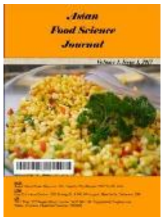

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Characterisation of Composition and Sensory Qualities of *Pupuru* Produced from Breadfruit (*Artocarpus altilis*) and Tigernuts Flour

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

Breadfruit (*Artocarpus altilis*) and tiger nuts are valuable crops with little or insignificant utilisation. In this work, the compositional and sensory qualities of *pupuru* produced from the composite flour of breadfruit and tiger nuts are characterised and reported. The substitution ratio of *pupuru* and tiger nut flour was 0, 10, 20, 30, 40 and 50% substitution. The composite flour was analysed for some chemical and physicochemical properties. The flour was added in boiling water and stirred continuously to form a thick paste of *pupuru* meal. The prepared *pupuru* meal was evaluated for sensory properties. The compositional analysis of the flour samples showed an increase in protein (2.75-3.73%), fat (3.25-11.48%), ash (1.07-1.43%) and fibre (3.31-5.11%) contents with increasing level of tiger nut flour. No significant change in bulk density and less water absorption capacity were observed for composite flour. Sensory evaluation of produced *pupuru* meal concludes that the samples with 10% substitution had a highest sensory score.

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Keywords: Pupuru; Breadfruits; tiger nuts; Compositional characterisation and sensory evaluation.

1. INTRODUCTION

Breadfruit (*Artocarpus altilis*) is a crop native to Malaysia and countries of the South Pacific and the Caribbean [1,2]. It is widely cultivated to an appreciable extent in the South-West States of Nigeria. The present level of breadfruit production in South-Western Nigeria has been estimated at about 10 million tonnes dry weight per year with potentials for exceeding 100 million tonnes every year [3-6]. Breadfruit has also been reported to be rich in fat, ash, fibre, protein and starch [7,8] and is therefore economically important [9,10]. The breadfruit pulps are processed into various dishes and flour used in bread and biscuit making [4]

Tiger Nuts Chufa is not a "nut" but a "tuber". This tuber was discovered more than 4000 years ago and has been cultivated ever since in more or fewer quantities. It is believed to help to prevent heart attacks, thrombosis and cancer especially of the colon [11-13], relieve indigestion especially when accompanied by halitosis. Approximately 100 g of tiger nuts contains 386 kcal (1635kj) as 7% proteins, 26% fats (oils), 31% starch, 21% glucose with 26% fibre of which 14% is non-soluble and 12% soluble [12].

Pupuru is a fermented cassava-based food product [14-16]. It is commonly consumed by the people living in the riverine areas of the western, southern, eastern and the middle belts of Nigeria, where it is also known as "Ikwurikwu" [17,18]. *Pupuru* and other cassava products are widely accepted and consumed in Nigeria. It is an important food, the consumption of which is steady and increasing in Nigeria. It has been produced from cassava as the raw material. It has been reported [19,20] that *pupuru* is a major profitable venture which serves as a source of earning income and plays a significant role in ensuring food security for some people in Nigeria. In Nigeria, *pupuru* production from breadfruit is limited, and cassava is used to meet the needs of the product and others such as *fufu* and *garri* starch which leads to scarcity of cassava. The effort has been made to promote the use of breadfruit by processing breadfruit into *pupuru* flour, thereby decreasing the demand for cassava and producing an enriched product. The use of breadfruit for *pupuru* will help to reduce over-dependence on cassava in Nigeria and also reduce underutilisation of breadfruit. The work, therefore, aims to produce *pupuru* from composite flour made from breadfruit and to characterise the compositional and sensory qualities of *pupuru* produced from the composite flour of breadfruit and tiger nuts.

