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The Acceptability of Five Varieties of Cassava for Local Food Uses Based On Pasting Characteristics.

TECHNICAL REPORT

Submitted by

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Abstract

The pasting characteristics of the starches and flours obtained from five varieties of cassava with the aim of evaluating their suitabilities for use in some Ghanaian paste-like food products were investigated. The flour samples were obtained through dehydration of 5 mm sliced cassava and milling, whilst the starches were by the sedimentation method. The pasting temperature, peak viscosity, viscosity at 95°C, viscosity at 50°C, paste stability at 50 ° C, and setback were the parameters investigated. Flour and starch from the cassava variety *Yebeshie* gave the highest peak viscosities 482 and 1057 BU, with equally very good setback values of 118 and 258 BU, respectively. There was very little coorerelation between the starch content and the pasting properities. These properties make cassava variety Yebeshie as being useful for paste-like food products like *fufu*. The starch from the *Yebeshie* cassava will have a greater ability to form a thicker paste. This property gave the idea of the texture and quality of the product from which the starch will be used for. For local products like *fufu*, a high peak viscosity and setback are desirable. *Yebeshie* cassava was the preferred option for paste-like local products

Keywords: Cassava variety, starch, pasting, flour, chemical composition

1.0 Introduction

Cassava is a starchy staple whose roots are very rich in carbohydrates, a major source of energy. In fact, the cassava plant is the highest producer of carbohydrates among crop plants with perhaps the exception of sugarcane. It has been reported that cassava can produce 250 x 10^3 calories/ha/day compared to 176 x 10^3 for rice, 110 x 10^3 for wheat, 200 x 10^3 for maize, and 114 x 10^3 for sorghum (Coursey and Haynes 1970). The chemical composition of cassava varies in different parts of the plant, and according to variety, location, age, method of analysis, and environmental conditions (Balagopalan *et al.*, 1988).

Although cassava roots are rich in calories, they are grossly deficient in proteins, fat, and some of the minerals and vitamins. Consequently, cassava is of lower nutritional value than are cereals, legumes, and even some other root and tuber crops such as yams (Latham, 1969).

The cassava root contains carbohydrates, 64 to 72 per cent of which is made up of starch, mainly in the form of amylose and amylopectin. About 17 per cent sucrose is found in sweet varieties, and small quantities of fructose and dextrose have been reported (Hendershot , 1972). The lipid content of cassava is only 0.5 per cent. Cassava is poor in proteins (1 to 2 per cent), and the amino acid profile of the cassava root is very low in some essential amino acids, particularly lysine, methionine, and tryptophan. (Hendershot et al). Cassava is reasonably rich in calcium and vitamin C, but the thiamine, riboflavin, and niacin contents are not as high. Large proportions of these nutrients have been reported to be lost during processing. All of this should be taken into account in cassava-processing in order to retain as much as possible of these nutrients.

Cassava (*Manihot esculenta Crantz*) roots are cultivated and widely consumed in warm tropical areas (Jackson and Jackson 1990; Bokanga 1998). Starch is widely distributed throughout the plant kingdom and may be considered a counter part of glycogen in the animal kingdom. The starch in the tuber crops exists relatively free from lipids and proteins, and hence its extraction and purification are relatively simple (Balagopalan *et al.*, 1988). The high starch content from cassava makes it an important industrial crop in addition to being a calorie rich food crop. (Balagopalan *et al.*, 1988). It contains about 70% starch and, for many people, it is the primary source of dietary carbohydrate.

Gelatinization and pasting of starch granules occurs because, as the temperature of a starch-water suspension increase, molecules within granules vibrate and twist so violently that intermolecular hydrogen bonds break and are replaced with hydrogen bonds to water molecules, producing more extensive hydration (Jeanne and Peckham, 1987).

Cooking behaviours of different starches can be compared with a Brabender viscoamylograph, which records the change in viscosity under low shear rates when the temperature is increased to 95°C. The temperature is held for a short time, and then decreased (Jeanne and Peckham, 1987).

The objective of this study was to determine the chemical composition of five varieties of cassava and assess their pasting characteristics of their starches and flour for local food uses.

