CARIBBEAN FOOD CROPS SOCIETY

SOCIETE CARAIBE POUR LES PLANTES ALIMENTAIRES

25

Twenty fifth
Annual Meeting 1989

25e CONGRES ANNUEL

Guadeloupe

Vol. XXV

STORAGE TIME/TEMPERATURE STUDIES ON THE BREADFRUIT

Rohanie MAHARAJ
Graduate Research Assistant
Clement K. SANKAT
Senior Lecturer

Faculty of Engineering
The University of the West Indies
St. Augustine, Trinidad

ABSTRACT

Breadfruit (*Artocarpus altilis*)is a crop with considerable economic potential, but its short shelf-life prevents its full, commercial exploitation. Methods aimed at improving the storability of this crop need to be examined. In an experimental storage trial, the shelf life of the breadfruit was compared when stored in air and in water, at four temperatures viz :-8, 12, 16 and 28°C (ambient). Storage of the breadfruit in water has been a traditional form of short term preservation. Fruits stored under ambient conditions exhibited a shelf life of 2-3 days, showing losses in weight and volume, together with increases in softening, browning and odour. Fruits stored in water under ambient conditions were acceptable up to four days, and these fruits showed significant increases in weight and volume. Under refrigeration in air and particularly at 16°C, fruits exhibited minimal decreases in weight loss, volume and firmness, with the shelf-life extending to 10 days.Skin browning is the limiting storage factor in refrigeration and is particularly severe at 8 and 12 °C. Fruits stored in water at 8, 12 and 16°C kept for 18 and 14 days respectively with skin browing being the limiting storage factor.

RESUME

ETUDES DES CONDITIONS DE CONSERVATION DU FRUIT A PAIN

Le fruit a pain (*Artocarpus altilis*) est un légume qui a un potentiel économique considérable mais sa faible durée de conservation nuit à sa pleine exploitation commercial. Des méthodes destinées à allonger sa durée de conservation ont été examinées. Dans un essai expérimental de stockage

on a comparé les durées de conservation du fruit à pain à l'air libre et dans l'eau, à 4 températures : 3, 12, 16 e 28°C (température ambiante). La conservation dans l'eau est traditionnellement utilisée. A 28°C et à l'air libre les fruits se conservent 2-3 jours, montrant des pertes de poids et de volume accompagnées d'un ramollissement, de brunissement et de formation d'odeur. Conservés dans l'eau à la température ambiante, les fruits sont acceptables jusqu'à 4 jours. Ils montrent une augmentation de poids et de volume. Réfrigérés à l'air libre et à 16°C, les fruits montrent les plus faibles variations en poids, volume, fermeté avec une durée de conservation pouvant atteindre 10 jours. Cette durée de conservation atteint 18 et 24 jours lorsque les fruits sont conservés dans l'eau et respectivement à 12 et 14°C. Seul le brunissement de la peau devient le facteur limitant.

INTRODUCTION

Breadfruit (Artocarpus altilis) is a very popular fruit in the Caribbean and is used for cooking in the mature, green form either boiled, baked, fried or roasted. The two main varieties grown in the Caribbean are the "Yellowheart" and the "Whiteheart". The Yellowheart variety is preferred by consumers because of its desirable taste, and at maturity, a distinctly yellowish pulp is observed.

Fruits are harvested manually, and fully mature fruits are detected by large fruit segments with little latex flow emanating upon breaking the stems of such fruits. The traditional method of harvest results in fruits falling to the ground from heights which are commonly 20 m or more. Alternative methods of harvest include the use of poles to which cutting aids are attached at the upper end and canvas bags for catching the fruits (Wootoon and Tumaalii, 1984 ; Marriot et al., 1979). Breadfruits exhibit a respiratory climacteric. After 5 days of harvest, detached breadfruits have a high rate of respiration peaking to a value greater than 3 ml CO2 per Kg/hr at 20°C (Baile and Barcus, 1970).

Breadfruit represents a valuable food resource as a staple carbohydrate. However its current usage is limited by the poor storage properties of the fresh fruit. According to Mathews et al (1986), there is a lack of simple, suitable information for preserving the fruit in the fresh form. The mature fruit ripens, softens and deteriotates after about 3-5 days under ambient, tropical conditions. Storage of the fruit in water, a traditional method, had proven not very effective (Thompson et al., 1974) and refrigerated storage leads to rapid darkening of the fruit.

