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Effect of storage techniques on the shelf life of *Xanthosoma sagittifolium* Cormels

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ABSTRACT: Cormels of three varieties of *Xanthosoma sagittifolium* (pink, white and yellow fleshed varieties) were subjected to various storage techniques in order to prolong their shelf life. Cormels stored in low-density polyethylene (LDPE) bags remained fresh for upward of five months while the control not stored in polyethylene bags deteriorated, shrivelled and hardened within 21 days. Moisture content of cormels stored in polyethylene bags remained above 50% even after five months of storage. fresh weight loss was significantly ($P \leq 0.05$) higher in cormels not stored in polyethylene bags than in cormels stored in polyethylene bags over the same period. temperatures of 15-30°C were suitable for storage for more than five months in polyethylene bags. Temperatures above 40°C were unsuitable for storage of cormels because they promoted desiccation of cormels even in polyethylene bags, while temperatures below 0°C caused freezing injury, electrolyte leakage and deterioration of the cormels. High humidity (91-100% relative humidity) inhibited transpirational water loss and consequently prevented physiological deterioration of cormels. Cormels stored in highly humid conditions, like those stored in polyethylene bags, maintained high moisture content and did not exhibit much fresh weight loss after over 16 weeks of storage. Cormels of the three varieties of *X. sagittifolium* all stored well in the polyethylene bags. Prolonged storage of cormels for up to five months should be done in polyethylene bags at temperatures of 15-30° or at 91-100% relative humidity and 30 ± 2°C.

Key Words: Root crops; *Xanthosoma sagittifolium;* Storage conditions; Shelf life.

Introduction

Xanthosoma sagittifolium (L.) Schott, a tropical root crop, is widely distributed in West Africa, tropical America and Asia. In West Africa, it is probably a more important staple food than *Colocasia* ranking third behind cassava and yam (10). Various types of food made with cormels of *X. sagittifolium* and different methods of utilizing the cormels have been described (4,7).

As a result of post harvest deterioration deterioration, *X. sagittifolium* cormels are usually utilized or consumed shortly after harvest. Long-term storage is not done because earlier attempts were unsuccessful (9). An estimated 40% of harvested cormels are lost to post-harvest rot (3).

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Losses of 80 – 100% within three weeks of storage are common. As a result, cormels are left in the farm and harvested as required, either for immediate sale or consumption. Consequently, several farms of *X. sagittifolium* are left unharvested until the next planting season when it inevitably begins to deteriorate in the soil, and lost its nutritional properties at the onset of rains (3,10). The resultant loss to the society is colossal because the labour and resources used to cultivate rotted cormels would have been wasted, and land used for such crops would have been tied down uneconomically in addition to being impoverished at the same time. Also the profit that would have been made if a different crop were cultivated is lost.

Hahn (5) specifically quoted post-harvest losses as the most important constraint in the production and utilization of *X. sagittifolium*. So far, the authors are not aware of any published report on how cormels of *X. sagittifolium* can be stored for a reasonable length of time. This study was therefore carried out to develop simple easily adaptable storage techniques for prolonging the shelf life of *X. sagittifolium.*

According to Wesby et al (13), a common criticism of previous post-harvest research, and indeed agricultural research in general is that technical innovation has been high, but adoption has been poor. The use of needs assessment improved this situation by actively involving beneficiaries in the key phases of the research cycle. Consequently, prospects for adoption by farmers and other end users and, therefore, impact, are greatly improved (6,8).

Materials and Methods

An informal needs assessment (1) was conducted between 1996 and 1999, to allow farmers to participate in the formulation of the research agenda. Systematic semi-structured interviews using a cheklist were conducted in markets in Lagos State and in farms in two villages (Ifo and Ota) in Ogun State, Nigeria. The study was conducted randomly on 20 sellers and 20 farmers each year before and after laboratory experiments.

Transparent, low-density polyethylene (LDPE) bags, with specific gravity of 0.92, CO_2 permeability of 280, O_2 permeability of 60, water absorption of <0.01 and resistivity 0hm CM2 of >10 (15) were obtained from a polyethylene bag maket in Yaba, Lagos. Healthy freshly harvested cormel samples of three varieties (pink, white fleshed and yellow fleshed) of *X. sagitttifolium* were obtained directly from various farms in Lagos, Ogun, Ondo, Oyo, Osun, Edo and Delta States of Nigeria. The cormels were carried to the plant pathology laboratory of the University of Lagos, Nigeria where the storage experiments were conducted. All cormels were carefully washed twice in clean tap water, air dried and then used for three storage experiments conducted as follows:

