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On-farm pre-treatment of yam tubers to extend shelf life

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Abstract. Yam is an important staple in Ghana and other West African countries such as Benin, Togo and Nigeria. In Ghana, it is mainly consumed in the urban centres and used for various food preparations. In recent times it has become an important non-traditional export crop second only to pineapples. Its major drawback is post-harvest storage/ handling that affects availability, quality and affordability. Pre-treatment of yams prior to storage is considered as one way to overcome the problem. On-farm pre-treatment studies were carried out using three varieties of yam, Pona (Pu), Labareko (Ko) and Lobare (Lo). These were pretreated by dehydrating in the solar chamber dryer for 2 months. Physical observation and sensory evaluation of samples were carried out at various moisture reduction points. Moisture, ash, crude fibre, crude protein, carbohydrate and dry matter of the dehydrated products were determined relative to the fresh samples. Dehydrated samples were then stored for 5 months in yam storage barns traditionally used by farmers. Results of pre-treated samples showed enhanced taste at higher levels of dehydration with decreased mealiness with significant differences between the samples. Pu was the most acceptable variety followed by Ko and Lo. Samples had low crude fibre, ash and protein levels. Moisture content was in the range 64 - 71.35% with appreciable dry matter and carbohydrate levels. For the shelf life studies all varieties could store up to 7 months but Pu had relatively higher rots with Lo having the least. Lo had the highest sprouting (75%) while Ko and Pu had sprout levels of only 18.5 and 20%, respectively.

Introduction

Yam is a major staple used for various food preparations in Ghana and other West African countries such as Benin, Togo and Nigeria. It plays an important role in the socio-cultural lives of the people in the yam zone. In recent times it has become an important non-traditional export crop second only to pineapples and contributes substantially to the Agricultural Gross Domestic Product (AGDP) (Nweke, 1994). Inspite of its potential, yam has not received the needed research attention especially in the area of post-production and marketing. Thus most farmers still use traditional storage systems that are associated with high storage losses. This forces farmers to sell their produce immediately after harvest at uneconomical prices. Among root and tuber crops, yam stores longest. However, the lack of effective storage system contributes in no small measure to the self in-sufficiency in production thus affecting availability, quality and affordability.

The high water content of yams at harvest significantly affects its storability as a tuber. It has been suggested that most agricultural produce can be preserved through pre-storage drying involving the quick reduction in moisture content by exposure to elevated air temperatures until the desired moisture content is attained (Fellows, 1992). Sun drying is the most widely used method for moisture reduction. However, pre-storage drying of yam tubers would require an improved system of drying for enhanced water removal due to tuber size.

The objective of this study, therefore, is to evaluate the effect of pre-storage treatment of selected yam varieties using a chamber dryer on shelf life extension.

Materials and Methods

Source of Yam tubers. Three varieties of white yam namely Pona (Pu), Labereko (Ko) and Lobare (Lo) were selected for this study based on preliminary survey results on yam consumption. Farm fresh tubers were obtained from 3 commercial farmers at Amponsakrom in the Wenchi district. They were transported to the study site at Kumasi.

Experimental design. A completely randomized design was used in the study and data obtained analysed by analysis of variance. The study was carried out in two parts; the first was to establish the appropriate pre-storage moisture level to use. This involved the use of sensory evaluation to evaluate the quality of selected yam varieties at 10%, 20% and 30% moisture reduction using the chamber dryer. In the second part of the study one moisture level was selected for the pre-treatment and shelf life study.

Sample preparation. For the first part of the study, 20 healthy tubers of each of the 3 varieties were selected, weighed and solar dried using the chamber dryer. Sixty healthy tubers of each of the three varieties were selected and treated as above. At about 20% moisture loss, samples were transferred from the chamber dryer to a barn and stored for 5 months.

Temperature and Relative Humidity determination. Temperature and relative humidity in the chamber dryer were measured at 9am, 12noon, 3pm and 5pm using a digital laboratory thermometer and a wet and dry bulb thermometer respectively. Corresponding values from the wet and dry bulb thermometer were read from a psychometric chart. During very hot days, the 2 vents at the back of the dryer were opened to prevent excessively high temperatures (above 60°C) and vice-versa during cloudy and humid days.

Sensory evaluation. For the first part of the study, samples of each variety of yams were randomly selected at 10%, 20% and 30% moisture reduction points during the dehydration process. They were peeled, cut into slices of 3cm and boiled for 20 minutes for sensory evaluation. Using a 7-point hedonic scale and 12 panelists, samples were evaluated for taste, mealiness and texture and overall acceptability.

