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Chemical Composition and Effect of Processing and Flour Particle Size on Physicochemical and Organoleptic Properties of Cocoyam *(Colocasia esculenta var. esculenta)* Flour

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ABSTRACT

This work investigated the chemical composition of cocoyam corms and cormels and the effect of processing and particle size on the physicochemical and organoleptic properties of the flours for use as soup thickener. Fresh cocoyam corms and cormels were peeled, sliced, washed, divided into four parts that were variously blanched, sulphited and sulphited/blanched. The control was not treated. The slices were sun dried (32 ± 2°C, 3 days), milled and classified with standard sieves into particle sizes of 0.1, 0.2, 0.4, 0.6 mm. The flour samples and fresh corms and cormels were analyzed for the proximate composition, ascorbic acid, anthocyanin and oxalic acid contents. The flours were also analyzed for the pH, bulk density, water and oil absorption capacities and the sensory properties of colour and texture. On dry weight basis, the protein, fat, crude fibre, ash and carbohydrate contents of the corms, cormels and flours were the same ($p > 0.05$). Ascorbic acid, anthocyanin and oxalic acid contents were respectively reduced from averages of 30.35, 31.58 and 173.88 mg/ 100 g (dry weight) in the corm/cormel to ranges of 8.95 – 16.28, 9.58 – 15.90 and 141.69 – 160.68 mg/ 100 g in the flours. Bulk density was increased ($p < 0.05$) by blanching and particle size. The water and oil absorption capacities were increased ($p < 0.05$) by blanching. Colour preference was improved by sulphiting, blanching and decreasing particle size. Texture preference was only affected by particle size. Acceptablility of soups from flours were not affected by treatments and particle sizes.

Keywords: Cocoyam, blanching, sulphiting, particle-size, physicochemical properties.

Introduction

A member of Aracea family, taro (*Colocasia esculenta*) is an ancient crop grown throughout the humid tropics for its edible corms and leaves (Ikpeme *et al.*, 2010). Jointly with tannia (*Xanthosoma sagitifolium*), *Colocasia* represents the third most important root crop after yam and cassava and are widely cultivated in Africa (Obomegheive *et al.*, 1998; Nwanekezi *et al.*, 2010). The total taro production in the world is about 9.22 million tons from an area of 1.57 million hectares (Ammar *et al.*, 2009). Ikpeme *et al.* (2010), however, reported the world production as 10.6 million metric tons with 60% (about 5.8 million metric tons) grown in Africa with Nigeria having the largest production. Cocoyam has been reported to contain digestible starch, protein of good quality, ascorbic acid, thiamin, riboflavin, niacin and high scores of amino acids (Onayemi and Nwigwe, 1987). Taro has been reported to contain 70 – 80% starch with small size granules (Perez *et al.*, 2007; Ammar *et al.*, 2009), which result in high digestibility. According to Jane *et al.* (1992), starch derived from taro corm is unique because of its very small granular size ranging from 1 – 5 μ, significantly smaller than that of corn and wheat.

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Cocoyams also have higher content of protein and amino acids than tropical root crops (Key, 1987; Ikpeme *et al.*, 2010). According to Huang *et al.* (2007), the essential amino acid contents of taro corm proteins were fairly similar to the FAO reference pattern, except for the contents of sulphur containing amino acids, tryptophan and histidine.

The major limiting factor in the utilization of cocoyam is the presence of oxalates which impart an acrid taste or cause irritation when foods prepared from it are eaten and interfere with bioavailability of calcium (Sefa-Dedeh and Agyir-Sackey, 2004; Mbofung *et al.*, 2006), high rate of post-harvest losses and the lack of scientific attention (Mbofung *et al.*, 2006). Other problems associated with processing and utilization of cocoyam, among others, include low storage and bulkiness. For greater utilization, Eleje (1987) recommended that (i) cocoyam should be processed into more stable forms for better storage, (ii) investigation be made into forms that cocoyam corms and cormels should be converted to for ready utilization and acceptability, and (iii) further exploration be made on the use of cocoyam flour as a composite in specialty foods. Akomas *et al.* (1987) also suggested that cocoyam could be prepared into dehydrated forms to maintain stability and offer convenience and ease in preparation into other food forms. Ammar *et al.* (2009) noted that food aroid flour could be advantageous in the preparation of myriad products by the food development industry since it could be used in dehydrated soup formulation, baking goods, formulation of baby food, snacks and breakfast products.

