IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)
e-ISSN: 2319-2402,p- ISSN: 2319-2399.Volume 14, Issue 8Ser. I (August 2020), PP 37-44
www.iosrjournals.org

Comparative Evaluation of Processing Treatments on the Functional and Pasting Properties of Two Cocoyam Varieties

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Abstract: *Comparative evaluation of blanching and boiling on two cocoyam varieties were studied. Raw Colocasia esculenta and raw Xanthosoma sagittifolium were subjected to blanching in water at 100^{0}C for 5 minutes and boiling in water at 100^{0}Cfor 20 minutes. All the samples were subjected to analysis. The result of the functional properties showed significant differences ($p<0.05$) among the raw, blanched and boiled Colocasia esculenta and Xanthosoma sagittifolium flours bulk density, water absorption capacity, oil absorption capacity,emulsion capacity, foam capacity and swelling capacity. The pasting results showed that boiled Colocasia esculentaflour and boiledXanthosoma sagittifolium flour recorded the lowest and second lowest values respectively, for peak, trough, breakdown, setback and final viscosities, and in pasting temperature and peak time compared to the other samples. This implies that the boiled cocoyam floursamples were more durable against heat and shear stress and more stable after cooling compared to the blanched and raw samples.*

Keywords:*Raw, blanching, boiling, Colocasia esculenta, Xanthosoma sagittifolium*

Date of Submission: 02-08-2020 Date of Acceptance: 17-08-2020

I. Introduction

Cocoyam is a herbaceous perennial plant belonging to the Aracea family. The two most important varieties of cocoyam are *Xanthosoma sagittifolium* (Tannia) of which its young leaf shoots are eaten as leafy vegetables and *Colocasia esculenta* (Taro) of which the leaves are not edible (Ekanem and Osuji, 2006).

Cocoyam is an ancient root crop grown throughout the humid tropics for its edible corms, cormels and leaves. They are an important staple food grown extensively in South-eastern Nigeria (Ukonze and Olaitan, 2010). Although they are less important than other root crops such as yam, cassava and sweet potato, they are still a major staple in some parts of the tropics and sub tropics (Opara, 2002) since they provide cheaper yam substitute especially during the period of food scarcity in many parts of Igboland (Azeez and Madukwe, 2010).

Cocoyam are consumed in many ways, boiled, roasted, baked or fried. They are eaten as porridge, pounded into fufu and eaten with soup or used as soup thickeners in most South-eastern states of Nigeria (Ugwuoke *et al*., 2008). According to Azeez and Madukwe (2010), cocoyam can be processed into flour which could be useful in bakery for bread, as stabilizer in ice cream and as thickener in soup. Ojinnaka *et al*. (2009) had earlier noted that processing of pre-gelatinized cocoyam flour could be useful in making instant pounded cocoyam fufu thereby eliminating the drudgery associated with its preparation by consumers.

The utilization of cocoyam has been hindered by the presence of high calcium oxalate (anti-nutrient) which affects its palatability, conferring acridity and a bitter-stringent taste (Owusu-Darko *et al*., 2014). The acridity factor in cocoyam cause sharp irritation and burning sensation in the mouth and throat on ingestion and this has affected its consumption (Akpan and Umoh, 2004). The adverse effects of high oxalate content can be eliminated or reduced by processing methods such as cooking, soaking, oven drying, sun drying and fermentation (Igbabul *et al*., 2014).

Cocoyam is rich in digestible starch, good quality protein, vitamin C, thiamin, riboflavin, niacin, among others (Lewu *et al*., 2009). The high carbohydrate content (mostly starch) provides energy and satiety to consumers and imparts desirable functional properties to foods (Owusu-Darko *et al*., 2014). Cocoyam can be used as an alternative to other starchy raw materials for a wide range of products in the food industry and with appropriate processing methods, could be a rich source of starch for food and other industrial applications (Owusu-Darko *et al*., 2014). But the application of any starch including cocoyam in foods is determined by its functional and pasting properties.

Therefore the aim of this study was to compare the functional and pasting properties of two varieties of cocoyam as affected by blanching and boiling in order to determine their applications in food systems.

II. Materials and Methods

2.1 Sample Collection

The corms and cormels of two cocoyam varieties (*Colocasia esculenta* and *Xanthosoma sagittifolium*) used for this study were purchased from Eke Amainyi, a market in Imo State, Nigeria.

