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Research Article

Quality and sensory evaluation of "pankoto" (cassava-overripe plantain pudding) supplemented with Bambara groundnut flour

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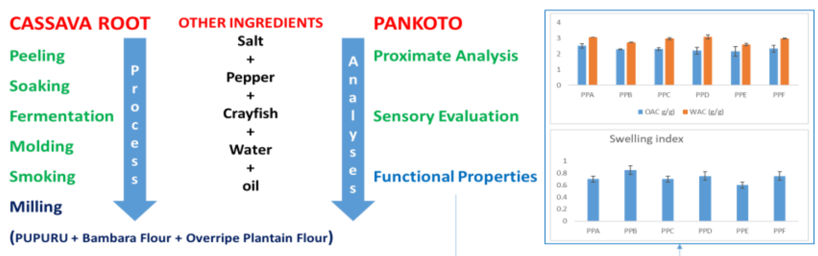
ABSTRACT

In an attempt to improve the nutritional value of *pankoto* (a steamed cassava-overripe plantain pudding), it was supplemented with Bambara groundnut flour and the effect of its supplementation on the physicochemical and sensory properties of *pankoto* was evaluated. Six blends were formulated for the production of *pankoto* in the ratios of plantain:*pupuru*:Bambara; 150:50:0 (PPA), 150:45:5(PPB), 150:40:10 (PPC), 150:35:15 (PPD), 150:30:20 (PPE), 150:25:25 (PPF). Standard methods were used to carry out all the analyses. Incorporating Bambara groundnut flour at 10–50% levels increased the protein and crude fibre from 9.03%-11.23% and 2.05–2.22% respectively, while the carbohydrate content ranged from 66.16%-72.56%. The values ranged from 7.02–10.04%, 3.22–4.20% and 6.13–6.74% for fat, ash and moisture, respectively. The water absorption, oil absorption and swelling capacities were low with values ranging from 2.61–3.09%, 2.18–2.51% and 60–85%, respectively. Sensory attributes of sample PPF (150:25:25) had the highest preference in terms of appearance, taste, aroma and general acceptability.



HIGHLIGHTS

- Nutritional qualities of pankoto was improved with Bambara groundnut supplementation.
- 6 ratios of blends of plantain, pupuru & Bambara in ratios were formulated.
- The supplemented flours exhibited good functionality.
- The Bambara groundnut supplemented pankoto was sensorially accepted.

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Pankoto; proximate composition; functional properties; sensory attributes.

1. Introduction

Pankoto is a traditional food consumed by the *Akpoi* tribe located in Sabomi, Ese-Odo local government area, Ondo state, Nigeria. It is made from overripe plantain (*Musa acuminata*) and cassava flour (*pupuru*). *Pankoto* is also consumed by the *Ilaje* tribe in Ondo state and it is referred to it as *imeki*; the *Ikale* and *Ijaw* tribes in the riverine areas are also major consumers of *pankoto*. The major ingredient is the overripe plantain; *pupuru* is added to thicken the pudding due to the soggy nature of the overripe plantain. Plantains are rich in carbohydrates (24.5%), dietary fibre (6%) *and* minerals like calcium (<0.5%), iron (7.5%), magnesium (9%), phosphorus (5%), zinc (1%), sodium (<1%), potassium (10.6%), and vitamins like folates (5.5%), niacin (4%), pyridoxine (23%), riboflavin (4%), thiamin (4%), vitamin A (37.5%), vitamin C (31%), vitamin E (1%), vitamin K (1%) however, it is low in proteins (2%) and cholesterol (0%) (Umesh, 2009). It can be consumed when duly processed in its three maturity forms: unripe, ripe and overripe and it is being used for a variety of domestic (plantain mosa, fried dodo, plantain chips, plantain pudding) and industrial (plantain flour, baby foods, wine, beer, dried flakes, biscuits and cookies) applications (Honfo *et al*., 2007; FAO, 1999). *Pupuru* is a fermented cassava-based food product dried by smoking. It is commonly consumed by the people living in the riverine areas of the western, southern, eastern and middle belts of Nigeria, where it is also known as 'pukuru', 'Ikwurikwu' or 'kumkum' (Shittu *et al.,* 2005). *Pupuru* is produced traditionally through a series of processing methods from cassava (*Manihot esculenta*) (Shittu *et al.,* 2005) and improved processing methods using starter cultures (lactic acid bacteria) work together to reduce the anti-nutritional components and improve the quality of the final product when done effectively (Wakil & Benjamin, 2015). *Pupuru* is complemented with various soups such as Black soup (*Marugbo*), *Ewedu*, and *Okra* soup among others and is used as a thickener in *Pankoto*.