In Nigeria, cocoyam flour is sold in some urban markets under the name "soup thickener". The particle size of these thickeners vary tremendously as the processors only make effort to remove coarse particles to improve eye appeal. Moreover, pre-treatments like blanching and sulphiting, which may likely improve the functional and organoleptic properties, are not considered by the local processors of the soup thickener. Most often, preference is made for the use of cormel over the corm. This work investigated the chemical composition of cocoyam corms and cormels and the effect of processing and particle size on the physicochemical and organoleptic properties of the flours for soup thickener.

Materials and Methods

Raw material procurement

Freshly harvested corms and cormels of taro (cocoyam) cultivar identified at the Department of Botany, University of Nigeria, Nsukka as *Colocasia esculenta var. esculenta* was purchased from Ekuluoko market at Afulugo in Igalamela/Odolu Local Government Area of Kogi State, Nigeria. The cocoyam was stored in a shade under a cashew tree and processed into flour within one week of procurement.

Processing of cocoyam into flour

Taro corms and cormels were separately washed, peeled into tap water to prevent or limit discolouration of the corms/cormels, cut into 3-5 cm thick slices and washed again to remove mucilage from the cut surfaces. The taro slices were divided into four equal parts. The first part was sun-dried without any treatment (NT). The second was blanched for 5 min in equal quantity of boiling tap water (w/v) before sun-drying (BT). The third was soaked (4 h, 0.025% (250 ppm) in sodium metabisulphite (Na_2S_2O5) solution (ST). The fourth was treated as the third and blanched in the same solution for 5 min (SBT). The treated (BT, ST and SBT) and untreated (NT) cocoyam slices were sun-dried (3 days, 34 ± 2^oC) on stainless steel trays placed on corrugated iron sheet 2 m above the ground.

The dried cocoyam slices were milled using 1A premier grinding mill driven by a Lister engine (Model RLA 201-80014, UK). The resulting cocoyam granules were sieved with Tyler Standard Screen mesh numbers 28, 35, 65 and 150 to give granule/flour particle sizes of 0.589, 0.417, 0.208 and 0.104 mm respectively. For convenience, these particle sizes were reported in this work as 0.6, 0.4, 0.2 and 0.1 mm respectively. The granules of particle size greater than 0.6 mm were discarded.

Preparation of cocoyam soup

Cocoyam soup was prepared using the recipe shown in Table 1. Slurry of cocoyam flour in boiling tap water was made. Vegetable oil (Canopy, Nigeria) and washed bitterleaf were added. After 10 min, Dried fish, crayfish, dried ground pepper, Magi seasoning and salt were added and the cooking continued for another 10 min over a kerosene stove. The soup was transferred hot into a food flask and kept warm till served.

Table 1: Recipe for cocoyam soup preparation

Ingredients	Quantity
Water	2 litres
Cocoyam flour	80 g
Washed bitterleaf	200 g
Dried fish	120 g
Crayfish	60 g
Magi	1 cube
Dried pepper	40 g
Salt	10 g
Groundnut oil	40 ml

Methods of Analysis

Proximate composition, amylose/amylopectin, ascorbic acid and oxalic acid contents determinations

Moisture content, air-oven method; crude protein, microKjeldahl method (N x 6.25); crude fat, Soxhlet extraction method; ash; and crude fibre were determined as described by Pearson (1976). Carbohydrate content was estimated by difference. That is, the sum of moisture, fat, ash, protein and crude fibre contents obtained from the above determinations was subtracted from 100. Amylose and amylopectin contents were determined using iodo-colourimetric assay as described by Bainbridge *et al.* (1996). Ascorbic acid content was determined using the indophenols titration method as described by Pearson (1976). Oxalic acid was determined using the method of Dye (1956) with slight modification described by Iwuoha and Kalu (1995).

