LAUTECH Journal of Engineering and Technology 19 (1) 2025: 79-89
10.36108/laujet/5202.91.0170

Functional, Physicochemical and Pasting Properties of Pupuru and Pupuru Analogue Made from Cassava-Orange Fleshed Sweet Potato

[1]Oladimeji T. E., [2]Otunola E. T. and [3]Adejuyitan J. A.

[1,2,3]*Department of Food Science, Ladoke Akintola University of Technology, P. M. B 4000 Ogbomoso, Oyo State, Nigeria.*

[1] teoladimeji@lautech.edu.ng, [2]jadejuyitan@lautech.edu.ng,[3]etotunola@lautech.edu.ng

Article Info

Article history:

Received: Dec. 01, 2024
Revised: Jan. 16, 2025
Accepted: Feb. 02, 2025

Keywords:

Cassava tubers,
Orange-fleshed sweet potato,
Pupuru analogue

Corresponding Author:
jadejuyitan@lautech.edu.ng +2348105049457
etotunola@lautech.edu.ng +2348033786651

ABSTRACT

Cassava (cas) mash was co-fermented with Orange Fleshed Sweet Potato (OFSP) during pupuru production to produce an analogue of "pupuru" at different percentage combination. This study aims at determining the functional, physicochemical and pasting properties of pupuru and pupuru analogues to expand the utilization of orange-fleshed sweet potato as pupuru analogue. The formulation was grouped into four ratios of 75:25%, 50:50%, 25:75%, and 0:100% (cas: OFSP), and 100% cassava as the control was processed at varying periods to pupuru flour. The packed bulk density and water absorption capacity ranged from 0.71-0.87, 0.79-0.93, 0.84-1.02 and 0.95-1.06 g/ml; and 2.01-4.05, 2.07-4.07, 2.04-3.12 and 2.07-3.15 g/ml at the four ratios, respectively. The pH and cyanide contents ranged from 4.00-5.15, 3.63-4.12, 3.53-4.00, 4.35-5.01; and 3.70-0.50, 3.40-0.42, 3.00-0.31, 0.27-2.97, 1.31-4.40 at the four ratios, respectively. The proportion of OFSP in the blend tends to increase peak viscosity, breakdown, and final viscosity. The 50:50 and 25:75% blends showed similar pasting properties, indicating that a higher proportion of OFSP can enhance these properties. The 100% OFSP blend showed relatively lower pasting properties, indicating that some cassava content may be beneficial for optimal pasting properties. Therefore, the blends of cassava and orange-fleshed sweet potato at 25:75 (72 hrs) 50:50 (96 hrs) ratio show optimal properties for the development of functional pupuru analogue flour.

INTRODUCTION

Orange-fleshed sweet potato *(Ipomea batatas*) is a dicotyledonous plant, a member of the morning glory family (*Convolvvulaceae*), is a biofortified crop that was initially created as part of a global initiative to combat vitamin A deficiency. It is a staple crop rich in vitamin A and other minerals such as magnesium, phosphorus and copper. It is high in starch which also includes lysine, an amino acid that is typically lacking in diets high in grain, and ascorbic acid (Iheonu *et al.,* 2023). The orange-fleshed sweet potato (OFSP) variety has been bio-fortified to contain high levels of beta-carotene, the precursor to vitamin A (Global Panel, 2015, Emmanuel *et al*., 2022). The OFSP has the potential to significantly lower nutritional deficits, raise incomes, and improve food security. Due to the high beta-carotene content of the orange-fleshed variety of sweet potato, several studies have focused on its addition to human diets and the different orange-fleshed sweet potato food preparations. This is to deal particularly with the worldwide health issues with micronutrients.

Cassava (*Manihot esculenta Crantz*) is a drought-tolerant crop that can be grown in areas with uncertain rainfall patterns which usually results in unsuccessful cultivation of many other crops (Otekunrin and Sawicka, 2019). Due to its high moisture content, cassava is normally processed immediately after harvest into different storable products; these include garri (cassava flakes), lafun (fermented cassava flour), fufu (steeped cassava starch dough), pupuru (fermented dried cassava) and cassava flour (Kuye *et al.,* 2015; Kuye *et al.,* 2017; Bechoff *et al.,* 2018; Adejuyitan *et al.,* 2018, Oyeyinka *et al*., 2019; Abiodun *et al.,* 2020

Pupuru, a local name for a fine fermented smoke-dried cassava flour, is usually eaten by the people living in the western, southern, eastern and middle belts of Nigeria, where it is also called "Ikwurikwu" (Shittu *et al*., 2010, Daramola *et al.*, 2010, Wakil, and Benjamin, 2015). *Pupuru* and other cassava products are widely accepted and consumed in Nigeria. It is molded into the shape of a smoke ball, which is usually made into dough in boiling water before consumption with any desired soup (Adejuyitan *et al*., 2018). *Pupuru* analogue a similar product to *pupuru* has been worked upon by various researchers (Adejuyitan *et al.*, 2018, Akinyele *et al.*,2020, Oladimeji *et al*., 2022), as a means of improving the nutritional deficiency of pupuru. Hence, the objectives of this study were to produce *pupuru* analogue from co-fermented cassava and orange-fleshed sweet potato blends and to evaluate the functional, physicochemical and pasting properties of the analogous *pupuru* produced.

