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*Full Length Research Paper*

# Effects of fermentation length and varieties on the pasting properties of sour cassava starch

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**The effects of length of fermentation (5, 10, 15, 20 and 25 days) on pasting properties of sour starches produced from six cassava varieties were investigated. There were significant differences ($p < 0.05$) in pasting properties except pasting temperature and breakdown viscosity, irrespective of the length of fermentation. Peak viscosity ranged from 308.50 to 466.63 rapid visco unit (RVU), trough ranged from 67.25 to 198.75 RVU, break down ranged from 147.71 to 320.25 RVU, final viscosity ranged from 100.29 to 233.00 RVU, set back ranged from 31.59 to 54.58 RVU, peak time ranged from 3.60 to 4.06 min and pasting temperature ranged from 62.85 to 65.45°C. Sour starches made from TMS 30572, TMS 4(2) 1425 and 96/0603 cassava varieties recorded the highest values.**

**Key words:** Cassava, fermentation, pasting, starch, varieties.

## INTRODUCTION

Cassava root is normally processed before consumption as a means of detoxification, preservation and modification. Various fermented cassava products are available, including 'garri', 'fufu' and 'lafun' (Oyewole, 1991). Fermentation processes play important roles in food process technology in developing countries. In traditional fermentation processes, natural micro-organisms are employed in the preparation and preservation of different types of food. These processes add to the nutritive value of foods as well as enhancing flavour and other desirable qualities associated with digestibility and edibility. The fermentation techniques are often characterized by the use of simple, non-sterile equipment, chance or natural inoculums, unregulated conditions, sensory fluctuations, poor durability and unattractive packaging of the processed products (Nout, 1985).

Fermentation is the metabolic process in which carbohydrates and compounds are oxidized with the release of energy in the absence of any external electron acceptors. This is a molecular characterization and the word “fermentation” has had many shades of meaning in the past (Doelle, 1975; Oyewole, 1991). Many African foods are fermented before consumption and the lactic acid bacteria are widely used as starter organisms in these food fermentations because they convert sugars into organic acids, thus, improving the organoleptic and theological properties of the products (Vogel et al., 2002). This study studied the effects of fermentation period on pasting properties of sour cassava starch.

## MATERIALS AND METHODS

Fresh cassava roots of 3 CMD resistance clones (96/0603, 96B/00061 and 96/01632) and 3 newly released cassava (4(2)1425, 30572 and TME 1) from IITA Ibadan trial field were used. The cassava plants were about 10 to 12 months old at the time of harvest. The cassava roots were processed within 60 min after harvesting.

### Starch extraction

The traditional eastern Nigerian methods (Osunsami et al., 1989; Oyewole and Obieze, 1995) were used. Cassava roots (50 kg) were peeled, washed in water and grated with a commercial

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mechanical grater. The resultant pulp was immediately sieved through a screen and suspended in 70 L of water. This separates the fibrous and other coarse root material from the starch pulp (Oyewole and Odunfa, 1989; Oyewole and Obieze, 1995). The starch pulp was allowed to settle for 4 to 6 h before decanting. The thick starch cake at the bottom of the bowl was pressed to remove water.

### Sour starch production

Sour cassava starch was produced following Brabet et al. (1998) method with little modification. Sour dough was produced by mixing 200 g native starch and 200 ml of distilled water and fermented at room temperature (30 ± 2°C). This involved natural fermentation of cassava starch for 5, 10, 15, 20 and 25 days followed by oven (Fisher Scientific Isotemp Oven, model 655F, Chicago, USA) drying at 50°C to approximately 10% moisture content. The dried sample was milled and stored in a cool place for analysis.

### Determination of pasting properties

Pasting properties of starches were measured by using a Rapid Visco Analyser (RVA) (Newport Scientific Instruments, Warriewood, Australia), following the RVA corn starch method (AACC, 2000). Sour cassava starch (3.0 g, db), was suspended in distilled water (25 ml), and the suspension was thoroughly stirred in the RVA at 960 rpm for 10 s and then at 160 rpm for the remainder of the test. The temperature was first maintained at 50°C for 1 min for equilibration and then raised to 95°C at 12°C/min. The sample was kept at 95°C for 2.4 min, cooled to 50°C at 12°C/min and finally maintained at 50°C for 2 min. The experiments were conducted in duplicate and the average values were recorded. The parameters recorded were pasting temperature ($P_{temp}$), peak viscosity (PV), peak time ($P_{time}$), trough, breakdown, set back and final viscosity.