Determination of total anthocyanin

Total anthocyanin (Acy) was determined using the method of Fuleki and Francis (1968) with slight modification. Five gram of cocoyam was macerated with 50 ml of 1.5 N HCl in 95 % ethanol (15:85), whose pH was adjusted to 1.0 in a Philip blender (type HR 1731, Brazil) at full speed (2000 rpm) for 5 min. the sample was transferred quantitatively to a 400 ml beaker using approximately 50 ml of extracting solvent for washing the blender jar. The beaker was covered with aluminum foil and stored overnight at 4^{o}C. The sample was filtered by suction on Whatman 1 paper through a Buchner funnel. The beaker and the residue on the filter paper were washed repeatedly with the extracting solvent until approximately 150 ml of extract was collected. The extract was transferred into 200 ml volumetric flask and made up to volume. This extract was kept in the dark to equilibrate for 2 h before the optical density (O.D.) was measured in 1 cm cuvette at 535 nm (Spectronic 21D, Milton Roy, Belgium). The total anthocyanin (T ACY) content was calculated in mg using the average extinction coefficient for cranberry anthocyanin.

$$\text{T ACY in mg per 5 g} = \text{O.D.} \times \frac{\text{TEV}}{\text{W}} \times \frac{1}{98.2}$$

Where O.D. = optical density (absorbance)
TEV = total extrac volume
W = weight of sample
98.2 = average extinction coefficient for cranberries divided by ten

The value obtained was multiplied by 20 so as to express as per 100.

Water and oil absorption capacities and bulk density determinations

The water and oil capacities were determined using centrifugal method as described by Okaka and Potter (1979) while bulk density was determined using the method of Akpapunam and Markakis (1981).

Statistical analysis

Data were subjected to analysis of variance and means, where significant, were discriminated using Tukey's least significant difference (LSD) test (Miller and Freund, 1987).

Results and Discussion

Chemical composition of fresh cocoyam corm/ cormel

Selected chemical compositions (dry weight basis) of fresh raw corms and cormels of *Colocasia esculenta var. esculenta* are shown in Table 2. The results showed that there were no significant differences ($p < 0.05$) in the compositions except in the oxalic acid content which is higher in the cormels. O'Hair *et al.* (1983) had reported that differences existed between the starch content of the corm and cormel of *Xanthosoma* species of cocoyam. Such was not observed in the *Colocasia* variety used in this work. The absorbances of various amylose/ amylopectin standards and of the cocoyam starch are shown in Table 3. From the regression equation ($\gamma = 0.0329X - 0.2627$) derived from the standard values, cocoyam corm and cormel respectively contain 34.04% and 34.26% amylose (and invariably about 66% amylopectin). Straus (1983) reported a range of means of amylose content of 3 to 43% for various taro (*Colocasia esculenta*) cultivars. The amylose content of sweet potato (19%), potato (25%), corn (25%), wheat 30%), rice (19%), cassava (17%) and sago palm (27%) was reported by Japan External Trade Organization (JETRO) (1980). According to Bainbridge *et al.* (1996), the ratio of amylose to amylopectin has a significant effect on the cooking properties of starch. Starches containing higher percentage of amylopectin have higher peak viscosity and paste stability. This means that the starch will produce thicker paste, which will be less likely to break down during cooking.

