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Physico-Chemical and Sensory Analysis of Instant Fufu Powder from Orange-Fleshed Sweet Potato and Cassava Starch Composite Extrudate Blends

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ABSTRACT

Physico-chemical and sensory analysis of instant fufu powder from orange-fleshed sweet potato and cassava starch composite extrudates blends were carried out. Total number of six extruded fufu composite samples were generated and subjected to analysis using standard conventional methods. The result findings ranged as follows: 4.95 to 7.25, 3.75 to 5.40, 3.48 to 4.32, 0.83 to 2.14, 2.19 to 3.44 and 79.91 to 83.41% for moisture, protein, ash, fat, crude fibre and carbohydrates, respectively; 0.43 to 0.67 g/cm^3, 2.43 to 3.61 g/mL, 3.06 to 8.78%, 6.93 to 14.65 g/100g, 14.57 to 20.06% and 1.00 to 5.00 min for bulk density, water absorption capacity, gelation, swelling index, solubility and wettability, respectively; 9.65 to 16.06 mg/100g, 7.04 to 10.52 mg/100g, 36.03 to 47.36 mg/100g, 55.31 to 63.47% and 4.76 to 8.65% for beta carotene, vitamin A, vitamin C, starch and sugar content, respectively. 263.50 to 1116.00, 251.50 to 632.50, 10.50 to 483.50, 424.50 to 966.50, 173.00 to 334.00 RVU, 4.87 to 6.96 min and 75.87 to 85.22^{o}C for peak,

trough, breakdown, final, setback viscosity, peak time and pasting temperature, respectively for the extruded composite flour blends. Sensory evaluation of the tepid water reconstituted fufu paste values ranged from 5.80 to 6.25, 5.75 to 6.40, 4.15 to 5.45, 4.30 to 5.75 and 5.10 to 5.70 for colour, flavor, handfeel, mouldability and overall acceptability, respectively.

Keywords: Extrusion cooking, instant fufu, OFSP flour, cassava starch flour and sensory evaluation.

INTRODUCTION

Instant fufu is a pregelatinized product made by extrusion of starch or flour from mostly root and tuber at relatively low temperature (Colonna et al., 1999). Pregelatinized starches or flours are paste forming products in the presence of warm or hot water or soluble products in hot water (Colonna et al., 1999).

Fufu is a thick paste made by boiling flour in water, stirring vigorously with a wooden paddle until a desired consistency is formed (Sanni et al. 2012). Fufu flour could be prepared from cassava, yam, potatoes, cocoyam, cereals etc. The consumption of fufu depends on the raw material used for its preparation and is widely consumed in all parts of Nigeria (Akubor and Ukwuru, 2003). The methods for the preparation of cassava starch flour for making cassava fufu is basically through sedimentation and drying. Generally, cassava starch flour is prepared by washing fresh cassava root, peeling, washing, rasping, pulping, sedimentation, drying and milling. The traditional method of processing cassava reduces the toxic cyanogenic glycosides (Achi and Akoma, 2006).

Orange-fleshed sweet potato (OFSP) (*Ipomea botatas)* is a good source of non-digestible dietary fibre, specific minerals, different vitamins, and antioxidants (Endrias et al. 2016). Phenolic compounds and carotenoids are responsible for distinguishing flesh and skin colours (deep yellow, red to orange, purple, and pale) of sweet potatoes along with antioxidant properties (Steed and Truong, 2008). Scientists established the role of OFSP in health, and this accredited to its rich nutritional components with anti-carcinogenic and cardiovascular disease (CVD) preventing attributes (Chandrasekara and Joseph, 2016). Recent scientific reports concluded the anti-oxidative and free radical scavenging activity of phenolic acid components in OFSP with beneficial health-promoting activities (Bovell, 2007). The OFSP possesses the characteristic of attractive sweet taste and eye-pleasing yellow to orange colour to children in comparison with white-fleshed sweet potato (WFSP) (Kaguongo, 2012); hence, OFSP has reported potential role to tackle calorific and vitamin A deficiency (VAD) malnutrition problems of children in targeted communities.

Cassava (*Manihot esculentus, Crantz)* is one of the root crops with growing food and industrial applications (Shittu et al., 2005). It has been one of the mainstays of several tropical and sub-tropical countries of the world (Shittu et al., 2005). According to FAO statistics, the world's cassava production had been on the increase form about 176 to 177 metric tons per year form the year 2000 to 2013. Africa contributed between 54 and 58% of the world's cassava within these periods (FAO, 2014).

Extrusion cooking of foods has been practiced over 50 years. During extrusion, thermal and shear energies are applied to raw food materials causing structural, chemical and nutritional transformations such as starch gelatinization and degradation, protein denaturalization, lipid oxidation, vitamin degradation, anti-nutritional factors and phytochemicals breakdown, formation of flavours, increase of mineral bioavailability and dietary fibre solubility (Singh et al., 2007).

