EFFECTS OF POSTHARVEST TREATMENTS ON THE QUALITY OF TUNA DURING STORAGE.

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INTRODUCTION

The total cultivated area of prickly pear fruits (PPF) in Mexico was 24,806 ha in 1990. Total yield on 18,379 bearing ha. was 153,282 metric tons. The main producing states were Mexico and Zacatecas. They produced 59.7% and 39.3% respectively, contributing about 99% of the national production (SARH, 1992).

Traditionally, PPF are harvested manually. After picking, they are swept with brooms to remove glochids. Fruits are sorted based on size, color, defects and injuries, then packed in wooden crates. Once fruits are packed, they are marketed in different ways; selling the crates on the road sides, to brokers, or wholesale in Mexico City (Corona, 1988; Borrego and Burgos, 1986; Pimienta 1990; Rodriguez-Felix, 1991).

In recent years, prickly pear fruits have been handled in a different way. Fruits are harvested with knives. Spines are eliminated with machines equipped with bristle brushes turning in opposite directions. Fruits without spines are sorted, and manually separated by color, size and injuries. Fruits are packed in wooden crates or cardboard boxes (Borrego and Burgos, 1986; Castillo and Pimienta, 1988; Pimienta, 1990; Rodriguez-Felix, 1991).

Prickly pear fruits are highly perishable and begin to show spotting and rotting 9 days after harvest. Twenty days after being harvested, there is usually about 70-80% loss. This is mainly due to mechanical injury during postharvest handling. Injured fruits are easily infected by microorganisms. Fusarium spp, Alternaria spp. and Chlamydomices spp. were identified as microorganisms causing stem end rot on prickly pear fruits (Guzman, 1982; Borrego and Burgos, 1986; Corona, 1988; Rodriguez-Felix, 1991).

The objective of this paper is to provide results of different postharvest studies during storage of prickly pear fruits. Data reported comes from studies on PPF and nopalitos grown at the University of Sonora's School of Agriculture farms.

MATERIALS AND METHODS

Four storage studies were conducted on prickly pear fruits. In those experiments white prickly pear fruits (Opuntia amyclaea) were obtained from 8-year-old plantings at the School of Agriculture of the University of Sonora, Hermosillo, Sonora, Mexico. Fruits with 70-90% green-yellowish color skin were randomly harvested during the morning. The picking was done manually with knives (removing a small piece of cladode). To remove glochids (spines), the fruits were spread on a lawn and swept with soft bristle brushes. Afterwards, fruits were sorted for color and size uniformity and for absence of defects. On the same day, fruits were transported to the laboratory.

First Experiment. Fruits were harvested on August 24, 1987 (late season fruit). Fruits without spines were washed with chlorinated water, dried, sprayed with Candelilla wax (CONAZA, C-9 formula), wrapped with paper and packed in boxes. The experiment consisted of 3 lots: 1) Control (fruit with glochids), 2) fruit without glochids, and 3) waxed fruit (without glochids and waxed). Each lot contained 192 fruits. They were stored at 3 different conditions: A) 20° C (60-70% RH) for 18 days, B) 5° C (85-90% RH) for 15 days, and C) 5° C (85-90% RH) for 30 days. Following storage at 5° C, the fruits were transferred to 20° C (60-70% RH) for 18 days. Every 3 days at 20° C, chilling injury and decay were visually evaluated.

A randomized complete block design with 9 treatments was used. Treatments were arranged into a factorial structure with 3 factors: a) presentation (fruits with and without glochids), b) wax (treated and non-treated fruits), c) storage periods at 5° C (0, 15 and 30 days).

Second Experiment. Fruits were harvested on July, 1988 (early season fruit). Fruits without spines were washed with chlorinated water, and dried. Candelilla wax (CONAZA, C-9 formula) was applied by immersing the fruits for 2 minutes in the wax emulsion. A combination of fungicides (benlate 0.2% w/v plus ridomil 0.1% w/v) was applied by inmersing the fruits. Fruits were wrapped with paper and packed in boxes. The experiment consisted of 5 lots: 1) Control (fruit with glochids), 2) fruit without glochids, 3) fruit without glochids and waxed, 4) fruit without glochids and with fungicides, and 5) fruit without glochids, waxed and with fungicides. Each lot contained 128 fruits. They were stored at 2 different conditions: A) 20° C (60-70% R.H.) for 18 days, and B) 5° C (85-90% R.H.) for 15 days. Following storage at 5° C fruits were transferred to 20° C (60-70% R.H.) for 18 days. Every 3 days at 20° C, chilling injury, weight loss and decay were evaluated.

