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Assessment of the Physicochemical Properties and Applications of Some Cassava Varieties

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Abstract: Sequel to the importance of cassava as a staple food for many and a source of starch and gums with widening applications in many domestic and in industrial operations, the physico-chemical assessment and applications of some common cassava varieties: *Manihot esculenta* (T.MS 3055), *Manihot esculenta* (T.MS 30572) and *Manihot utilissima* (tree cassava) were undertaken. Results were obtained for percentage starch yield, fat content, ash, moisture and amylose content of the cassava varieties using standard methods. Gums produced from the starch of the three varieties were examined for adhesive strength and drying time and compared with commercial gums as standard. The results show that *manihot utilissima* showed better industrial potentials than the other two varieties T.MS 3055 and T.MS 30572 which gave better nutritive value indices.

Key words: Cassava, varieties, adhesives, starch, gums, nutritive

INTRODUCTION

Cassava is a dicotyledonous plant belonging to the botanical family Euphorbiaceae (Schulthness *et al*., 2004) and like most members of the family, the cassava plant contains laticifiers and produces latex (Weber *et al*., 1978a, b). Cassava is generally called *Manihot esculenta crantz* (synonymous with *Manihot utilissima*) (Oboh and Elusiyan, 2007). Cassava is not a cereal but a tuber. It originated from North-East Brazil (South America). It is now grown in Indonesia, Malaysia, Philippines, Thailand and parts of Africa including Nigeria that has recently become the world's greatest producer of cassava (Leotard *et al*., 2009). It is often seen as a drought-tolerant famine reserve crop and is therefore thought to be ideal for marginal rainfall areas. However, it has been found to be difficult to grow in some areas of East Africa receiving <762 mm of rain per annum (Weber *et al*., 1978a).

Cassava grows on most soils but best in light to medium loams which facilitate tuber development and harvesting. Cassava extracts less nitrogen and phosphates than most other crops but has a high demand for potassium and the roots are well developed to take up sulphur and zinc (Rasper and Coursey, 1967). Cassava is known as a source of starch and a staple food where it is eaten as fufu or garri. It has been applied in making some kind of cakes and biscuits.

Its industrial applications as a source of starch and gums are well known (Weber *et al*., 1978b; Azeez, 2005; FAO, 2010). Two of the three varieties studied T.MS 3055 and T.MS 30572 are edible and the flour has been applied for bread making. The high content of hydrogen cyanide in cassava has been a source of concern because of its toxicity. However HCN is a gas (b.p 25°C) that easily dissipates into air at ambient temperature once produced. Different processing methods have been found to reduce the HCN level. Steeping of cassava in water for an extended period of time (2-5 days) allows a submerged fermentation to occur and leads to the breakdown of the cyanogenic glycosides. Grinding and fermentation have been reported to achieve the highest rate of detoxification of cassava food resulting in HCN reduction by over 90% (Kent, 1980). Other studies have found that HCN is reduced to 14.2% by boiling, 11.3% by baking and 11.3% by frying while steaming and drying reduces the HCN level by 15.7 and 27.5%, respectively (Othmer, 1978). However, these rates are low and it is due to the fact that they do not alter the integrity of the plant cells and inactivates the enzyme kinamase (Kent, 1980). Ayenor (1985) reported a cyanide reduction of 98.6% in the roots of cassava by retting and sun drying. A simple wetting method that reduces the cyanide content of cassava flour has also been reported (Bradbury, 2006).

Starch adhesives or glues are applied in a large scale in industries in packaging. Native starches are also applied as adhesives for veer, plywood and corrugated cartons and laminated boards where water resistance is not necessary. Starch have been applied in various industries including paper sizing and coating, textiles, foods, pharmaceuticals etc. (Kraak, 1992; Jonhed, 2006).

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Starch adhesives have the advantages that they can be applied in the cold and do not have the undesirable characteristic odours of animal glues though they are not as strong as animal glues and have lower water resistance. However, the starch adhesives have the advantage of being less costly than synthetic resins and more environmentally friendly owing to their biodegradability. When incorporated with 5-15% resins such as urea formaldehyde, it is used for cartons where water resistance is important. It forms the raw material for conversion into dextrins and British gums which are modified glues for glass, metals, wood, cartons, laminated boards and padding glues (Othmer, 1978). Apart from the environmental friendly and non toxic nature of starch it is also a renewable biomass (Fang and Fowler, 2003). Additives are usually added to improve the properties of the adhesives. Such additives include borax for increase in viscosity, gumminess and rate of tack and speed production (Smith and Montgomery, 1978).

