

Chemical and Sensory Evaluation of African Yam Bean (*Sphenostylis Sternocarpa*) Seed-Enriched Cassava (*Manihot esculenta*) Product (*Pupuru*)

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Abstract

This study evaluated the proximate composition, total energy values and mineral profiles of *Pupuru* flour blends produced from fermented cassava (*Manihot esculenta* Crantz) roots enriched with African yam bean (*Sphenostylis stenocarpa*) seeds (AYBS) and sensory qualities of stiff dough meals prepared from them. African yam bean seeds were cleaned, washed with and soaked in clean water for 24 h, manually dehulled, rinsed, cooked for about 45 min, rinsed, dried in an oven at 60 °C for 5 h, cooled to about 30 ± 2°C, milled, sieved and added to cassava which was previously spontaneously-fermented for 96 h, toasted, cooled, milled, sieved and packaged to form *Pupuru* flour blends of various proportions (0:100 (P100), 5:95 (EP5), 10:90 (EP10) 15:85 (EP15) of AYB seed : cassava) and a commercial sample (CP) was used as a control. The proximate compositions indicated significant (p<0.05) reductions in moisture, fibre and carbohydrate but increased the protein, fat and ash contents and energy values of all the blends as enrichment levels with AYBS increased. Moisture (dry basis), protein, fat, fibre, ash, carbohydrate and total energy contents of the blends ranged from 6.78 - 9.26%, 3.18 - 21.74%, 2.18 - 4.98%, 2.79 - 3.57%, 2.91 - 3.93%, 59.78 - 80.26% and 364.02 - 387.20 Kcal, respectively. Mineral compositions were significantly (P<0.05) different: Sodium (143.00-187.00 mg/100g), Potassium (537.00-675.00 mg/100g), Calcium (129.30-201.50 mg/100g), Phosphorus (63.50-124.00 mg/100g), Magnesium (49.10-71.00 mg/100g), Copper (2.3-3.4 mg/100g), Manganese (1.20-21.20 mg/100g), Zinc (4.50-11.00 mg/100g), Iron (5.20-12.50 mg/100g) while lead was below detection level. All samples had good sensory scores and overall acceptability. Enrichment of *Pupuru* with AYBS, significantly (p<0.05) improved proximate and energy compositions, mineral profile, and sensory properties, hence, could be used to enhance food security and combat malnutrition in Africa.

Keywords: *Pupuru*, Cassava, African yam bean (*Sphenostylis stenocarpa*) seed, Malnutrition, Food security

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1. Introduction

Pupuru, is a dough meal, traditionally fermented, ball-moulded, smoke-dried cassava food, native to the Ilajes of Ikale tribe, Ondo State and popularly consumed by the riverine area dwellers in the Southern, Eastern, Western and Middle belts of Nigeria (where it is known as Ikwurikwu) (Shittu et al., 2003; Aboaba et al., 1988). It serves as a major income source for those who produce it from cassava and plays a substantial role in enhancing food security in Nigeria (Opeke et al., 1986). Cassava is predominantly carbohydrate, with a deficiency in protein (1 - 2%, fresh weight (Charles et al., 2005), 1-3% dry weight (Buitrago, 1990), minerals and vitamins, and a rapid postharvest deterioration limit its utilisation as a vital food and feed in Africa (Kimaryo et al., 2000; Nwabueze and Odunsi, 2006; Wobeto et al., 2007; Chauynarong et al., 2009; Ogunjobi and Ogunwolu, 2010). Cassava is a staple food in various forms, such as *Garri*, *Lafun*, *Fufu*, *Abacha*, *Agbelima*, *Tapioca*, *Attieke* and *Pupuru*, for about 500 million people, in the developing countries (Okafor et al., 1998). In view of the low protein content of cassava, on a dry matter basis, and the safety implication of the inadequately smoke-dried, moulded *Pupuru* balls, this study, therefore, utilised the underutilised African yam bean (*Sphenostylis stenocarpa*) (AYB) seed at 5, 10 and 15% substitutions for *Pupuru* fortification, toasting as opposed to smoke-drying the spontaneously fermented cassava (TMS 0581) and AYB seed paste blends and investigated the proximate and mineral compositions of the AYB seed-fortified *Pupuru* flours blends, using standard methods.

