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Quality Evaluation and Sensory Properties of *Gari* Enriched with Pigeon Pea Flour

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Abstract
Gari is a staple food for many families in Nigeria and other sub-Saharan African countries, but it is very low in protein. However, pigeon pea has the potential of increasing its protein content, thereby, improving the protein intake of the people. The study aimed at evaluating the proximate composition, antinutrients content and sensory properties of *gari*-pigeon pea flour blends. Seven blends were produced from different proportions of *gari* and pigeon pea flour in the ratios of 95:5, 90:10, 85:15, 80:20, 75:25, 70:30 and 100:0 (control). The proximate composition, antinutrients content and sensory attributes of the blends were determined using standard methods. Significant differences ($p<0.05$) exist in the values of the proximate composition, antinutrients content and sensory properties. The proximate composition indicated significant ($p<0.05$) increase in protein (1.87 – 3.66 %), ash (1.01 – 1.60 %), fat (0.72 – 1.30 %), crude fibre (0.68 – 1.26 %), and significant ($p<0.05$) decrease in carbohydrate (88.51 – 84.96 %) and energy value (368.0 – 366.18 Kcal/100g) as the inclusion of pigeon pea flour into *gari* increased. The antinutrients content significantly ($p<0.05$) decreased with increase in the addition of pigeon pea flour. The sensory scores were significantly ($p<0.05$) affected with increase in pigeon pea flour inclusion. However, the samples with up to 15% pigeon pea flour inclusion were acceptable to the panelists. The study has shown that enriched *gari* with increased protein content and acceptable qualities can be produced from *gari*-pigeon pea flour blends.

Keywords: Gari, staple food, pigeon pea flour, families, protein

Introduction

Cassava (*Manihot esculenta* Crantz) is the 4th most important staple crop in the world after rice, wheat and maize (Onabolu *et al*., 2001). In terms of production, cassava ranks second after yam among the roots and tuber crops of economic importance (FAO, 2007). Nigeria is the largest producer of cassava in the world, followed by Thailand, Brazil, Indonesia, Ghana among others (Bassey and Harry, 2013; Nwafor *et al*., 2015). Cassava is an important source of eatable carbohydrate, but it is highly perishable (Oluwole and Adeyemo, 2001). However, it can be processed into several foods like *gari*, *abacha*, *fufu*, *eba*, *lafun*, etc., and industrial products like alcohol and starch (Okoro, 2007). Cassava is low in nutrients such as protein, vitamins and minerals (Olugbemi *et al*., 2010). Onabolu *et al*. (2001) reported that cassava contains 1% protein, 97% starch, 1% fibre with traces of fat and other minerals. Pigeon pea is a leguminous crop which has high protein, vitamin and mineral content (Nwanekezi *et al*., 2017; Arukwe and Nwanekezi, 2022). But it is still underutilized due to some inherent problems such as antinutritional factors. However, these antinutrients can be removed by fermentation and heat (Nwanekezi *et al*., 2017a; Arukwe, 2021a).

Gari is a staple food for many people in Nigeria, but is mostly consumed by the poor majority of the population. *Gari* accounts for over 70% of the entire cassava production in Nigeria (FAO, 2004), very palatable and have long shelf life. It is a good source of energy to the consumers and can be eaten in different forms, either made into stiff paste (*eba*) with hot water and eaten with soup or soaked in water and taken with milk, groundnut, coconut, bread, etc.

The prevalence of protein malnutrition in Nigeria necessitated the desire to supplement the traditional meals of the people such as *gari* with pigeon pea flour. Pigeon pea has the potential of increasing the protein content of *gari*, thereby improving the protein intake of the people. *Gari* is a staple food in Nigeria but it is poor in protein content. Enriching *gari* with pigeon pea flour is a better and safer means of upgrading the nutrient content, and adding value to the underutilized crop, pigeon pea. The study aimed at evaluating the proximate composition and antinutrients content of *gari*-pigeon pea flour, and sensory properties of stiff paste (*eba*) prepared from the blends.

