EFFECT OF DURATION OF POST-HARVEST STORAGE ON FUNCTIONAL AND PASTING PROPERTIES OF YAM FLOUR PRODUCED FROM *D. alata and D. rotundata*

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ABSTRACT

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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 (0-3months) 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 (156.17-358.08RVU), (104.17-216.00 RVU), (7.25-189.42RVU), (144.07-390.67RVU), (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%), (0.65-0.69gcm^{-3}), (13.50-19.38 w/v), (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 ($p \leq 0.05$) 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 (*Diocorea 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, Ogbomoso, 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 60ºC 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* (A_0) and *D. rotundata* stored for 3 month (A_3) had the lowest (156.17 RVU) and highest peak viscosity (358.08 RVU) respectively. Both *D. rotundata* (A_1) *and D. alata* (B_1) stored for one month were not significantly different ($p \leq .05$) 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. Bhattachaya *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 setback 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 retro-gradation 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 retro-gradation 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 ºC and 94.58 ºC 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 ($p \leq 0.05$) 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 2^{nd} month of storage and thereafter, a decrease was observed. This observation may be attributed to the possiblie 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 ($p \leq 0.05$) 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 siginificant 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 amylopectin in the native granules of starch and weaker associative forces maintaining the granules structure that takes place during storage (Lorenz and Collins, 1990). 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*

Sample	Peak Viscosity(RVU)	Trough (RVU)	Breakdown Viscosity (RVU)	Final Viscosity (RVU)	Setback (RVU)	Peak Time (min)	Pasting Temp.(°C)
A_0	156.17f	148.92d	7.25g	229.50c	80.58c	5.80b	93.45a
B_0	184.55d	165.50c	19.08f	287.50b	122.00b	7.00a	94.58a
A_1	358.08a	168.67c	189.42a	228.42c	59.75e	4.53d	81.65c
B_1	345.83a	181.67b	164.17b	230.75c	49.08f	4.73c	79.90c
A_2	168.92e	128.75e	40.17e	207.17d	78.42d	5.13b	84.80b
B_2	302.58b	216.00a	86.58d	390.67a	174.64a	4.80c	80.80c
A_3	240.25c	104.17f	136.08c	144.07f	40.52f	4.33d	75.25d
B_3	304.08b	132.92e	171.17b	177.83e	44.92f	4.13e	74.35d

Means with the same letters along the column are not significantly different from each other ($p \leq 0.05$)
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*

Sample	Swelling Power (%)	Solubility Index (%)	Water Absorption Capacity (%)	Bulk Density (gcm^{-3})	Gel strength (w/v)	Specific gravity	Soluble Sugar (%)	Reconstitution Index (%)
A_0	17.30f	4.09e	25.74a	0.69a	19.38a	0.50a	5.38c	85.60a
B_0	17.44f	5.24c	26.04a	0.68a	18.24b	0.48a	6.34a	81.30c
A_1	21.40e	5.90b	15.40b	0.65a	19.22a	0.47a	5.94b	86.40a
B_1	27.60d	6.70b	16.30b	0.68a	18.57b	0.47a	6.48a	83.50b
A_2	56.33b	5.70b	13.13c	0.67a	14.80d	0.45b	4.70d	84.10b
B_2	67.71a	4.80d	13.07c	0.67a	15.50c	0.42c	4.93d	77.19d
A_3	26.80d	7.30a	13.73c	0.67a	13.50e	0.41c	4.53e	72.60e
B_3	43.99c	8.60a	13.47c	0.67a	14.80d	0.41c	4.13f	70.34e

Means with the same letters along the column are not significantly different from each other ($p \leq 0.05$)
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.

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