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Full Length Research Paper

Evaluation of the pasting and some functional properties of starch isolated from some improved cassava varieties in Nigeria

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Improved cassava of 13 cultivars (NR01/004, NR01/0161, NR01/0071, CR14A-1, CR.41 – 10, AR38 – 3, TMS01/0040, TMS01/1086, TMS00/0210, TMS00/0203, TMS00/0214, TMS30572CK and Local best (CK) were converted into starch and analysed for some functional and pasting properties. Variations were observed in the functional properties of the starch samples; water absorption capacity ranged from 59.75 – 68.02%; oil absorption capacity 60.70 – 80.01%; swelling power 5.49 – 6.92% and solubility index 4.25 – 5.96%. Significant differences ($P < 0.05$) were observed in the functional properties of the starch samples. The peak viscosity ranged from 74.25 – 178.25 RVU. Starch from the local best CK had the highest peak viscosity (at a temperature of 63.80°C in 3.68 min) and TMS01/0040 had the lowest (at 63.90°C in 3.88 min). The breakdown viscosity ranged from 56.50 – 107.75 RVU with starch from local best CK having the highest and starch from TMS01/0040 had the lowest. The final viscosity ranged from 21.50 – 111.33 RVU. Starch from local best CK had the highest and that from TMS00/0203 had the lowest. The setback viscosity ranged between 9.75 – 49.25 RVU with starch from local best CK having the highest and that from TMS01/0040 having the lowest. The pasting temperature ranged from 63.00 – 64.70°C, with starch from TMS00/0214 having the highest and that from NR01/0161 having the lowest. There were significant differences ($P < 0.05$) in the pasting properties of the starch samples. The apparent starch amylose ranged from 13.88 – 16.35% with local best CK having the highest and that from AR 38 – 3 having the lowest; percentage starch content ranged between 48.25 – 52.05%. The local best CK had the highest and that from TMS00/0203 had the lowest. Significant differences were observed in the amylose and starch contents of the cassava cultivars.

Key words: Improved cassava, starch, functional and pasting properties.

INTRODUCTION

Cassava (*Manihot escutenta* Crantz) is a major food crop in Nigeria, supplying about 70% of the daily calorie of over 50 million people in Nigeria (Oluwole et al., 2004). It has also been estimated that cassava provides food for over 500 million people in the world (Abu et al., 2006). It is essentially a carbohydrate food with low protein and fat. Edible part of fresh cassava root contains 32 – 35% carbohydrate, 2 – 3% protein, 75 – 80% moisture, 0.1% fat, fibre and 0.70 – 2.50% ash (Ihekoronye and Ngoddy, 1985; Oluwole et al., 2004). The consumption of cassava have currently been on the increase, and the growing of cassava is expanding to semi- arid areas where cassava was not cultivated some thirty years ago (Omodamiro et al., 2007). Nigeria has become since 1989, the largest cassava producer in the world (FAOSTAT, 2002). New cassava genotypes are regularly being bred and assessed and selected by the International Institute for Tropical Agriculture (IITA), Ibadan and the National Root Crops Research Institute (NRCRI), Umudike for high yield, and resistance to pests and diseases, with a particular reference to the most dreaded cassava mosaic disease (CMD).

In Nigeria the fresh starchy cassava roots are highly perishable and a lot of pest-harvest losses occur also as a result the inherent high moisture content of fresh roots, which promote both microbial deterioration and unfavour-

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able biochemical changes in the commodity (Wenham, 1995). This limits its availability as a raw material to the industries that need it, but are largely processed and used as human food and animal feed. One of the major processing indices of the cassava tuber is its ability to gelatinize and form thick pastes for human consumption. The gelatinization process is a property of the starch granule found in cereals and tuber crops (Iwe et al., 1999). Starch is one of the major products of cassava processing in Nigeria, which deserve investigation, with particular reference to the improved varieties. The objective of this work was to evaluate the pasting and some functional properties of starch from the new resistant cassava cultivars.

