ABSTRACT

Yam is a staple food in many parts of sub-Saharan Africa and perishable due to its high moisture content. One of many ways of extending the shelf life of yams is to store them in barns. The aim of this study was to investigate the effect of duration of postharvest storage (0-3-months) on the pasting and functional properties of two yam cultivars (Dioscorea rotundata and Dioscorea alata) stored in yam barns at room temperature. Freshly harvested yams were sorted, cleaned and stored in barns for a period of 3 months. The yams were oven dried and made into flours and their pasting and functional properties evaluated at the end of each month. All experimental data were subjected to analysis of variance and their means separated. The pasting values obtained ranged between (156.17-358.05 RVU), (104.17-216.00 RVU), (7.25-189.42 RVU), (144.07-390.67 RVU), (40.52-174.64), (4.13-7.00) and (74.35-94.58) for peak viscosity, trough breakdown viscosity, final viscosity, setback, peak time and pasting temperature respectively. Functional properties ranged between (17.30-56.33%), (4.09-8.60%), (13.07-26.04%), (0.65-0.69g/cm³), (15.50-19.38 w/A), (0.41-0.50) (4.13-6.48) and (70.34-86.40%) for swelling power, solubility index, water absorption capacity, bulk density, gel strength, specific gravity, soluble sugar and reconstitution index respectively. The storage period had significant (p≤0.05) influence on both pasting and functional properties except in the bulk density throughout the storage period of 3 months. However, increase in the storage period increased the peak viscosity, breakdown viscosity and decrease in the final viscosity. Yams should therefore be stored in barns for a maximum period of one month in order to have desirable pasting and functional properties.

Keywords: yam flour, storage period, functional properties, pasting properties

INTRODUCTION

Yam (Dioscorea spp) are climbing plants with smooth leaves and twining stems, which coil readily around a stake (Udensi et al., 2008). They are perennial through root system but are grown as annual crops and are the third most important tropical root crops after cassava and sweet potato (Fu et al., 2005). It is one of the staple foods in Nigeria and a crop of economic, social and cultural importance in many tropical countries particularly in West Africa, South Asia and Caribbean (Manuel et al., 2005). According to FAOSTAT (2006), Nigeria is the largest producer of yam in the world accounting for 67% of the total world’s production and 72% of the total production in West Africa in 2005. Yam is an important source of carbohydrate for about 300 million people throughout the world (Ettien et al., 2009). In absence of good storage facilities, yams tubers are prone to gradual physiological deterioration after harvest. However, yam can be processed into less perishable products such as yam flour through drying process. The flour can later be reconstituted with hot water to form paste or dough. The reconstituted flour (known as kokonte in Ghana and amala in Nigeria) is popular for feeding both adults and children, and it is an important source of carbohydrate for many people in yam zone of West Africa (Akissoe et al., 2003).

The pasting and functional properties of flour and starches are important in determining their application in the industry. The functional properties determine the application and use of food material for various food products. Atwell et al. (1988) describes pasting as the phenomenon following the gelatinization of starch involving granular swelling, exudation of molecular components from the granules and total disruption of the granules. Water yam (Dioscorea alata) is one of the most economically important yam species, which serves as a staple food for millions of people in tropical and subtropical countries (Hahn, 1995). Although literature abounds on the use of different species of yam; Dioscorea rotundata, Dioscorea alata and Dioscorea cayenensis in the production of acceptable flour (Akissoe et al., 2003; Iwuoha, 2004; Ekwu et al., 2005; Babajide et al., 2007; Ukpabi and Omodamiro, 2008; Akinwande et al., 2008), however, there is little information on the effect of postharvest storage on the functional and pasting properties of yam flour from D. rotundata and D. alata. This work therefore studies the effect of postharvest storage on the functional and pasting properties of D. rotundata and D. alata.
MATERIALS AND METHODS

The yam tubers used for this work was obtained from the University farm of Ladoke Akintola University of Technology, Ogbomosho, Nigeria.