2 Materials and methods

2.1 Materials

Fresh cassava (*Manihot esculenta*, Crantz) (TME 0581) tubers were sourced from the research farm of the Federal

University of Technology, Akure, Ondo State, African Yam Bean (AYB) (*Sphenostylis stenocarpa*) seeds (TSs 091) were from a farm in Efon Alaaye, Ekiti State and characterised by the International Institute of Tropical Agriculture (IITA), Ibadan, Oyo State while chemicals of analytical grade were purchased from a local chemical store in Akure, Ondo State.

2.2 Methods

Pre-processing of African yam bean (AYB) (*Sphenostylis stenocarpa*) seeds

African yam bean seeds (AYBS) were pre-processed into flour using modified method of Oluwamukomi and Akinlabi, 2011. The seeds were manually cleaned to remove dirt, stones, defective seeds, dead insects, and other unwanted materials. The cleaned seeds were washed with and soaked in clean tap water for 24 h, manually dehulled, rinsed, cooked for about 45 min, drained of water, rinsed, dried in an oven at 60°C for 5 h, cooled to about 30 ± 2°C, milled, sieved and the resultant flour was packaged in an airtight container for further uses.

Formulation of *Pupuru* flour blends

One kilogram (1 kg) of peeled, chipped and washed cassava tubers was soaked in one litre of water in a sterile plastic container and left to ferment for 96 h. Fibrous materials were manually removed from the dewatered, fermented cassava which was then pressed with a hydraulic jack, for further removal of water before being pulverized. Various percentages (5, 10 and 15) of the African yam bean (*Sphenostylis stenocarpa*) seed (AYBS) flour were homogeneously mixed with the fermented cassava paste before toasting in an open and wide pan until it was dry (Oluwamukomi and Akinlabi, 2011). The resultant cassava and AYBS blends (Table 1) were cooled to about 30 ± 2 °C, milled, sieved and packaged in an airtight container for further analyses. A commercial sample of *Pupuru* flour (CP) with 100% cassava and another prepared during this study (P100) were both used as commercial and laboratory controls, respectively.

2.3 Determination of Proximate Composition of *Pupuru* Flour Blends

Proximate compositions of the *Pupuru* flour blends were determined using the method of A.O.A.C. (2012) and the carbohydrate content was obtained by difference.

Table 1. Formulated *Pupuru* flour blends

| Sample code | Formulation ratio AYBS flour: Cassava (%) |
|-------------|--|
| P100 | 0 : 100 |
| EP5 | 5 : 95 |
| EP10 | 10 : 90 |
| EP15 | 15 : 85 |

AYBS = African yam bean (*Sphenostylis stenocarpa*) seed

2.4 Total Energy Value Determination

The total energy values of the flour blends were calculated using the method of AOAC (2012) and the following equation:

$$\text{Total energy (kcal/100 g)} = [(\% \text{ available carbohydrates} \times 4) + (\% \text{ protein} \times 4) + (\% \text{ fat} \times 9)] \quad \text{Eqn. 1.}$$

2.5 Mineral Content Determination

Determination of sodium and potassium contents of each sample was carried out using flame photometry (Pearson, 1976). Phosphorus was determined by the phosphovanado-molybdate (yellow) method (AOAC, 2012) while the other elemental concentrations were determined after wet digestion of the sample ash, with a mixture of nitric and perchloric acids (1:1 v/v), using Atomic Absorption Spectrophotometer (AAS, Buck Model 20A, Buck Scientific, East Norwalk, CT06855, USA) (AOAC, 2012). All the determinations were carried out in triplicates. The AAS is based on the principle that an excited atom of an element has the ability to absorb energy from wavelengths of light of the same frequency as the element. A blank solution is used to adjust instrument to zero absorbance or 100 % transmittance, working standards introduced to adjust instrument to give agreeable readings before the plant digest (prepared sample solution) was introduced. The absorbance of the digest was then recorded.

