Proximate and Some Physicochemical Properties of Yam Flour as a Function of Yam Tuber Storage Methods

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Abstract

This paper reports the proximate and some physicochemical properties of yam flour and yam tuber storage methods with a view to identifying the best storage method for yams. Two varieties of yam (*D. cayenensis* and *D. alata*) were processed directly into flour immediately after harvest and after storage in pits and barns specially created for this particular study for between 1 and 3 months using a laboratory hammer mill. The proximate and functional properties of flours produced from the stored yam tubers were determined by standard methods. The protein content for *D. cayenensis* flour ranged from 1.04 to 1.26 for tubers stored in pits while it ranged from 1.08 to 1.26 for tubers stored in barns. The results obtained were significantly different at P › 0.05 except for those of one storage for the two storage methods and varieties. Tubers stored using the pit method for one (1) and two (2) months were not significantly different for all parameters and showed that protein values are a function of storage method and period.

The fibre content of the two varieties are very low, which make the yam flour suitable for noodle production. Also, there was a general decrease in the moisture content for the two varieties, though not significantly different. Starch content for *D. cayenensis* ranged from 68.86 to 71.08 and from 69.94 to 72.07 for *D. alata.*.

The swelling properties of *D. cayenensis* were not different from that of *D. alata.* Swelling properties ranged from 8.75 to 9.34 (pit) and 8.75 to 9.11 (barn) for *D. alata* and from 8.47 to 9.13 (pit) and 8.75 to 9.31 (barn) for *D. cayenensis.* Solubility also followed the same trend as swelling properties with significant differences in values obtained.

Generally, storage methods and periods have significant effects on the properties of yam flour produced from *D. cayenensis* and *D. alata.*

Keywords: *D. cayenensis. D. alata,* Yam flour, Storage method and Storage period

Introduction

Yam belongs to the genus *Dioscorea* of the family *Dioscoreaceae. Dioscorea rotundata* (white yam), *Dioscorea cayenensis* (yellow yam), and *Dioscorea alata* (water yam) are some of the important species of yam (Tetteh and Saakwa, 1994). Yam is cultivated predominantly in the humid forest, forest / savanna transition and the Southern Guinea Savanna (SGS) zones of West Africa, with most of the current production in the SGS. Nigeria, the world's largest producer of yam accounted for 68 per cent of the world's production and about 74 per cent of the total production in West Africa (FAOSTAT, 2002).

Traditional yam flour (*elubo*) processing has been the major means of preserving excess yam harvested. However, the volume of production and attendant wastage has necessitated a search for methods that would reduce post-harvest losses. This is with the view to processing convenient foods from the unfermented yam flour that will be readily available. Asiedu et al. (1997) reported that research on post-harvest physiology and handling of yam tubers after harvesting have been fragmented and that several attempts have been made to extend the dormant period and hence the storage life of yam by physical and/or chemical means. However, such methods have, to a large extent, met with relatively little practical application.

Due to the relatively high cost of wheat flour and the wide availability of cheaper flours, of which yam flour is one, efforts are being directed towards its partial or total substitution in high quality flour products. This study was designed to determine the influence of yam tuber storage methods on some of the chemical properties of yam flour with the aim of identifying the best storage method for preserving the quality parameters of the flour for the production of a wholesome food product.

Materials and Methods

Materials

Two varieties of yam (*D. cayenensis* and *D. alata*) were obtained from the Research Farm of Ladoke Akintola University of Technology, Ogbomoso, Nigeria. The yam tubers were harvested at full maturity. Some batches of the harvested tubers were processed into flour immediately while others were stored in pits and barns specially created for this particular study, for periods ranging between 1 and 3 months, before processing them into flour.

Yam flour production

Yam tubers for flour were peeled inside water containing sodium metabisulphate to prevent browning reaction. All yam slices were drained and dried in a cabinet dryer at 60°C for three days. The dried chips were subsequently milled into flour with a laboratory hammer mill to pass through a mesh of 150µm screen size. The flour samples were stored in air tight containers until needed.

Proximate and physicochemical properties analysis

The proximate and functional properties of the flours produced from the stored yam tubers were determined by standard methods.

Results and Discussion

Proximate analysis

The result for proximate analysis test on fresh *D. cayenesis* flour and tubers stored in pits and barns are presented in Table 1. The protein content ranged from 1.04 and 1.26 for tubers stored in pits and from 1.08 and 1.26 for the tubers stored in barns. Generally, there was a decrease in protein content with increasing months of storage; this result is in agreement with that of Osuji (1981), which reported that proteins in yam tubers are continually being degraded by endogenous proteinases during storage. This observed reduction may be as a result of sprouting. The results obtained were generally statistically significantly different at $P > 0.05$.