MATERIALS AND METHODS

The roots of thirteen newly improved cassava cultivars (NR01/004, NR01/0161, NR01/0071, CR14A-1, CR41-10, AR38-3, TMS01/0040, TMS01/1086, TMS00/0210, TMS00/0203, TMS00/0214, TMS30572CK and Local best CK) used for this work were obtained from Department of Crop and Landscape Management, Ebonyi State University farm in collaboration with IITA Ibadan.

Preparation of sample

The cassava roots used for the study were harvested at 12 months after planting. The following steps were adopted in the production of starch. Manual peeling of cassava roots, washing, grating, sieving, sedimentation, decantation, drying and milling (Figure 1).

Fresh cassava roots

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Peeling

↓

Washing

↓

Rasping

↓

Sieving

↓

Sedimentation

↓

Decantation

↓

Drying

↓

Milling

Figure 1. Production of cassava starch.

Pasting properties determination

Pasting characteristics were determined with a Rapid Visco Analyzer (RVA) (Model RVA 3D+, Newport Scientific Australia). First, 2.5 g of cassava starch sample were weighed into a dried empty canister; then 25 ml of distilled water was dispensed into the canister containing the sample. The solution was thoroughly mixed and the canister was well fitted into the RVA as recommended. The slurry was heated from 50 to 95°C with a holding time of 2 min followed by cooling to 50°C with 2 min holding time. The rate of heating and cooling were at a constant rate of 11.25°C per min. Peak viscosity, trough, breakdown, final viscosity, set back, peak time, and pasting temperature were read from the pasting profile with the aid of thermocline for windows software connected to a computer (Newport Scientific, 1998).

Swelling power and solubility pattern

The swelling power and solubility of starch isolates were determined according to the methods described by Tester and Morrison (1990). About 0.2 g ground samples (< 60 mesh) was suspended in 10 ml of water and incubated in a thermostatically controlled water bath at 95°C in a tarred screw cap tube of 15 ml. The suspension was stirred intermittently over 30 min periods to keep the starch granules suspended. The tubes were then rapidly cooled to 20°C. The cool paste was centrifuged, at 2200 x g for 15 min to separate the jell and supernatant. Then, the aqueous supernatant was removed and poured into dish for subsequent analysis of solubility pattern. After this, the weight of the swollen sediment was determined.

Supernatant liquid (dissolved starch) was poured into a tarred evaporating dish and put in air oven at 100°C for 4 h. Water solubility index was determined from the amount of dried solids removed by evaporating the supernatant, and was expressed as gram dried solids per gram of sample.

$$\text{Solubility (\%)} = \frac{W_1 \times 100}{W_s(1 - Mc)} \quad (1)$$

$$\text{Swelling power (\%)} = \frac{W_2 \times 100}{W_{dm}(100 - \text{solubility})} \quad (2)$$

$$\text{Dry matter weight} = Ws\ (1 - MC) \quad (3)$$

Where, W_1, W_2 = Weight of supernatant and centrifuged swollen granules; Ws = weight of sample; Mc = moisture content of sample, dry basis (decimal); and Wdm = weight of dry matter.

The method of Beuchat (1977) was used to determine the water and oil absorption capacities of the isolated improved cassava starches. The methods of Williams et al. (1970) and Mcready et al. (1950) were used to determine the amylose and starch contents, respectively.

Statistical analysis

A simple completely randomized design was used while analysis of variance was adopted in analyzing the data. The mean separation was carried out with Duncan New Multiple Range Tests (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Pasting properties of Starch from different CMD cassava cultivars

Table 1 shows the pasting properties of starch from diffe-

Table 1. Pasting properties of starch isolates from 13 improved cassava cultivars.