2. MATERIALS AND METHODS

2.1 Production of Breadfruit *Pupuru* Flour

Matured fresh breadfruit and tiger nut were procured from a local market in Ogbomoso, Oyo State, Nigeria. Breadfruit was weighed, manually peeled, washed and steeped in water for four days till it becomes soft. After the fourth day the water was decanted, the soft wet mash was packed into a sack and was dewatered in a mechanical press. Fibres were manually removed from the mash and it was moulded into balls or circular shape. The moulded ball was smoked till a golden brown colour appears [21]. The soot colour of the smoked balls was scraped off and pulverised and lightly toasted and sieved with 60 mesh size to obtain dried breadfruit pupuru flour.

2.2 Production of Tiger Nut Flour

Tiger nut was weighed and washed to remove dirt or extraneous material, and it was sundried for four days and was milled using a hammer mill, and it was sieved to produce flour.

2.3 Analyses

Prepared breadfruit flour and tiger nut flour were mixed in the percentage of 10,20,30,40 and 50 to make the composite flour. The composite flour samples were analysed chemically as described by the Association of Official Analytical Chemist [22] for moisture, ash, crude fibre, crude protein, crude fat and carbohydrate. Ten grams (10 g) of the samples were taken into sterile bottles, mixed with 100 ml of distilled water and pH was determined using the pin electrode of pH meter (JENWAY Instrument, model 3505). Titratable acidity was determined by allowing the mixture to stand for 15 minutes, with shaking at 5 minutes intervals and filtered with Whatman No. 4 filter paper. Ten-milliliter aliquots (triplicates) were pipette from the filtrate into a conical flask and then titrated against 0.1N NaOH using 1% phenolphthalein as the indicator to determine the amount of acid (as lactic acid) in the sample. The percentage of titratable acidity was calculated by multiplying the titre value by 0.09 [23]. All samples were tested for functional properties such as bulk density [24], water absorption capacity [25] and swelling index [26]. The mineral content was determined by the method described by AOAC [22]. The ash obtained was boiled with 10 mL of 20% hydrochloric acid in a beaker and then filtered into a 100 mL standard flask. Potassium (K) was determined from the solution using the standard flame emission photometer. NaCl and KCl were used as the standards [22]. Calcium (Ca) and magnesium (Mg) and Zinc (Zn) were determined using an atomic absorption spectrophotometer (AAS, Model SP9, Pye Unicam Ltd, Cambridge, UK). All values were expressed in mg/100 g.

The *pupuru* flour was made into a meal traditionally by stirring in hot water to make the gelatinised ball that could be eaten or swallowed. The *pupuru meal* samples produced from *pupuru* flour were subjected to a sensory test using 20 panellists. The products were rated in terms of taste, colour, texture, aroma, and overall acceptability on a 9-point hedonic scale ranging from 9 (dislike extremely) to 1 (like extremely) and the results generated were analysed using Analysis of Variance (ANOVA).

3. RESULTS AND DISCUSSIONS

3.1 Proximate Composition of *Pupuru* Analogue from Breadfruit Enriched with Tiger Nut

The results of the proximate composition of breadfruit pupuru analogue are as shown in Table 1. The protein content was significantly different ($p < 0.05$) and ranged from 2.75 to 3.73%, with 100% breadfruit having the lowest value while breadfruit with 50% tiger nut substitution had the highest value. The *pupuru* made from cassava mash (control) had a protein content of 1.70% which is lower to that of the composite flours. The protein content increased with increased tiger nut substitution. The protein content of the 100% bread fruit *pupuru* flour was higher than the value of 0.56% reported by Akanbi et al. [3] for breadfruit starch. The difference in the protein content can be attributed to the climatic conditions and the processing method employed [3,27]. The protein content of tiger nut was reported by to be 7.15%, hence when added to *pupuru* made from breadfruit; it increased the protein content considerably. Moisture content of the composite flour (breadfruit and tiger nut) sample was within the ranges of 6.94 to 9.57%. The moisture content of 13% has been reported for breadfruit starch [4], while Akanbi et al. [3] also reported a moisture content of 10.83%. The moisture content of 3.5% has been reported for tiger nut [28]. The moisture content of the composite flour (breadfruit and tiger) samples ranged between that of tiger nut and breadfruit. The lower initial moisture content of a product to be stored triggers better storage stability of the product [29, 30]. The ash content of breadfruit samples ranged between 1.07 and 1.43% where *pupuru* made from 100% breadfruit had the least value of 1.07% and breadfruit: tiger nut (50:50) flour samples had the highest value of 1.43%. However, the ash content of breadfruit *pupuru* (1.06%) was lower than that of the composite flour samples indicating lower minerals content. The ash content of the samples did not show any significant difference ($p < 0.05$) from one another.