MATERIALS AND METHODS

Source of Materials

Matured OFSP tubers (carrot C and Ejumula) and cassava roots (H-226 and H-165) were purchased form Zadok farm, Yenagoa, Bayelsa State. The raw materials were transported in a polyethylene sac and processed. The equipment and chemicals used were of analytical grade.

Experimental Design

A Simplex-Lattice Mixture Design (MD) was used for the formulation ratio and generated six different ratios of instant fufu composite flours which include: 90:10, 80:20, 50:50, 60:40, 70:30, and 100:0 for OFSP: Cassava starch, respectively. One hundred percent of OFSP flours served as the control samples.

Production of OFSP Flour

The OFSP flour was produced using the method described by (Shittu et al., 2002). Three kilograms of OFSP tuber was washed with clean water, peeled with sharp stainless knife and re-washed. The peeled, washed potato tubers was then chipped into thin layers. The chipped potato was dried at 70 ^{o}C for 9 h in a cabinet dryer before milling (Shittu et al., 2002). The milled potato was sieved and packaged in air tight container for use.

Production of Cassava Starch Flour

The cassava starch flour was produced according to the method (Sriroth et al., 2000). The cassava root was washed with clean water to remove soil, sand, and other impurities. The cassava root was then peeled manually. The peeled root was cut and pulped with water. The pulp was suspended in clean water, mixed properly, and allowed to stay for 6 h at room temperature. Water used for the pulping process contained 0.05% sulphur dioxide. The slurry was sieved and allowed to sediment before decantation to obtain the starch cake. The starch cake was then dried at 70 ^{o}C for 15 h in a cabinet dryer to attain a moisture content of level of 10-14%. The dried starch cake was milled and sieved using a mesh size 180 micron. The starch flour was packaged in an air tight container and kept for storage.

Production of Instant Fufu Powder

The instant fufu powder was produced according to the method described by (Odoh et al., 2022). Each of the flour was reconstituted with metered amount of potable water; the dough was fed into the extruder at 80 ^{o}C for 100 rpm. The resultant extrudate was further dried at 70 ^{o}C for 10 h in a cabinet dryer. The dried extrudate was crushed using a crusher; and then milled. The OFSP and cassava starch extrudate flours were blended based the different mixture ratio of 90:10, 80:20, 50:50, 60:40, 7:30 and 100:0; with the sample code as: ABC, DEF JKL, MNO, STU and YZ*.

Proximate Composition Determination

The proximate composition was carried out on the instant fufu powder produced from the OFSP and CS extrudate flours. The moisture, protein, ash, fat and crude fibre content of the samples were determined according to the conventional standard method (AOAC, 2010) in percentage. Carbohydrate was determined by difference.

Functional Properties Determination

The bulk density, water absorption capacity, gelation, swelling index, solubility and wettability of the instant fufu powder samples were determined by the conventional standard methods as described by (Onwuka, 2005).

Biochemical Composition Determination

The beta carotene, vitamin A, vitamin C, starch and sugar content of the instant fufu powder samples were determined according to the method described by (Biswas et al., 2011) and (AOAC, 2010), respectively.

Pasting Properties of Instant Fufu Powder

The pasting properties (peak, trough, breakdown, final and setback viscosity, pasting time and temperature, RVA model WK 300 LAUDA was used) of the instant fufu powder samples were determined by the conventional standard methods as described by (Onwuka, 2005).

Sensory Evaluation

The sample of the instant fufu powder were reconstituted into fufu in warm water while stirring vigorously. The fufu samples were coded and served warm to the 20-member panels that are identified as regular fufu consumers. The panelists evaluated for colour, flavor, handfeel/texture, mouldability and overall acceptability using a 9-point Hedonic scale with 1 representing the least score (dislike extremely) and 9 representing the highest score (like extremely).

Statistical Analysis of Data

All data obtained from this study were subjected to analysis of variance (ANOVA) and means were separated using Duncan's multiple range test at $p<0.05$ significant level using SPSS software version 15.

RESULTS AND DISCUSSION

Proximate Composition of Instant Fufu Powder Blends

The proximate composition of instant fufu powder samples from OFSP and CS extrudates are shown in Table 1. The moisture content ranged between 4.95 to 7.25%. Sample JKL (50:50) ranked the highest with 7.25% while YZ* (control) had the least value of 4.95%, respectively. The values obtained in this study were slightly lower than that reported by Odoh et al. (2022) in unfermented fufu composite flour made from cassava sievate, guinea corn and unripe plantain flour blends. The low moisture content could be attributed to the extrusion cooking and drying effects.

The protein contents of the instant fufu powder varied significantly ($p<0.05$) among each samples. The values ranged from 3.75 to 4.63% The protein content value obtained in this study contradicted with the outcome values of 1.14 to 2.24% reported by Deniran et al. (2022) in fufu powders produced from cassava varieties.

The ash contents varied significantly ($p<0.05$) among all the samples. The ash content ranged between 3.48 to 4.32%. The ash values obtained from this study were higher than that reported by Obasi et al. (2018) in fufu flours produced from yellow root cassava varieties.

