Production and Quality Assessment of Biscuit from Acha Flour Supplemented with Pigeon Pea

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Authors’ contributions
This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT
This research work evaluates the production of biscuits from blends of acha and pigeon pea flour. Acha and pigeon pea flour were blended in the ratio 95:5, 90:10, 85:15, 80:20 and 100:0 (control) to produce biscuits. Biscuits made from this blend were analyzed for proximate analysis, antinutrient composition, physical attributes, and sensory qualities. The moisture, protein, fat, crude fiber, ash, and carbohydrate content of the biscuits ranged from 7.87-9.84%, 7.36-8.14%, 21.99-26.33%, 0.39-0.59%, 0.87-1.24%, and 58.06-63.01%, respectively. The antinutrient composition varied from 4.24-6.82% for tannin and 3.85-4.68% for phytate. The physical attributes of the biscuits ranged from 8.34-10.98 g, 0.56-0.85 cm, 4.77-5.03, 5.99-8.59 for weight, thickness, diameter and spread ratio, respectively. The sensory evaluation showed that the biscuit sample with the blend ratio of 95% and 5% (acha to pigeon pea flour) was the most acceptable because it gave the best colour, appearance, crispness and overall acceptability. The result shows that acceptable biscuits with improved nutritional attributes can be produced from the blend of acha and pigeon pea flour. This will eliminate or reduce the problems associated with protein-energy malnutrition common in most local communities, and reduce wheat importation, thereby increasing the use of the most underutilized sources of flour in most developing countries.

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Keywords: Antinutrient; composite flour; proximate composition; sensory evaluation; biscuit.

1. INTRODUCTION

Biscuit is one of Nigeria's most commonly eaten non-fermented baked snacks [1]. The significant components of simple biscuits are wheat flour, water, sugar, fat, and eggs, which are blended into the dough with the addition of another compound if needed [2]. Despite being an everyday diet in most cultures with relatively high carbohydrate, fat, and calorie content, the daily consumption of biscuits is not encouraged because of the low presence of protein, fiber, vitamins, and minerals [3]. Nevertheless, biscuits have a wide range of acceptance in terms of consumption by individuals under different age groups across various rural and urban communities. Moreover, it can be consumed due to its good sensory attributes and relatively long shelf life [4].

Biscuit as a snack food tends to be used for protein fortification and substitute for diet improvements due to its general acceptance by various individuals regardless of their age bracket [5]. In addition, various researchers have demonstrated that an acceptable range of biscuits can be produced from a blend of non-wheat and wheat flours or different sources of flours other than wheat flours [6,7]. However, over-reliance and dependency on wheat flour for the production of different snacks in the pastry industries in Nigeria has discouraged and prevented, to an extent, the use of other flour sources, such as flour from cereals and tuber crops sources for domestic use.

Recently, the collaborative efforts of the Nigerian government with various research institutes across the nation have improved the utilization of composite flour in producing different snacks such as biscuits and other seemingly related food products for example bread. This recent development has encouraged the exploration of other flour sources such as plantain, sweet potato, cassava flour, and other underutilized crops that can be used as flour sources other than wheat flour. Using this indigenous flour in the various baking industries across the nation will multiply the usage of local crops cultivated in Nigeria, reduce over-dependency on wheat flour and, most importantly, lower the cost of baked food products [8].

Acha (Digitaria exilis) is a grain crop that has historically been consumed whole as tuwo, couscous, gwater, acha jollof, and kunun acha [9]. Acha has high pentosane content (3.3%) and thus a high water absorption capacity, making it suitable for use in bakeries [10]. It is roughly 73% carbohydrates and high in micronutrients like iron and iodine (28.5 mg/100 ml and 22.9 mg/100 ml, respectively) [11]. Acha is used as a health grain due to its gluten-free property and consumption as a whole food product [12]. It is abundant in methionine, therefore, it has low sugar concentration when consumed; this serves as an advantage to diabetics patients [13,14].