The objective of this study was to evaluate the post-harvest behaviour of breadfruits stored in air and in water and under different temperature

conditions with a view to defining an appropriate storage system for the fruit.

MATERIALS AND METHODS

Breadfruits of the variety "Yellowheart" were carefully harvested from a 20 *m tall tree situated in* Blancheississe, Trinidad using a "cacoa cutter". All fruits were severed with some stem intact, and fruits on falling from the tree were caught in a bag. Large, dark green, mature fruits with large segments were chosen. Damaged fruits were rejected.

Fruits were pre-cooled in the field and during transport using chipped ice. On arrival at the laboratory, fruits were randomly numbered, weighed, individually washed with tap water and dipped in a Benomyl solution (0.05%) for 2 minutes at room temperature. The weights of fruits submerged in water (using a sinker) were also determined. Fruits were pre-cooled further to an internal, centre temperature of approximately 16°C after 2 hours using an ice/water bath.

Thirty-six fruits each averaging 1.2 kg in weight were randomly separated into 2 treatments using the following desigh : -

(i) Air :- 18 fruits stored in *refrigerated air at* 8, 12 and 16°C and at 28°C (ambient).

(ii) Water :- 18 fruits stored in refrigerated water at 8, 12 and 16°C and at 28°C (ambient).

Fruits were placed in three "walk-in" regrigerated rooms maintained at the low temperatures mentioned above, with their relative humidities kept above 85%. Fruits stored under ambient conditions were analysed after 4, 5 and 8 days, while those in refrigeration were analysed after 5, 10, 14, 18 and 25 days. One fruit was used for analysis at each sampling interval and for each storage condition. At the beginning of the trial four fruits were analysed for weight changes, volumetric changes, pH, softening, browning and odour. These analyses were repeated at each sampling interval as follows :

(i)% weight loss was calculated from the initail weights of fruits and their weights after storage.

$$\text{i.e. \% weight loss} = \frac{\text{initial weight} - \text{(weight on removal from storage)}}{\text{initial weight}} \times 100$$

(ii)Fruit volume was calculated from its upthrust in water and % volume

Table 1 : Acceptability of the breadfruit, based upon fruit firmness for fruits stored in refrigerated air and water

Storage time (day)	Storage temperature (°C)							
	28		16		12		8	
	Acceptability rating							
	Air	Water	Air	Water	Air	Water	Air	Water
0	1	1	1	1	1	1	1	1
4	4	2	-	-	-	-	-	-
5	5	4	1	1	1	1	1	1
8	5	4	-	-	-	-	-	-
10	-	-	1	1	1	1	1	1
14	-	-	3	1	4	2	1	1
18	-	-	3	3	5	3	3	1
25	-	-	2	2	5	4	5	1

Table 2 : Browning of the breadfruit skin for fruits stored in refrigerated air and water

Storage time (day)	Storage temperature (°C)							
	28		16		12		8	
	Browing index							
	Air	Water	Air	Water	Air	Water	Air	Water
0	1	1	1	1	1	1	1	1
4	3	2	-	-	-	-	-	-
5	5	5	4	2	4	2	5	4
8	4	2	-	-	-	-	-	-
10	-	-	3	2	5	3	5	5
14	-	-	4	3	5	2	5	5
18	-	-	3	3	5	2	5	5
25	-	-	2	1	5	4	5	5

Table 3 : Odour rathing of the breadfruit for fruits stored in refrigerated air and water

Storage time (day)	Storage temperature (°C)							
	28		16		12		8	
	Odour rating							
	Air	Water	Air	Water	Air	Water	Air	Water
0	1	1	1	1	1	1	1	1
4	2	2	-	-	-	-	-	-
5	2	1	1	1	1	1	1	1
8	2	4	-	-	-	-	-	-
10	-	-	3	3	2	3	1	2
14	-	-	2	2	1	3	1	1
18	-	-	1	3	1	3	2	2
25	-	-	2	4	4	4	2	4

change was calculated from the volume of fruit before and after storage.

Volume on removal from storage
i.e. % vol. change = (- initial volume) x 100
initial volume

(iii)pH was determined using a Glass Electrode pH meter.

