

Evaluation of Cocoyam Cormels and Their Sections' Flours For A Traditional Stiff Porridge ''Amala''

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Abstract
Cocoyam Cormels, an underutilized crop of two varieties *Xanthosoma sagittifolium* of cultivars (NX_s001, NX_s002) and *Colocasia esculenta* of cultivars (NC_e002, NC_e003 and NC_e005) length were sectioned into three (apical, middle and distal) and processed into flour using traditional method. This was done with the aim of using the flour to produce a stiff porridge "Amala" – a dough like meal, popular among the "Yoruba" tribes in the Southwest of Nigeria. Physicochemical, functional, and pasting properties of the flours as well as sensory textural evaluation of their pastes were evaluated. Proximate composition of sections of the cocoyam cultivars revealed moisture (10.25-12.54%), Crude Fat (0.39-0.75%), Crude Protein (3.25-4.26%), Ash (2.56-3.54%), Carbohydrate (78.20-80.76%) and Crude Fibre (1.28-2.38%). Protein is concentrated in the apical section of all the cultivars; similarly flours from apical section had higher water absorption capacity (120.25%). Flour obtained from the middle section of the cormels had higher level of Ash, Crude Fibre, Carbohydrate, Swelling Power, and Solubility Index. Pasting properties of sections of cocoyam cormels flours were significantly different, with apical section having higher peak viscosity (72.50-305.42RVU), breakdown viscosity (3.75-15.07RVU) for *Colocasia* variety. High set back viscosity (170.25-184.58RVU) was recorded at the distal section of *Colocasia* varieties. Dough obtained from the middle section of NCe002 was relatively more elastic, mouldable, cohesive, smooth and fairly adhesive. Variations in the physiochemical properties of flour obtained from different sections of the cormels could enhance their use in different food applications. Cocoyam can be processed into flour through a traditional method of producing yam flour 'Amala'.
Keywords:- Cocayam Cormels, Cocoyam Section, Cocoyam Flour, Physicochemical Properties, Textural Properties. Amala.

1. Introduction

Root and Tuber crops contribute majorly to food security in Africa. They present an important starch rich staple food particularly in West Africa. The principal root and tuber crops of the tropic are Cassava *(Manihot esculenta Crantz)*, Yam *(Dioscorea spp)*, Sweet Potato *(Ipomoea batatas L)*, Potato *(Solanum spp)* and edible aroids *(Colocasia spp* and *Xanthosoma sagittifolium)*. The potential of these crops is particularly high in the humid and those sub-humid tropics, and it is estimated that about 300million tons were produced in 1993. (FAO, 1993).

Root and Tuber crops are second only in importance to cereals as a global source of carbohydrate, they also provide some minerals and essential vitamins, although a proportion of the minerals and vitamins may be lost during processing. In most traditional diets, vegetable soups, meat, groundnuts, grain legumes and fish are good sources of protein and are frequently used to supplement root crops and their products to compensate their protein deficiencies. In some parts of Africa the diet is supplemented with the tendered leave of sweet potato, cassava and cocoyam which are rich in protein minerals and vitamins. (Hahn,1954).
They are characterized with high moisture content typically 70%-80%, large unit size - typically 100g to 15kg, high respiration rate, soft texture and easily exposed to losses caused by rotting (bacteria and fungi), senescence, sprouting and bruising (FAO, 1983). All these are factors responsible for their perishability and their natural shelf life is a few days to few months. The high moisture content is critical for high deterioration rate after harvest and perishability that follows result in their limited availability especially during off season. This informed processing of root and tuber corps into flour which eventually reduces food losses, transportation cost and increase their versatility and utilization in food formulations.

Among the flour produced through traditional methods which may include peeling, cutting, parboiling, fermentation, sundrying, and milling is "Elubo". It is transformed to a dough like food popularity called "Fufu" when turned in boiling water until a gelatinous mass "Amala" is obtained Onayemi (1985) described important characteristics common to African foods made from root and tuber corps of which "Amala" is one, and stated that the characteristics used to measure overall acceptability were smoothness, cohesiveness, springiness, ability to work into spherical mass and ease of swallowing without mouth coating.