### Statistical analysis

Data generated from all experiments were subjected to analysis of variance and means were separated using Duncan's multiple range test while Pearson's correlation and factor analysis were also determined using statistical analysis software (SAS), (Model 8e,SAS institute Inc. Cary, NC, USA).

## RESULTS AND DISCUSSION

Tables 1 to 5 show the pasting properties of sour starch at different length of fermentation. Peak viscosity during heating was found to decrease as the fermentation length increases, for cassava variety 30572, it decreases from 466.63 to 360.38 RVU at the end of the fermentation, for 4(2)1425, it decreases from 460.09 to 333.17 RVU, for 93B/00061, it decreases from 357.25 to 342.29 RVU, for 96/0603, it decreases from 395.75 to 362.96 RVU and for TME1, decreases from 458.36 to 380.75 RVU. Pasting temperature also increased as the length of fermentation increases irrespective of the varieties used. Both final viscosity and peak time decreased as the fermentation progresses.

Pasting temperature gives an indication of the gelatinezation time during processing. It is the temperature at which the first detectable viscosity is measured and an index characterized by initial change due to the swelling of starch. Pasting temperature has been reported to relate to water binding capacity, a higher pasting temperature implies higher water binding capacity, higher gelatinization and lower swelling property of starch due to high degree of association between starch granules (Ezeala, 1984; Oyewole, 1990). The pasting temperature of the sour cassava starch was slightly lower to that of native starch. This might be due to conversion of starch to simple sugars by fermenting microorganisms, thereby reducing the structural stability of the starch materials.

The transition from a suspension of starch granules to a paste, when heat is applied, is accompanied by a large increase in viscosity. Changes in viscosity also accompany the formation of gels upon cooling of starch pastes. Similar pasting temperature for cassava starch has also been reported by Dreher and Berry (1983) and Dreher et al. (1983). During the hold period of a typical pasting test, the sample is subjected to a period of constant temperature (usually 95°C) and mechanical shear stress. This further disrupts the starch granule and amylose molecules generally leach out into solution and align in the direction of the shear. A gradual decrease of the paste viscosity during the hold period indicates thermal breakdown of starch and thus, may be considered as a measure of stability. The period is sometimes called shear thinning, holding strength, hot paste viscosity or trough due to the accompanied breakdown in viscosity. It is the minimum viscosity value in the constant temperature phase of RVA profile and it measures the ability of paste to withstand breakdown during cooling. Large values indicate little breakdown of sample starches. The rate of breakdown depends on the nature of the material, the temperature and degree of mixing and shear applied to the mixture (IITA, 2001).

As the temperature is increased, the starch granules swell and increase the viscosity of the starch paste until the peak viscosity is reached. A higher peak viscosity corresponds to a higher thickening power of a starch. In this study, fermentation tends to reduce the peak viscosity of the starch, irrespective of cassava variety. Since a high peak viscosity corresponds to higher thickening power; paste from sour cassava starch is expected to be thinner than paste from its corresponding native starches. This is in agreement with findings of Alummoottil et al. (2004) that a fall in peak viscosity and viscosity breakdown was observed for fermented cassava starch, while the pasting temperature was enhanced significantly.

Figure 1 shows the effect of fermentation period on pH and total titratable acidity (TTA) of sour cassava starch from TMS 30572. During the spontaneous fermentation, pH fell gradually from 6.00 at the onset of fermentation to 3.91 at the end of fermentation (25 days). As the pH decreased, the total titratable acidity (TTA) increased, indicating that the starch is becoming more acidic in