The ascorbic acid content of fresh raw corms and cormels of the cocoyam were 31.54 and 29.16 mg/ 100 g (dry weight). These values are lower than the range of 7 – 9 mg/ 100 reported by Onwueme

Table 2: Certain chemical composition of *Colocasia esculenta* fresh corms/cormels and flour as affected by treatments

Parameters	Fresh raw cocoyam			Cocoyam flour			
	Corm	Cormel	average	NT	ST	BT	SBT
Moisture* (%)	69.25	71.02	70.14	6.88^{b}	7.00^{b}	8.63^{a}	8.69^{a}
Protein (%)	8.72	9.35	9.04	7.85	-	8.07	8.02
Ash (%)	3.25	3.38	3.32	3.24	-	3.31	3.34
Crude fiber (%)	5.85	4.83	5.34	5.29	-	5.38	5.43
Crude fat (%)	0.78	0.86	0.82	0.80	-	0.79	0.81
Carbohydrate (%)	81.40	81.57	81.49	82.82	-	82.45	82.42
Amylase (%)	34.04	34.26	34.15	-	-	-	-
Amylopectin (%)	65.96	65.74	65.85	-	-	-	-
Ascorbic acid (mg/ 100 g)	31.54	29.16	30.35	8.95^{c}	16.28^{a}	13.73b	15.65^{a}
Anthocyanin (mg/ 100 g)	30.89	32.26	31.58	9.58^{c}	15.90^{a}	15.53^{a}	14.08^{b}
Oxalic acid (mg/100 g)	167.80	179.95	173.88	160.68^{a}	156.7^{b}	156.65^{b}	141.69^{c}
pH	-	-	-	6.51	6.34	6.62	6.36

-, not determined. Values with the different superscript along the row are different ($p > 0.05$)

(1978) and 15 mg/ 100 g total ascorbic acid reported by Eka (1998). The oxalic acid content of 167.80 and 179 mg/ 100 g dry weight were obtained for fresh raw cocoyam corms and cormels. These values are higher than 65 mg/ 100 g reported by Eka (1998) and 20 – 90 mg/ 100 g reported for 22 cultivars of taro in Papua New Guinea using high performance liquid chromatography (Wills *et al.*, 1983) but lower than 367 – 710 mg/ 100 g reported for three cocoyam cultivars (Iwuoha and Kalu, 1995). The anthocyanin content of 30.89 and 32.26 mg/ 100 g was obtained in the corms and cormels respectively (Table 2). These values are higher than 4.29 mg % reported for the *Lehua maoli* variety of *Colocasia esculenta* determined using gas chromatography (Chan and Kao-Jao, 1977).

Proximately, only moisture content was affected ($p < 0.05$) by blanching. Sulphiting as a treatment had no effect on the composition. As a result, the blanched (BT) and the sulphited and blanched (SBT) cocoyam flours had significantly ($p < 0.05$) higher moisture than the non-blanched (NT) and sulphited (ST) cocoyam flours. The higher moisture content may be as a result of reduced moisture loss through the hard external crust formed by drying gelatinized surface starch of cocoyam slices (Crabtree and Baldry, 1982).

Treatments significantly ($p < 0.05$) affected the ascorbic acid, anthocyanin and oxalic acid contents of cocoyam flours (Table 2). Lower ascorbic acid and anthocyanin contents in NT flour may have been caused by enzyme-catalyzed oxidation of ascorbic acid to dehydroascorbic acid (Fox and Cameron, 1984) and enzyme catalyzed hydrolysis of anthocyanin to anthocyanidin and simple sugars. These enzymes were likely inactivated by heat during blanching. Though to a lesser extent, ascorbic acid and anthocyanin contents of the cocoyam flour were reduced by blanching due to their heat susceptibility (Fox and Cameron, 1984; Markakis, 1982; Maza and Brouillard, 1987; Strack and Wray, 1989). Ascorbic acid could also be leached out into blanching water since it is water-soluble (Fox and Cameron, 1984). The greater retention of ascorbic acid in the SBT flours could be associated with combined effect of heat and metabisulphite on the oxidative enzymes. Sulphure dioxide (SO_2) is an oxidative enzyme poison (Potter, 1973). Fox and Cameron (1984) also stated that sodium metabisulphite ($Na_2S_2O_5$) is usually added to the water used for blanching vegetables because it improves both the colour and ascorbic acid retention.

