# CONTROLLED ATMOSPHERE STORAGE OF PAPAYAS

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Abstract

In separate storage trials, papayas of the varieties Known You No. 1 and Tainung No. 1 were held under controlled atmosphere (CA) conditions (16°C, 1.5-2.0% $O_2$ and 5% $CO_2$) for periods of 27 and 29 days respectively. The storage behaviour of such fruits was compared to similar fruits but held under refrigerated conditions (16°C). In the first trial, Known You No. 1 fruits were stored for a maximum of 27 days in perforated polyethylene bags under both refrigerated and CA conditions. Refrigerated and controlled atmosphere stored fruits remained acceptable in storage for 13 and 17 days respectively. Decay was the limiting factor both in storage and on subsequent ripening. In the second trial, Tainung No. 1 fruits (without packaging) were stored for a maximum of 29 days under the same conditions of refrigeration and CA. Controlled atmosphere stored fruits remained acceptable for the duration of the storage period compared to refrigerated fruits which were unacceptable after 17 days in storage due to decay. Controlled atmosphere fruits in storage showed lower losses in weight, negligible changes in firmness and a longer time for ripening under ambient conditions. Colour development was also reduced in CA storage, and on extended storage, colour development was restricted when fruits were ripened under ambient conditions.

## INTRODUCTION

Under refrigeration, a range of storage temperatures have been reported for different varieties of papayas usually for fruits harvested at the colour-break stage of maturity. It was reported (6) that papayas at 10 and 15°C can be stored for 16 days, while 12°C has been recommended (5) as an optimum storage temperature for 2 weeks. Storage below 10°C has been known to cause chilling injury (9).

The use of modified atmosphere using sealed polyethylene bags can also be used to extend the storage life of papayas however decay during storage was found to be the limiting factor (10). Controlled atmosphere storage has been

reported for extending the life of papayas (3) but its use should be combined with a decay control pre-treatment such as the hot water treatment (2), fruit fly control using the double dip method (7) and which also serves as a possible alternative to ethylene dibromide (EDB) fumigation.

Papayas benefitted slightly from storage in low oxygen (1-1.5%) conditions and at 13°C, the shelf-life of fruits on removal from CA storage after 6-12 days was found to be approximately 1 day longer than that of fruits stored in air only (3). The use of high carbon dioxide ($CO_2$) levels to modify the storage atmosphere showed no advantage in terms of decay control (1) as fruits stored at $CO_2$ levels of 10% or greater at 18°C decayed very rapidly on removal to normal atmospheric conditions. It was concluded (8) that the best atmosphere for maintaining acceptability and market quality of papayas during storage for 14 and 21 days was 1% $O_2$ and 5% $CO_2$ with these conditions allowing for 90% of fruits stored to be acceptable compared to 10% for fruits stored in air only.

The objectives of this study were therefore to evaluate the shelf-life and quality of two varieties of papayas grown in Trinidad and Tobago (Known You No. 1 and Tainung No. 1) in refrigerated and controlled atmosphere.

## MATERIALS AND METHODS

Separate experimental storage trials were conducted on 2 varieties of papayas viz:- Known You No. 1 and Tainung No. 1. In both trials fruits were harvested at the colour-break stage, washed, hot water treated (48°C for 20 min.), dipped in Benomyl (52°C for 2 min.) at concentrations of 1.23 gm/l and 1.50 gm/l for trials 1 and 2 respectively. All fruits were randomly numbered and weighed before storage.

Fruits were stored in a Forma Scientific "Walk-in" refrigerated room maintained at 16±0.5°C. In this room, a gas tight chamber (0.61 x 1.00 x 0.61 m) was maintained under the desired CA conditions, using a flow through $CO_2$ and $O_2$ system, using commercially available oxygen, nitrogen and carbon dioxide gas in cylinders. An ADC infra-red gas analyzer, type SS-100 was used for $CO_2$ analysis with a range of 0-20%, and a Servomex Gas Analyser, type 580A was used for $O_2$ analysis, with a range of 0-25%.