From the readings obtained, the mineral concentration in each sample was calculated thus:

$$R = \frac{\text{sample reading} \times 10 \text{ ppm}}{\text{standard reading}}$$

$$S \text{ (ppm)} = \frac{R \times v \text{ (volume of sample after making up)}}{\text{weight of sample}}$$

$$T \text{ (mg / 100 g)} = s/10$$

Where, T is the value of mineral.

Eqn. 2.

2.5.1 Determination of sodium and potassium

Determination of sodium

Five grams (5 g) of sample was ashed and 10 ml of distilled water and 5 ml of concentrated nitric acid were added with stirring. The mixture was transferred to a 100 ml volumetric flask and made up to the mark with distilled water. The flame photometer was set up so that the scale read 0 with distilled water and 10 divisions when the standard dilute Na was sprayed. The sample solution was sprayed and the Na content calculated by simple proportion (Pearson, 1976).

Determination of potassium

Five gram (5 g) of each sample was ashed and 100 ml of distilled water and 10 ml of concentrated HCl were added. The mixture was boiled for 10 min, cooled and diluted to a final concentration of approximately 15 mg/l K₂O. Using a filter to give a spectrum range of 766-770 nm, the sensitivity of the flame photometer was set so that the full deflection (100 divisions) was equivalent to 20 mg/l K₂O. The diluted sample solution was sprayed and the amount of K in the sample was estimated from the calibration graph (K = 0.83 x K₂O).

2.5.2 Determination of phosphorus

Phosphorus was determined colorimetrically using phosphor-vanadomolybdate (yellow) method and the absorbance measured at 470 nm (AOAC, 2012). About 1 ml of the sample solution was pipetted into 50 ml volumetric flask and 10 ml of vanadomolybdate reagent was added with few ml of distilled water, mixed and diluted to the volume with distilled water and allowed to stand for 10 min. A blank solution was also prepared by mixing 5 ml of water with 10 ml of vanadomolybdate and making it up to 50 ml.

The standard stock solution (100 ppm phosphorus) was prepared by dissolving 4.39 g of anhydrous KH₂PO₄ in 1 litre of distilled water. The stock solution was further diluted down to 50 ppm. About 20 g of ammonium molybdate was dissolved in 200 ml of hot distilled water and cooled. About 1 g of ammonium metavanadate (NH₄VO₃) was also dissolved separately in 120 ml of hot distilled water and cooled. Approximately, 140 ml concentrated nitric acid (HNO₃) was gradually added to the vanadate solution and diluted to 1 L. The absorbance of standard was read and a graph of absorbance against concentration was plotted (wavelength 470 nm). Phosphorus was determined from the calibration curve obtained by taking 0, 2, 4, 6, 8 and 10 ml out of the 50 ppm stock solution of phosphorus diluted to 50 ml in a volumetric flask. The absorbance was also taken and the concentration of phosphorus was calculated thus:

$$P \left(\frac{\text{mg}}{\text{kg}} \right) = \frac{A \times Fv \times D}{\text{Weight of sample}}$$

Eqn. 3

Where,

A = Absorbance;

Fv = Final volume of extract;

D = Dilution factor.

2.6 Sensory Evaluation

Sensory characteristics (colour, taste, mouthfeel, mouldability, texture, aroma, flavor and overall acceptability) of the samples were assessed by 30 semi-trained panelists (students and staff) of Federal University of Technology, Akure, Ondo State. The panelists were in good health and familiar with the taste, flavour and other attributes of *pupuru* while the samples were assessed using a 9 points hedonic scale ranging between 1 (extremely like) to 9 (extremely dislike) (IFT, 1981; Larmond, (1982).

2.7 Statistical Analysis

All the data obtained in this study were subjected to Analysis of Variance (ANOVA) using IBM SPSS version 21. Duncan Multiple Range Tests (DMRT) were carried out for the separation of means and determination of significant differences between means. Results are presented as mean ± standard deviation accepted at $p \leq 0.05$

confidence limit (Steel et al., 1997).