Storage of yam tubers
Freshly harvested yam tubers were cleaned properly to remove soil from the surface and stored in yam barns at room temperature for a period of 0 to 3 month.

Production of yam flour
Yam flour was prepared by the method of Akissoe et al., (2003). The two species of yam were stored for 0 month, 1 month, 2 month and 3 month. The stored yam was weighed, washed and peeled using a stainless knife and sliced out thinly into 2cm thickness and steam blanched for 5 minutes at 80°C and left in the blanched water for 12 hours. The blanched yam slices were drained, dried at 60°C for 24 hrs, milled and sieved into flour.

Pasting properties
The pasting properties of the flour samples were obtained using a Rapid Visco-Analyser (RVA) with the aid of a thermocline for Windows version 1.1 software (Newport Scientific, 1998). The curves obtained were recorded directly on a personal computer by connecting the RVA machine to a computer system. Flour suspension was prepared by adding 3.0 g dry flour to distilled water to make a total of 28.0 g suspension in the RVA sample canister. This was placed centrally into the paddle coupling and was inserted into the RVA machine. The 12 min profile used was seen as it runs on the monitor of a computer to the instrument. The starting temperature was 50°C for 1 min and later heated from 50 - 95°C for 3 minutes before the sample was subsequently cooled to 50°C over 4 minutes. This was followed by a period of 1 min where the temperature was kept at constant temperature of 50°C. Pasting properties were carried out in duplicate.

Functional properties
The functional properties of the flour samples (swelling power, solubility index, water absorption capacity, bulk density, gel strength, specific gravity, soluble sugar and reconstitution index) were obtained using methods described in Jimoh and Oladitoye (2009) and Udensi et al. (2008).

Statistical analysis
Experiments were carried out in duplicates and data were subjected to analysis of variance. Duncan’s multiple range test was used to separate the significantly different means at 5% probability level.

RESULTS AND DISCUSSION

Pasting properties
The pasting properties of D. rotundata (A) and D. alata (B) are presented in Table 1. The result showed that freshly harvested D. rotundata (A0) and D. rotundata stored for 3 month (A3) had the lowest (156.17 RVU) and highest peak viscosity (358.08 RVU) respectively. Both D. rotundata (A0) and D. alata (B0) stored for one month were not significantly different (p≤.05) in their peak viscosity. A sharp increase in the peak viscosity was observed for both yam species from 0 month of storage till the 1st month after which they both showed a sharp decline in their peak viscosity, followed by an increase at the end of the 3rd month of storage. This inconsistency observed in peak viscosity is similar to the observation reported by Akinwande et al. (2007) for starch extracted from different cultivars of D. rotundata stored for 4 months after vine emergence. Peak viscosity is often associated with final product quality and provides an indication of the viscous load likely to be encountered during mixing (Maziya-Dixon et al., 2004). Findings from this study therefore suggests that storage period may increase the ability of starch in flour to bind water molecules since water was lost during storage by respiration creating more sites available for binding during subsequent use. Adebowale et al. (2005) reported that high peak viscosity influences water binding capacity of starch granules and also increases the strength of paste formed during processing. Therefore, Diocorea. rotundata and D. alata stored for 1 month may be suitable for products requiring high gel strength and elasticity (Odedeji and Adeleke, 2010).

The analysis of the two yam species showed that D. alata stored for 2 months had the highest trough value of 216 RVU, while D. rotundata stored for 3 months had the lowest value of 104.17 RVU. It was observed that the trough value of D. rotundata increased up till the 1st month of storage and decreased thereafter till the 3rd month of storage. On the contrary, D. alata increased up till the 2nd month of storage and decreased thereafter. Bhattacharya et al. (1999) reported that high holding strength or trough generally represents low cooking loss and superior eating quality. Therefore, for best eating quality, D. rotundata and D. alata can be stored for 1 month and 2 months respectively.