Materials and Methods

Raw Materials Procurement

Cassava roots and pigeon pea grains used for this study were procured from Ubani Main Market in Umuahia North Local Government Area, Abia State.

Production of Cassava Mash and Pigeon Pea Flour

Two kilograms of cassava roots were washed, manually peeled with a sharp knife, washed and grated with a locally fabricated mechanical grater to produce the mash. One kilogram of pigeon pea seeds was sorted, cleaned, washed and soaked in water for about 12 hrs and the water drained. The seeds were manually dehulled by rubbing between the palms and the cotyledons were rinsed in water. The grains were dried in an oven at 60°C for 7 hrs (Gallenkemp, 300 Plus, England), milled into flour using disc attrition mill (Asiko A11, Addis Nigeria) and sieved with 0.25 mm particle size mesh. Then, some portion of cassava mash and pigeon pea flour were mixed in a basin at the ratios of 95:5, 90:10, 85:15, 80:20, 75:25, 70:30 and 100:0 (control). These were packed into different hessian bags and allowed to ferment for two days, after which the mash was dewatered in a hydraulic press and the cake sifted into grits with a woven sieve made from raffia to remove fibrous materials.

Blending of Cassava Mash and Pigeon Pea Flour

Seven blends were produced from different proportions of cassava mash and pigeon pea flour in the ratios of 95:5, 90:10, 85:15, 80:20, 75:25, 70:30 and 100:0 (control).

Production of Gari (Garification)

The production of *gari* was done as described by Amponsah (2018) with slight modification. The frying pan was placed on fire and left to heat up for 5 minutes. Then, each of the blends of cassava-pigeon pea flour sifted grits were added to the pan and toasted separately for about 15 - 20 minutes with regular stirring to curb the formation of lumps and burning, and to guarantee uniform heating of the granules. After toasting, the *gari* samples were removed from the frying pan and spread over a large clean surface of polyethylene to cool, sieved and packed in polyethylene bags for further studies.

Determination of Proximate Composition and Energy Value

The AOAC (2010) methods were used to determine the protein, moisture, crude fibre, fat, ash and carbohydrate contents of the samples and the analysis was done in triplicates. The energy value was determined by Atwater factor (AOAC, 2010).

Determination of Antinutrients Content

The glycoside (cyanide) content was determined by the method of Bradbury *et al*. (1985). Phytate was analyzed using the method described by Haugh and Lantzsch (1993). The gravimetric method described by Harbone (1973) was employed to determine the saponin content. Tannin content was analyzed by the Folin Denis colometric method (Pearson, 1976). The AOAC (2005) method was used to determine oxalate content, while the trypsin inhibitor content was analyzed by Arntfield *et al*. (1985) spectrophotometric method.

Preparation of Gari stiff Paste (Eba)

Two hundred and fifty grams (250 g) of each of the *gari*-pigeon pea flour blends were added into 450 ml boiling water and stirred using a wooden spatula until it forms a smooth stiff paste. The stiff paste was scooped into a plate and left to cool before using it for sensory evaluation.

Sensory Evaluation

Sensory evaluation of the *gari* stiff paste (*eba*) samples was carried out using the 5-point Hedonic scale (where 5 = like very much, 4 = like slightly, 3 = neither like nor dislike, 2 = dislike slightly and 1 = dislike very much) as described by Iwe (2014). Twenty semi-trained panelists were involved in the evaluation of appearance, texture, aroma, mouldability and overall acceptability.

Statistical Analysis

The laboratory data obtained were subjected to analysis of variance using the SPSS version 22, while treatment means were separated using Duncan's Multiple Range Test at 95% confidence level ($p<0.05$).