The fat content varied significantly, and it increased from *pupuru* (0.86%) made from 100% cassava (control) to (11.48%) for *pupuru* made from breadfruit substituted with 50% tiger nuts. A sharp increase in fat content value was observed from composite flour ratio 70:30 to 50:50. The work of Oladele and Aina [28] reported a fat content value of 32.13% for tiger nut, hence the addition of it to low-fat breadfruit will increase the fat content of the composite flour formed. Effective mixing of the two flours will also affect the fat content of the mixture. There was no significant difference in the crude fibre content of the composite flour samples except that of composite flour sample of 50% and the *pupuru* made with cassava mash. The crude fibre content value ranges from 1.38% for *pupuru* made from cassava mash to 5.11% for breadfruit-tiger nut composite flour with 50% substitution. Processing techniques like milling might likely affect the crude fibre content of the composite flour.

The carbohydrate content value of the composite flour samples varied significantly. The carbohydrate content of the composite flour with a ratio of 90:10 had the highest value of 81.90%, though not higher than that of *pupuru* made from cassava mash that had a value of 85.58% and composite flour with 50% tiger nut substitution having the least value of 70.85%. Oladele and Aina [28] reported a carbohydrate content of 46.99% for tiger nut flour and Famurewa et al., [21] also reported a carbohydrate content of 85.64% for breadfruit flour. The carbohydrate content of the composite flour ranged between these values.

3.2 Physiochemical Properties of *Pupuru* Analogue from Breadfruit Enriched with Tiger Nut and *Pupuru* Flour from Cassava

The results of the physicochemical properties of breadfruit *pupuru* flours are shown in Table 2. The pH of flour samples increased significantly ($p<0.05$) from 4.64 - 6.12 with the 50:50 composite (breadfruit: tiger nut) flour having the highest value. While the *pupuru* produced from cassava mash had the least (4.64). A pH of 6.51 for breadfruit flour has been reported previously [4]. However, because of fermentation that might have taken place during the processing of the breadfruit mash to *pupuru*, there was a slight decrease in the pH content of 100% breadfruit *pupuru*. The increase in pH values could be as a result of the addition of tiger nut flour to fermented breadfruit flour resulting in decreased acidity. Acidic products are more shelf stable than their non-acidic counterpart [31,32]. The total titratable acidity varied significantly with 100% breadfruit *pupuru* flour having the least value of 0.25%, followed by 50:50 composite flour with 0.32% and the highest value of 0.48 was recorded for *pupuru* made with cassava mash.

The water absorption capacity decreased significantly with increase in tiger nut flour substitution. The values ranged from 1.90-3.70g/mL with the *pupuru* made from cassava mash sample having the highest value and the flour with 40% tiger nut substitution the least. Oladele and Aina [28] reported a value of 1.37 ml/g for tiger nut flour. Hence, the addition of tiger nut flour might have caused the reduction in the value of water absorption capacity as the substitution increased. The bulk density does not show the much significant difference ($p<0.05$) in value with an increase in the tiger nut flour substitution levels. The values for the samples ranged from 0.79- 0.87 g/ml. Bulk density is generally affected by the particle size and density of the flour and it is very important in determining the packaging requirement, material handling and application in the wet processing in the food industry [33,34]. The lower the bulk density, the higher the amount of flour particles that can bind together leading to higher energy values [35,36]. Swelling capacity is an indication of the water absorption index of the granules during heating [37,38]. The swelling capacity value shows a significantly unstable pattern of increase and decreased in value with an increase in tiger nut flour substitution ranging from 2.03 - 3.77 with *pupuru* made from cassava mash recording the lowest value. The swelling capacity of flours depends on the size of particles, types of variety and types of processing methods or unit operations. The vitamin C content increased significantly ($p<0.05$) with an increase in tiger nut flour substitution ranging from 0.20 to 0.410 mg/100 g.

