

The Effect of Waxing and Packaging on Prolonging the Storage Life of Papaya Under Refrigerated Conditions

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Papaya of the variety Known You No. 1, harvested at the colour-break stage were pretreated by dipping in hot water at 48°C for 20 minutes followed by a fungicidal dip in benlate for two minutes at 52°C.

Fruits were then separated into three experimental groups viz:

- (1) Stretch film packaging.
- (2) A.T. wax (food grade)
- (3) Fresh Mark wax (food grade)

and stored at 16°C and a relative humidity (R.H.) of 98%.

At weekly intervals, four fruits were taken out of storage from each treatment, two fruits were analyzed immediately, while the others were left to ripen at room temperature and subsequently analyzed. Fruits were analyzed for acceptability using the following parameters: weight loss, colour, decay, soluble solids, citric acid and starch.

After 12 days in storage the first signs of fungal growth were observed in all treatments. Papayas which were analyzed after both storage and ripening were found to be acceptable for up to three weeks in storage. On the fourth week the experiment was terminated due to the severity of fungal decay.

INTRODUCTION

The papaya is an important tropical fruit for the Caribbean islands as it is extensively utilized in the fresh state both locally and for the export market. The optimum stage of maturity for satisfactory storage and subsequent ripening is the onset of yellow colour development in the apex (Thompson and Lee, 1971). Papaya picked at this stage of maturity normally has a shelf-life of five days under ambient tropical conditions (Pantastico, 1975).

The fruit is very susceptible to mechanical damage, pest attack and infection. The most important pest and disease of the papaya in the Caribbean are the fruitfly and anthracnose respectively (Harvey, 1986). Anthracnose is caused by the fungus *Colletotrichum gloeosporioides* a latent infection which develops in the field. Post-harvest preventative measures include dipping the fruits in hot water for 20 minutes at 48°C (Akamine and Arisumi, 1953). A combination treatment using benomyl (0.1%) or thiabendazole (1.29 g/l) to the hot water improves control of anthracnose even when the water temperature is 52°C (Spalding and Reeder, 1978).

According to the United States quarantine regulations, papayas destined for the US markets must be less than quarter ripe and be disinfested for fruit flies within 18 hours of harvest. A double hot water immersion treatment is recommended consisting of an initial 30 minute immersion at 42°C, followed by a 20 minute immersion at 49°C (Nishijima and Alvarez, 1987).

Refrigerated storage can be used to extend the storage life of papayas. The recommended temperature for storage varies considerably and values between 13°C and 16°C have been reported to be adequate for storing papayas (Wardlaw *et al.*, 1934). Arriola *et al.* (1980), recommended 12°C as the critical temperature for a period not greater than two weeks since chilling injury developed at longer times or lower temperatures than 12°C.

Limited research has been reported on the use of modified and controlled atmospheres for papaya storage. According to Akamine and Goo (1969), controlled atmosphere and refrigeration can be used for storing papaya by keeping oxygen levels at 1% – 1.5%, but must be preceded by hot water treatment and fumigation. Polyethylene bags or plastic film wraps may also be used to extend the storage life of papayas. The polyethylene film provides a modified atmosphere condition which delays the normal ripening process. The application of various solutions which provide a membrane over the fruit thereby limiting gaseous exchange, has been found to be satisfactory in achieving modified atmospheres. Waxing when applied to fruits serves a two-fold purpose of reducing water loss (and therefore shrivelling) and improving the fruit appearance to the consumer (Wills *et al.*, 1981).

The objectives of this study were to evaluate the effectiveness of waxing and stretch film packaging on the storage life and quality of papayas under low temperature.

MATERIALS AND METHODS

A total of 75 fruits of the variety Known You No. 1, with an average weight of 2.24 kg were harvested at the colour-break stage. A storage time of six weeks under refrigerated conditions (16°C and 98% relative humidity) was projected. Using a randomised block design fruit were stored with three different pre-treatments as follows:

- (i) A.T. Wax (T_1) – 24 fruits. This wax was obtained from Agri-Chem, Incorporated of Florida, U.S.A. and was applied by brushing on the diluted wax (1:4) with a paint brush.
- (ii) Stretch Film (T_2) – 24 fruits. This film (0.5 ml type AF-50) was obtained from the Borden Chemical company of Canada. The wrapping exercise was performed by Hi-Lo Food Stores of St. Augustine, Trinidad.
- (iii) Fresh Mark Wax (T_3) – 24 fruits. A high solid paste paraffin wax "Fresh Wax 51V" obtained from the Fresh Mark Chemical corporation of Florida, U.S.A. The method of application involved brushing on the heated (38°C) undiluted wax with a paint brush.

