INFLUENCE OF FERMENTATION PERIOD ON NUTRITIONAL COMPOSITION AND SENSORY ATTRIBUTES OF CASSAVA-ORANGE FLESH SWEET POTATO PUPURU

ABSTRACT

Pupuru, a cassava-derived food product, has gained significant popularity globally, with its demand steadily increasing. However, one of the major defects of pupuru is its lack of essential nutrients, particularly beta-carotene, a precursor to vitamin A. The study explored the benefits of OFSP supplementation in cassava products to address regional dietary needs and boost nutritional content. Co-fermentation was carried out on blends of four cassava and orange fleshed sweet potato (OFSP) in the (ratio) of 75:25%, 25:75%, 50:50% and 0:100% (cas: ofsp) respectively. The products obtained were evaluated for proximate composition, anti-nutritional factors, and sensory properties using standard analytical methods. The result obtained for moisture, protein and fat for blends of (cas:ofsp) ranged for 75:25% (6.71- 9.93%), (4.45-5.11) and (0.17 - 0.82%) 50:50% blends (6.28 - 10.3%), (5.35– 5.46%) and (0.20-0.82%), 25:75% blends (6.59-9.85-%), (5.17-5.29%) and (0.60-0.84%), 0:100% blends (7.60-10.7%%), (4.50-4.99%) and (0.14-0.82%) from 0 to 96 hour. A reduction in total carbohydrate content was observed in all pupurublends. The beta carotene content from the blended sample recorded 2.14mg/100g, 2.20mg/100g, 2.56mg/100g and 3.11mg/100g for the blended ratio. The result obtained for the phytate ranged {(2.51- 4.32) (2.23- 4.02) (2.23-3.45) (2.20-3.05) mg/100g} and oxalate {(38.8-80.63) (37.1-80.1) (37.5-80.8) (39.0-87.5) mg/100g} for 75:25%, 50:50%, 25:75% and 0:100% blends respectively. The sensory score indicated that 75:25% (cas:ofsp) at 72 h was the most acceptable when compared with the control samples and showed no significant differences ($p>0.05$). Aroma and colour were rated high for 75:25% (72 h) and 50:50% (96 hrs) (cas:ofsp) samples of pupuru analogue produced when compared with *pupuru* from 100 % cassava were preferred most. The analogue pupuru produced offers a promising solution to addressing micronutrient deficiencies, especially vitamin A deficiency, in regions where cassava is a staple food.

Key words: "*Pupuru*", Cassava, Orange Fleshed Sweet Potato (OFSP),

1. INTRODUCTION

Malnutrition is a significant issue in many developing nations, primarily due to a lack of nutrient-rich foods. In 2021, approximately 350 million more individuals faced moderate-to-severe food insecurity than before the COVID-19 pandemic, amounting to about 2.3 billion people (29.3%) worldwide (FAO, 2022). Sweet potatoes are recognized for their outstanding nutritional and functional benefits, making them a focus of recent research. Almost every

part of the sweet potato plant—stem, leaf, and root—can be consumed, each with varying levels of nutrients, non-nutrients, and anti-nutrients (Alamu, 2021).Among sweet potato varieties, orange-fleshed sweet potatoes (OFSPs) are particularly rich in provitamin A, which plays a crucial role in combating vitamin A deficiency (VAD) in over 43 million children, especially in many African nations (Itodo*et al.*, 2022). Consuming OFSP is considered an effective strategy in reducing vitamin A deficiency, a condition responsible for the premature blindness and death of over 250,000 children annually in Africa (Honi et al., 2018). Therefore, promoting the consumption of foods high in provitamin A offers a flexible and valuable approach to improving nutrition (Uzoaga et al., 2020a; Uzoaga et al., 2020b).Cassava (*Manihot esculenta Crantz*) is the most widely consumed staple food in Nigeria, with traditional products such as gari, lafun, fufu, and pupuru.Pupuru, is a locally made fine white flour made from processed cassava tubers also called 'Ikwurikwu. Its Originated from the Ilaje people of Ondo State, pupuru holds cultural significance and is consumed in various regions across Nigeria, particularly in riverine areas in the western, southern, eastern, and middle belts (McNulty and Oparinde, 2015; Shittu, 2010; Daramola, 2010; Oluwamukomi and Akinlabi, 2011; Adejuyitan*et al.*, 2018).Pupuru is rich in carbohydrates, containing significant levels of ash and crude fiber, but is low in protein and fat. It also provides essential minerals such as potassium (K), calcium (Ca), iron (Fe), magnesium (Mg), and zinc (Zn), although its vitamin content is generally low, except for Vitamin C (Gil and Buitrago, 2002; Burns et al., 2012). Fermentation is an important process in pupuru production as it helps break down complex substances into simpler compounds with the help of microorganisms like bacteria, yeasts, and molds, improving the nutritional and sensory qualities of the food (Otunola, 2018).