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Pankoto is a meal rich in carbohydrates, vitamins, minerals and fibre; it is a fairly-rich meal that can be consumed by young and old. However, it is lacking in protein, which may lead to protein-energy malnutrition (PEM) among the people who are the major consumers of the meal. PEM refers to a form of malnutrition where there is an inadequate intake of protein. Ubesie and Ibeziakor (2016) reported that the burden of PEM in Nigeria is still high and that the severe forms of the disease are usually associated with a high level of morbidity even in tertiary health facilities. Protein is greatly needed by the body for proper functioning and this is the basis of the need to supplement *pankoto* with Bambara groundnut flour, which is a very good source of plant protein.

Bambara groundnut is rich in essential amino acids (Ijarotimi & Esho, 2009). Bambara groundnut seed consists of 49%-63.5% carbohydrate, 15%-25% protein, 4.5%-7.4% fat, 5.2%-6.4% fibre, 3.2%-4.4% ash and 2% mineral (Murevanhema & Jideani, 2013). Bambara groundnut is also referred to as a complete food as it is rich in carbohydrates, rich in protein and has the needed amount of fat (Akpapunam & Darbe, 1994; Goli, 1997). Bambara groundnut has great agronomic and nutritional potential but it remains scientifically neglected (Mubaiwa *et al*., 2017). Several researchers (Arise *et al*., 2019; Arise *et al*., 2019; Olapade *et al*., 2014; Alakali *et al*., 2016) have reported on the effectiveness of Bambara groundnut in nutritionally improving traditional meals. Arise *et al*. (2019) reported an increase in the protein content of *kokoro* (maize-based snack) fortified with Bambara groundnut from 13.0% to 32.3%, Arise *et al*. (2019) reported an increase in the protein content of *abari* (maize-based pudding) nutritionally improved with Bambara groundnut from 6.21% to 31.69%, Olapade *et al*., (2014) reported an increase in the protein content of *fufu* enriched with Bambara groundnut from 7.13% to 18.9%, and Alakali *et al*., (2016) reported an increase in the protein content of *ojojo* (water yam balls) enriched with Bambara groundnut from 5.42% to 7.92%.

From the foregone, Bambara groundnut has protein-improving potential, but its impact on the protein contents of *pankoto* has not been investigated. Therefore, this work was set to improve the nutritional value of *pankoto*, traditionally produced from plantain and *pupuru* (smoked cassava balls), by supplementing it with Bambara groundnut; and further determine the functional properties of the flour blends, proximate composition and sensory attributes of the improved *pankoto* pudding.

2.0 Materials and Methods

2.1 Materials

Plantain, cassava, Bambara groundnut and other ingredients, like salt, maggi, scotch bonnet pepper, onions, crayfish, moi-moi leaf (*Thaumatococcus danielli* leaves), were purchased from Ipata market in Ilorin, Kwara State, Nigeria.

2.2 Production of pupuru

Pupuru was prepared using the method described by Shittu *et al*. (2005). Fresh cassava roots were sorted and the bruised ones were removed. The cassava roots were peeled (removal of the cortex and the corky periderm), washed with clean water and soaked in clean potable water. Fermentation took place for 4 days. During the fermentation, the tissue of the cassava roots softened. The fermented cassava mash was removed from the water into a jute bag to drain off the water. Prior to dewatering, the tissues were manually disintegrated by hand. A stone was placed on the bag to aid the removal of the water. The cassava mash was then moulded into balls and smoked upon a platform popularly known as *aka* in Yoruba. It was left to dry, the cassava ball developed a

Table 1. Sample Formulation fo Bambara-*pankoto* production (grams)

Sample codes	Overripe plantain	Pupuru	Bambara groundnut flour
PPA	150	50	0
PPB	150	45	5
PPC	150	40	10
PPD	150	35	15
PPE	150	30	20
PPF	150	25	25

brownish outer coating during smoking. When it was dry, the outer crust (dirty) was scraped off and the inner portion was pounded lightly to form large crumbs and further pounded till the crumbs were broken into powder. The powdered cassava was then sieved to remove shafts. The *pupuru* was stored in an air-tight and moisture-free container.