1. *Effect of polyethylene bags on the shelf life, moisture content and fresh weight of cormels of* X. *sagittifolium*

To determine the effect of polyethylene bags on storability of *X. sagittifolium* cormels, 50 fresh and healthy similar sized cormels of each of the 3 varieties were placed in 10 transparent polyethylene bags (five cormels per bag for each variety) and stored on the laboratory shelves at room temperature (30°C ± 1°C). Fifty other cormels from each of the three varieties were placed separately on laboratory shelves with out polyethylene bags. These served as control. The entire set up was observed over 20 weeks and any signs of spoilage were noted. Analysis of variance was used to determine whethere there was a significant difference between the treatments. The effect of polyethylene bag storage on moisture content of cormels was determined as follows: Fifty healthy similar sized cormels of each of the three varieties of *X. sagittifolium* were used. At the beginning of the experiment, the moisture content of 10 randomly selected cormels of each variety was determined. The remaining 40 cormels of each variety were placed in a polyethylene bag and stored on the laboratory shelf as above. At intervals of 10 days up to day 40, 10 cormels per variety were randomly collected from the polyethylene bags and their moisture content determined. A control experiment was set up similarly using other 50 cormels of each variety, but they were stored on the shelf without polyethylene bags. The experiment was carried out in three replicates and repeated twice.

For determining the effect of polyethylene bag storage on the fresh weight of cormels, 20 cormels of each of the varieties were placed in polyethylene bags of known weight. These were weighed and stored at room temperature. Twenty other cormels of each of the varieties were weighed and placed on the shelves at room temperature to serve as control. At days 10, 20, 30 and 40, the cormels were weighed and put back for storage. Analysis of variance was conducted on the results obtained from three experiments.

2. *Effect of storage temperature on storability of cormels inside polyethylene bags.*

Thirty healthy and similar sized cormels of each of the three varieties were selected, placed in polyethylene bags and stored at –15°C, 15°C, 30°C, 35°C, 40°C. They were observed for signs of physiological and pathological spoilage. The experiments were conducted three times.

3. *Effect of different relative humidity levels on storability of cormels.*

Supersaturated solutions were prepared by a method similar to that of Winston and bates (1960). One litre of supersaturated solutions of anhydrous $CaCl_2$, NaOH pellets, $MgCl_2.6H_2O$, $C_6H_{12}O_6$, KNO_3 and H_2O were prepared to produce relative humidity levels of 0%, 10%, 35.5%, 55%, 91% and 100% respectively. These were each poured into desiccators, covered and allowed to stand for 24 hours for the humidity to adjust to the desired level. Twenty-four healthy cormels, eight from each of the three varieties, were washed, air-dried and placed in a desiccator of known relative humidity. This was done for all the humidity levels in three replicates. They were left at 28 – 30°C over a period of 16 weeks and regular observations were made for signs of rot development. At the end of 16 weeks, the percentage of spoilt cormels was determined for each humidity level. The experiment was repeated twice. The moisture content and fresh weight of the cormels were determined at the beginning and also at the end of the experiment.

All experiments were subjected to Analysis of Variance (11) to determine whether there was significant difference within and between the treatments at $P \leq 0.05$. Means from analysis of variance were separated using Duncan's Multiple Range Test (2).

Results

Survey

Needs assessment results revealed that 95% of the respondents no longer engaged in any form of post harvest storage of cormels of *X. sagittifolium* as previous attempts had been unsuccessful. They all confirmed that cormels do not remain fresh and healthy for up to 21 days after harvest. Five percent of the sample population stored harvested cormels in loamy soil, but complain that most cormels in loamy soil sprout within a couple of weeks and go bad completely within one month. All the respondents agreed that a low-cost cormel storage technology that will maintain the quality and freshness of cormels for a number of months was desirable.

Effect of polyethylene bag storage on shelf life, moisture content and fresh weight of cormels.

None of the cormels stored in open counters stayed fresh for up to four weeks. Symptoms included twisting, warping, hardness, dryness and shrinking (Plate 1b) as result of physiological deterioration (compare with control, Plate 1a). For cormels stored in polyethylene bags, 94%, 89% and 73% of the cormels of pink, white and yellow-fleshed varieties respectively were still fresh and healthy after a storage period of 20 weeks. Twenty to 25% of cormels of each of the varieties stored in polyethylene bags showed signs of sprouting (Plate 1c) indicating their viability, while the rest did not show any signs of sprouting (Plate 1d) though they remained fresh (showing none of the symptoms associated with deterioration).

Figure 1 shows that the moisture content of cormels stored in polyethylene bags dropped to less than 10%. As a result, the cormels hardened and became unsuitable for consumption, after only one month of storage. The highest content of the cormels ranged between 61 and 65% (Figure 1). There was no significant difference between the three varieties in terms of change in moisture content.