The fat and oil showed significant ($p<0.05$) difference among each other except sample ratio 90:10. The values obtained in this study agreed with the reported values of 1.33 to 2.71% by Ogungbemi et al. (2022) in odourless fufu flour produced using different processing techniques. The crude fibre content varied significantly ($p<0.05$) except sample 80:20 ratio. The values ranged between 2.19 to 3.44%. Sample ratio 50:50 (JKL) and 80:20 (DEF) had the lowest and highest values, respectively. The fibre values obtained in this study are higher compared to the reported values 1.40 to 1.90% by Omosuli et al. (2017) in fufu flour produced from cassava stored roots. The carbohydrate content of the instant fufu powder blends are not significantly ($p>0.05$) different from each other. The values obtained from this study is in accordance with the reported values 78.87 to 87.78% by Odoh et al. (2022).

Functional Properties of Instant Fufu Powder Blends

The functional properties of instant fufu powder blends from OFSP and cassava starch extrudate flours are shown in Table 2. The bulk density and water absorption values of the instant fufu blends significantly ($p<0.05$) differed with each other including the control sample 100:0 (YZ*). The values obtained for the bulk density in this study agreed with the reported value 0.66 to 0.73 g/cm^3 by Obasi et al. (2018) in fufu flours produced from different varieties of yellow root cassava. The water absorption capacity of the samples have significant ($p<0.05$) difference. The values obtained in this study corresponds with the reported values 1.61 to 4.01 g/cm^3 by Obasi et al. (2018) in fufu flours produced from yellow root cassava varieties.

The gelation capacity values ranged between 3.06 to 8.78%. Sample 80:20 had the highest value; while the control had the least gelation capacity of 3.06%. The values obtained in this study agreed slightly with the report by Sanni et al. (2006) in quality of flash and rotary dried fufu flour. Least gelation concentration is a measure of the minimum amount of flour or blends of flour that is needed to form gel in a measured volume of water. The lower the values, the better the gelling ability of the blends (Akintayo, 1999).

The values of swelling index ranged between 6.93 to 14.65 g/100g, with 70:30 having the highest value; while YZ* had the lowest swelling index content. The high swelling index values are within the range of values reported by Ogungbemi et al. (2022). The variation in the swelling power indicates the degree of exposure of the internal structure of the starch present to the action of water (Roules et al,.1993). When aqueous suspension of starch granules is heated in excess water, the structure is disrupted due to breakage of the hydrogen bond. Water molecules becomes linked by the hydrogen bonding to expose hydroxyl group of amylose and

amylopectin which causes an increase in granule swelling and amylose leaching (Bemiller and Whistler, 2009)

The solubility index ranged from 14.57 to 20.06%, with sample 80:20 having the highest value, while sample YZ* had the lowest value, respectively. The results obtained in this study corresponds with the reported values 9.85 to 21.90% by Akinsola et al. (2017) in OFSP extruded pasta products. Scrichuwong et al.,(2005) stated that solubility could imply the amount of amylose leaching out when swelling occurs, thus the higher the solubility, the higher the amount of amylose leaching.

The values of the wettability ranged between 1.00 to 5.00 min. Sample YZ* and 60:40 had the lowest and highest values, respectively. The values of the wettability in this study was higher than the reported values 0.25 to 0.47 min by Akinsola et al. (2017) in OFSP extruded pasta products. Wettability is a function of ease of dispersing flour samples in water and the sample with the lowest wettability dissolve fastest in water (Akinsola et al., 2007)

Biochemical Properties of Instant Fufu Blends

The biochemical properties of instant fufu powder blends from OFSP and cassava starch extrudate flour are shown in Table 3. The beta carotene of the instant fufu blends significantly ($p<0.05$) differed with each other. The values ranged from 9.65 to 16.06 mg/100g. Sample YZ* had the highest beta carotene content while 60:40 had the lowest value. The values obtained in this study does not correspond to the reported values 0.04 to 8.04 mg/100g by Hacineza et al. (2000) in Yellow and Orange fleshed sweet potato flours. Burgo et al. (2001) opined that the beta carotene content varied in the intensity of coloration of the sweet potatoes.

The vitamin A content showed significant ($p<0.05$) difference among each other. The values obtained from this study contradicted the values reported by Obasi et al. (2018) in fufu flours produced form yellow root cassava varieties. The high vitamin A content in this study might be due to the bio-fortification of OFSP extrudate flour.

The vitamin C contents showed significant ($p<0.05$) difference among the samples except sample 80:20. The values obtained in this study agreed with the reported values 30.13 to 50.17 mg/100g by Hacineza et al. (2000).

The starch content of the instant fufu powder blends showed significant ($p<0.05$) difference among the samples except 90:10. The values ranged between 55.31 to 63.47%. These values agreed with the reported values 55.73 to 65.23% by Gamaliel and Joseph (2022) in OFSP evaluation for dry matter, starch and beta carotene. This indicates that the six flour blends evaluated could be used for industrial processing. OFSP based composite flours have been used in many countries for making small baked goods like cakes, cookies, biscuits, buns, muffins, doughnuts etc (Teferra et al.,2015).