It was observed that the colour of NT cocoyam flour was bluish-gray while those of ST, BT and SBT were white. Greenwell (1947) had reported that the gray to pink colour of taro posed a problem to its many uses such as a source of flour. Chan and Kao-Jao (1977) reported that freshly processed poi is also generally bluish-gray and that its probable colour change during lactic acid fermentation is due to anthocyanins, which are known natural pH indicator. They, however, observed that although anthocyanogens were detected in taro, they probably contributed little to the colour of poi because of the pH 6.3 of taro. The fact that sulphited (ST) and blanched (BT and SBT) cocoyam flours were white in colour, though containing higher amounts of anthocyanin (Table 2), is evident to this. The gray colour reported by Greenwell (1947), Chan and Kao-Jao (1977) and observed in NT flour could be caused by enzymatic browning and/or browning due to polyphenol-metal complex (if drying is done on non-stainless steel surfaces) rather than anthocyanin pigments.

Table 2 also indicates that blanching treatment and its combination with sulphiting has significant effect ($p < 0.05$) on the oxalic acid content of cocoyam flours. Heat is known to be effective in reducing the oxalic acid content of cocoyam. Hence, the lower oxalic acid content of the blanched (BT and SBT) flours than those of NT and ST flours. The loss of 7.52% of oxalic acid in NT may be suggesting that washing could reduce oxalic acid and that losses encountered in the blanched (BT and SBT) flours may not be due to heat alone. Oxalates such as sodium and potassium oxalates are soluble in water (Fox and Cameron, 1984) and could have probably leached into the washing and blanching waters. Sodium ion (Na^+) from the ionized $Na_2S_2O_5$, being higher in activity series, may have displaced the hydrogen ion (H^+) of oxalic acid and calcium ion (Ca^{++}) of insoluble calcium oxalate to form soluble Na oxalate. This may have leached into blanching water thereby leading to greater loss of oxalic acid in SBT flour.

The pH of cocoyam flour was increased by blanching treatment (BT) but was reduced when the latter was combined with sulphiting treatment (SBT) (Table 2). This may be indicating that certain acids volatilized during blanching treatment. Wills *et al.* (1983) reported that the major acids present in cocoyam were malic, citric and oxalic acid and that in all cultivars, malic is the major acid, which on the average comprises 60% of total acids. Citric and oxalic comprised about 25 and 15% of the total acids respectively. However, none of these acids is known to be volatile acid. The leaching out of some of these acids into the blanching water may have contributed to the increase in the pH of BT flour while $Na_2S_2O_5$, an acid salt, may have contributed to the reduction of the pH of the SBT flour.

Functional properties of cocoyam flour

Table 4 shows the effect of sulphiting, blanching, the combination of the two and particle size on the bulk density of cocoyam flours. Bulk density was significantly affected ($p < 0.05$) by blanching treatment. The bulk densities of blanched flours were generally higher. Ajewole and Ozo (1994) observed a similar increase in bulk density in pregelatinized tannia cocoyam flour. They reported that pregelatinized cocoyam flour was denser (0.7330 g/ cm^3) than the unpregelatinized cocoyam flour (0.5772 g/cm^3) and that since the two are less dense than water (1 g/cm^3), they can be prepared as slurries. Sulphiting did not affect the bulk density. Bulk density decreased with increasing particle size. The bulk density of unclassified ground cocoyam samples was not different from those that passed through 0.2 mm sieve. This may be indicating that the majority of the flour particles fall within this range.

Table 3: Absorbance of various amylase/amylopectin standards and of the cocoyam starch samples

% Amylose	Absorbance
0	0.000
10	0.210
20	0.425
25	0.520
30	0.605
Cocoyam corm	0.860
Cocoyam cormel	0.862