Results obtained for *D. alata* flour (Table 1) followed the trend observed in *D. cayenensis* flour. The values obtained for tubers stored using the pit method for 1 and 2 months were not significantly different and showed that protein values are a function of storage method and period.

The values obtained for fat in *D. cayenensis* ranged from 0.44 to 0.53 for both storage methods. There was a general decrease in the fat content as the storage period increased. However, the values are suitable for what is required for noodle production, because high lipid content of the flour may result in low clarity of starch paste and regress starch granule swelling (Kasemsuwan et al., 1998). There were no significant differences in the values obtained for the first and second months of storage for the two species. Guoquan and Mark (1998) reported that low ash content in flour is always an advantage for noodle production since flour ash is traditionally viewed as causing noodle colouration. The values obtained for fibre content for the two varieties used in this research were very low, which would make the yam flour suitable for noodle production. For moisture content, there was a general decrease in the values obtained for the two varieties while values obtained for the first and second months of storage were not significantly different. It was also observed that the rate of water loss was higher in the first month of storage using both storage methods; however, the moisture content was a function of the extent of drying of the tubers before milling.

Table 1: Result for Proximate Analysis of Flour Produced from *D. cayenensis* Stored using Pit and Barn Storage Methods

Sample	Protein	Fat	Ash	Fibre	MC	Sugar	Starch
Freshly harvested	1.26^{a}	0.52^{a}	1.96^{c}	1.73^{e}	10.15^{a}	4.07^{c}	71.08^{a}
Pit Storage Method							
1 month storage	1.23^{ab}	0.53^{a}	2.05^{b}	1.83^{bc}	9.66^{c}	4.14^{bc}	70.69^{b}
2 months storage	1.16^{bcd}	0.48^{b}	2.06^{b}	1.85^{b}	9.66^{c}	4.22^{ab}	69.97^{c}
3 months storage	1.04^{e}	0.45^{c}	2.12^{a}	1.89^{a}	9.44^{d}	4.25^{a}	69.33e
Barn Storage Method							
1 month storage	1.22^{abc}	0.48^{b}	2.05^{b}	1.77^{d}	9.81^{b}	4.11^{c}	69.95^{c}
2 months storage	1.13^{cde}	0.49^{b}	2.09^{ab}	1.81^{c}	9.75^{b}	4.13^{c}	69.74^{d}
3 months storage	1.08^{de}	0.44^{c}	2.12^{a}	1.76^{de}	8.83^{e}	4.15^{bc}	68.86^{f}

Notes: Values are means of triplicate measurements. Values with the same superscript are not significantly different at P<0.05.

The results obtained for starch content for *D. cayenensis* ranged from 68.86 to 71.08 with a steady reduction in the starch content while it ranged from 69.94 to 72.07 for *D. alata.* Starch in yam tubers is frequently converted to sugars as a result of stress experienced during growth and storage. Starch also contributes to the textural attributes of pastry products with good firmness and dehydration capacities. Starch properties largely influence noodle quality while starch with high amylase is generally preferred for noodle production. The result obtained for sugar content was not unexpected since normally it is expected that starch will be converted to sugar, hence the increase in sugar content is in order. Values obtained for flours produced from tubers stored in pits were higher than those obtained for the barn method (Table 2). It is evident from this result that sugar content is a function of storage method and period, since values obtained were significantly different statistically.

Table 2: Average Mean Values for *D. cayenensis* Proximate Contents for Pit and Barn Storage Methods

Sample	Protein	Fat	Ash	Fibre	MC	Sugar	Starch
Pit Storage	1.17^{a}	0.49^{a}	2.08^{a}	1.83^{a}	9.73^{a}	4.17^{a}	70.27^{a}
Barn Storage	1.14^{a}	0.47^{b}	2.04^{b}	1.78^{b}	9.46^{b}	4.13^{a}	69.52^{b}

Note: Values with the same superscript are not significantly different at P<0.05.

From the results obtained for the average mean values for the triplicate measurements of all parameters as presented in Tables 2 and 4, it is evident that mainly, the values for both species for pit and barn storage methods were significantly different except for protein content for *D. cayenensis* and fibre and sugar values for *D. alata*. Generally, the results reveal that the storage methods have a role in the determination of concentrations of the parameters analysed in flours from stored yam tubers.