Subjective determinations of acceptability, browning and odour were rated as follows : -

(iv)Acceptability based upon firmness to the touch was rated as 1 - hard, very acceptable ; 2 - medium hard, acceptable ; 3 - initiation of softening, partially acceptable ; 4 - medium soft, unacceptable and 5 - very soft, spongy, unacceptable.

(v)Skin browning was rated as 1 - no browning ; 2 - first signs of browning < 25% ; 3 - 25-50% brown ; 4 - 50-75% brown and 5 - >75% brown.

(vi)Odour was rated as 1 - none ; 2 - slight odour ; 3 - strong odour and 4 - intense odour.

RESULT & DISCUSSION

Statistical analyses were performed on the data obtained from the storage trial to determine the effects of storage time, temperature and treatment as well as the interactive effects.

Weight changes

As illustrated in Figure 1, weight losses increased significantly with time for fruits stored in air and averaged 2.64, 0.62, 1.77 and 1.16%/ day at 28, 16, 12 and 8°C respectively. For fruits stored in water however, there were significant weight gains
with storage time, with mean values of 1.57, 1.14, 0.41 and 0.35%/ day at 28, 16, 12 and 8°C. Fruits stored in water increased in weight due to the uptake of water by the cells, with this being particularly noticeable at 28°C. As the water temperature was lowered, water absorption decreased and this may be due to reduced diffusion rates of water into the fruits.

For fruits stored in air, those under ambient conditions showed the highest weight loss, with this increasing to 20.9% after 8 days in storage. Refrigerated storage significantly reduced this parameter due to reduced transpiration and respiration rates of fruits. Fruits at 16°C showed the lowest weight

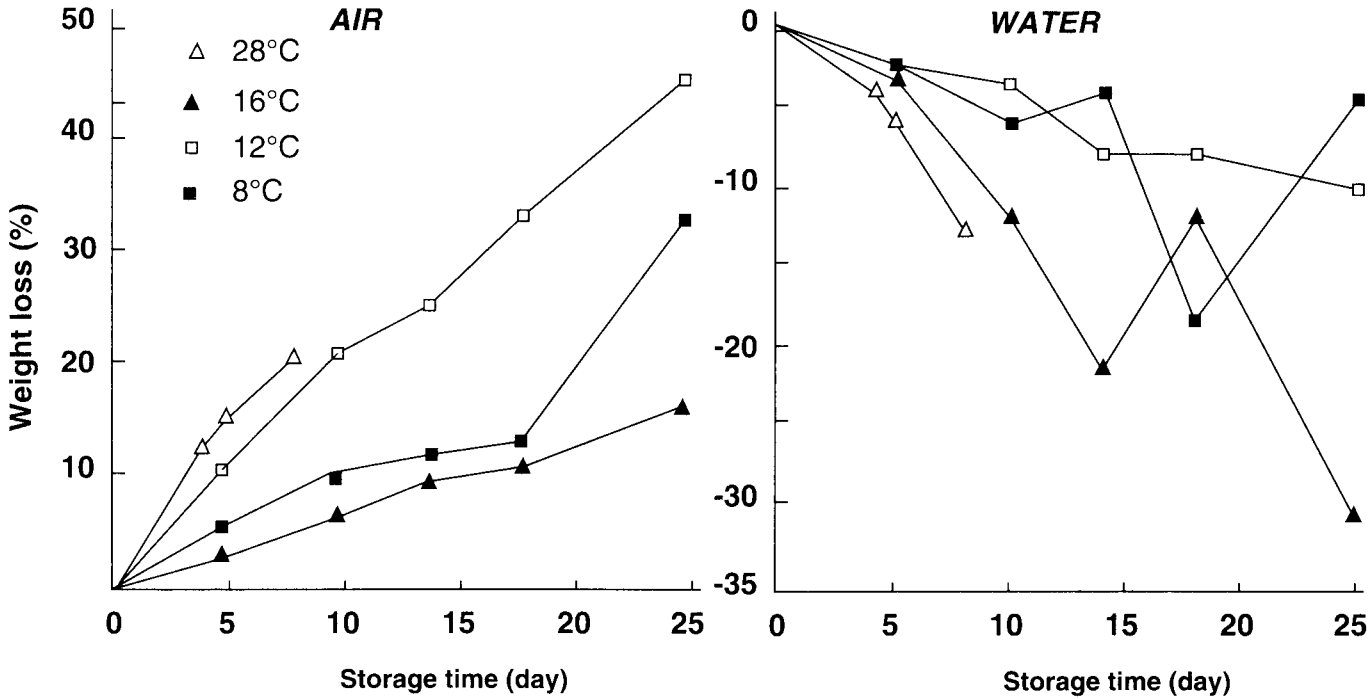

Figure 1 : Weight changes of the breadfruit when stored in air and water at different temperatures