"Amala" is a popular starchy ethnic "Fufu" like meal commonly eaten by ethnic Yoruba's of South-Western Nigeria and it is increasingly consumed among non-ethnic Yoruba consumer in Nigeria and some other countries in the Western Coast of Nigeria (Idowu et al, 2013). It is exclusively produced from yam or cassava . Among these sources, yam flour is believed to be the most preferred because of its traditional importance and unique textural properties (Jimoh et al., 2007). Proximate composition of yam flour indicates moisture (8%), protein (3.2%), fibre (1.2%) and carbohydrate (83.5%), (Abiodun et al, 2012). Development of dough like "Fufu" from flours of underutilized tuber like cocoyam is possible because cocoyam is consumed essentially the same forms as yam. It can be eaten boiled, fried and pounded into "Fufu", although it is not considered prestigious as yam. Cocoyam corms supply easily digestible starch and are known to contain substantial amount of protein, vitamin C, thiamine, riboflavin, niacin and significant amount of dietary fibre (Niba, 2003). Cocoyam has also been reported in folklore medicine in the management of diabetic mellitus (Eleazu, et al, 2013). The current trend in nutrition is the consumption of slowly digested food product as well as an increase intake of functional food. Therefore, cocoyam, apart from offering similar usage as yam, offers nutritional advantages that could make them useful in the production of functional foods. Cocoyam cormels has also been reported to show distinctive variation within the tuber from the distal attachment to the growing apex. Studying the production potential of "Amala" from varieties of cocoyam *(Colocasia spp and Xantosoma sagittifolium)* and their sections (apical, middle distal) could enhance its utilization. Therefore, the aim of this work was to evaluate the production potential of "Amala" from cocoyam cormels and present the physicochemical properties of flour obtained from sections of cocoyam cormels.

2.0 Methodology

2.1 Materials

The materials used for the research, cocoyam cormels varities – *Colocasia esculenta* (NCe002, NCe003, NCe005) and *Xanthosoma sagittifolium* (NXs001, NXs002) were obtained from the National Roof Crops Research Institute, Umudike, Abia Sttae, Nigeria.

2.2 Preparation of Cocoyam Flour

Cormels of Cocoyam varieties investigated were sorted, peeled and sectioned into three (apical, middle and distal) using a modified method of Sefah-Dedeh and Sackey (2002). The peeled samples length taken was cut and divided into three in ratio 2:3:1 for distal, middle and apical sections.

The samples were parboiled at 50^{o}C for 15minutes, they were left to cool in the same parboiled water for 24hours, drained and dried for 2weeks in a locally made solar dryer. The dried samples were milled in a laboratory harmer mill with mesh size 600µm. Samples were packed in HDPE, sealed and kept in the laboratory at ambient temperature.

2.3 Cocoyam Paste "Amala" preparation:

The method of Babajide and Olowe (2013) was used in preparing the paste. 50g of cocoyam flour was stirred in 150ml of boiling water until gelatinized; the gelatinized paste was left to cook for 5 minutes with constant stirring until a consistent smooth paste was formed. The pastes were wrapped in polyethylene films and left inside warmer until sensory evaluation was conducted.

2.4 Sensory evaluation

Texture characteristics of the pastes were evaluated in terms of Elasticity, Mouldability, Cohesiveness, Adhesiveness and Smoothness by 15 member panelist using texture characteristic method as described by Szezesniak (1963). Samples were scored based on 9points hedonic scale where 9 was extremely liked, 5 was neither like nor disliked and 1 was extremely disliked.

2.5 Analysis

2.5.1 Proximate composition of cocoyam flours

Chemical analysis was conducted by determining the moisture, crude protein, crude fat, crude fibre and ash contents of the flours by the standard official methods (AOAC, 1990). Carbohydrate was determined by difference.

