

Effect of Isolation Methods on Physicochemical and Functional Properties of Cassava Starch

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ABSTRACT

Physicochemical and functional properties of cassava starch determine its applications in food systems. This study was undertaken to isolate and to determine the physicochemical and functional properties of cassava starch. Cassava starch was isolated from fresh root and dry chips by centrifugation and sedimentation methods. Physicochemical and functional properties of the starches were analyzed. Fresh root yielded (26.07-30.17%) the highest starch followed by dry chips (17.59-23.60%) in sedimentation method. Fresh root starch had lower moisture content (8.88-10.24%), high swelling power (10.86-11.58g/g) and water absorption capacity (84.02-86.18%) compared with dry chips starch. Nevertheless no significant difference was seen in dry matter (87.17-89.99%), ash content (0.23-0.41%), and pH (5.07-5.50), among the isolated starches. Hence fresh root starch with high water absorption capacity and high swelling power could be used for the preparation of bakery products.

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Introduction:

Cassava (*Manihotesculenta* Crantz) belongs to the family Euphorbiaceae. It is a root crop with starchy tubers and consumed approximately in 102 countries (FAO, 2006). As cassava roots are highly perishable, physiological and microbiological deterioration occurred rapidly during storage. Therefore it needs to be processed into dried forms that are more self stable. Processing of cassava into dry form reduces the moisture content; convert it into more durable and stable product with less volume which makes it more transportable (Abera and Rakshit, 2003; Cardoso, 2005).

Cassava flour is obtained by milling of the dried raw root whereas the starch is obtained by washing and wet milling of the root followed by multistage purification of the slurry (Podonou et al., 2005). Cassava starch is equitable to other tuber and cereal starches on top of being easily extracted (FAO, 2000). Starch was isolated from freshly dried chips and it exhibited some changes in functional properties as compared to their fresh root. However, they were in acceptable quality and desirable functionality (Abera and Rakshit, 2004). Starch characteristics such

as swelling power, solubility pattern, pasting behaviour and physico-chemical properties are important to improve the quality of food products (Ikegwu et al., 2010).

The objective of our study was to isolate starch from fresh root, dry chips dry milled and dry chips wet milled cassava through different methods and to determine the physicochemical and functional properties of isolated cassava starches.

Materials and Methods:

Sample preparation:

Fresh cassava root of CO-2 variety was obtained from Tapioca and Castor Research Centre at Yethapur in Salem district of Tamil Nadu. The collected plant material was kept in a polyethylene bag to prevent microbial and insect contamination during transportation to the laboratory of Food Science and Nutrition Department, Periyar University where the study was conducted and it was immediately put into water for preventing spoilage and colour change.

Dry chips preparation:

Fresh cassava roots were cleaned, washed, peeled, and hand chopped into slices, placed on drying trays

and kept under the sun for drying. These were stirred for every two hr. After 24 hr of drying, the moisture content was dropped to 12 - 15%. Dried chips were packed in polyethylene bag of 0.1 mm thickness and stored at room temperature until required for starch extraction (Abera and Rakshit, 2003).

Starch isolation methods:

Starch was isolated from different raw material of cassava such as fresh root; dry chips dry milled and dry chips wet milled through various methods. Starch was isolated from raw materials through the method of Vasanthan(2001) and it was known as Method A. The same method with slight modification was termed as Method B. Isolation methods that were described by Riley et al. (2006) and Oyewole and Obieze (1995) known as Method C and Method D respectively.

Freshly harvested cassava roots were cleaned, peeled and sliced into small pieces. The slices were ground with water in grinder until to get the smooth slurry and it was used for the isolation of starch. Isolation of starch from dry chips was conducted in two ways such as dry milling and wet milling. In dry milling, chips were ground to powder by pestle and mortar then water was added into the powder and filtered with 200 mesh sieve. And the slurry was used for the separation of starch. In wet milling, the prepared dry chips were steeped in water at room temperature for 24 hr. Then every 6hr the water was changed and the steeped chips were ground into slurry which was used for the isolation of starch.