In the first trial, 75 fruits (Known You No. 1) each averaging 2 kg in weight were individually packaged in perforated polyethylene bags (30 cm x 20 cm, 100 gauge) before being stored under two systems viz:-

(1) Refrigerated (R) - 36 fruits stored at 16°C and

(2) Controlled atmosphere (CA) - 36 fruits stored at 16°C, 1.5-2.0% $O_2$ and 5.0% $CO_2$.

Fruits were stored for a period up to 27 days, during which time fruit samples were removed after 5, 8, 11, 16, 20, 24 and 27 days for analysis. On removal from storage 50% of the fruits were left to ripen under ambient conditions and subsequently analyzed; while the remainder were analysed immediately.

In the second trial, 26 fruits (Tainung No. 1) each averaging 0.89 kg in weight were stored, after being pre-treated under the same refrigerated and controlled atmosphere conditions as mentioned for trial 1. No packaging was used. Fruits were separated into two post-harvest treatments with 14 fruits per treatment, as follows:-

(1) Refrigerated (R)
(2) Controlled atmosphere (CA).

As in trial 1, fruit samples from refrigerated and CA storage were removed after 7, 13, 17, 20, 23, 26 and 29 days and analyzed immediately, while others removed at the same time intervals, were left to ripen at 28°C and subsequently analyzed. Three fruits were analysed on the day of harvest for trial 1, and two for trial 2.

In assessing the storage life and quality of fruits under refrigerated and CA, the following parameters were measured as a function of storage time:- % weight loss, firmness, % soluble solids, titratable acidity, colour and decay.

The percent weight loss of fruits was calculated from the initial weights of fruits and their weights after storage. Fruit firmness was measured by a penetrometer, using a 0.8 mm plunger with a 50 gm weight and a penetration time of 15 seconds. Percent soluble solids (Brix %) was determined using a refractometer on a 1:1 dilution of papaya pulp. Titratable acidity (% citric acid) was determined by the AOAC method (4). Fruit colour was rated subjectively using a colour rating scheme as follows:- 1 - fully grown but completely green; 2 - fully grown but

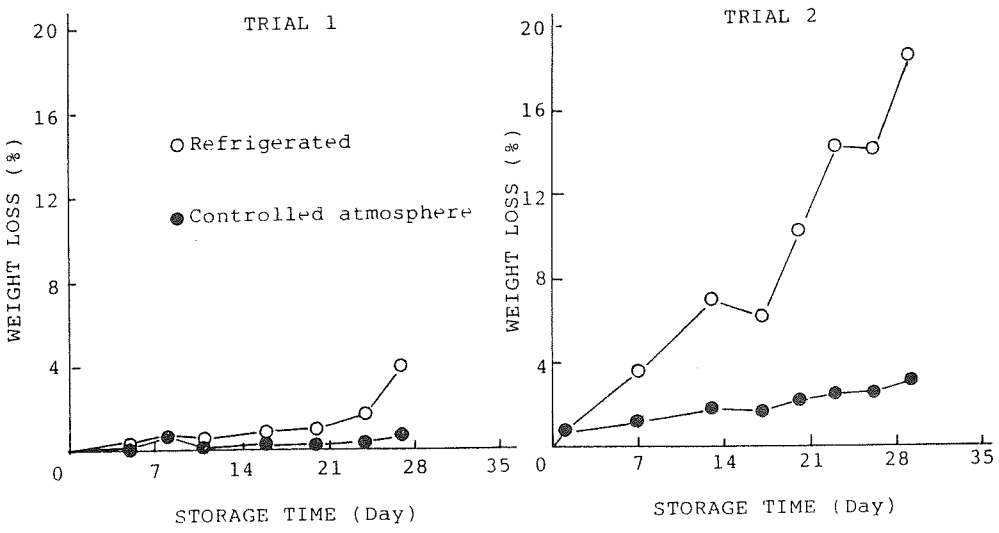


Figure 1 : The weight loss of papayas (Known You No. 1 - trial 1 and Tainung No. 1 - trial 2) in refrigerated and controlled atmosphere