The sugar content varied significantly ($p<0.05$). The values ranged from 4.76 to 8.65%. Sample YZ* and 90:10 had the lowest and highest values, respectively. The values of sugar contents were higher than that reported by (Hacineza et al. 2000) for yellow and OFSP flours. Values

obtained from this study also agreed to closely related values 5.15 to 8.30 % by Jisha et al., (2010) for extruded cassava, cereal and legume composite flour blends. A high sugar content can trigger high sugar level in the body which can result in permanent damage to parts of the body such as eyes, nerves, kidney and blood vessels. This is generally known as hyperglycemia. On the other hand, low content can result to low blood sugar, also known as hypoglycemia. It can become a lot more dangerous more quickly and if left untreated, can result in diabetic coma and death.

Pasting Properties of Instant Fufu Powder Blends

The pasting properties of the instant fufu powder blends showed significant ($p<0.05$) difference among each other. The peak viscosity ranged from 263.50 to 1116.00 RVU with sample 50:50 and YZ* having the highest and lowest values, respectively. The results obtained from this study correlates with the reported values 92.00 to 1190.01 RVU by Obasi et al. (2018) in fufu flour produced from different yellow root cassava. The differences observed in the peak viscosity could be due to different rate of water absorption and swelling of starch granules of these flours during heating (Ragaee and Abdel-Aal, 2006). This implies that sample 50:50 would have maximum ability to swell before its physical breakdown which indicate good water-holding capacity (Sanni et al., 2004).

The trough viscosity ranged from 251.50 to 632.50 RVU. Sample 50:50 had the highest while YZ* had the least values, respectively. The values obtained from this study agreed slightly with the reported values 296.63 to 374.29 RVU by Awoyale et al. (2002) in fufu flour produced from cassava varieties. The trough viscosity indicates the breakdown or stability potential of the starch gel during cooking. This implies that the lower the trough viscosity, the lesser the degree of disintegration of the starch granules while the higher the trough viscosity, the better the disintegration of granules (Newport Scientific, 1998).

The breakdown viscosity varied from 9.50 to 483.50 RVU. The highest and lowest values were recorded in sample 50:50 and ABC, respectively. The results obtained in this study were similar with the reported values 16.01 to 342.00 RVU by Obasi et al. (2018). However, the breakdown viscosity measures the susceptibility of the starch granule to disintegrate during heating and this may affect the stability of the flour blends (Oyeyinka et al., 2019) and is regarded as a measure of paste stability (Maziya-Dixon et al., 2004). The lower the breakdown viscosity, the higher the paste stability and the higher the breakdown viscosity, the lower the paste stability (Ocheme et al., 2018).

The final viscosity ranged from 424.50 to 966.50 RVU; with sample 50:50 and YZ* having the highest and least values, respectively. The results obtained in this study were higher when compared to that reported by Odoh et al. (2022) for unfermented fufu composite flour blends. The final viscosity is the most commonly used parameter to determine a particular starch-based sample's quality as it indicates the ability of the material to form gel after cooking (Olapade et al., 2014). Higher values of final viscosity have been attributed to the aggregation of the amylose molecules in the paste (Oluwamukomi et al., 2004). The high final viscosity in these flour samples could be due to the presence of starch granule in the flour blends. The higher the final viscosity, the better the dough formation. This implies that cooked dough

prepared from 50:50 might be more acceptable than dough from other flours. Bechoff et al., (2018) write that fast gelatinization of the starch paste is the attribute that fufu processor highly appreciate. The setback viscosity of the instant fufu powder blends varied significantly ($p<0.05$) except sample 90:10. The values ranged from 173.00 to 334.00 RVU with sample 50:50 and 100:0 having the highest and least values, respectively. The results obtained in this study were higher compared to the reported values 95.54 to 129.50 RVU by Awoyale et al. (2022) for fufu flour produced form different cassava varieties. The setback viscosity is the point where retrogradation of starch molecules occurs. Setback value is also the difference between final viscosity and trough viscosity. Lower setback back viscosity during the cooling of paste indicates a better resistance to retrogradation while higher setback values are synonymous to reduced dough digestibility and lesser resistance to retrogradation (Adebowale et al., 2007).

The pasting temperature of the instant fufu powder blends ranged from 75.87 to 85.22^{o}C, with flour sample 100:0 and 50:50 having the highest and lowest values, respectively. The results obtained in this study is synonymous to the reported values 78.78 to 81.23^{o}C by Awoyale et al. (2022) for fufu flour produced from different cassava varieties. The pasting temperature measures the minimum require energy to cook a given food sample with implications for the stability of other components and indicated energy costs (Newport Scientific, 1998). This means that the products from 50:50, 60:40, and 90:10 flour blends might consume less energy because of their low and statistically comparable pasting temperatures. The peak time ranged from 4.87 to 6.96 min; with 50:50 and 100:0 having the highest and lowest values, respectively. The values obtained in the study agreed with the reported values 6.17 to 6.95 mins by Odoh et al. (2022) in unfermented fufu flour made from cassava sievate, guinea corn and unripe plantain flour blends.