MATERIALS AND METHODS

Materials

The raw materials used were sweet cassava (Manhot *esculenta Crantz)* and Mother's Delight orange-fleshed sweet potato (*Ipomea batatas L*). The cassava tubers were obtained from LAUTECH Teaching and Research Farm, Ogbomoso, Oyo State, Nigeria, while the Orange Fleshed Sweet Potato (*Ipomea Batatas L*) was obtained from a farm in Osogbo, Osun State, Nigeria. The cassava and OFSP were co-fermented and carried out on blends of five cassava and orange-fleshed sweet potato in the ratio of 75:25%, 25:75%, 50:50% 0:100% and 100:0% (cas: OFSP), respectively. The cassava and OFSP were co-fermented at varying proportions and processed into pupuru and pupuru analogue.

METHODS

Determination of loose bulk density

Packed Bulk density was determined using the method described by Onabanjo and Ighere, (2014). Ten grams (10 g) of the sample was weighed into a 50 ml graduated measuring cylinder. The sample was packed until it was full without tapping the cylinder on the bench top and leveling the surface using the meter rule. The volume of the surface using a meter rule sample without tapping was recorded in equation (1).

$$\text{Packed bulk density (g/ml)} = \frac{Weight\ of\ the\ sample}{The\ volume\ of\ the\ sample\ after\ tapping} \qquad (1)$$

Water absorption capacity (WAC) of starch

The water absorption capacity measurement was performed using the method described by Bashir *et al*. (2017). A total of 3.0±0.1 g of flour sample was mixed into 25 mL of distilled water before being weighed into a centrifugal tube. The mixture was mixed for 30 mins at room temperature and centrifuged at 2500×g for 15 mins. The supernatant was decanted; excess moisture was removed by draining. Then, the centrifugal tube containing the sample is re-weighed. The accumulated weight is expressed as grams of water absorbed per gram of flour. The determinations were done in triplicates.

$$\text{WAC \%} = \frac{W_2 - W_1}{W_0} \qquad (2)$$

Determination of pH

pH was determined by measuring 10 g of sample flour into 100 ml of distilled water and was stirred, after which it was allowed to settle, the pH meter was readjusted to neutral pH 7 reading with buffer solution after which the reading of the '*pupuru* analogue' sample was determined using pH meter.

Determination of total titratable acidity (TTA)

Ten grams (10 g) of *pupuru* analogue flour was weighed into a 250 ml conical flask and 200 ml of carbon dioxide-free distilled water was added. The flask was allowed to stand in a water bath at 40^{C} for 1 hr so that the flask was covered to just about the level of liquid. Its laws swirled occasionally to ensure complete mixing and filtering. Phenolphthalein was added after filtration before being titrated against 0.1M NaOH solution.

$$\text{Acidity\%} = \frac{Volume\ of\ 0.1M\ NAOH\ used \times 0.09 \times 100}{10(Volume\ of\ sample\ taken)} \quad (3)$$

Determination of total sugar contents

The technique described by AOAC (2012) was used for the determination of total sugar. Ten grams of the sample was dissolved in 100 ml of distilled water and 10 ml of concentrated HCl was added to the solution and warmed in a water bath for 8 minutes which was then neutralized with NaOH. The solution was diluted further and made up to 200 ml with distilled water and filtered. Thereafter, 25 ml of mixed Fehling's solution was pipetted into a conical flask followed by the addition of 15 ml of the solution from the burette. The solution was heated and three drops of methylene blue were added when boiling began. Further quantities of the solution were added from the burette (1 ml at a time) at 10 sec intervals to the boiling liquid until the indicator was completely decolourized. The titre values obtained corresponded to the sugar content reported in mg/100 ml.

Determination of pasting properties

This was determined using the Rapid Visco Analyser (RVA TECMASTER, Perten Instrument) as described by Falade and Okafor (2015). Three grams (on a 100% dry matter basis) of the sample was weighed into the canister and dissolved with 25 milliliters of distilled water. The slurry was heated uniformly from 25 ^{0}C to 95 ^{0}C, held for 15 min and cooled at 50 ^{O}C. The cooked paste viscosity of the slurry was determined. The precise linear ramped heating and cooling abilities of the RVA along with steady state temperature control of the cooking environment with changes in viscosity were continuously recorded. The rotation speed was maintained at 200 × g during the process. All samples were tested in triplicates. The RVA parameters measured include pasting temperature (^{0}C), peak viscosity (PV), breakdown viscosity (BD), final viscosity (FV), trough and setback value (SB=FV-TV).