Table 3: Result for Proximate Analysis on Flour Produced from *D. alata* Stored using Pit and Barn Storage Methods

Sample	Protein	Fat	Ash	Fibre	MC	Sugar	Starch
Freshly harvested	1.25[a]	0.45[b]	1.94[c]	1.67[d]	12.14[a]	3.96[d]	70.11[c]
Pit Storage Method							
1 month storage	1.24[ab]	0.51[a]	1.98[bc]	1.89[ab]	12.07[ab]	4.04[bc]	72.07[a]
2 months storage	1.23[ab]	0.53[a]	2.06[ab]	1.93[a]	12.01[b]	4.08[a]	70.13[c]
3 months storage	1.16[c]	0.43[b]	2.09[a]	1.93[a]	11.98[b]	4.09[a]	70.12[c]
Barn Storage Method							
1 month storage	1.22[b]	0.38[c]	2.06[ab]	1.77[c]	11.76[c]	4.01[c]	69.94[c]
2 months storage	1.14[c]	0.38[c]	2.09[a]	1.82[bc]	11.24[d]	4.03[c]	70.13[c]
3 months storage	1.07[d]	0.39[c]	2.12[a]	1.86[ab]	10.77[e]	4.07[ab]	70.43[b]

Notes: Values are means of triplicate measurements. Values with the same superscript are not significantly different at P<0.05.

Table 4: Average Mean Values for *D. alata* Proximate Contents for Pit and Barn Storage Methods

Sample	Protein	Fat	Ash	Fibre	MC	Sugar	Starch
Pit Storage	1.22[a]	0.48[a]	2.09[a]	1.85[a]	12.05[a]	4.04[a]	70.61[a]
Barn Storage	1.14[b]	0.38[b]	2.02[b]	1.82[a]	11.26[b]	4.04[a]	70.17[b]

Note: Values with the same superscript are not significantly different at P<0.05.

Physicochemical Properties

The results obtained for the two varieties of yam used are presented in Tables 5 and 7. The values obtained for swelling properties for *D. alata* ranged between 8.75 and 9.34 (pit) and 8.75 and 9.11 (barn), while for *D. cayenensis*, the range was between 8.47 and 9.13 for pit samples and 8.75 to

9.31 for those stored in barns. The swelling power of flour samples is often related to their protein and starch contents (Woolfe, 1992). High protein content in flour may cause the starch granules to be embedded within a stiff protein matrix, which subsequently limits the access of the starch to water and restricts the swelling power. In addition to protein content, a high concentration of phosphorus may increase hydration and swelling power by weakening the extent of bonding within the crystalline domain (Singh et al., 2003). Furthermore, amylopectin is primarily responsible for granule swelling, thus a higher amylose content would reduce the swelling factor (Tester and Morisson, 1990). From the results obtained from both storage methods for *D. alata,* it was observed that in the first month of storage, there was an increase in the swelling property of the flours, thereafter it decreased after the second month of storage before increasing again after the third month of storage using the barn method. Swelling property had been submitted by Crosbie (1991) as an indicator of water-holding capacity and demonstrates the differences between various types of starches and examines the effect of starch modification.

Table 5: Results for Physicochemical Properties of Flour from *D. alata* Stored Using Pit and Barn Storage Methods

Sample	Swelling Property	Solubility	Amylose Content
Freshly harvested tuber	8.75^{ab}	7.11^{e}	22.67^{f}
Pit Storage Method			
1 month storage	9.14^{a}	8.12^{ab}	26.05^{d}
2 months storage	8.76^{ab}	7.25^{de}	28.33^{a}
3 months storage	9.34^{a}	8.34^{a}	27.45^{b}
Barn Storage Method			
Freshly harvested tuber	8.75^{ab}	7.11^{e}	22.67^{f}
1 month storage	9.11^{ab}	8.07^{abc}	26.46^{c}
2 months storage	8.46^{b}	7.77^{bc}	26.17^{d}
3 months storage	8.90^{ab}	7.66^{cd}	23.76^{e}

Notes: Values are means of triplicate measurements. Values with the same superscript are not significantly different at $P<0.05$.

Table 6: Average Mean Values for *D. alata* Physicochemical Properties for Pit and Barn Storage Methods

Storage Method	Swelling Property	Solubility	Amylose content
Barn	8.81[a]	7.65[a]	24.77[b]
Pit	8.99[a]	7.70[a]	26.13[a]

Note: Values with the same superscript are not significantly different at $P<0.05$.

