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EFFECT OF STORAGE ENVIRONMENT AND PACKAGING MEDIA ON THE DISEASE INCIDENCE AND WEIGHT LOSS OF STORED AFRICAN STAR APPLE (*Chrysophyllum albidum*)

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Abstract

A study was conducted to study the effect of storage environment and packaging media on the disease incidence and weight loss of stored African Star Apple (*Chrysophyllum albidum*). Three storage environments were identified in this study namely- evaporative cooling basket, refrigerator and ambient storage and freshly harvested ripe African star apples were wrapped in perforated polythene, moist jute material and without packaging and stored under these three storage environment. The apples were observed for deteriorations mediated by microbial infection and insect infestation. Manifestation of infestation which affected the shelf-life of African Star Apple was delayed most in the refrigerator. The level of infestation of the apples stored in evaporative cooling basket was next to the refrigerator in the decreasing order. Weight losses were lower in apples wrapped with moist jute sack (0.48% ± 1.6) stored in refrigerator than those wrapped with perforated polythene (0.79% ± 1.2) and unwrapped (1.45% ±1.4). Similar wrapping effects were obtained in the evaporative cooling basket and ambient. Weight losses were lower in apples stored in refrigerator (0.91%) than in the evaporative cooling basket (2.84 %) and ambient shade (7.41 %).

Keywords: apple, diseased, microbial, storability, structure, temperature, vitamin, wrapping

1. Introduction

African Star Apple (*Chrysophyllum albidum*) is a forest plant but is usually planted as a compound tree in villages. The plant produces edible fruit and the composition of this fruit is very common in the entire gulf of Guinea and other African countries such as Cameroon, Congo and Nigeria (Ejiofor and Okafor, 1997).The post-harvest losses could discourage farmers from producing and marketing fresh produce, and limit the urban consumption of fresh fruits and vegetables. Hence, development of post-harvest technologies is believed to make great contribution to improve quality and use of these crops. It is essential to control storage temperature and relative humidity during storage as they are the main causes of fruit and vegetable deterioration during ripening and storage.

One of the limiting factors that influence the fruits economic value is the relatively short shelf-life period caused by spoilage organisms and pathogens' attack (Rashad *et al*., 2011). It is estimated that about 20-25% of harvested fruits are lost during post-harvest handling even in the developed countries (Droby, 2006; Zhu, 2006). In developing countries however, post-harvest losses are often more severe due to inadequate storage and transportation facilities (Rashad *et al*., 2011). Fungal infections of fruits may occur during the growing season, harvesting, handling, transport and post-harvest storage and marketing conditions, or after purchase by consumers.

Deterioration of apples could be seen visually with the discoloration in the head region (stem end) which could be extended into the edible pulp. The lesion advanced gradually bursting the apple resulting in loss of firmness and fermentation (Gomes and Ledward, 1996): barman *et al*, 2015). This syndrome suspected to be end rot has been associated with poor harvesting technique (Babarinsa *et al*., 1997).

Water is an important constituent of most fruits and vegetables and it adds up to the total weight. Losses of water will definitely reduce the weight. The loss of weight comprises of both respiratory and evaporative losses. The former, which occurs as a result of respiration, depends mainly on the temperature of the surrounding air. The latter occurs as a result of water vapour deficit of the environment compared with that of the produce (FAO, 1989).

Packaging fruits is one of the most commonly used post-harvest practice that puts them into unitized volumes which are easy to handle while also protecting them from hazards of transportation and storage (Burdon, 1997). If both temperature and packaging is optimum, ageing of fruit and vegetables can be slowed down with up to more than 80% (DTIPT, 2008).

2. Materials and Methods

2.1 Collection of fresh African Star Apple and Weight Determination

Two hundred and seventy (270) standardized ripe African star apple fruits of average weight of 40g were purchased from a local market (Ipata) in Ilorin Kwara State, Nigeria.. The samples selected were at the peak of their freshness (fairly soft to touch, plump with orange-yellowish color. The fruits were washed with potable water, sorted to remove bruised, diseased and unwholesome fruits prior to storage. The apples were randomly assigned to the following treatments: Fruits wrapped in perforated polythene (standardized at 8.5% perforation), fruits wrapped in moist jute material and unwrapped fruits. The apples were stored in three storage environment namely refrigerator, evaporative cooling basket and ambient storage.

The two hundred and seventy fruits were stored to compare their nutritional changes, and physiological weight changes in an evaporative cooling basket (ECB); conventional refrigerator and ambient condition. Each treatment contained 30 fruits and replicated three times. The weight of all the samples were measured before storage using a weight balance (Model CS 200) with an accuracy of 0.1g and a capacity of 200g .On the second day of storage, three (3) samples were picked at random from each treatment and labeled properly. The weights of the picked samples were taken. After weighing, the samples were returned back to their respective treatment and storage chambers. This process was repeated at interval of two days during the duration of the experiment and the weight changes were correctly recorded.

