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Abstract

In this study, the recommended cassava roots storage method using Moist Sawdust were investigated for the effect of storage of cassava roots variety on the functional and pasting properties of product produced from the stored cassava roots in 6 weeks storage period. Stored cassava roots of 2 cultivars (TMS30572 and TMS 4(2)1425) were converted into 'gari' and analysed for some functional and pasting properties. Variations were observed in the functional properties of the 'gari' samples; water absorption capacity value ranged between 4.04±0.01 – 5.67±0.02g/cm^3; least gelation capacity 8 – 12%; swelling power 14.50±0.00–21.00±0.06cm^3 and bulk density 0.61±0.01 – 0.81±0.01g/cm^3. Significant differences ($P < 0.05$) were observed in the functional properties of the 'gari' samples except on least gelation capacity. The peak viscosity value ranged between 165.50±0.42 – 307.40RVU. The breakdown viscosity value ranged between 10.90±5.79 – 55.30±5.50 RVU. The final viscosity value ranged between 347.30±57.2 – 451.00±1.62 RVU. The setback viscosity value ranged between 136.80±17.25RVU – 222.60±5.16RVU. The pasting temperature value ranged between 51.27±0.04 – 86.43±0.04°C. There were significant differences ($P < 0.05$) in the pasting properties of the 'gari' samples. Storage period of cassava roots (six weeks) have significant effect ($p<0.05$) on the functional and the pasting properties of the 'gari' product processed from it at the level investigated.

Keywords: Bitter Cassava, Sweet Cassava, 'Gari', Functional and Pasting Properties.

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Introduction

Cassava (*Manihot esculenta*, Crantz) is a staple crop of high importance in Africa and South America. It has the ability to grow on a marginal land in low nutrient soil with appreciable yield where many others will hardly survive. It is also fairly drought resistant (O'Brien *et al*., 1991). Cassava utilization largely depends on the level of production and the quantity of starch in the root. Starch is the major component of the cassava root and its use is primarily determined by its physicochemical properties (Onitilo *et al.*, 2007). Cassava tubers are processed into various pre-gelatinised instant and convenient foods which include 'gari', 'pupuru', fermented cassava flour and 'fufu'. All these differ in their pasting characteristics which are determined by the varieties of cassava and the processing methods employed (Sanni *et al.*, 2003, Onitilo *et al.*, 2007 and Etundaiye *et al*., 2009).

Booth (1977) observed that rapid deterioration of cassava tubers has been a major problem for production, marketing, utilization and industrialization. As a result of this problem, cassava tubers mainly cultivated by peasant farmers are left on the ground until they are required; they are harvested and utilized immediately. To solve this problem of storage before processing, several methods of storage have been proposed for cassava roots. However, most of the methods are not economically viable for storing the roots prior to processing on cottage or an industrial scale, considering the low prices of cassava products. Storage methods which result in a reduction of moisture loss from the roots have good potential for pre-process storage on an industrial scale. Falade and Akingbala (2008) reported that cassava roots were stored in moist sawdust for up to 8 weeks with minimum deterioration. Also, Nigerian Stored Products Research Institute has since recommended the use of Trench and Moist Sawdust methods for storage of cassava roots (NSPRI, 1995). However, storage quality may be very different from utilization quality. Akingbala *et al.* (1989) reported that cassava food utilization properties change long before physical deterioration is observed in stored roots. Therefore, it is expedient to process cassava roots promptly, or store for a minimal period prior to processing.

Hence, this study will look at the effect of storage of cassava roots variety on the functional and pasting properties of product produce from the stored cassava roots.

Materials and Methods

Cassava roots used for this study were 15 months old Bitter variety (TMS 30572) and Sweet varieties (TMS 4(2)1425) lots harvested by gently lifting out the roots from Gede farm settlement in Ayede Ekiti, Nigeria. The harvesting was done when the soil was still wet and soft after a fairly heavy rain to minimize damage. Harvesting of the roots was done with part of the stem (2 – 5cm) still attached to limit ingress of any decay into the roots. The trimmed freshly harvested cassava roots lots were carefully transported in Pick-Up Van under leaf cover to Nigerian Stored Products Research Institute, Ilorin.