2.3 Production of Bambara groundnut flour

The Bambara groundnuts were processed using the method reported by Arise *et al*. (2019). The Bambara nuts were cleaned to remove extraneous materials, soaked in clean potable water and allowed to ferment for 72 hours at room temperature (32 ± 2 °C). It was then dehulled manually and oven-dried for 2-3 days at 50 °C. The dried seeds were milled into flour using a disc attrition mill. The flour was stored in an air-tight container at room temperature.

2.4 Production of Pankoto

Samples were formulated by modification of the method by Barber *et al.* (2010) following preliminary production. Fresh overripe plantains were weighed and blended along with the scotch bonnet pepper, onions, cray-fish with the addition of a tablespoon full of water. The flours (*pupuru* and Bambara groundnut) were mixed with about 30 ml of warm water, after which the plantain mix was added to it and manually mixed (stirrer) thoroughly along with palm oil and a pinch of salt. The mixture was wrapped in *Thaumatococcus danielli* leaves (used as moimoi leaves) and steamed for 20-25 minutes.

2.5 Proximate Analysis

The moisture, crude protein (Nx6.25), crude fat, crude fibre and ash contents were determined according to AOAC (2005) methods while total carbohydrate was calculated by difference. Briefly, 2 g of the sample was weighed and dried to constant weight in an oven (at 105 ºC for 5 hours), cooled, and percentage moisture determined. Protein was determined by weighing 2 g of the samples into the Kjeldahl flask. Digestion and distillation processes took place before titrating the outcome to determine the percentage crude protein content. For percentage fat content determination, the soxhlet extraction method was used where 2 g of the sample was weighed into the extraction thimble. For percentage ash content, 2 g of the sample was transferred into a muffle furnace adjusted to 550 ºC for 4 hours. The percentage crude fibre was determined by weighing 2 g of the sample into a fibre flask and 100 ml of 0.255 N H_2SO_4 was added. The mixture was boiled for 30 minutes with a heating mantle, cooled and filtered. The filter paper with the residue was oven dried at 105ºC for 3 hours before determination, while the percentage carbohydrate content was determined by difference.

2.6 Functional Properties of the Flour Blends

The functional properties including water absorption capacity (WAC), oil absorption capacity (OAC) and swelling capacity of the *pupuru* and Bambara flour blends were determined using the method described by Abbey & Ibeh (1988). Exactly 2 g of flour samples were suspended in 10 ml of distilled water in a clean centrifugal tube. The slurry formed *was shaken by hand and left for 25 minutes;* the dispersion was centrifuged at 2000 rpm for 30 minutes. The supernatant was decanted and discarded, with the adhering drops used for the determination of water absorption capacity (g/g). The same procedure was adopted for the oil absorption capacity, but in this case, the 2g of the flour sample was suspended in 10 ml of oil and not water. One (1) gram of flour sample was weighed into a 10ml graduated measuring cylinder and 5ml of distilled water was added, swirled and allowed to stand for 30 minutes. The difference between the volume before and after soaking the flour sample in water for 30 minutes was used to determine the swelling capacity.

2.7 Sensory Evaluation

Sensory evaluation of the *pankoto* samples was conducted using 50 panellists, using a scale of preference as described by Iwe (2002). Coded samples (PPA, PPB, PPC, PPD, PPE, PPF) were presented to the panellists, with the evaluations on a 9-point hedonic scale. On the hedonic scale, 9 (like extremely) was the maximum while 1 (dislike extremely) was the minimum. The panellists were provided with water to rinse their mouths after tasting each food sample. The samples were rated for aroma, taste, appearance, as well as overall acceptability.