Gums are natural hydrocolloids which may be classified as anionic or non-ionic polysaccharide or salts of polysaccharides. Gums are also polymers of plant origin which when in appropriate solvents or swelling agents produces gels, highly viscous suspensions or solutions at low and dry substance content (Smith and Montgomery, 1978).

They are solids usually insoluble in alcohol and most organic solvents. Gums are used as stabilizers for insecticides, paraffin oil, natural latex and emulsion. Seaweed gums have been used as stabilizers for dairy products such as ice cream and cheese. Other application include, use in ore refining where they coat impurities enabling them to separate or float. It is also used in drilling muds in lithography, plasma extenders, laxatives, paper, beer, cosmetic, lubricants, friction reducers depending on the shape and chemical nature of the particular gum (Kent, 1980). Some of these applications often requires improvement of mechanical and barrier properties of the cassava starch for suitability (Nwokocha *et al*., 2009; Pelissari *et al*., 2009). In this study we have focused on the assessment of some cassava varieties for the possibility of wider applications including non-food uses especially for *Manihot utilissima* which is underutilized as it is not yet used for edible purposes.

MATERIALS AND METHODS

The cassava species *Manihot esculenta* (T.MS 3055) *Manihot esculenta* (T.MS 30572) and *Manihot utilissima* (tree cassava) were collected from Abakaliki in Ebonyi State, Nigeria where the fresh tubers were harvested and 2 kg of each species collected.

Sample preparation: The fresh tubers of each cassava sample was peeled using a kitchen knife washed and grated and water added. The water added contained 0.05% formaldehyde to prevent microbial action or fermentation of the starch. The pulp was suspended in water by means of a mesh of sieves. The fibrous materials were removed by the aid of the sieves, leaving the starch milk. The starch milk was allowed to stay for 4 h after which it was decanted and the starch collected from the basin, sprayed on a tray and dried to reduce the moisture content to 12-14% in a circulating air at a temperature of 35°C. After drying, the dry starch samples for each of the cassava samples were weighed.

Preparation of cassava starch paste using the unmodified starch samples: The preparation of the cassava paste was done using 33.4 g of unmodified starch sample from each of the cassava variety. About 50 mL of water was added and forms a kind of slurry. The slurry was heated to 71°C holding under agitation. Then 60 mL of cold water was added to thin the paste so as to make it less viscous and of good flow rate. The mixture was allowed to cool and digest very well for 25 min before the addition of 1 mL of (46% w/v) formaldehyde for preservation and long storage.

Preparation of starch adhesives and viscosity determine: The starch adhesives were prepared by weighing 15 g of dry starch sample and placed in 500 mL beaker and 25 mL of distilled water added, stirred and shaken properly to form lump free slurry. The slurry was then transferred to a 500 mL volumetric flask and the volume made up to 450 mL at 25°C and mixed. The slurry was then transferred to a Brabender Amylogarph which is a rotational instrument that enables continuous viscosity determination while boiling and cooling the starch paste. Heating was done and controlled by a mechanically operated thermoregulator to maintain a constant temperature. Heating continued till 95°C and the paste cooled at 50°C at a rate of 1.5°C per min. About 1 mL of 46% formaldehyde was added for preservation and paraffin oil added to prevent skin formation.

Determination of physico-chemical properties: The physicochemical properties of the samples were determined using common methods. The moisture content was determined by drying 1 g of each of the samples of cassava starch in a force oven for 2 h at 115°C. The ash content was determined by using a previously weighed nickel crucible in a furnace whose temperature was raised gradually to a final temperature of 600°C for 5 h then cooled and reweighed. Iodine affinity was determined using an automated method with Amperometric Iodine Affinity apparatus. The pH was determined using E/L pH meter with buffers maintained at pH 4.0 and 7.0, respectively. The fat content of the samples was determined by solvent extraction using a laboratory bench Sohxlet-extractor for cellular materials with petroleum ether.

Production commercial gums: The production of commercial gums forms from the cassava varieties was done using 15 g of starch sample placed in 800 mL beaker and 25 mL of water was added with stirring. About 15 g of urea formaldehyde was crushed and ground then added to the starch powder and dissolved in 30 mL of water 0.5 g of NH_4Cl was added as catalyst and heated for 8 min until boiling between 100-120°C with proper stirring. Cooling and determination of viscosity followed this. The gum samples were preserved by adding 0.5 mL 46% w/v formaldehyde and liquid paraffin added on the top to prevent skin formation.

