Effect of Storage on the Pasting Characteristics of Yam Tubers

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ABSTRACT
Yam is a popular root and tuber crop which is important as a dietary staple and potential export crop. Storage of yam tubers is an age long practice in yam growing communities of West Africa, while pasting characteristic is an important indicator of potential utilization of yam tubers. The study was carried out to investigate effect of storage of the tubers on their pasting characteristics. Six varieties each of *D. alata* and *D. rotundata* were used for the study. At harvest, the tubers were divided into two groups. The first group was stored in a conventional open-air yam barn for four months, while tubers in the second group were not stored. Pasting characteristics of both fresh and stored tubers were determined by Rapid Visco Analyser (RVA). The result showed that the effect of storage on the yam tubers were species dependent. In *D. alata* there was an increase in peak viscosity (231.36 to 257.56 RVU), breakdown (71.68 to 122.47 RVU), setback (42.58 to 65.99 RVU), while there was a decrease in most of the parameters except break-down and setback viscosities in *D. rotundata*. Generally, a decrease in peak viscosity, holding strength, final viscosity and peak time of the yam tubers during storage was observed, while the breakdown and setback viscosities of the tubers increased significantly (*p* < 0.05) on storage. The industrial implication of this is that starches of stored tubers may have high retrogradation tendencies but more resistance to shear-thinning and have more paste stability during processing.

Keywords: Yam, storage, pasting, viscosity.

Introduction
Yam is a popular starchy staple in West Africa. It constitutes a nutritious, high carbohydrate and high fibre food source. Yam is prized for its excellent eating qualities and potential for being an export crop. Yam as a starchy staple in West Africa is of higher per unit weight fresh tuber than cassava, cocoyam or taro (Orkwor, 1998) and hence generates more income in local markets than these other crops (Tamiru *et al.*, 2008).

Storage of yam tubers is a popular farming practice in West Africa. It is usually done principally to ensure availability of yam tubers during the hunger period of the year (November to June) and to provide seed for the next planting season. Quality of the tuber for the production of yam-based food products is a major criterion for acceptance of yam varieties by the stakeholders: farmers, processors and consumers (Otegbayo *et al.*, 2010). The food quality of stored yam tubers is usually preferred than the fresh yam tubers, hence it is usually more expensive than fresh yam tubers in the market. This is probably because of its perceived better food quality (especially textural quality and taste) compared with fresh tubers (Otegbayo *et al.*, 2011). Pasting is a result of a combination of processes that follows gelatinization from granule rupture to subsequent polymer alignment due to mechanical...
shear during heating and cooling of starches (Anonymous, 2003). It has been widely reported as an important indicator of cooking and textural quality in foods (Be Miller, 2011; Zhang et al., 2011) and especially textural quality in yam food products such as pounded yam (Otegbayo et al., 2006). It is also an important indicator of the functionality and potential utilization of yam starch (Tamiru et al., 2008; Otegbayo et al., 2014). The most commonly cultivated yam species in West Africa yam belt (Nigeria, Ghana, Togo and Cote d’ivoire) are Dioscorea rotundata Poir and D. alata Linn.

Yam is a multi-species crop in which inter and intra-specific variations in their quality attributes have been reported (Egesi et al., 2003; Tamiru et al., 2008). According to Otegbayo et al., (2011), the effect of storage on the food quality of yam tubers is species dependent and there was pronounced storage effect on D. rotundata than D. alata tubers. This study was thus conducted to determine the effect of storage of D. rotundata and D. alata tubers on their pasting characteristics an important indicator of their potential end use.

Materials and Methods
Fresh yam tubers from six varieties of each of D. rotundata (Danacha, Lasinrin, Olodo, Abi, Ehuru and TDr 96/02229) and D. alata (Florido, TDa 297, TDa 85/00250, TDa 95/00328, Weredede and Agbo) obtained from the yam germplasm of yam breeding unit, International Institute of Tropical Agriculture (IITA), Ibadan were used for this study.

Storage
At harvest a batch of healthy looking tubers was sorted out from each variety, and divided into two groups. The first group was stored in a conventional open – air yam barn (mean temperature 27.4 ± 3.8 °C; mean relative humidity 52.9 ± 22.4%) for four months before use. Yam tubers in the second group were not stored but used as fresh tubers.

Determination of pasting characteristics
The pasting characteristics of both fresh and stored tubers were studied according to the method of Otegbayo et al., (2006). The yam tubers were peeled, washed, diced and homogenised with a calculated amount of water in a warring blender (Warring blender 21/8110ES, Model 38BL40, Christison Particle Technologies, Gateshead, UK) for 15 min. The blender was used in short bursts to avoid heat generation during the blending. The weight of the tubers used and volume of water was calculated according to the RVA manual (2003), as reported by (Otegbayo et al., 2006).