2.0 Materials and Methods

2.1 Proximate Analyses of Raw materials

The moisture, crude protein (NX 6.25), fat, and ash contents of the five varieties of cassava were determined by Association of Official Analytical Chemists' Approved methods (AOAC 2000). 925.10, 984.13, 920.39 and 923.03, respectively. Carbohydrate contents were determined by difference. Starch content was determined by Linther's method and Energy using Atwater factor (Pearson, 1970).

Table 1 gives the varieties, their ages, types and sources.

Table 1 *Variety, age and sources of raw materials*

Sample	Source	Age at harvest (months)	Type
Cassava			
061	Botany Dept. Univ. of Ghana, Legon	24	Experimental accession
094	Botany Dept. Univ. of Ghana, Legon	24	Experimental accession
065	Botany Dept. Univ. of Ghana, Legon	24	Experimental accession
Yebeshie	Ministry of Food and Agriculture, Pokuase	12	High yielding
Bosom nsia	Ministry of Food and Agriculture, Pokuase	12	Local

2.2 Starch Extraction

Starch was extracted from the five cassava varieties by the sedimentation method (Trim *et al.*, 1993). The harvested cassava tubers were first sorted out, weighed and washed with clean water. The tubers were peeled, washed with clean water to remove all the dirt and cut into chunks of about 0.5-1mm thick. The chunks were milled using a Phillips Waring blender with about 200g of water to blend each sample smoothly. The slurry was filtered through a clean cheese cloth. The solids retained by the cloth were washed with more water and filtered through the cheese cloth. The process was repeated five times until there was little or no starch in the filtrate. Starch in the filtrate was allowed to sediment overnight and the liquid decanted and discarded. The starch was weighed and dried in a mechanical dryer (Apex 27585 Royce Ross Ltd, London) at 50°C for 4h and weighed. The starch was pulverised with a disc attrition mill. The extraction was done in three batches for each of the five varieties of cassava.

2.3 Processing of Cassava Flour

The harvested cassava tubers were weighed, washed and peeled. The peeled tubers were weighed again and cut into 2 to 5mm thick pieces using a food slicer (Fold-up electric Food Slicer *mod.CFE 1954, Philips Atlantis.*). After weighing the slices were dried in a mechanical dryer (Apex, Royce Ross Ltd) at 54.0°C for 10 h, to attain moisture content of about 8-10%. The dried slices were weighed and milled using a disc attrition mill and after cooling stored in air tight containers (Badrie and Mellowes, 1992). This process was carried out for all five varieties of cassava.

2.4 Pasting characteristics

The pasting characteristics of the cassava flours and starches were determined using the Brabender Viscograph E (IDENT. NO. 802525, Duisburg, Germany). An aqueous suspension was made by dissolving 40g of each sample in 400ml of distilled water (8.7% slurry). The suspension was heated at a rate of 1.5°C/min by means of a thermoregulator. When the suspension reached 95°C, it was held constant for 15min (first holding period) while being continuously stirred. The paste was then cooled down to 50°C at a rate of 1.5°C/min and held at this temperature for another 15min (Second holding period). The parameters obtained were pasting temperature, peak viscosity, and viscosity at 95°C, viscosity at 50°C, and paste stability at 50 ° C, setback (Mazurs *et al.*, 1957).

3.0 Results and discussion

Table 2: Chemical composition of the Raw materials.

assava ariety	Moisture (g/100g)	Ash (g/100g)	Fat (g/100g)	Protein (g/100g)*	Carbohydrate (g/100g)**	Energy (Kcal/100g)	Starch (g/100)
061	70.9 ±0.38c	0.65±0i	0.08±0c	0.52 ±0.01c	27.9± 0.39i	113.02±0.03c	11.2c
094	60.0 ±0.39e	1.2 ±0.01j	0.08±0c	0.92 ±0.01d	38.22± 0.27j	155.4± 1.53d	15.4d
065	61.7 ±0.31f	0.9±0.01k	0.11±0.01d	0.6 ± 0.01e	36.73 ± 0.30k	150.1±1.07e	14.7a
om nsia	56.7 ±0.02b	1.1± 0h	0.06±0.01b	1.2 ± 0.22b	40.9±0.23h	169.3±0.16b	17.5b
beshie	58.8 ±0.20a	1.2±0.02g	0.29± 0.01a	0.6± 0.01a	39.1±0.21g	161.4±0.91a	14.8a

Mean values (g/100g, dry matter basis) from duplicate analyses ± standard deviation, *NX 6.25, **Calculated by difference,

Values in a column with the same letter are not significantly different at P≤0.05.