losses under these conditions and this may be attributed to the favourable environmental conditions (low air velocity, high relative humidity) in the storage chamber compared to the other two maintained at 8 and 12°C.

Volume changes

As expected, for fruits stored in air, these were significantly decreased in volume (shrinkage) with storage time at all four temperature conditions (Figure 2). Over the 8 day storage period, fruits stored in air under ambient conditions (28°C) lost volume at an average rate of 3.46%/day. This rapid decline in volume is the result of the shrivelling of fruit cells due to water lost principally through transpiration. Fruits stored in air under refrigerated conditions also showed decreases in volume with these results being consistent with weight losses previously reported.

The uptake of water by fruits stored in water, resulted in volumetric increases or swelling of fruits. However as the storage trial progressed, some reduction in the swelling action was noticed.

pH

There was a significant decrease in the pH of fruits stored in air and water under all the storage temperature conditions (Figure 3). However for fruits in refrigerated storage, this decline was particularly noticeable after day 14, and this factor may indicate the onset of ripening. Under ambient conditions, the decline in pH was greater for fruits in water compared to air, with average pH changes/day of 0.15 (water) to 0.06 (air). This could be due to fermentation arising from the modified environmental conditions of the fruit stored in water.

Acceptability

The acceptability of breadfruits based upon firmness to the touch of the whole fruit was rated subjectively, and the results shown in Table 1. Fruits stored under ambient conditions in air (28°C) softened rapidly and were unacceptable by day 4, whereas those which were stored in stored in water under ambient conditions were unacceptable by day 5. Under refrigerated conditions, fruits in air appeared unacceptable at days 14, 14 and 18 when stored at 16, 12 and 8°C respectively. For fruits stored in water, the limiting storage time was 18 days for fruits stored at 12 and 16°C, while fruits which were stored at 8°C were acceptable for the duration of the storage trial (25 days). It appears that breadfruits when stored in water remain firmed compared to storage in air, and this may be due to modified atmosphere storage conditions which prevail in water storage.

Browning

Under ambient conditions, fruits stored in air and water showed considerable skin browning by the fifth day of storage (Table 2). For fruits stored under refrigerated conditions at 8°C, browning was almost complete by the fifth day of storage, both in air and in water. At 12°C, browning was complete for fruits stored in air by the tenth day, while fruits stored in water under similar conditions showed reduced browning levels. At 16°C, browning was considerably reduced for fruits stored in air, compared to storage at 8 and 12°C. It has been reported that browning is due to discoloration of the vascular bundles which gives fruit a dull colour and is probably due to the enzyme polyphenol oxidase released from the vacuole after chilling (Palmer, 1977 and Wills et al., 1981). It appears that for fruits stored under refrigerated conditions, browning is a result of chilling injury whereas for fruits stored under ambient conditions it results from ripening.

Odour

As illustrated in Table 3, there was a significant increase in the odour rating of fruits stored both in air and water under all temperature conditions. Additionally the odour rating of fruits in water was higher than for fruits in air, at all temperatures. Mean odour rating values for fruits stored in water were 2.00, 2.33, 2.50 and 1.83 at 28, 16, 12 and 8°C while the corresponding values for fruits in air were 1.75, 1.67, 1.67 and 1.33 at 28, 16, 12 and 8°C.

CONCLUSION

Breadfruits stored under ambient air conditions are characterised by rapid decreases in weight and volume, together with increases in fruit softening and skin browning, rendering such fruits unacceptable within four days of harvest. Storage of breadfruits in water under ambient conditions, a traditional method of preservation, results in increases in fruit weight and volume as well as the maintenance of fruit firmness. However a shelf life of no more than 5 days is possible by the method.