Sensory Evaluation of Instant Fufu Powder Blends

Table 4 shows the result of sensory evaluation carried out on the instant fufu powder blends for colour, flavor, handfeel, mouldability and overall acceptability using a 9-point Hedonic scale. The mean score range for colour was 5.80 to 6.25 with no significant ($p< 0.05$) difference among all the samples. Samples 90:10 and 80:20 had the highest score of 6.25 each, meaning like slightly while sample 100:0 had the lowest mean score. This low score might be due to the brown colour. Flavor mean scores ranged from 5.90 to 6.40. Sample 80:20 and 90:10 had the highest and lowest mean score, respectively. In terms of texture, samples have no significant difference ($p<0.05$) among each other. Mouldability mean scores ranged from 4.20 to 5.75. The lowest values was observed in sample 100:0. This lowest score might be due to the low amylose content in the sample. The overall acceptability of the samples ranged from 5.10 to 5.70. Sample (50:50) OFSP and Cassava starch extrudate) was preferred slightly above other samples.

CONCLUSION

The results obtained from this study have showed that cassava starch extrudate was able to modify OFSP fufu flour to slightly liked level at formulation ratio 50:50. Thus, an addition to instant food list especially for swallow meal as traditional way of pounding or stirring in a boiling water to cook fufu is laborious. This would also increase the food utilization of OFSP as it is packed with valuable nutrients.

Table 1: Proximate Composition of Instant Fufu Powder Blends (%)

Sample	moisture	protein	ash	fat	fibre	carbohydrates
ABC	5.25±0.00^{c}	3.97±0.11^{cd}	3.66±0.02d	1.95±0.10^{bc}	3.22±0.02^{c}	81.94±0.026^{a}
DEF	5.70±0.00^{b}	3.75±0.01^{d}	4.10±0.01^{b}	2.14±0.04a	3.44±0.09a	80.86±0.14c
JKL	7.25±0.00^{a}	4.63±0.11^{a}	3.92±0.05^{c}	1.46±0.03e	2.19±0.04f	80.54±0.09c
MNO	7.05±0.00^{a}	4.37±0.02^{b}	3.48±0.01^{e}	1.83±0.03d	2.87±0.02d	80.39±0.09d
STU	6.35±0.00^{b}	4.26±0.03^{bc}	4.08±0.03b	2.03±0.00^{b}	3.35±0.01ab	79.91±0.00e
YZ*	4.95±0.00^{c}	4.47±0.51^{b}	4.32±0.12a	0.83±0.00^{f}	2.41±0.02e	81.41±0.11b

Data represent of three determinations ± Standard Deviation. In the same column, means with different superscripts indicate a significant difference ($p<0.05$).

Table 2: Functional Properties of Instant Fufu Powder Blends

Sample	BD	WAC	LGC	SP	SI	Wettability
	(g /cm^3)	(g/mL)	(%)	(g/100g)	(%)	(min)
ABC	0.63±0.00^{ab}	3.53±0.00^{a}	8.43±0.00b	12.33±0.02^{c}	19.85±0.01^{b}	2.00±0.00^{c}
DEF	0.55±0.00^{d}	3.25±0.49c	8.78±0.16a	14.03±0.03^{b}	20.06±0.04a	2.25±0.35c
JKL	0.67±0.00^{a}	2.45±0.04e	7.91±0.09c	10.33±0.03^{d}	16.33±0.03d	3.00±0.00b
MNO	0.59±0.00^{c}	2.63±0.04d	7.67±0.02c	12.21±0.14c	17.93±0.07c	5.00±0.00a
STU	0.43±0.00^{e}	3.61±0.01b	8.39±0.04b	14.65±0.01a	15.96±0.02e	5.00±0.00a
YZ*	0.52±0.03^{d}	2.43±0.03e	3.06±0.03d	6.93±0.00^{e}	14.57±0.03f	1.00±0.00d

Data represent means of three determinations ± Standard Deviation in the same column, means with different superscripts indicate a significant difference ($p<0.05$).

Table 3: Biochemical Properties of Instant Fufu Powder Blends

Sample	BC	Vit. A	Vit. C	Starch Content	Sugar Content
	(mg/100g)	(mg/100g)	(mg/100g)	(%)	(%)
ABC	13.27±0.01^{b}	10.24±0.02^{b}	46.75±0.02^{b}	55.84±0.08^{e}	8.65±0.00^{a}
DEF	12.16±0.00^{c}	10.52±0.05^{a}	46.40±0.10^{c}	58.60±0.02^{d}	8.36±0.05^{b}
JKL	10.97±0.01^{d}	8.94±0.02^{c}	38.20±0.01^{e}	60.40±0.00^{c}	6.75±0.01^{d}
MNO	9.65±0.02^{e}	8.74±0.05^{c}	36.03±0.00^{f}	62.43±0.03^{b}	6.87±0.02^{d}
STU	13.09±0.02^{b}	10.20±0.01^{b}	47.36±0.02^{a}	63.47±0.01^{a}	7.12±0.01^{c}
YZ*	16.06±0.03^{a}	7.04±0.04^{d}	45.24±0.03^{d}	55.31±0.03^{f}	4.76±0.00^{e}

Data represent means of three determinations ± Standard Deviation. In the same column, means with different superscripts indicate a significant difference ($p<0.05$).