3.1 Chemical composition of raw materials

As part of the baseline information of the raw materials used, the chemical composition was determined. The chemical composition of cassava varieties is shown in Table 4.1. The ash content varied from 0.65g/100g (cassava variety *061)* to 1.2 g/100g for cassava varieties *Yebeshie* and *094*. The carbohydrate content of the cassava varieties ranged from 27.9 to 40.9g/100. The starch content also varied from 11.2 to17.5g/100. The protein content varied from 0.52 to 1.2g/100g. In both cases, the cassava variety *Bosom nsia* recorded the higher value followed closely by the *Yebeshie* variety. The differences and similarities in the chemical composition could be attributed to the age, variety, the stability. Pasting temperature of the cassava starches ranged from 64.4-66.6°C with only a small variation. The effect of varietal differences on the gelatinization temperature was also evident. *065* starch recorded the lowest pasting temperature as a result it had the most poor cooking quality compared to the others. Also lower pasting temperatures are associated with low paste stability is considered an undesirable property (Moorthy, 1994).

High peak viscosity indicates high swelling of the starch granules. Peak viscosity and viscosity at 95°C measure the ability of starch samples to form paste on heating. It varied from 633 BU for *065* cassava starch to 1052 BU for *Yebeshie* starch. This meant that the *Yebeshie* starch would form a thicker paste compared to the others.

Hoover and Sosuiski (1985) pointed out that initial pasting viscosity appeared to reflect, in part, differences in amylose content in starch. Viscosity at 95°C ranged from 262-411 BU as shown in Table 3. The viscosity of all the cassava starches increased at the onset of pasting but decreased at viscosity at 95°C and after the first holding period, which indicate the strength of the various starch pastes. The viscosity values were very high at the cold paste for all the cassava starch samples. This increase in viscosity shows the tendency of the starch samples to associate or retrograde.

Paste stability at 95°C ranged from 69BU for *061* starches to 148 BU for *bosom nsia* starch. Paste stability at 95°C measures the tendency of the paste to breakdown during cooking. The sample with low paste stability had very weak cross-linking within the granule and requires less heating. The lowest setback or retrogradation value was recorded by *061* cassava starch and the highest value by the *Yebeshie* starch (Table 3). This meant that the solubilized starch polymers of *Yebeshie* cassava will readily associate to form a gel during cooling. This is desirable especially if the starch is to be used for starch-based product formulation. A high setback value is useful if the starch is to be used in products such as *fufu*, which require a high viscosity and paste stability at low temperature (Kim *et al.*, 1991). A low setback shows that the sample will give a non-cohesive paste which is useful in industrial applications (Kim *et al.*, 1991).

3.3 Cassava flour

The results of this study are presented in Table 3.

climatic and environmental conditions of the cassava varieties. According to (Balagopalan *et al.*, 1988), the starch content increases with the growth of the tubers and reaches a maximum between the 8th and 12month after planting. Thereafter the starch content decreases and the fiber content increases.