Storage of breadfruits in refrigerated air conditions results in reduced weight and volume losses, together with the maintenance of fruit firmness compared to ambient conditions. However storage in air at 8°C results in rapid skin browning, rendering such fruits unacceptable after only 5 days. At 16°C and to a lesser extent at 12°C, skin browning is less severe, and a satisfactory shelf life of 10 days appears possible based upon this limiting factor.

Fruits stored in refrigerated water show increases in fruit weight and volume,

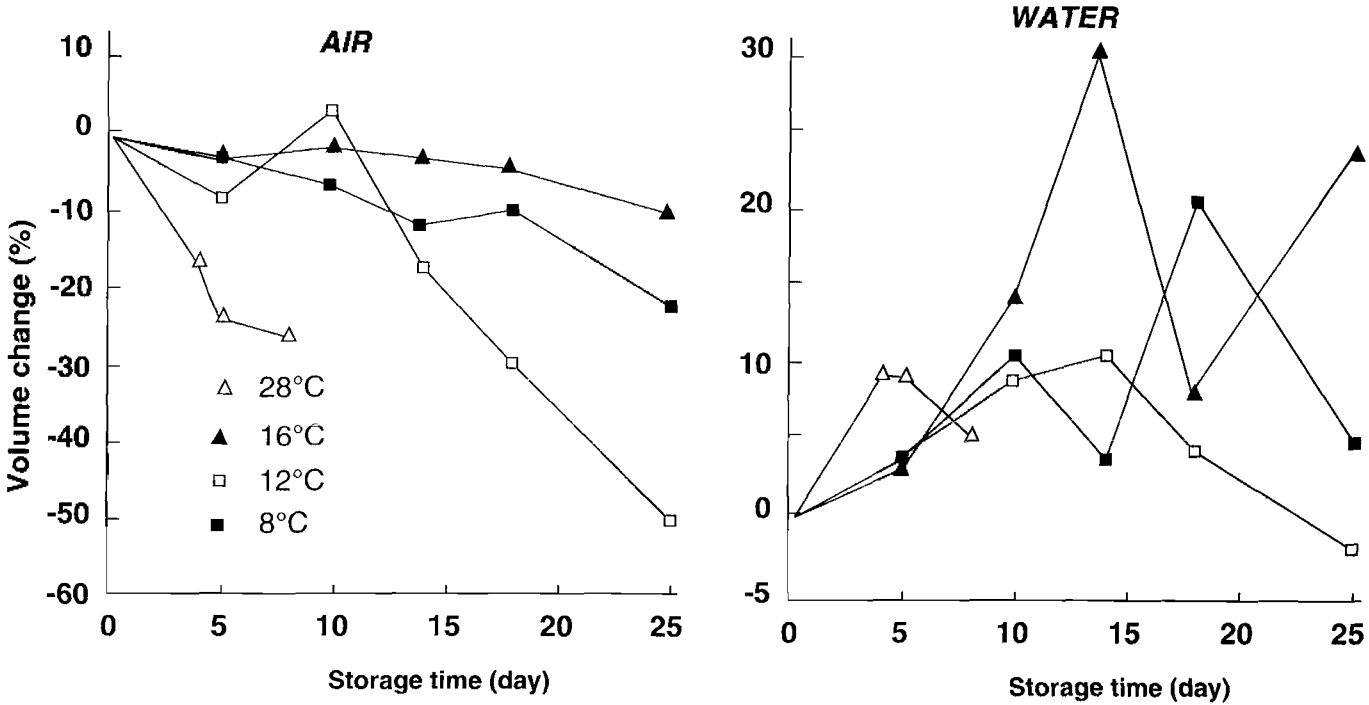

Figure 2 : Volume changes of the breadfruit when stored in air and water at different temperatures