2.8 Statistical analysis

All experiments were carried out in duplicates, and data obtained were subjected to analysis of variance. The Duncan multiple range (Duncan, 1955) test was used to separate the differences in the mean. Statistical analysis was done using SPSS version 20.0 software.

3.0 Results and Discussion

3.1 Proximate analysis

Table 1 shows the proximate composition of the *pankoto* samples. Supplementation with Bambara groundnut flour at 10%, 20%, 30%, 40% and 50% increased the protein and crude fibre contents from 9.03% to 11.23% and 2.05% to 2.22% respectively. The carbohydrate, fat, ash and moisture contents did not exhibit a definite pattern. Their values ranged from 66.16%-72.56%., 7.02%-10.04%, 3.22%-4.20%, 6.13%-6.74%, respectively. The inconsistency in the carbohydrate, fat, ash and moisture contents was similarly observed in the report by Olapade *et al*. (2014) on Bambara inclusion in *fufu*. The inconsistency could be attributed to uneven mixing of the flours during the preparation and possibly leaching out some nutrients during cooking. It could be observed that the protein content of the *pankoto* samples increased with increased supplementation with Bambara thus confirming the beneficial effect of vegetable protein as reported by Olapade *et al*. (2014). This observation can be attributed to the higher protein content of Bambara groundnut. Bambara groundnut seed consists of 49%-63.5% carbohydrate, 15%-25% protein, 4.5%-7.4% fat, 5.2%-6.4% fibre, 3.2%-4.4% ash and 2% mineral (Murevanhema & Jideani, 2013; Alhassan *et al*., 2015).

3.2 Functional properties

Sample PPE (60:40) had the lowest swelling capacity mean value of 0.60g/ml and sample PPB (90:10) had the highest swelling capacity mean value of 0.85g/ml as shown in Figure 1a. The values were lower than the values (4.60g/ml-7.40g/ml) reported by Otegbayo *et al*. (2013) for soy-enriched tapioca and the values (4.20g/ml-5.32g/ml) reported by Adetuyi & Adelabu (2011) for the addition of okra seed flour to plantain flour. Swelling capacity measures the strength of attractive forces within the starch granules, their ability to imbibe and swell or an indicator of extent of starch damage (Adebowale *et al*., 2012). The low swelling capacity may be due to the formation of starch-lipid and starch-lipid-protein complex (Wang *et al*, 2020; Feng *et al.,* 2018). Bambara groundnut starch has high amylose content (31.5%) as reported by Oyeyinka *et al*. (2016). Amylose and lipids form complexes due to the presence of ligands which leads to the formation of tight helical structures with hydrophobic cavities. The complex structures formed reduces the interaction of amylose with water via interactions associated with van der Waals forces and hydrogen bonding and as a result, reduces the swelling power in food systems (Wang *et al*, 2020; Feng *et al.,* 2018; Oyeyinka *et al*., 2016). There were inconsistencies in the oil absorption capacities with increased incorporation of Bambara groundnut flour (Figure 1b) as equally observed in the report by Arise *et al*. (2019) for Bambara inclusion in *abari* (maize-based pudding). The mean values for oil absorption capacity ranged from 2.18%-2.52%. Oil absorption capacity is an index of the sensory properties and also plays a role in shelf-life (Aremu *et al*., 2007). The mean values observed from water absorption capacity of the

Table 2. Proximate Composition of Bambara-*pankoto*

SAMPLES	Protein (%)	Fat (%)	Moisture (%)	Ash (%)	Crude fibre (%)	Carbohydrate (%)
PPA	9.03±0.42^{f}	7.02±0.85^{b}	6.13±0.07^{c}	3.22±0.28^{d}	2.05±0.01^{d}	72.55±0.87^{a}
PPB	10.41±0.14^{e}	8.96±0.35^{a}	6.63±0.30^{ab}	3.16±0.01e	2.18±0.00^{c}	68.66±0.28^{b}
PPC	10.69±0.14^{d}	10.04±0.14^{a}	6.41±0.01^{bc}	4.09±0.35^{b}	2.21±0.01^{ab}	66.57±0.17^{cd}
PPD	10.77±0.14^{c}	8.63±0.61^{a}	6.71±0.01^{ab}	3.90±0.01^{c}	2.20±0.00^{ab}	67.80±0.62^{bc}
PPE	11.06±0.28^{b}	9.96±0.46^{a}	6.44±0.00^{bc}	4.20±0.01^{a}	2.20±0.01^{bc}	66.16±0.49^{d}
PPF	11.23±0.21^{a}	8.65±0.72^{a}	6.74±0.01^{a}	3.87±0.14^{c}	2.22±0.01^{a}	67.23±0.76^{bcd}