3 Results and Discussions

3.1 Proximate Composition and Total Energy Values

The results of the proximate analysis of the *Pupuru* flour blends (dry basis) are presented in Table 2. The moisture content (MC) of all the flour blends were significantly different ($p < 0.05$), ranging from 6.78 (EP15) to 7.87% (P100) and were significantly ($p < 0.05$) lower than in CP (9.26%). These results implied that the samples in this study would possess longer shelf lives compared to the commercial control sample (CP). A reduction in MC with increased enrichment with AYB seed which was not significant ($p < 0.05$) until at 15% inclusion of AYBS was observed. This might be due to the binding action of the protein in AYBS with water molecules. The MCs of the all the *Pupuru* flour blends were within the acceptable limit recommended for flour (10%) by the FAO (2003). The protein content (PC) of all the *Pupuru* flour blends were significantly different ($p < 0.05$), ranging from 3.48 (P100) to 21.74% (EP15), and were significantly ($p < 0.05$) higher than the commercial sample (3.18 %). These results were higher than 1 – 3% reported by Olugbemi *et al.* (2010) for cassava and implied that the protein contents of all the AYB seed-enriched samples could provide half of 56 g/kg body weight protein requirements of an adult (FAO, 2003). The fat contents (FC) ranged between 2.49 (P100) and 4.98% (EP15) and differed significantly ($p < 0.05$). The fat contents of the samples increased with increased inclusion of AYB seed. Thus, the increase in fat contents of the blends might have been due to the lipid content of the AYB seed. The crude fibre contents (CFC) of all the *Pupuru* flour blends ranged from 2.79 % in EP15 to 3.08 % in P100. This study showed that the CFC of the enriched flour blends were significantly ($p < 0.05$) lower than the commercial control sample. The trend in the results showed reduction in crude fibre with increased percentage of AYBS substitution in the samples. The CFC reported in this study were similar to those reported by Adejuyitan (2011) and Famakin *et al.* (2016) for the plantain-based dough meal enriched with Soy-cake and rice bran, respectively. The variation in the results might be as a result of different crops used for the food products. The results of ash content (AC) of all the samples were significantly different ($p < 0.05$) with EP15 having the highest (3.93%) and P100 having the lowest (2.91%) values. The AC of a food sample is the inorganic residue after the water and organic matter have been removed by heating in the presence of oxidizing agents, and is a measure of the total amount of minerals in it. The ACs of the flour blends in this study increased with increased enrichment with AYBS and implying increased mineral content. The carbohydrate content (CC) showed significant differences ($p < 0.05$), ranged from 59.78 – 80.26% in EP15 and P100, respectively. Significant ($p < 0.05$) reductions were observed in all the *Pupuru* flour blends with increased inclusion of AYB seed flour and the results agreed with the findings of Montagnac *et al.* (2009) and Adebayo-Oyetoro *et al.* (2017) in studies on cassava flours.

Table 2. Proximate composition and total energy values of *Pupuru* flour blends and the commercial control sample

| Sample | Moisture Content | Crude Protein | Crude Fat | Crude Fibre | Ash | Carbohydrate | Energy (Kcal) |
|--------|------------------------|-------------------------|------------------------|------------------------|------------------------|-------------------------|--------------------------|
| CP | 9.26±0.02 ^a | 3.18±0.02 ^c | 2.18±0.02 ^c | 3.57±0.02 ^a | 2.95±0.02 ^d | 78.82±0.73 ^b | 364.02±0.13 ^c |
| P100 | 7.87±0.02 ^b | 3.48±0.31 ^d | 2.49±0.13 ^c | 3.08±0.09 ^b | 2.91±0.03 ^c | 80.26±0.42 ^a | 374.12±0.30 ^d |
| EP5 | 7.47±0.17 ^b | 13.58±1.11 ^c | 2.89±1.89 ^c | 2.89±0.09 ^c | 2.98±0.05 ^c | 70.29±0.26 ^c | 378.26±0.26 ^c |
| EP10 | 7.45±0.01 ^b | 18.00±0.99 ^b | 4.19±0.64 ^b | 2.85±0.11 ^d | 3.23±0.53 ^b | 64.28±0.27 ^d | 383.27±0.21 ^b |
| EP15 | 6.78±0.09 ^c | 21.74±0.59 ^a | 4.98±0.48 ^a | 2.79±0.01 ^e | 3.93±0.01 ^a | 59.78±0.78 ^c | 387.20±0.03 ^a |