**Table 1.** Pasting properties of fermented starch for 5 days period of fermentation.

| Variety | Peak viscosity (RVU) | Trough (RVU) | Break down (RVU) | Final viscosity (RVU) | Set Back (RVU) | Peak time (min) | Pasting temperature (℃) |
|---|---|---|---|---|---|---|---|
| 30572 | 466.63$^{a}$ | 155.63$^{a}$ | 320.25$^{a}$ | 199.71$^{a}$ | 44.08$^{a}$ | 3.88$^{a}$ | 63.10$^{c}$ |
| 4(2)1425 | 460.09$^{a}$ | 194.63$^{a}$ | 224.80$^{c}$ | 192.83$^{ab}$ | 34.71$^{c}$ | 3.80$^{a}$ | 64.13$^{a}$ |
| 92B/00061 | 357.25$^{c}$ | 114.71$^{a}$ | 235.42$^{bc}$ | 153.09$^{c}$ | 38.38$^{bc}$ | 3.90$^{a}$ | 63.73$^{ab}$ |
| 96/01632 | 308.50$^{d}$ | 109.79$^{a}$ | 194.83$^{d}$ | 144.50$^{c}$ | 34.71$^{c}$ | 3.93$^{a}$ | 63.38$^{ab}$ |
| 96/0603 | 395.75$^{b}$ | 139.96$^{a}$ | 255.33$^{b}$ | 182.67$^{b}$ | 42.71$^{ab}$ | 3.96$^{a}$ | 63.45$^{bc}$ |
| TME1 | 458.36$^{a}$ | 194.58$^{a}$ | 222.26$^{c}$ | 192.41$^{ab}$ | 36.20$^{c}$ | 3.83$^{a}$ | 64.13$^{a}$ |
| Mean | 407.76 | 151.55 | 242.15 | 177.53 | 38.46 | 3.88 | 63.65 |
| R-Square | 0.99 | 0.76 | 0.98 | 0.97 | 0.92 | 0.70 | 0.91 |
| C.V | 2.858 | 21.65 | 4.07 | 3.23 | 5.42 | 1.54 | 0.314 |
| Std Dev | 63.49 | 45.34 | 41.88 | 23.56 | 5.12 | 0.07 | 0.45 |
| Range | 308.50-466.63 | 109.79-194.63 | 194.83-320.25 | 144.50-199.71 | 34.71-42.71 | 3.80-3.96 | 63.10-64.13 |
| P of Clone | ** | NS | ** | ** | * | NS | * |

Each value represent mean of three replicates. Mean values having the same alphabet within column are not significantly different at 5% confidence level.
*P<0.05; **P<0.01; ***P<0.0001; NS, not significant; RVU, rapid visco unit.

**Table 2.** Pasting properties of fermented starch for 10 days length of fermentation.

| Varieties | Peak viscosity (RVU) | Trough (RVU) | Break down (RVU) | Final viscosity (RVU) | Set back (RVU) | Peak time (Min) | Pasting temperature (℃) |
|---|---|---|---|---|---|---|---|
| 30572 | 370.63$^{b}$ | 133.13$^{b}$ | 230.33$^{bc}$ | 167.08$^{bc}$ | 33.96$^{a}$ | 3.88$^{ab}$ | 63.23$^{ab}$ |
| 4(2)1425 | 364.34$^{b}$ | 130.50$^{bc}$ | 208.34$^{c}$ | 175.50$^{b}$ | 35.15$^{a}$ | 3.78$^{b}$ | 63.10$^{ab}$ |
| 92B/00061 | 353.50$^{b}$ | 113.21$^{d}$ | 235.04$^{abc}$ | 153.92$^{c}$ | 40.71$^{a}$ | 3.99$^{ab}$ | 64.08$^{a}$ |
| 96/01632 | 352.08$^{b}$ | 121.96$^{c}$ | 215.29$^{bc}$ | 160.34$^{bc}$ | 38.38$^{a}$ | 3.81$^{b}$ | 63.80$^{ab}$ |
| 96/0603 | 446.54$^{a}$ | 152.84$^{a}$ | 283.33$^{a}$ | 200.42$^{a}$ | 47.58$^{a}$ | 4.06$^{a}$ | 62.85$^{b}$ |
| TME1 | 402.80$^{ab}$ | 133.09$^{b}$ | 262.21$^{ab}$ | 174.21$^{b}$ | 41.13$^{a}$ | 3.88$^{ab}$ | 63.93$^{a}$ |
| Mean | 381.65 | 130.79 | 239.09 | 171.91 | 39.48 | 3.88 | 63.50 |
| R-Square | 0.78 | 0.97 | 0.82 | 0.91 | 0.53 | 0.78 | 0.79 |
| C.V | 7.30 | 2.58 | 8.07 | 4.19 | 17.26 | 1.94 | 0.59 |
| Std Dev | 40.44 | 13.17 | 30.84 | 16.37 | 6.70 | 0.11 | 0.55 |
| Range | 352.08-446.54 | 113.21-152.84 | 208.34-235.04 | 153.92-200.42 | 33.96-47.58 | 3.78-4.06 | 62.85-64.08 |
| P of clone | NS | ** | NS | * | NS | NS | NS |

Each value represent mean of three replicates; Mean values having the same alphabet within column are not significantly different at 5% confidence level.
*P<0.05; **P<0.01; ***P<0.0001; NS, not significant; RVU, rapid visco unit.