Results and Discussion

Proximate Composition and Energy Value of Blends of Gari-Pigeon Pea Flour

Table 1 depicts the proximate composition and energy value of blends of *gari*-pigeon pea flour. The results showed that there were significant differences ($p<0.05$) between all the measured parameters except the moisture content where there was no significant differences ($p>0.05$) in the blends. The protein, ash, fat and crude fibre contents of the formulated blends increased with increasing addition of pigeon pea flour, while, the carbohydrate and energy value reduced with increased inclusion of pigeon pea flour. The moisture content of a food product determines its storability and shelf life, and high moisture can adversely affect the storage stability (Olaoye *et al*., 2015). The results show that the moisture contents of the *gari*-pigeon pea blends were low. Iombor *et al*. (2016) noted that low moisture content in foods might be due to some of the water being tightly bound to food matrixes, thereby making it unavailable to food pathogens proliferative activities, and which likely may promote shelf stability of the *gari* blends. Also, moisture content of the *gari* was affected by the extent of toasting, particle size distribution and fermentation time (Agbara and Ohaka, 2018). Abu *et al*. (2006) recommended maximum of 12% moisture content for shelf stable *gari* and the values obtained in this study are lower, suggesting that the blends will be shelf stable. Protein is crucial to the regulation and maintenance of the body. The protein contents of the formulated blends were higher than that of the control sample. This could be attributed to the inclusion of pigeon pea flour in the blends since pigeon pea is rich in protein. This justifies the aim of this study which was to enrich the staple food of the people with protein so as to mitigate the incidence of protein malnutrition.

The ash content of a food indicates its total mineral content. Ash content represents assessment of minerals in foods (Onwuka, 2005). The rise in ash content of the formulated *gari* blends as the level of pigeon pea flour increased in the blends could be attributed to the high ash content of pigeon pea flour. Pigeon pea is a good depository of minerals (Nwanekezi *et al*., 2017, Arukwe and Nwanekezi, 2022). This suggests that the formulated blends will help to improve the mineral intake of the *gari* consumers, thereby ameliorating the effects associated with micronutrient deficiencies in developing countries (Arukwe and Nwanekezi, 2022). Fat content of the blends were low. The low fat content will ensure longer shelf life of the blends because chances of rancidity will be drastically reduced. The increase in the crude fire content of the *gari*-pigeon pea flour obtained in this study could be attributed to the addition effect of pigeon pea flour inclusion on the *gari*, since pigeon pea is rich in fibre (Arukwe, 2021a). This increase in crude fibre for the enriched *gari* samples is advantageous because dietary fibre has been reported to reduce the incidence of diabetes, colon cancer, and heart disease, among others. Carbohydrate is the energy provider for the body. The carbohydrate content of the control sample was the highest (88.51%). This is expected since cassava roots are good sources of carbohydrates. The carbohydrate content of the blends reduced with increased inclusion of pigeon pea flour. This suggests that the *gari*-pigeon pea flour blends will be a good food for diabetic patients that require low carbohydrate diets.

Energy is an important attribute of food and is required by human beings for their daily activities. The highest energy value was recorded for 100% *gari* (control) and could be attributed to its higher carbohydrate content compared to the other samples. The energy value for the *gari*-pigeon pea flour blends decreased with increased addition of pigeon pea flour. This could be attributed to the low carbohydrate and fat content of pigeon pea flour. This indicates that the *gari*-pigeon pea flour blends with reduced energy value can act as functional foods and will be suitable for people with overweight, obesity, diabetics, hypertension, etc.