A randomized complete block design with 10 treatment was used. Treatments were arranged into a factorial structure with 4 factors: 1) presentation (fruits with and without glochids), 2) wax (treated and non-treated fruits), 3) fungicide (treated and non-treated fruits), and 4) storage days at 5° C (0 and 15 days).

Third experiment. Fruits were harvested on August 24, 1988. Fruit without spines were wrapped with paper and packed in boxes. They were stored at 2 different conditions: A) 20° C (60-70% R.H.) for 18 days, B) 5° C (85-90% R.H.) for 20 days, and C) 5° C (85-90% R.H.) for 32 days. Following storage at 5° C, fruits were transferred to 20° C (60-70% R.H.) for 18 days. Every 3 days at 20° C, chilling injury, weight loss and decay were evaluated.

A randomized complete block design with 3 treatments (0, 20 and 32 days at 5° C) was used.

Fourth Experiment. Fruits were harvested on July, 1988 (early season fruit). Fruits without spines were washed with chlorinated water, and dried. Candelilla wax

(CONAZA, C-9 formula) was applied by inmersing the fruits for 2 minutes in the wax emulsion. A combination of fungicides (benlate 0.2% w/v plus ridomil 0.1% w/v) was applied by inmersing the fruits. Fruits were packaged in low density polyethylene (LDPE) bags (5 fruits/bag). LDPE films used had a thickness of 0.03 mm, and their permeabilities were 3.31 g $H_2O/m^2 \cdot day \cdot atm.$ and 17,094 cc $O_2/m^2 \cdot day \cdot atm.$ Non-packaged fruits were wrapped with paper and packed in boxes. The experiment consisted of 4 lots: 1) Control (non packaged fruits), 2) Waxed fruit (fruit without glochids, 3) Packaged fruits (fruit without glochids and packaged in LDPE bags), 4) Waxed and packaged fruits. They were stored at 2 different conditions: A) 20° C (60-70% R.H.) for 18 days, and B) 5° C (85-90% R.H.) for 15 days. Following storage at 5° C fruits were transferred to 20° C (60-70% R.H.) for 18 days. Every 3 days at 20° C, chilling injury, weight loss and decay were evaluated.

A randomized complete block design with 8 treatment was used. Treatments were arranged into a factorial structure with 3 factors: a) presentation (packaged and non-packaged fruits), b) wax (treated and non-treated fruits), and c) storage days at 5° C (0 and 15 days).

All of the statistical analysis were made using Statistical Analysis System (SAS Institute, 1985).

RESULTS AND DISCUSSION

PPF are sensitive to chilling injury. Chavez-Franco and Saucedo-Veloz (1985) reported chilling injury (CI) in 'Tuna Blanca' stored below 10° C. Figure 1 shows the percent chilling injury in late-season PPF stored at 5° C (85-90% RH) for 15 and 30 days. After these periods, fruits were transferred to 20° C. On the day of the harvest, temperature was 28.5° C. This factor has been related with fruit susceptibility to chilling injury (Saltveit and Cabrera, 1987). Chilling injury on PPF with or without glochids was similar. Wardowski et al. (1973) reported that waxing reduces chilling injury on grapefruit stored at 4.5° C for 7 weeks. However, Candelilla wax (CONAZA, C-9 formula) did not minimize chilling injury on PPF. CI on fruits stored for 15 days at 5° C was observed after 9 days at 20° C. CI was higher in fruits stored for 30 days at 5°C than in PPF stored for 15 days at 5° C.

Decay, a significant problem during storage of PPF, is illustrated in Figure 2. Fruits stored for 0 days at 5° C (directly at 20° C) began to decay after 9 days. Whereas fruits stored for 15 days at 5° C started to rot after 3 days at 20° C, and fruits stored for 30 days at 5° C started rotting after 0 days at 20° C. PPF storage at low temperature (5° C) increased fruit rotting. The removal of glochids did not increase decay. Estrella (1977) studied different types of waxes (TAG, Flavor Seal, Candelilla and DECCO-31) and reported that Candelilla wax (unknown formula) gave the best results in reducing weight loss and decay on PPF. In our experiment waxed fruit showed similar decay to non-waxed fruits.