Pigeon pea is indigenously available, has a low production cost, and is an underutilized grain legume both in the sub-tropics and tropics areas. Wide pigeon pea varieties have protein content varying from 23-26% [15]. Pigeon pea is rich in minerals and fiber, and its protein content is comparable with other leguminous crops like cowpea and groundnut. Pigeon pea is well suited and adapted to Nigeria’s climate for cultivation. However, its utilization in various food products has been limited mainly because its antinutrient or phytochemicals make up the hard-to-cook phenomenon [16,17]. Pigeon pea is desirous among the low-income earners in the urban area due to the taste, but it seems unaffordable due to the long cooking time and high fuel cost. Aside from the hard-to-cook phenomenon, pigeon pea seeds are challenging to dehull. Therefore, the seemingly tedious process of dehulling is a limiting factor in its utilization and processing [18].

Most underdeveloped and developing countries like Nigeria depend heavily on wheat flour to make bread, biscuits, cookies and other pastry products. For this reason, most of these countries are investigating the possibility of replacing or substituting wheat for other flour sources needed for making baked goods, wholly or partly with flour obtained from homegrown products. Flour from other sources that can be used as a wheat substitute or composite flour includes legumes, tubers, fruits, and cereals [19]. However, in Nigeria, using acha and pigeon pea flour in the production of baked goods is uncommon. This is because pigeon pea and acha flour are underutilized crops. Hence, this study aims to evaluate the quality attributes of biscuits produced from acha and pigeon pea flour blends.
2. MATERIALS AND METHODS

2.1 Samples Procurement

Acha (Digitaria exilis) grains were purchased from Nyanya market, Abuja, and pigeon pea (Cajanus cajan) was purchased at a local market in Bodija Ibadan, Oyo State. Margarine, sugar, salt, milk, egg, and baking powder were procured from Wazo market in Ogbomoso, Oyo State, Nigeria.

2.2 Sample Preparation

The method described by Adegoke [20] was used to obtain flour from acha seeds. Two kilograms of acha were washed and dried. Hammer mill was used to mill the dried acha, sieved, and then the flour was obtained through continuous sieving with a sieve aperture of 300 - 400 µm. Pigeon pea (2 kg) was cleaned, sieved, washed and soaked in water to dehull and remove the shaft. Pigeon pea was oven dried in Genlab Cabinet dryer (Model DC 500, Serial number 12B154) at 55°C for 12 hours, milled using Fritsch hammer mill (Serial number: 15.302/982) into flour, sieved at 450 µm aperture and pigeon flour was obtained at the end of this process.

2.3 Production of Biscuit

Five formulation blends were prepared using acha flour (AF) and pigeon pea flour (PPF) ratio. Ihekoronye and Ngoddy [21] method was adopted with slight modification for biscuit production. The formulations containing sugar (60 g), baking powder (1%), milk (25 g), flavouring (2 g) and water (50 ml) were used to produce biscuits. The dry ingredients were first weighed and mixed before adding butter and then creamed. Water was added and mixed properly until desired thickness is achieved. The batter was later cut into a circular shape using a biscuit cutter. The biscuits were baked at 180°C for (15-20) minutes, cooled and packed in polyethylene bags, sealed and kept at room temperature until used for chemical analysis, physical attributes and sensory evaluation.

2.4 Analyses

2.4.1 Proximate analysis

The proximate composition of samples were determined according to the method described by AOAC [22]. The soxlet extraction method was used to determine fat content in which hexane was used as the solvent. The protein content was determined by the Kjeldahl method. The crude fiber was determined by weighing approximately 0.5 g of the sample defatted in a tar-impregnated porcelain crucible. Then it is burned at 600°C for about six hours in the oven until the fiber is obtained. Ash content was also determined by this method. Moisture content was determined by hot air oven method. Carbohydrate content was determined by sample difference, that is:

\[
\text{% carbohydrate content} = (100 - \text{% crude fiber + % protein + % fat + % ash + moisture content})
\]

2.4.2 Antinutritional factors

Folin-Denis Spectrophotometric method was used to determine the tannin content [23]. The phytate content of the samples were determined according to the method of AOAC [22].