Given the importance of nutrition and the potential benefits of sweet potatoes, this research aims to evaluate the effects of fermentation period on the nutritional composition, antinutritional factors, and sensory properties of cassava-orange fleshed sweet potato pupuru.

2. Materials and Methods

2.1 Materials

The raw materials used for this study were sweet cassava (*Manihot esculenta Crantz*) and the Mother's Delight orange-fleshed sweet potato (*Ipomoea batatas L*.). The cassava tubers were sourced from the LAUTECH Teaching and Research Farm, Ogbomoso, Oyo State, Nigeria, while the orange-fleshed sweet potatoes were obtained from a farm in Osogbo, Osun State, Nigeria. All reagents used in the analysis were of analytical grade and sourced from reputable suppliers. The parameters assessed included ash, carbohydrate, crude protein, crude lipid, crude fiber, beta carotene, phytate, oxalate, and sensory attributes.

2.2 Method

2.2.1 Production of Cassava-Orange Fleshed Sweet Potato Pupuru

Cassava and orange-fleshed sweet potato were weighed peeled, washed, and grated. The resulting soft, wet mash was placed into a sack and dewatered using a mechanical press. The fiber was manually removed from the mash, which was then transferred into a sterile container. The two mashed ingredients were mixed according to a specific formulation ratio using an automated mixer. The mixture was then placed into sterilized plastic containers, appropriately labeled, and left to ferment for 96 hours. After fermentation, the mixture was molded into ball shapes and smoked until a golden brown color appeared (Adejuyitan et al., 2017; Oladimeji et al., 2022).

The soot from the smoking process was scraped off, and the molded balls were pulverized, lightly toasted, and sieved using a 60-mesh size to obtain dried cassava-orange flesh sweet potato pupuru (pupuru analogue).