2.5.2 Swelling Power

Swelling power of the samples was determined by the modified method of Leach et al (1959) as described by Oladeji et al (2013). 5g of sample was dispensed in 40ml distilled water. The resultant slurry was heated in the water bath at 70^{o}C for 30minutes. The slurry was cooled to room temperature and centrifuged at 2300rpm for 30minutes. The supernatant liquid was decanted and the centrifuge tube was dried in a hot air oven at 50^{o}C for 25 minutes. The weight of the gel in the centrifuge tube was determined. The swelling power was calculated as:-

Swelling power = $\frac{Weight\ of\ the\ wet\ mass\ of\ \ se\dim ent}{Weight\ of\ Sample} \times 10\%$

2.5.3 Bulk Density
The bulk density was determined by the method of Wang and Knisella (1976). 5g of sample was weighted into 50ml graduated measuring cylinder. The samples were packed by gently tapping the cylinder on the bench top 10times from height of 5cm. The volume of the sample was recorded:-

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

2.5.4 Water Absorption Capacity and Water Solubility Index
Solusulki (1962) method of determining Water Absorption and Water solubility index was used. The crucible and centrifuge tubes were dried in the hot air oven at 105^{o}C for 20miutes and allowed to cool in a descicator. 1g of sample was weighted into the tube and 10ml of distilled water added and stirred gently for 30minutes. The tube containing the paste was centrifuged at 4000rpm for 15min, on completion of the 15minutes, the supernatant was decanted into crucibles and dried in the oven at 105^{o}C until the supernatant was dried off. The residue remaining in the tubes was weighed and the crucible after drying was weighed.

$$\text{Water absorption index} = \frac{Weight\ of\ tube + residue - Wgt\ of\ empty\ tube}{Weight\ of\ Sample} \times 100\%$$

Water solubility Index = $\frac{Weight\ of\ crucible\ after - Wgt\ of\ empty\ crucible}{Weight\ of\ Sample} \times 100\%$

2.5.5 Pasting Properties
Pasting properties were determined using Rapid Visco Analyser (RVA Super 3, Newport Scientific Pty. Ltd. Australia). A 3g sample of flour was dissolved in 25ml of water in a sample canister. The sample was thoroughly mixed and fitted into the RVA. The slurry was heated from 50-95^{o}C within a holding time of 2min followed by cooling to 50^{o}C with another 2min holding time. The 12min profile was used and the rate of heating and cooling was at constant rate of 11.25^{o}C/min. Corresponding values for peak viscosity, trough breakdown viscosity, final viscosity, set back, peak temperature and peak time forms the pasting profile read through the computer connected to the RVA.

Variation was generally observed in the proximate composition values obtained among the varieties and cormels sections, this is indicated by a significant difference shown through statistical analysis.
Proximate composition of flours from different sections of cocoyam varieties is shown in Table 1. Moisture content ranged between 10.33-12.54%. The moisture is still within the safe moisture level for prevention of microbial proliferation if packaged in a well sealed environment. Low level of moisture has been reported to be unfavourable to microbial growth but give relatively longer shelf life to food (Jimoh and Adeoti, 2009). Crude fat content of all the varieties and sections investigated was found to be less than 1%, this is desirable as fat especially those containing saturated fatty acid cause heart related diseases. Generally, the protein content of all the flours investigated was between 3.25-4.25%, the result is in contrast to the one reported by Oladeji et al (2013). This could be due to varietal difference as the particular species of *Colocasia esculenta* used was not reported.

Sections of cocoyam cormels revealed that protein is more concentrated in the apical section of all the varieties investigated, this is in contrast with the report of Sefa-Dedeh and Agyir-Sackey (2002) where distal section was reported to have higher protein. *Colocasia esculenta* varieties generally have higher protein content (3.66-4.25%) than Xanthosoma varieties (3.25-3.81%). Similar observation has been reported for protein composition of cocoyam varieties (Agbo-Egbe and Richard, 1990, Sefa-Dedeh and Agyir Sackey, 2002). Protein contents of root and tubers from which African traditionally processed staples are produced are lacking in proteins. A low value of protein content (0.31%) for cassava garri, (3.16%) for yam flour, (5.1%) for plantain flour, (5.7%) for breadfruit flour have been reported (Kolapo and Sanni 2009., Jimoh and Olatidoye, 2009., Oladeji et al, 2013).