Analysis. For the second part of the study more analyses were carried out on the samples to assess the quality of the tubers prior to barn storage. Moisture, ash, crude fibre and proteins of tubers in the chamber dryer were determined using standard official methods (AOAC, 1990). Dry Matter content of the tubers were determined by drying 100g of the inner portion of 2-3cm cut pieces of fresh tubers to constant weight in an oven at 110°C and expressed as a percentage.

Barn storage. After 2 months of dehydration in the dryer, the tubers were all weighed to determine the extent of moisture reduction. They were then removed and sent to a farmer's field at Kwanwoma for storage under the traditional storage conditions. Tubers were monitored for any physical changes such rot or any form decay, sprouting and skin wrinkling.

Results and Discussion

Sensory results from the first part of the study showed that at 10% moisture reduction, there was no significant difference ($p<0.05$) in the taste of Pona (Pu) and Labareko (Ko). However, differences existed between Pona (Pu) and Lobare (Lo) and, Ko and Lo. (Table 1). Mealiness and texture showed no significant difference, for all the 3 samples. Data showed that panelists preference for taste was Pu and for mealiness and texture, Ko. At 20% moisture reduction, significant differences existed in the taste, mealiness and texture between Pu and Lo, and Ko and Lo but not Pu and Ko (Table 1). The panelists preference for the varieties was in the order Ko, Pu and Lo in decreasing order. At 30% moisture reduction there was no significant difference, in the taste of the 3 samples and also in the mealiness and texture between Pu and Ko. However, a significant difference existed between Pu and Lo, and Ko and Lo. Lo performed poorly with respect to texture and mealiness at 30% moisture loss. Preference was more for Pu and Ko. Thus based on the data obtained (Table 1), 20% moisture reduction was selected for the second part of the study due to the favourable response of the panelists.

The dryer temperature during the 2 months of dehydration was in the range 30 – 58°C with a relative humidity of 60 – 81%. The ambient temperature for the same period was in the range 24 – 32°C with a relative humidity of 64 – 97%. However, during the 5 months of barn storage the ambient temperature was in the range 28.4 – 34.3°C.

Moisture content of the fresh tubers of the 3 varieties was in the range 64 - 71.35% and were consistent with data reported by Osagie (1992) which ranged between 65 - 81.0%. After dehydration, the moisture content of the tubers dropped to 44.57 - 45.07%; 45.18 - 45.86% and 46.94 - 47.44% for Pu, Ko and Lo, respectively (Table 2). The relatively high moisture content of edible fresh yam tubers is probably the greatest factor influencing storability.

Dry matter of the tubers was 30.27 - 30.79%, 34.01 - 35.95% and 36.05 - 37.01% for Lo, Ko and Pu respectively. For most agricultural products dry matter content has an inverse relationship with moisture content. Thus Lo with the highest moisture content had the least

Table 1: Mean values of sensory results on yam samples

Parameter	Varieties								
	10% moisture loss			20% moisture loss			30% moisture loss		
	Pu	Ko	Lo	Pu	Ko	Lo	Pu	Ko	Lo
Taste	4.1^{a}	4.3^{a}	4.9^{a}	2.3^{a}	2.4^{a}	3.0^{b}	1.6^{a}	1.7^{a}	1.9^{a}
Mealiness/Texture	2.0^{b}	1.9^{b}	2.3^{b}	3.2^{b}	3.1^{b}	4.0^{c}	3.5^{b}	3.6^{b}	4.8^{c}
Overall acceptability	3.3^{c}	3.2^{c}	4.1^{d}	2.8^{c}	2.7^{c}	3.3^{d}	2.6^{c}	2.3^{c}	3.1^{d}

Pu - Pona, Ko – Labareko Lo - LobareFor each parameter and moisture level, values with the same letter are not significantly different.

Table 2: Nutritional data on fresh and dehydrated yam samples

Varieties		Moisture (%)	CHO (%)	Ash (%)	Crude fibre (%)	Crude protein(%)	Drymatter (%)
Pu	Fresh	64.51-66.67	26.7-28.2	0.63-0.68	1.04—1.47	1.26-1.40	36.05-37.01
	Dehy	44.57-45.07	29.8-31.2	0.78-0.91	1.49-1.54	1.60-1.90	54.10-55.10
Ko	Fresh	66.25-67.99	24.8-26.5	0.70-0.78	1.51-1.70	1.54-1.95	34.01-35.95
	Dehy	45.18-45.86	28.5-30.2	1.01-1.12	1.72-1.76	1.98-2.00	52.40-53.10
Lo	Fresh	70.28-71.35	23.7-22.1	0.79-0.81	1.45-1.52	1.92-2.11	30.27-30.79
	Dehy	46.94-47.44	26.1-27.8	1.10-1.14	1.72-1.82	2.21-2.41	54.10-55.06

Pu - Pona; Ko - Labareko; Lo - Lobare, CHO – Carbohydrate Dehy. - Dehydrated.

dry matter content. Higher dry matter content indicates low moisture content and respectively higher nutrient content with anticipated reduced weight losses on prolonged storage of tubers. It also has implication for high yield when processed into products like flour. The trend was however different for the dehydrated samples.