2.4.3 Physical attributes

An electronic scale was used to measure biscuit weight, and the mean of biscuit samples was recorded. The biscuit diameter was determined using [22]. Six biscuit samples are placed horizontally next to each other, and the diameter of the biscuit was measured with a digital caliper. The mean of six biscuit samples was obtained and used to indicate the diameter of the biscuit. The biscuit thickness was determined using the method described by Man et al. [24]. This method stacked six biscuit samples and the average thickness was obtained using a caliper. The average value obtained is used to specify the thickness of the biscuit. The biscuit spread ratio was defined as the mean diameter to mean thickness [25].

2.5 Sensory Evaluation

The biscuit samples were presented to 50 panelists from Food Engineering Department, LAUTECH, Ogbomoso for sensory evaluation in the laboratory. Individual panelists were randomly given six (6) samples of biscuits neatly arranged on a rectangular plastic tray. The biscuits were sealed separately in a pouch and coded before the commencement of the sensory evaluation process. The panelists were required to evaluate sensory attributes such as colour, crispness, taste and the overall acceptability of the biscuits using a 9-point hedonic scale [26].
2.6 Statistical Analysis

Results obtained were analyzed using Statistical Package for the Social Sciences version 15 software (SPSS Inc., Chicago, IL, USA). The results were mean values of three individual replicates ± the standard deviation (SD). Data obtained were subjected to analysis of variance (ANOVA) and means separated with Duncan multiple range test at a significance level of p<0.05.

3. RESULTS AND DISCUSSION

3.1 Proximate Composition

The proximate composition of biscuits made from acha and pigeon pea flour are shown in Table 1. The moisture content ranged from 7.87 to 9.84%. The moisture content is less than the recommended 14% for long-term storage, indicating a good potential during storage [27] on biscuits made from acha-date palm flour. The protein content of biscuits ranged from 5.36 to 8.14%. The protein content of the biscuits increased with the addition of pigeon pea flour. The increase can be attributed to pigeon pea being a rich source of protein [16, 17]. The high protein content of the sample will be of great nutritional importance, especially in developing countries such as Nigeria to curb the menace of protein-energy malnutrition. The fat content of the biscuit ranged from 2.19-2.63%. Addition of pigeon pea flour increased the fat content of the biscuit. This agrees with a report from Usman et al. [28] who reported increase in fat content of biscuits produced from wheat flour and maize bran composite flour fortified with carrot extract. The low content of fat in the biscuit produced indicates that the biscuit can be recommended for people requiring low fat diet.

The ash content ranged from 0.87 to 1.24%. The ash in biscuits and any other baked food product indicates the presence of minerals in the food. The results obtained in this study for ash content were similar to those obtained by Usman et al. [28] on biscuit produced from wheat flour and maize bran composite flour fortified with carrot extract. Ash is an inorganic compound used as a mineral indicator in foods that contributes to the metabolic activities of other compounds such as proteins, lipids and carbohydrates [29]. The crude fibre content of the biscuits ranged from 0.39 to 0.59%. The crude fibre content of the biscuit samples decreased as the amount of pigeon pea flour added increased. High fibre is said to improve gastrointestinal health by promoting normal bowel movement and reducing constipation, which can lead to colon cancer. Carbohydrate content ranged from 58.06 to 63.01%. The results obtained for carbohydrates in this study were similar to the findings of Ufot et al. [30] on functional biscuits from whole wheat flour supplemented with acha and kidney bean flour. Carbohydrates are an excellent source of energy used in daily human activities. The carbohydrate content of the biscuit samples suggests that the products may be a prominent energy source.

3.2 Antinutritional Composition of Biscuit

Table 2 shows the antinutrients properties of biscuits. The antinutrient contents of the sample ranged from 4.24 to 6.82 mg/100 g, 3.85 to 4.68 mg/100 g for tannin and phytate, respectively. It was discovered that when pigeon pea flour was added, the antinutritional value increased. However, the levels of these antinutrients in all the samples were relatively low, suggesting that they may not interfere with the bioavailability of essential nutrients in the flours. Tannin has astringent properties that aid in the healing of wounds and inflamed mucous membranes [31] and its antioxidative properties can inhibit the generation of superoxide radicals [32]. The maximum permissible dose of phytate in the body, according to Bushway [33] is between 250 and 500 mg/100g. Thus, biscuit produced from acha and pigeon pea flour is safe for consumption.