In 1988, a second storage experiment was conducted with early season PPF. Fruits were stored at 5° C for 15 days. But, in this year we did not observe CI, as it was observed in late season PPF stored in the same conditions in 1987. Mean temperature on harvest day was 28.0° C, which was similar to the one observed during the previous year.

A combination of fungicides (benlate 0.2% w/v plus ridomil 0.1% w/v) was applied by immersing the fruits. Figure 3 shows the % decay of PPF. Neither waxing nor fungicides reduced fruit decay. Stem-end rot was the cause of decay. Nevertheless, fruits were carefully harvested with knives and no visible injury was observed.

Weight loss, mostly as water loss, is illustrated in Figure 4. Weight loss increased during storage at 20° C. PPF stored at 5° C for 15 days had a higher weight loss than fruits stored directly at 20° C (up to 7.7%). However, fruit wilting, which affects visual appearance, was not observed.

PPF with spines lost less weight than PPF without spines, when they were stored directly at 20° C, but it is not practical to market fruit with spines. This behavior was not observed during the storage at 5° C for 15 days, because of the natural loosening of spines during storage.

In 1988, a second harvest was performed at the end of the season (late-season fruit). Fruits were stored at 5° C. CI developed on fruits without spines stored at 5° C for 20 and 32 days (Figure 5). Late-season PPF were more susceptible to chilling injury than early season PPF.

Fruits stored at 5° C for various periods (0, 20 and 32 days) had similar weight losses during storage at 20° C (Figure 6). Weight loss of PPF was lower than 4.8% and did not affect fruit appearance.

Decay on late-season PPF is illustrated in Figure 7. Fruits stored directly at 20° C (0 days at 5° C) showed a low decay percentage. This value is similar to % decay of late-season PPF of the previous year (1987) and early-season PPF stored at the same conditions. Fruits stored at 5° C had higher % decay than fruits stored directly at 20° C.

Packaging of fruits in polyethylene bags (which creates and maintains a modified atmosphere around the commodity) is a postharvest technique. It has been used in combination with others, such as cooling, to reduce decay, and to extend the storage life of several horticultural crops (Kader et al., 1992; Scott and Chaplin, 1978; Wardowski et al., 1973; Chaplin and Hawson, 1981).

In-package O_2, CO_2 and ethylene concentrations are illustrated in Figure 8. In-package O_2 concentration declined during storage, and although it varied some, it was below 13% for the storage period. In-package CO_2 concentration accumulated up to 8% after 9 days, and subsequently declined to about 2%. In-package ethylene content slowly increased up to approximately 1.5 ppm.

Percentage decay on packaged prickly pear fruits was higher than percentage decay on non-packaged PPF (Figure 9). Stem-end rot was the main cause of fruit decay, even though fruits were carefully harvested with knives and without visible injuries. The higher decay incidence observed in packaged fruit could be attributed to water condensation inside the package, or to an inadequate modified atmosphere created inside the package (oxygen levels above 5% and CO_2 levels under 8% during the storage), or to the number of fruits per bag.

SUMMARY

- The removal of glochids (spines) did not increase decay on prickly pear fruits.
- Late season prickly pear fruits developed chilling injury after storage at 5 °C for 15 days.
- Candelilla wax (CONAZA, C-9 formula) reduced weight loss. However, it did not reduce neither decay nor chilling injury on prickly pear fruit.
- Fungicides (benlate 0.2% w/v plus ridomil 0.1% w/v) did not reduce fruit decay.
- Late season prickly pear fruits were more susceptible to chilling injury than early season prickly pear fruits.
- Weight losses on fruits were under 7.7% and did not affect fruit appearance.
- Packaging of prickly pear fruits on LDPE bags increased decay.