Method A and B:

The fresh roots were cleaned, washed, peeled, sliced and grounded with water at a ratio of 1:10 until smooth slurry form (5 - 10 min). For preventing microbial contamination, 0.01% (w/v) sodium metabisulfite was added to the slurry, filtered through double-layered cheese cloth. During filtration, the starch was repeatedly washed by spraying water into the residue. The resulting filtrate contained medium and small fibers then it was subjected to further filtration through a series of polypropylene screens (250, 175, 125, and/or 75 μm). The filtrated starch milk was centrifuged 20 - 30 min at 5000 \times g, 20°C and the supernatant was decanted in method A. The filtrated starch milk was sedimented for 4 - 6 hr in method B and the sedimented wet starch was sun dried. The dried starch was ground into powder using a mortar and pestle and stored in closed plastic air tight container at room temperature.

Method C:

Fresh cassava starch extraction was carried out according to Riley et al. (2006) with slight modification. The cleaned fresh tuberous roots (100 g) were homogenised with 1M NaCl solution (100 g of tuber in 200 ml of solution) using a grinder. The pulp was stirred for 2 min and filtered using a triple cheese

cloth. The filtrate was allowed to stand until the starch was sedimented. The top liquid was decanted and discarded. The starch sediment was again washed with distilled water followed by centrifugation at 3,000 g for 10 min and the supernatant solution was discarded. The isolated starch was dried under the sun on aluminium pans and stored in plastic air tight container.

Method D:

Fresh root cassava starch extraction was done by the method of Oyewole and Obieze (1995) with slight modification. Freshly harvested cassava roots were peeled, washed, grated and grounded with water using a grinder. The resultant pulp was immediately sieved through a screen and suspended in water. Sieving separated the fibrous and other coarse root material from the starch pulp. The starch pulp was allowed to settle for 4 - 6 hr before decanting. The supernatant was decanted and the thick sediment was sun dried and packed.

Starch isolation from dry chips:

Starch extraction from the dry chips through dry milling and wet milling was carried out the same way as described for the fresh root isolation methods.

Starch yield:

Starch yield (%) was calculated as per the method described by Thao and Noomhorm (1995).

Determination of starch properties:

Moisture content (%), Dry matter (%) and Ash (%) were estimated by AOAC Method (1990). pH was estimated according to Adeleke and Odedeji (2010).

Swelling power (g g^{-1}) was measured as per the method described by Leach et al. (1959). Water absorption capacity (%) and oil absorption capacity (g g^{-1}) were determined according to Beuchat (1977).

Statistical analysis:

Data were analyzed using single factor ANOVA. Significant level at 5 % ($p < 0.05$) was applied to test the significant difference among the isolated starch samples.

Results and Discussion:

Starch yield:

Starch yield from fresh root, dry chips dry milled and dry chips wet milled through various methods are given in Table-1. The starch yield of fresh root, dry milling and wet milling through method A was 27.75%, 17.68%, and 19.59% respectively. The yield of starch was in the range of 20.70-28.93 and 17.86-26.07 percent through method B and C respectively, similarly 20.52-30.17 % of starch was obtained through method D. This result is confirmed with Moorthy (2001) who stated that the starch yield of cassava was 21.8%. Oludarc and Macdonald (2010) reported that starch yield of cassava was 13.86% and 24.68% in

TMS 9134 and TMS 3001 respectively. On the whole, dry chips dry milled yielded less amount of starch than fresh root and dry chips wet milled. In dry milled, the starch loss might be attributed to the small size starch particles removed together with the fine fiber particles during cleaning of the starch cake and processing of starch from dry chips resulted in more fine fiber

particles in the starch (Abera and Rakshit, 2003). On the whole, fresh root yielded the highest percent of starch (30.17) followed by dry chips wet milled (23.60) and dry chips dry milled (20.92). Method D provided the greater yield of starch from different raw materials of cassava. Isolation methods and raw material products significantly changed the yield of starch in cassava root.

Table 1 Yield (%) of Cassava starch through different isolation methods from different raw materials

| Raw material type | Isolation methods | | | |
|----------------------|-------------------------|--------------------------|-------------------------|-------------------------|
| | Method A | Method B | Method C | Method D |
| Fresh root | 27.75±1.56 ^a | 28.93± 0.67 ^a | 26.07±1.01 ^a | 30.17±0.70 ^b |
| Dry chips Dry milled | 17.68±0.69 ^b | 20.70±0.78 ^b | 17.86±0.36 ^b | 20.92±0.48 ^b |
| Dry chips Wet milled | 19.59±0.21 ^b | 23.60±0.08 ^c | 19.28±0.64 ^b | 20.52±0.95 ^b |
| F- value | 87.32* | 149.14* | 111.37* | 164.69* |
| CD- value | 2.17 | 1.79 | 2.99 | 2.22 |

Mean ± SD values with different superscripts in a column are significantly (p<0.05) different,

* = Significant at 5%.