3.0 Results and Discussion

Table 1: Proximate Composition of flours of Cocoyam Varieties and their Sections

Samples	Moisture	Fat	Protein	Ash	CHO	Fibre
NCe002						
Apical	10.34^{k}±0.01	0.64^{d}±0.07	4.25^{a}±0.01	3.23^{d}±0.02	80.30^{d}±0.07	1.70^{l}±0.03
Middle	10.25^{l}±0.01	0.66^{c}±0.00	3.78^{f}±0.01	3.35^{h}±0.01	80.76^{a}±0.01	1.66^{f}±0.01
Distal	11.46^{e}±0.01	0.64^{d}±0.01	3.87^{d}±0.01	2.85^{h}±0.01	79.17^{j}±0.01	1.58^{g}±0.01
NCe003						
Apical	11.05^{h}±0.01	0.66^{c}±0.01	3.93^{h}±0.01	3.05^{f}±0.02	78.21^{m}±0.02	1.36^{j}±0.01
Middle	12.54^{a}±0.01	0.58^{f}±0.03	3.67^{h}±0.01	3.54^{a}±0.01	80.58^{b}±0.02	1.43^{l}±0.02
Distal	10.25^{l}±0.01	0.59^{f}±0.00	3.78^{f}±0.01	2.76^{i}±0.02	80.08^{e}±0.02	1.87^{g}±0.01
NC_e005						
Apical	11.77^{d}±0.01	0.65^{d}±0.01	3.96^{b}±0.01	2.60^{j}± 0.01	79.36^{h}±0.02	1.68^{f}±0.01
Middle	10.33^{k}±0.01	0.74^{a+}±0.01	3.66^{i}±0.01	3.26^{c}±0.01	80.28^{d}±0.01	2.38^{a}±0.01
Distal	11.87^{c}±0.01	0.57^{g}±0.00	3.82^{e}+0.01	2.76^{i}±0.01	78.82^{l}±0.01	1.63^{g}±0.01
NXs001						
Apical	11.45^{f}±0.02	0.74^{a}±0.00	3.81^{e}±0.01	2.96^{g}±0.01	79.35^{h}±0.02	1.75^{e}±0.01
Middle	10.46^{j}±0.01	0.46^{h}±0.00	3.68^{k}±0.01	2.96^{g}±0.01	80.16^{e}±0.01	2.26^{b}±0.09
Distal	12.24^{b}±0.02	0.62^{e}±0.00	3.76^{g}±0.01	2.75^{i}±0.01	79.32^{i}±0.01	1.28^{l}±0.09
NXs002						
Apical	11.24^{g}±0.01	0.39^{i}±0.03	3.68^{h}±0.01	2.56^{k}±0.01	79.86^{t}±0.01	1.48^{h}±0.01
Middle	10.65^{l}±0.02	0.74^{a}±0.02	3.25^{k}±0.01	3.18^{e}±0.01	80.38^{c}±0.02	2.17^{c}±0.01
Distal	11.34^{f}±0.02	0.69^{b}±0.00	3.52^{j}±0.01	3.23^{d}±0.01	79.41^{g}±0.02	1.34^{k}±0.01

Values are Means ± SD (n=3). Values in the same column with different superscripts are significantly difference ($p < .05$).

Ash, an indication of mineral elements, as well as fibre were found to be concentrated in the middle sections of the cormels of Colocasia varieties. Comparing these to the values reported for flours obtained from yam, breadfruit and plantain by Oladeji et al (2013), cocoyam flour seems to be better in terms of nutrient composition, as higher Ash level indicates higher mineral content and higher crude fibre indicates higher content of roughage that aids digestion (Eva, 1983).

The middle sections of all the varieties investigated contain higher content of carbohydrate. Carbohydrate is a function of starch, cellulose, hemicelluloses etc present. Results indicated that cocoyam cormels flour is highly rich in carbohydrate, the starch level in cocoyam flour has been reported to be around 78.5% (Oladeji et al 2013). "Amala" is a gelatinized paste and the chemistry of its paste development is highly linked to its starch content, nature and quality (Jimoh et al 2009). The starch content of cocoyam flour may be responsible for the textual characteristics observed in cocoyam flour paste (Amala).