Cassava cultivar	Viscosity (RVU)						
	Viscosity	Trough	Breakdown	Final viscosity	Setback	Peak time (min)	Pasting temp. (°C)
NR01/004	106.42[a]	34.92[a]	71.50[a]	51.42[a]	16.50[a]	4.01[a]	63.75[a]
NR01/0161	105.33[a]	35.08[a]	68.67[a]	51.25[a]	16.17[a]	3.81[b]	63.00[b]
NR01/0071	139.92[b]	52.58[b]	87.08[b]	77.17[b]	24.58[b]	3.94[b]	64.50[c]
CR14A-1	137.42[b]	46.00[b]	87.67[b]	69.00[c]	23.00[c]	3.85[b]	64.55[c]
CR41-10	120.83[c]	34.25[a]	81.75[c]	51.17[a]	16.92[a]	3.85[b]	64.00[a]
AR38-3	85.17[d]	20.83[c]	61.08[d]	33.67[d]	12.83[d]	3.84[b]	63.10[b]
TMS01/0040	74.25[e]	16.08[d]	56.50[e]	25.83[e]	9.75[e]	3.88[b]	63.90[a]
TMS01/1086	97.58[a]	26.75[e]	67.83[a]	41.92[f]	15.17[f]	3.84[b]	64.45[c]
TMS00/0210	101.33[a]	28.00[e]	68.58[a]	41.00[f]	13.00[d]	3.81[b]	64.45[c]
TMS00/0203	80.08[d]	10.67[f]	60.00[d]	21.50[g]	10.83[g]	3.68[c]	63.70[a]
TMS00/0214	100.92[a]	30.75[e]	68.08[d]	48.50[h]	17.75[h]	3.91[a]	64.70[d]
TMS30572CK	89.75[d]	22.25[c]	62.67[d]	33.58[d]	11.33[g]	3.81[b]	63.85[a]
LOCAL BEST CK	178.25[f]	62.08[g]	107.75[f]	111.33[i]	49.25[i]	3.68[c]	63.80[a]

Values are means of triplicates. Mean values having different superscript within column are significantly different (P < 0.05).

rent cassava cultivars. The peak viscosity, which is the maximum viscosity developed during or soon after the heating portion, ranged from 74.25 to 178.25 RVU. Starch from local best CK gave the highest (178.25 RVU at a temperature of 63.80°C in 3.68 min) and TMS01/0040 had the lowest (74.25 RVU at a temperature of 63.90°C in 3.88 min). There is significant difference in the peak viscosity of the starch samples (P < 0.05). This variation in the peak viscosity might be as a result of the amylose contents of the starches. Oguntunde (1987) reported that the associative bonding of the amylose fraction is responsible for the structure and pasting behaviour of starch granule. The viscosity or more correctly the consistency of a cooked starch paste simply reflects the resistance to stirring of the swollen mass gel particles. Peak viscosity has been reported to be closely associated with the degree of starch damage and high starch damage results in high peak viscosity (Sanni et al., 2001).

The results show that there were significant differences (P < 0.05) in the pasting temperature of the starch isolated from the improved cultivars. Pasting temperatures of the starch samples ranged from 63.00°C for sample NR01/0161 to 64.70°C for sample TMS00/0214. The gelatinization temperature obtained was similar to the results for CMD resistant cassava 64.5 to 74.0°C (Omodamiro et al., 2007), chick pea 63.5 to 69.0°C and horse bean 61.0 to 70.0°C starches (Lineback and Ke, 1975). The pasting temperature is one of the pasting properties which provide an indication of the minimum temperature required for sample cooking, energy cost involved and other components stability. It is clear from the results that the starch sample from NR01/0161 will cook faster and less energy consumed, thereby saving cost and time compared to the other starch samples because of its lower pasting temperature.

The breakdown viscosity ranged from 56.50RVU to 107.75RVU. Local best CK had the highest (107.75RVU). The values of breakdown viscosity of the starch samples were significantly different (P < 0.05). Adebowale et al. (2005) reported that the higher the breakdown in viscosity, the lower the ability of the sample to withstand heating and shear stress during cooking. Hence, the starch sample from TMS 01/0040 and TMS 00/0203 might be able to withstand heating and shear stress compared to starch sample from Local best CK because of their low breakdown value.