All fruits were washed, hot water treated for 20 minutes at 48°C, dipped in a 1.5 g/l solution of benlate for two minutes at 52°C, air dried, randomly numbered, weighed and then subjected to the above treatments before storage in a Refrigerated Walk-In Room.

At weekly intervals four fruits from each treatment were taken out of storage. Two of these fruits were analyzed immediately while the remaining two fruits were left to ripen under ambient conditions. Fruit quality was assessed using physical, chemical and sensory tests as follows, viz:

- (i) percent weight loss: calculated from the weight of the fruit immediately before and after storage;
- (ii) colour was rated subjectively using the following schemes – (1) fully grown but completely green, (2) fully grown but showing first signs of yellowing at the apex, (3) fully grown and quarter ripe, (4) fully grown and half ripe, (5) fully grown and three quarter ripe, (6) fully grown, yellow and firm, (7) fully grown yellow with softening and (8) over-ripe, very soft on touch;
- (iii) decay: (1) None, (2) trace spotting now showing up, (3) slight spots increasing in size and numbers, (4) moderate 25% – 50% decay and (5) severe >75% decay;
- (iv) soluble solids: determined from the AOAC (1980), using a refractometer;
- (v) titratable acidity (percent citric Acid): determined from the methods of Raganna (1977) and AOAC (1980);
- (vi) sugar/acid ratios: calculated from (iv) and (v) above;
- (vii) firmness: papaya samples were penetrated for 15 seconds using an ELE penetrometer with a 0.8 mm plunger and a 50g weight attached. The depth of penetration of the fruit was reported in millimeters;
- (viii) starch: determined from the method of Ward and Johnson (1960).

The above tests were also performed on three fruits at the beginning of the storage trial.

RESULTS AND DISCUSSION

The changes in the measured fruit parameters for treatments T₁ to T₃ were compared by ANOVA. Significant differences for certain parameters were observed for the following component variances:

- (1) The effect of treatment: percent weight loss, colour, firmness
- (2) The effect of time: percent weight loss, colour, decay, firmness
- (3) The effect of ripening: percent weight loss, colour, decay
- (4) Time/ripening interactions: colour, decay, soluble solids, firmness

No significant differences in results obtained from ANOVA were found for treatments T₁ to T₃ for the following parameters: percent citric acid, sugar/acid ratio and starch.

Percent Weight Loss

Significant differences in percent weight loss of fruits were found with storage time, treatment and ripening. Weight loss increased with storage time for all treatments as shown in Figure 1. Stretch film packaged fruits had the lowest weight loss compared to waxed fruits and averaged 1.32%, 2.17% and 2.74% for stretch film, A.T. and F.M. waxes respectively.

There was a general increase in weight loss for all fruits when ripened under ambient conditions compared to when fruits were in storage. With post-harvest storage and ripening, the weight of papaya fruits decrease due to loss of water by transpiration.

Colour

Significant differences in colour of fruits were found with storage time, treatment and ripening. Under refrigerated storage there was an increase in colour rating for all treatments. Mean colour rating values for the three treatments over the duration of the storage trial were: 4.3(T₂), 3.8(T₁) and 3.3(T₃).

Over the ripening period there was an increase in colour above the storage rating values for treatments (T₂) and (T₃). However (T₁) fruits did not improve in their colour rating on ripening, as the values show a small decrease.

Associated with the ripening of fruits is an increases in the carotenoids content and a decrease in chlorophyll. Stretch film fruits had the highest colour rating values and also were the most uniform in terms of colour development both during storage and on ripening. This may be attributed to the accumulation of ethylene in the sealed package and its effect on ripening.