RESULTS AND DISCUSSION

The Functional Properties of *Pupuru* Analogue produced from Cassava and Orange-Fleshed Sweet Potato blends

The result obtained in Figure 1 for packed bulk density ranged from 0.71-0.87 g/ml, 0.79-0.93 g/ml, and 0.84-1.02 g/ml, 0.95-1.06 g/ml respectively for 75:25%, 50:50%, 25:75% and 0:100% cassava-OFSP blends. The value for the control sample of *pupuru* was 0.86 g/ml. The range was comparable to the bulk density (0.40-0.62) reported by Alaba *et al*., (2013) for cassava *pupuru* but lower than 1.07 to 1.42 g/ml for *pupuru* analogue produced from orange-fleshed sweet potato (OFSP) as influenced by fermentation with Rhizopus oligosporous as reported by Oladimeji *et al*., (2022). 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 (Onwuka, 2015), and low bulk density is desired in our blends as it contributes to lower dietary bulk, ease of packaging and transportation (Aluge *et al*., 2016). The results of water absorption capacity ranged from 2.01-4.05, 2.07-4.07, 2.04-3.12 and 2.07- 3.15 g/ml at 75:25%, 50:50%,

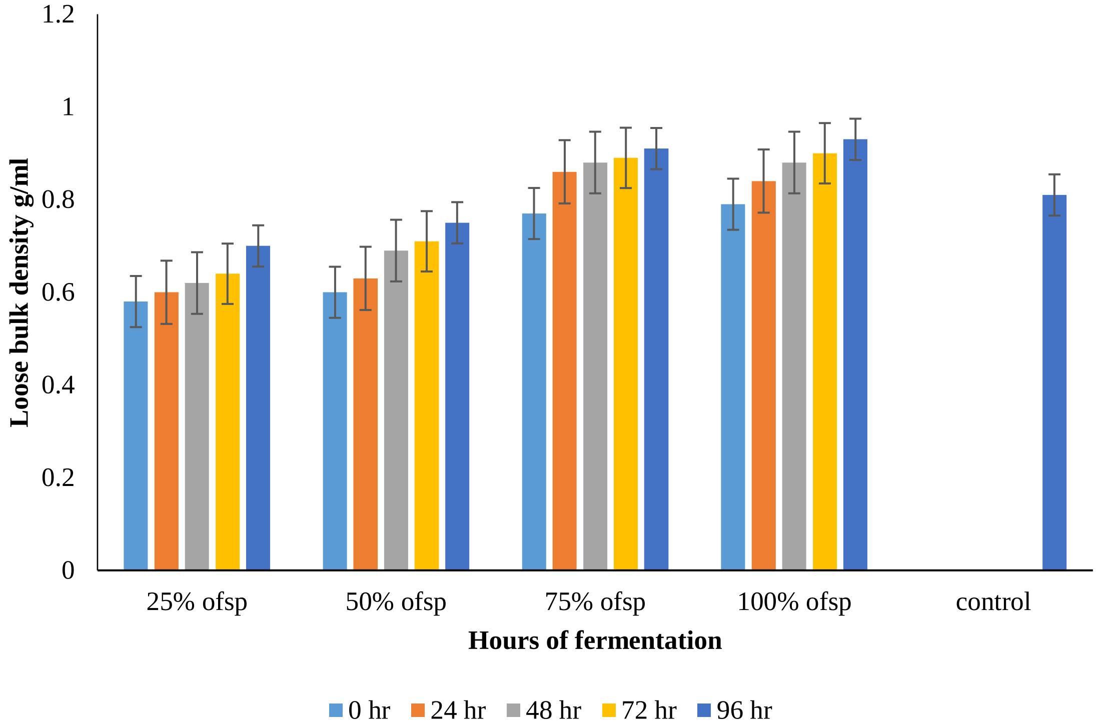

Figure 1: Effect of fermentation period on the loose bulk density of *pupuru* and *pupuru* analogue produced from co-fermented cassava-orange fleshed sweet potato blends.