2.2 Sample Preparation

The corms and cormels of *Colocasia and Xanthosoma* varieties were washed with clean water to remove adhering soil and other extraneous materials. The cocoyam corms and cormels were hand-peeled under water using kitchen knife and sliced into sizes of 2cm thickness. The slices of each of the two cocoyam varieties were separated into three parts for production of raw, blanched and boiled flour samples.

2.2.1Production of raw cocoyam flour: The raw cocoyam slices were dried in an oven at 65^0C for 9hours after which they were milled into flour using a disc attrition mill (Asiko AII, Addis Nigeria). The flour was then sieved (0.42 mm mesh) and packed in polyethylene bags for further studies.

2.2.2 Production of blanched cocoyam flour: This was carried out according to the method described by Ibe and Iwueke (1984) with slight modification. The cocoyam slices were blanched in a basin of water at 100^0C for 5 min and the water drained. The blanched cocoyam slices were dried in an oven at 65^0C for 9hours after which they were milled into flour using a disc attrition mill (Asiko AII, Addis Nigeria). The flour was then sieved (0.42mm mesh)and packed in polyethylene bags for further studies.

2.2.3 Production of boiled cocoyam flour: This was carried out according to the method described by Ibe and Iwueke (1984) with slight modification. The cocoyam slices were boiled in water at 100^0C for 20 min and the water drained. The boiled cocoyam slices were dried in an oven at 65^0C for 9hours after which they were milled into flour using a disc attrition mill (Asiko AII, Addis Nigeria). The flour was then sieved (0.42 mm mesh) and packed in polyethylene bags for further studies.

2.3 Determination of functional properties

2.3.1 Bulk density: Bulk density was determined according to the method described by Narayana and Narasinga (1984). Ten grams (10g) of the sample was weighed into a 25ml graduated measuring cylinder. The sample was gently tapped continuously on a laboratory table to eliminate spaces between the flour particles until a constant volume is obtained. The experiment was done in triplicate and the mean taken. Bulk density was calculated as:

$$\text{Bulk density (g/ml)} = \frac{Weight}{Volume\ of\ sample\ after\ tapping}$$

2.3.2 Water absorption capacity: The modified method of Lin *et al.* (1974) as described by Onimawo and Egbekun (1998) was employed. Water absorption capacity is expressed as the amount of water absorbed and held by a unit weight of the sample. One gram (1g) of each sample was dispersed into a weighed centrifuge tube. Ten milliliters (10ml) of distilled water was added to sample and mixed very well. The mixture was allowed to stand for one hour before being centrifuged at 3500rpm for 30min. The excess water (unabsorbed was decanted) and the tube was inverted over an absorbent paper to drain dry. The weight of water absorbed was determined by difference. This experiment was done in triplicate and the mean taken.

$$\text{WAC} = \frac{w2-w1}{w3} \times \frac{100}{1}$$

Where W_1= weight of sample

W_2=weight of empty tube + sample used

W_3=weight of empty tube + sample + water absorbed

2.3.3 Oil absorption capacity: This was carried out according to the method described by Adebowale *et al*. (2005). One gram (1g) of each sample was mixed in 10ml of oil in a weighed centrifuge tube. The mixture was allowed to stand for one hour. Then it was centrifuged at 3500rpm using spectra scientific centrifuge (Model: Merlin, SN976137) for 30min before the excess oil was decanted and the tube was inverted over an absorbance paper to drain dry. The experiment was done in triplicate and the mean taken.

$$\text{OAC} = \frac{w3-w2}{w1} \times \frac{100}{1}$$

Where W_1= weight of sample

W_2=weight of empty tube + sample used

W_3=weight of empty tube + sample + water absorbed

2.3.4 Emulsion capacity: This was determined by the method described by Yasumatsu et al. (1972).One gram (1g) of each sample was blended with 10ml of distilled water and 10ml of soybean oil in calibrated centrifuge tube. The emulsion was centrifuged at 2000 x g for 5min. The ratio of the height of emulsion layer to the total heightof the mixture was calculated as emulsion capacity in percentage.