There was an increase in ash content after dehydration for all the tubers with Lo having a slight but not significantly higher ash content (1.10 - 1.14%) compared to Ko (1.01 - 1.12%). Pu had the lowest ash level (0.78 - 0.91%) (Table 2). The relatively high ash content of the dehydrated samples is due to concentration effect as a result of the loss of water. The trend was the same for the fresh tubers ranging between 0.63 - 0.81% (Table 2). These values even though relatively low, reflect the mineral content in the food material. However, it falls within the range (0.60 - 1.70%) reported by Purseglove (1992). The ash content of the tubers depends on several factors such as soil mineral content, climatic conditions and harvest maturity.

Crude fibre content of the dehydrated samples was generally low (1.49 - 1.82%) with Lo having the highest range of 1.72 - 1.82%. Ko followed with 1.72 - 1.76% then Pu (1.49 - 1.54%). The values obtained for the dehydrated samples were higher than that of the fresh tubers (1.04 -1.70%) as a result of the concentration effect. Osagie (1992) had reported crude fibre content of West African yams to be in the range 0.4% - 10.0%. The low fibre levels have some nutritional advantage, as higher fibre content may result into fibrous tubers on long storage. Generally tubers have low protein levels and this is reflected in the protein content of the yam tubers. The dehydrated tubers had protein levels in the range 1.60 to 2.41% with the fresh tubers having a range of 1.26 - 2.11%. for both fresh and dehydrated samples, Pona had the lowest level and Lobare, the highest. The observed levels are within the range reported by Osagie (1992) in his work on the nutritive value of West African yams.

Carbohydrate content was higher in the dehydrated tubers (26.1 - 31.2%) compared to fresh samples (22.1 - 28.2%) (Table 2). These values were higher than reported values for African yam (Ngambeki, 1981). The high total carbohydrate levels of the samples is an important attribute because yams in Ghana are consumed principally for the carbohydrate it provides.

Physical changes. During dehydration the percentage rot was in the range 5 - 12.5% with an average value of 8.33% (Table 3). Pona had the highest rot (12.5%) and Lobare, the lowest (5.0%). However, during storage in the barn the percentage rot was higher and was in the range of 5.26 -21.52% (Table 4). Pona had the highest rot of 21.52% and Labareko the lowest (5.26%). Almost all these rots occurred within the first month of barn storage. This may be attributed to the sharp change in temperature between the chamber dryer (mean 44°C) and

Table 3: Observable defects during solar chamber dehydration (2 months).

Observable defects	Variety		
	Pu	Ko	Lo
Rots/Decay (%)	12.5[a]	7.5[b]	5.0[c]
Skin Wrinkling (%)	5[d]	2.5[e]	10[f]
Sprouts (%)	-	-	-

Pu - Pona,Ko - Labareko, Lo – Lobare. For each observable defect values with different letters are significantly different.

Table 4: Observable defects during barn storage (5 months).

Observable defects	Variety		
	Pu	Ko	Lo
Rots/Decay (%)	21.52[a]	5.26[b]	10.52[c]
Skin Wrinkling (%)	-	-	-
Sprouts (%)	20.0[d]	18.18[e]	75.40[f]

Pu - Pona, Ko - Labareko,Lo - Lobare. For each observable defect values with different letters are significantly different.

the barn (mean 31.08°C). Between the second and fifth months, no rot was observed.

Skin wrinkling was low during the dehydration process and ranged between 2.5 and 10% with Labareko having the lowest 2.5% and Lobare (10%) the highest (Table 3). However, during the 5 months barn storage there was no wrinkling or shriveling (Table 4). This may be due to a variety of factors including reduced moisture content, relatively lower storage temperature and good air circulation. Bushek and Lee (1978) reported that decreasing both moisture content and temperature prolong the preservation quality of products.

Sprouting was quite high in the Lobare samples (75.4%) with Pona and Labareko having 18.18% and 20.0% sprouting levels, respectively during the barn storage (Table 4). During dehydration, no sprouting was observed (Table 3). Generally, the initiation of sprouting in stored yams marks the end of dormancy period, which are controlled by external conditions. The vast difference in the degree of sprouting between Lobare and the other two varieties may be attributed to varietal differences and the relatively high degree of moisture reduction in the Lobare samples.

Conclusion

The study has shown that the application of pre-storage "accelerated" drying has the potential of extending the storage life of yam varieties. However, different varieties respond differently to this treatment. Further studies need to be carried out using large amounts of yam tubers and involving stakeholders to establish the true efficacy of the technology.

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