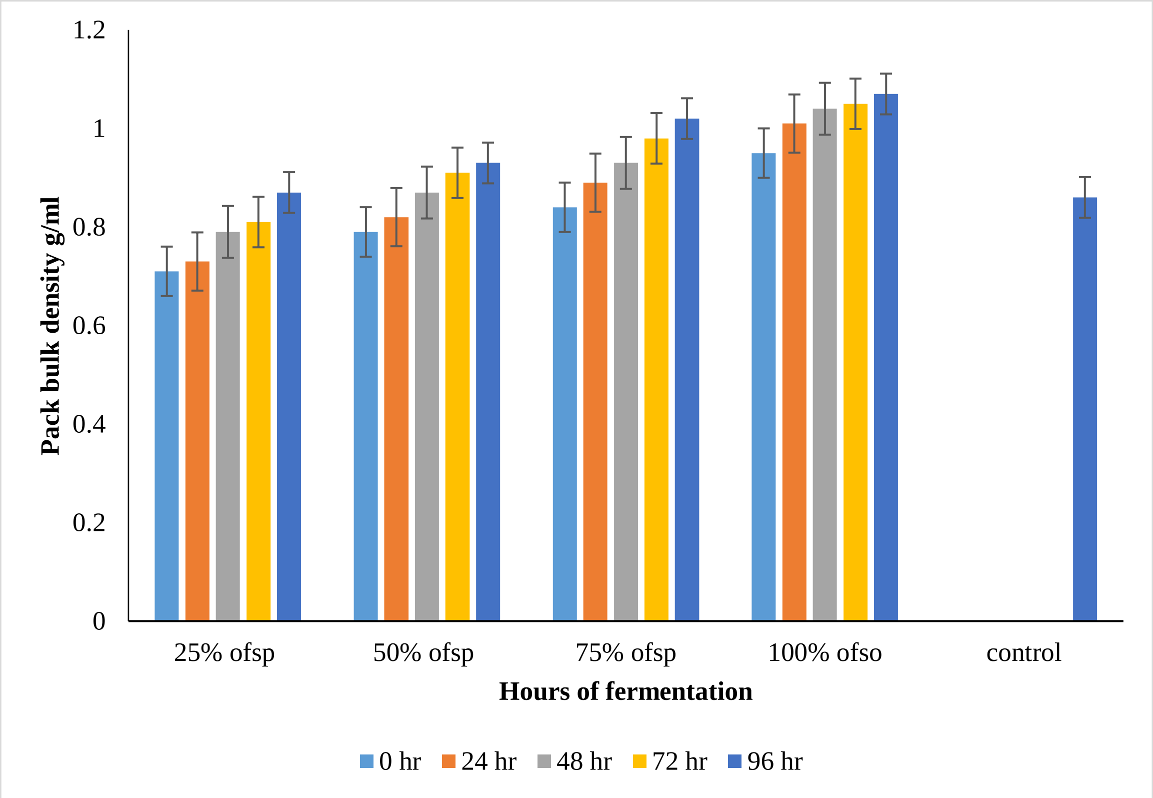

Figure 2: Effect of fermentation period on the Pack bulk density of *pupuru* and *pupuru* analogue obtained from co-fermented cassava-orange fleshed sweet potato blends.

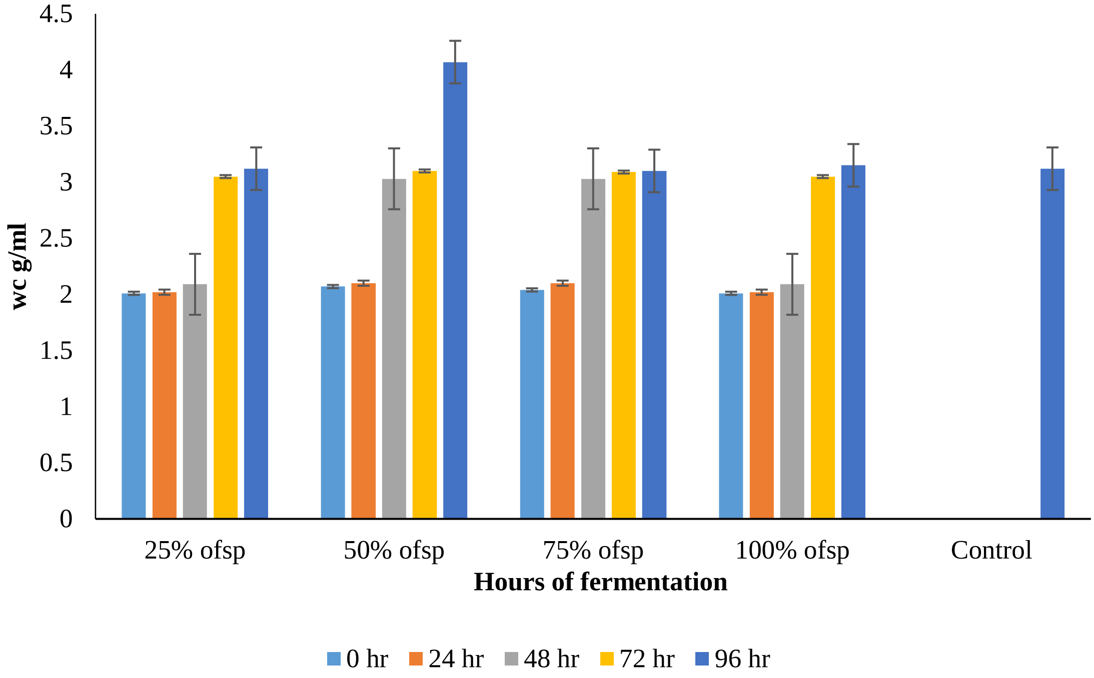

Figure 3: Effect of fermentation period on the Water Absorption Capacity of *pupuru* and *pupuru* analogue obtained from co-fermented cassava-orange fleshed sweet potato blends.