Antinutrient Content of Blends of Gari-Pigeon Pea Flour

Antinutritional factors or antinutrients are those substances that hinder the intake, digestion, absorption and utilization of nutrients. Their presence in large amounts can have unfavourable consequences on health through hindering the digestion of protein, and the absorption of iron and zinc (Larsson *et al*., 1996). The results of the antinutrients content of blends of *gari* and pigeon pea flour are shown in Table 2. There were significant differences ($p<0.05$) in the antinutrients contents of the blends. The glycoside content ranged from 0.001 – 0.005 g/100 g. The 100% *gari* sample had the highest value (0.005 g/100 g) which was consistently reduced with increased inclusion of pigeon pea flour. The phytate content also decreased with increased inclusion of pigeon pea flour. The saponin, tannin, oxalate and trypsin inhibitor followed the same trend of reduction as the percent of pigeon pea flour increased in the blends. The low antinutrients contents of the blends could be attributed to the fermentation, toasting and addition of pigeon pea flour into the blends. The value obtained for glycosides was lower than the recommended standard value of 20 mg/kg (NIS 181, 2004) and also lower than 0-32 mg/kg recommended by Adindu *et al*. (2003). The reduction in the values of glycosides might have been due to fermentation, heat used for toasting of the *gari* and dilution effect of pigeon pea flour. The same trend was observed for phytate which was hydrolysed by the processing methods used such as soaking, fermentation (Sandberg and Svanberg, 1991), because of the activation of intrinsic plant phytases, extrinsic microbial phytases or both. The decrease of phytate during fermentation of the cassava mash could be attributed to enzymatic action which increased the level of phytase that caused the reduction in phytate. (Nwanekezi *et al*., 2017a). Heat processing such as toasting of the *gari*-pigeon pea flour blends also led to partial nonenzymatic hydrolysis of the phytate (Tabekhia and Luh, 1980). Bishnoi and Khetarpaul (1994) reported that phytate forms complexes with protein and minerals which leads to their unavailability. Therefore, the low values obtained for phytate indicates higher nutrient bioavailability for the samples. The glycoside, phytate, saponin, tannin, oxalate and trypsin inhibitor contents of the blends were very low. This could be attributed to the soaking, fermentation, inclusion of pigeon pea flour, and heat used in toasting the *gari*. Furthermore, the low values recorded for the antinutrients analyzed in this study suggest better nutritional quality and safety of the blends (Arukwe and Arukwe, 2021).

Sensory Properties of Blends of Gari-Pigeon Pea Flour

The mean sensory scores for the prepared *gari* stiff paste (*eba*) are presented in Table 3. There were significant differences ($p<0.05$) in the sensory attributes of most of the blends. The results of sensory properties of blends of *gari* and pigeon pea flour showed that the higher the ratio of pigeon pea flour inclusion, the lower the sensory scores, although the sensory parameter of appearance did not differ significantly ($p>0.05$) in all the blends. The results showed that the control sample (100% *gari*) was most preferred, but sample 95:5 (95% *gari* and 5%

pigeon pea flour) was more preferred among the test samples followed by sample 90:10 (90% *gari* and 10% pigeon pea flour) in terms of appearance, texture, aroma, mouldability and overall acceptability. It was observed that the pigeon pea flour substituted samples 95:5, 90:10 and 85:15 were acceptable to the panelists with sensory scores of like slightly while sample 80:20, 75:25 and 70:30 were evaluated by the panelists as neither like nor dislike. This is so as the pigeon pea flour increased, the sensory scores decreased, making the samples less preferred. This result is in consonance with the work of Ubbor and Iguh (2021) who reported that the dough (*eba*) samples made from sieved *gari* and pearl millet blends were acceptable to the panelists, but in disagreement with the result of Ojo and Akande (2013) who produced *gari* from cassava and sweet potato tuber mixes.

Conclusion

The result has shown that production of enriched *gari* with addition of pigeon pea flour was feasible. The 30% inclusion of pigeon pea flour produced the highest protein content and this can be utilized to alleviate the protein malnutrition in Nigeria and other developing countries. The sensory evaluation result showed that all the samples up to 15% pigeon pea flour supplementation were acceptable, although the 5% inclusion was preferred among the test samples. Also, the antinutrients greatly reduced due to fermentation, inclusion of pigeon pea flour, and heat used in toasting the *gari*. Therefore, inclusion of pigeon pea flour into *gari* increased the nutritional contents and reduced the antinutrients content, thereby producing *gari* of higher quality and safety. Pigeon pea has been an underutilized crop despite its immense nutritional benefits due to its inherent constraints such as its content of antinutrients and the hard-to-cook syndrome. Therefore, its utilization for enriching the staple food of the people (*gari*), should be encouraged. Sensitization programs should be organized to create awareness on the need for consumption and commercialization of the enriched *gari* produced from cassava mash and pigeon pea flour.