The breakdown viscosity of the two yam species ranged between 7.25 and 189.42 RVU for freshly harvested D. rotundata and D. rotundata stored for 1 month. All the samples varied in their behaviour except D. alata stored up to 1st and 3rd month. Similarly, as observed for peak viscosity, the breakdown viscosity for both samples showed a sharp increase up to the 2nd month and an increase at the end of the 3rd month of storage for both yam
species. Reports of Adebowale et al., (2005) indicated that high breakdown viscosity is associated with decreased ability of starch to withstand heating and shear stress during cooking, hence the ability of the flour samples produced from the stored yam tubers to withstand heating and shear stress may decrease as they may become less stable under hot conditions with increase in storage period.

The final viscosity which is the change in the viscosity after holding cooking starch at 50°C for the two yam varieties ranged between 144.07 RVU and 390.67 RVU for D. rotundata stored for 2 month and D. alata stored for 3 month respectively. Freshly harvested D. rotundata, D. rotundata stored for 1 month and D. alata stored for 1 month are not significantly different in their final viscosity. It was observed that the final viscosity of D. rotundata decreased with increase in the storage period. Final viscosity is the most commonly used parameter to define the quality of a particular starch based sample as it indicates the ability of a material to form a viscous paste or gel after cooking and cooling as well as resistance of the paste to shear force during stirring (Adeyemi and Idowu, 1990). The set back value for all the samples were significantly different with D. alata stored for 2 month having the highest value of 174.64 RVU and D. rotundata stored for 3 month with the lowest value of 40.52 RVU. The set back values for the samples showed a similar trend as observed for peak and breakdown viscosities. Lower set back viscosity indicates higher potential for retrogradation in food products (Niba et al., 2001; Adeyemi and Idowu, 1990) and gives information about the tendency of starch to retrograde (Perez-Sira and Gonzalez-Parada, 1997). Hence increase in storage period may increase the retrogradation tendency of yam flour as yam species stored for 3 months.

Freshly harvested D. alata had the highest peak time, while D. alata stored for 3 months had the lowest. D. rotundata and D. alata stored for 2 months and 3 months are not significantly different in their peak times. Peak time is a measure of cooking time (Adebowale et al., 2005) hence results from this study suggests that cooking or processing time should decrease with increase in storage period as samples stored for longer periods recorded lower peak time values suggesting low cost implication regarding processing. Pasting temperature has been reported to be related to water binding capacity (Odedeji and Adeleke, 2010), higher gelatinization and lower swelling capacity of starch due to a high degree of association between starch granules (Eniola and Delarosa, 1981; Numfor et al., 1996). It is also a measure of the minimum temperature required to cook a given food sample (Sandhu et al., 2005) and accounts for the temperature at which perceptible increase in viscosity occurs (Moorthy, 2002). The pasting temperature of the flours ranged between 74.35 °C and 94.58 °C for D. alata stored for 3 month and D. alata freshly harvested.

**Functional properties**

The functional properties of yam flour prepared from D. rotundata and D. alata stored for a period of 3 months is as shown in Table 2. The swelling power, which is an indication of the water absorption index of the granules during heating (Loos et al., 1981) varied significantly (p<0.05) throughout the storage period with an increase up to the 2nd month of storage for both yam species. D. alata stored for 2 month had the highest swelling power of 67.71%, while freshly harvested D. rotundata had the lowest value of 17.30%. There was a decrease in the swelling power up to the 2nd month of storage and thereafter, a decrease was observed. This observation may be attributed to the possible modification of starch caused by moisture loss during storage. Swelling power could be used to demonstrate differences among various types of starches, and to examine the effect of starch modification (Crosbie, 1991).