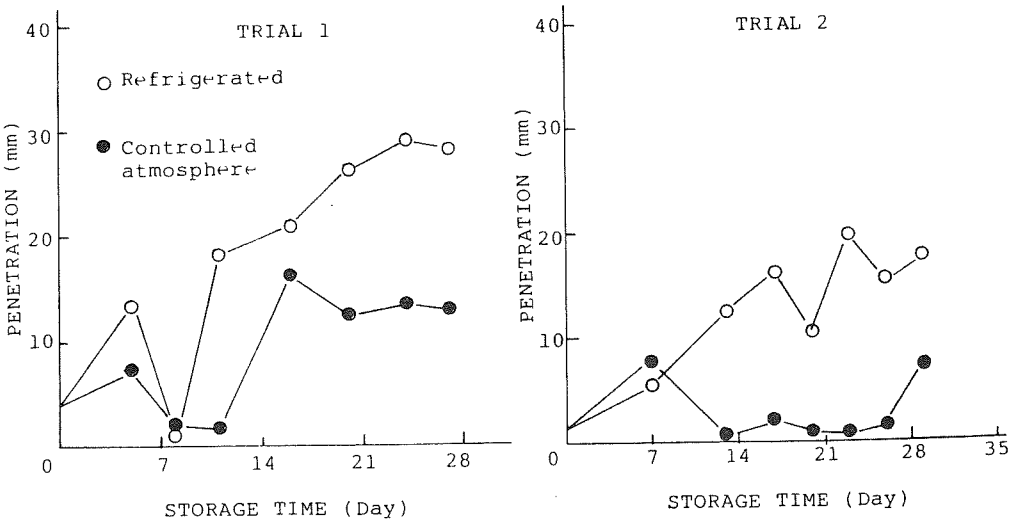


Figure 2 : The firmness of papayas (Known You No. 1 - trial 1 and Tainung No. 1 - trial 2) as measured by a penetrometer in refrigerated and controlled atmosphere

showing first signs of yellowing at the apex; 3 - fully grown and 1/4 ripe (showing yellowing in the apex); 4 - fully grown and 1/2 ripe; 5 - fully grown and 3/4 ripe; 6 - fully grown yellow and firm; 7 - fully grown, yellow with softening and 8 - over-ripe, very soft on touch. Decay was also rated subjectively (11) as follows:- 1 - none; 2 - trace spotting first appearing; 3 - slight spots, increasing in size and numbers; 4 - moderate (25-50%) and 5 - severe, > 75% decay.

## RESULTS AND DISCUSSION

### Percent weight loss

As illustrated in Figure 1, weight loss increased with time for fruits (Known You No. 1) under both refrigerated and controlled atmosphere conditions, with refrigerated fruits showing higher losses in weight after 11 days. Loss in weight for CA stored fruits was small, averaging 0.01%/day, while for refrigerated fruits it was 0.11%/day.

In the second trial with Tainung fruits, weight loss was again higher for refrigerated fruits averaging 0.65%/day, while for CA stored fruits it was 0.08%/day (Figure 1). Overall therefore, weight losses were lower in trial 1 compared to trial 2. This may be attributed to the polyethelene packaging used in the first trial resulting in much lower transpiration rates, despite the fact that fruits used in the first trial were almost twice as large as fruits used in the second trial.

After 25 days in storage, estimated weight losses (based upon generalised, linear models) for fruits from trial No. 1 were 1.96(R) and 0.39%(CA), and on ripening these values were 1.95 and 0.73% respectively. In trial No. 2, estimated weight losses after 30 days in storage were 16.77(R) and 3.02%(CA), and on ripening of fruits, these values increased to 17.92 and 10.12% respectively. These results show that respiration and transpiration of papayas are severely restricted in CA storage, compared to refrigerated storage, however on ripening such stored fruits, these processes are resumed with considerable vigour.

### Fruit firmness

In both trials, papayas softened in either refrigerated or controlled atmosphere storage, with softening being significantly greater for refrigerated fruits.

Penetrometer readings for both trials are shown in Figure 2. In the first trial, Known You No. 1 fruits showed mean penetration increases of 1.02(R) and 0.45mm/day(CA), while in the second trial, Tainung fruits showed values of 0.56(R) and 0.12mm/day(CA). Tainung fruits were initially firmer compared, to Known You (initial penetration values of 1.29 and 3.97 mm respectively), and this behaviour continued during storage.