Table 1. Proximate composition of biscuits produced from acha-pigeon pea flour blends

<table>
<thead>
<tr>
<th>Sample</th>
<th>Moisture (%)</th>
<th>Protein (%)</th>
<th>Fat (%)</th>
<th>Ash (%)</th>
<th>Fibre (%)</th>
<th>CHO (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>7.87±1.00</td>
<td>7.36±1.00</td>
<td>2.19±0.18</td>
<td>0.87±1.00</td>
<td>0.59±1.00</td>
<td>61.32±0.72</td>
</tr>
<tr>
<td>B</td>
<td>8.94±0.15</td>
<td>7.59±0.00</td>
<td>2.28±0.18</td>
<td>1.00±1.00</td>
<td>0.54±1.00</td>
<td>63.01±0.95</td>
</tr>
<tr>
<td>C</td>
<td>8.99±0.15</td>
<td>7.74±0.11</td>
<td>2.28±1.77</td>
<td>1.10±1.00</td>
<td>0.47±0.13</td>
<td>62.97±0.95</td>
</tr>
<tr>
<td>D</td>
<td>9.38±0.15</td>
<td>7.82±0.11</td>
<td>2.46±1.00</td>
<td>1.20±0.13</td>
<td>0.43±0.17</td>
<td>60.49±0.72</td>
</tr>
<tr>
<td>E</td>
<td>9.84±0.22</td>
<td>8.14±0.81</td>
<td>2.63±0.18</td>
<td>1.24±0.13</td>
<td>0.39±0.17</td>
<td>58.06±1.00</td>
</tr>
</tbody>
</table>

Means with the same superscript within the same column are not significantly different (p>0.05). A = 100% Acha flour; B = 95% Acha flour + 5% pigeon pea flour; C = 90% Acha flour + 10% pigeon pea flour; D = 85% Acha flour + 15% pigeon pea flour; E = 80% Acha flour + 20% pigeon pea flour
Table 2. Antinutritional properties of biscuit from blends of acha and pigeon pea flour

<table>
<thead>
<tr>
<th>Sample</th>
<th>Tannin (mg/100g)</th>
<th>Phytate (mg/100g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>4.24±1.00</td>
<td>3.85±1.00</td>
</tr>
<tr>
<td>B</td>
<td>5.46±1.00</td>
<td>4.09±0.12</td>
</tr>
<tr>
<td>C</td>
<td>5.63±1.00</td>
<td>4.11±0.12</td>
</tr>
<tr>
<td>D</td>
<td>6.23±1.00</td>
<td>4.26±0.12</td>
</tr>
<tr>
<td>E</td>
<td>6.82±1.00</td>
<td>4.68±1.00</td>
</tr>
</tbody>
</table>

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

*Symbols A, B, C, D and E are as defined in Table 1

3.3 Physical Attributes of Biscuit

The results of the physical attributes of the biscuits are shown in Table 3. The physical attributes of the biscuit samples varied between 8.34 to 10.98 g, 0.56 to 0.85 cm, 4.77 to 5.03 cm, 5.99 to 8.59 for weight, thickness, diameter and spread ratio, respectively. The increase observed in the physical attributes of acha-flour biscuits could result from the acha flour's higher fat and starch content. Ayo et al. [34] and Okaka and Isieh [35] reported similar observations on acha-wheat biscuits supplemented with soybean flour and cowpea-wheat biscuits. The spread ratio decreased with the addition of pigeon pea flour. The presence of pigeon pea flour showed more effect on the spread ratio of the biscuits.