Table 2 shows the functional properties of cocoyam cormels flour. High water absorption capacity and retention has been suggested to aid better performance of product texture development. Generally, there was a significant difference in the water absorption capacity of samples especially in the flour obtained from the cormels sections, the apical sections had is linked to higher content of undamaged starch granules in flour (Mayaki et al., 2003). Cocoyam cormels flour is the closest alternative to yam especially in terms of pounding for food (Oladeji et al 2013), a relatively same Water Absorption Capacity (WAC) could be a contributive factor.

Table 2. Functional Properties of Flour of Cocoyam Varieties and its Sections

Samples	WAC(%)	SWP(%)	SI	Bulk density (g/ml)
NCe002				
Apical	117.54^{c}±0.01	11.65^{f}±0.03	10.97^{f}±0.01	0.52^{b}±0.02
Middle	100.45^{i}±0.01	12.66^{b}±0.01	11.36^{c}±0.01	0.53^{b}±0.01
Distal	110.54^{h}±0.01	11.66^{f}±0.01	11.04^{de}±0.01	0.51^{d}±0.01
NCe 003				
Apical	11.24^{ef}±0.01	11.76^{e}±0.01	11.13^{b}±0.01	0.50^{c}±0.02
Middle	115.55^{e}±0.01	12.40^{c}±0.00	11.76^{b}±0.01	0.54^{c}±0.01
Distal	113.35^{g}±0.01	12.14^{c}±0.01	11.06^{de}±0.01	0.54^{d}±0.01
NC$_e$005				
Apical	120.25^{a}+0.01	11.25^{h}±0.02	10.29^{i}±0.00	0.52^{b}±0.03
Middle	119.95^{b}±0.01	12.43^{c}±0.01	10.36^{h}±0.01	0.54^{d}±0.01
Distal	111.10^{h}±0.01	11.23^{h}±0.01	10.26^{i}±0.02	0.55^{a}±0.01
NX$_5$001				
Axial	116.63^{d}±0.01	11.35^{h}±0.01	10.02^{j}±0.01	0.37^{d}±0.02
Middle	100.36^{i}±0.01	12.24^{d}±0.01	11.47^{c}±002	0.47^{d}±0.01
Distal	100.23^{ij}+0.01	11.48^{g}+0.01	10.56^{g}±0.01	0.47^{d}±0.01
NX$_5$002				
Axial	112.23^{g}±0.01	12.25^{d}±0.01	11.45^{c}±0.02	0.44^{e}±0.02
Middle	112.24^{g}±0.01	12.77^{a}±0.01	11.87^{a}±0.01	0.47^{d}±0.01
Distal	110.76^{h}±0.01	11.14^{i}±0.01	10.23^{ij}±0.02	0.49^{cd}±0.01

Values are Means ± SD (n=3). Values in the same column with different superscripts are significantly difference ($p <.05$).

Cocoyam Cormels flour generally showed good swelling power in all the varieties investigated, although the middle section had highest swelling index. Swelling power may be attributed to small particle size of the cocoyam starch and its highly digestible nature. Carbohydrate content and damage done on the starch during milling operation could also be responsible for different swelling index among the sections.

Middle section of the cormel had higher carbohydrates and the starch is likely to be more damaged due to irregularity in its shapes and size,this may be one of the reasons for its high swelling power. Sefa Dedeh and Agyir (2002) reported differences in the starch granules of the varieties *(Coclocasia and Xantosoma)* as well as their cormels sections (Apical, middle and distal). Water solubility index was significantly different in all the varieties, NCe005 had the lowest solubility index, this was even indicated in the section as lowest solubility index was observed in the flours from apical, middle and distal sections (Table 2). *Colocasia spp* has been reported to have small size granules and lower solubility. (Kar et al., 2002).