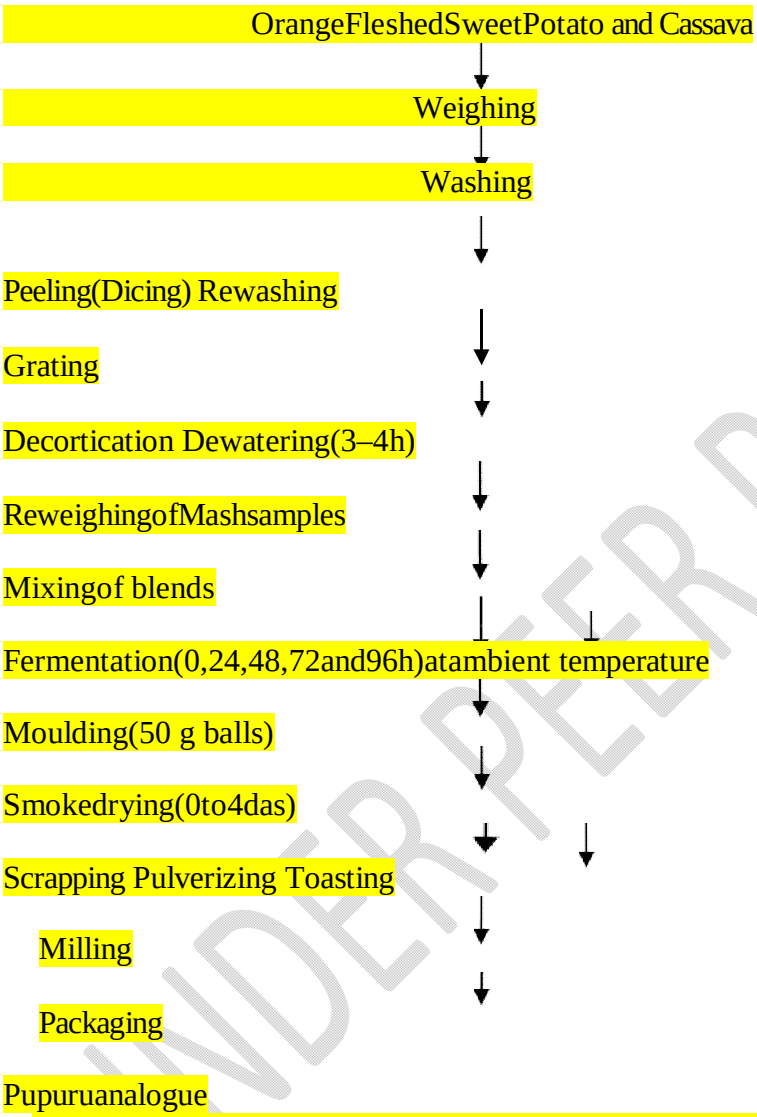

Chart 1:FlowchartofPupuru AnalogueProcessingfromBlendsofCassavaand Orangefleshed sweet potato

Source: Adejuyitan*et al.*,(2017) Oladimeji *et al.*, (2022).

2.2 Proximate analysis

The obtained flour blends were analysed chemicallyfor moisture, ash, crude fibre, protein, crude fat and the carbohydrate content was determined by difference method as described by the Association of Official Analytical Chemist (2019).

2.3 Beta-carotene determination

The beta - carotene content in approximately 2g aliquots of the samples was analyzed in duplicate by high-performance liquid chromatography (HPLC) as previously described by Rautenbach *et al.* (2010).

2.4 Determination of anti-nutritional factors

The tannin content of the flours was determined as described by Wang *et al.* (2021)using Folin Denis reagents and phytate content as described byAOAC (2019).

2.5 Sensory evaluation

This was carried out by selecting randomly 30 semi-trained panelists who have consumed *pupuru*produced from cassava and is familiar with its quality attributes. The cassava orange fleshed sweet potato meal was prepared and served hot with delicacy soup in coded plates. The panelistswere asked to examine the quality factors such as appearance, taste, colour, odour, texture, aroma and over all acceptability, using a 9 point Hedonic scale ranging from 1 (Extremely dislike) to 9 (Extremely like).

2.6 Statistical Analysis

All the analysis was done in triplicates and the mean values were determined in each case. The data were subjected to one-wayANOVA using the Statistical Package for Social Sciences (SPSS) version 16.0 and the means were separated with the use of Duncan's multiple range test to detect significant difference ($p<0.05$) among the samples.

3. RESULTS AND DISCUSSION

3.1 Proximate composition of co-fermented cassava-orange flesh sweet potato at varying level of substitution along the processing period from 0 to 96 hours