3.3 Mineral Composition

The mineral contents of 100% bread fruit *pupuru*, cassava *pupuru* and composite flour made from a mixture of breadfruit *pupuru* and tiger nut flour are presented in Table 3. The analysis revealed the presence of sizeable amounts of several minerals. Some of them were affected significantly ($p<0.05$) by the degree of substitution. Indeed, mineral contents increased with the substitution for some of the minerals up to the 30% substitution level. There was an initial decrease in minerals content for potassium, zinc and calcium before they increased again up to 30% substitution level. For magnesium, there was a steady increase up to 30% substitution. Substitution did not affect the calcium content of the composite flour significantly ($p<0.05$). A report by Anigo et al. [39] indicated that some anti-nutrients interfered with the availability of minerals by compelling with them. Similarly, Appiah et al. [40] also reported that fermentation affects the mineral composition of foods. Processing techniques like drying, milling which produced heat, fermentation and proper mixing of the flour blend might also have an effect on the mineral composition. Potassium was found to be the predominant mineral in the composite flour. Its content in the 100% breadfruit and cassava *pupuru* and the composite flour ranged from 0.154 to 1.771 mg/kg. Generally, the potassium contents of both the breadfruit pupuru and the composite flours were higher than in cassava (0.154 mg/kg). It has been reported to be an important mineral maintaining electrolyte balance in humans [5,41] and its presence in the flours is very useful. From the results of this study, the composite flour blend could constitute a rich source of potassium.

3.4 Sensory Evaluation

The mean sensory scores of the meal made from composite flour samples are summarised in Table 4. The result showed that flour produced from 100% breadfruit *pupuru* was the most preferred in terms of taste and flavour. However, pure cassava *pupuru* flour which acted as the control was best preferred in terms of aroma, texture, appearance and overall acceptability. The panellists rated the taste of the control sample better than the rest, followed by the 100% breadfruit p*upuru* flour, while the flour produced from breadfruit *pupuru* substituted with 10% tiger nut was least rated. There were no significant differences ($p<0.05$) in the taste ratings for the control sample, breadfruit *pupuru* flour containing 20%, 30%, 40% and 50% tiger nut four. The texture of *pupuru* flour produced from 100% cassava had the best rating, while the flour from breadfruit *pupuru* substituted with 40% and 50% tiger nut *pupuru* flour was least preferred by the panellists. Statistical analysis of the data showed that all the breadfruit samples containing tiger nut at varying proportions except the one with 10% and 20% tiger nut had texture attribute similar to the pure cassava *pupuru* flour. In terms of flavour, 100% breadfruit *pupuru* flour sample had the best rating while breadfruit *pupuru* with 10% tiger nut flour substitution was least preferred by the panelists. The panellists preferred the aroma of pupuru flour produced from 100% cassava, while the *pupuru* flour from breadfruit *pupuru* substituted with 20% tiger nut flour was least preferred. The panellists preferred the appearance of *pupuru* produced from 100% cassava mash to the rest, while the flour produced from breadfruit mash substituted with 40% tiger nut had the lowest score. A control sample was best preferred in terms of overall acceptability, followed by the flour produced from breadfruit flour substituted with 20% and 50% tiger nut, while the flour from breadfruit mash substituted with 10% tiger nut flour had the least rating. Statistical analysis of the data indicated that there were no significant differences ($p<0.05$) in the ratings for aroma, appearance and overall acceptability of the flour samples.