After 25 days in storage, estimated penetration values of 23.33 and 13.90 mm were calculated for Known You fruits, with these values increasing to 25.35 and 18.58 mm on ripening such fruits under ambient conditions. In the second trial, Tainung fruits behaved similarly, with little change occurring to refrigerated fruits as they had ripened in storage. CA stored fruits showed an estimated penetration value of 4.11 mm after 30 days, with this increasing to 9.66 mm on ripening.

Soluble solids/titratable acidity

The soluble solids content of papayas in the first trial showed no significant changes with either storage time or treatment (refrigerated vs controlled atmosphere). Average values during storage were 8.9% (R) and 8.5% (CA), while on ripening these values increased marginally to 9.0% (R) and 8.7% (CA). In the second trial, a similar behaviour was observed, with average values during storage being 10.0% (R) and 9.5% (CA), increasing to 11.1% (R) and 10.9% (CA) on ripening.

In the first trial, for Known You fruits, a significant difference in the titratable acidity (% citric acid) was found with respect to storage time, with acid levels decreasing as storage time increased. From an initial value of 0.120%, estimated values of % citric acid after 25 days in storage were 0.081% (R) and 0.083% (CA). On ripening such fruits no significant changes were found. In the second trial, Tainung fruits showed an initial citric acid level of 0.280%, with estimated values after 30 days in storage being 0.210% (R) and 0.200% (CA).

Colour

Colour development of fruits was significantly affected by the storage treatment, with refrigerated fruits showing higher colour indicies, compared to CA fruits (Figure 3). Mean colour scores during storage for trial 1 were 4.3 (R) and 2.3 (CA), while for trial 2, mean scores

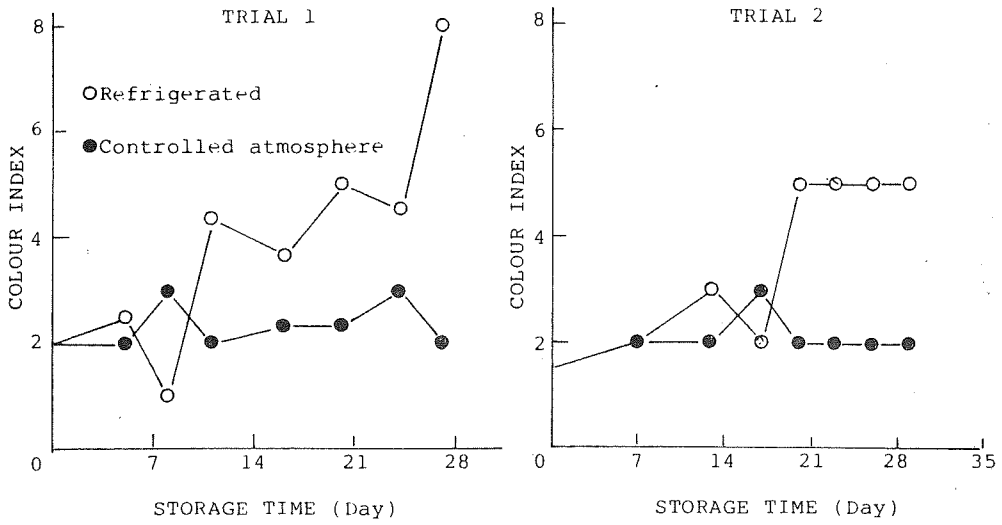


Figure 3 : The colour indicies of papayas (Known You No. 1 - trial 1 and Tainung No. 1 - trial 2) in refrigerated and controlled atmosphere