The weight of starch used for RVA analysis was calculated by correcting it to the dry weight basis by this formula:

\[ \text{Corrected sample weight for RVA (S)} = \frac{(A \times 100)}{\text{Sample DM}} \]

\[ \text{Volume of water used = (W)} = 25 - (S-A) \]

Where A = Sample weight (depending on the type of sample, this is taken from the general guide on weight of sample from RVA manual)

\[ S = \text{Corrected sample weight for RVA} \]
\[ M = \text{Actual moisture content of the sample}. \]
\[ W = \text{volume of water used} \]

The pasting profile of yam paste from both fresh and stored yam tubers were studied by means of a Rapid Visco Analyser (RVA) (series 4, Newport Scientific PTY, LTD. Warriewood, NSW, Australia) with the aid of Thermocline for Windows (version 1.1 software, 1996). Parameters studied were: peak viscosity, holding strength, breakdown, final viscosity, setback, peak time and pasting temperature. The 13-min profile was used: idle temperature 50°C for 1 min, then paste was heated from 50°C to 95°C in 3 min 45 sec and then held at 95°C for 2 min 30 sec. The sample was then cooled to 50°C over a 3 min 45 sec period, followed by a period of 2 min where the temperature was controlled at 50°C.
Statistical analysis
Data generated from the pasting profile of the yam tubers (fresh and stored) were statistically analyzed using the SAS package (Systems Analysis Software, version 9.2 of SAS Institute, Inc., Cary, NC).

Result and Discussion
Generally, *D. rotundata* starches had higher values than *D. alata* for peak viscosity, breakdown, final viscosity, holding strength as well as setback viscosity but lower values for pasting temperature. Peak time values were about equal for varieties of the two species and also between the fresh and stored yam tubers (Table 1). The temperature at which the first detectable viscosity was measured is the pasting temperature; it gives an indication of the gelatinization temperature hence, minimum temperature to cook a sample. High pasting temperature can also indicate that the starch exhibits restriction to swelling (Kaur and Singh, 2005). There was no significant difference between the pasting temperature of fresh and stored yam starches in both species, therefore storage does not appear to have any effect on pasting temperature. The effect of storage on the peak viscosity of the two yam species was different. There was an increase in *D. alata* tubers while there was a decrease in *D. rotundata* tubers. This may be adduced to the differences in the effect of storage on the chemical composition (starch) of the tubers as reported by Otegbayo et al., (2012). Peak viscosity usually indicates the viscous load of the cooked starch and reflects the ability of the starch to swell freely before their physical breakdown (Singh et al., 2003). The holding strength is the ability of the starch granules to remain undisrupted when the yam starch was subjected to a hold period of constant high temperature and mechanical shear stress. It measures the ability of the paste to break down during cooking. In both yam species, the holding strength of starches from the stored tubers was lower than those from fresh yam starches even though the difference was more significant amongst *D. rotundata* tubers (Table 1). The breakdown viscosity of the two yam species increased on storage, this implies that there was less granule rupture in the starches and were also more resistant to break down or shear thinning in viscosity. Oduro et al., (2000) reported that starches with low paste stability or breakdown have very weak cross-linking within the granules. Thus a high break down viscosity in the starch of the stored tubers may indicate that storage strengthens the internal cross-linking within the starch granules. In addition, Otegbayo (2004) reported an increase in the size of starch granules of yam tubers that were stored for four months, the increase in size of the granules during storage might have contributed to strengthening of the inter-granular bonds of the starch granules leading to less rupturing of the granules during mechanical shear. The industrial implication of this is that starches from the stored tubers will have more paste stability with more resistance to shear-thinning and mechanical fragmentation during processing than those from fresh yam tubers. The phase of the pasting curve after cooling of the starches (cooling to 50°C) is called the setback region (Fig. 1a – m). This stage involves re-association, retrogradation or re-ordering of starch molecules, it shows the tendency of the starch to associate and retrograde. The

Table 1: Summary pasting characteristics of fresh and stored *D. alata* and *D. rotundata* yams.