About 250 kg of the two varieties of wholesome cassava roots each were taken to the cassava storage warehouse the same day as they were harvested and stored separately using the storage method described by Nigerian Stored Products Research Institute (1995) with slight modification. Sawdust derived from mahogany tree to be used as moisten material was sterilized by using an autoclave set at a temperature of 121^{o}C for 30 min. The sterilized sawdust was then moistened by mixing it with clean tap water at ratio 3:1 to give moisture content of 38%. It was then spread on the floor of the cassava storage house which had been previously swept, washed and cleaned with aseptic solution (Jik). A layer of wholesome cassava roots still attached to 5 – 6cm of stem was carefully arranged on top of the moisten sawdust so that the roots do not touch each other. The roots were then covered with another layer of moist sawdust followed by a second layer of roots; moist sawdust was packed between the roots and also at the top of the final layer of cassava roots. The storage house was inspected every 3 days throughout the storage period of six weeks to ensure that the sawdust is moist. The two cassava roots varieties were each collected at random from the cassava storage warehouse (moist sawdust) for analysis and processing every two weeks for the six weeks of storage.

The traditional method of production of 'gari' in Nigeria as described by Onyekwere *et al.* (2004) was employed in the processing of 'gari' as can be seen in figure 1. The processing of the two varieties of cassava roots into 'gari' began with the scrubbing of 20kg cassava roots each randomly removed from the moist sawdust manually in water to remove mud or dirt. Peeling was done with clean sharp kitchen knife to remove the non-starchy portion. The clean starchy part was diced, washed and grated manually by using a perforated aluminium sheet attached to a flat plank on one side. The mash formed was filled into a sack bag and placed under a screw press to expel cassava liquor and simultaneously ferment, for 4 days. The fermented mash now having a reduced moisture content of about 50% was broken up with a wooden mallet, granulated manually and roasted in a thick iron pot on a hot wood fire to gelatinize and dry. A piece of calabash was used to stir the mash to ensure that it does not stick and char on the heated pot. The coarse 'gari' obtained was then cooled and sifted through a screen of 850μm to collect fine 'gari'. The fine 'gari' was packed in a sealed polyethylene bag.

Water absorption capacity (WAC), bulk density and the least gelation capacity was determined using the method as described by Ogungbenle *et al.* (2002). Swelling index was determined by the method of Oshodi *et al.* (1995). Pasting properties were determined with the Rapid Visco Analyser (RVA) (model Super 4, Newport Scientific Australia). Three and half grams of the test sample was weighed and dispensed into the test canister. 25.0 ml of distilled water was then dispensed into the canister containing the sample (≥14% moisture). The solution was thoroughly mixed and the canister was fitted into the RVA as recommended by the manufacturer (manual). The slurry was heated from 50^{0}C to 90^{0}C with holding time of 2 minutes followed by cooling to 50^{0}C with 2 minutes holding time. The rate of heating and cooling was at constant rate of 11.25^{0}C per minute. Peak viscosity, trough, breakdown, final viscosity, set back, peak time and pasting temperature were read from the pasting profile with the aid of thermo cline for Windows software connected to a computer (Newport Scientific, 1998).

Results and Discussion

The functional properties (bulk density, swelling index, least gelation capacity and water absorption capacity) of 'gari' produced from both bitter and sweet cassava tubers stored in moist sawdust are presented in Figures 1and 2 respectively. The least gelation capacity values of 'gari' produced from bitter cassava roots stored in moist sawdust varies from 8% to 10% and that of 'gari' produced from sweet cassava roots stored in moist sawdust ranges from 10% to 12% as recorded in figures 1and 2 . There was no significant different between the least gelation capacity of the 'gari' produced from both bitter and sweet cassava roots respectively. The variation in the gelling properties of different flours may be due to variation in the ratio of different constituents such as carbohydrates, lipids and protein that make up the flours. Abbey and Ibeh (1988) suggested that interaction between such constituents may have a significant effect on functional properties of flour. Higher least gelation capacity of a product, leads to lower ability to form gel or to be used as firming agent. The 'gari' produced from freshly harvested and 4th week bitter cassava roots stored in moist sawdust will have higher ability to form gel because of its lower least gelation capacity.