Table 1. Proximate composition (%) of the bread of fruit *pupuru* flour, cassava *pupuru* flour and tiger nut flour blends

Sample	Moisture content	Protein	Fat	Ash	Fibre	Carbohydrate
BFP	9.57^{c}	2.75^{b}	3.25^{b}	1.07^{a}	3.79^{b}	79.59^{c}
BTP 1	7.18^{a}	2.88^{b}	3.55^{b}	1.17^{a}	3.31^{b}	81.90^{d}
BTP 2	8.34^{b}	3.17^{bc}	4.17^{c}	1.34^{a}	3.52^{b}	79.47^{c}
BTP 3	7.53^{ab}	3.43^{cd}	10.48^{d}	1.35^{a}	3.54^{b}	73.79^{b}
BTP 4	6.94^{a}	3.45^{d}	11.22^{e}	1.39^{a}	3.57^{b}	73.45^{b}
BTP 5	7.41^{ab}	3.73^{d}	11.48^{e}	1.43^{a}	5.11^{c}	70.85^{a}
CSP	9.29^{c}	1.70^{a}	0.86^{a}	1.19^{a}	1.38^{a}	85.58^{e}

Means with different superscript within the same column are significantly different ($P \le 0.05$).
***BFP**= 100% Breadfruit pupuru flour analogue; **BTP1**= 90:10(breadfruit: tigenut) pupuru flour analogue **BTP2** = 80:20 (breadfruit:tigernut pupuru) flour analogue; **BTP3** = 70:30 (breadfruit:tigernut) pupuru flour analogue; **BTP4**= 60:40 (breadfruit : tigernut) pupuru flour analogue; **BTP5**= 50:50 (pupuru:tigernut) pupuru flour analogue**; CSP** = 100% Cassava pupuru flour*

Table 2. Physicochemical properties of bread fruit p*upuru* flour, Cassava *pupuru* flour and tiger nut flour blends

Samples	Water absorption capacity	Swelling capacity (g/ml)	Bulk density	pH	Titratable acidity	Vitamin A
BFP	2.77^{e}	3.77^{e}	0.87^{b}	5.44^{b}	0.25^{a}	0.200^{a}
BTP 1	2.47^{d}	2.40^{c}	0.79^{a}	5.62^{c}	0.34^{ab}	0.310^{b}
BTP 2	2.30^{c}	2.74^{d}	0.79^{a}	5.76^{d}	0.34^{ab}	0.370^{bc}
BTP 3	2.17^{bc}	2.20^{b}	0.79^{a}	5.99^{e}	0.39^{b}	0.390^{c}
BTP 4	1.90^{a}	2.40^{c}	0.79^{a}	5.44^{b}	0.36^{b}	0.400^{c}
BTP 5	2.40^{c}	2.20^{b}	0.80^{b}	6.12^{f}	0.32^{ab}	0.410^{c}
CSP	3.70^{f}	2.03^{a}	0.80^{b}	4.64^{a}	0.48^{c}	ND

Means with different superscript within the same column are significantly different ($P \le 0.05$).
***BFP**= 100% Breadfruit pupuru flour analogue; **BTP1**= 90:10(breadfruit: tigenut) pupuru flour analogue **BTP2** = 80:20 (breadfruit:tigernut pupuru) flour analogue; **BTP3** = 70:30 (breadfruit:tigernut) pupuru flour analogue; **BTP4**= 60:40 (breadfruit : tigernut) pupuru flour analogue; **BTP5**= 50:50 (pupuru:tigernut) pupuru flour analogue**; CSP** = 100% Cassava pupuru flour*

Table 3. Mean values of mineral composition of bread fruit *pupuru* flour, cassava *pupuru* flour and tiger nut flour blends (mg/100 g)

Sample	Mg	K	Zn	Ca
BFP	0.165^{b}	1.771^{f}	0.081^{c}	0.081^{a}
BTP	0.199^{c}	1.192^{c}	0.071^{b}	0.074^{a}
BTP	0.204^{d}	1.093^{a}	0.083^{d}	0.092^{a}
BTP	0.231^{f}	1.280^{d}	0.098^{d}	0.093^{a}
BTP	0.188^{a}	1.600^{e}	0.066^{a}	0.075^{a}
BTP	0.222^{e}	1.129^{b}	0.064^{a}	0.088^{a}
CSP	0.176^{c}	0.154^{a}	0.074^{d}	Not detected