The water holding (absorption) capacity (WHC) of the cocoyam flours was significantly increased ($p < 0.05$) by blanching treatment (Table 5). This was also observed by Fagbemi and Olaofe (1998) who reported that precooking increased the WHC of taro from 275 to 300 % (m/m) and tannia 325 to 350 % (m/m). Also Iwuoha and Kalu (1995) reported an increase in the WHC of flours from cultivars of *Colocasia esculenta* from 2.49 ml/g to 2.96 ml/g after 3 min and to 3.44 ml/g after 30 min boiling at 90°C. Although the WHC of cocoyam flour decreased with increasing particle size (Table 5), the decrease was insignificant ($p > 0.05$). Generally, WHC is a measure of gum's (material's) ability to pick up water and retain it. It is equal to the moisture content of material after equilibration under a given condition such as humidification (Wallingford and Labuza, 1983). Based on this, the little variation in the WHC among the flours of different particle sizes may not have been expected considering an hour period of equilibration. According to Kinsella *et al.* (1985), the binding water includes all types of hydrated water and some water remaining loosely associated with protein following centrifugation. The smaller the particle size, the greater the surface area per unit mass. Hence, the higher WHC of flours of smaller particle size could be attributed to greater loosely adhering/associated surface moisture on the flours of smaller particle size. The presence of water in

Table 4: Bulk density (g/cm^3) of treated and non-treated cocoyam flours of various particle sizes

Treatments	Particle size (mm)				
	< 0.1	<0.2 >	< 0.4	<0.6	UCS
None	0.782^{ax}	0.753^{bx}	0.730^{cx}	0.650^{dx}	0.758^{bx}
Sulphited	0.778^{ax}	0.756^{bx}	0.728^{cx}	0.650^{dx}	0.761^{bxy}
Blanched	0.820^{ay}	0.795^{bz}	0.758^{cy}	0.667^{dy}	0.803^{by}
Blanched and sulphited	0.814^{ay}	0.788^{by}	0.758^{cy}	0.657^{dxy}	0.780^{by}

Values with different (i) superscripts along the row and (ii) subscripts within a column are significantly different at 5 % confident level. UCS – Unclassified cocoyam sample

Table 5: Water and oil absorption capacities (g/g) of treated and non-treated cocoyam flours of various particle sizes

Treatments	Particle sizes (mm)				
	< 0.1	**<0.2**	**<0.4**	**<0.6**	**UCS**
Water absorption capacity (g/ g)					
None	2.91_{x}	2.74_{x}	2.61_{x}	2.55_{x}	2.54_{x}
Sulphited	2.88_{x}	2.76_{x}	2.65_{x}	2.50_{x}	2.63_{x}
Blanched	3.24_{y}	3.20_{y}	3.17_{y}	3.11_{y}	3.02_{y}
Blanched and sulphited	3.17_{y}	3.12_{y}	3.12_{y}	3.05_{y}	3.10_{y}
Oil absorption capacity (g/ g)					
None	1.10_{ax}	1.05_{bcx}	1.08_{abx}	1.05_{bcx}	1.02_{cx}
Sulphited	1.13_{ax}	1.12_{axy}	1.09_{abx}	1.05_{bx}	1.14_{ay}
Blanched	1.18_{ay}	1.16_{ay}	1.15_{ay}	1.16_{ay}	1.13_{ay}
Blanched & sulphited	1.22_{ax}	1.14_{bcy}	1.17_{aby}	1.11_{cxy}	1.10_{cy}

Values with different (i) superscripts along a row, (ii) subscripts within a column are significantly different at 5 % confident level

Table 6: Mean sensory scores on preference for cocoyam flours colour and texture and acceptability of soup prepared from the flours

Treatments	Particles sizes				
	< 0.1	**< 0.2**	**< 0.4**	**< 0.6**	**UCS**
Colour preference for flours					
None	4.9^{a}_{z}	3.6^{bc}_{x}	2.9^{c}_{x}	3.9^{b}_{x}	3.6^{bc}_{x}
Sulphited	5.8^{a}_{xy}	5.1^{b}_{y}	4.7^{b}_{y}	4.4^{b}_{x}	4.5^{b}_{xy}
Blanched	5.3^{a}_{xy}	4.4^{b}_{xy}	4.4by	4.1^{b}_{x}	4.6^{b}_{y}
Blanched % sulphited	6.4^{a}_{y}	4.8^{b}_{xy}	4.5^{b}_{y}	4.3^{b}_{x}	4.4^{b}_{xy}
Texture preference for flours					
None	5.25^{a}	4.25^{b}	3.75^{b}	3.50^{b}	4.00^{b}
Blanched	5.90^{a}	4.80^{b}	4.30^{bc}	3.60^{d}	4.00^{b}
Sulphited	4.86^{a}	4.13^{bc}	4.50^{ab}	3.45^{c}	4.50^{ab}
Blanched and sulphited	6.25^{a}	4.63^{b}	3.88^{c}	3.50^{d}	4.25^{bc}

