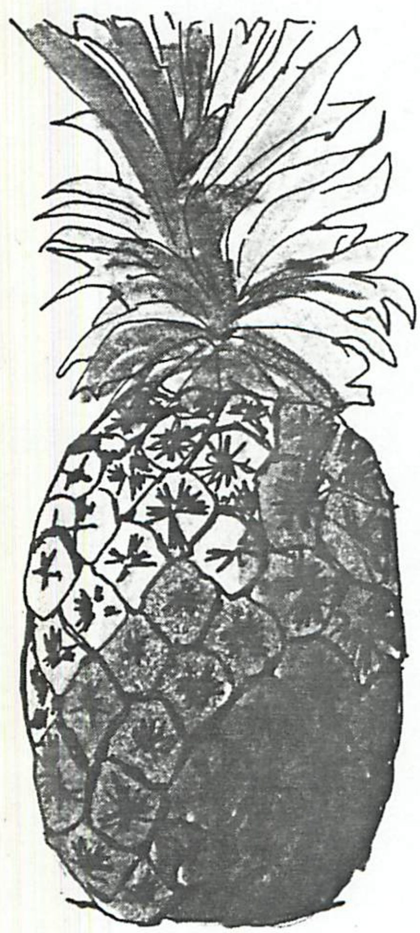

Controlled Atmosphere Storage of Fresh Pineapple (*Ananas comosus* (L.) Merr. 'Smooth Cayenne')

Ernest K. Akamine and Theodore Goo

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THEODORE T. S. GOO is Research Associate, Hawaii Agricultural Experiment Station.

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Controlled Atmosphere Storage of Fresh Pineapple (*Ananas comosus* (L.) Merr. 'Smooth Cayenne')[1]

ERNEST K. AKAMINE and THEODORE GOO

INTRODUCTION

The use of controlled atmosphere (CA) or modified atmosphere storage for extending the shelf life of fresh commodities has been investigated extensively *(6,8)*, but is in extensive use only for the storage of apples *(7)*. However, extensive experimentation is currently occurring in many institutions to extend the range of the use of CA in transit and stationary storage. In Hawaii, investigations of the effects of CA storage on fresh papayas *(1,3,4,5)* have established the optimum levels of oxygen during simulated shipping conditions for maximum shelf life extension of fumigated *(5)* and irradiated *(4)* fruits. Papayas and pineapples are the main fresh Hawaiian commodities shipped from Hawaii to the mainland United States and elsewhere. Unlike the papayas and other fresh export commodities which require disinfestation treatments for the destruction of fruit flies and other insects, there are no such quarantine requirements for fresh pineapples. Although some pineapples are currently shipped by air, most fruits are shipped in refrigerated containers by surface transportation.

In the present study, the effects of CA storage on the shelf life of fresh pineapples were tested under simulated transit conditions.

[1] This investigation was aided by a grant from Oxy[illegible], Division of Occidental Petroleum Corporation, through The Best Fertilizers Company, [illegible]yogenics Division, Lathrop, California, and Best Chemicals and Fertilizer Company, Ltd., Honolulu, Hawaii.

MATERIALS AND METHODS

Fresh pineapples (*Ananas comosus* (L.) Merr. 'Smooth Cayenne') for this study were provided by Dole Company from their fields at Kunia, Oahu. Immediately after harvest in early morning, the butt (exposed remnant of peduncle in detached fruit) was dipped in Dowicide A (6 lb/100 gal water) by the company to control decay (commercial procedure for export pineapples). Experiments were started in the afternoon of the day of harvest. The initial degree of yellowing on the fruit surface (commercially called shell color) varied from 10 to 29 percent. The fruits were used with the crowns intact. The number of fruits per treatment varied from 7 to 14. The initial storage period under CA was 7 days to simulate approximately the shipping period by surface transportation from Hawaii to the West Coast. The temperature of CA storage was 45 F (±0.5), the optimum temperature for the storage of fruits with the degree of surface yellowing used in these studies *(2)*. Oxygen levels were maintained by a controlled flow system in which proportionate volumes of pure gaseous nitrogen and compressed air were mixed to obtain the desirable oxygen concentration. A large glass jar (11 inches in diameter by 24 inches high) in which the fruits were placed was continuously purged with the gas mixture at a flow rate of approximately 500 ml/min. This rate was found sufficient to prevent the accumulation of respiratory carbon dioxide and ethylene in the fruit chamber. The oxygen concentration in the effluent atmosphere was determined daily with a Johnson-Williams oxygen indicator.