Means with different superscript within the same column are significantly different (P≤0.05).
***BFP**= 100% Breadfruit pupuru flour analogue; **BTP1**= 90:10(breadfruit: tigenut) pupuru flour analogue **BTP2** = 80:20 (breadfruit:tigernut pupuru) flour analogue; **BTP3** = 70:30 (breadfruit:tigernut) pupuru flour analogue; **BTP4**= 60:40 (breadfruit : tigernut) pupuru flour analogue; **BTP5**= 50:50 (pupuru:tigernut) pupuru flour analogue**; CSP** = 100% Cassava pupuru flour*

Table 4. Mean sensory scores of breadfruit *pupuru* meal from cassava *pupuru* flour and tiger nut flour blends

Sample	Taste	Aroma	Flavour	Texture	Appearance	Overall acceptability
BFP	2.90^{a}	3.80^{a}	2.40^{a}	4.20^{b}	3.80^{a}	3.80^{a}
BTP 1	3.80^{b}	3.80^{a}	4.90^{b}	3.10^{ab}	3.10^{a}	4.70^{a}
BTP 2	4.00^{ab}	4.80^{a}	3.70^{ab}	3.60^{ab}	3.40^{a}	3.40^{a}
BTP 3	4.20^{ab}	3.70^{a}	3.20^{ab}	4.00^{b}	3.70^{a}	4.40^{a}
BTP 4	3.50^{ab}	4.60^{a}	3.30^{ab}	4.40^{b}	4.10^{a}	4.00^{a}
BTP 5	3.90^{ab}	3.80^{a}	4.00^{ab}	4.40^{b}	3.70^{a}	3.40^{a}
CSP	3.20^{ab}	3.60^{a}	4.00^{ab}	2.00^{a}	2.70^{a}	2.80^{a}

Means with different superscript within the same column are significantly different (P≤0.05).
***BFP**= 100% Breadfruit pupuru flour analogue; **BTP1**= 90:10(breadfruit: tigenut) pupuru flour analogue **BTP2** = 80:20 (breadfruit:tigernut pupuru) flour analogue; **BTP3** = 70:30 (breadfruit:tigernut) pupuru flour analogue; **BTP4**= 60:40 (breadfruit : tigernut) pupuru flour analogue; **BTP5**= 50:50 (pupuru:tigernut) pupuru flour analogue**; CSP** = 100% Cassava pupuru flour analogue; **CSP** = 100% Cassava pupuru flour*

4. CONCLUSION

The study reveals the potential of breadfruit and tiger nut in food formulation in the food industry. *Pupuru* analogue produced from breadfruit with 10% tiger nut substitution brought a significant highest overall acceptability while sample with 50% tiger nut substitution had the highest nutritional content in terms of protein (3.73%), fat (11.48%), and fibre (5.11%) contents. The control sample of *pupuru* from 100% cassava had a protein content of 1.70% while that of 100% breadfruit was 2.75% protein. Conclusively, breadfruit substituted with tiger nut has the potential of producing an enriched and more acceptable *pupuru* analogue than from cassava alone.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Taylor M, Tuia VS. Breadfruit in the pacific region. Acta Horticulturae. 2007; 757(757):43-50.
DOI: 10.17660/ActaHortic.2007.757.4
2. Ajani AO, Osundahunsi OF, Akinoso R, Arowora KA, Abiodun AA, Pessu PO. Proximate composition and sensory quality of snacks produced from breadfruit flours. Glob. J. Sci. Front. Res. Biol. Sci. 2012; 12(7):1-9.
3. Akanbi TO, Nazamid S, Adebowale AA. Functional and pasting properties of a tropical breadfruit (*Artocarpus altilis*) starch from Ile-Ife, Osun State, Nigeria International Food Research Journal. 2009;16:151-157.
4. Amusa NA, Kehinde IA, Ashaye OA. Biodeterioration of the Africa Star Apple (*Artocarpus communis*) in storage and its

effects on the nutrient composition. Afr. J. of Biotechnol. 2002;1(2):57-60.