Table 4: Pasting Properties of Instant Fufu Powder Blends

Sample	Peak Viscosity	Trough Viscosity	Breakdown Viscosity	Final Viscosity	Setback Viscosity	Time	Temperature
	(RVU)	(RVU)	(RVU)	(RVU)	(RVU)	(Min)	(°C)
ABC	392.50±21.92^{e}	383.00±19.79^{e}	9.50±0.70^{f}	591.58±30.40^{e}	208.50±10.60^{e}	6.36±0.33^{b}	80.88±1.27^{d}
DEF	513.50±14.84^{d}	456.50±12.02^{d}	57.00±2.82^{d}	704.00±18.38^{d}	247.50±6.36^{d}	5.13±0.00^{cd}	82.32±1.09^{bc}
JKL	1116.00±33.94^{a}	632.50±17.67^{a}	483.50±16.26^{a}	966.50±6.36^{a}	334.00±11.31^{a}	4.87±0.00^{d}	75.87±0.10f
MNO	836.50±26.16^{b}	566.50±7.77^{b}	270.00±18.38^{b}	867.00±16.97^{b}	300.50±9.19^{b}	4.90±0.04^{d}	78.27±0.03^{e}
STU	664.50±7.77^{c}	525.50±7.77^{c}	139.00±0.00c	793.00±4.24^{c}	267.50±3.53^{c}	5.10±0.04^{cd}	81.15±0.56^{cd}
YZ*	263.50±0.70^{f}	251.50±2.12^{f}	12.00±1.41e	424.50±2.12^{f}	173.00±0.00^{f}	6.96±0.04^{a}	85.22±0.03^{a}

Data represent means of three determination ± Standard Deviation. In the same column, means with different superscripts indicate insignificant difference (p>0.05).

Table 5: Sensory Evaluation of Instant Fufu Powder Blends

Sample	Colour	Flavour	Handfeel	Mouldability	Overall acceptability
ABC	6.25±0.91^{b}	5.90±1.20^{a}	5.15±1.30^{a}	5.20±1.28^{a}	5.55±0.88^{ab}
DEF	6.25±0.71^{b}	6.40±1.14^{a}	5.10±0.91^{a}	5.35±0.87^{a}	5.60±0.59^{ab}
JKL	5.80±1.28^{b}	6.05±1.31^{a}	5.45±1.19^{a}	5.75±1.11^{a}	5.70±0.86^{ab}
MNO	5.80±1.00^{b}	5.75±0.91^{a}	5.35±1.49^{a}	5.60±1.04^{a}	5.45±0.88^{ab}
STU	9.0±1.11^{a}	5.65±1.49^{a}	5.45±1.27^{a}	5.55±1.43^{a}	5.60±0.75^{ab}
YZ*	5.85±0.93^{b}	6.15±1.03^{a}	4.30±1.13^{b}	4.30±1.03^{b}	5.10±0.44^{b}

Data represent means of three determination ± Standard Deviation. In the same column, means with different superscripts indicate insignificant difference (p>0.05).

Reference

Achi, O.K. and Akoma, N.S. (2006). Comparative assessment of fermentation techniques in the processing of fufu-a traditional fermented cassava product. *Pakistan Journal Nutrition* 5(3):224-229.

Adebowale, A.A., Sanni, L., Awonorin, S., Daniel, I. and Kuye, A.(2007). Effect of cassava varieties on the Sorption Isotherm of Tapioca Grits. *International Journal of Food Science and Technology,* 42(4):448-452.DOI:10.1111/J.1365-2621.2007.01261.x.

Awoyale, W., Oyedele, H., Adenitan, A.A., Adesokan, M., Alamu, E.O. and Maziya-Dixon, B. (2002).Correlation of the quality attributes of fufu flour and the sensory and instrumental texture profiles of the cooked dough produced from different cassava varieties. *International Journal of Food Properies,*25:1 326-343.DOI:10-1080/10942912.2022.2026955.

Akintayo, E.T., Oshodi, A.A. and Esuoso, K.O. (1999). Effects of NaCL, Ionic strength and P^{H} on the foaming and Gelation of pigeon pea (*Cajanus Cajan)* protein concentrates. Food Chemistry 66:51-56.

Akinsola, A.O., Idowu, O.A., Laniran, A.M., Ojubanire, B.A. and Oke,E.K. (2017). Development, Evaluation and Sensory Quality of Orange Fleshed Sweet Potato (*Ipomea batataslam).* Extruded Pasta Products. *Croatian Journal of Food Technology, Biotechnology and Nutrition* 12(1-2), 83-89.