Significant difference (p<0.05) existed among the samples throughout the storage period of 3 months for both D. rotundata and D. alata with respect to their water absorption capacity. Although, the water absorption capacity of the flours varied significantly throughout the storage period, the values obtained for the two varieties did not differ for each storage period. Hence, cultivar and storage period had no significant effect on the water absorption capacity of the flours. Freshly harvested D. rotundata and D. alata are not significantly different from each other with D. alata stored for 2 months and freshly harvested D. alata having the lowest and highest water absorption capacity respectively (Table 2). Generally, the water absorption capacity decreased with increase in the storage period up to the 2nd month for both species and thereafter decreased. This observation suggests that yam storage may affect the affinity of yam flour to absorb water when held for a very long time; this may be due to the changes in starch structure during storage. This effect is probably due to lose association of amylose and amylpectin in the native granules of starch and weaker associative forces maintaining the granules structure that takes place during storage (Lorenz and Sira, 1997). Hence increase in storage period may increase the retrogradation tendency of yam flour as yam species stored for 3 months.

The observed bulk density for the yam flour prepared from the two yam species had no significant differences throughout the storage period of 3 month. D. rotundata stored for one month and freshly harvested D. rotundata had the lowest and highest bulk density respectively (0.65 and 0.69 gcm⁻³). Bulk density is generally affected by the particle size and density of the flour and it is very important in determining the packaging requirement, material handling and application in wet processing in the food industries (Karuna et al., 1996).

The gelling strength of yam flour prepared from both yam species showed a decline throughout the storage period. D. rotundata stored for 3 month and freshly harvested D. rotundata had the lowest and highest gelling strength respectively. This observation indicated clearly that storage period may affect the ability of flours to form gels and may affect their industrial use as more flours may be needed to form gel in yam tubers stored for longer periods (Adebowale et al., 2005).

This variation may also be attributed to changes in the composition of the yam tubers during storage. It is expected that the tuber will lose moisture and some other components during respiration. This observation agrees well with previous findings of Abbey and Ibeh (1998) that variations in the gelling properties of different flours may be due to variations in the ratio of different constituents such as carbohydrates, lipids and proteins that make up the flours.
Table 1: Pasting Properties of yam flour produced from freshly harvested and stored D. rotundata and D. alata

<table>
<thead>
<tr>
<th>Sample</th>
<th>Peak Viscosity(RVU)</th>
<th>Trough Viscosity(RVU)</th>
<th>Breakdown Viscosity (RVU)</th>
<th>Final Viscosity (RVU)</th>
<th>Setback (RVU)</th>
<th>Peak Time (min)</th>
<th>Pasting Temp.(°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A0</td>
<td>156.17f</td>
<td>148.92d</td>
<td>7.25g</td>
<td>229.50c</td>
<td>80.58c</td>
<td>5.80b</td>
<td>93.45a</td>
</tr>
<tr>
<td>B0</td>
<td>184.55d</td>
<td>165.50c</td>
<td>19.08f</td>
<td>287.50b</td>
<td>122.00b</td>
<td>7.00a</td>
<td>94.58a</td>
</tr>
<tr>
<td>A1</td>
<td>358.08a</td>
<td>168.67c</td>
<td>189.42a</td>
<td>228.42c</td>
<td>59.75e</td>
<td>4.53d</td>
<td>81.65c</td>
</tr>
<tr>
<td>B1</td>
<td>345.83a</td>
<td>181.67b</td>
<td>164.17b</td>
<td>230.75c</td>
<td>49.08f</td>
<td>4.73c</td>
<td>79.90c</td>
</tr>
<tr>
<td>A2</td>
<td>168.92e</td>
<td>128.75e</td>
<td>40.17e</td>
<td>207.17d</td>
<td>78.42d</td>
<td>5.13b</td>
<td>84.80b</td>
</tr>
<tr>
<td>B2</td>
<td>302.58b</td>
<td>216.00a</td>
<td>86.58d</td>
<td>390.67a</td>
<td>174.64a</td>
<td>4.80c</td>
<td>80.80c</td>
</tr>
<tr>
<td>A3</td>
<td>240.25c</td>
<td>104.17f</td>
<td>136.06c</td>
<td>144.07f</td>
<td>40.52f</td>
<td>4.33d</td>
<td>75.25d</td>
</tr>
<tr>
<td>B3</td>
<td>304.08b</td>
<td>132.92e</td>
<td>171.17b</td>
<td>177.83e</td>
<td>44.92f</td>
<td>4.13e</td>
<td>74.35d</td>
</tr>
</tbody>
</table>

