm, and 55.07 mm, respectively, and there was no discernible difference (p >0.05). However, when compared to samples RBU (56.56 mm) and RUB (53.52 mm), these samples were substantially different (p >0.05).

Vitamin Composition (mg/100g) of Biscuits produced from Blends of Rice, Bambara Groundnut and African Eggplant Leaves

Table 5 shows the vitamins that are present in the created biscuits. The samples of biscuits ranged in vitamin A concentration from 0.52 mg/100g to 0.94 mg/100g. Sample RBU recorded the lowest value, while sample UUB recorded the highest. The findings revealed that samples RUB, URB, and UUB did not significantly differ from one

another (p >0.05), but that they did significantly differ from samples RBU and UBR (p >0.05). According to Ukom and Obi [21], African eggplant leaves have a high concentration of vitamin A (370.64 mg/100g). This may be the cause of the elevated vitamin A levels in all of the composite samples. The results of this study's measurements were within the range (0.39 mg/100g - 0.86 mg/100g) that was previously reported for wheat-moringa leaf composite biscuits [23].

Samples	Vitamin A	Vitamin B1	Vitamin B3
RBU	$0.52^{b} \pm 0.02$	$0.02^{a} \pm 0.03$	$0.32^{a} \pm 0.10$
RUB	$0.87^{a} \pm 0.10$	$0.07^{a} \pm 0.02$	$0.36^{a} \pm 0.00$
URB	$0.89^{a} \pm 0.21$	$0.05^{a} \pm 0.22$	$0.33^{a} \pm 0.00$
UUB	$0.94^{a} \pm 0.01$	$0.03^{a} \pm 0.21$	$0.24^{a} \pm 0.00$
UBR	$0.55^{b} \pm 0.22$	$0.01^{a} \pm 0.00$	$0.23^{a} \pm 0.10$

Table 5: Vitamin compositions (mg/100g) of biscuits produced from blends of rice, bambara groundnut and African eggplant leaves.

*Values are means ± standard deviation of triplicate determinations. Means with the same superscript in the same column are not significantly different (p >0.05). Key: RBU - 0:100:0 Rice-Bambara groundnut-African Eggplant leaf, RUB- 20:75:5 Rice-Bambara groundnut-African Eggplant leaf, URB - 40:55:5 Rice-Bambara groundnut-African Eggplant leaf, UUB - 45:50:5 Rice-Bambara groundnut-African Eggplant leaf, UBR - Beloxi biscuits (control).

Table 5 demonstrates that there was no significant difference (p >0.05) between the amount of vitamin B1 and vitamin B3 in the prepared biscuits. Their respective values ranged from 0.01 to 0.07 and 0.23 to 0.36. However, compared to samples RBU (100% bambara groundnut) and UBR (control), the values of the samples adding African eggplant leaf powder are somewhat higher. According to Ukom and Obi [21], vitamin B1 is necessary for the upkeep of nerve tissue and for the generation of energy from carbohydrate metabolism, whereas vitamin B3 is a precursor for the co-factors that enzymes need to function as catalysts in body metabolism. Pellagra is brought on by it lack [34].

Microbial Quality of Biscuits produced from Blends of Rice, Bambara Groundnut and African Eggplant Leaves

Table 6 displays the microbiological quality of biscuits made from a combination of rice, Bambara groundnut, and African eggplant leaves. The biscuit samples' total viable counts (TVC) ranged from 1.2×10^2 cfu/g in sample RUB to 1.7×10^2 cflu/g in sample RBU. All of the samples were free of mold growth, with the exception of sample UUB, which had 1.0×10 cfu/g of mold. This finding is consistent with those, who found no microbial growth in biscuits made from date fruit, acha, and malted bambara groundnuts. According to the Centre for Food Safety [35], the unsatisfactory threshold for bakery and confectionery items is greater than or equal to 10^6 cfu/g. The biscuits were therefore still within the permitted range. The product's post-handling could be the cause of the minimal TVC growth that was seen.

Samples	TVC (cfu/g)	MouldCount (cfu/g)
RBU	1.7×10^2	0
RUB	1.2×10^2	0
URB	1.5×10^2	0
UUB	1.6×10^2	1.0×10
UBR	1.3×10^2	0

Table 6: Microbial quality of biscuits produced from blends of rice, bambara groundnut and African eggplant leaves flours.

*Values are means ± standard deviation of triplicate determinations. Means with the same superscript in the same column are not significantly different (p >0.05). Key: RBU - 0:100:0 Rice-Bambara groundnut-African Eggplant leaf, RUB- 20:75:5 Rice-Bambara groundnut-African Eggplant leaf, URB - 40:55:5 Rice-Bambara groundnut-African Eggplant leaf, UUB - 45:50:5 Rice-Bambara groundnut-African Eggplant leaf, UBR - Beloxi biscuits (control). TVC: Total viable count.

CONCLUSION

The findings of this study demonstrated that the chemical, physical, and sensory characteristics of biscuits were significantly affected by the composition of biscuits made from composite flours of rice, Bambara groundnut, and African eggplant leaves. The sensory qualities of the biscuits were unaffected by the addition of up to 5% African eggplant leaf powder; however, the level of preference dropped with increasing rice flour incorporation. After the control sample, the sample made from 100% bambara groundnut flour and 40:50:5 rice-bambara groundnut-African eggplant composite flour had the highest preference. The biscuits' micronutrients were all improved

and increased by the composite flours. The biscuit samples also grew in weight, diameter, and thickness. The samples of biscuits had good microbiological quality. Therefore, using composite flours made of rice, bambara groundnut, and African eggplant in the formulation of biscuits is a superior way to improve the nutritional value of the finished good. By reducing the nation's dependency on wheat imports, this will significantly lower the amount of foreign currency utilized for wheat importation. The addition of these composite flours as functional components in the creation of food products can result in significant economic change that will aid in the eradication of the global problem of food insecurity.

COMPETING INTERESTS

No conflict of interest or conflicting interests.

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