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Table 1: Proximate Composition and Energy Value of Blends of *Gari*-Pigeon Pea Flour

Sample GR:PP	Moisture %	Protein %	Ash %	Fat %	Crude Fibre %	Carbohydrate %	Energy Kcal/100 g
100:0	$7.21^a \pm 0.01$	$1.87^g \pm 0.0$	$1.01^g \pm 0.02$	$0.72^g \pm 0.01$	$0.68^g \pm 0.0$	$88.51^a \pm 0.01$	$368.00^a \pm 0.0$
95:5	$7.20^a \pm 0.02$	$2.40^f \pm 0.01$	$1.12^f \pm 0.0$	$0.80^f \pm 0.01$	$0.75^f \pm 0.01$	$87.73^b \pm 0.02$	$367.72^b \pm 0.01$
90:10	$7.22^a \pm 0.00$	$2.62^e \pm 0.02$	$1.19^e \pm 0.01$	$0.90^e \pm 0.02$	$0.84^e \pm 0.02$	$87.23^c \pm 0.00$	$367.50^c \pm 0.00$
85:15	$7.20^a \pm 0.01$	$2.90^d \pm 0.01$	$1.30^d \pm 0.0$	$1.10^d \pm 0.00$	$1.05^d \pm 0.00$	$86.45^d \pm 0.0$	$367.30^d \pm 0.0$
80:20	$7.21^a \pm 0.02$	$3.18^c \pm 0.0$	$1.40^c \pm 0.01$	$1.15^c \pm 0.0$	$1.13^c \pm 0.02$	$85.93^e \pm 0.01$	$366.79^e \pm 0.02$
75:25	$7.20^a \pm 0.0$	$3.40^b \pm 0.02$	$1.51^b \pm 0.0$	$1.22^b \pm 0.01$	$1.20^b \pm 0.0$	$85.47^f \pm 0.01$	$366.46^f \pm 0.01$
70:30	$7.22^a \pm 0.01$	$3.66^a \pm 0.01$	$1.60^a \pm 0.01$	$1.30^a \pm 0.02$	$1.26^a \pm 0.01$	$84.96^g \pm 0.02$	$366.18^g \pm 0.0$

Values are means ± standard deviation of duplicate determination. Mean values in the same column with different superscript are significantly different (p<0.05).

Key: GR (gari), PP (pigeon pea flour), 100:0 (100% gari), 95:5(95% gari and 5% pigeon pea flour), 90:10(90% gari and 10% pigeon pea flour), 85:15(85% gari and 15% pigeon pea flour), 80:20(80% gari and 20% pigeon pea flour), 75:25(75% gari and 25% pigeon pea flour) and 70:30(70% gari and 30% pigeon pea flour).