The result in Figure 1 indicates that moisture content level ranged from 6.71-9.93% 6.28-10.5%, 6.59-9.85%, 7.60-10.7% for 75:25%, 50:50%, 25:75%, and 0:100%respectively for blends of co-fermented cassava and OFSP to produce *pupuru* analogue meal at varying length of fermentation from 0 to 96 hoursand the control sample (100% cassava) was (7.17%) moisture content. There was asignificant difference ($p<0.05$) between the fermented samples and the unfermented at 0 hour. Therefore, it is noteworthy that the moisture contents of all substituted samples were lower (Figure 1) than the control sample (100% cassava) at 96 hours of fermentation. The moisture content range in this study was lower than the range (11.86-12.98%) reported for *pupuru* and *pupuru* analogue from co-fermented cassava and bread fruits by Akinyele *et al*.. (2020). The protein content obtained from *pupuru* produced from co-fermented cassava and OFSP along 0 to 96 hours of fermentation ranges for 75: 25%, (4.45 to 5.11) for 50: 50% (5.35 to 5.46%) for, 25:75% (5.17 to 5.29%) and for 0%:100% (4.50-4.99) for blend of cassava and OFSP as represent in (Figure 2). This is similar to the findings of Ojo and Akande (2013) and Atuna*et al*., (2021).

The fats contents(Figure 2) obtained ranged from 0.17-1.07%, 0.20-1.20%, and 0.60-0.89%, 0.14-0.87% for 75:25%, 50:50%, 25:75% and 0:100%, respectively for *pupuru* analogue. The ash content, which is a reflection of the mineral contents preserved in food was found to increase down the period of fermentation and the highest value of ash content was 2.17 % found in *pupuru* meal produced from 50 % OFSP substitution while the lowest was 1.54% obtained from 100% cassava (control sample). The result of carbohydrate content shows little significant difference along the periods of fermentation while the highest carbohydrate difference was

obtained for 100% cassava and the lowest at 50 % substitution with OFSP. The total carbohydrate content (Figure 3) of the composite *pupuru* from 100% cassava and orange flesh sweet potato were found to decrease with increase in OFSP substitution.

3.2 Vitamin Composition of Co-Fermented *Pupuru* and *Pupuru* Analogue from Cassava-Orange Fleshed Sweet Potato

The vitamin C content increased significantly ($p<0.05$) with an increase in co-fermented OFSP substitution ranging from 10.4 to 32.2mg/100g, 13.4 to 35.6mg/100g, 9.57 to 29.2mg/100g and 7.81 to 31.5mg/100g for 25, 50, 75 and 100% level of substitution, respectively, while control sample was 17.0mg/100g (Table 1). The B-carotene values for all the substituted samples were found to range from 2.10 to 2.14mg/100g, 2.12 to 2.20mg/100g, 2.55 to 2.56mg/100g and 3.10 to 3.11mg/100g for 25, 50, 75 and 100% level of substitution respectively, while control sample was 0.03