Fresh weight losses observed during storage of cormels, both in polyethylene bags and the control after 16 weeks are shown in Figure 2. Cormels stored in polyethylene bags showed gradual loss in fresh weight, which did not exceed 10% within 40 days. fresh weight loss of about 50% was observed for cormels stored

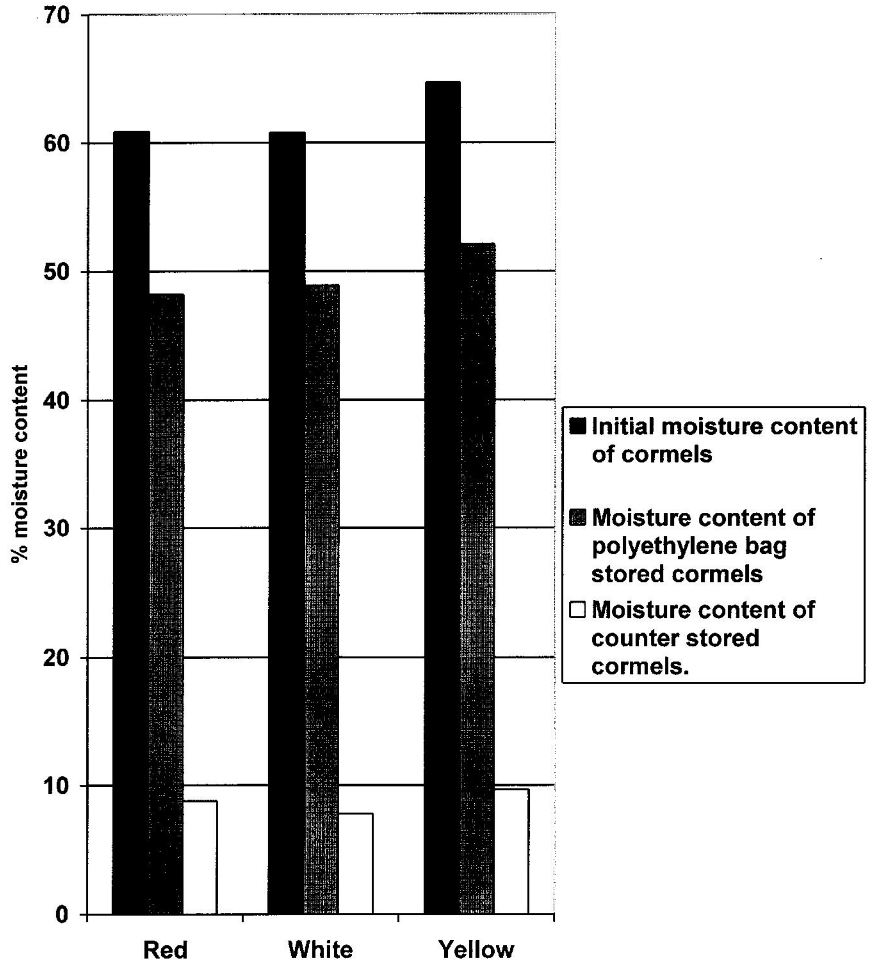

Fig. 1: Effect of polyethylene bag storage on moisture content of cormels after five months of storage.

without polyethylene bags within the same period. The difference in fresh weight loss was significant at P≤0.05. However, the difference between the varieties was not significant at P≤0.05.

Effect of temperature on the storability of cormels in polyethylene bags.

Results showed that cormels stored at –15°C on defrosting showed various symptoms of freezing injury including softening, sogginess and discolouration (Table 1). These made them unsuitable for consumption. All cormels stored at 15°C were still fresh (showing no signs of softening, sogginess or discolouration) after 20 weeks of storage. They showed no signs of freezing injury and were quite suitable for consumption. At 30°C storage, about 90% of the cormels stayed fresh and edible at the end of the storage period (Table 1). Various degrees of hardening were recorded for the cormels stored at 40° and 45°C over the same period (Table 1).

Table 1: Effects of various temperature regiments on cormels stored in polyethylene bags over a period of 20 weeks.