Determination of the tensile strength of the commercial gums produced: The tensile strength of the commercial gums produced from the three cassava varieties was evaluated by binding pieces of glass with 0.5 mm film of gum. After drying the gummed materials were carefully peeled off to determine the tensile strength using a tensiometer which works with the principle of Hook's experiment.

Determination of drying time of the commercial gums: The drying time was evaluated by smearing 0.5 mm film of gum prepared from the three varieties and using a stopcock to know the time taken for each of them to dry.

RESULTS AND DISCUSSION

The results of the measurements of the yield of cassava starch adhesive of the three cassava varieties are shown in Table 1. The results show that *Mainhot utilissima* gave the highest yield of starch followed by *Manihot esculenta* T.MS 3072 while the 3055 was the least. The percentage yield of the adhesive is not very high. This might be due to the amount lost during processing and the season when the products were harvested especially the season when they tend to be more fibrous due to dryness. This can also be compared with the results of the yield of commercial gums from the three cassava varieties shown in Table 2. The results also follow the trend as shown in the Table 2. Tree cassava gave the highest yield of gum followed by the improved varieties T.MS 3055 and 30572, respectively. This means that for gum production, the tree cassava will be the best source of raw material followed by T.MS 3055. The multiplication rate is encouragingly quantitative. So an industry using the raw materials for gum production is sure of the excellent yields of gums. Since the other two are more edible than the first, the tree cassava can serve mainly for such industrial gum production. The higher swelling power of the tree cassava may be due to a higher rate of disruption of the hydrogen bonds and the greater rate of attachment of water molecules to the liberated hydroxyl molecules. The swelling power and solubility of starches provide evidence for the non-covalent bonding between molecules within the starch (Kent, 1980; Vittadini *et al*., 2008). The swelling power is usually proportional to the solubility. Solubility is a desired quality of a good gum which should be within a certain range not <3.8 or >6.5 mol dm^{-3}. The swelling power of tree cassava particularly was determined to be 4.7 mol dm^{-3} and falls within the range.

Table 1: Yield of cassava starch adhesive

Samples	Amount of cassava tuber processed (g)	Quantify of starch adhesive obtained (g)	Yield of starch adhesive (%)
Manihot utilissima (Tree cassava)	2000	950	47.50
Manihot esculenta T.MS 3055	2000	5009	25.00
Manihot esculenta T.MS 30572	2000	700	35.00

Table 2: The yield of commercial gums

Samples	Quantity of starch used for gum production (g)	Quantity gum obtained (g)	Yield (%)	Rate or increase or swelling power
Manihot utilissima (Tree cassava)	15.00	60.00	400.00	26.67X
Manihot esculenta (T.MS 3055)	15.00	51.20	341.33	22.75X
Manihot esculenta (T.MS 30572)	15.00	48.30	322.00	21.46X

Physicochemical properties: The results of the physicochemical tests of the cassava varieties are shown in Table 3.

Fat content: The results show that the tree cassava has the least fat content of 0.40% followed by T.MS 3055 with 0.66% and T.MS 3072 of 0.75%. The fat content is a measure of solubility in water and hence swelling power. The higher the fat content the less the solubility and the swelling power. The solubility and the swelling power will be of the order T.MS 3072<TMS 305<Tree cassava. However, in terms of nutritional quality, the fat content is a measure of food quality. All the three varieties have a fat content below 28% acceptable value for many foods.

Table 3: Results of the physicochemical properties of the cassava varieties

Samples	Fat content (%)	Starch content (%)	Ash (%)	Moisture (%)	Iodine affinity (%)	Amylose content (%)	pH
Manihot utilissima (tree cassava)	0.40	89.50	1.00	12.48	1.06	17.00	5.20
Manihot esculenta (T.MS 3055)	0.66	84.00	0.22	10.48	0.85	16.00	5.50
Manihot esculenta (T.MS 30572)	0.75	87.00	0.23	13.10	1.00	15.20	6.50

However, the tree cassava will have relatively less food value than the other two and of more industrial value while the other two are of better nutritional value.

Starch content: The starch content of 89.5, 84.0 and 87.0% for tree cassava, T.MS 3055 and T.MS 30572, respectively was obtained from the tests. This is in agreement with the iodine affinity which shows the highest value for tree cassava and the least for T.MS 3055.