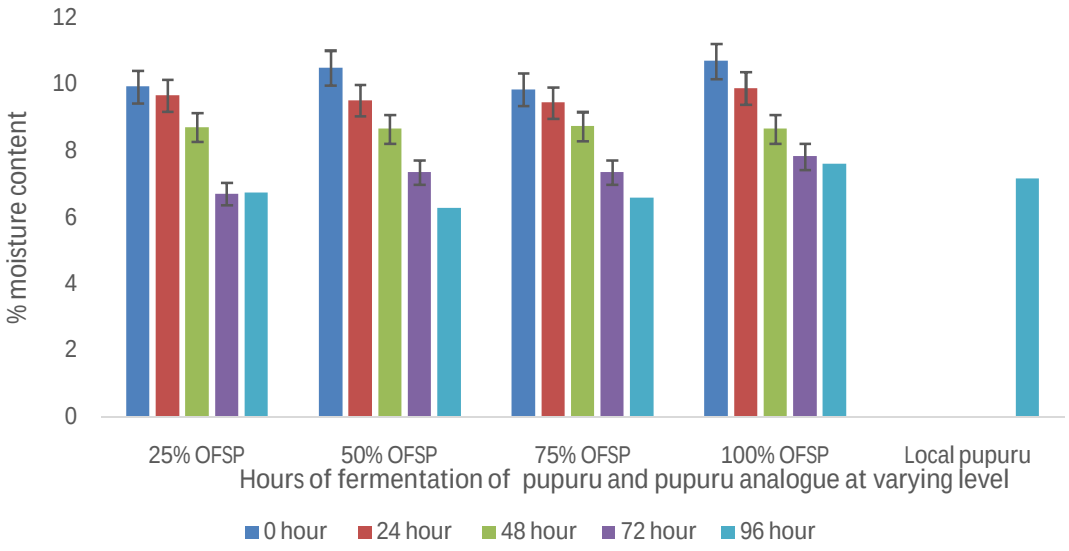

Figure 1: Effect of fermentation period on the moisture content of *pupuru* and *pupuru* analogue obtained from co-fermented cassava- orange fleshed sweet potato blend

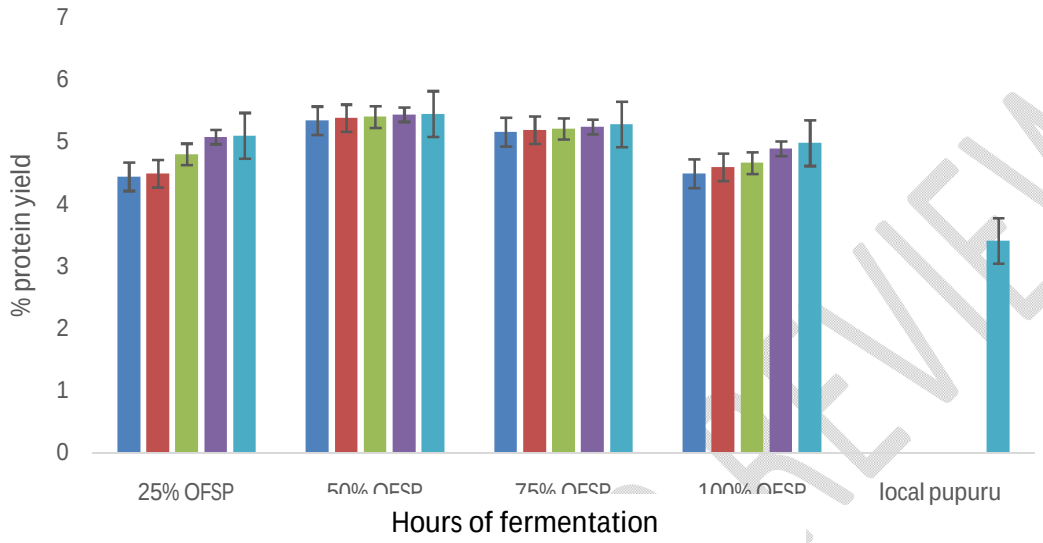

Figure2: Effect of fermentation period on the protein content of *pupuru* and *pupuru* analogue obtained from co-fermented cassava-orange fleshed sweet potato blend.