Physico-chemical properties of isolated cassava starch:

Moisture content:

Moisture contents of fresh root, dry milling and wet milling starches (Table 2) that were obtained through method A was 8.88 %, 12.85%, and 10.12% respectively. Dry chips dry milled starches had the highest moisture content (12.48-13.26%) whereas the moisture content of fresh root starch was less (8.88-10.24%). Nuwamanya et al. (2010) reported that the moisture content of cassava starch was ranged from 14 to 16 %, but in this study it was found that all isolated starches had less moisture content. Moisture content may be affected by the environment and the method of storage used for starch and the moisture content of the starch was generally depended upon the duration of the drying process (Nuwamanya et al., 2009). Moisture content of dry starch varies from 6-16%, depends on the process used for drying the starch. Higher levels of moisture can lead to microbial damage and subsequent deterioration in quality (Redley, 1976).

Dry Matter, Ash and pH content:

The percentage of dry matter (Table 3) of cassava starch ranged from 86 to 89. This result is confirmed with Oludarc and Macdonald (2010) who stated that the dry matter of cassava starch ranged from 86.71 to 87.18 %. Ash content of all the isolated starches (Table 4) was in the range of 0.28 – 0.41%. The same result is reported by Numfor et al. (1999) and Karam et al. (2006) who reported that the ash content

of cassava starch was 0.22%. Nevertheless, dry milled starches that were separated through all methods contained the higher ash content (0.31 - 0.41%) than fresh root starch. The main component of ash or mineral matter in starch was phosphorus which affected swelling power, solubility, and pasting properties of starch (Karim et al., 2007). Phospholipid content of the starch is proportional to the amylose content of the starch (Morrison et al., 1984; Morrison et al., 1993). Phospholipids present in starch have a tendency to form a complex with amylose and long branched chains of amylopectin which results in limited swelling. Wheat and rice starches have higher phospholipid contents and produce starch pastes with lower transmittance than corn and potato starches with lower phospholipid contents (Singh et al., 2003). Ocloo et al. (2010) stated that the pH value gives a measure of acidity or alkalinity of the flour and the level of pH is used to estimate the quality of flour. The pH (Table 5) range of starches isolated through method A, B, C and D was 5.07 -5.50, 5.26 - 5.45, 5.22 – 5.45 and 5.07 - 6.20 respectively. The highest pH content was found to be in wet milled starch that was isolated through method D among the starches. Oludarc and Macdonald (2010) reported that the pH value of native cassava starch was 6.00. The pH of the starches varied independently for different raw materials. These variations could be due to the influence of the composition of starch and presence of impurities (Sangeetha-Mishra, 2006).

Table 2 Moisture content (%) of cassava starches

| Raw material type | Isolation methods | | | |
|----------------------|--------------------|--------------------|--------------------|--------------------|
| | Method A | Method B | Method C | Method D |
| Fresh root | 8.88±1.92 | 9.88±3.17 | 10.24±0.52 | 9.88±3.17 |
| Dry chips Dry milled | 12.85±3.54 | 12.48±1.87 | 13.26±0.45 | 13.00±3.00 |
| Dry chips Wet milled | 10.12±0.53 | 10.82±1.13 | 10.69±2.04 | 10.70±1.22 |
| F- value | 2.23 ^{NS} | 1.05 ^{NS} | 5.11 ^{NS} | 1.14 ^{NS} |

Ns = not significant

Table: 3. Dry matter (%) of cassava starches

| Raw material type | Isolation methods | | | |
|----------------------|--------------------|--------------------|--------------------|--------------------|
| | Method A | Method B | Method C | Method D |
| Fresh root | 88.99±2.02 | 87.06±0.69 | 88.79±2.30 | 86.84±3.06 |
| Dry chips Dry milled | 89.83±0.88 | 89.99±1.62 | 89.44±2.03 | 89.69±1.35 |
| Dry chips Wet milled | 88.88±1.92 | 89.23±1.88 | 88.88±1.92 | 87.17±0.55 |
| F- value | 0.28 ^{NS} | 3.11 ^{NS} | 0.08 ^{NS} | 1.89 ^{NS} |