Table 2: Antinutrient Content of Blends of *Gari*-Pigeon Pea Flour

Sample GR:PP	Glycoside (g/100g)	Phytate (g/100g)	Saponin (g/100g)	Tannin (g/100g)	Oxalate (g/100g)	Trypsin Inhibitor (g/100g)
100:0	$0.005^{a}\pm0.0$	$0.010^{a}\pm0.0$	$0.012^{a}\pm0.0$	$0.011^{a}\pm0.0$	$0.008^{a}\pm0.01$	$0.005^{a}\pm0.0$
95:5	$0.004^{b}\pm0.0$	$0.009^{b}\pm0.01$	$0.010^{b}\pm0.0$	$0.010^{b}\pm0.01$	$0.007^{b}\pm0.0$	$0.004^{b}\pm0.0$
90:10	$0.004^{b}\pm0.0$	$0.008^{c}\pm0.0$	$0.008^{c}\pm0.0$	$0.008^{c}\pm0.0$	$0.006^{c}\pm0.0$	$0.004^{b}\pm0.0$
85:15	$0.003^{c}\pm0.0$	$0.007^{d}\pm0.0$	$0.006^{d}\pm0.0$	$0.007^{d}\pm0.01$	$0.004^{d}\pm0.0$	$0.003^{c}\pm0.0$
80:20	$0.002^{d}\pm0.0$	$0.005^{e}\pm0.01$	$0.005^{e}\pm0.0$	$0.006^{e}\pm0.0$	$0.003^{e}\pm0.0$	$0.002^{d}\pm0.0$
75:25	$0.002^{d}\pm0.0$	$0.004^{f}\pm0.0$	$0.004^{f}\pm0.0$	$0.005^{f}\pm0.0$	$0.002^{f}\pm0.01$	$0.001^{e}\pm0.0$
70:30	$0.001^{e}\pm0.0$	$0.003^{g}\pm0.01$	$0.003^{g}\pm0.0$	$0.004^{g}\pm0.01$	$0.002^{f}\pm0.0$	$0.001^{e}\pm0.0$

Values are means ± standard deviation of duplicate determination. Mean values in the same column with different superscript are significantly different ($p<0.05$).

Key: GR (gari), PP (pigeon pea flour), 100:0 (100% gari), 95:5(95% gari and 5% pigeon pea flour), 90:10(90% gari and 10% pigeon pea flour), 85:15(85% gari and 15% pigeon pea flour), 80:20(80% gari and 20% pigeon pea flour), 75:25(75% gari and 25% pigeon pea flour) and 70:30(70% gari and 30% pigeon pea flour).

Table 3: Sensory Properties of Blends of *Gari*-Pigeon Pea Flour

Sample GR:PP	Appearance	Texture	Aroma	Mouldability	Overall Acceptability
100:0	$3.95^{a}\pm0.01$	$4.00^{a}\pm0.0$	$3.96^{a}\pm0.01$	$4.16^{a}\pm0.0$	$4.12^{a}\pm0.01$
95:5	$3.60^{b}\pm0.0$	$3.82^{b}\pm0.01$	$3.52^{b}\pm0.0$	$4.0^{b}\pm0.01$	$3.85^{b}\pm0.0$
90:10	$3.56^{c}\pm0.0$	$3.63^{c}\pm0.0$	$3.19^{c}\pm0.01$	$3.90^{c}\pm0.0$	$3.70^{c}\pm0.01$
85:15	$3.55^{c}\pm0.01$	$3.60^{d}\pm0.0$	$2.70^{d}\pm0.0$	$3.75^{d}\pm0.0$	$3.55^{d}\pm0.0$
80:20	$3.53^{d}\pm0.0$	$3.56^{e}\pm0.01$	$2.56^{e}\pm0.01$	$3.55^{e}\pm0.0$	$3.13^{e}\pm0.0$
75:25	$2.70^{e}\pm0.0$	$2.66^{f}\pm0.0$	$2.21^{f}\pm0.01$	$3.22^{f}\pm0.0$	$2.68^{f}\pm0.01$
70:30	$2.65^{f}\pm0.01$	$2.54^{g}\pm0.01$	$2.10^{g}\pm0.0$	$3.10^{g}\pm0.0$	$2.56^{g}\pm0.0$

Values are means ± standard deviation of duplicate determination. Mean values in the same column with different superscript are significantly different ($p<0.05$).

Key: GR (gari), PP (pigeon pea flour), 100:0 (100% gari), 95:5(95% gari and 5% pigeon pea flour), 90:10(90% gari and 10% pigeon pea flour), 85:15(85% gari and 15% pigeon pea flour), 80:20(80% gari and 20% pigeon pea flour), 75:25(75% gari and 25% pigeon pea flour) and 70:30(70% gari and 30% pigeon pea flour).