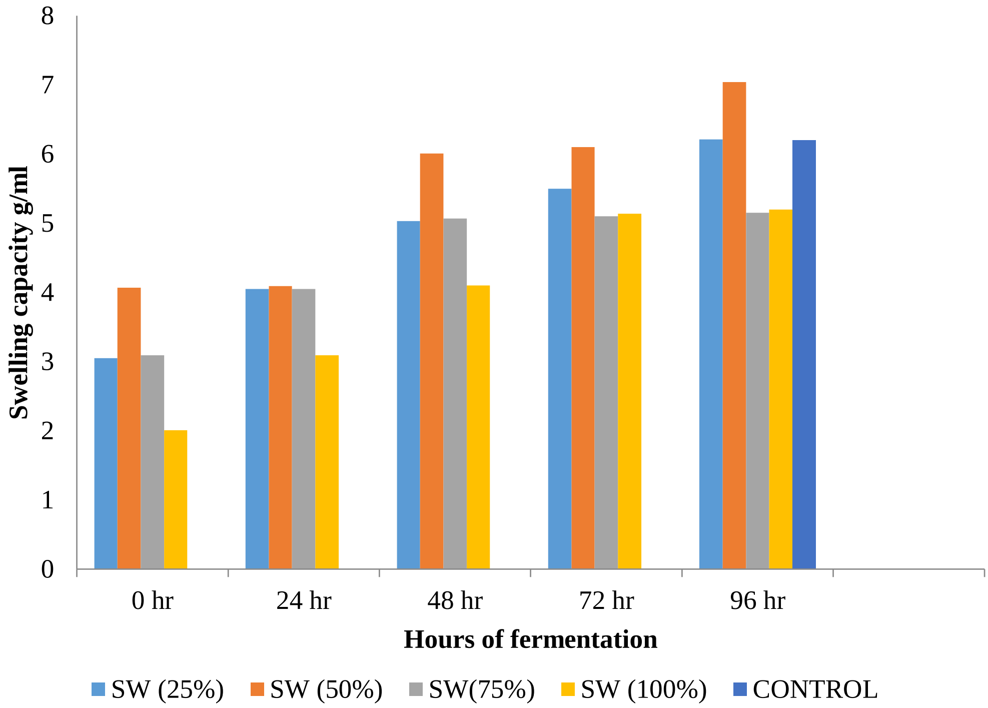

Figure 4: Effect of fermentation period on the swelling capacity of *pupuru* and *pupuru* analogue obtained from co-fermented cassava-orange fleshed sweet potato blends.

25:75% and 0:100%, respectively for cassava and OFSP blends as shown in Figure 2. Pupuru analogue from 50:50% blend of cassava-OFSP (96 hours having the highest value of 4.07 g/ml). The water absorption capacity increases significantly with an increase in the co-fermented sample and 100% pupuru analogue from OFSP along the period of fermentation. Hence, the effect of co-fermentation of the samples might have caused the increase in the value of water absorption capacity as the level of substitution increases. The value was higher than the water absorption capacity (2.03-2.60g/ml) reported by Adejuyitan *et al*., (2019) for pupuru as influenced by various processing methods.

The Physicochemical Composition of Pupuru Analogue from Cassava and Orange-Fleshed Sweet Potato Blends

PH values of pupuru produced from co-fermented cassava and OFSP from the result obtained in Table 1 showed that for all the substituted samples, the pH value decreases down the period of fermentation. The pH value for the control sample (100% cassava) ranges from 4.35 to 5.01 at 72h along the periods of fermentation, while the pH values for pupuru analogue ranged from 4.15 to 4.00, 4.12 to 3.63, 4.03 to 3.60 and 4.00 to 3.53 for 75:25%, 50:50%, 25:75% and 0:100 % co-fermented cassava-orange flesh sweet potato to produce pupuru analogue. The highest pH (5.01) was observed for the control sample at 0 hr of fermentation while the lowest pH (3.53) was obtained for 100% substitution at 96 hours of fermentation. It was observed that there was a subsequent decrease in the first 24 hours and a rapid drop depending on the level of substitution of OFSP. The pH of the pupuru flour is a function of fermentation and an indicator of its storage life. The lower the pH, the better the storage life as it inhibits microbial activity. The pH value of pupuru from 100% cassava (4.35) at 72 hours of fermentation was lower than the value reported by Adejuyitan *et al*. (2018) for similar products of pupuru reported a pH value of 4.64. This was in line with the report of Akinyele *et al*., (2020), Wakil and Benjamin, (2015) and Soyoye, (2021) who investigated the quality characteristics of pupuru produced from the combination of fresh cassava roots and dried cassava chips pH between pH 4.05-4.78. The pH decreased as a result of the secretion of lactic acid, which implies that the more the cassava stays in the water during fermentation, the more there is a reduction in the pH by the action of fermenting organisms. Acidic products are more shelf-stable than their non-acidic counterparts (Akinyele *et al*., 2020).

The total titratable acidity (TTA) results (Table 2) ranged from 0.08 g/ml to 0.60 g/ml. There was a significant difference ($p < 0.05$) in the total titratable acidity for all the substituted samples and the control sample. The value was higher than 0.13-0.16 g/ml for cassava flour (pupuru) as reported by Alaba *et al*., (2013). The Titratable acidity gives a measure of the amount of acid present in the food. The level of this index is used to estimate the quality of the flour. These values were in agreement with the Nigerian Industrial Standard recommendation of less than 10 g/100 ml total titratable acidity for gari samples. The result obtained was lower than the value of TTA reported by Oladimeji *et al*., ((2022), for pupuru produced from 100% OFSP inoculated with Rhizopus oligosporus, therefore it shows that natural fermentation at the solid-state level plays an important role in the pupuru analogue produced. This shows that the period of fermentation of the various samples was adequate.