5. National Tropical Botanical Garden (NTBG). Hunger Initiative. Breadfruit Institute. National Tropical Botanical Garden. (Breadfruit/hunger.phb); 2009.
6. Ajani AO, Fasoyiro SB, Arowora KA, Ajani OO, Popoola CA, Zaka KO. Functional properties of composite flour made from wheat and breadfruit. Applied Tropical Agriculture. 2016;21:89-93.
7. Omobuwajo TO. Compositional characteristics and sensory quality of biscuit, prawn crackers and fried chips. Journal of Innovative food Science and Emerging Technologies. 2003;4(2): 219-225.
8. Oke EK, Tijani AO, Abiola OT, Adeoye AK, Odumosu BO. Effects of partial substitution of wheat flour with breadfruit flour on quality attributes of fried doughnut. Journal of Agricultural Sciences. 2018;13(1).
9. Ragone D, Cavaletto CG. Sensory Evaluation of Fruit Quality and Nutritional Composition of 20 Breadfruit (*Artocarpus*, Moraceae) Cultivars. Economic Botany. 2006;60(4):335-346. Available:https://doi.org/10.1663/0013-0001(2006)60[335:SEOFQA]2.0.CO
10. Smith Jr, James P. Economically Important Plants Arranged Systematically; 2017.
11. Morton Julia F. "Breadfruit" Fruit of warm Climates (Miami, florida). 1987;50-58.
12. Bamishaiye EB, Muhammad NO, Bamishaiye OM. Assessment of biological value of tiger nut (*C. esculentus*) tuber oil meal based diet in rats. Annals of Biological Research. 2010;1(4):274-280.
13. Adel AAM, Awad AM, Mohamed HH, Iryna S. Chemical composition, physicochemical properties and fatty acid profile of Tiger Nut (*Cyperus esculentus* L) seed oil as affected by different preparation methods. International Food Research Journal. 2015;22(5):1931.
14. Maton A, Jean H, McLaughlin CW, Warner MQ, Lattart D, Wright JD. Human Biology and Health. Eaglewood Cliffs, New Jersey, Prentice Hall, USA; 1993.
15. Daramola OA, Idowu' MA, Atanda OO, Oguntona CRB. Effects of packaging material on the quality of "pupuru" flour during storage. African. Journal of Food Science. 2010;4(5):258–263.
16. Akinyele OF, Ikujenlola AV, Omobuwajo TO. Functional and pasting characteristics of pupuru and pupuru analogues from cassava (*Manihot esculenta*) and breadfruit (*Artocarpus altilis*) blends. In Proceedings of the OAU Faculty of Technology Conference. 2015;20-25.
17. Shittu TA, Lasekan OO, Sanni LO, Oladosu MO. The Effect of Drying Methods on the Functional and Sensory Characteristics of Pupuru-A Fermented Cassava Product. Asset Series. 2001; 1(2):9-16.
18. Aboaba OO, Nwachukwu SU, Opesanwo NA. Microorganisms associated with cassava fermentation for "pupuru" Production. J. Food. Agric. 1988;2(1):39-41.
19. Shittu TA, Oyewole OB, Olawuyi O, Daramola O. Processing technology pupuru: A survey of practices and product quality in the South West of Nigeria. ASSET Series. 2005;B2(2):17-27.
20. Opeke LK, Laogun EA, Onayemi OO, Adetiloye PO, Williams TO. The place of cassava in household food security and nutrition. A Rapid Case Study of Owo Local Government Area, Ondo State, Nigeria. A Report on the existing Storage and Processing Techonology in the Southern Nigeria. UNICEF/IITA. 1986;75-87.
21. Famurewa JAV, Oluwamukomi MA, Alaba JO. Effect of different drying methods on the physicochemical characteristics of cassava flour ("pupuru"). Int. J. Biol. Chem. Sci. 2013;7(2):832-839.
22. AOAC. Association of Official Analytical Chemists. Official methods of analysis of the Association of Analytical Chemists International 18th ed. Gaithersburg, MD; 2005.
23. Vasconcelos AT, Twiddy DR, Westby A, Reilly PJA. Detoxification of cassava during gari preparation. Int. J. Food Sci. Technol. 1990;25:198-203.
24. Okaka JC, Potter NN. Functional properties of cowpea-wheat flour blend in bread making. J Food Sci. 1977;42:828–833. DOI: 10.1111/j.1365-2621.1977.tb12614
25. Gould JM, Jasberg BK, Cote GL. Structure-function relationships of alkaline-peroxide treated lignocellulose from wheat straw. Cereal Chem. 1989;66:213–217.
26. Lin MJY, Humbert ES, Sosulski F. Certain functional properties of sunflower meal products. J. Food Sci. 1974;39:368.
27. Chen AH. Characterization of functional properties of breadfruit flour *(Artocarpus*