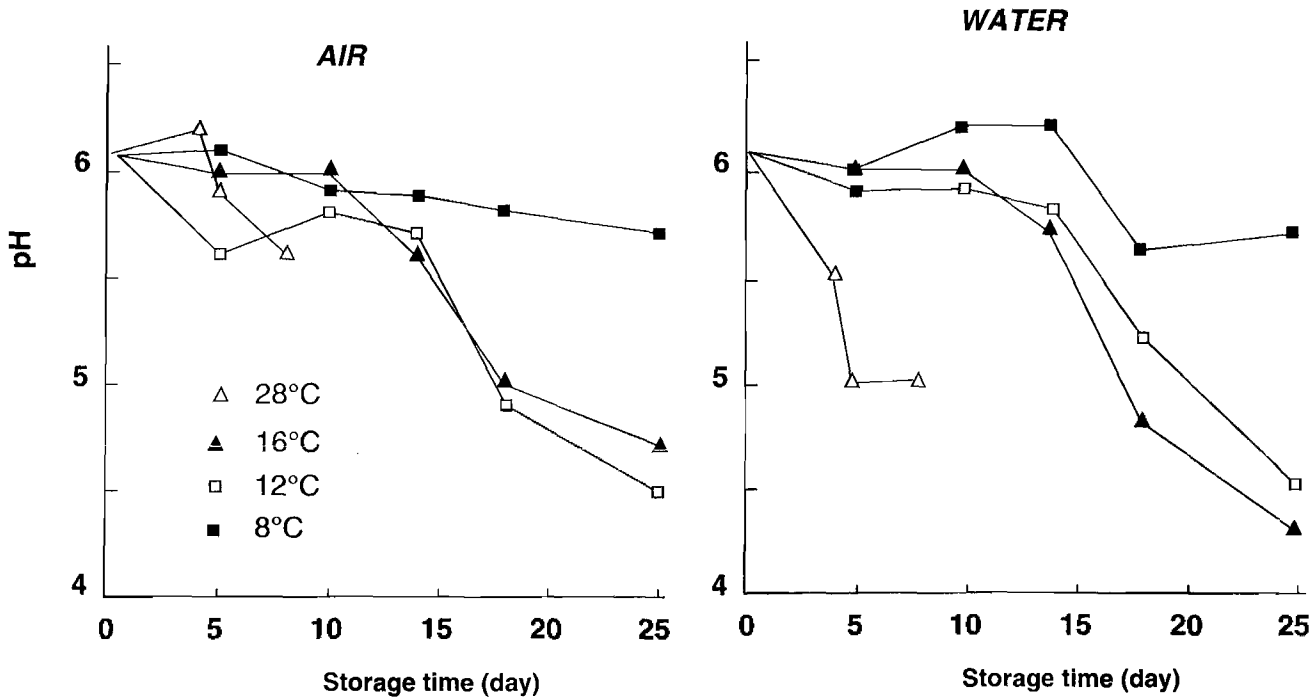

Figure 3 : Changes in pH of the breadfruit when stored in air and water at different temperatures

and remain firmer in storage compared to fruits stored in air. However the shelf life of such fruit is again limited by skin browning, as for fruits stored in air only.

ACKNOWLEDGEMENTS

The authors wish to tank the Organisation of American States (OAS) and NIHERST (Trinidad & Tobago) for their financial support of this Project.

REFERENCES

BAILE, J.B. and BARCUS, D.E. (1970). Respiratory patterns of tropical fruits of the Amazon basin. Trop. Sci. 12, 93-104.

MARRIOTT, J., PERKINS, C. and BEEN, B.O. (1979). Some factors affecting the storage of fresh breadfruit. Sci. Hort. 10, 177-181.

MATHEWS, R.F., BATES, R.P. and GRAHAM, H.D. (1986). Utilization of breadfruit in the tropics. Proceedings Interamerican Society for Tropical Horticulture, 30, 83-89, San Jose, Costa Rica.

PALMER, J.K. (1971). The banana. In : The biochemistry of fruits and their products. Vol. 2, Ed. A. C. Hulme. Academic Press, London.

THOMPSON, A.K., BEEN, B.O. and PERKINS, C. (1974). Storage of fresh breadfruit. Trop. Agric. (Trinidad). 51 (3), 407-415.

WILLS, R. B. H., LEE, H.T., GRAHAM, D., McGLASSON, W.B. and HALL, E. G. (1981). Post-harvest - An introduction to the physiology and handling of fruits and vegetables. AVI, Westport, Conn.

WOOTOON, M. and TUMAALII, F. (1984). Breadfruit production, utilization and composition - a review. Food Technology in Australia 36 (10), 464-465.