The final viscosity ranged from 21.50RVU to 111.33RVU. The starch sample from local best CK had the highest (111.33 RVU) final viscosity, while sample from TMS00/0203 had the lowest. There is significant difference in the final viscosity of the starch samples (P < 0.05). Shimelis et al. (2006) reported that final viscosity is used to indicate the ability of starch to form various paste or gel after cooling and that less stability of starch paste is commonly accompanied with high value of breakdown. This imply that starch paste from local best CK will be less stable after cooling compared to the improved cultivars. The variation in the final viscosity might be due to the simple kinetic effect of cooling on viscosity and the re-association of starch molecules in the samples.

Results of the set back viscosity of the starch samples ranged between 9.75 and 49.25 RVU with local best CK having the highest (49.25 RVU) and that from TMS01/0040 was the lowest (9.75 RVU). There is significant difference (P < 0.05) in the set back viscosity of the starch samples. Sanni et al. (2001) reported that lower set back viscosity during the cooling of *gari* indicates higher resistance to retrogradation. This means that local best CK will exhibit higher resistance to retrogradation.

Table 2. Functional properties of starch isolates from 13 improved cassava cultivars.

Cassava cultivar	Water absorption capacity (%)	Swelling power %	Solubility Index (%)	Oil absorption capacity (%)
NR01/004	60.40 [a]	5.73 [a]	4.25 [a]	69.04 [a]
NR01/0161	68.02 [b]	6.92 [b]	5.58 [b]	80.01 [b]
NR01/0071	59.75 [a]	6.39 [b]	5.48 [b]	60.70 [c]
CR14A-1	62.14 [c]	6.18 [a]	5.36 [b]	70.75 [a]
CR41-10	66.22 [d]	5.66 [a]	4.66 [a]	77.07 [d]
AR38-3	67.45 [d]	6.77 [b]	5.44 [b]	78.68 [d]
TMS01/0040	60.77 [a]	6.79 [b]	5.77 [b]	69.22 [a]
TMS01/1086	65.28 [d]	5.88 [a]	4.78 [a]	65.30 [e]
TMS00/0210	62.07 [c]	5.66 [a]	4.33 [a]	63.10 [f]
TMS00/0203	64.85 [d]	6.22 [b]	5.29 [b]	73.45 [g]
TMS00/0214	60.22 [a]	6.28 [b]	5.18 [a]	69.30 [a]
TMS30572CK	64.41 [d]	6.15 [a]	5.96 [b]	75.13 [h]
LOCAL BEST CK	63.29 [c]	5.49 [c]	4.77 [a]	71.29 [a]

Values are means of triplicates. Mean values having different superscript within column are significantly different (P < 0.05).

The results of the functional properties of starch isolates from newly improved cassava cultivars are presented in Table 2. The swelling index which is the measure of the ability of starch to imbibe water and swell, ranged from 5.49 to 6.92%. NR01/0161 starch had the highest value (6.92%), while local best CK starch had the lowest (5.49%). The starch samples were significantly different (P<0.05) in their swelling power. The resulting swelling power indicates that the starch isolates obtained were highly restricted type. The Local best CK had significantly lower swelling power than the improved cultivars presumably due to the higher amylose contents of the Local best CK starch. Leach et al. (1959) reported that the amylose acts both as diluents and inhibitor of swelling. The lower swelling power value obtained in Local best CK than improved cultivar starches suggest a more highly ordered arrangement in its granules than the improved cultivars. Sanni et al. (2005) reported that the swelling index of granules reflect the extent of associative forces within the granules, therefore the higher the swelling index, the lower the associative forces.