2.3.5 Foam capacity: The method of Narayana and Narasinga Rao (1982) was used. One gram (1g) of each sample was blended with 50ml of distilled water in a warring blender for 5min at room temperature to foam. The mixture was quickly but carefully transferred to the measuring cylinder and the foam volume was measured and recorded after 30seconds in the first instance, then the foam volume was recorded at 15min interval for one hour. The experiment was done in triplicate and the foam capacity was calculated from the volume of foam after the first 30 seconds as given by the formula:

$$FC = \frac{va - vb}{vb} \times \frac{100}{1}$$

Where: Va=volume after blending
Vb=volume before blending

2.3.6 Swelling capacity: This was determined with the method described by Okaka and Potter (1977). Hundred milliliters (100ml) graduated cylinder was filled with each sample to 10ml mark. The distilled water was added to give a total volume of 50ml. The top of the graduated cylinder was tightly covered and mixed by inverting the cylinder. The suspension was inverted again after 2 min and left to stand for a further 8 min. The volume occupied by the sample was taken after the 8^{th} min.

2.4 Pasting properties

Pasting properties was determined with a Rapid Visco Analyzer (RVA) (Model RVA 3DH, Newport Scientific Australia). Twenty five grams (25g) of each sample was weighed into a dried empty canister, and then 25ml of distilled water was dispensed into the canister containing the sample. The slurry was thoroughlymixed and the canister was well fitted into the RVA as recommended. The slurry was heated from 50^0C to 95^0C with a holding time of 2 min followed by cooling to 50^0C with 2 min holding time. The rate of heating and cooling was at 22.5^0C per min. Peak viscosity, trough viscosity, breakdown viscosity, final viscosity, setback viscosity, pasting temperature and peak time were read from the pasting profile with the aid of a thermocline for windows software connected to a computer (Newport Scientific, 1998).

2.5 Statistical Analysis

The results of the studies were expressed as means $\pm$ SD (standard deviation) of triplicate determinations. All the data obtained were subjected to one way analysis of variance (ANOVA) using SPSS statistical package to determine variations between the treatments at 5% level of significance.

III. Results and Discussion

3.1 Functional propertiesof the cocoyam flour samples

3.1.1 Bulk density: The result of bulk density of the cocoyam samples is presented in Table 1. The bulk density of the samples ranged from 0.532 - 0.980g/cm^3 with raw *Xanthosoma sagittifolium* recording the highest (0.980g/cm^3) followed by raw *Colocosia esculenta* (0.971 g/cm^3). The lowest value (0.532g/cm^3) was recorded for the boiled *Colocasia* variety followed by the boiled *Xanthosoma* variety (0.661 g/cm^3) and the blanched samples recorded second lowest values. There were significant differences ($p<0.05$) among the samples. Bulk density is a measure of the heaviness of flour samples which is important in packaging requirements, material handling and application in the food industry. Akubor and Badifu (2004) reported that flours with high bulk density (>0.7g/ml) are useful as thickeners in food products. This implies that the raw flour samples of *Colocasia* and *Xanthosoma* varieties from this study will be useful as thickeners while the boiled and blanched samples with low bulk densities can find use in baby food formulations where high nutrient density to bulk is desired (Mepba *et al*., 2007). The bulk density reported in this work is within the ranges (0.58-0.59 g/ml) and (0.592-0.647 g/cm^3)respectively reported for cocoyam–breadfruit-wheat flour blends by Ubbor and Nwaogu (2010) and for pigeon pea flour by Arukwe *et al*. (2017). Ojinnaka *et al*. (2009) also reported comparable values for raw Ede Uhie (0.67g/ml) and Ede Ocha (0.62g/ml). It was observed that boiled cocoyam samples had lower bulk densities than the blanched and raw samples. This is in agreement with the report of Njitanga and Mbofung (2005) that increasing the pre-cooking temperatures reduced the bulk density of cocoyam flours.