The cyanide content decreased along the period of fermentation also as the level of substitution of OFSP to cassava increases. The cyanide contents obtained for pupuru analogue produced from co-fermented cassava and OFSP ranged from 3.70-

0.50, 3.40-0.42, 3.00-0.31 and 2.97-0.27 mg/100g for 75:25%, 50: 50%, 75:25 % and 0:100% blends for cassava and orange flesh sweet potato to produce pupuru analogue. The cyanide contents of pupuru 100% cassava (control samples) range from 1.3-4.4 mg/100g (Table 1).

Table 1: Physicochemical Properties of *Pupuru* and *Pupuru* analogue Obtained from Co-fermented Cassava-Orange fleshed Sweet Potato.

			Fermentation	Time		
Parameter	Blend	0 hr	24 hr	48 hr	72 hr	96 hr
P^H	75:25%	4.15^b	4.12^c	4.11^b	4.07^b	4.00^c
	50:50%	4.12^b	4.03^b	3.98^{ab}	3.74^a	3.63^b
	75:25%	4.03^a	4.00^b	3.80^a	3.70^a	3.60^b
	0:100%	4.00^a	3.94^a	3.76^a	3.70^a	3.53^a
	100:0%	5.01^c	4.68^d	4.50^c	4.35^c	4.38^d
TTA	75:25%	0.12^a	0.15^{ab}	0.18^a	0.29^b	0.37^b
	50:50%	0.26^b	0.30^c	0.34^c	0.38^d	0.42^c
	75:25%	0.29^b	0.32^c	0.37^c	0.39^d	0.43^c
	0:100%	0.08^a	0.11^a	0.16^a	0.18a	0.21^a
	100:0%	0.12^a	0.18^b	0.24^b	0.32^c	0.40^c
CN	75:25%	3.70^c	3.10^d	2.96^d	0.75^e	0.50^c
	50:50%	3.40^b	2.60^c	1.80^c	0.60^d	0.42^b
	75:25%	3.00^{ab}	2.50^b	1.75^b	0.55^c	0.31^{ab}
	0:100%	2.97^a	2.20^a	1.25^a	0.30^a	0.27^a
	100:0%	4.40^d	3.34^e	2.98^d	1.49^b	1.31^{ab}

Samples with the same superscript along the column are not significantly different at 5% probability

There was a significant difference between the control samples produced from cassava (1.31 mg/100g) and that of OFSP (0.27 mg/100g) at P<0.05. Similar trends were also reported by Richard *et al*., (2021) for the HCN content of the 100% cassava gari which was significantly ($p < 0.05$) higher than the OFSP-based gari. Hydrogen cyanide (HCN) is the predominant toxic substance in cassava tubers and cassava products. The level of cyanide (0.42-0.47 mg/100g) reported by Alaba *et al*., (2013) for cassava pupuru was higher than the values obtained from this study. The significant reduction in HCN characterized by the OFSP-based pupuru could be attributed to the inclusion of OFSP which is reported to be low in HCN (Tumwegamire *et al*., 2014).

Pasting Characteristics of *Pupuru* and *Pupuru* analogue from Cassava and Orange Fleshed Sweet Potato blends

The peak viscosity of pupuru and pupuru analogues made from cassava and orange-fleshed sweet potato (OFSP) blends increased with fermentation time. The peak viscosity ranged from 38.75 to 276.33

RVU, within the range reported by Nwokeke *et al.* (2013). Two factors determine peak viscosity: granule swelling and solubility. Higher swelling capacity indicates higher peak viscosity, while higher solubility reduces paste viscosity. Trough viscosity, a measure of hot paste stability, ranged from 490 RVU to 1500 RVU. Pupuru flour had the highest trough viscosity, indicating greater stability to heating. Breakdown viscosity, indicating stability to shearing, ranged from 44.0 RVU to 990.0 RVU. The 75% cassava and 25% OFSP at day 3 had the highest stability ratio (trough/ peak viscosity) and are therefore expected to withstand shear better at high temperatures according to (Obomeghei *et al*., 2020). Final viscosity, indicating the ability to form firm gel or viscous pastes, ranged from 1060 RVU

Table 2: Pasting properties of *pupuru* and *pupuru* analogue obtained from co-fermented Cassava and Orange Fleshed Sweet Potato blends