NS = Not Significant

Table: 4. Ash content (%) of cassava starches.

| Raw material type | Isolation methods | | | |
|----------------------|--------------------|--------------------|--------------------|--------------------|
| | Method A | Method B | Method C | Method D |
| Fresh root | 0.33±0.02 | 0.23±0.05 | 0.28±0.05 | 0.28±0.14 |
| Dry chips Dry milled | 0.36±0.02 | 0.31±0.16 | 0.31±0.02 | 0.41±0.07 |
| Dry chips Wet milled | 0.26±0.07 | 0.26±0.02 | 0.26±0.12 | 0.30±0.05 |
| F- value | 3.11 ^{NS} | 0.52 ^{NS} | 0.29 ^{NS} | 1.62 ^{NS} |

NS = Not Significant

Table: 5. pH content of cassava starches.

| Raw material type | Isolation methods | | | |
|----------------------|-------------------------|--------------------|--------------------|--------------------|
| | Method A | Method B | Method C | Method D |
| Fresh root | 5.50±0.29 ^a | 5.30±0.10 | 5.31±0.06 | 5.07±0.02 |
| Dry chips Dry milled | 5.07±0.02 ^b | 5.26±0.19 | 5.45±0.08 | 5.25±0.18 |
| Dry chips Wet milled | 5.07±0.03 ^{ca} | 5.45±0.17 | 5.22±0.19 | 6.20±1.36 |
| F- value | 6.46* | 1.19 ^{NS} | 2.40 ^{NS} | 1.72 ^{NS} |
| CD- value | 0.51 | - | - | - |

Mean ± SD values with different superscripts in a column are significantly (p<0.05) different,

* = Significant at 5% and NS = not significant

Table: 6. Swelling power (g g⁻¹) of cassava starches.

| Raw material type | Isolation methods | | | |
|----------------------|--------------------|-------------------------|--------------------------|-------------------------|
| | Method A | Method B | Method C | Method D |
| Fresh root | 11.58± 0.98 | 11.51±0.45 ^a | 10.86±0.18 ^a | 10.95±0.12 ^a |
| Dry chips Dry milled | 10.21±0.17 | 10.19±0.56 ^b | 9.72±0.08 ^b | 9.58±0.50 ^a |
| Dry chips Wet milled | 11.34±0.27 | 11.31±0.26 ^b | 10.34±0.31 ^{ca} | 10.21±0.70 ^a |
| F- value | 4.31 ^{NS} | 7.81* | 22.22* | 5.53* |
| CD- value | - | 1.20 | 0.57 | 1.37 |

Mean ± SD values with different superscripts in a column are significantly (p<0.05) different,

* = Significant at 5% and NS = not significant

Functional properties of isolated cassava starches:**Swelling Power:**

Results of functional properties of the isolated cassava starch are presented in Table 5, 6, 7 and 8. Swelling power of the starch depends on the processes such as grinding, drying, heating and physical properties of the starch matrix (Thibault et al., 1992). Rickard et al. (1992) reported that the swelling power was a measure of hydration capacity because the determination was a weight measure of swollen starch granules and their occluded water. Tester and Morrison (1990) suggested that swelling of starch was attributed to amylopectin. Furthermore, swelling has a high negative correlation with amylose (Tomoko and Junko, 1998). Swelling is inhibited by lipid content of starch (Atwell et al., 1988). Swelling power of cassava starches that were isolated through all methods from different raw material varied significantly (p<0.05) except starches isolated through method A. The

swelling power of cassava fresh root, dry chips wet milled and dry chips dry milled starches which were isolated through method A at 80°C was 11.58 g g⁻¹, 11.34 g g⁻¹ and 10.21 g g⁻¹ respectively. The swelling power of starches isolated through method B, C and D was in the range of 10.19 – 11.52 g g⁻¹, 9.72 – 10.86 g g⁻¹ and 9.58 – 10.95 g g⁻¹ respectively. This result is confirmed with Daramola and Osanyinlusi (2006) who stated that the swelling power of native cassava starch was 8.90 g/g.

