Original Research Article

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

Abstract

This study aimed to evaluate the effect of substituting whole wheat flour with acha and pigeon pea flours on the proximate composition, antinutrient content, physical characteristics, and sensory attributes of biscuits made from the blends. The blend of acha and pigeon pea was used to produce composite flour in the ratio of 100:0, 95:5, 90:10, 85:15, and 80:20. Biscuits made from this blend were analyzed for proximate composition, antinutrient content, physical attributes and sensory qualities. The results of 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 biscuit sample's protein, fat, moisture, and ash content increased while the fibre and carbohydrate content decreased with the addition of pigeon pea flour. The antinutrient content of the biscuit samples ranged from 41.24-64.23% for tannin and 3.85-4.68% for phytate. The biscuit samples showed a high concentration of anti-nutrients with the addition of more pigeon pea flour. The physical attributes of the biscuits ranged from 8.34-10.98kg, 0.56-0.85cm3, 4.21-7.21cm3, 4.77-5.03, 5.99-8.59 for weight, thickness, volume, 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 ratio) was the most acceptable because it gave the best colour, appearance, crispness and overall acceptability. The result obtained 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, which is common in most local communities, as well as reduce wheat importation, increasing the use of the most underutilized sources of flour in most developing countries.

Keywords: Anti-nutrient, composite flour, proximate composition, sensory evaluation and biscuit

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1. INTRODUCTION

Biscuit is one of Nigeria's most commonly eaten non-fermented baked snacks [1]. Eggs, sugar, butter, and wheat flour are the essential raw materials widely used in the production process of biscuits. 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 (Ref). Nevertheless, biscuits have a wide range of acceptance in terms of consumption by different 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 properties.

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Biscuit as a snack food has the tendency to be used for protein fortification and substitute for diet improvements as a result of its general acceptance by various individuals regardless of their age bracket [2]. 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 [3, 4].

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.

Lately, 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 such as 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. The use of this indigenous flour in the various baking industry 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 [5].

Acha (*Digitariaexilis*) is a grain crop that has historically been consumed whole as *tuwo, couscous, gwate,* acha jollof, and *kunun*acha[6]. Acha has high pentosane content (3.3%) and thus a high water absorption capacity, making it suitable for use in bakeries [7]. It is roughly 73% carbohydrates and high in micronutrients like iron and iodine (28.5 mg/100ml and 22.9 mg/100ml, respectively) [8].Acha is used as a health grain due to its gluten-free property and its consumption as a whole food product[9]. It is abundant in methionime, therefore has low sugar concentration when consumed; this serves as an advantage to diabetics patients [10, 11].

Pigeon pea is indigenously available, it has a low cost of production, and it is an under-utilized grain legume both in the sub-tropics and tropics areas. Wide varieties of pigeon pea have protein content varying from 23-26% [12]. 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, but its utilization in developing various food products has been limited majorly because its anti-nutrient or phytochemicals make up the hard-to-cook phenomenon [13, 14]. 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 [15].

Most underdeveloped and developing countries like Nigeria depend heavily on wheat flour to make bread, rolls, biscuits, and other pastry products. For this reason, the majority of these countries are conducting research to see 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 (Ref)., etc. In our modern world, constipation and diabetic patients are selective and careful with what they eat, especially sugary foods. Composite flour made from pigeon pea and acha blends is used to make biscuits suitable for everyone and contain more nutrients (Ref). However, in Nigeria, the use of acha and pigeon pea flour in the production of baked goods is uncommon. There are scanty or no studies on using acha and pigeon pea flour in biscuit production in Nigeria. This is because pigeon peas 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.

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2. MATERIALS AND METHODS

2.1 Samples Procurement

Acha(*Digitariaexilis*) grains were purchased from Nyanya market, Abuja, and pigeon pea (*Cajanus cajan*) was purchased at a local market in Bodija market in Ibadan, Oyo State. In addition, 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[16]was used to obtain acha flour from acha seeds. Two kilograms of acha were washed and dried. Hammer mill was then used to mill the dried acha, sieved and then the flour was obtained through continuous sieving with a sieve aperture of 300 -400 µm. About 2 kg of pigeon pea was cleaned, sieved, washed and soaked in water to dehull and remove the shaft. The dehulled pigeon pea was oven dried (Type of oven use, model and maker) at 55 °C for 12 hours, milled (which machine) 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 mixes were prepared using acha flour (AF) ratios and pigeon pea flour (PPF). According to IhekoronyeandNgoddy[17], the method was adopted with slight modification. The formulations containing sugar (60 g), baking powder (1%), milk (25g), flavoring (2g) and water (50ml) have been used to produce different cookie patterns. Different proportions of flour are weighed and mixed with the dry ingredients

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(sugar, baking powder, water, cooking fat, vanilla, salt and milk. The dry ingredients are first weighed and mixed before added butter and then whipped cream. Add water and mix well, until desired thickness is achieved. The dough is then cut into a circle using a cookie cutter. The formed biscuits are baked at 180 ºC for 15 - 20 minutes, cooled and packed.