Bulk density is a measure of how compacted the flour is, it is important for determination of material handling and packaging. Flours from *Colocasia spp* species appears to be denser than those from *Xantosoma spp* as shown for *NCe002*, *NCe003* and *NCe005*. For the cormels sections, it appears as if the bulk density of flours increased across apical, middle and distal sections. High bulk density of flour may results from blanching and milling processes the cormels undergone during flour production, as these processes might have removed the inter cellular air space in the material.

Table 3. Pasting Properties of Flour of Cocoyam Varieties and its Sections

Samples	Peak viscosity (RVU)	Through (RVU)	Breakdown (RVU)	Final Viscosity (RVU)	Set back (RVU)	Real True (MU)	Real Temp. (^{O}C)
NC_e002							
Apical	$296.16^{b}\pm0.23$	$145.66^{b}\pm0.00$	$15.87^{a}\pm0.06$	$202.28^{j}\pm0.07$	$56.63^{m}\pm0.04$	$6.32^{f}\pm0.03$	$83.66^{f}\pm0.01$
Middle	$44.67^{hi}\pm0.02$	$39.42^{n}\pm0.00$	5.25 ± 0.00	110.17 ± 0.00	$70.75^{d}\pm0.00$	$6.45^{d}\pm0.00$	$84.16^{b}\pm0.00$
Distal	$62.75^{f}\pm0.00$	$60.58^{i}\pm0.00$	$2.17^{m}\pm0.00$	$230.83^{f}\pm0.00$	$170.25^{f}\pm0.00$	$5.43^{l}\pm0.00$	$84.12^{c}\pm0.00$
NC_e003							
Apical	$305.42^{a}\pm0.00$	$160.50^{a}\pm0.00$	$14.92^{b}\pm0.00$	$216.17^{l}\pm0.00$	$55.67^{n}\pm0.00$	$6.44^{d}\pm0.00$	$83.38^{g}\pm0.00$
Middle	$74.75^{d}\pm0.00$	$70.58^{d}\pm0.00$	$4.17^{g}\pm0.00$	$262.500^{a}\pm0.00$	$88.33^{t}\pm0.00$	$6.95^{a}\pm0.00$	$83.46^{l}\pm0.00$
Distal	$68.67^{e}\pm0.00$	$66.00^{g}\pm0.00$	$2.67^{k}\pm0.00$	$257.33^{b}\pm0.00$	$191.33^{c}\pm0.00$	$6.18^{g}\pm0.00$	$83.95^{c}\pm0.00$
NC_e005							
Apical	$72.50^{d}\pm0.00$	$68.75^{g}\pm0.00$	$3.75^{i}\pm0.00$	$252.75^{d}\pm0.00$	$161.00^{h}\pm0.00$	$5.28^{m}\pm0.00$	$83.38^{h}\pm0.00$
Middle	$47.50^{h}\pm0.00$	$43.58^{m}\pm0.00$	$3.92^{h}\pm0.00$	$112.25^{n}\pm0.00$	68.67 ± 0.00	$5.5^{gj}\pm0.00$	$83.46^{i}\pm0.00$
Distal	$65.75^{ef}\pm0.00$	$60.83^{i}\pm0.00$	$4.92^{c}\pm0.00$	$222.42^{g}\pm0.00$	$184.58^{d}\pm0.00$	$5.57^{k}\pm0.00$	$84.22^{d}\pm0.00$
$NX_5$001							
Axial	$60.83^{f}\pm0.00$	$58.25^{i}\pm0.00$	$2.58^{l}\pm0.00$	$220.17^{h}\pm0.00$	$163.92^{g}\pm0.00$	$5.86^{h}\pm0.00$	$84.05^{d}\pm0.00$
Middle	$238.20^{c}\pm0.17$	$125.42^{c}\pm0.00$	$12.65^{c}\pm0.00$	$162.27^{k}\pm0.00$	$170.20^{f}\pm0.00$	$6.88^{c}\pm0.00$	$82.59^{a}\pm0.00$
Distal	$69.92^{e}\pm0.00$	$67.25^{f}\pm0.00$	$2.67^{k}\pm0.00$	$250.00^{c}\pm0.00$	$192.92^{b}\pm0.00$	$5.86^{c}\pm0.00$	$82.95^{m}\pm0.00$
$NX_5$002							
Axial	$50.33^{g}\pm0.00$	$46.83^{l}\pm0.00$	$3.50^{j}\pm0.00$	$120.25^{nn}\pm0.00$	$143.42^{c}\pm0.00$	$5.50^{i}\pm0.00$	$83.45^{i}\pm0.00$
Middle	$66.67^{e}\pm0.00$	$62.42^{h}\pm0.00$	$4.25^{f}\pm0.00$	$256.75^{c}\pm0.00$	$161.92^{h}\pm0.00$	$5.55^{k}\pm0.00$	$82.55^{m}\pm0.00$
Distal	$57.33^{g}+0.00$	$48.67^{k}\pm0.00$	$2.67^{k}\pm0.00$	$137.25^{k}\pm0.00$	$194.58^{a}\pm0.00$	$5.50^{e}\pm0.00$	$83.52^{h}\pm0.00$