Hours of fermentation	Peak Viscosity (RVU)	Trough 1 (RVU)	Breakdown (RVU)	Final viscosity (RVU)	Set back (RVU)	Peak Time (min)	Pasting Temperature (°C)
Cass $_{75\ \%}$ OFSP $_{25\%}$							
0	992^{a}	490^{a}	502^{c}	1060^{a}	570^{b}	5.67^{d}	87.2^{f}
24	1047^{b}	697^{c}	350^{b}	1281^{c}	584^{c}	5.00^{c}	82.4^{d}
48	2015^{e}	1025^{d}	990^{f}	1750^{d}	725^{e}	4.05^{a}	66.2^{a}
72	1364^{d}	1320^{e}	44^{a}	1777^{e}	457^{a}	6.00^{e}	83.2^{e}
96	2585^{f}	1767^{f}	818^{e}	2645^{f}	878^{f}	4.60^{b}	72.6^{c}
Cass $_{50\%}$ OFSP $_{50\ \%}$							
0	816^{a}	695^{c}	121^{a}	2361^{e}	1666^{e}	5.40^{d}	85.5^{e}
24	2300^{f}	1500^{f}	800^{d}	2000^{d}	500^{c}	4.50^{b}	75.5^{c}
48	850^{b}	450^{a}	400^{b}	2400^{f}	210^{a}	7.50^{e}	87.3^{f}
72	1690^{d}	700^{d}	990^{f}	1200^{a}	210^{a}	5.40^{d}	80.5^{d}
96	1866^{e}	948^{e}	918^{e}	1368^{c}	420^{b}	4.20^{a}	66.4^{a}
Cass $_{25\%}$ OFSP $_{75\%}$							
0	806^{a}	699^{c}	131^{a}	2281^{e}	1556^{e}	5.50^{d}	83.5^{e}
24	2200^{f}	1520^{f}	830^{d}	2100^{d}	509^{c}	4.70^{b}	74.5^{c}
48	850^{b}	458^{a}	410^{b}	2300^{f}	222^{a}	7.20^{e}	86.8^{f}
72	1670^{d}	720^{d}	980^{f}	1250^{a}	220^{a}	5.55^{d}	81.9^{d}
96	1856^{e}	928^{e}	928^{e}	1268^{c}	440^{b}	4.30^{a}	69.5^{a}
Cass $_{0\%}$ OFSP $_{100\ \%}$							
0	606^{a}	459^{c}	121^{a}	2081^{e}	1556^{e}	5.50^{d}	81.5^{e}
24	1300^{f}	1020^{f}	630^{d}	1600^{d}	509^{c}	4.40^{b}	73.5^{c}
48	650^{b}	258^{a}	210^{b}	2200^{f}	222^{a}	7.20^{e}	82.8^{f}
72	1170^{d}	520^{d}	680^{f}	950^{a}	220^{a}	5.55^{d}	80.9^{d}
96	1256^{e}	728^{e}	648^{e}	1028^{c}	440^{b}	4.20^{a}	65.5^{a}
F (control)	**1028^{c}**	**428^{b}**	**355^{c}**	**1012^{b}**	**659^{d}**	**5.20^{c}**	**70.1^{b}**

to 2400 RVU. Co-fermentation of cassava and OFSP produced pupuru analogues with improved pasting characteristics. Setback viscosity, indicating retrogradation tendency, ranged from 210 RVU to 1600 RVU. Peak time and pasting temperature decreased with fermentation time. The combination of pasting temperature and time determines the energy required to cook the flour's paste. Pasting temperatures for all samples differed significantly. The pasting time of *pupuru* analogue substituted for (75:25 %) at 72 hours of fermentation shows a level of significant difference ($P \leq 0.05$) with the control sample 100% *pupuru* produced at day 4. Pasting temperatures for all samples are significantly different from one another at $P \leq 0.05$. Flours with higher pasting temperatures may not be recommended due to high energy costs (Olatunde *et al*., 2016). The variation in pasting temperature is attributed to sugar content, which affects moisture and starch interaction.

CONCLUSION

The study on co-fermented cassava and Orange Fleshed Sweet Potato (OFSP) blends for *pupuru* analogue production found that fermentation and substitution levels significantly impact the product's physicochemical and pasting properties. The blends had a desirable bulk density, increased water absorption capacity, and decreased pH values, indicating improved storage stability. OFSP reduced cyanide content, making them safer for consumption. Pasting characteristics varied with fermentation time and blend ratios, with the 75% cassava and 25% OFSP blend demonstrating the best shear stability.

REFERENCES

A.O.A.C. (2012). Official methods of analysis (19th edition). Washington, DC: Association of Official Analytical Chemists.

Abiodun, O. A., Ayano, B. and Amanyunose, A. A. 2020. Effect of fermentation periods and storage on the chemical and physicochemical properties of biofortified cassava gari, Journal of Food Processing and Preservation, 44 (12): e14958

Adejuyitan JA, Olanipekun BF, Olaniyan SA, Oyedokun RI, Oyero GO (2018). Assessment of Some Chemical and Physicochemical Properties of Gari and Pupuru Produced from Different Varieties of Cassava. Haya: The Saudi Journal of Life Sciences, 3(6),481488. https://www.europub.co.uk/articles/-A-397804

Adejuyitan, J. A., Abiona, O.O., Oyeleye, K.S and Osunbade, A. O (2019). Compositional Characteristics of Pupuru As Influenced by Variation in Processing Methods. Annals. Food Science and Technology. 20 (3) 520-526.

Akinyele, F.O., Ikujenlola, A.V., ann Omobuwajo, T.O. (2020), Physico-chemical and sensory properties of pupuru and pupuru analogues from co-fermented cassava (Manihot esculenta Crantz) and breadfruit (Artocarpus altilis) blends, Acta University Sapientiae Alimentaria, 13 (11) 32-50.

Alaba, J. O., Famurewa, J. A. V and Oluwamukomi, M. O. (2013). Effect of different drying methods on the physicochemical characteristics of cassava flour (“pupuru”). International Journal of Biology Chemistry Science, 7 (2): 832–839.Aluge, O.O., Akinola, S.A. and Osundahunsi, O.F. (2016). Effect of Malted Sorghum on Quality Characteristics of Wheat-Sorghum-Soybean Flour for Potential Use in Confectionaries. Food and Nutrition Sciences

Aluge, O.O., Akinola, S.A. and Osundahunsi, O.F. (2016). Effect of Malted Sorghum on Quality Characteristics of Wheat-Sorghum-Soybean Flour for Potential Use in Confectionaries. Food and Nutrition Sciences America, 48(3): 64-71.