Mean ± SD with different superscripts in the same column are significantly different ($p < 0.05$), $n = 3$.

Key: CP = Commercial *Pupuru* Sample; P100 = 100% *Pupuru*; EP5 = 5% AYB-enriched *Pupuru*; EP10 = 10% AYB-enriched *Pupuru*; EP15 = 15% AYB-enriched *Pupuru*.

3.2 Total energy values

The energy values (EVs) of the flour blends ranged with significant difference ($p < 0.05$) from 374.12 kcal/100 g in P100 to 387.20 kcal/100 g in EP15. The EVs increased significantly ($p < 0.05$) with increased AYB seed enrichment of the *Pupuru* flour blends, were significantly ($p < 0.05$) higher than in commercial control sample (CP) (364.02 Kcal/100g), and the recommended 344 Kcal /day (FAO, 2004). The observed high energy values of these flour

blends could be attributed to fat, protein and an appreciable quantity of carbohydrate in AYB seed. The proximate compositions of the *Pupuru* flour blends produced in this study indicated that they could provide the necessary nutrients and energy requirements for both children and adults, thereby, enhancing food security in Africa.

3.3 Mineral Contents of *Pupuru* Flour Blends

Tables 3 show the major mineral (Na, K, Ca, P, Mg and their ratios) compositions of commercial, spontaneously-fermented-African yam bean (AYB) (*Sphenostylis stenocarpa*) seed-enriched *Pupuru* flour blends. The mineral compositions showed that sodium ranged between 143.00 mg/100 g in sample EP10 and 179 mg/100 g in sample EP15. These values were higher than those reported by Dossou *et al.* (2014) i.e. 84.24 mg/100 g, 73.37 mg/100 g, 123.65 mg/100 g and 171.20 mg/100 g for oven dried, freeze dried, defatted oven dried and defatted freeze dried ackee apple aril respectively. The recommended daily value for sodium is 1100- 3300 mg/kg for adults Bolt *et al.* (1978). Potassium was the most abundant mineral in the *Pupuru* flour blends for this study, ranging from 537.00 mg/ 100 g in EP10 (10% AYBS-enriched *Pupuru*) to 675.00 mg/100 g in sample EP15 (15% AYBS-enriched *Pupuru*) flour blends. Na/K ratio of less than 1 mg/100 g is recommended in the diet of people with high blood pressure and children with immature heart Ijarotimi and Keshinro, (2012). The Na/K ratios of all the *Pupuru* flour blends were less than 1 mg/100 g. This is an indication that the formulated flour blends would be suitable as complementary food for infants. Calcium content was between 129.30 mg/100 g in sample EP10 and 201.50 mg/100g in sample CP. CSEP5 had the highest calcium content 294.15 mg/100 g. Calcium content in this study was higher when compared with smoked-dried, oven-dried, and toasted *Pupuru* flour which ranged from 144.1 mg/100 g to 167.33 mg/100 g as reported by Famurewa *et al.* (2013). Calcium plays an important role in blood clotting, muscle contraction and in certain metabolic processes, hence, sample CSEP5 could be a good source of calcium. The calcium content was high compared to foods from other plant sources (Ijarotimi and Keshinro, 2012). The Ca/P ratio were higher than the recommended which is 1.0 (NRC, 1989; Ijarotimi and Keshinro, 2012). This shows that the flour blends would serve as a good source of minerals such as calcium and phosphorous, whose consumption is considered essential for bone and teeth formation in children and for regulation of calcium in the blood. Magnesium content ranged between 49.10 in EP15 and 61.80 mg/100 g in sample EP10. Magnesium has been reported to be involved in maintaining the electrical potentials in leaves and activation of some enzymes. (Ferro *et al.*, 1987).