<table>
<thead>
<tr>
<th><em>Pasting characteristics</em></th>
<th><em>D. alata</em></th>
<th><em>D. rotundata</em></th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Fresh</td>
<td>Stored</td>
</tr>
<tr>
<td>Pasting temp (°C)</td>
<td>82.57&lt;sub&gt;a&lt;/sub&gt;</td>
<td>82.66&lt;sub&gt;a&lt;/sub&gt;</td>
</tr>
<tr>
<td>Peak time (min)</td>
<td>4.62&lt;sub&gt;a&lt;/sub&gt;</td>
<td>4.54&lt;sub&gt;a&lt;/sub&gt;</td>
</tr>
<tr>
<td>Peak viscosity</td>
<td>231.36&lt;sub&gt;a&lt;/sub&gt;</td>
<td>257.56&lt;sub&gt;a&lt;/sub&gt;</td>
</tr>
<tr>
<td>Holding strength</td>
<td>159.68&lt;sub&gt;a&lt;/sub&gt;</td>
<td>135.09&lt;sub&gt;a&lt;/sub&gt;</td>
</tr>
<tr>
<td>Breakdown</td>
<td>71.68&lt;sub&gt;b&lt;/sub&gt;</td>
<td>122.47&lt;sub&gt;a&lt;/sub&gt;</td>
</tr>
<tr>
<td>Setback</td>
<td>42.58&lt;sub&gt;a&lt;/sub&gt;</td>
<td>65.99&lt;sub&gt;b&lt;/sub&gt;</td>
</tr>
<tr>
<td>Final viscosity</td>
<td>202.26&lt;sub&gt;a&lt;/sub&gt;</td>
<td>180.30&lt;sub&gt;a&lt;/sub&gt;</td>
</tr>
</tbody>
</table>

Means with same subscripts in the same row under *D. alata* are not significantly different at 5% level of significance.
Means with same subscripts in the same row under *D. rotundata* are not significantly different at 5% of significance.
* All measurements in Rapid Visco Units (RVU).
result showed that the setback viscosity of paste from the two yam species increased on storage. Starches from the *D. rotundata* tubers had higher values than those of the *D. alata*. The set-back values from stored tubers of *D. alata* yam species were significantly higher than in fresh tubers. High setback value has been associated with a cohesive paste and has been reported to be significant in domestic products such as pounded yam, which requires high setback, high viscosity and high paste stability (Kim *et al.*, 1995; Lawal, 2004; Odoro *et al.*, 2000). The implication of the high set back viscosity of the stored yam tubers is that their starches will have greater tendency to retrograde than those from fresh yam tubers, thus they will be more useful as ingredients in products such as noodles where starch retrogradation is desired. Final viscosities of the yam starches generally decreased on storage. Final viscosity indicates whether the starch material forms a gel or a paste on cooling. It also indicates the strength of the cooked yam pastes. It occurs as a result of re-association of starch molecules on cooling, when it occurs to a greater extent it leads to the formation of a gel which is usually indicated by a rise in viscosity. Among *D. alata* tubers the final viscosity of starches from both fresh and stored tubers were lower than the peak viscosity, while in *D. rotundata*, the final viscosity in both fresh and stored tubers were higher than the peak viscosity. This implies that starches from *D. rotundata* tubers formed stronger gels than those from *D. alata* tubers. On storage however, the final viscosities of starches from both yam species decreased indicating that they formed weaker gels than those from fresh tubers. The decrease in the viscosities of the yam starches on storage is as a result of biochemical changes (breakdown of starch into sugars) that took place during storage especially at the post-dormancy stage in the yam tuber life cycle which led to reduction of the starch content of the tubers. However, from this study it was observed that the viscosity of *D. alata* increased on storage, (though the value is still not as high as that of *D. rotundata*) while for *D. rotundata* it decreased. This may point to the fact that starch reduction in *D. alata* yams during storage is not as pronounced as in *D. rotundata* (Muthkumarasamy and Paneerselvan, 2000; Otegbayo *et al.*, 2012).

Fig. 1 a: Pasting curve of *TDr 96/02229*

![Pasting curve of *TDr 96/02229*](Newport Scientific Pty Ltd)

*Fig. 1 b: Pasting curve of TDr Olodo (D. rotundata)*

*TDr – Tropical Dioscorea rotundata.*
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Fig. 1 c: Pasting curve of Abi (*D. rotundata*)

Fig. 1 d: Pasting curve of **TDa 95/00328**

**TDa Tropical Dioscorea alata**

Fig. 1 e: Pasting curve of Danacha (*D. rotundata*)

Fig. 1 f: Pasting curve of Ehuru (*D. rotundata*)

Fig. 1 h: Pasting curve of Lasinrin (*D. rotundata*)
Fig. 1 i: Pasting curve of Florido (*D. alata*)
Conclusion
The result showed that the effect of storage on the pasting characteristics of yam tubers is species dependent; this is probably as a result of biochemical changes taking place in the yam tubers during storage. In *D. alata* there was an increase in peak, breakdown and setback viscosities of the tubers while in *D. rotundata* most of the parameters except breakdown decreased. Increase in the breakdown viscosity of the yam tubers implied that storage strengthened internal cross-linking within starch granules. This also indicates that starches from stored yam tubers have more paste stability and can withstand heating and mechanical shear stress during industrial processing than those from fresh yam tubers.
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References