2.2 Determination of environmental parameters

The temperature (^oC) was measured using a thermometer. The relative humidity (%) was taken using a wet and dry bulb thermometer and the reading was measured on the humidity table (i.e. difference between the dry and wet bulb readings). The readings were taken daily, for 10 days, from the ambient storage, evaporative cooling basket and refrigerator.

The effects of the storage parameters on the nutritional value and weight loss on the produce were determined using statistical analysis of variance (ANOVA). Further analysis by Duncan’s New Multiple Range Test (DNMRT) was carried out to compare the means.

2.3 Determination of disease incidence

Disease incidence was calculated as the percentage of diseased fruit per total number of fruits. The fruits were observed visually for rotting and microbial infection. Percent disease incidence was identified and calculated using the formula of Mamatha and Rai (2000).

$$\%D_i = \frac{Do}{D} \times 100 \qquad (1)$$

Where, D_i= Disease incidence
D_o= Number of diseased fruit
D= Total number of fruits

3. Results and Discussion

Table 1 indicates that weight loss of stored fruits statistically depend on storage duration. This is in line with Ghafir*et al.*, (2009) who reported an incremental increase in storage duration due to water loss and respiration. Table 2 also shows increase in the percentage weight loss over the duration of storage, and Table 3 shows the effect of wrapping on weight loss of the stored African star apple. Percentage weight loss of African star apple unwrapped was lowest in refrigerator (1.45 %) followed by those stored in evaporation cooling basket (5.50%) and highest in the ambient condition. This may be attributed to the effectiveness of the refrigerator and evaporative cooling basket increasing the temperature and raising the relative humidity thereby reducing the rate of metabolism (Perez *et al.*, 2004).

Table 1: Effect of Storage Structure, Storage Media and Storage Days on Weight Loss

Source	Sum of Squares	Df	Mean Square	F	Sig.
A	432.832	2	216.416	6.029	0.003*
B	167.234	2	83.617	2.329	0.103
C	1278.866	4	319.716	8.906	0.001*
A*B	278.154	4	69.538	1.937	0.111
A*C	480.459	8	60.057	1.673	0.116
B8C	359.149	8	44.894	1.251	0.280
A*B*C	529.485	16	33.093	0.922	0.547
Error	3230.806	90	35.898		
Total	6756.986	134			

A=Storage Structure, B=Packaging Condition, C=Storage Days,
*Significant at 5% Probability Level

Table 2: Comparison between the Different Levels of the Three Factors (Storage Structure, Storage Media, and Storage Days), Using New Duncan Multiple Range Test (NDMRT)

Main factors	Levels	% weight Loss
Storage Structure	Ambient Condition	7.413d
	Evaporative Cooling Basket	2.844b
	Refrigerator	0.910a
Storage Days	2	0.869a
	4	1.996
	6	5.943c
	8	6.162
	10	7.363d
Storage treatment / Condition	Unwrapped	5.865c
	Perforated Polythene	2.689b
	Moist Jute Bag	2.621b

Means with the same alphabet are not significantly different from each other

Table 3: Mean Percentage of Weight Loss in African Star Apple under Different Storage Structures

Storage treatment/condition	AMB	ECB	REF
Unwrapped	10.62 ± 4.9^{a}	5.50 ± 4.8^{a}	1.45 ± 1.4^{c}
Perforated Polythene	5.61 ± 2.8^{b}	1.66 ± 2.4^{b}	0.79 ± 1.2^{c}
Moist jute Bag/Sack	6.01 ± 1.8^{c}	1.37 ± 2.2^{b}	0.48 ± 1.6^{c}

Standard deviation from 3 replications in each treatment.
$^{a-c}$Data with the same superscript in the same row are not significantly different
ECB = Evaporative cooling basket, REF = Refrigerator, AMB = Ambient Storage

Deterioration of the apples was manifested visually with the discoloration in the head region (stem end) that extended into the edible pulp. The lesion advanced gradually bursting the apple resulting in loss of firmness and fermentation. This syndrome suspected to be end rot has been associated with poor harvesting technique (Babarinsa *et al.*, 1997).

Data on the effect of wrapping and storage treatment on disease development in ripe African star apple are presented in table 4. As was expected, disease developed at a slower rate in the apples wrapped and stored in the refrigerator relative to those stored in the evaporative cooling basket (ECB) and those stored under ambient shade conditions. Diseased apples increased from zero to 33.3, 62.5, and 33.3 % on the 4th day in perforated polythene, moist jute wrapping and unwrapped treatments, respectively in the ambient condition. A similar period (on the 4th day) of disease manifestation continued in apple stored in an evaporative cooling basket (ECB). Diseased fruits increased from zero to 12, 31, and 23 % in perforated polythene, moist jute bag and unwrapped on the 4th day, respectively. On the contrary, a less similar period of disease manifestation was observed in the refrigerator. Diseased fruit increased from zero to 4 % in both perforated polythene and unwrapped on the 4th day. The moist jute wrapping responded differently, no diseased fruits were recorded (except in refrigeration storage) until the 8th day of storage (Table 4).