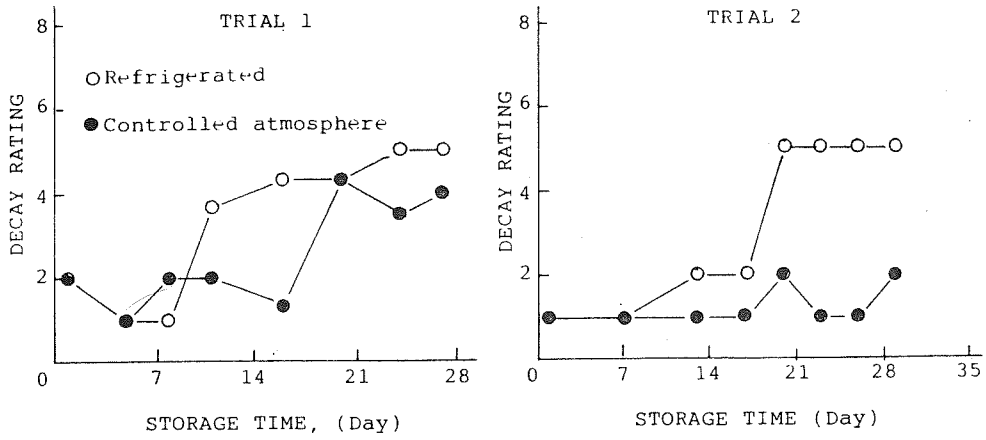


Figure 4 : The decay rating of papayas (Known You No. 1 - trial 1 and Tainung No. 1 - trial 2) in refrigerated and controlled atmosphere

obtained were 3.6 (R) and 2.1 (CA). These results show considerable ripening and colour development for refrigerated stored fruits, while fruits stored under CA showed little colour development in storage. Colour scores for fruits at the beginning of the storage trials were 2.0 for Known You and 1.5 for Tainung.

Fruits removed from CA storage and ripened under ambient conditions were significantly affected by a storage time/ ripening interaction, in terms of colour development. Fruits from the early part of the storage trial, showed good colour development on ripening, while those stored for much longer periods, showed reduced colour development on ripening. This effect was most pronounced for Known You fruits, as those stored in CA beyond 16 days showed little colour development on ripening.

Decay

In both trials, decay of papayas was significantly affected by storage time and treatment, as illustrated in Figure 4. Decay increased with storage time, with the rate of decay being higher for refrigerated fruits compared to CA fruits. For trial No. 1, mean decay values obtained for fruits in storage were 3.3 (R) and 2.5 (CA), while for trial No. 2 the corresponding values were 3.4 (R) and 1.3 (CA). Decay was significantly increased when fruits were removed from storage and ripened under ambient conditions. In trial No. 1, a mean decay value on ripening of 4.6 was obtained for both refrigerated and CA fruits. In trial No. 2 the corresponding values on ripening were 4.2 (R) and 3.0 (CA).

In the first trial, decay of ripened fruits appeared independent of the fruits' duration of storage. However in the second trial, fruits stored under both refrigerated and CA conditions were more susceptible to decay on ripening when the storage period was increased. In the first trial, decay was observed in the form of dark rots on the sixteenth day of storage, for both refrigerated and CA stored fruits. In the second trial, refrigerated stored fruits showed the first signs of decay, in the form of small, dark brown, water soaked spots after 13 days in storage. CA stored fruits exhibited little signs of decay for the duration of the storage trial.

Ripening

The time taken for fruits to ripen under ambient conditions on removal from refrigerated and CA storage, reduced with

the length of the storage period. In the first trial with Known You fruits, average ripening times were 1.5 and 1.8 days for refrigerated and CA storage. In the second trial with Tainung fruits, the corresponding average ripening times were 2.5 (R) and 4.0 days (CA).

## CONCLUSIONS

Papayas of the varieties Known You No. 1 and Tainung No. 1, harvested at the colour-break stage and stored in controlled atmosphere conditions of 1.5-2.0% $O_2$ and 5.0% $CO_2$ at 16°C showed:-

(i) significantly reduced losses in weight,
(ii) negligible changes in firmness
(iii) little colour development
(iv) reduced decay levels and
(v) longer ripening time under ambient conditions

when stored for up to 29 days, compared to fruits stored in refrigeration only.

On ripening such CA stored fruits under ambient conditions, weight losses increase and softening occur indicating that the normal metabolic processes are not impaired. However for storage periods beyond 16 days, colour development on ripening may be reduced.

Decay appears to be the limiting factor in terms of papaya storage under both refrigerated and CA conditions. A storage life of 2 weeks in refrigerated conditions (16°C) is possible, however under CA conditions, this may be doubled.

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