Table 3. Major mineral (Na, K, Ca, P, Mg and their ratios) composition (mg/100 g) of spontaneously-fermented-African yam bean (AYB) (*Sphenostylis stenocarpa*) seed-enriched *Pupuru* flour blends and the commercial control

| Sample | Na | K | Na/K | Ca | P | Ca/P | Mg |
|--------|--------------------------|--------------------------|------------------------|--------------------------|--------------------------|------------------------|-------------------------|
| CP | 153.00±0.92 ^d | 596.50±3.1 ^c | 0.26±0.04 ^a | 201.50±1.56 ^a | 63.50±1.03 ^c | 3.17±0.13 ^a | 71.00±1.93 ^a |
| P100 | 185.00±1.06 ^b | 596.50±3.11 ^c | 0.33±0.08 ^d | 135.20±1.32 ^d | 124.00±2.14 ^a | 1.09±0.10 ^c | 52.50±1.34 ^d |
| EP5 | 187.00±1.87 ^a | 604.00±3.70 ^b | 0.31±0.07 ^c | 196.10±1.65 ^b | 105.30±2.33 ^b | 1.86±0.05 ^d | 57.38±1.05 ^c |
| EP10 | 143.00±1.19 ^e | 537.00±2.51 ^d | 0.27±0.03 ^b | 129.30±1.53 ^e | 67.90±1.14 ^d | 1.90±0.06 ^c | 61.80±1.13 ^b |
| EP15 | 179.00±1.06 ^c | 675.00±3.00 ^a | 0.27±0.05 ^b | 177.50±1.47 ^c | 89.60±0.05 ^c | 1.98±0.09 ^b | 49.10±1.04 ^e |

Values are means ± SD with different superscripts in the same column are significantly different (p<0.05), n = 3.

Key: CP = Commercial 100% Cassava *Pupuru* Sample; P100 = 100% Cassava *Pupuru*; EP5 = 5% AYB-enriched *Pupuru*; EP10 = 10% AYB-enriched *Pupuru*; EP15 = 15% AYB-enriched *Pupuru*.

Tables 4 show the minor / trace mineral (Cu, Mn, Zn, Fe and Pb) compositions of commercial, spontaneously-fermented-African yam bean (AYB) (*Sphenostylis stenocarpa*) seed-enriched *Pupuru* flour blends. Copper in the *Pupuru* samples differed significantly (p<0.05) ranging from 2.30 (P100) to 3.40 m/100 g and were within the recommended limits (FAO/WHO, 2011; WHO and Mahler, 1975). The flour blends are therefore, suitable for consumption, without posing any form of copper toxicity. Iron contents of the flour blends studied, were higher than those recommended for men (1.37 mg/day) and women (2.94 mg/day). Zinc contents for the samples in this study ranged from 4.5 – 6.30 mg/100 g and were significantly (p<0.05) lower than in the commercial control sample. Inadequate zinc can lead to stunted growth (Guria, 2006) and the minimum daily requirement is 3 mg (IOM, 2001). The samples could meet the minimum daily requirements. Lead was below detection level in all the

analysed samples, indicating that the *Pupuru* flour blends in this study would be suitable for consumption without posing any health risks. Lead is one of the vital elements considered as an index for food-chain contamination (Emurotu *et al.*, 2012), and the maximum recommended level is 0.2 mg/kg (FAO/WHO, 2013). This study showed that the *Pupuru* flour blends compared well with some cereal and legume-based complementary foods (Enomfon and Umoh, 2004; Mohamed and Huiming, 2007; Onoja *et al.*, 2014) and also followed the trend reported for cocoyam by Njoku and Ohia, (2007).