Akubor, P.I. and Ukwuru, M.U. (2003). Functional Properties and biscuit making potential of soybean and cassava flour blends. *Plant Foods for Human Nutrition* 58:1-2.

AOAC, (2010). Official Methods of Analysis Association of Official Analytical Chemists, Washington DC.

Bechoff, A., Tomlins, K.I., Chijioke, U., Ilona, P., Westby, A., and Boy, E. (2018). Physical Losses Could Partially Explain Modest Carotenoid Retention in Dried Food Products from Biofortified Cassava. *Plos one,* 13(3), e0194-402. Doi.10.1371/journal.pone.0194402.

Bemiller, J. and Whisther, R. (2009). Starch: Chemistry and Technology 3rd ed. P. 310-315. Academy press USA.

Biswas, A.K., Sahoo, J. and Chatli, M.K. (2011). A simple UV-V spectrophotometric method for determination of β-carotene in raw carrot, sweet potato and supplemented chicken meat nuggets.LWT- *Food Science and Technology,* 44(8) :1809-1813.

Bovell-Benjamin, A.C. (2007). Sweet potato: A reviews of its past, present, and future role in human nutrition. *Advance in Food and Nutrition Research, 52,1-59.*

[Burgo, G., Carpio, R., Sanchez, C., Paola S., Edouardo, P., Espinoza, J. and Grunerberg, W. (2001). A colour chart to screen for high beta-carotene in orange fleshed sweet potato breeding. International Potao Center. Cairo, Egypt.

[Chandrasekara, A. and Joseph, K.T. (2016). Root and tuber crop functional foods: A review on phytochemical constituents and their potential health benefits. *International Journal of Food Science,*2016 ,1-5 https://doi.org/10.1155/2016/363/647

Colonna, P., Doublier, J.L., Melcion, J.P., Monkredon, F. and Mercier, C. (1999). Extrusion cooking and drum drying of cassava and wheat starch, part 1, physical and macromolecular modification. *Cereal Chemistry,* 61(6); 538-543.

Deniran, I.A., Oyelere, O.E., Oyegbade, S.A., Akinduro, W.O. and Adelaja O.A. (2022). Comparison of Functional Properties of Fufu Powder and Sensory Evaluation of the Dough from TME 419, TME 693 and IBAO 11371 Cassava Varieties. *Journal of Food and Nutrition Sciences.* Vol. 10,No 6, pp178-184.doi:10.11648/j.fns.2022 1006.12.

Endrias, D., Negussie, R. and Gulelat, D. (2016). Comparison of three sweet potato (*Ipomoea batatas, Lam)* varieties on nutritional and anti-nutritional factors. *Global Journal of Science Frontier Research;* Agriculture and Veterinary, 16(4), 1-11.

FAO. (1970). Human nutrition in tropical Africa.

FAO. (2014). Final 2012 Data, and Preliminary 2013 Data for five major aggregates.

Gamaliel, I.H. and Ulasi, J.I. (2022). Evaluation of Orange-fleshed Sweet Potato (OFSP) Genotypes for Yield, Dry Matter, Starch and Beta carotene Content in Uyo, South Southm Nigeria. International Journal of Environment, Agriculture and Biotechnology. Vol. 7, issue 1. Httpss://ijeab.com/doi:102216/ijeab.

Hacineza, E.H., Vasanthakaalam., Ndirigwe, J. and Mukwantali, C. (2000). A Comparative study on the β-carotene content and its retention in yellow and orange-fleshed sweet potato flours.

Jisha, S., Sheriff, J.T. and Padmaja, G. (2010). Nutritional, functional and physical properties of extrudates from blends of cassava flour with cereal and legume flours. *International Journal of Food Properties,* 13(5): 1002-1011, Doi: 10.1080/10942910902934090.

Kaguongo, W. (2012). Factors influencing adoption and intensity of adoption of orange flesh sweet potato varieties: Evidence from an extension intervention in Nyanza and Western Provinces.

Maziya-Dixon, B., Dixon, AGO. and Adebowale, A.A. (2004). Targeting different end uses of cassava: genotype variations for cyanogenic potentials and pasting properties, presented at ISTRIC-AB Symposium, Mombasa, Kenya.

Newport Scientific. (1998). Applications Manual for the Rapid Visco TM analyzer Using Thermocline for Windows; Newport Scientific Pty Ltd, Warrie wood, NSW: Australia, pp 2-26.

Obasi, N.E., Arungwa, C.L. and Okakpu. C.J. (2018). Evaluation of the Physicochemical, Pasting and Organoleptic Properties of Fufu Flour Produced from Different Varieties of Yellow Root Cassava (*Manihot esculenta Crantz). Asian Food Science Journal* 3(1): 1-10.