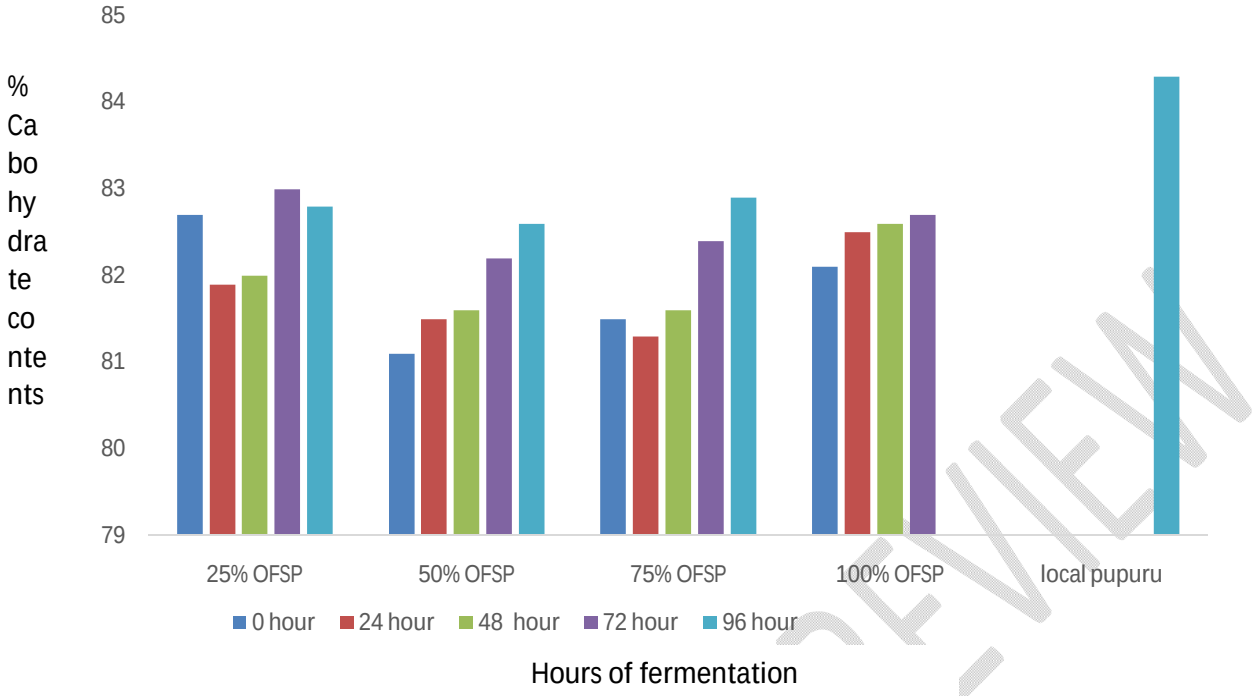

Figure 3: Effect of fermentation period on carbohydrate composition of *pupuru* and *pupuru* analogue obtained from co-fermented cassava-orange fleshed sweet potato blend.

Table 1. Vitamin Contents of *Pupuru* and *Pupuru* analogue Obtained from Cassava-Orange Fleshed Sweet Potato Substitution

Sample	Vitamin C (m/100g)	B-Carotene (m/100g)	Vitamin B_1 (m/100g)	Vitamin B_3 (mg/100g)	Vitamin B_{12} (mg/100g)
Cass $_{75\ \%}$ OFSP $_{25\%}$					
A	10.4^{a}	2.10^{b}	0.09^{a}	0.20^{a}	0.28^{a}
B	10.9^{a}	2.11^{b}	0.13^{b}	0.23^{a}	0.26^{a}
C	29.3^{c}	2.11^{b}	0.17^{c}	0.24a	0.28^{a}
D	30.1^{c}	2.12^{b}	0.12^{b}	0.21^{a}	0.32^{b}
E	32.2^{d}	2.14^{b}	0.15^{b}	0.22^{a}	0.33^{b}
F	17.0^{b}	0.03^{a}	0.10^{a}	0.22^{a}	0.25^{a}
Cass $_{50\%}$ OFSP $_{50\ \%}$					
A	13.4a	2.12b	0.64e	0.39b	0.46b
B	15.7b	2.14b	0.24b	0.43c	0.47b
C	30.3d	2.15b	0.30c	0.50e	0.47b
D	34.5e	2.17b	0.32c	0.48d	0.62c
E	35.6f	2.20c	0.41d	0.46d	0.67c
F	17.0c	0.03a	0.10a	0.22a	0.25a
Cass $_{25\%}$ OFSP $_{75\%}$					
A	9.57^{a}	2.55^{bc}	0.17^{b}	0.36^{b}	0.33^{b}
B	10.6^{a}	2.55^{bc}	0.22^{c}	0.44^{c}	0.42^{c}
C	27.3^{c}	2.50^{b}	0.26^{cd}	0.47^{d}	0.46^{c}
D	26.8^{c}	2.54^{bc}	0.28^{cd}	0.44^{c}	0.68^{d}
E	29.2^{d}	2.56^{c}	0.30^{d}	0.42^{c}	0.64^{d}
F	17.0^{b}	0.03^{a}	0.10^{a}	0.22^{a}	0.25^{a}
Cass $_{0\%}$ OFSP $_{100\ \%}$					
A	7.81^{a}	3.10^{c}	0.13^{b}	0.33^{c}	0.47^{d}
B	11.5^{b}	3.07^{b}	0.17^{c}	0.20^{b}	0.18^{a}
C	23.5^{d}	3.09^{c}	0.32^{d}	0.22^{b}	0.23^{b}
D	30.7^{e}	3.10^{c}	0.37^{e}	0.17^{a}	0.23^{b}
E	31.5^{f}	3.11^{c}	0.39^{f}	0.22^{b}	0.25^{c}
F	17.0^{c}	0.03^{a}	0.05^{a}	0.22^{b}	0.25^{c}