Means with the same letters along the column are not significantly different from each other (p ≤ 0.05)

A: D. rotundata freshly harvested  B: D. alata freshly harvested

Subscripts 0, 1, 2 and 3 denote freshly harvested, storage for 1, 2 and 3 months respectively

Table 2: Functional Properties of yam flour produced freshly harvested and stored D. rotundata and D. alata

<table>
<thead>
<tr>
<th>Sample</th>
<th>Swelling Power (%)</th>
<th>Solubility Index (%)</th>
<th>Water Absorption Capacity (%)</th>
<th>Bulk Density (g/cm³)</th>
<th>Gel strength (w/v)</th>
<th>Specific Gravity</th>
<th>Soluble Sugar (%)</th>
<th>Reconstitution Index (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A0</td>
<td>17.30f</td>
<td>4.09e</td>
<td>25.74a</td>
<td>0.69a</td>
<td>19.38a</td>
<td>0.50a</td>
<td>5.38c</td>
<td>85.60a</td>
</tr>
<tr>
<td>B0</td>
<td>17.44f</td>
<td>5.24e</td>
<td>26.04a</td>
<td>0.68a</td>
<td>18.24b</td>
<td>0.48a</td>
<td>6.34a</td>
<td>81.30c</td>
</tr>
<tr>
<td>A1</td>
<td>21.40e</td>
<td>5.90b</td>
<td>15.40b</td>
<td>0.65a</td>
<td>19.22a</td>
<td>0.47a</td>
<td>5.94a</td>
<td>86.31a</td>
</tr>
<tr>
<td>B1</td>
<td>27.60d</td>
<td>6.70b</td>
<td>16.30b</td>
<td>0.68a</td>
<td>18.57b</td>
<td>0.47a</td>
<td>6.48a</td>
<td>83.50b</td>
</tr>
<tr>
<td>A2</td>
<td>56.33b</td>
<td>5.70b</td>
<td>13.13c</td>
<td>0.67a</td>
<td>14.80d</td>
<td>0.45b</td>
<td>4.70d</td>
<td>84.10b</td>
</tr>
<tr>
<td>B2</td>
<td>67.71a</td>
<td>4.80d</td>
<td>13.07c</td>
<td>0.67a</td>
<td>15.50c</td>
<td>0.42c</td>
<td>4.93d</td>
<td>77.19d</td>
</tr>
<tr>
<td>A3</td>
<td>26.80d</td>
<td>7.30a</td>
<td>13.73c</td>
<td>0.67a</td>
<td>13.50e</td>
<td>0.41c</td>
<td>4.53e</td>
<td>72.60e</td>
</tr>
<tr>
<td>B3</td>
<td>43.99c</td>
<td>8.60a</td>
<td>13.47c</td>
<td>0.67a</td>
<td>14.80d</td>
<td>0.41c</td>
<td>4.13f</td>
<td>70.34e</td>
</tr>
</tbody>
</table>

Means with the same letters along the column are not significantly different from each other (p ≤ 0.05)

A: D. rotundata freshly harvested  B: D. alata freshly harvested

Subscripts 0, 1, 2 and 3 denote freshly harvested, storage for 1, 2 and 3 months respectively

CONCLUSION

Pasting and functional properties of flours produced from D. rotundata and D. alata were affected by storage period. An increase in the storage period increased the peak viscosity, breakdown viscosity and decreased the final viscosity. Also, a decrease in the functional properties of the flours was observed as storage of yam progressed except the swelling power and solubility index. Storage period and yam variety had no significant effect on the bulk density of the flours. D. alata had higher values than D. rotundata for all parameters measured. The result from this study could provide useful information in selecting best storage period for D. rotundata and D. alata. D. rotundata and D. alata therefore should not be stored for more than one month to have yam flour with good pasting and functional properties.

REFERENCES


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