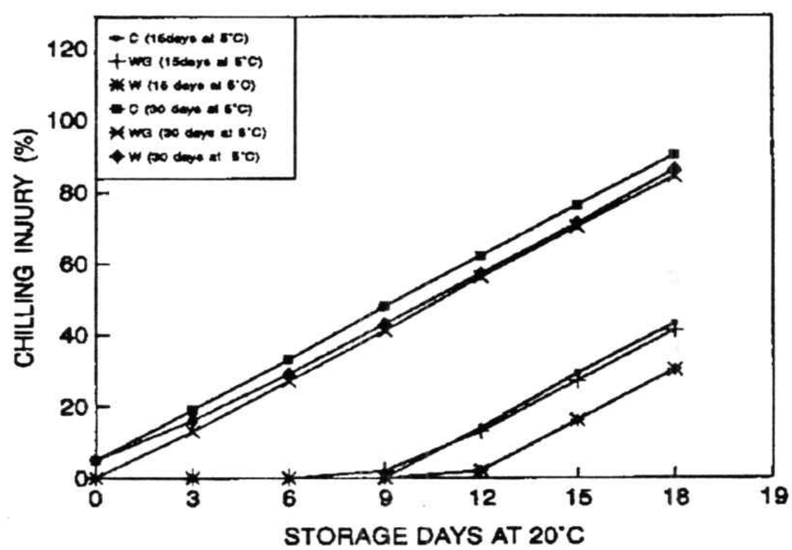

Figure 1. Chilling injury development on prickly pear fruit (<u>Opuntia amyclaea</u>, T.) harvested in August, 1987, and stored at 5° C for 15 and 30 days. (C) control, (WG) without glochids (W) waxed.