Samples with the same superscript along the column are notsignificantly different at 5% probability.

Key:

Sample A: Blends of cassava and orange fleshed sweet potato "pupuru" produce at day 0
Sample B: Blends of cassava and orange fleshed sweet potato "pupuru" produce at day 1
Sample C: Blends of cassava and orange fleshed sweet potato "pupuru" produce at day 2
Sample D: Blends of cassava and orange fleshed sweet potato "pupuru" produce at day 3
Sample E: Blends of cassava and orange fleshed sweet potato "pupuru" produce at day 4
Sample F: control sample (100% cassava) pupuru" produce at day 4

mg/100 g was found to be lower than the level of substitution with OFSP. The highest value of 3.11mg/100 g was recorded for sample E at 100 % OFSP fermented for 96 hours.

This result corroborates with the findings of Abano *et al*. (2020) and Richard *et al*. (2021) who reported higher levels of b-carotene in cassava OFSP composite gari as the OFSP concentration increased.

3.3 Anti-Nutrient properties of Co-fermented *Pupuru*and *Pupuru* analogue produced from Cassava and Orange Fleshed Sweet Potato

The result obtained for the phytate for the entire substituted sample at varying hours of production ranged from {2.51 to 4.32, 2.23 to 4.02, 2.23 to 3.45 and 2.20 to 3.05mg/100g} for 75:25%, 50:50%, 25:75% and 0:100%, respectively. The phytate result for the control sample was 3.01 mg/100 g. The result obtained for phytate from co-fermentation of the two samples were higher than the result reported by Oladimeji *et al*. (2022) for "*pupuru* analogue" (100% OFSP) was found to be within 1.62 to 1.12 mg/100g. The oxalate value for all the blends ranged from {38.8 to 80.63, 37.1 to 80.1, 37.5 to 80.8 and 39.0 to 87.5mg/100g} for blends of 75:25, 50:50, 25:75 and 0:100% respectively. The control sample (100% cassava *pupuru*) produced at 96 hours was 40.1 mg/100g.

There was significant difference ($p<0.05$) in all the substituted samples along the periods of fermentation. The result for tannin ranges from {86.4 to 145.6, 79.6 to 109.3, 90.2 to 141.0 and 93.0 to 155.0mg/100g} for blended ratio respectively. The control sample for the level of tannin was 90.0 mg/100g. The lowest value of tannin in the entire substituted sample was 79.6mg/100g for 50% OFSP substitution at 96 hours.

The results of saponin content ranged from {0.54 to 3.70, 0.88 to 2.28, 1.35 to 2.52 and 2.20 to 3.05%} for the blended ratio respectively.High levels of anti-nutrients (phytate, oxalate, and tannin) in food are undesirable because they form complexes with minerals and proteins, making

these nutrients unavailable to the body. This can result in adverse health effects, such as carcinogenicity, shock, and renal damage, as reported by Olaniyan *et al.* (2021).

3.4 Sensory scores of pupuru from co-fermented cassava and orange flesh sweet potato (OFSP)

Sensory evaluation results of pupuru produced from different blends of co-fermented cassava and OFSP (25%, 50%, 75%, and 100% OFSP substitutions) after fermentation periods ranging from 0 to 96 hours.