**Table 3.** Pasting properties of fermented starch for 15 days length of fermentation.

| Variety | Peak viscosity (RVU) | Trough (RVU) | Break down (RVU) | Final viscosity (RVU) | Set back (RVU) | Peak time (Min) | Pasting temperature (°C) |
|---|---|---|---|---|---|---|---|
| 30572 | 440.33[a] | 135.58[ab] | 293.42[a] | 184.84[a] | 49.25[b] | 3.85[ab] | 63.53[ab] |
| 4(2)1425 | 406.50[b] | 134.59[b] | 243.04[b] | 188.21[a] | 53.63[a] | 3.72[b] | 63.98[ab] |
| 92B/00061 | 347.84[c] | 115.67[c] | 231.55[b] | 147.25[c] | 31.59[d] | 4.04[a] | 63.00[b] |
| 96/01632 | 333.25[c] | 110.05[c] | 199.17[c] | 151.13[c] | 41.08[c] | 3.73[b] | 64.55[ab] |
| 96/0603 | 388.92[b] | 145.42[a] | 241.46[b] | 189.29[a] | 43.88[c] | 3.98[a] | 64.50[ab] |
| TME1 | 414.54[ab] | 140.75[ab] | 246.38[b] | 173.25[b] | 32.50[d] | 3.70[b] | 65.08[a] |
| Mean | 388.56 | 130.34 | 242.50 | 172.33 | 41.99 | 3.83 | 64.10 |
| R-Square | 0.96 | 0.97 | 0.95 | 0.99 | 0.99 | 0.89 | 0.68 |
| C.V | 2.88 | 2.94 | 4.15 | 1.81 | 2.63 | 1.95 | 1.17 |
| Std Dev | 39.85 | 13.79 | 29.73 | 18.16 | 8.60 | 0.15 | 0.89 |
| Range | 333.25-440.33 | 110.05-145.42 | 199.17-293.42 | 147.25-189.29 | 31.59-53.63 | 3.70-4.04 | 63.00-65.08 |
| P of clone | ** | ** | ** | ** | *** | * | NS |

Each value represent mean of three replicates; Mean values having the same alphabet within column are not significantly different at 5% confidence level.
*P<0.05; **P<0.01; ***P<0.0001; NS, not significant; RVU, rapid visco unit.

**Table 4.** Pasting properties of fermented starch for 20 days length of fermentation.

| Variety | Peak viscosity (RVU) | Trough (RVU) | Break down (RVU) | Final viscosity (RVU) | Set back (RVU) | Peak time (Min) | Pasting temperature (°C) |
|---|---|---|---|---|---|---|---|
| 30572 | 400.67[a] | 157.00[ab] | 207.08[b] | 211.58[a] | 54.58[a] | 3.68[bc] | 65.45[a] |
| 4(2)1425 | 410.84[a] | 198.75[a] | 174.71[c] | 233.00[a] | 34.25[bc] | 3.65[c] | 64.25[b] |
| 92B/00061 | 358.42[ab] | 67.25[c] | 229.50[a] | 100.29[d] | 33.04[c] | 3.60[c] | 64.58[ab] |
| 96/01632 | 290.290[c] | 103.13[bc] | 147.71[d] | 145.50[c] | 42.38[abc] | 3.63[c] | 64.73[ab] |
| 96/0603 | 378.54[a] | 147.04[ab] | 211.38[b] | 198.33[b] | 51.29[a] | 3.78[a] | 64.48[b] |
| TME1 | 325.13[bc] | 135.63[b] | 168.79[c] | 184.50[bc] | 48.88[ab] | 3.75[ab] | 64.43[b] |
| Mean | 360.65 | 134.80 | 189.86 | 178.87 | 44.07 | 3.68 | 64.65 |
| R-Square | 0.92 | 0.91 | 0.99 | 0.95 | 0.84 | 0.90 | 0.73 |
| C.V | 5.45 | 15.08 | 2.074 | 8.79 | 12.78 | 0.95 | 0.56 |
| Std Dev | 46.12 | 45.80 | 29.65 | 47.50 | 9.60 | 0.08 | 0.471 |
| Range | 290.29-410.84 | 67.25-198.75 | 147.71-229.50 | 100.29-233.00 | 33.04-54.58 | 3.60-3.78 | 64.25-65.45 |
| P of clone | ** | * | *** | * | * | * | NS |

Each value represent mean of three replicates; Mean values having the same alphabet within column are not significantly different at 5% confidence level.
*P<0.05; **P<0.01; ***P<0.0001; NS, not significant; RVU, rapid visco unit.