After storage under CA, the pineapples were held in room temperature (71 to 78 F) and atmosphere to simulate retail conditions. The following parameters were noted daily: shell color as percent of fruit surface with visible yellow pigmentation; percent of butt area with superficial surface mold growth; decay incidence; crown condition; fruit weight; and number of senescent fruits. A shipper's standard was adopted for the last parameter, and a fruit was counted senescent and therefore unmarketable when six or more fruitlets turned brownish and/or watery. Observations were made until all fruits in an experiment were judged senescent. When a fruit became senescent, it was opened and the number and degree or intensity of darkening of the spots in the pulp characteristic of "endogenous brown spot" were recorded. The following hedonic scale was used to score the degree of darkening of the spots: 0 = no spots; 1 = slightly darkened spots; 2 = moderately darkened spots; and 3 = severely darkened spots. The percent weight loss

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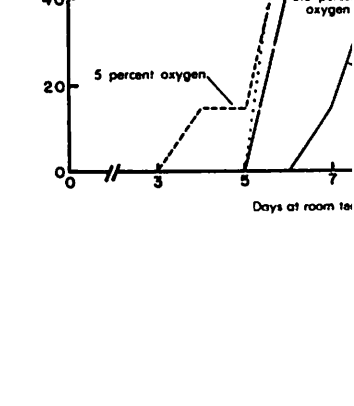

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was calculated from decreases in weight of the fruits from their original weight. The average number of marketable days was calculated from the number of fruits senescing each day.

RESULTS

In preliminary experiments, the oxygen concentration in the initial storage medium was varied from 0.5 to 21 percent (air) and it was found that such CA treatments had no effect on the crown of the pineapple; if decay ever developed, it occurred after the fruit became senescent. These experiments also indicated that oxygen levels of approximately 5 percent and lower were necessary for shelf life extension. Therefore, in succeeding experiments, only these oxygen levels were used and observations on crown condition and decay were omitted.

In one experiment, fruits with approximately 19.5 percent shell color were stored initially in 2, 3.5, and 5 percent oxygen and air. Seven fruits were used for each treatment. When fruits were placed in room conditions, shell color development was slightly delayed and degree of molding in the butt area was also slightly decreased by all low levels of oxygen. There was no difference in the rate of weight loss among the treatments. As seen in Figure 1, the percentage of senescent fruit was only slightly decreased by 3.5 and 5 percent oxygen tensions. Two percent oxygen level, however, significantly delayed the senescence rate compared with air.

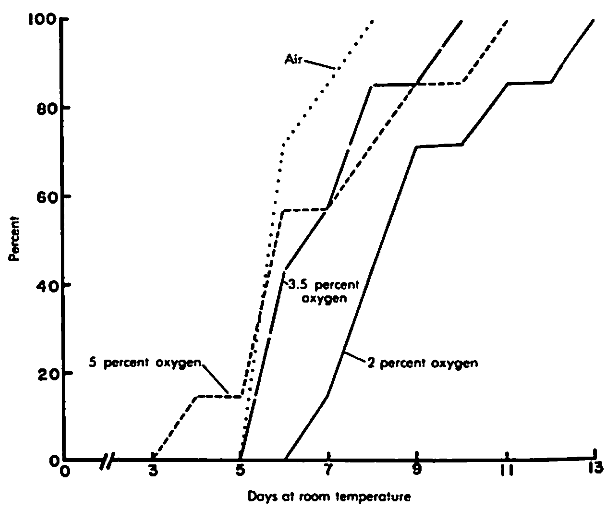

Figure 1. The effect of initial storage under 2, 3.5, and 5 percent oxygen and air at 45 F for 7 days on incidence of senescent fruit in pineapples subsequently stored in room conditions.