The solubility values of the starch samples ranged from 4.25 to 5.96%. Starch from TMS 30572Ck had the highest (5.96%), while starch from NR01/004 had the lowest (4.25%) solubility index. The solubility values of the samples were significantly different (P < 0.05).The ability to absorb water is a very important property of all flours and starches used in food preparations. The range of water absorption capacity (59.75 – 68.02%) observed for the different starches analysed showed that NR01/0161 had the highest (68.02%) while NR01/0071 had the lowest (59.75%) water absorption capacity. The starch samples were significantly different (P < 0.05) in their water absorption capacity. The observed water absorption capacity of the improved cassava cultivars used in this study was lower than that reported by Omodamiro et al. (2007) for *lafun* and starch from improved cassava. The ability of food materials to absorb water is sometimes attributed to its proteins content (Kinsella, 1976). The observed water absorption capacity of starches studied cannot, however, be attributed to their protein content since cassava and cassava starch in particular is very poor in protein. The observed differences in water absorbed may have been due to the nature of the starch (Sathe and Salunkhe, 1981b). Increase in water absorption capacity in food systems enables bakers to manipulate the functional properties of dough in bakery products (Achinewhu and Orafun, 2000; Iwe and Onadipe, 2001). NR01/0161 with the highest level of water absorption capacity will be useful in meeting the cassava initiative for the bread industry in Nigeria.

The oil absorption capacity value of the starch samples used in this study ranged between 60.70 and 80.01%. NR01/0161 had the highest value (80.01%) and NR01/0071 had the lowest (60.70%) value. The oil absorption value of the starch samples were significantly different (P < 0.05). This range is lower than that reported by Omodamiro et al. (2007) for starch from improved cassava and higher than 3.80% reported by Yusuf et al. (2007) for Jack bean starch.

The results of the starch and amylose contents of the starch samples are presented in Table 3. The percentage starch of the improved cassava cultivars ranged from 48.25 to 52.05%. Local best CK had the highest value (52.05%), while TMS 00/0203 had the lowest (48.25%) value of starch. The percentage starch content of the cassava cultivars were significantly different (P < 0.05). The starch levels obtained in these experiments are similar to those reported for Taro (41.27 to 64.44%) by Mbofung et al. (2006). The differences observed in this

Table 3. Starch and amylose contents of 13 improve cassava cultivars.

Cassava cultivar	Starch (%)	Apparent amylose (%)
NR01/004	50.22[a]	15.17[a]
NR01/0161	49.65[a]	15.18[a]
NR01/0071	50.15[a]	15.66[a]
CR14A-1	51.33[a]	15.75[a]
CR41-10	50.42[a]	15.42[a]
AR38-3	49.75[a]	13.88[b]
TMS01/0040	48.85[b]	14.75[c]
TMS01/1086	50.22[a]	15.02[a]
TMS00/0210	50.73[a]	15.25[a]
TMS00/0203	48.25[b]	14.92[c]
TMS00/0214	49.88[a]	15.08[a]
TMS30572CK	48.44[b]	14.78[c]
LOCAL BEST CK	52.05[c]	16.35[d]

Values are means of triplicates.
Means values having different superscript within column are significantly different ($P < 0.05$).

experiment might be related to the maturity of the cassava roots because starch tends to accumulate with maturity. In the present study only mature cassava roots (12 months) were used.

Variation was equally observed in the apparent amylose content of the different samples. Starch amylose levels ranged between 13.88 to 16.35% with local best CK variety having the highest content while the AR 38.3 variety had the least. The amylose content of the samples was significantly different ($P < 0.05$). On a comparative basis, most of the samples analysed were lower than the range of values (17 to 35%) reported by Mbofung et al. (2006), for six varieties of taro. The observed values are also lower than potato (20%) and corn (28 – 30%) starches (Lineback, 1984). The extractable starch and the amylose contents of the local best CK cultivar were comparatively different when compared to the improved cultivars. A relationship was observed between starch and amylose levels and thus inferring that high starch containing cultivars are equally high in amylose content. Since the retrogradation of starch is usually influenced by its amylose content (Klucinec and Thompson, 2002), the correlation between starch and amylose suggest the retrogradation pattern of the starch in the different cultivars.

Conclusion

On the whole, the pasting and functional properties of cassava starch were observed to vary with cultivar. The swelling power of starch isolate from the cassava cultivars studied is in the group of highly restricted-swelling starch. This characteristic is desirable for starch extracts to be used for the manufacture of value-added products such as noodles and composite blends with cereals. TMS00/0203 possessed the most stable gel after cooling. The pasting and functional properties obtained also indicate that the starches can be used in the food processing industry and non-food applications of starch such as in paper and textile industries.

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