Ocheme, O.B., Adedeji, O.E., Chinma, C.E., Yakubu, C.M. and Ajibo, U.H. (2018). Proximate composition, functional, and pasting properties of wheat and groundnut protein cocnetrate flour blends. *Food Science and Nutrition,* 6(5);1173-1178.https://doi.org/10.1002/fsn3.670.

Odoh, E.N., Okafor, R.O., Ikegwu, T.M., Okolo, C.A., Mba, J.C., Ezegbe, C.C., Kolawole, O.O., Orjiakor, S.N. and Obiegbuna, J.E. (2022). Physicochemical and Sensory Properties of Unfermented Fufu Composite Flour Made from Cassava Sievate, Guinea Corn and Unripe Plantain Flour Blends. *American Journal of Food Science and Technology,* vol. 10, no1:27-34 doi: 10.12691/ajfst-10-1-14.

Ogungbemi, K., Balogun, B., Ajisafe, S.S., Ayangbemi, B.T., Ilori, A.O. and Oyewole, O.S. (2022). Assessment of cyanide content and nutritional composition of odourless fufu flour produced using different processing techniques. *Food Research* 6(2):330-336.

Olapade, A.A., Babalola, Y.O. and Aworh, O.C. (2014). Quality attributes fufu (fermented cassava) flour supplemented with Bambara flour. *International Food Research Journal* 21(5):2025-2032.

Oluwamukomi, M.O., Eleyinmi, A.F. and Enujuigha, V.N. (2004). Effects of soy supplementation and its stage of inclusion on the quality of ogi- a fermented maize meal. *Food Chemistry,* 91:651-657.

Omosuli, S.V., Ikujenlola, A.V. and Abisuwa, A.T. (2017). Quality assessment of stored fresh Cassava Roots and 'fufu' flour produced from stored roots. *Journal of Food Science and Nutrition Therapy* 3(1):009-013.

Onwuka, G.I. (2005). Food Analysis and Instrumentation. Theory and Practice. Naphtali prints. A Division of HG Support Nigeria Limited, Surulere, Lagos, Nigeria. Pp 119-121.

Oyeyinka, S.A., Adeloye, A.A.., Smith, A.A., Adesina, B.O. and Akinwande, F.F. (2019). Physicochemical properties of flour and starch from two cassava varieties. Agrosearch, 19(1), 28-45. https://doi.org/10.4314/agrosh.v19il.3.

Ragaee, S. and Abdel-Aal, E.M. (2006). Pasting properties of starch and protein in selected cereals and quality of their food products. *Food Chemistry:* 95:9-18.

Ruales, J., Valencia, S. and Nair, B. (1993). Effect of processing on the physicochemical characteristics of guinea flour. (Chenopodium guinea Wild). *Starch,* 46(1) : 13-19.

Sanni, L.O., Kosoko, S.B., Adebowale, A.A. and Adeoye, R.J. (2004). The influence of Palm Oil and Chemical Modification on the Pasting and Sensory Properties of Fufu Flour. *International Journal of Food Properties,* 7 (2):229-237.

Sanni, L, O., Adebowale, A.A., Filani, T.A., Oyewole, O.B. and Westby, A. (2006). Quality of flash and rotary dried fufu flour. *Journal of Food, Agriculture and Environment,* vol. 4 (3&4): 74-75.

Sanni, L.O., Ashaye, O.A. and Arowosafe, B.E. (2012). Physicochemical, Rheological and Consumer acceptability of cassava starch. *Journal of American Science* 6(1): 65-72.

Shittu, T.A., Awonorin, S.O., Sanni, L.O. and Udiwy, M.A. (2002). Dry milling characteristics of dried cassava chips as related to moisture content. *Journal of Applied Science and Technology* 2(1): 13-18.

Shittu, T.A., Oyewole, O.B., Olawuyi, O. and Daramola, O. (2005). Dry milling characteristics of dried cassava chips as related to moisture content. *Journal of Applied Science and Technology,* 2(1):13-18.

Singh, B., Sekhon, K.S. and Singh, N. (2007). Effects of moisture, temperature and level of pea grits on extrusion behavior and product characteristics of rice. *Food Chemistry.* 100:198-202.

Sriroth, K., Piyachomkwam, K., Wanlapatit, S. and Oates, C.G. (2000). Cassava starch technology: Thai experience starch-starke, 52:439-449.

Srichuwong, S., Suharti, C., Misharti, U., Mishima, T., Isono, M. and Isamatu, M, (2005). Starches from different botanical sources. Contribution of starch structure to swelling and pasting properties. *Carbohydrate polymer* 62(1) : 25-34.

Steed, L.E. and Truong, V.D. (2008). Anthocyanin content, anti-oxidant activity, and selected physical properties of flowable purple-fleshed sweet potato purees. *Journal of Foo Science,* 73(5), 215-221.

Teferra, T.F., Nigusse, G. and Kurabachew, H. (2015). Nutritional, microbial and sensory properties of flat-bread prepared from blends of maize (zea mays L.) and orange-fleshed sweet potato (Ipomoea batatas L.) flours. *International Journal fo Food Science and SNutrition Engineering;* 5(1): 33-39.