The average shelf life at room temperature was 8.3, 6.3, 6.7, and 5.4 days for the 2, 3.5, and 5 percent oxygen and air treatments, respectively. Only the difference in shelf life between the 2 percent oxygen and air storage was significant (P = .05). Thus an extension of 2.9 days in shelf life was realized by an initial CA storage in which the oxygen level was maintained at 2 percent.

Three experiments (7 to 14 fruits per treatment) were then conducted using the 2 percent oxygen concentration for initial storage. The average extension in shelf life (significant at P = .05) due to CA

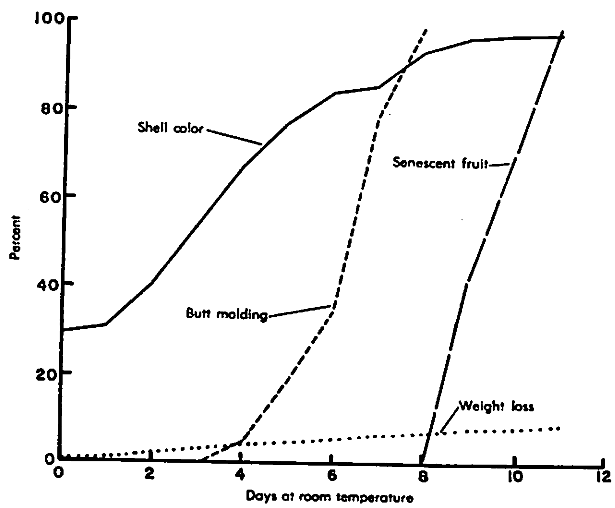

Figure 2. The progress with time of various factors associated with shelf life of pineapples initially stored under 2 percent oxygen at 45 F for 7 days, then stored in room conditions.

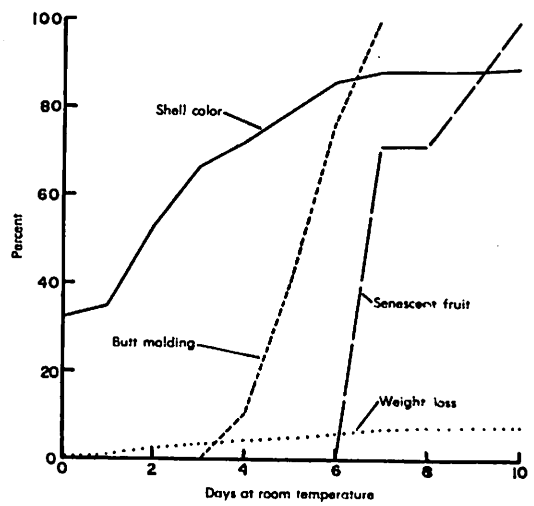

Figure 3. The progress with time of various factors associated with shelf life of pineapples initially stored in air at 45 F for 7 days, then stored in room conditions.

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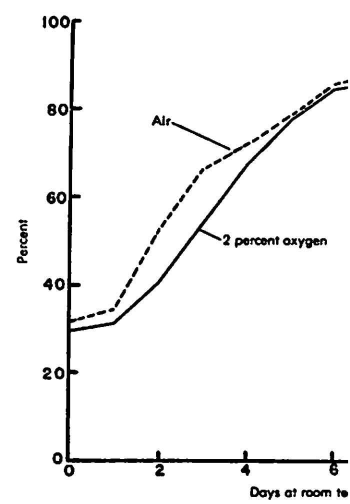

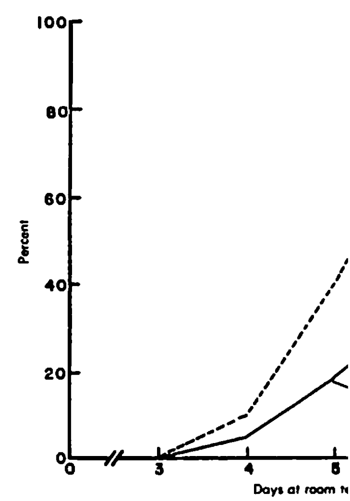

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Figure 2. The progress with time of various factors associated with shelf life of pineapples initially stored under 2 percent oxygen at 45 F for 7 days, then stored in room conditions.