Values are Means ± SD (n=3). Values in the same column with different superscripts are significantly difference ($p <.05$).

Table 3 shows the pasting properties of cocoyam cormels and their sections. There was a significant difference in the peak viscosities of the varieties as well as the sections of the cormels. Apical sections of Colocasia species (NCe002, NCe003, NCe005) had highest peak viscosity, this is in contract to the work reported by Sefa-Dedah and Agyir, (2002) where distal section was reported to have higher viscosity. Xanthosoma species (NX_S001 and NX_S002) had higher peak and through viscosities in the middle section, this is in agreement with the findings of Sefa-Dedah and Agyir, (2002). Hoover (2001) reported easy disintegration of granules due to weaker cohesive forces when subjected to heat, as reason for high peak viscosity. Flours of apical section of *Colocasia spp* and the middle section of *Xantosoma Spp* have high viscosities probably due to their smaller granular size as reported by Sefah-Dedeh and Agyir (2002). The peak viscosity of cocoyam, bread fruit and plantain was also reported to be lower compared to that of yam flour; this could be part of the reasons for a better pasting performance of yam flour as reported by Oladeji et al (2013), this infers that there is correlation between high viscosity of flours and better pasting performance. The apical section of *Colocasia spp* and middle section of *Xantosoma spp* have higher viscosities; this may be responsible for a good pasting performance exhibited in their textural evaluation. The tendency of cooked paste to recover back to its crystalline form of its native flour form is determined by set Back value. The distal sections of all the cultivans had higher set back value; this is more noticeable in the *Xantosoma spp*. Sefah Dedeh and Agyir (2002) ascribed high retrogradation property of *Xantosoma spp* to high degree of association of starch molecules caused by strong tendency for hydrogen bond formation. Retrogradation is one of undesirable properties exhibited during cooling by paste of some starchy roots and tubers in which yam flour paste is among. Cocoyam flour paste exhibited similar pattern and this is reflected in the low scores of sensory textual ratings for mouldability, cohesiveness and smoothness of pastes obtained from the distal section of *Xantosoma spp* especially NX_S002.

Table 4. Sensory Textural Evaluation of Paste from Flours Cocoyam Cormels and their sections