Values are mean±SD. Mean values with different superscripts along a column are significantly different ($P \leq 0.05$).
Key: PPA: 100% *pupuru*, PPB: 90% *pupuru* and 10% Bambara groundnut, PPC: 80%*pupuru* and 20% Bambara groundnut, PPD: 70% *pupuru* and 30% Bambara groundnut, PPE: 60% *pupuru* and 40% Bambara groundnut, PPF: 50% *pupuru* and 50% Bambara groundnut

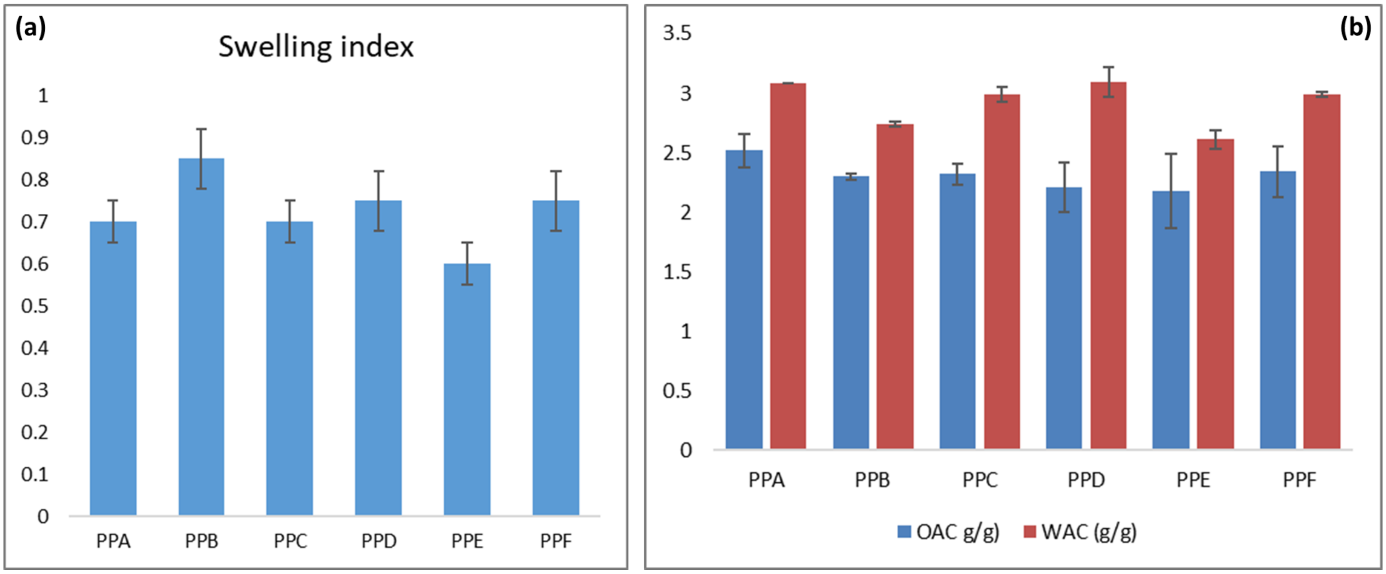

Figure 1. Swelling capacity (g/ml) of Bambara-pankoto flour samples (a) and WAC and OAC of Bambara-*pankoto* flour samples (b)
Key: PPA: 100% *pupuru*, PPB: 90% *pupuru* and 10% Bambara groundnut, PPC: 80%*pupuru* and 20% Bambara groundnut, PPD: 70% *pupuru* and 30% Bambara groundnut, PPE: 60% *pupuru* and 40% Bambara groundnut, PPF: 50% *pupuru* and 50% Bambara groundnut, WAC: water absorption capacity (g/g), OAC: oil absorption capacity (g/g).