Figure 3. The progress with time of various factors associated with shelf life of pineapples initially stored in air at 45 F for 7 days, then stored in room conditions.

storage in these experiments ranged from 1 to 2.1 days. The results of one experiment are shown in Figures 2 to 7. The original shell color was approximately 14.5 percent, and 14 fruits comprised a treatment. The trend of the parameters during the period in room conditions was similar for the treated and control fruits (Figures 2 and 3). In order to observe more readily the effect of storage treatment, the parameters were individually graphed in Figures 4 to 7. The shell color development was slightly delayed by the 2 percent oxygen level (Figure 4). The extent of molding in the butt area was significantly reduced by CA

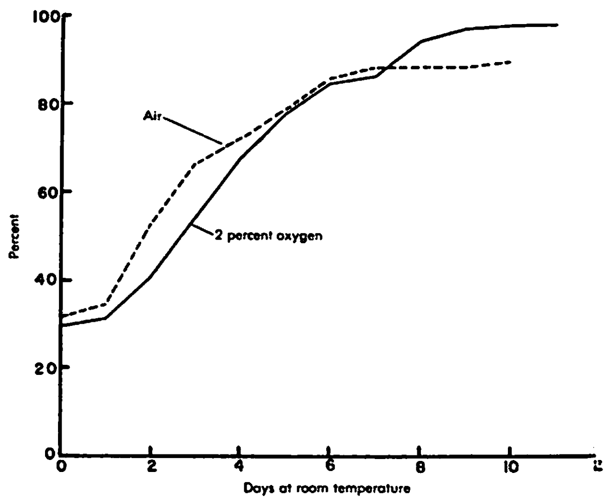

Figure 4. The effect of initial storage under 2 percent oxygen and air at 45 F for 7 days on shell color in pineapples subsequently stored in room conditions.

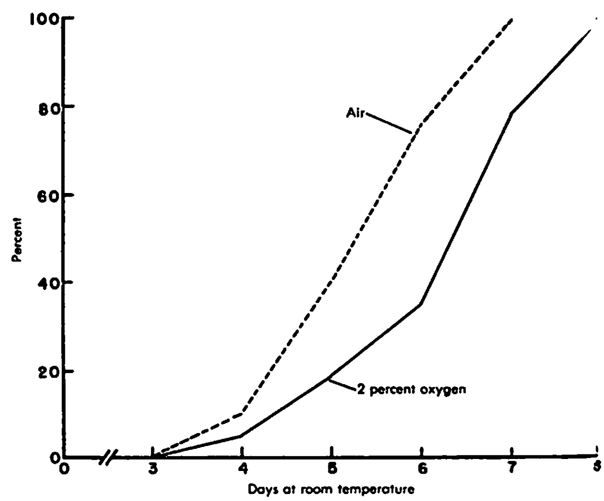

Figure 5. The effect of initial storage under 2 percent oxygen and air at 45 F for 7 days on butt molding in pineapples subsequently stored in room conditions.

storage (Figure 5). There was no significant difference in percent weight loss between fruits initially stored in 2 percent oxygen and those in air (Figure 6). The mean shelf life at room temperature was 8.8 days for CA-stored pineapples and 6.7 days for air-stored fruits, the difference of 2.1 days being significant (P = .05). This is a reflection of the delayed incidence of senescent fruits in CA-stored pineapples (Figure 7).