The decrease in colour rating values for ripened A.T. waxed (T₁) fruits could be due to the wax used. After one week in storage A.T. waxed fruits had a brown, discoloured surface. This effect in storage could have disrupted the normal colour development associated with ripening.

Decay

Fruits stored under refrigeration were significantly affected by the duration of storage (Figure 2) and on ripening. Mean decay rating values over the duration of the storage trial were 2.6(T₃), 2.5(T₂) and 1.9(T₁). On ripening, decay increased with indices of 3.8(T₂), 3.7(T₁) and 3.6(T₃).

After 12 days in storage, fruits from all treatments showed first signs of decay. Diagnosis of fungal rots showed that *Rhizopus stolonifer* was the predominant pathogen on T₃ (waxed) fruits, while the superficial rots for T₁ (waxed) and T₂ (packaged) fruits were associated with minor pathogens. The onset of decay was earlier than expected and may have been due to abrasion with other fruits on the trees before harvest as well as during the harvest period in the rainy season.

Decay due to *Colletotrichum gloeosporioides*, (anthracnose) was not observed until the fourth week of storage. This would suggest that the hot water treatment used in addition to the fungicidal dip (benlate) was effective for the control of anthracnose, the primary cause of post-harvest wastage of papayas.

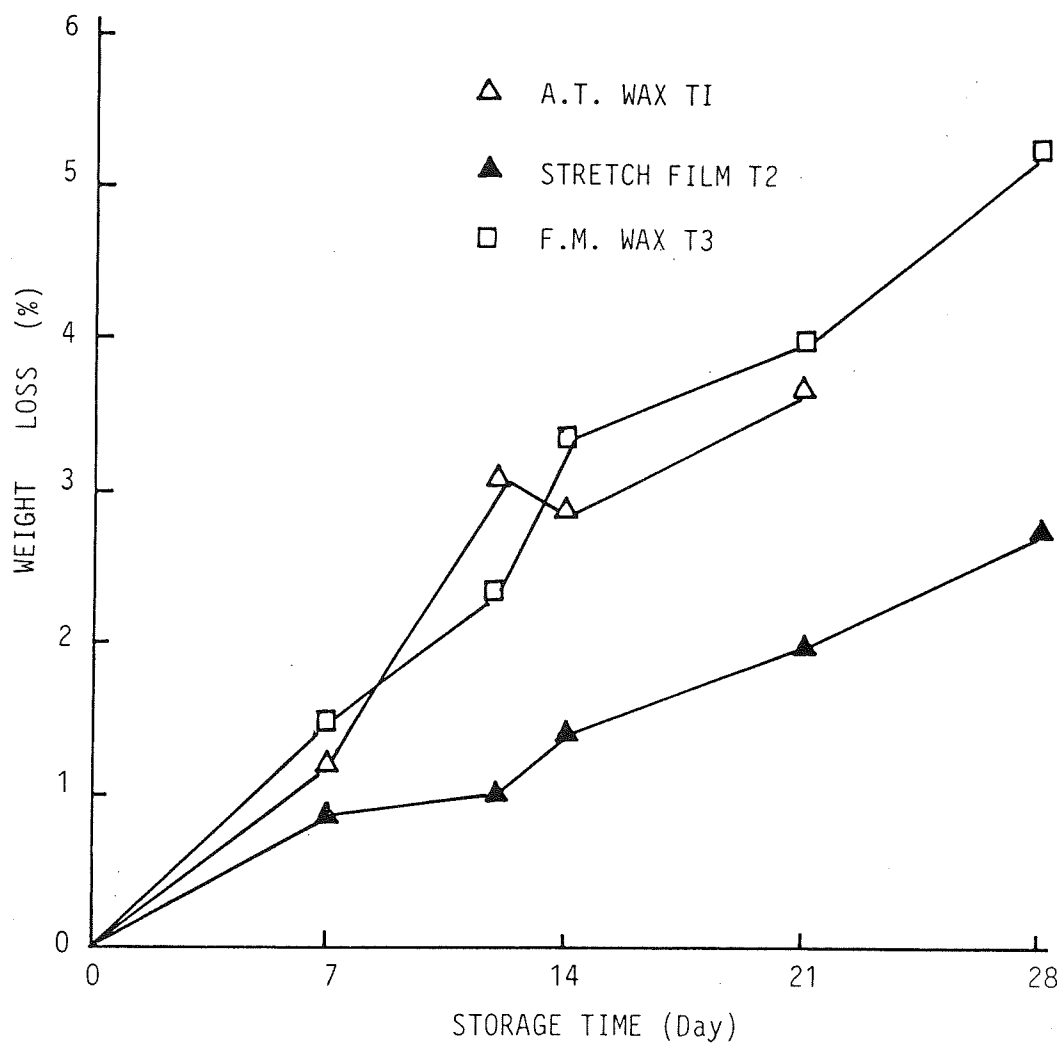


Figure 1
Percent Weight Loss of Stored Papayas

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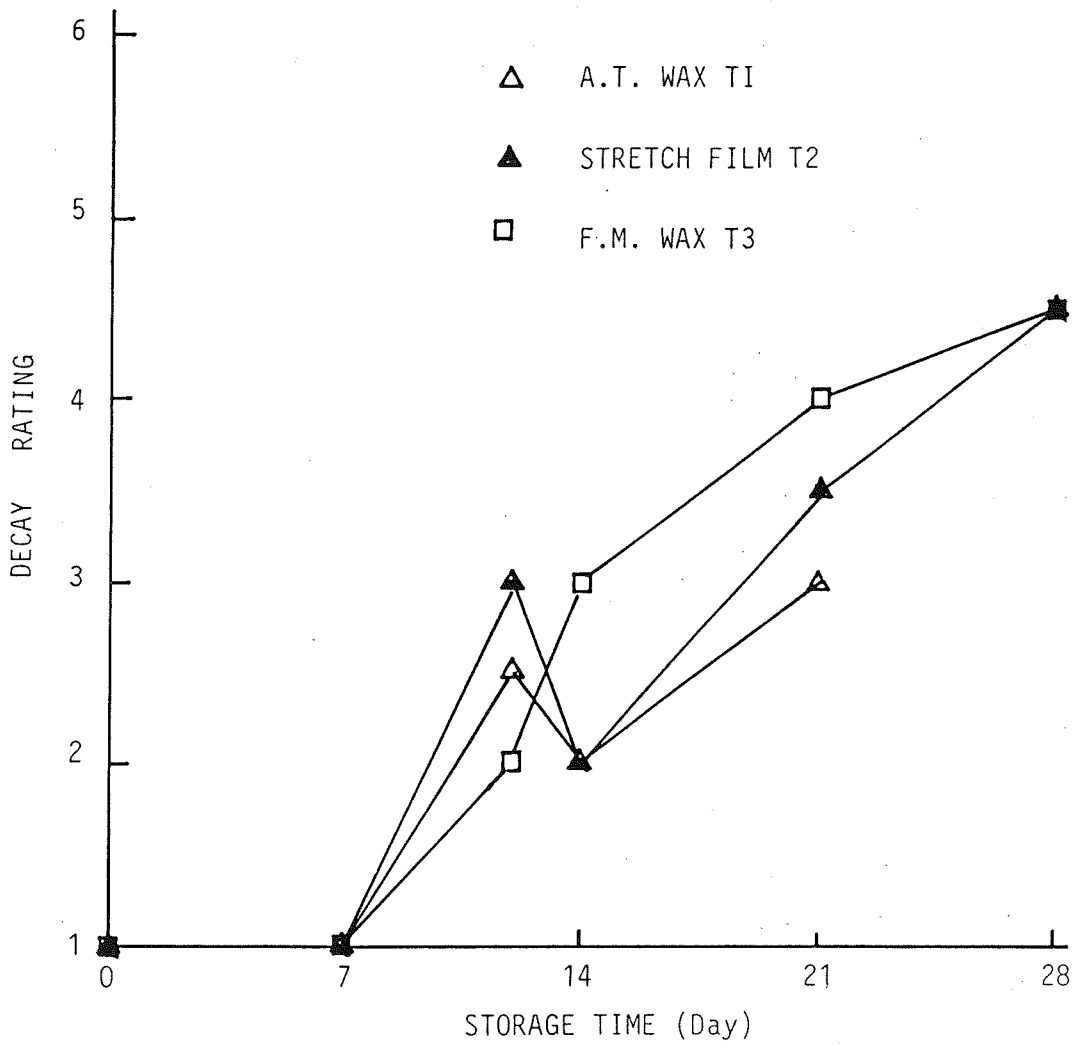