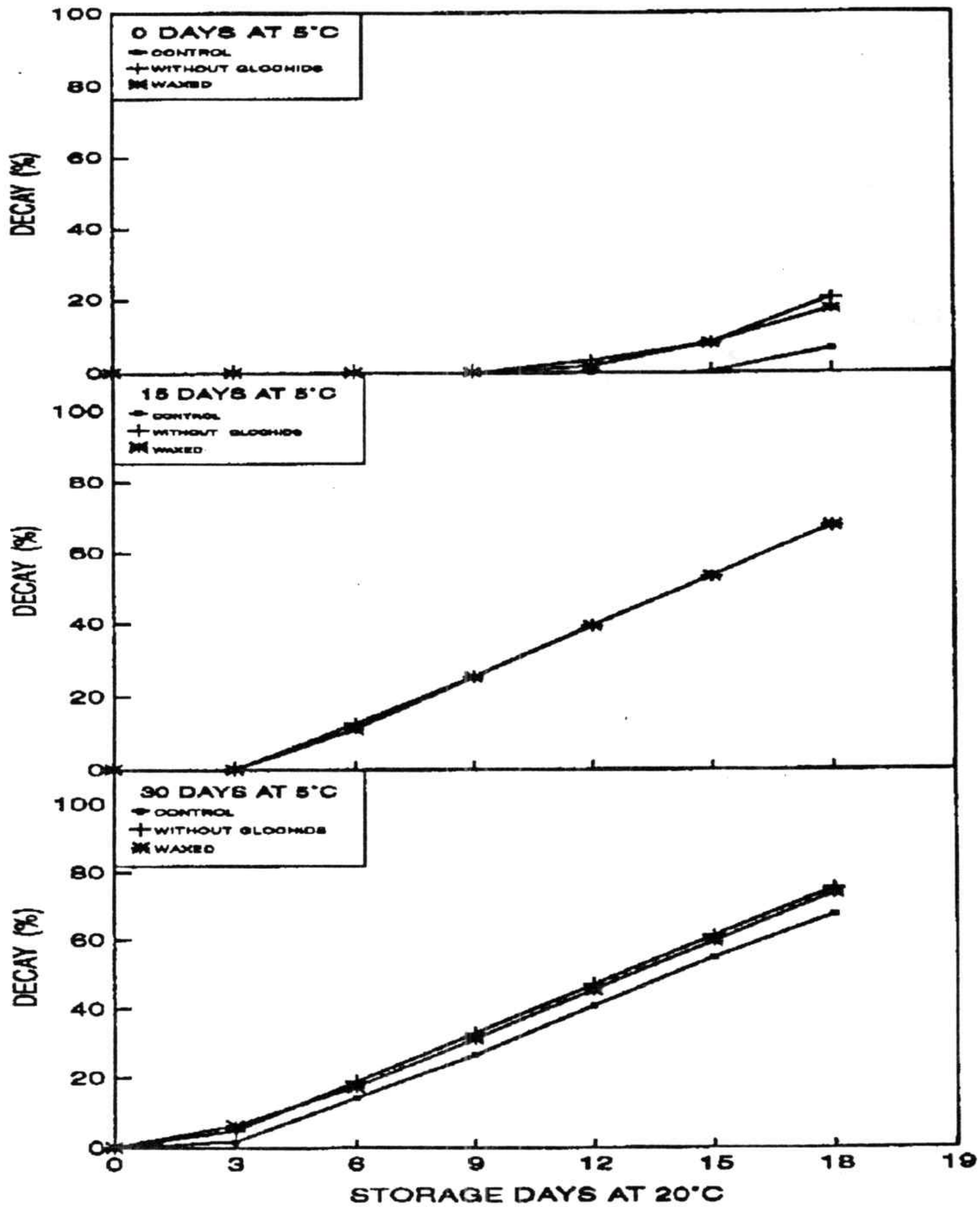

Figure 2. Decay incidence on prickly pear fruit (Opuntia amyclaea, T.) harvested in August, 1987, and stored at 5° C for (A) 0 days, (B) 15 days and (C) 30 days.