'Gari' products show series of increase and decrease in bulk density value throughout the storage period and they differ significantly ($p<0.05$). The bulk density of 'gari' produced from bitter and sweet cassava roots ranges from 0.70±0.01g/cm^3 - 0.81±0.01 g/cm^3 and 0.61±0.01 g/cm^3 - 0.77±0.01 g/cm^3 respectively. From the figures 1and 2, the bulk density of 'gari' produced from sweet cassava roots stored in moist sawdust was lower than that produced from bitter cassava roots also, stored in moist sawdust. The bulk density is a reflection of the load the samples can carry if allowed to rest directly on one another. Bulk density is affected by moisture and reflects particle size distribution of the 'gari' products.

The swelling index value of 'gari' produced from bitter and sweet cassava roots stored in moist sawdust ranges from 14.50±0.00cm^3 - 20.00±0.00cm^3 and 12.00±0.00cm^3-21.00±0.06cm^3 respectively (figures 1 and 2). The 'gari' samples were significantly different ($p<0.05$) in their swelling index. 'Gari' produced from sweet cassava roots variety stored in moist sawdust had the highest swelling index (21.00±0.06cm^3) at 2nd week of storage and lowest (12.00±0.00cm^3) when produced from freshly harvested sweet cassava roots respectively. Swelling index is the measure of the ability of starch to imbibe water and swell and it depends on the capacity of starch molecules to hold water through hydrogen bonding. The differences in the extent of swelling also indicate structural differences among starches (Mweta, 2005).

The water absorption ability is a very important property of all flours or starches used in food preparations. The water absorption capacity value of 'gari' produced from bitter and sweet cassava roots stored in moist sawdust ranges from 4.04±0.01g/cm^3 - 4.76±0.02g/cm^3 and 4.80±0.00g/cm^3 – 5.67±0.02g/cm^3 respectively (figures1 and 2). The 'gari' samples were significantly different ($p<0.05$) in their water absorption capacity. The water absorption capacity value of 'gari' produced from 4 weeks old stored sweet cassava roots was the highest (5.6g/cm) while 'gari' produced from 4 weeks old stored bitter cassava roots was the lowest (4.04g/cm). The observed differences in water absorption capacity of the 'gari' products might be due to various factors such as particle size, amylose/amylopectin ratio and molecular structure. The larger the granular size, the greater the water absorption capacity while the higher the amylose levels, the lower the water binding capacity of starches (Akalu *et al.*, 1998). Processing factors such as fermentation have also been found to increase water absorption capacity.

Effects of storage method and period on the pasting properties of 'gari' produced from both bitter and sweet cassava roots stored in moist sawdust are presented in Tables 1 and 2. The peak viscosity which is the maximum viscosity developed during or soon after the heating portion, ranged from 202.30±5.72 to 249.00±3.74 RVU for 'gari' produced from bitter cassava roots stored in moist sawdust and 165.50±0.42 to 307.40±10.90 RVU for 'gari' produced from sweet cassava stored in moist sawdust. 'Gari' produced from 2 and 4 weeks old sweet cassava roots stored in moist sawdust gave the lowest (165.50±0.42 RVU at a temperature of 56.50±1.34°C in 7.00min) and highest (307.40±10.9RVU at a temperature of 52.36±2.97°C in 6.12 min) respectively. There was a significant difference in the peak viscosity of the 'gari' samples ($P < 0.05$). The viscosity 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 peak viscosity indicates the water binding capacity and is also affected by fermentation. Sandhu and Singh (2000) reported that higher peak viscosity value can be attributed to difference in protein content. The loosely packed starch granules with lower protein to starch ratio in the fine fractions seem to hydrate and swell more rapidly in the presence of heat. The peak viscosity values of 'gari', both produced from bitter and sweet cassava roots stored in moist sawdust were observed to decrease from 0 to 2nd week before increasing until the 6th week. The decrease in peak viscosity may be due to alteration in chemical structure as a result of the activities of the micro-organism which were isolated from the stored cassava roots. These activities have the tendency to alter the chemical structure of starch with time (Ray, 2000; Adam and Moss, 1997).