Figure 2
Decay Rating of Papayas in Storage

Soluble Solids

Soluble solids content was not affected by treatment or storage time. In storage, soluble solids content ranged from 6.0 – 13.5 for fruits in all treatments. On ripening under ambient conditions, fruits removed from storage showed significant increases in soluble solids with respect to the duration of storage.

Ripened fruits after one week in storage had adjusted mean soluble solids values of 9.9(T₃), 9.4(T₁) and 8.5(T₂) while after four weeks in storage, ripened fruits had adjusted mean soluble solids content of 12.2(T₁), 12.0(T₃) and 11.6(T₂) as illustrated in Table 1. Salunkhe and Desai (1984), stated that with the ripening of papayas, sugars increase due to metabolism of polysaccharides in the cell wall while Jones and Kubota (1940), noted that with ripe papayas there was a high percentage of reducing sugars from the hydrolysis of sucrose.

Table 1
Soluble Solids Values of Ripened Papayas from Refrigerated Storage

Storage Time (days)	Soluble Solids* Treatments		
	A.T. Wax (T ₁)	Stretch Film (T ₂)	F.M. Wax (T ₃)
7 + R**	9.36 ± 1.55	8.51 ± 1.55	9.85 ± 1.43
14 + R	10.05 ± 1.55	9.28 ± 1.55	10.30 ± 1.43
21 + R	11.12 ± 1.55	10.44 ± 1.55	11.14 ± 1.43
28 + R	12.20 ± 1.55	11.61 ± 1.55	11.98 ± 1.43

*Adjusted mean values given together with standard errors.

**R – variable ripening time.

Firmness

Ripening is associated with a reduction in fruit firmness due to the degradation of insoluble proto-pectins to more soluble pectin and pectic acid. While in refrigerated storage there was a significant decrease in firmness of fruits with storage time as shown in Figure 3. This suggests that ripening was occurring in storage.

F.M. Waxed (T₃) fruits had significantly lower penetration values than A.T. waxed (T₁) and stretch film (T₂) fruits, indicating a higher degree of firmness both during storage and on subsequent ripening. F.M. was applied in an undiluted form compared to A.T. wax, and the heavier application of the F.M. wax may have resulted in an internal product atmosphere of low oxygen and high carbon dioxide, thus retarding the fruit's normal metabolism.

Percent Citric Acid, Sugar/Acid Ratio and Starch

No significant differences in results were obtained from the ANOVA for the following measured parameters: percent citric acid, sugar/acid ratio and starch with respect to storage time, treatment or on ripening. Over the duration of the trial and for all treatments, percentage starch ranged from 1.0– 4.6, sugar/acid ratios ranged from 22.6 – 69.8 and percentage citric acid from 0.09 – 0.56.