Table 1: Functional properties of the cocoyam flour samples

Flour sample	Bulk Density (g/cm^3)	Water Absorption Capacity (%)	Oil Absorption Capacity (%)	Emulsion capacity (%)	Foaming Capacity (%)	Swelling Capacity (%)
RCS	0.971 ± 0.0^b	180.08 ± 0.10^f	115.11 ± 0.1^f	5.15 ± 0.01^b	9.60 ± 0.01^d	1.80 ± 0.0^f
B_1CS	0.601 ± 0.01^d	240.51 ± 0.0^d	120.40 ± 0.0^c	4.51 ± 0.0^d	11.01 ± 0.0^b	2.55 ± 0.01^c
B_2CS	0.532 ± 0.0^f	320.60 ± 0.0^b	124.60 ± 0.10^b	3.95 ± 0.10^f	13.80 ± 0.0^a	2.78 ± 0.0^b
RXS	0.980 ± 0.02^a	181.10 ± 0.0^e	117.23 ± 0.0^e	5.24 ± 0.0^a	5.05 ± 0.10^f	1.81 ± 0.0^e

B_1XS	0.661±0.01[c]	241.41±0.01[c]	120.20±0.01[d]	4.55±0.10[c]	7.50±0.0[e]	1.88±0.0[d]
B_2XS	0.560±0.10[e]	322.50±0.0[a]	125.10±0.0[a]	4.0±0.01[e]	10.0±0.0[c]	3.15±0.0[a]
LSD	0.00135	0.01658	0.01708	0.01080	0.00452	0.00173

Mean values with different letters within the same column are significantly different (p<0.05)

Key: RCS= Raw *Colocasia esculenta*, B_1CS= Blanched *Colocasia esculenta*, B_2CS= Boiled *Colocasia esculenta*, RXS=Raw *Xanthosoma sagittifolium*, B_1XS=*Xanthosoma sagittifolium*, and B_2XS=*Xanthosoma sagittifolium.*

3.1.2 Water absorption capacity: There were significant differences (p<0.05) in water absorption capacities of the cocoyam flour samples which ranged from 180.05-322.50%. The highest value was recorded for boiled *Xanthosoma* sample (322.50%) followed by the boiled *Colocasia* sample (320.60%). The lowest value was recorded for raw *Colocasia* sample (180.08%) followed by raw *Xanthosoma* sample (181.10%). The blanched *Colocasia* and *Xanthosoma* samples recorded values of 240.51% and 241.41% respectively. This result is in agreement with the report of Fagbemi (1999) that water absorption capacity can be enhanced by boiling. The results of water absorption capacity in this study are within the range reported for cassava pulp (171.3-551.2%) by Nwabanne (2009) and for raw, soaked and cooked rice flour(225-250%) and plantain flour (284%) respectively by Mepba *et al*. (2007). The results obtained in this study are higher than those (1.683-1.982%) and (36%) respectively reported by Arukwe *et al*. (2017) for pigeon pea flour and Mepba *et al*. (2007) for fluted pumpkin seed flour. Water absorption capacity describes flour water association ability under limited water supply. The increased water absorption water absorption capacity of the boiled samples implies increase in digestibility of the flour which makes them useful in formulation of infant or weaning foods (Ojinnaka *et al*., 2009). During heating (boiling), proteins disassociate into sub-units with more water binding sites than the native or oligomeric proteins (Akubor and Eze,2012).

3.1.3 Oil absorption capacity: The oil absorption capacity of the cocoyam flour samples ranged between 115.11-125.10%. The blanched *Colocasia* andblanched *Xanthosoma* samples recorded increase of (115.11-120.40%) and (117.23-121.20%) respectively in oil absorption capacity and these were significantly (p<0.05) increased in the boiled samples to (124.60% and 125.10%) respectively. The oil absorption capacity like water absorption capacity was increased by all the processing treatments in this study but the increase was more on the boiled samples. The oil absorption capacity values obtained in this study are higher than those reported by Arukwe *et al*. (2017) for pigeon pea flour (1.623-1.692%) but similar to that obtained by Mepba *et al*. (2007) for plantain flour (130%). Oil absorption capacity is important because, oil enhances flavor retention and gives soft texture to food to improve mouth feel (Appiah *et al*., 2011). The increased oil absorption capacity of the flour samples indicate their usefulness in food preparation that involves oil mixing such as in bakery products (Fagbemi, 1999) or as thickeners in some foods where fat absorption is desired such as sausages, and soups (Lawal and Adebowale, 2004).