In a series of four experiments (seven fruits per treatment), pineapples were initially stored under oxygen tensions ranging from 2.5

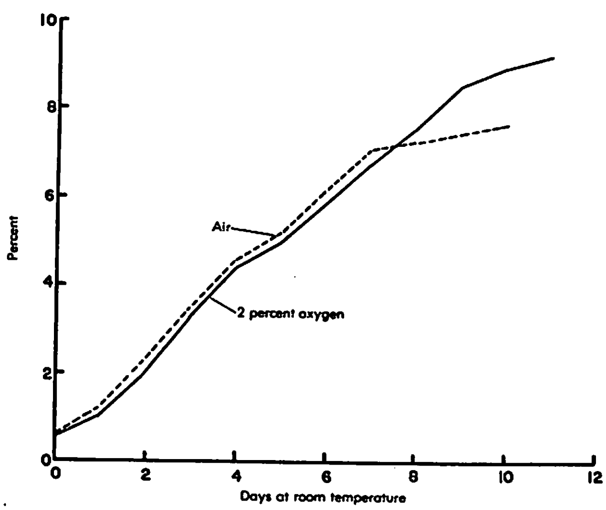

Figure 6. The effect of initial storage under 2 percent oxygen and air at 45 F for 7 days on weight loss in pineapples subsequently stored in room conditions.

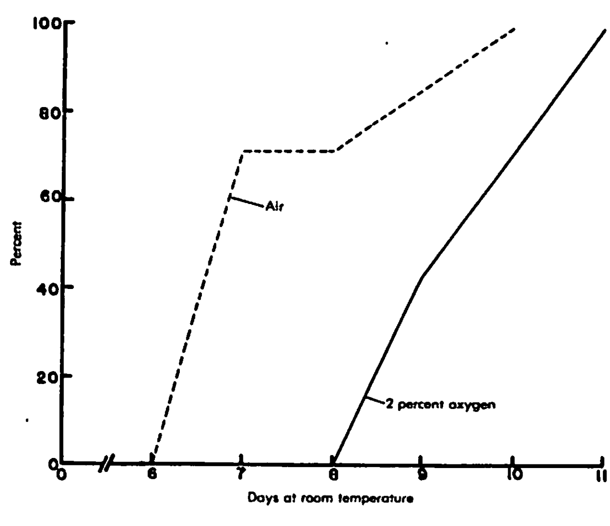

Figure 7. The effect of initial storage under 2 percent oxygen and air at 45 F for 7 days on incidence of senescent fruit in pineapples subsequently stored in room conditions.

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Figure 6. The effect of initial storage under 2 percent oxygen and air at 45 F for 7 days on weight loss in pineapples subsequently stored in room conditions.

Figure 7. The effect of initial storage under 2 percent oxygen and air at 45 F for 7 days on incidence of senescent fruit in pineapples subsequently stored in room conditions.

to 5 percent. Under these conditions, no significant increase in shelf life was attained.

In four additional experiments (seven fruits per treatment), oxygen levels of 0.5 to 1.5 percent were used for initial CA storage. No significant increase in shelf life resulted from initial storage under these very low oxygen tensions. There was a significant decrease in shelf life in the treatment with 0.5 percent oxygen, suggesting the possibility of injury to the fruit.

In these studies, the incidence of "endogenous brown spot" was evident in all treatments in every experiment. However, none of the CA treatments had any significant effect on the number or intensity of the brown spots.

DISCUSSION AND CONCLUSION

The data indicated that the CA storage treatments employed in this investigation had no effect on the fruit crown, fruit weight loss, or decay incidence when pineapples were stored until the senescence stage. CA storage delayed shell color development slightly without affecting the marketability of the fruit. CA storage also improved the appearance of the fruit and hence marketability by reducing the incidence of superficial mold growth on the butt. The incidence of "endogenous brown spot," the symptoms of which are externally invisible, was not affected by CA storage.

Using rate of senescence as the criterion for marketability, the results indicated the possibility of extending the shelf life of fresh pineapples by CA storage. The optimum atmosphere for the extension of shelf life was 2 percent oxygen maintained with a proportionate mixing of air with nitrogen. Shelf life extension with this treatment was 1 to 3 days. Oxygen levels higher than 2 percent were ineffective for shelf life extension and levels below 2 percent were not only ineffective, but also injurious.

The shelf life of fresh Hawaiian pineapples exported to the U.S. mainland may be extended when shipped by surface transportation if storage is in 2 percent oxygen at 45 F. CA storage for the shipment of this commodity merits economic feasibility studies.

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