Diseased apples increased to 100% on the 10th day in the treatment in the ECB and ambient shade. That non uniformity in the time diseased symptoms were noted in the treatments under all the conditions studied may partly have been due to the effect of different storage conditions. This quiescence infection syndrome phenomenon is not fully understood as reported by Babarinsa, *et al.,* 1997).Comparing the various treatments in relation to disease manifestation, perforated polythene wrapping in ECB appeared more effective in delaying disease symptoms than other treatments similarly stored. Generally fruits packed inside perforated polythene wrapping gave the lowest number of diseased apple (~3.7-25.9%) as compared with fruits packed in unwrapped (~ 3.7-33.3 %) and fruits packed in moist jute bag (~30-33.3%) (Table 4).

Figure 1 shows the graphical representation of the effect of storage structure and treatment on the manifestation of disease. Refrigerated moist jute wrapping appeared to be the most effective in suppressing manifestation of disease symptom was observed in the apples thus stored throughout the period with 22.2 % diseased compared to 27.8 and 55.5 % in perforated polythene and unwrapped treatment respectively in the refrigerator (Table 4). Low temperature prolongs storage life by reducing respiration rate as well as reducing growth of spoilage microorganisms (Roura *et al.*, 2000; Watada *et al.*, 1996). Under ambient shade storage condition and ECB, the fruit wrapped with moist jute bag became 100% infested with disease after the 8th day, unlike other treatments. Comparing the three storage environments for suppressing manifestation of disease, the evaporative cooling basket (ECB) appears next to the refrigeration in order of effectiveness.

Table 4: Assessment of Diseased Ripe African Star Apples in Different Wrapping Stored under Different Structure

Storage environment	Type of wrapping	Percentage of Diseased African Star apple					
		0	2	4	6	8	10
Ambient shade	Perforated polythene	0.0	6.6	33.3	70.8	85.7	100
	Moist jute	0.0	6.6	62.5	62.5	76.6	100
	Unwrapped	0.0	3.3	33.3	70.8	100	100
Evaporative cooling basket	Perforated polythene	0.0	3.3	22.2	37.5	95.2	100
	Moist jute	0.0	3.3	11.1	37.5	76.2	100
	Unwrapped	0.0	10.0	30.33	37.5	100	100
Refrigeration	Perforated polythene	0.0	0.0	3.7	4.17	33.3	55.5
	Moist jute	0.0	0.0	3.7	12.5	14.3	27.8
	Unwrapped	0.0	0.0	0.0	0.0	19.4	22.2

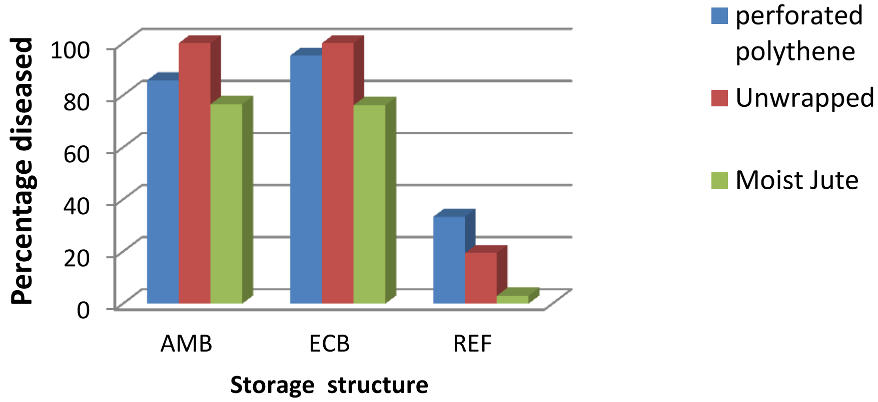

Figure 1: Assessment of Diseased African star apple after the 10th day.

4. Conclusion

The study was based on the development of an alternative source of storage in combination with packaging material and their effect on the weight loss and disease development in African star apple (*Chrysophyllum albidum*). The following conclusion can be inferred from this research:

1. Percentage weight loss of the African star apple (*chrysophyllum albidum*) was less in the refrigerator and evaporative cooling compared to the ones stored under ambient condition.
2. Refrigerator and Evaporative cooling basket in combination with moist jute sack packaging material better delayed the manifestation of disease of the African star apple (*chrysophyllum albidum*)

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