2.4 Analyses

2.4.1 Proximate composition of biscuits

The proximate composition of the biscuit samples was determined according to the method described by AOAC [18]. The fat content was determined by the soxlet extraction method 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 deffated in a tar-impregnated porcelain crucible. Then it is burned at 600 ℃ for about six hours in the oven until the fiber is obtained. Ash content is also determined by this method. Moisture content is determined by the hot air oven method. Carbohydrate content was determined by sample difference, i.e.

% carbohydrate content = (100 - % crude fiber + % protein + % fat + % ash + moisture content) (1)

2.4.2 Anti-Nutritional Factors of Biscuits

Folin-Denis spectrophotometric method was used to determine the tannin content [19]. The phytate content of the samples was determined according to the method of AOAC [18].

2.4.3 Physical attributes of biscuits

An electronic scale was used to measure the weight of biscuits and the mean of biscuit samples was recorded. The biscuit diameter was determined using [18]. 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*. [20]. In this method, six biscuits samples were stacked, and the average thickness was obtained using a caliper. The average value obtained is used to specify the thickness of the cookie. The biscuit spread ratio was defined as the mean diameter to mean thickness [21].

2.5 Sensory Evaluation

The biscuits samples were presented to 50 panelists from Food Engineering Department, LAUTECH, Ogbomoso for sensory evaluation in the sensory laboratory. Individual panelists were given at random six (6) samples of biscuits neatly arranged on a rectangular shaped plastic tray. The biscuits were sealed separately in a pouch and were coded before the commencement of the sensory evaluation process. Panelists were required to evaluate sensory attributes such as colour, crispness, taste and the overall acceptability of the biscuits with the aid of a 9-point hedonic scale according to Larmond[22].

2.6 Statistical Analysis

The data results obtained were analyzed using ANOVA, and Duncan's multiple range test was used to detect significant differences ($p<0.05$) between sample values using Statistical Package Version for the Social Sciences (IBM SPSS) 21.0.

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3. RESULTS AND DISCUSSION

3.1 Proximate Composition

Proximate composition results for biscuits made from acha and pigeon peas flour are shown in Table 1. The moisture content of biscuits ranged from 7.87 to 9.84%. The value of the results obtained in this study is similar to the results reported by Ayo and Andrew [23] on biscuit made from acha-date palm flour. Biscuits with less than 5% moisture content have a long shelf life as less than 5% moisture content is reported to be damaged free and harmful bacteria.

Comment [A6]: Reported by who?

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 may be due to the high protein content in pigeon peas [13, 14]. The high concentration of protein in the biscuits can also be attributed to the addition of a significant amount of whole eggs in the formulation and also acha is considered as ~~one of the~~ nutritious ~~of all~~ grains.~~;~~ its seeds contain 8.79% protein

The biscuit fat content ranged from 21.99 to 26.33%. The fat content was significantly different ($p<0.05$). The addition of pigeon pea flour increased the ash content of the cookie sample. The presence of ash in cookies 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*. [25] when carrot extract was added to the flour and cornmeal mixture. Ash is an inorganic compound used as a mineral indicator in foods. It contributes to the metabolic activities of other compounds such as proteins, lipids, and carbohydrates [24].

Carbohydrate content ranged from 58.06 to 63.01%. The results obtained for carbohydrates in this study were similar to those reported by Ufot*et al*. [26]. However, there is a significant difference ($p<0.05$) between the samples. Carbohydrates are an excellent source of energy used in daily human activities. The carbohydrate content in these samples suggests that the products ~~are a~~may be prominent energy source.

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

Sample	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Fibre (%)	CHO (%)
A	7.87±1.00^{c}	7.36±1.00^{a}	21.99±0.18^{a}	0.87±1.00^{a}	0.59±1.00^{d}	61.32±0.72^{c}
B	8.94±0.15^{a}	7.59±1.00^{b}	22.83±0.18^{a}	1.00±1.00^{b}	0.54±1.00^{c}	63.01±0.95^{d}
C	8.99±0.15^{a}	7.74±0.11^{c}	22.88±1.77^{a}	1.10±1.00^{c}	0.47±0.13^{b}	62.97±0.95^{d}
D	9.38±0.15^{a}	7.82±0.11^{c}	24.68±1.00^{b}	1.20±0.13^{d}	0.43±0.17^{ab}	60.49±0.72^{b}
E	9.84±0.22^{b}	8.14±0.81^{d}	26.33±0.18^{c}	1.24±0.13^{d}	0.39±0.17^{a}	58.06±1.00^{a}

Means with the same superscript within the same column are not significantly different ($p>0.05$).A= 100% Acha flour + 0% pigeon pea 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 + 200% pigeon pea flour