The trough viscosity value ranged from 182.40±0.28 to 230.40±4.95 RVU for 'gari' produced from bitter cassava roots stored in moist sawdust and 139.40±6.64 to 279.30±17.25 RVU for 'gari' produced from sweet cassava stored in moist sawdust. Trough viscosity value of both 'gari' produced from bitter and sweet cassava roots stored in moist sawdust shows a decrease from 0 to 2nd week and then increased from 2nd to 6th week of storage as can be seen in tables 1 and 2. Products with high trough or holding viscosity value show the ability to withstand heating and shear stress during processing (Newport Scientific, 1998). Bhattacharya *et al.,* (1998) reported that high holding strength represents low cooking loss and superior eating quality.

The breakdown viscosity ranged from 10.90±5.79RVU to 19.90±5.44RVU for 'gari produced from bitter cassava roots stored in moist sawdust (table 1) and 24.80±1.13 to 55.30±5.50 for sweet cassava roots stored in moist sawdust (table

2). The 'gari' produced from 4 weeks old sweet cassava roots stored in moist sawdust had the highest (55.30±5.50RVU) as can be seen in table 2. The values of breakdown viscosity of the 'gari' samples produced from both bitter and sweet cassava roots in tables 1 and 2 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 'gari' sample produced from stored bitter cassava roots might be able to withstand heating and shear stress compared to 'gari' sample produced from stored sweet cassava roots because of their low breakdown value.

The final viscosity ranged from 347.30±57.20RVU to 371.70±7.67RVU for 'gari' produced from bitter cassava stored in moist sawdust and 361.80±6.01RVU to 451.00±1.62RVU for sweet cassava stored in moist sawdust. The 'gari' sample produced from 4 weeks old sweet cassava roots had the highest (451.00±1.62 RVU) final viscosity while 'gari' sample produced from 2 weeks old bitter cassava roots stored in moist sawdust had the lowest. There was a significant difference in the final viscosity of the 'gari' 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 'gari' paste produced from sweet cassava roots stored in moist sawdust will be less stable after cooling compared to the ones produced from bitter cassava roots stored in moist sawdust. 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 setback viscosity of the 'gari' samples ranged between 136.80±17.25RVU - 164.90±6.71RVU for 'gari' produced from bitter cassava roots stored in moist sawdust and 147.70±13.15RVU – 222.60±5.16RVU for sweet cassava roots stored in moist saw dust with 'gari' produced from 2 weeks old sweet cassava roots stored in moist sawdust having the highest (222.60±5.16 RVU) and that from 6 weeks old bitter cassava roots stored in moist sawdust was the lowest (136.80±17.25 RVU). There was a significant difference ($P < 0.05$) in the setback viscosity of the 'gari' samples. Sanni *et al*. (2001) reported that lower set back viscosity during the cooling of 'gari' indicates higher resistance to retrogradation. This means that 'gari' produced from bitter cassava roots stored in moist sawdust will exhibit higher resistance to retrogradation and staling rate.

The result of the pasting time of 'gari samples ranged from 6.30±0.33mins – 6.97±0.05mins and 6.12±0.14mins – 7.00±0.00mins for 'gari' produced from bitter cassava and sweet cassava roots stored in moist sawdust respectively. The peak time indicate the ease of cooking and it is the time taken for the sample to reach pasting temperature during heating and the time taken to reach peak viscosity. Adeyemi and Beckley (1986) suggested that the shorter the time of cooking, the greater the ease of cooking. Hence, of all the products 'gari' produced from 4 weeks old sweet cassava roots stored in moist sawdust had the lowest peak or pasting time value while 'gari' produced from 2 weeks old sweet cassava roots stored in moist sawdust had the highest.