3.1.4 Emulsion capacity: There were significant (p<0.05) differences in the emulsion capacities of the cocoyam samples. The emulsion capacity ranged from 3.95-5.24%. The lowest value (3.95%) was recorded for boiled *Colocasia* flour followed by boiled *Xanthosoma* flour (4.00%). The blanched samples recorded values of 4.51% and 4.55% respectively while the highest value was recorded for raw *Xanthosoma* (5.24%) followed by raw *Colocasia* flour (5.15%). It was observed that emulsion capacity decreased for the blanched and boiled samples but more for the boiled samples. This result is consistent with the finding of Narayana and Rao (1982) and Fagbemi (1999) who reported that heat processing diminishes the emulsification process. The emulsion capacity resultin this study are similar to that obtained by Mepba *et al*. (2007) for plantain flour (3.5%) and lower than those of Eltayeb *et al*. (2011) for groundnut flour (89%) and groundnut protein isolates (76%) and that of Mepba *et al*. (2007) for wheat flour (12.8%). The emulsion capacities in this study are higher than those reported for breadfruit flour (1.8%) and calabash seed flour (2.32%) (Olaofe *et al*., 2009). Emulsion capacity is an important consideration in the production of pastries,coffee whiteners and frozen desserts. The boiled cocoyam flours contained denatured proteins which lost their emulsification power due to the degree of heat processing (Mepba *et al*., 2007). The blanched cocoyam flours which retained their emulsification power could find use in food formulations such as communited meat products, salad dressings, frozen desserts and mayonnaises (Mepba *et al*., 2007).

3.1.5 Foaming capacity: There were significant differences (p<0.05) in the foaming capacities of the cocoyam flour samples and they ranged from 5.05-13.80%. The highest foam capacity was recorded for the boiled *Colocasia esculenta* flour (13.80%) followed by boiled *Xanthosoma sagittifolium* flour (10.0%). The blanched samples recorded values of 11.01% and 7.50% for *Colocasia* and *Xanthosoma* varieties respectively. The lowest foam capacity was recorded for raw *Xanthosoma sagittifolium* flour (7.50%) followed by raw *Colocasia esculenta* flour (9.60%). The foam capacity obtained in this work is within the range recorded for germinated tigernut varieties (4.00-11.33%) by Chinma *et al*. (2009). Ojinnaka *et al*. (2009) reported a value of 3.86% for native Ede Ocha (*Xanthosoma sagittifolium* variety) and 11.64% for native Ede Uhie (*Colocasia* variety) while Arukwe *et al*. (2017) reported values of 12-13% for pigeon pea flour. The boiled cocoyam flour samples recorded the highest foam capacities and such flours can be used as foaming agents in food formulations requiring foamability such as ice cream or cake toppings (Lee *et al*., 1993). Boiling may have caused surface denaturation of the seed protein and thus reduced surface tension of the protein molecules which gave good foamability (Sosulki *et al*., 1976).

3.1.6 Swelling capacity: The swelling capacity of the cocoyam flour samples ranged from 1.80-3.15%. The least value (1.80%) was recorded for raw *Colocasia* flour while the highest value (3.15%) was recorded for the boiled *Xanthosoma* flour. There were significant differences ($p<0.05$) in the swelling capacities of the samples. The boiled samples of the cocoyam varieties had higher swelling capacity than their respective raw and blanched samples. This is in agreement with the findings of Bainbridge *et al*. (1996) who opined that boiled flours has higher swelling and water absorption capacity values and therefore can hold large amounts of water during their preparation as gruels. Okorie *et al*.(2013) also reported increase in the swelling index of boiled *Irvingia gabonesis* flour. Swelling is an increase in volume of dry starch when kept in a moist environment and is a desired index in baking.

3.2 Pasting Properties of Cocoyam Flour Samples

The pasting properties of the cocoyam flour samples are shown in Table 2.

3.2.1 Peak viscosity: The peak viscosity of the cocoyam flour sample ranged from 376.15-565.10RVU. There were significant differences ($p<0.05$) in the peak viscosities of the flour samples. The highest peak viscosity was recorded for the raw *Xanthosoma* flour (565.10RVU) followed by the raw *Colocasia* flour (505.40RVU). The lowest peak viscosity was recorded for the boiled *Colocasia* flour sample followed by the boiled *Xanthosoma* flour sample. The blanched *Colocasia* and Xanthosoma flours had peak viscosity values of 406.50RVU and 410.20RVU respectively. Peak viscosity is the maximum viscosity attained during or soon after the heating portion of the pasting test(Newport Scientific, 1998). The peak viscosity is associated with degree of starch damage, and high starch damage results in high peak viscosity (Oladunmoye *et al*., 2014; Ribotta *et al*., 2007). Peak viscosity is an indication of the suitability of blends for products requiring high gel strength and stability. Therefore the raw *Xanthosoma* flour with the highest peak viscosity will find application in products requiring high gel strengths and stability.