Table 3: Pasting characteristics of starches and flour from 5 Cassava varieties

Sample	Pasting temperature (°C)	Peak viscosity (BU)	Viscosity at 95 °C (BU)	Viscosity at 50°C	Pasting stability at 50 °C (BU)	Setback
Starch						
061	66.6 ± 0.1	690 ± 38.97	262 ± 3.46	331 ± 60.93	24 ± 13.89	137 ± 35.23
094	65.3 ± 0.12	741.3 ± 55.89	325 ± 8.14	339 ± 21.28	21 ± 1.53	221 ± 13.45
065	64.4 ± 0.46	633 ± 263	300 ± 86.31	399 ± 117	19 ± 2	189 ± 50.82
Bosom nsia	66.2 ± 0.21	773 ± 30.57	411 ± 32.92	486 ± 14.01	27 ± 4.73	222 ± 11.15
Yebeshie	65.7 ± 0.11	1057 ± 56.02	366 ± 4.04	522 ± 19.65	18 ± 3.06	258 ± 12.09
flour						
061	73.13± 5.50	482 ± 4.36	218 ± 15.04	244 ± 18.72	13 ± 2.08	106 ± 4.16
094	67.6 ± 0.1	299 ± 12	151 ± 4.04	137 ± 2.31	8.69 ± 0.58	55.3 ± 1..53
065	68.4 ± 0.06	384 ± 2	169 ± 5.77	164 ± 3.46	9.67 ± 0.58	76.6 ± 0.58
Bosom nsia	64.4 ± 5.83	400 ± 17.00	197 ± 10.69	162 ± 6.08	11 ± 1.16	66 ± 4.51
Yebeshie	69.2 ± 0.12	482 ± 8.39	207 ± 7.51	219 ± 8.50	10.3 ± 2.52	118 ± 5.68

Mean of three determination± standard deviation

3.2 Starch

The results of pasting characteristics are shown in tables 3.

The pasting temperature/gelatinization temperature provides an indication of the minimum temperature required to cook a given sample, which can have implications for

Pasting behaviour of the cassava flour from the five varieties showed significant variations ($p < 0.05$). Pasting temperatures ranged from 64.4°C for cassava flour obtained from *065* cassava to 69.2°C for *bosom nsia* cassava. Peak viscosity and viscosity at 95°C ranged from 299 to 482 BU and 151 to 218 BU respectively (Table 3). These indices measured the ability of the samples to form paste on heating. The viscosity of all samples increased after the onset of pasting, but decreased at viscosity of 95°C and after the first holding period, indicating the strength of the various cassava flour. However, the viscosities at 50°C (cold paste viscosities) were very high for all the cassava flour samples. These increases in viscosity indicate the tendency of the sample to associate during cooling.

Paste stability gives a measure of the tendency of the paste to break down during cooking. High paste stability is a frequent requirement for industrial users of starch. Paste stability ranged from 71.3BU for cassava flour from *094* to 101 BU for that from *bosom nsia* cassava.

The viscosity value at 50°C gives a measure of the set back or retro gradation. The set back ranged from 55.3 for cassava flour obtained from *094* cassava to 118 for cassava flour from *Yebeshie* cassava. This meant that the solubilized starch polymers of *Yebeshie* cassava will readily associate to form a gel during cooling.

3.4 Comparison of pasting properties of cassava starch and cassava flour

There were significant differences in peak viscosities of flour and starch from the 5 varieties of cassava assessed (Table 3). Starch peak viscosity values ranged from 633 BU for *065* cassava starch to 1052 BU for *Yebeshie* starch. For the cassava flour samples, the peak viscosity ranged from 299 BU for 094 cassava flour to 482 BU for *Yebeshie* and *061* cassava flours.

Starch peak viscosity values were generally higher than those identified for flour samples. This could be probably due to the presence of interfering non-starch components in the flour which are not present in the starch samples. It may also be due to amylase activity in the flour, which results in changes in viscosity (Niba *et al.*, 2001). Amylase activity has been suggested to result in decrease in gelling and thickening ability of cassava starch (Aguliera and Rojas 1996; Moorthy *et al.*, 1993).

Differences in peak viscosity of the starches and flours implied differences in paste strength and attendant differences in behaviour during processing (Niba *et al*., 2001). Setback viscosity indicates gel stability and potential for retrogradation (Niba *et al*., 2001). Setback viscosities for starch ranged from 137 BU for *061* cassava starch to 258 BU for *Yebeshie* cassava *starch* while values for flour, ranged from 55.3 BU for *094* cassava flour to 118 BU for *Yebeshie* cassava flour. Final viscosities are important in determining ability of the sample material to form a gel during processing (Niba *et al*., 2001). For starch, the viscosity at 50ºC (final viscosities) were between 331 BU for *061*starch to 522BU for the *Yebeshie starch* while for flour these ranged from137 for *094* cassava flour to 244 for *061* cassava flour (Table 3).