3.2 Anti-Nutritional Composition of Biscuit

Table 2 shows the ~~anti-nutritive composition~~antinutritional factors of the biscuits. The antinutrient content of the sample ranged from 41.24 to 64.23 mg/100 g for tannin and 3.85 to 4.68 mg/100 g for phytate, respectively. There is a reduction in the antinutrient content of biscuits compared to raw beans. This is likely due to the heat applied when making the biscuits. Apata and Ologhobo[27] reported that some anti-nutrients are heat-labile and thus are significantly reduced when heat is applied. The phytate content of the pigeon pea flour used in biscuit production is hydrolyzed when stored at 55% relative humidity and 50 °C, contributing to the increased titratable acidity of the biscuit samples. The results of the phytate content obtained in this study were different in value compared to the result obtained and reported for some underutilized legumes and some cookies [28]. Tannins have been linked to lower feed intake, growth rate, feed efficiency, and protein digestibility in humans and animals. This study's findings were superior to those reported by Amadi[29]. The amount of tannin discovered in this study was~~is~~ considered ~~in~~ higher. ~~concentrations and thus toxic.~~ Prior to use, the tannin level in the pigeon pea should be reduced carefully through processing.

Comment [A7]: What is titratable acidity doing in the sentence? The author did not carry out titratable acidity. You have to reconstruct the sentence.

Comment [A8]: What is superior doing in scientific report? Reconstruct the sentence. Doing similar research does not mean having one finding superior than the other.

Table 2. Anti-nutritional properties of biscuit from blends of acha and pigeon pea flour

Sample	Tannin (mg/100g)	Phytate (mg/100g)
A	41.24±1.00^{a}	3.85±1.00^{a}
B	64.23±1.00^{e}	4.09±0.12^{b}

C	60.82±1.00[d]	4.11±0.12[b]
D	51.63±1.00[c]	4.26±0.12[b]
E	50.46±1.00[b]	4.68±1.00[c]

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 physical attributes of the biscuits are shown in Table 3. The physical attributes values of the biscuits 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 the biscuit samples could result from the higher fat and starch content of the pigeon pea flour. Ayo *et al.*[30] and Okaka and Isieh[31] reported similar observation on biscuits produced from acha-wheat biscuit supplemented with soybean flourand cowpea-wheat biscuits. The spread ratio decreased with the addition of pigeon pea flour. The pigeon pea flour had a high and positive effect on the spread ratio. The inclusion of pigeon pea flour enhanced the spreadability of the biscuit samples reduced with the level of replacement with acha flour.

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

Sample	Weight (g)	Thickness (cm)	Diameter (cm)	Spread ratio
A	8.34±0.014[a]	0.56±0.014[a]	4.77±0.021[a]	8.59±0.021[f]
B	9.34±0.014[b]	0.70±0.021[b]	4.87±0.035[b]	7.00±0.000[e]
C	10.04±0.007[c]	0.76±0.014[c]	4.94±0.021[c]	6.58±0.021[d]
D	10.38±0.021[d]	0.78±0.021[c]	4.99±0.007[d]	6.31±0.014[c]
E	10.98±0.014[e]	0.85±0.007[d]	5.03±0.007[d]	5.99±0.007[b]

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

3.4 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 indicate that the average scores of the sensory attributes ~~tasting ratings for~~ 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). Biscuits had mean scores ranging from 4.2 to 8.0, which differed significantly

(p<0.05). The mean overall acceptance scores ranged from 4.0 to 8.0, with significant differences (p<0.05). However, sample A (100% of wheat flour and 0% pigeon pea flour) with the highest mean score (Mean scores for which attributes?) was the best-accepted sample in terms of overall acceptability while sample E (80% of flour and 20% pigeon pea flour) is the least preferred in terms of general acceptability. The average overall acceptance score for samples A (100% of flour and 10% pigeon pea flour) and E (80% of flour and 20% of pigeon pea flour) was less preferred (p<0.05).

Comment [A10]: The statement is confusing. Which biscuits? Which attributes? Many things are wrong with that statement.

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

Sample	Taste	Sweetness	Crunchiness	Appearance	Colour	Flavour	Overall acceptability
A	7.90^{c}	7.90^{c}	7.80^{c}	8.00^{d}	8.30^{d}	7.95^{b}	8.00^{c}
B	7.95^{c}	7.90^{c}	8.20^{c}	8.00^{d}	8.00^{d}	7.95^{d}	8.00^{c}
C	7.96^{cd}	7.80^{c}	7.00^{bc}	6.40^{bc}	7.10^{cd}	8.00^{ab}	7.00^{bc}
D	6.85^{cd}	6.40^{b}	5.60^{ab}	5.40^{ab}	7.10^{cd}	6.60^{ab}	5.80^{ab}
E	5.10^{a}	5.05^{a}	4.80^{a}	4.20^{ab}	5.25^{a}	5.15^{a}	4.00^{a}

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

The findings of this study indicated that composite flour from acha and pigeon pea could be used to make biscuits with improved nutritional attributes and characteristics. Biscuits produced from 95% of acha flour and 5% of pigeon pea flour were the most accepted by the panelists. Therefore, the production of biscuits from achaand pigeon pea flour blends should be encouraged as it will enhance the usage, increase the income of local farmers, and reduce or eliminate the problem associated with protein-energy malnutrition is prevalent in most communities and developing countries including Nigeria.

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