3.4 Sensory Attributes

The results of the sensory evaluation of biscuits are shown in Table 4. The assessment of sensory attributes of any food product plays a vital role in its development as it is used to assess the general acceptability of a food product. Table 4 indicates that the average scores of the sensory attributes taste, sweetness, crispiness, shape, colour and flavour varied between samples. Taste and appearance are among the most commonly used sensory parameters to assess the end consumer's overall acceptability of any finished food product. The mean scores for the biscuit flavour ranged from 5.10 to 7.96, and they differed significantly (p<0.05). The appearance of the biscuits has an average score ranged between 4.2 and 8.0 and significantly different from (p<0.05). The average of the scores for the general acceptability varied from 4.0 and 8.0, and they were significantly different (p<0.05) from each other. Moreover, the addition of pigeon pea flour improved sensory characteristics with overall acceptability in sample B (95% acha and 5% pigeon pea). Therefore, the usage of acha and pigeon pea flour in production of biscuits can be recommended for targeting of nutritional and sensorial properties of this bakery product.

Table 3. Physical attribute of biscuit from blends of acha and pigeon pea flour

<table>
<thead>
<tr>
<th>Sample</th>
<th>Weight (g)</th>
<th>Thickness (cm)</th>
<th>Diameter (cm)</th>
<th>Spread ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>8.34±0.014a</td>
<td>0.56±0.014a</td>
<td>4.77±0.021a</td>
<td>8.59±0.021f</td>
</tr>
<tr>
<td>B</td>
<td>9.34±0.014b</td>
<td>0.70±0.021b</td>
<td>4.87±0.035b</td>
<td>7.00±0.009e</td>
</tr>
<tr>
<td>C</td>
<td>10.04±0.007c</td>
<td>0.76±0.014c</td>
<td>4.94±0.021c</td>
<td>6.59±0.021d</td>
</tr>
<tr>
<td>D</td>
<td>10.38±0.021d</td>
<td>0.78±0.021c</td>
<td>4.99±0.007d</td>
<td>6.31±0.014c</td>
</tr>
<tr>
<td>E</td>
<td>10.98±0.014e</td>
<td>0.85±0.007d</td>
<td>5.03±0.007d</td>
<td>5.99±0.007b</td>
</tr>
</tbody>
</table>

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

*Symbols A, B, C, D and E are as defined in Table 1

Table 4. Sensory evaluation of biscuit from acha and pigeon pea flour blends

<table>
<thead>
<tr>
<th>Sample</th>
<th>Taste</th>
<th>Sweetness</th>
<th>Crunchiness</th>
<th>Appearance</th>
<th>Colour</th>
<th>Flavour</th>
<th>Overall acceptability</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>7.90c</td>
<td>7.90c</td>
<td>7.80c</td>
<td>8.00c</td>
<td>8.30c</td>
<td>7.95c</td>
<td>8.00c</td>
</tr>
<tr>
<td>B</td>
<td>7.95c</td>
<td>7.90c</td>
<td>8.20c</td>
<td>8.00c</td>
<td>8.00c</td>
<td>7.95c</td>
<td>8.00c</td>
</tr>
<tr>
<td>C</td>
<td>7.96d</td>
<td>7.80c</td>
<td>7.00c</td>
<td>6.40c</td>
<td>7.10d</td>
<td>8.00ab</td>
<td>7.00bc</td>
</tr>
<tr>
<td>D</td>
<td>6.85d</td>
<td>6.40b</td>
<td>5.60h</td>
<td>5.40ab</td>
<td>7.10d</td>
<td>6.60ab</td>
<td>5.80ab</td>
</tr>
<tr>
<td>E</td>
<td>5.10a</td>
<td>5.05a</td>
<td>4.80a</td>
<td>4.20ab</td>
<td>5.25a</td>
<td>5.15a</td>
<td>4.00a</td>
</tr>
</tbody>
</table>

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

*Symbols A, B, C, D and E are as defined in Table 1
4. CONCLUSIONS
This study suggested that acceptable and good quality biscuits could be made from acha and pigeon pea composite flour. Biscuits produced from 95% of acha flour and 5% of pigeon pea flour were the most accepted by the panelists. As a result, the production of biscuits from acha and pigeon pea flour blends should be encouraged to increase usage. It will also increase local farmers' income and reduce or eliminate the problem of protein-energy malnutrition, which is prevalent in most communities and developing countries, including Nigeria.

COMPETING INTERESTS
Authors have declared that no competing interests exist.

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