**Table 5.** Pasting properties of fermented starch for 25 days length of fermentation.

| Variety | Peak viscosity (RVU) | Trough (RVU) | Break down (RVU) | Final viscosity (RVU) | Set back (RVU) | Peak time (Min) | Pasting temperature (°C) |
|---|---|---|---|---|---|---|---|
| 30572 | 360.38[b] | 134.17[a] | 209.96[ab] | 167.75[a] | 33.58[b] | 3.78[b] | 65.14[a] |
| 4(2)1425 | 333.17[c] | 98.790[d] | 201.30[b] | 140.33[b] | 41.54[a] | 3.60[c] | 64.28[a] |
| 92B/00061 | 342.29[c] | 123.71[b] | 214.50[ab] | 165.54[a] | 41.84[a] | 3.91[a] | 63.78[a] |
| 96/01632 | 334.46[c] | 109.00[c] | 208.84[b] | 149.88[b] | 40.88[a] | 3.77[b] | 64.13[a] |
| 96/0603 | 362.96[b] | 132.59[a] | 211.75[ab] | 166.38[a] | 33.79[b] | 3.75[b] | 64.08[a] |
| TME1 | 380.75[a] | 127.92[ab] | 228.96[a] | 163.00[a] | 35.09[b] | 3.74[b] | 64.45[a] |
| | | | | | | | |
| Mean | 352.33 | 121.03 | 212.55 | 158.81 | 37.78 | 3.75 | 64.30 |
| R-Square | 0.94 | 0.98 | 0.76 | 0.95 | 0.87 | 0.95 | 0.61 |
| C.V | 1.91 | 2.58 | 3.51 | 2.39 | 5.87 | 0.81 | 0.82 |
| Std Dev | 18.55 | 13.65 | 10.25 | 10.94 | 4.12 | 0.093 | 0.57 |
| Range | 333.17-380.75 | 98.79-134.17 | 201.30-228.96 | 140.33-167.75 | 33.58-41.84 | 3.60-3.91 | 63.78-65.13 |
| P of clone | * | ** | NS | * | * | * | NS |

Each value represent mean of three replicates; Mean values having the same alphabet within column are not significantly different at 5% confidence level. *P<0.05; **P<0.01; ***P<0.0001; NS, not significant; RVU, rapid visco unit.

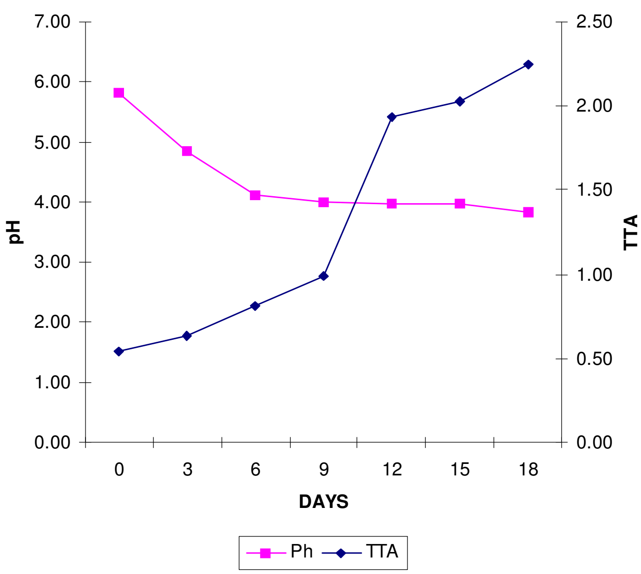


**Figure 1.** Effect of fermentation period on pH and total titratable acidity (TTA) of sour starch from TMS 30572 cassava variety.

nature. Since lactic acid bacteria are involved in cassava starch fermentation, decrease in pH as fermentation progressed is due to acid production by the lactic acid bacteria. Earlier reports have shown similar trend in cereal-based fermentation (Hounhouigan et al., 1993) and root based fermentation (Oyewole, 1990; Brabet et al., 1998). Brabet (1994) reported that the pH of the non-fermented cassava starch is usually 6 to 7 and it decreased to 4 to 4.5 after sedimentation during starch extraction and reached 3 to 4 at the end of the fermentation. This pH shift was correlated with the increase in the TTA due to the production of organic acids, mainly lactic acid and substantial amount of acetic acid. These results further corroborated the fact that lactic acid bacteria are the predominant fermentative micro-flora during cassava starch fermentation.

## Conclusion

The effect of fermentation period on pasting properties of sour cassava starch was presented. The more the length of fermentation period, the lower the strength and stability of sour cassava starch paste.

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