altilis) (Doctoral dissertation, University of Hawai ʻI at Mānoa); 2016.

28. Oladele AK, Aina JO. Chemical composition and functional properties of flour produced from two varieties of tigernut (*Cyperus esculentus*).African Journal of Biotechnology. 2007;6(21): 2473-2476.
29. Akubo PI. Proximate composition and selected functional properties of African breadfruit and sweet potato flour blends. Journal of Plant Foods for Human Nutrition. 1997;51:53-60.
30. Kumar N, Jha A. Temperature excursion management: A novel approach of quality system in pharmaceutical industry. Saudi Pharmaceutical Journal. 2017;25(2):176-183.
31. Ihekoronye AI, Ngoddy PO. Integrated food science and technology for the tropics. 1st ed. McMillan Publishers. 1985;261-291.
32. Caballero B, Finglas P, Toldrá F. Encyclopedia of food and health. Academic Press; 2015.
33. Karuna D, Noel G, Dilip K. Production and use of raw potato flour in Mauritian traditional foods. Food and nutrition bulletin, United Nation University. 1996; 17(2).
34. Onwuka GI, Onyemachi AD, David-Chukwu NP. Comparative evaluation of proximate composition and functional properties of two varieties of cooking banana. IOSR Journal of Environmental Science, Toxicology and Food Technology. 2015;9(1):01-04.
35. Onimawo AI, Egbekun KM. Comprehensive food science and nutrition. Macmillan Publishers, Ibadan. 1998;228.
36. Chandra S, Singh S, Kumari D. Evaluation of functional properties of composite flours and sensorial attributes of composite flour biscuits. Journal of Food Science and Technology. 2015;52(6): 3681-3688.
37. Loos PJ, Hood LF, Graham HD. Isolation and characterization of starch from breadfruit. Journal of Cereal Chemistry. 1981;58(4):282-286
38. Sun Q, Xiong CSL. Functional and pasting properties of pea starch and peanut protein isolate blends. Carbohydrate Polymers. 2014;101:1134-1139.
39. Anigo IA, Ameh DA, Ibrahim S, Danbauchi SS. Nutrient composition of commonly used complimentary foods in north western Nigeria. Afr. J. Biotechnol. 2009;8:4211-4216.
40. Appiah F, Oduro I, Ellis WO. Proximate and mineral composition of *Artocarpus artilis* pulp flour as affected by fermentation. Pakistan Journal of Nutrition 2011;10(7):653-657.
41. Terker AS, Zhang C, McCormick JA, Lazelle RA, Zhang C, Meermeier NP, Weinstein AM. Potassium modulates electrolyte balance and blood pressure through effects on distal cell voltage and chloride. Cell Metabolism. 2015;21(1):39-50.

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