General acceptability of soups from flours					
None	5.50	4.50	4.80	4.70	4.90
Sulphited	5.20	4.40	4.50	4.60	4.70
Blanched	4.00	4.00	4.60	4.00	3.90
Blanched & sulphited	4.20	4.90	4.60	4.20	4.80

Values with different (i) superscripts within a row (ii) subscripts within a column
are significantly different at 5 % confident level

foodstuff and its concentration depends on water absorption capacity and stability and this determines to a high degree the palatability, digestibility, physical structure and technical handling (Rey and Labuza, 1981).

The oil absorption capacity (OAC) of cocoyam flour is shown in Table 5. Like the WHC, blanching treatment significantly increased ($p < 0.05$) the OAC. Fagbemi and Olaofe (1998) and Iwuoha and Kalu (1995) reported similar increase in the OAC of taro and tannia by precooking. The influence of particle size on the OAC was not certain. The table revealed that the OAC of NT, ST and SBT flours were significantly affected ($p < 0.05$) by particle size whereas that of the BT flour was not. In the samples where particles size had significant effect on OAC, only the difference in the values for the flours of 0.1 and 0.6 mm particle sizes seemed to be significant ($p < 0.05$).

Sensory properties

The mean sensory scores on colour preference of cocoyam flours as affected by processing treatments (NT, BT and SBT) and particle size are provided in Table 6. The colour of the blanched cocoyam flours (BT and SBT) and sulphited cocoyam flour (ST) was significantly rated higher ($p < 0.05$) than that of the non-blanched, non-sulphited (NT) flour. Although the description of the colour was not evaluated due to lack of trained panellists, it was observed that NT flour was bluish-gray whereas ST, BT and SBT flours were white. Particle size also significantly affected ($p < 0.05$) the rating of the colour of the cocoyam flours. The colour of the flours of 0.1 mm particle size was significantly rated higher ($p < 0.05$) than those of 0.2, 0.4, 0.6 mm and the UCS. The preference for the colour of the flour particle sizes of 0.2, 0.4, 0.6 mm and the UCS are the same ($p > 0.05$). The greater preference for the flours of 0.1 mm particle size may be attributed to higher reflectance of the samples.

The texture scores of the flours were significantly affected ($p < 0.05$) by particle size only. It decreased with increasing particle size. This implies that generally, irrespective of treatment, the flours with finer particle size were preferred. This is not surprising because soup thickening and smoothness demand that the thickener should undergo fine milling. Like in bulk density, the texture scores of UCS flours were not different ($p < 0.05$) from those of the 0.2 mm particle size flours thereby suggesting that most of the flour particle size fall around 0.2 mm. However, neither the treatments nor the particle size significantly ($p > 0.05$) affected the mean sensory scores on acceptability of the soups prepared from the cocoyam flours.

Conclusion

The chemical compositions of *Colocasia esculenta* corm and cormel, considered on dry weight basis, are not different. Hence, the choice of either corm or cormel for any preparation may not be necessary. Blanching and sulphiting treatments did not affect the proximate compositions of the flours but affected the ascorbic acid, anthocyanin and oxalic acid contents. Blanching increased the water and oil absorption capacities, bulk density and aesthetic value of the flour. Sulphiting and particle size classification only improved the aesthetic value of the flour. Neither treatment nor particle size classification affected the acceptability of the soups prepared from the cocoyam flours. The increase in aesthetic value by the treatment and particle size classification may be a marketing tool. The effect of the treatments and particle size classification on other applications of the flour should be studied.

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