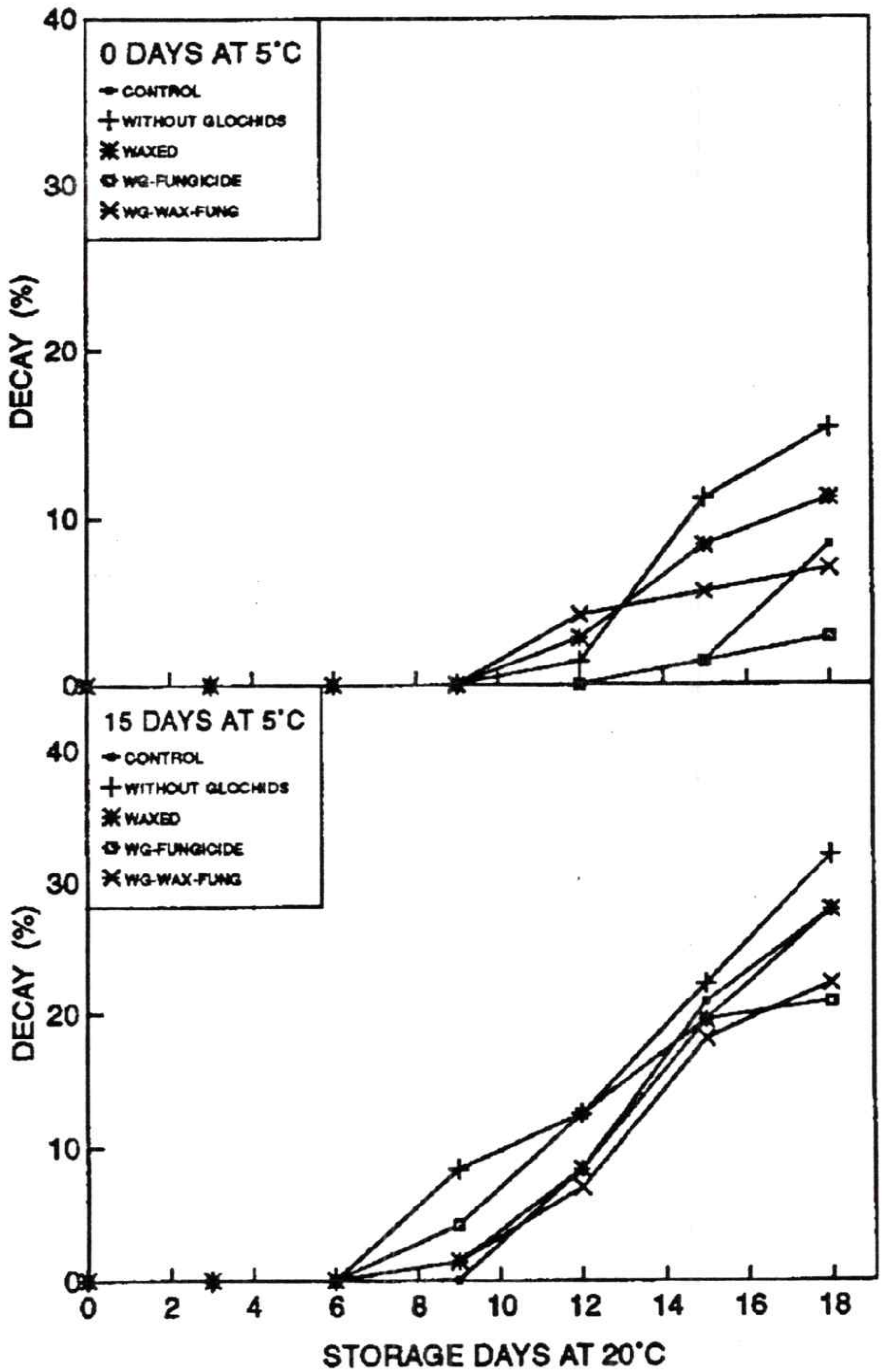

Figure 3. Decay incidence on prickly pear fruit (Opuntia amyclaea, T.) harvested in July, 1988, and stored at 5° C for 0 and 15 days. (WG) without glochids, (WG-WAX-FUNG) without glochids, waxed and with fungicide.