Table 7: Results for Physicochemical Properties of Flours from *D. cayenensis* Stored Using Pit and Barn Storage Methods

Sample	Swelling Property	Solubility	Amylose content
Freshly harvested tuber	8.75[b]	7.09[d]	22.87[e]
Pit Storage Method			
1 month storage	9.13[a]	8.04[b]	26.43[c]
2 months storage	8.47[b]	7.76[c]	26.19[c]
3 months storage	8.57[b]	7.65[c]	23.41[d]
Barn Storage Method			
1 month storage	9.12[a]	8.12[ab]	26.02[c]
2 months storage	8.75[b]	7.22[d]	28.32[a]
3 months storage	9.31[a]	8.32[a]	27.42[b]

Notes: Values are mean of triplicate measurements. Values with the same superscript are not significantly different at $P<0.05$.

Table 8: Average Mean Values for *D. cayenensis* Physicochemical Properties for Pit and Barn Storage Methods

Storage Method	Swelling Property	Solubility	Amylose content
Barn	8.98[a]	7.69[a]	26.16[a]
Pit	8.73[b]	7.64[a]	24.73[b]

Note: Values with the same superscript are not significantly different at $P<0.05$.

Swelling power is affected by the extent of chemical cross-bonding within the granules (Schoch, 1964) and non-carbohydrate substances such as lipids or phosphates (Leach et al., 1959). The results obtained for *D. cayenensis* swelling properties were not in any way different from the trend obtained for *D. alata.* The values obtained for solubility followed the same trend as observed for swelling properties. The general observation is that the storage period and methods do have significant effect on these two physicochemical properties. It was reported by Galliard and Bowler (1987) that the presence of lipids in starch may have a reducing effect on the swelling property of the individual granules, therefore the little differences in the values obtained for fat may explain the differences in the swelling power of these flours. The swelling power and solubility provide evidence of the magnitude of interaction between starch chains within amorphous and crystalline domains. The extent of this interaction is also influenced by ratio of amylose to amylopectin, and by the characteristics of amylose / amylopectin in terms of molecular weight / distribution, degree and length of branching and conformation (Hoover, 2001). The differences obtained in the solubility values may be attributed to differences in the morphological structure of the starch granules. Amylose plays a role in restricting swelling. The increase in solubility with concomitant suspension clarity is seen mainly as the result of granule swelling, permitting the exudation of the amylose, the lipid content of the starch and the ability of the starch to form amylose-lipid complexes. Shinelis et al. (2006) reported that swelling power and solubility pattern, pasting behaviour, physicochemical and functional properties are important qualities of food products.

The values obtained for amylose content actually followed a different pattern for *D. alata* stored in pits and barns. For the *D. alata* stored in barns, there was a steady decrease in the values obtained, after an initial increase in values obtained for freshly harvested tubers, while for the pit-stored tubers there was an increment in values until the third month of storage when it decreased slightly. Deatherage et al. (1955) reported that the amylose content of wheat starch varies from 18 to 30 per cent. The variations observed in the amylose content may be attributed to the activities of the enzymes involved in starch biosynthesis (Krossmann and Lloyd, 2000). The variation in amylose contents among the starches from different and similar plant sources, may also be attributed to the different starch isolation procedures and analytical methods used to determine amylose content (Kim et al., 1995).

The result obtained for *D. cayenensis* also followed the same trend as what was obtained for *D. alata*, giving an indication that the differences which were found to be statistically significant were storage conditions and period dependent. The average mean values obtained for physicochemical properties (Tables 6 and 8) show that yam storage method is a factor in determining the concentration levels of the parameters except for values obtained on solubility for both species and storage methods.

Conclusion

There was a decrease in the protein content with increasing months of storage. The values obtained for tubers stored using the pit method for one (1) and two (2) months were not significantly different and showed that protein values are a function of storage method and period.

There was a general decrease in the fat content as the storage period increased. It is evident from this study that sugar content of tubers is a function of storage method and period.

The general observation is that storage period and method have significant influence on swelling properties and solubility. This is the indication that the differences in values obtained for amylose content which were found to be statistically significant were storage conditions and period dependent.

Generally, this study has shown that storage method and period have significant effects on the properties of yam flour. We also recommend an optimization of the storage methods and periods for effective maximization of the findings of this study.

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