Asiru, I. B. AbdulKareem, B. Alenkhe, D. B. Ayo and L. O. S anni. (2017). Design, fabrication and drying performance of flash dryer for high quality cassava flour. *Agricultural Mechanization in Asia, Africa and Latin America*, *48*(3), 63-70.

Bashir, K., Swer, T.L., Prakash, K.S. and Aggarwal, M. (2017). Physico-chemical and functional properties of gamma irradiated whole wheat flour and starch. LWT - Food Science and Technology, 76(Part A), 131-139.https://doi.org/10.1

Bechoff, A., Tomlins, K., Fliedel, G., Becerra Lopez-lavalle, L. A., Westby, A., Hershey, C., & Dufour, D. (2018). Cassava traits and end-user preference: Relating traits to consumer liking, sensory perception, and genetics. Critical Reviews in Food Science and Nutrition, 58(4): 547-567.

Daramola, O.A., Idowu, M.A., Atanda, O.O. and Oguntona, C.R.B. (2010) Effect of Packaging Materials on the Quality of “Pupuru” Flour during Storage. African Journal of Food Science, 4, 259. Different Varieties of Cassava. Haya: The Saudi Journal of Life Sciences, 3(6): 481-488.

Emmanuel, D., Amos, A. O., Abdullahi, M.,Ambrose, A., Stephen, A. A., Salihu, Y and Moses, A. O. (2022) Factors Influencing the Adoption of Orange Fleshed Sweet potato (OFSP) Production among Smallholder Farmers in Kwara State, Nigeria. International Journal of Research and Innovation in Social Science (IJRISS), 6 (3): ISSN 2454-6186.

Falade, K.O. and Okafor, C.A. (2015). Physical, functional, and pasting properties of flours from corms of two Cocoyam (Colocasia esculenta and Xanthosoma sagittifolium) cultivars. Food Science and Technology, 52, 3440–3448.

Global Panel (2015). Biofortification: An agricultural investment for nutrition (Policy Brief No.1). Global Panel on Agriculture and Food Systems for Nutrition, London, UK.

Kuye A. O., D. B. Ayo, L. O. Sanni, A. O. Raji, E. I. Kwaya, O. O. Otuu, W. B. Asiru, B. Alenkhe, I. B. Abdulkareem. (2015). Methods and Apparatus for Producing Dried Cassava Flour, NG/P/2015/000086, April 14.

Kuye, A., A. O. Raji, O. O. Otuu, E. I. Kwaya, W. B. Asiru, I. B. AbdulKareem, B. Alenkhe, D. B. Ayo and L. O. Sanni. (2017). “Design, Fabrication and Drying Performance of Flash Dryer for High Quality Cassava Flour”, Agricultural Mechanization In Asia, Africa, and Latin America, 48(3): 64-71.

Oladimeji, T.E., Otunola, E.T., Adejuyitan, J.A., (2022). Quality Attributes of Pupuru Analogue Produced from Orange Fleshed Sweet Potato (OFSP) as Influenced by Fermentation with Rhizopus oligosporous. International Journal of Biochemistry Research & Review, 31(4), 1–10. https://doi.org/10.9734/ijbcrr/2022/v31i430312

Olutosin, A .O and Barbara, S. (2019). Cassava, a 21st Century Staple Crop: How can Nigeria Harness Its Enormous Trade Potentials? Acta Scientific Agriculture 3 (8): 2581-365X

Oluwamukomi M. O. and Olayemi O. S.(2012). Physico-thermal and pasting properties of soy-melon-enriched “gari” semolina from cassava. Agric Eng Int: CIGR Journal 14 (3): 105

Onabanjo, O. O., and Ighere, D. A., (2014). Nutritional, functional, and sensory properties of Biscuit produced from wheat-sweet potato composite. Journal of Food Technology Research, 1(3): 111 – 121.

Onwuka, G.I. (2015). Peroxide Value. In: Food Analysis and Instrumentation: Theory and Practical, Naphthali Prints, Lagos, 70-72.

Oyeyinka, S.A., Ajayi, O.I., Gbadebo, C.T., Kayode, R.M.O., Karim, O.R. and Adeloye, A.A. (2019). Physicochemical properties of gari prepared from frozen cassava roots. LWT, 99: 594–599.

Soyoye, B.T. (2021). Comparative quality characteristics of pupuru (a traditional cassava-based dough meal) from the blends of fresh cassava roots and dried cassava chips. (M.Tech Thesis).

Wakil S. M., and Benjamin I. B., (2015). Starter developed pupuru, a traditional Africa fermented food from cassava (Manihot esculenta). International Food Research Journal, 22(6): 2565- 2570.

Wakil, S.M. and Benjamin, I.B. (2015) Starter Developed Pupuru, a Traditional African Fermented Food from Cassava (Manihot esculenta). International Food Research Journal, 22, 2566.