Table 4. Minor / trace mineral (Cu, Mn, Zn, Fe and Pb) composition (mg/100 g) of spontaneously-fermented-African yam bean (AYB) (*Sphenostylis stenocarpa*) seed-enriched *Pupuru* flour blends and the commercial control

| Sample | Cu | Mn | Zn | Fe | Pb |
|--------|--------------------------|---------------------------|---------------------------|---------------------------|-----|
| CP | BDL | 21.20 ± 0.22 ^a | 11.00 ± 0.15 ^a | 12.50 ± 0.09 ^a | BDL |
| P100 | 2.30 ± 1.21 ^d | 1.70 ± 0.24 ^c | 6.30 ± 0.14 ^b | 5.20 ± 0.10 ^c | BDL |
| EP5 | 2.50 ± 1.01 ^c | 1.90 ± 0.08 ^b | 4.50 ± 0.10 ^c | 5.70 ± 0.05 ^d | BDL |
| EP10 | 2.70 ± 1.00 ^b | 1.20 ± 0.14 ^c | 5.90 ± 0.11 ^c | 9.00 ± 0.07 ^b | BDL |
| EP15 | 3.40 ± 0.19 ^a | 1.50 ± 0.3 ^d | 4.80 ± 0.17 ^d | 7.20 ± 0.08 ^c | BDL |

Values are means ± SD with different superscripts in the same column are significantly different ($p < 0.05$), $n = 3$.

Key: CP = Commercial 100% Cassava *Pupuru* Sample; P100 = 100% Cassava *Pupuru*; EP5 = 5% AYB-enriched *Pupuru*; EP10 = 10% AYB-enriched *Pupuru*; EP15 = 15% AYB-enriched *Pupuru*.

3.4 Sensory Evaluation

Table 5 shows the results of the sensory evaluation of stiff porridge dough meals prepared with the commercial and spontaneously-fermented-African yam bean (AYB) (*Sphenostylis stenocarpa*) seed-enriched *Pupuru* flour blends. Appearance ratings for all the dough meals differed significantly ($p < 0.05$), ranging from 5.79 (EP15) to 7.79 (P100) and decreased with increased level of enrichment with AYB. This trend might have been due to the brown tainting of the flour blends due to Maillard reaction (a chemical reaction between amino acids and reducing sugars in the presence of heat resulting to browning of the food and formation of new aromas and flavours) during the toasting of the enriched *Pupuru* flour blends. This appearance trend was also reported by Blanca *et al.* (2009) in a study that supplemented *Lafun* with African breadfruit 'tempe' flour, whereby, *Lafun* without substitution scored significantly ($p < 0.05$) higher in appearance than *Lafun-tempe*. The significantly different ($p < 0.05$) aroma of the porridge meals prepared with spontaneously fermented blends ranged from 5.96 (EP5) to 6.50 (EP15), indicating preference for the most highly enriched flour with AYB seed. The pleasant aroma of the toasted AYB seed could be attributed to the trend in these results, as supported by the finding of Njoku *et al.* (2013), with *Lafun* enriched with breadfruit *tempe* flour whereby *Lafun-tempe* scored significantly ($p < 0.05$) higher in aroma than *Lafun*. The textural characteristic of the porridge meals prepared with all the *Pupuru* flour blends differed significantly ($p < 0.05$) ranging from 6.42 (P100) to 7.21 (EP5) while CP was rated 7.00. These results were at variance with what was obtained in a study where *Lafun* was rated significantly ($p < 0.05$) higher in texture than the *Lafun-tempe* (Njoku *et al.*, 2013). This might be as a result of AYB seed being able to form a smooth bond with the cassava starch molecules more than breadfruit (*tempe*).