Table 3. Mean Sensory Scores of Bambara-*pankoto*

SAMPLES	Appearance	Taste	Aroma	Texture	Overall acceptability
PPA	5.93±1.64^{b}	6.30±1.54^{b}	6.43±1.22^{a}	7.73±0.79^{a}	6.27±1.57^{b}
PPB	7.23±1.28^{a}	7.37±1.45^{a}	6.57±1.68^{a}	7.30±0.60^{b}	7.03±1.30^{a}
PPC	7.03±0.96^{a}	7.13±1.46^{a}	7.07±1.08^{a}	7.27±0.58^{b}	7.30±1.02^{a}
PPD	6.93±0.98^{a}	7.10±1.06^{a}	7.00±1.11^{a}	6.97±0.62^{b}	7.23±1.04^{a}
PPE	6.77±1.10^{a}	7.23±1.48^{a}	7.03±1.40^{a}	6.37±1.13^{c}	7.17±1.23^{a}
PPF	7.23±1.22^{a}	7.40±1.04^{a}	7.17±1.09^{a}	6.37±0.67^{c}	7.50±0.97^{a}

Values are mean±SD. Mean values with different superscripts along a column are significantly different (P≤0.05)
Key: PPA: 100% *pupuru*, PPB: 90% *pupuru* and 10% Bambara groundnut, PPC: 80%*pupuru* and 20% Bambara groundnut, PPD: 70% *pupuru* and 30% Bambara groundnut, PPE: 60% *pupuru* and 40% Bambara groundnut, PPF: 50% *pupuru* and 50% Bambara groundnut

pankoto samples varied from 2.61%-3.08% with a significant difference (P≤0.05) as shown in Figure 1b. Olapade *et al*. (2014) equally recorded varying but higher values (114%-199%) in the water absorption capacity for the supplementation of fermented cassava (*fufu*) with Bambara flour. The low water absorption capacity influences the storage life positively as pointed out by Ayo *et al*. (2013).

3.3 Sensory evaluation

The sensory evaluations of *pankoto* with different levels of Bambara flour inclusion are presented in Table 3. There were no significant differences in the samples for all the attributes evaluated except for sample PPA (100% *pupuru*). The mean value on appearance ranged from 5.93-7.23, the ratings for taste ranged from 6.30-7.40, the mean ratings for aroma ranged from 6.43-7.17, the mean ratings for texture ranged from 6.37-7.73 and on the overall acceptability, the mean value ranged from 6.27-7.50. Sample with 50% Bambara flour supplementation (PPF) had the highest score in all the attributes evaluated in terms of appearance, aroma, taste and overall acceptability except texture. It was observed that the texture became harder with an increase in Bambara groundnut inclusion while the taste and aroma were better improved as the Bambara groundnut inclusion increased. The increased hardness of the texture as the inclusion increased indicates that Bambara groundnut flour has a higher water absorption capacity. The higher values recorded in this study for appearance, aroma, taste and overall acceptability were in line with the report of Arise *et al.,* (2019) for the production of *abari* (maize-based pudding) with Bambara flour inclusion which equally had higher ratings in all the sensory attributes evaluated but were in contrast with the report of Agbara *et al*. (2018) for the production of pearl millet-Bambara ground nut *yarsala* which showed a decrease in the scores for appearance and aroma, as well as Olapade *et al*. (2014) for the production of *fufu* (fermented cassava) flour supplemented with Bambara flour which showed a decrease in the scores for taste and overall acceptability.

4.0 Conclusions

This study has shown that it is possible to enrich *pankoto* with 50% Bambara groundnut flour without adverse effects on sensory attributes. The water absorption, oil absorption and swelling capacities were low; however, it exhibited good functionality. The addition of Bambara groundnut flour to *pankoto* resulted in a significant increase in the crude protein content from 9.03% to 11.23%. Sensory-wise, sample PPF (150: 25:25) had the highest preference in terms of appearance, taste, aroma and general acceptability.

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