Table 2: Pasting properties of cocoyam flour samples

Flour sample	Peak Viscosity (RVU)	Trough Viscosity (RVU)	Breakdown Viscosity (RVU)	Setback Viscosity (RVU)	Final Viscosity (RVU)	Pasting Temperature (°C)	Peak Time (min)
RCS	$505.40\underline{+}0.0^b$	$318.05\underline{+}0.01^b$	$109.10\underline{+}0.11^b$	$81.21\underline{+}0.0^b$	$400.10\underline{+}0.10^b$	$71.15\underline{+}0.0^b$	$5.58\underline{+}0.01^b$
B_1CS	$406.50\underline{+}0.01^d$	$236.33\underline{+}0.0^d$	$106.15\underline{+}0.10^d$	$70.50\underline{+}0.10^d$	$307.19\underline{+}0.02^d$	$69.23\underline{+}0.0^d$	$4.60\underline{+}0.0^c$
B_2CS	$376.15\underline{+}0.04^f$	$106.25\underline{+}0.05^f$	$95.20\underline{+}0.02^f$	$60.10\underline{+}0.01^f$	$167.46\underline{+}0.11^f$	$65.01\underline{+}0.01^f$	$3.57\underline{+}0.0^e$
RXS	$565.10\underline{+}0.02^a$	$327.50\underline{+}0.04^a$	$111.50\underline{+}0.0^a$	$85.20\underline{+}0.0^a$	$425.15\underline{+}0.05^a$	$81.50\underline{+}0.0^a$	$5.86\underline{+}0.10^a$
B_1XS	$410.20\underline{+}0.11^c$	$241.10\underline{+}0.02^c$	$107.10\underline{+}0.20^c$	$76.05\underline{+}0.02^c$	$316.47\underline{+}0.10^c$	$70.10\underline{+}0.02^c$	$4.51\underline{+}0.02^d$
B_2XS	$388.00\underline{+}0.10^e$	$120.15\underline{+}0.10^e$	$97.25\underline{+}0.10^e$	$66.12\underline{+}0.20^e$	$185.504\underline{+}0.0^e$	$68.25\underline{+}0.0^e$	$3.11\underline{+}0.10^f$
LSD	0.02160	0.01803	0.020	0.01080	0.01044	0.00962	0.00355

Mean values with different letters within the same column are significantly different ($p<0.05$)

Key: RCS= Raw *Colocasia esculenta*, B_1CS= Blanched *Colocasia esculenta*, B_2CS= Boiled *Colocasia esculenta,* RXS=Raw *Xanthosoma sagittifolium*, $B_!$XS=*Xanthosoma sagittifolium*, and B_2XS=*Xanthosoma sagittifolium.*

3.2.2 Trough viscosity: The trough viscosities ranged between 106.25 – 327.50 RVU. The highest trough viscosity (327.50 RVU) was recorded for the raw Xanthosoma flour sample compared to the other samples which had lower values. The trough viscosities varied significantly ($p<0.05$) among all the flour samples. Trough viscosity is the minimum viscosity value and measures the ability of paste to withstand breakdown during cooling (Newport Scientific, 1998). It is also called hot paste stability, paste stability or holding strength. It measures the vulnerability of the cooked starch to disintegration and the lower the value, the more stable is the starch gel. Therefore the boiled *Colocasia* flour (106.25RVU) and boiled *Xanthosoma* flour (120.15RVU) could be said to have hot paste stability and can find use in filler meat canning industry.

3.2.3 Breakdown viscosity: There were significant differences ($p<0.05$) in the breakdown viscosities of cocoyam flour samples studied. The highest breakdown viscosity (111.50RVU) was recorded for raw *Xanthosoma sagittifolium*and this was significantly higher ($p<0.05$) compared to the value recorded for raw *Colocasia esculenta*(109.10RVU) and the other samples. High peak viscosities are associated with high breakdown viscosities which in turn are related to the degree of swelling of the starch granules during heating (Ribotta *et al*., 2007). A low breakdown value indicates stability of starches under hot condition. This implied that the higher the breakdown viscosity, the lower the ability of the sample to withstand heating and shear stress during cooking (Adebowale *et al*., 2005). Therefore the boiled cocoyam samples with low breakdown viscosities might be able to withstand heating and shear stress. Boiling of the samples decreased the breakdown viscosities in all the samples studied. This trend is in agreement with the findings of Oluwalana *et al*. (2011).