Table 5. Sensory evaluation of stiff porridge dough meals prepared with commercial and spontaneously-fermented-African yam bean (AYB) (*Sphenostylis stenocarpa*) seed-enriched *Pupuru* flour blends.

| Sample | Appearance | Aroma | Texture | Mouldability | Taste | Mouthfeel | Overall acceptance |
|--------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| CP | 6.43 ± 0.67 ^o | 6.46 ± 0.45 ^h | 7.00 ± 0.22 ^e | 6.93 ± 0.46 ⁱ | 6.18 ± 0.58 ^l | 6.36 ± 0.36 ^k | 6.85 ± 0.29 ^f |
| P100 | 7.79 ± 0.25 ^h | 6.43 ± 0.21 ^j | 6.42 ± 0.31 ^m | 6.36 ± 0.85 ^q | 6.37 ± 0.37 ^j | 6.22 ± 0.56 ^l | 6.46 ± 0.66 ^m |
| EP5 | 7.64 ± 0.03 ^j | 5.96 ± 0.52 ^o | 7.21 ± 0.16 ^e | 7.04 ± 0.35 ^g | 6.64 ± 0.57 ^b | 6.43 ± 0.39 ^h | 6.60 ± 0.52 ^j |
| EP10 | 6.71 ± 0.21 ⁿ | 6.04 ± 0.36 ^l | 6.79 ± 0.39 ^g | 7.07 ± 0.41 ^f | 6.21 ± 0.36 ^k | 6.32 ± 0.25 ⁱ | 6.66 ± 0.21 ^e |
| EP15 | 5.79 ± 0.17 ^q | 6.50 ± 0.35 ⁱ | 6.46 ± 0.50 ^o | 7.25 ± 0.43 ^b | 6.59 ± 0.59 ⁱ | 5.85 ± 0.45 ^q | 6.32 ± 0.52 ⁿ |

Values are means ± SD with different superscripts in the same column are significantly different ($p < 0.05$), $n = 3$. Key: CP = Commercial 100% Cassava *Pupuru* Sample; P100 = 100% Cassava *Pupuru*; EP5 = 5% AYB-enriched *Pupuru*; EP10 = 10% AYB-enriched *Pupuru*; EP15 = 15% AYB-enriched *Pupuru*.

Mouldability of porridge meals prepared with the flour blends were significantly different ($p < 0.05$) and ranged between 6.36 (P100) and 7.25 (EP15) and the commercial sample was 6.93. The taste of porridge meals prepared with the *Pupuru* flour blends differed significantly ($p < 0.05$) ranging from 6.21 (EP10) to 6.64 (EP5) while CP was rated 6.18. The enriched samples seemed to be significantly ($p < 0.05$) higher than the control samples, as in agreement with the report of Njoku et al. (2013) that *Lafun-tempe* scored significantly ($p < 0.05$) higher in taste than *Lafun*. All the porridge meals prepared with *Pupuru* flour blends varied significantly ($p < 0.05$) in mouthfeel and ranged between 5.85 (EP15) and 6.43 (EP5) with CP being 6.36. Overall acceptance of porridge meals prepared with all the *Pupuru* flour blends differed significantly ($p < 0.05$) ranging from 6.32 (EP15) to 6.66 (EP10) while CP was rated 6.85. The results obtained for sensory evaluation of the flour blends in this study were at variance with the report of Oluwamukomi and Akinlabi (2011), in a study that enriched *Pupuru* with AYB seed whereby, the stiff dough meal prepared from the unenriched flour was rated significantly ($p < 0.05$) higher than the enriched samples in all the attributes (taste, aroma, colour, texture, mouldability and overall acceptance) evaluated; and the enriched samples were acceptable only up to 5% African yam bean flour inclusion as there was no marked significant difference ($p < 0.05$) between the sensory attributes of the sample and the control. The variations in the findings might be as a result of differences in the processing methods such as pre-gelatinisation at various stages, cassava and AYB seed varieties, starter cultures employed in preparing the various flour blends and flour-water ratios used to prepare the stiff porridge dough meals in both studies. There was, however, no rejection of any of the stiff porridge dough meals in this study.

4. Conclusion

African yam bean (AYB) (*Sphenostylis stenocarpa*) seed has successfully been used to enrich the nutritional, functional and sensory properties of *Pupuru*. The enriched *Pupuru* can therefore, be used to tackle protein energy malnutrition as well as mineral deficiencies in Africa.

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