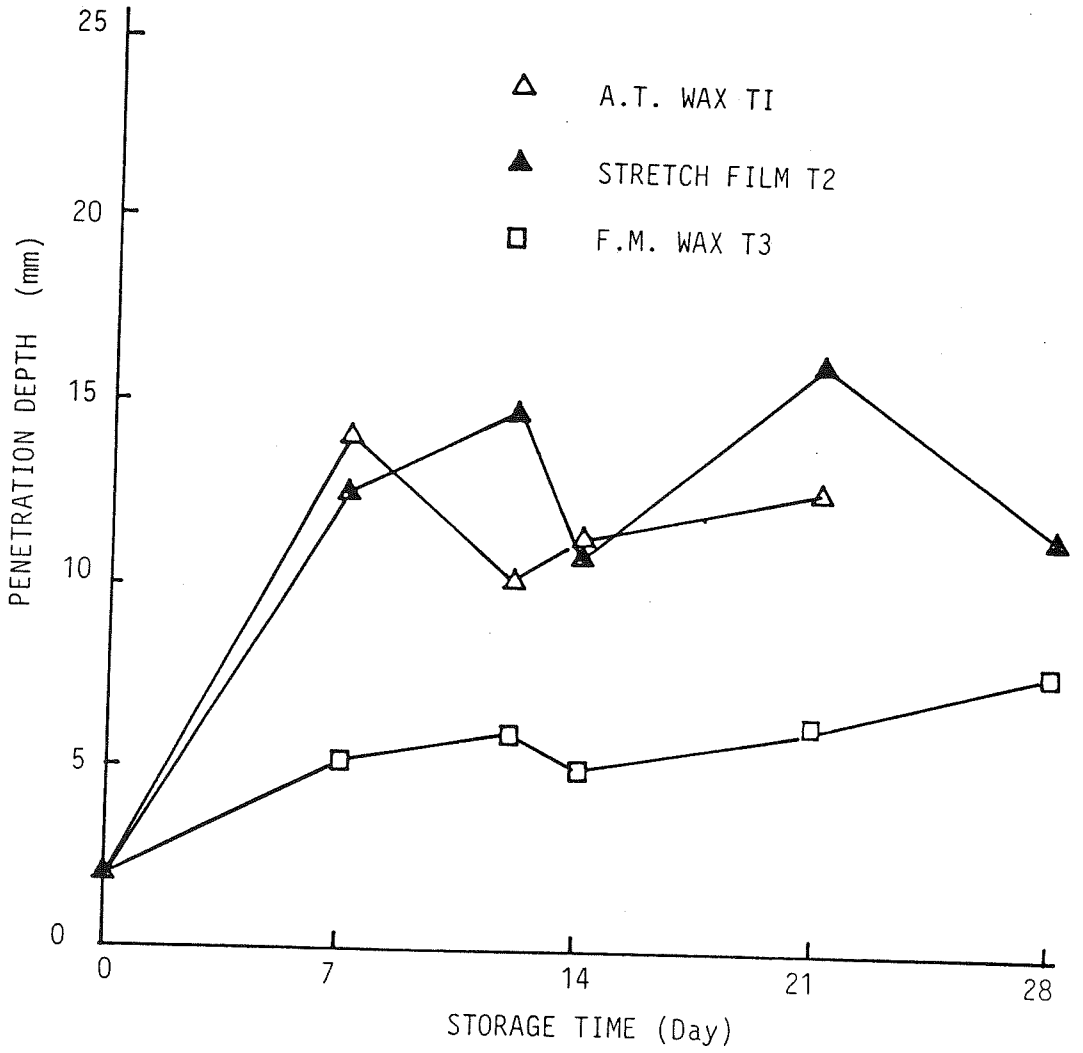


Figure 3
Firmness of Papayas in Storage

CONCLUSIONS

Papaya fruits stored under ambient tropical conditions are characterised by a rapid rate of ripening, senescence and decay. Control of these processes is essential for orderly marketing of the fruit, particularly for export.

The storage trial on papayas was limited to four weeks by the extent of fungal decay mainly due to secondary infections. Decay was first observed after 12 days in storage. Stretch film packaged (T₂) fruits and F.M. waxed (T₃) fruits had a maximum storage life of 28 days compared to the 21 days for A.T. waxed (T₁) fruits. Fruits in storage and for all treatments had acceptable flavours, however, by the third week off-flavours had developed. The maximum time required for ripening fruits on removal from storage were eight days for F.M. waxed (T₃) fruits, four days for stretch film (T₂) fruits and three days for A.T. waxed (T₁) fruits. F.M. waxed (T₃) fruits retained a glossy appearance, developed approximately 50% yellowing and had comparatively good shelf-life both during storage and particularly on ripening. However such fruits did not ripen properly with respect to taste, firmness and colour development.

Compared to the waxed fruits, the stretch film packaged fruits had the lowest weight loss in storage, increased colour development both during storage and on ripening, an increase in sugars (soluble solids) on ripening, reduction in firmness in storage and a sweeter taste both during storage and on subsequent ripening. Of the three treatments evaluated, this appeared to be the best.

However further research needs to be pursued so that the incidence of fungal decay may be reduced both during storage and ripening.

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