4.0 Conclusion

The chemical composition of the cassava varieties was different and this could be attributed to variety, location, age, method of analysis, and environmental conditions. Starch peak viscosity, final viscosity and setback were generally higher compared to that for flour. *Yebeshie* starch recorded the highest peak viscosity, viscosity at 95ºC and 50ºC and setback of all the 5 cassava starches studied. The *Yebeshie* cassava flour had the highest peak viscosity and setback of all the flour samples assessed. *Yebeshie* pasting properties stood out greatly compared to the local *bosom nsia* variety and the experimental accessions. The ability of a starch containing product to form a paste or gel determines the texture of that food product. Cassava products processed using *Yebeshie* cassava will give good quality products. The setback for *Yebeshie*, *bosom nsia* and 061 cassava starches and flours recorded high values. These varieties could be used in *fufu* flour and other paste-like products which require a high setback.

5.0 References

Aguilera, J.M. and Rojas E. (1996). Rheological, thermal and Microstructural properties of whey protein cassava starch gels. J Food Sci. 61 (5): 962-966.

Badrie, N. and Mellowes W.A. (1992). Cassava starch or amylase effects on characteristics of cassava (*Manihot esculenta* Crantz) extrudate. J Food Sci 57(1):103-107.

Balagopalan, C., Padmaja, G., Nanda, S .K., Moorthy, S. N.(1988). Cassava in Food, Feed and Industry. CRC Press, Inc. Boca, Florida, USApp. 113-127

Bokanga, M. (1998). Cassava in Africa: the root of development in the twenty first century. Trop Agric 75 (1-2): 89-92.

Coursey D.G. and P.H. Haynes, (1970) "Root Crops and Their Potential as Food in the Tropics," World Crops, 261 - 265

Hendershot C.H. eds, A Literature Review and Research Recommendations on Cassava (*Manihot esculenta, Crantz*) (University of Georgia, Athens, Georgia, USA, 1972 .

Hoover, R. and Solsulski, F. (1985). Effect of cross-linking on fundamental properties of legume starches, Starch/Staerke, **38**, 149-155

Jackson, FLC and Jackson RT (I 990). The Role of Cassava in African Famine Prevention. Food Nutr. Hist Anthropol. 7: 207-225.

Jeanne, H. F. and Peckham, G.C. (1987). Foundations of Food Preparation 5th edition. Macmillan Publishing Company. New York. Pp264-269.

Kim, Y.S., Wiesenborg, D.P, Orr, P. H. and Grant, L. A. (1995). Screening potato starch for novel properties using differential scanning calorimetry, J. Fd. Sci., 60, 1060-1065

Latham, M.C. Human Nutrition in Tropical Africa (FAO, Rome, 1969).

Leach, M, W. Gelatinization of starch. In starch chemistry and technology, vol. 1 Whistler, R. L. and Paschall. E. F., Eds., Academic Press. New York. (1965). chap. 12

Mazurs, E. G., Schoch, T. J. and Kite, F. E. (1957). Graphical representation of the Brabender viscosity curves of various starches. Cereal chemistry, 34; 141-152.

Moorthy, S. N., George M, Padmaja, G. (1993). Functional properties of the starchy flour extracted from cassava on fermentation with a mixed culture innoculum. J. Sc.Food Agric. 61:443-447.

Niba, l..l., Bokanga, M.M., Jackson, F.L., Schlimme, D.S and. Li, B.W Physicochemical Properties and Starch Granular Characteristics of Flour from Various *Manihot esculenta* (Cassava) Genotypes Journal of Food science Vol. 67, Nr. 5, (2001) 1702-1705

Trim, D.S.; Nanda, S.K.; Curran, A.; Ariantharaman, M.; and Nair, J. (1993). Investigation of cassava starch and sago production in India. Paper presented at the international symposium on Tropical Root crops, 6-9 Nov., Thiruananthapurarn, India.