Sample	Elasticity	Mouldability	Cohesiveness	Adhesiveness	Smoothing
NCe002					
Apical	$2.10^{d}\pm0.03$	$2.00^{d}\pm0.03$	$2.70^{e}\pm0.09$	$2.30^{hi}\pm0.09$	$2.80^{ef}\pm0.02$
Middle	$3.80^{ab}\pm0.03$	$3.80^{b}\pm0.02$	$4.20^{b}\pm0.03$	$5.50^{b}\pm0.03$	$5.50^{b}\pm0.02$
Distal	$3.10^{c}\pm0.02$	$3.30^{bc}\pm0.06$	2.40 ± 0.03	$4.50^{cd}+0.03$	$3.10^{e}\pm0.02$
NCe 003					
Apical	$2.50^{cd+}\pm0.01$	$2.10^{d}\pm0.08$	$3.30^{d}\pm0.02$	$3.30^{ef}+0.07$	$4.90^{bc}\pm0.02$
Middle	$3.20^{bc}+0.02$	$3.20^{bc}\pm0.09$	$3.45^{cd}\pm0.01$	$3.30^{ef}+0.01$	$4.30^{d}\pm0.02$
Distal	$2.80^{cd}\pm0.09$	$2.00^{d}\pm0.01$	$2.50^{e}\pm0.08$	$2.30^{hi}\pm0.01$	$4.60^{cd}\pm0.02$
NC_e005					
Apical	$2.70^{cd}\pm0.02$	$2.90^{c}\pm0.08$	$3.10^{d}\pm0.09$	$2.90^{g}\pm0.01$	$4.80^{c}\pm0.03$
Middle	$4.20^{a}\pm0.03$	$3.30^{bc}\pm0.06$	$3.10^{d}\pm0.05$	$3.40^{e}\pm0.02$	$4.00^{de}\pm0.01$
Distal	$2.40^{d}\pm0.08$	$3.10^{bc}\pm0.06$	$4.60^{ab}\pm0.02$	$4.00^{d}\pm0.02$	$2.50^{f}\pm0.02$
$NX_5$001					
Axial	$3.20^{bc}\pm0.02$	$5.00^{a}\pm0.04$	$4.50^{ab}\pm0.02$	$5.00^{b}\pm0.01$	$5.64^{b}\pm0.07$
Middle	$3.60^{b}+0.02$	$3.80^{b}\pm0.03$	$4.40^{ab}\pm0.02$	$4.60^{c}\pm 0.02$	$5.06^{bc}\pm0.02$
Distal	$3.40^{bc}\pm0.05$	$4.50^{ab}\pm0.05$	$4.00^{bc}\pm0.06$	$4.60^{c}\pm0.01$	$6.10^{a}\pm0.01$
$NX_5$002					
Axial	$3.60^{b}\pm0.09$	$4.70^{ab}\pm0.03$	$4.80^{a}\pm0.03$	$5.90^{a}\pm0.01$	$5.40^{b}\pm0.02$
Middle	$3.90^{ab}\pm0.06$	$3.60^{ab}\pm0.03$	$3.50^{cd}\pm0.02$	$3.5^{e}\pm0.02$	$4.70^{c}\pm0.02$
Distal	$3.30^{bc}\pm0.01$	$2.77^{c}\pm0.01$	$2.40^{f}\pm0.06$	$2.50^{h}\pm0.02$	$2.50^{f}\pm0.02$

Values are Means ± SD (n=3). Values in the same row with different superscripts are significantly difference ($p < .05$).

Sensory textural evaluation (Table 5) revealed that cocoyam utilization could be enhanced by processing it into flour through a similar process flow for yam flour. The sections (Apical, Middle and distal) presented dough of different textual properties. Middle sections of all the varieties investigated were elastic, mouldable and cohesive for *Colocasia spp*, the apical section of *Xantosoma spp* gave similar textural characteristics. The differences in the textural properties among the varieties as well as the sections of the cormels could also be due to different chemical composition. Sefah-Dedeh and Agyir (2002) reported high protein content in the apical section and high levels of ash, fibre and minerals of the distal section of the cormel. The middle section of NCe002 is relatively elastic, mouldable, cohesive, smooth and fairly adhesive, these properties were reported for good textural quality of "Amala" (Yam flour paste) (Jimoh et al, 2009).

4.0 Conclusion

Flours of cocoyam cormels varieties and sections showed variant proximate composition, functional properties, pasting properties and sensory textural properties in their pastes. *Colocasia esculenta* varieties had higher protein, carbohydrate, water absorption capacity, bulk density, peak viscosity and set back. All these were concentrated at the apical section of the cormels except for carbohydrate and set back which were higher at the middle and distal sections respectively. Sensory textural evaluation revealed that cocoyam utilization could be enhanced by processing it into flour. Middle section of *Colocasia* varieties presented a mouldable, elastic and cohesive paste, a preferred textural characteristic for traditional yam flour paste (Amala).

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