The results show that there were significant differences ($P < 0.05$) in the pasting temperature of the 'gari 'produced from both bitter and sweet cassava roots stored in moist sawdust. Pasting temperatures of the 'gari' samples ranged from51.78±1.59°C -86.43±0.04°C and 51.27±0.04°C – 77.43±1.10°C respectively. 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 of the pasting temperature that the 'gari' sample produced from 6 weeks old sweet cassava roots stored in moist sawdust will cook faster and consumes less energy thereby saving cost and time compared to the other 'gari' samples because of its lower pasting temperature.

Conclusion and Recommendations

This study revealed that the storage period (six weeks) have significant effect ($p<0.05$) on the functional and the pasting properties of the processed 'gari' products at the level investigated. It has also been established that cassava can be stored for a period of six weeks in moist sawdust without considerable loss of quality either to the fresh roots or the processed product (gari) but adequate attention should be given to the handling and processing method.

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Tables

Table 1: Pasting properties of 'gari' produced from bitter cassava stored in moist sawdust

PARAMETERS	BITTER CASSAVA (STORAGE WEEKS)			
	0	**2**	**4**	**6**
Peak Viscosity (RVU)	220.10±3.25^{b}	202.30±5.72^{a}	249.00±3.74^{d}	237.30±4.10^{c}
Trough Viscosity (RVU)	208.80±7.84^{b}	182.40±0.28^{a}	230.40±4.95^{d}	226.40±1.69^{c}
Breakdown Viscosity (RVU)	12.00±4.59^{b}	19.90±5.44^{d}	18.60±8.69^{c}	10.90±5.79^{a}
Final Viscosity (RVU)	351.20±4.54^{a}	347.30±57.20^{a}	371.70±7.67^{c}	363.20±15.55^{b}
Setback Viscosity (RVU)	142.40±17.39^{c}	164.90±6.71^{d}	141.30±12.58^{b}	136.80±17.25^{a}
Pasting Time (mins)	6.30±0.33^{a}	6.97±0.05^{d}	6.55±0.28^{c}	6.43±0.05^{b}
Pasting Temperature (^{o}C)	86.43±0.04^{d}	66.88±18.35^{c}	54.35±4.24^{b}	51.78±1.59^{a}

Values are means of triplicates and standard deviation. Mean values having different superscript within row are significantly different ($P < 0.05$).

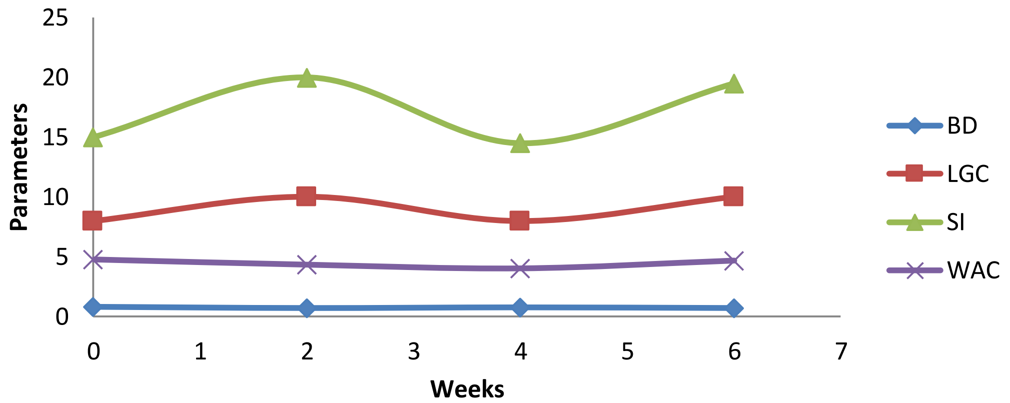
Table 2: Pasting properties of 'gari' produced from sweet cassava stored in moist sawdust