Water binding capacity:

Environmental conditions such as temperature, pH, and ionic strength, dielectric constant of the surrounding solution and nature of the ions can also influence the hydration characteristics of the starches (Fleury and Lahye, 1991). Except dry milled starches, both fresh root and wet milled starches exhibited the water absorption capacity in the range of 83.00 – 86.18%. Water absorption capacity of cassava starches was found to be higher than that reported by

Ikegwu et al. (2009) who stated water absorption capacity of cassava starch was 59.75 – 68.02%. The observed differences in water absorbed cassava starch might be due to the nature of the starch (Sathe and Salunkhe, 1981). Dry chips starches had lower water

absorption capacity than fresh root starches; the differences in WAC of starches from different corn types may be attributed to the variation in their granule size and structure (Hoover and Sosulski, 1986).

Table: 7.Water binding capacity (%) of cassava starches.

| Raw material type | Isolation methods | | | |
|----------------------|--------------------------|--------------------|--------------------------|--------------------|
| | Method A | Method B | Method C | Method D |
| Fresh root | 86.18±1.53 ^a | 84.64±5.30 | 84.02±3.61 ^a | 84.09±4.89 |
| Dry chips Dry milled | 79.06±0.08 ^b | 78.29±0.63 | 77.44±1.50 ^b | 77.99±3.59 |
| Dry chips Wet milled | 84.53±0.41 ^{ca} | 83.00±1.73 | 84.66±1.15 ^{ca} | 83.66±1.52 |
| F- value | 49.20* | 3.10 ^{NS} | 8.63* | 2.66 ^{NS} |
| CD- value | 2.76 | - | 4.70 | - |

Mean ± SD values with different superscripts in a column are significantly (p<0.05) different, * = Significant at 5% and NS = not significant

Table: 8.Oil absorption capacity (g g⁻¹) of cassava starches.

| Raw material type | Isolation methods | | | |
|----------------------|-------------------------|-------------------------|--------------------------|-------------------------|
| | Method A | Method B | Method C | Method D |
| Fresh root | 1.45±0.02 ^a | 1.44±0.02 ^a | 1.44±0.03 ^a | 1.44±0.02 ^a |
| Dry chips Dry milled | 1.36±0.02 ^b | 1.35±0.03 ^b | 1.36±0.005 ^b | 1.35±0.02 ^b |
| Dry chips Wet milled | 1.41±0.01 ^{ba} | 1.41±0.01 ^{ba} | 1.42±0.005 ^{ba} | 1.41±0.01 ^{ca} |
| F- value | 13.72* | 9.17* | 10.94 * | 11.92* |
| CD- value | 0.05 | 0.08 | 0.06 | 0.06 |

Mean ± SD values with different superscripts in a column are significantly (p<0.05) different, * = Significant at 5%.

Oil Absorption Capacity:

Oil absorption capacity of cassava starch from fresh root, dry chips wet milled and dry chips dry milled through method A was 1.45g g⁻¹, 1.41 g g⁻¹ and 1.35 g g⁻¹ respectively. Likewise in method B oil absorption capacity of fresh root starch was the highest (1.44 g g⁻¹) one followed by wet milled (1.41 g g⁻¹) and dry milled (1.36 g g⁻¹). And the same trend was observed in method C, however fresh root starch isolated through method D had the highest oil absorption capacity (1.44 g g⁻¹) followed by wet milled (1.41 g g⁻¹) and dry milled (1.35 g g⁻¹) starch. **Uzomah and Ibe (2011)** reported that oil absorption capacity of the cassava starch ranged from 1.02 - 1.51 g g⁻¹. Among the starches, dry chips dry milled had the lowest oil absorption capacity, because protein is composed of both hydrophilic and hydrophobic parts affecting the oil absorption capacity of starch. Non-polar amino acid side chains can form hydrophobic interactions with hydrocarbon chains of lipid (**Eltayeb et al., 2011**).

Conclusion:

It can be concluded that the fresh root yielded the highest starch in all methods. Fresh root starch contained less moisture followed by dry chips dry milled and dry chips wet milled. In view of chemical properties no significant difference was seen in dry mater, ash content and pH of starches isolated through all methods as well as starches from different raw

materials. Swelling power was significantly higher in fresh root starch than dry chip starches. Water and Oil absorption capacity was also high in fresh root starches when compared to dry chips starches. The higher water absorption capacity of starches is very useful for preparing bakery products like biscuits, cookies and bread.

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