3.2.4 Setback viscosity: The setback viscosity values of the cocoyam flour samples ranged from 60.10 – 85.20RVU with raw *Xanthosoma* flour having the highest value (85.20RVU) followed by raw *Colocasia* flour with a value of 81.24RVU. There were significant differences (P<0.05) in the setback viscosities among all the cocoyam flour samples. Higher setback viscosity or cool paste viscosity values are synonymous to reduced dough digestibility while lower setback viscosities indicate lower tendency to retrogradation (Sandhu *et al*., 2007) and enhanced dough digestibility. The boiledcocoyam samples had lower setback values than those of the blanched and raw cocoyam samples. This implies that theboiled cocoyam samples had a lower tendency to retrogradation and higher digestibility compared to the other samples.

3.2.5 Final Viscosity: The final viscosities of the cocoyam flour samples ranged from 167.46 – 425.15RVU with the boiled samples recording the lowest values followed by the blanched samples and the raw samples recorded the highest values in final viscosities. There were significant differences (p<0.05) in the final viscosities of the cocoyam flour samples. Final viscosity is the most commonly used parameter to determine the quality of a starch-based sample. The final viscosity is an indication of the ability of the starch based food sample to form a viscous paste or gel after cooking and cooling (Shimelis *et al*., 2006). This implies that the boiledcocoyam flour samples with the lowest final viscosity values will be more stable after cooling than the raw and blanched samples.

3.2.6 Pasting temperature: The pasting temperature of the cocoyam samples ranged from 65.01 – 81.50^{0}C with the boiled *Colocasia* and *Xanthosoma* samples recording the lowest values of 65.01^{0}C and 68.25^{0}C respectively. The blanched samples had values that were higher than the boiled samples while the raw samples had the highest pasting temperatures. This is expected since the boiled samples werepre-gelatinized and therefore needed lower temperature to undergo gelatinizationunlike the blanched and raw samples. The pasting temperature is a measure of the minimum temperature required to cook a given food sample (Sandhu *et al*., 2007).

3.2.7 Peak time: This ranged between 3.11 – 5.8mins with the boiled samples of the*Xanthosoma* and *Colocasia* varieties recording values of 3.11mins and 3.57mins respectively. The values recorded for all the raw, blanched and boiled samples were significantly different (p<0.05) compared to each other. Peak time is a measure of cooking time (Adebowale *et al*., 2005). The results showed that boiled *Xanthosoma* (3.11mins) cooked faster than boiled *Colocasia* (3.57mins), blanched*Xanthosoma* (4.51mins), blanched *Colocasia* (4.60mins) and the raw samples which cooked the longest time. This suggests that pre-gelatinization of the boiled samples resulted to their fast cooking compared to the blanched and raw samples. This result is in agreement with the report of Oluwalana *et al*. (2011) who observed that the peak time of plantain flour reduced with increased pre-cooking.

IV. Conclusion

The functional and pasting properties of two cocoyam varieties as affected by blanching and boiling treatments were studied.It was observed that boiled Colocasia and Xanthosoma flour recorded the highest increase in water absorption capacity, oil absorption capacity and foaming capacity and highest decrease in bulk density. This indicates their usefulness in infant and weaning food formulations, in bakery products or in sausages and in food formulations requiring foamability. On the other hand, the blanched cocoyam flour samples had better emulsion and swelling capacities, suggesting their usefulness in production of salad dressings, mayonnaise and baked products.

Also, the low breakdown, setback, and final viscosities of the boiled cocoyam flour samples implies that they have higher digestibility and lower tendency to retrogradation.

This knowledge gained on the utilization potential of cocoyam flours will encourage their cultivation leading to food security.

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Arukwe, D. C, et. al. "Comparative Evaluation of Processing Treatments on the Functional and Pasting Properties of Two Cocoyam Varieties." *IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)*, 14(8), (2020): pp 37-44.