PARAMETERS	SWEET CASSAVA (STORAGE WEEKS)			
	0	**2**	**4**	**6**
Peak Viscosity (RVU)	256.90±24.04^{b}	165.50±0.42^{a}	307.4±10.90^{d}	303.9±18.39^{c}
Trough Viscosity (RVU)	229.50±8.98^{b}	139.40±6.64^{a}	252.10±5.45^{c}	279.30±17.25^{d}
Breakdown Viscosity RVU)	27.10±15.06^{b}	25.20±0.21^{a}	55.30±5.52^{c}	24.80±1.13^{a}
Final Viscosity (RVU)	377.20±22.13^{b}	361.80±6.01^{a}	451.00±1.62^{d}	444.20±2.45^{c}
Setback Viscosity (RVU)	147.70±13.15^{a}	222.60±5.16^{d}	198.90±7.07^{c}	164.90±19.80^{b}
Pasting Time (mins)	6.20±0.19^{a}	7.00±0.00^{b}	6.12±0.14^{a}	6.17±0.52^{a}
Pasting Temperature (^{o}C)	77.43±1.10^{d}	56.50±1.34^{c}	52.36±2.97^{b}	51.28±0.04^{a}

Values are means of triplicates and standard deviation. Mean values having different superscript within row are significantly different ($P < 0.05$).

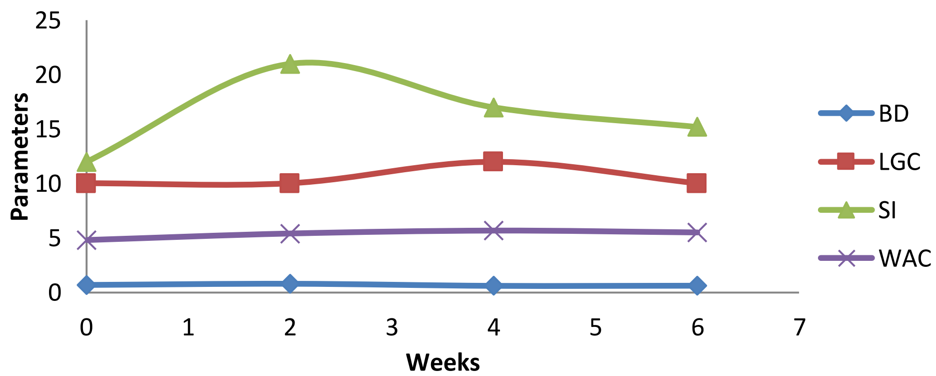
Figures

Figure 1: Functional properties of 'gari' produced from bitter cassava stored in moist sawdust



BD = Bulk Density, LGC = Least Gelation Capacity, SI = Swelling Index, WAC = Water Absorption Capacity

Figure 2: Functional properties of 'gari' produced from sweet cassava stored in moist sawdust



BD = Bulk Density, LGC = Least Gelation Capacity, SI = Swelling Index, WAC = Water Absorption Capacity

Figure 3: Flow chart for 'gari' production

Raw Cassava tubers

↓

Wash and peel-manually

↓

Grate mechanically in
Village grating service

↓

Ferment in cloth bag
Squeezing liquor using local
screw press service (1 to 5 days)

↓

Disintegration of cake manually
When the cloth bag feels dry to the touch

↓

Sift through roughly punched
Aluminium sheet, using the smooth side;
Discard oversized lumps and fibers

↓

Roast in heavy cast iron frying pan
Scraping and turning mash with half calabash

↓

Add pinch of red palm oil
(Optional)

↓

Coarse 'gari'
Cool, sieve manually through
Wire mesh sieve

↓

'Gari' (stored in sacks)

Source: Onyekwere, *et al*., (2004)