Temperature	Effects				
	Softened cormels (%) ± S.E.	Soggy cormels (%) ± S.E.	Hardened cormels (%) ± S.E.	Edible cormels (%) ± S.E.	Cormels that remained fresh (%) ± S.E.
-15°C	100 ± 0	100 ± 0	0 ± 0	0 ± 0	0 ± 0
+15°C	0 ± 0	0 ± 0	0 ± 0	100 ± 0	100 ± 0
30°C	0 ± 0	0 ± 0	6.7 ± 1.67	91.2 ± 1.20	87.5 ± 2.19
35°C	0 ± 0	0 ± 0	38.3 ± 1.64	51.1 ± 2.25	44.3 ± 1.67
40°C	0 ± 0	0 ± 0	94.1 ± 1.16	8.3 ± 1.46	5.5 ± 1.98
45°C	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0

Effect of different relative humidity levels on storage of cormels.

It was observed that high relative humidity significantly improved the storagability All the cormels stored at 100% relative humidity remained healthy and fresh after 16 weeks of storage (Figure 3). Cormels stored at 0% and 10% relative humidity levels dried up and hardened. About 80% of the cormels stored at 91% relative humidity level remained fresh after 16 weeks of storage. All three cormel varieties showed the same pattern of response of humidity levels. The highest weight loss of 45.1% was recorded at 0% relative for the pink and yellow varieties while the highest weight gain of 1.6% was recorded at 100% humidity for white cormel variety (Table 2). The least weight losses were observed at 91% humidity level.

Analysis of variance showed that P ≤ 0.05, the differences in weight between humidity levels were significant, but the differences between varieties were not. Cormels stored under higher relative humidity level had low moisture content, while those stored under higher relative humidity levels had higher moisture content. As can be seen in Figure 4, the lowest moisture contents of 8.3, 8.8 and 9.3% were recorded at 0% relative humidity for pink, white and yellow fleshed varieties respectively.

Storage trials conducted with the sellers and farmers in Lagos and Ogun States respectively (after laboratory experiments) confirmed that polyethylene bags kept the cormels fresh for more than 5 months compared to less than 21 days using conventional techniques. The sellers and farmers displayed eagerness to adopt the new technology.

Table 2: Change in weight of cormels after storage in different humidity levels.

Relative humidity level	Pink fleshed variety	White fleshed variety	Yellow fleshed variety
	Mean % weight change ± S.E.	Mean % weight change ± S.E.	Mean % weight change ± S.E.
0%	-45.1 ± 0.42	-42.7 ± 0.64	-45.1 ± 0.28
10%	-41.6 ± 0.71	-39.0 ± 0.42	-36.7 ± 2.19
32.5%	-27.0 ± 1.2	-28.7 ± 0.95	-26.3 ± 0.57
55%	-23.5 ± 0.71	-22.5 ± 0.75	-21.7 ± 1.98
91%	-12.8 ± 0.64	-10.7 ± 0.92	-9.0 ± 2.69
100%	+0.9 ± 0.16	+1.6 ± 0.14	+0.8 ± 0.21

Discussion

Results of storage experiments carried out in this study showed that cormels of *Xanthosoma sagittifolium* remained fresh for more than five months, when stored in polyethylene bags. This result is considered to be very important and significant, as storage in polyethylene bags increased the shelf life of cormels from less than 21 days to more than five months. This appears to be the first report on the prolongation of the shelf life of *Xanthosoma sagittifolium* cormels under storage. Moisture content of cormels, even after five months of storage (in polyethylene bags), remained quite high (above 50%) compared to less than 10% moisture content recorded for control samples.

Weight loss was also minimal in cormels stored in polyethylene bags but was drastic in cormels not stored in polyethylene bags. More than 50% of the weight loss may be due to transpirational water loss. Excessive water loss was expressed as shrinkage, hardening, spoilage, drying and weight loss observed in physiologically deteriorated cormels. Storage in polyethylene bags prevent these. Polyethylene bags are cheap and easily available and can therefore be used even in large-scale post harvest storage of cormels.

It is being suggested that the efficacy of polyethylene bags in the storage of cormels of *Xanthosoma sagittifolium* may be linked directly with humidity. This is because for cormels stored in polyethylene bags, water vapour resulting from transpiration and respiration would find it difficult to escape through the waterproof polyethylene bags, and hence accumulates inside the bags creating a highly humid microclimate, which would inhibit further transpirational water loss. Consequently, this would prevent cormel desiccation which according to observations in this study is a problem militating against prolonged storage of cormels. many authors including Sutcliuffe (1968) have earlier held the view that high relative humidity inhibits transpiration.

The effect elicited by temperature may also be linked to water loss as high temperature (35 – 45°C) that is known to facilitate water loss (12) also causes desiccation, while lower temperature (15 – 30°C) reduces water loss and desiccation.

This study recommends that in order to prevent physiological spoilage and prolong the freshness of harvested *X. sagittifolium* cormels, the cormels should be stored in polyethylene bags at temperatures of between 15° and 30°C. This will keep the cormels fresh for a period of over five months.

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