Ash: The ash content which measures the bulk of the residue left after burning is also often indicative of the metallic content. The results show that the cassava varieties contain 1.0, 0.22 and 0.23% for tree cassava, T.MS 3055 and 30572, respectively. The highest quantity of ash for the tree cassava is due to the highest starch percentage which accounts for greater residue left after incineration.

As the starch content increases, the concentration increases which will also increase viscosity and gel strength which also is proportional to molecular weight (Kent, 1980). Also the result is also indicative of higher metallic content for the tree cassava. This could be due to the better developed roots of the tree cassava which makes it grow very tall and would likely take up more metallic elements especially K^+ and Zn^{2+} than the hybrids (Rasper and Coursey, 1967).

Amylose: The amylose content is shown as 17.0% for tree cassava, 16.0% for T.MS 3055 and 15.20 for T.MS 3072. Amylose is essentially a linear polymer of 1,4-linked α-D-glucopyranose units which constitutes about 15-20% of the starch whereas amylopectin which is a highly branched polymer with a 1, 4 and 1, 6 linked D-glucopyranosyl units constitutes 80-85%. It is also a measure of the tackiness of the starch. The highest value of 17.0 for tree cassava accounts for the high tackiness and stickiness of the gums from it. When amylase (dextrinogenase) attacks starch, gummy dextrins of low molecular weight are formed and can produce sticky crumbs in bread therefore lower amylose content for T.MS 3055 and 30572 will favour the use of their flours for bread production or for blending with wheat or maize flours (Hug-Iten *et al.*, 2003; Williams and Pullen, 2007).

pH: The pH accounts for the acidic and basic nature of the starch and gums. The high content of HCN is the basis for toxicity in cassava. The higher the HCN content the lower the pH. So the lowest pH value for tree cassava potrays greater HCN content. T.MS 30572 which show the hightest pH will have the least HCN content and will be of best food value. However, we have already mentioned earlier that many of the processing steps, reduce the HCN value to 467% by boiling, 14.2% by baking and 11.03% by frying. Steaming reduce the HCN content by 15.7% and drying by 27.2% Grinding and fermentation achieve the highest detoxification (Rasper and Coursey, 1967). For the production of industrial gums, pH values of 5.2, 5.5 and 6.5 for tree cassava starch, T.MS 3055 and 30572, respectively show that the tree cassava has the lowest pH followed by T.MS 3055 and this fall within the standards of between 4.0-5.5 for good quality gums. If the pH falls below 4.0 or rises above 5.5 there will be decreased gel strength due to the weakening of the granular structure of cassava starch (Rattanapitigorn *et al.*, 2005). Therefore, the cassava variety TMS 30572 will not be the best for commercial gum production with its high pH of 6.5.

Table 4: Drying times for the commercial gums prepared from the three cassava varieties with a standard gum

Samples	Drying time (min)
Manihot utilissima (tree cassava)	21
Manihot esculenta (T.MS 3055)	25
Manihot esculenta (T.MS 30572)	32
Stephen golden gum (Standard)	15

Drying time: The results of the drying time measurements for the produced. Commercial gums is shown in Table 4 and compared with the popular commercial Stephen golden gum. Table 4 shows the drying times of the gums prepared from the tree varieties were relatively good compared with the standard Stephen Golden gum. Tree cassava showed the shortest drying time of 21 min while TMS 3055 took the longest time of 25 min to dry. The long drying times and the differences are due to the water content of the cassava gums. Nonetheless they showed promising commercial applications with the addition of dryers.

Moisture: The order of moisture content for the cassava varieties are T.MS 30572>tree Cassava>T.MS 3055 with the values 13.0, 12.48 and 10.4%, respectively. High moisture content suggests improved food quality and standards. The tree cassava would be expected to have the lowest moisture content but the deviation here could be form the nature of the soil where the cassava was grown. Cassava grown in swampy soil as in Abakaliki where the cassava was obtained would likely have more water molecules in the interstitial chains of their bond.

CONCLUSION

The study has shown that there are significant differences in the yield of cassava starch and commercial gums in the three varieties of cassava studied. The tree cassava showed greater promise for industrial applications as in production of gums and can also be applied in paper sizing and for strengthening of textile materials more so as it is not often eaten. The high swelling power of cassava starch which ensure the production of a large quantity of gum from a small amount of starch is attractive.

Countries that produce or utilize cassava and cassava products can can widen their scope of application of these products. A good example here is Nigeria that has become the world's greatest producer of cassava and there is a requirement for industries to blend their raw material with a certain percentage of cassava flour and the flours from the two improved cassava varieties T.MS 3055 and 30572 will be the best for this purpose.

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