At 25% OFSP substitution, no significant differences were observed in sensory attributes at 72-96 hours of fermentation when compared to the control sample. The highest rated value was observed at 72 hours in terms of taste (7.16), colour (7.29), aroma (7.34), texture (7.43), and overall acceptability (7.50).followed by pupuru produced at 96 hours in terms of taste (7.14), colour (7.22), aroma (7.29), texture (7.34), and overall acceptability (7.45). Pupuru produced for 0 to 48 hours shows a decrease in significant differences.

The pupuru produced from 50% cassava:50% OFSP fermented for 96 hours was rated by the panellists highest in term of taste (7.27), colour (7.16), aroma (7.46), texture (7.32), and overall acceptability (7.48), followed by that of pupuru produced from co-fermented cassava and OFSP (50% cassava:50% OFSP) fermented for 3 days in term of taste, colour, aroma, texture, overall acceptability (7.20, 7.11, 7.35, 7.22 and 7.41) while the co-fermented pupuru for 0 to 48 hours were rated low.

The 75% OFSP substitution at 0-72 hours, there was a significant difference in sensory quality over time, with 96 hours showing significant improvements across all sensory parameters. The higher level of OFSP contributed to a more vibrant color and an enhanced aroma, which might be attributed to the increased sweetness and floral notes typical of OFSP.

Similarly, the texture and overall acceptability ratings were also higher, suggesting that a greater proportion of OFSP not only improved the sensory appeal but also enhanced the perceived freshness and desirability of the final product.

At the 100% OFSP substitution the sensory attributes displayed the most significant changes over time. Samples at 0 -72 hours exhibited gradual but substantial improvements in all sensory characteristics, with 96 hours and the control sample achieving the highest scores. This supports the idea that OFSP, when used as the sole ingredient in the fermentation process, results in a product with superior sensory properties, likely due to the natural sweetness, texture, and aroma of the sweet potato. However, it is interesting to note that the 100% OFSP sample still showed some variation in overall acceptability, highlighting the potential challenges of achieving a balance in taste and texture when using OFSP exclusively.

A 50% substitution of cassava with OFSP maintained good sensory qualities, while higher OFSP content of 75% and 100% OFSP reduced appeal, particularly in taste, aroma, and texture. A balanced blend of cassava and OFSP is recommended for optimal sensory qualities

In general, the study found that pupuru produced from 25% and 50% OFSP substitution showed no significant differences in sensory attributes towards the end of fermentation (72 to 96 hours), indicating that these formulations reached an optimal balance in terms of sensory properties fairly early in the fermentation process.

The fermentation process enhanced the integration of cassava and OFSP components, resulting in improved sensory qualities, particularly in texture and aroma. The study suggests

that a 50% OFSP substitution may offer a balance between desirable sensory characteristics and optimal fermentation time.

4. CONCLUSION

This study has shown significant changes and differences in the chemical, functional, nutritional and anti-nutritional properties of *pupuru* and *pupuru analogue* obtained along the period of fermentation of cassava and orange fleshed sweet potato (OFSP) for its production. The result produced*pupuru analogue* with higher levels of protein, fats carbohydrate, vitamins and minerals. The result obtained shows that incorporating orange fleshed sweet potato (OFSP) tends to boost the nutritional value of *pupuru*analogue produced.It has been shown that significant changes and differences in the sensory properties between pupuru and pupuru analogues obtained along the periods of fermentation. The panellists most preferred blend was the pupuru analogue produced from co-fermented cassava and OFSP were 50% cassava: 50% OFSP fermented for 4 days followed by pupuru blend fermented for 3 days having the highest overall acceptability score of 7.48 and 7.45. This was in-line with the findings of Akinyele *et al.*, (2020). It was also observed that fermentation improved the taste and overall acceptability of the cassava - OFSP pupuru. Fermentation, however did not appear to have influence on the appearance, texture and flavour of the OFSP-cassava pupuru.

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