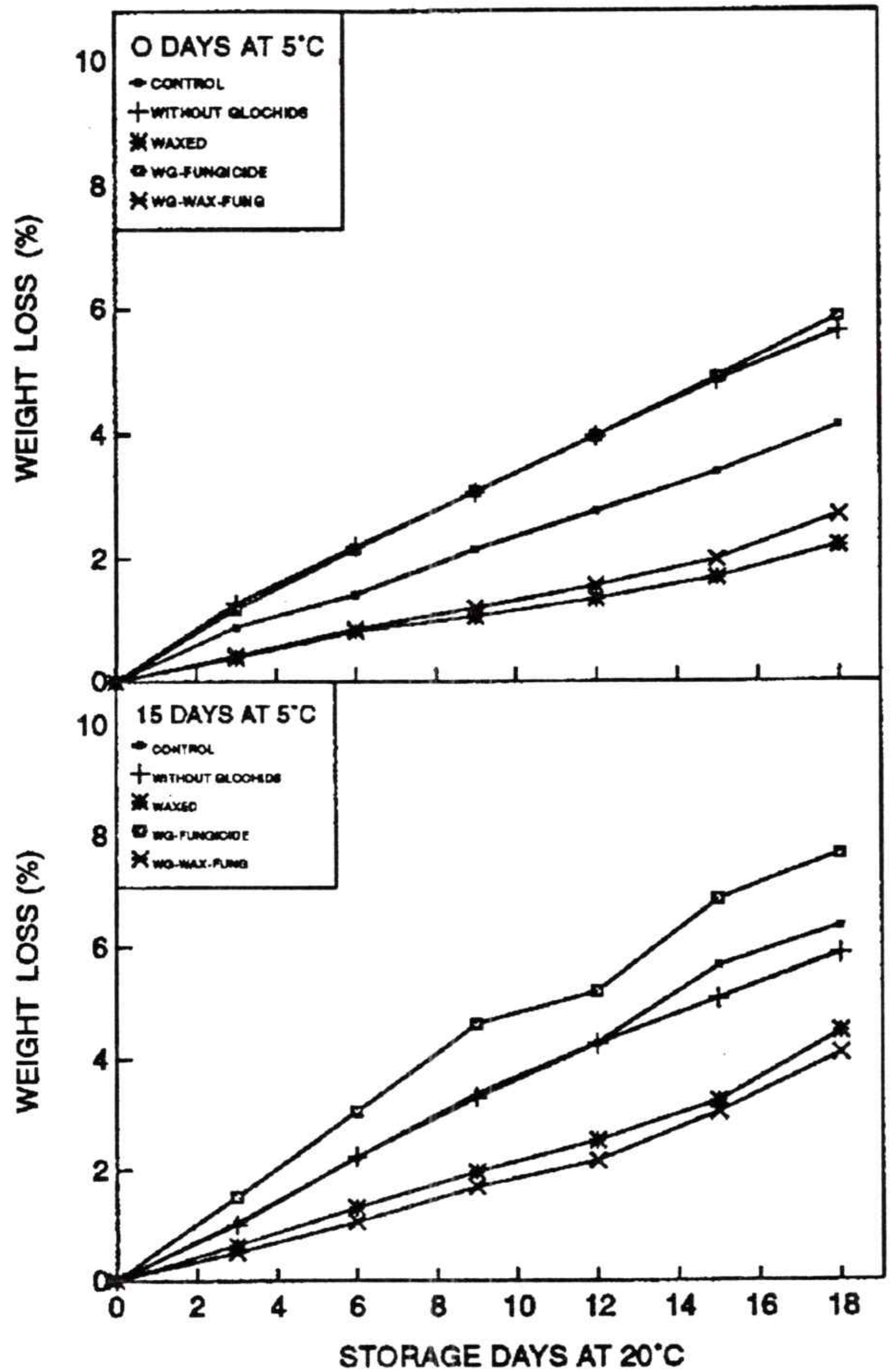

Figure 4. Weight loss of prickly pear fruit (Opuntia amyclaea, T.) harvested in July, 1988, and stored at 5° C for 0 and 15 days. (WG-FUNGICIDE) without glochids and with fungicide (WG-WAX-FUNG) without glochids, waxed and with fungicide.

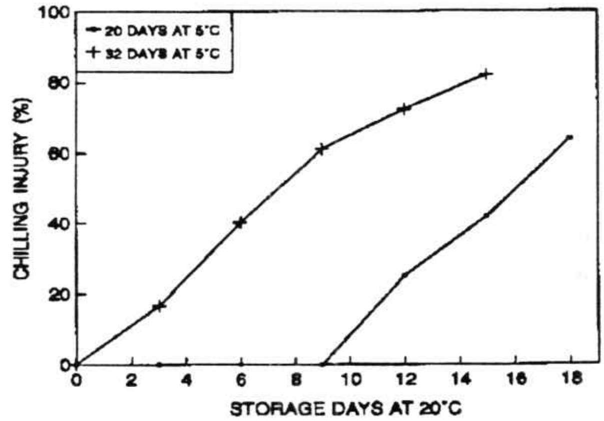

Figure 5. Chilling injury development on prickly pear fruit (Opuntia amyclaea, T.) harvested in August, 1988, and stored at 5° C for 20 and 32 days.

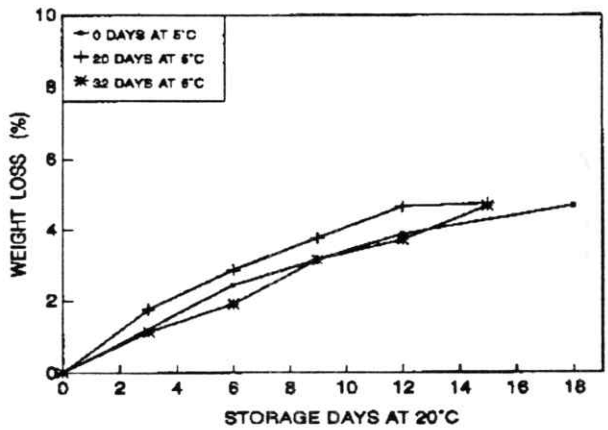

Figure 6. Weight loss of prickly pear fruit (Opuntia amyclaea, T.) harvested in August, 1988 and stored at 5° C for 20 and 32 days.

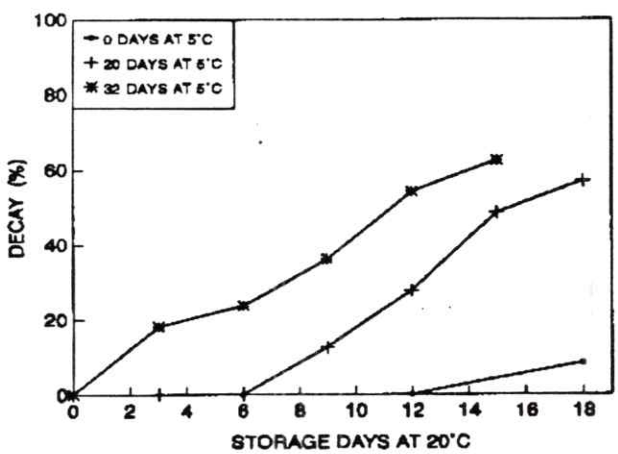

Figure 7. Decay incidence on prickly pear fruit (Opuntia amyclaea, T.) harvested in August, 1988, and stored at 5° C for 20 and 32 days.

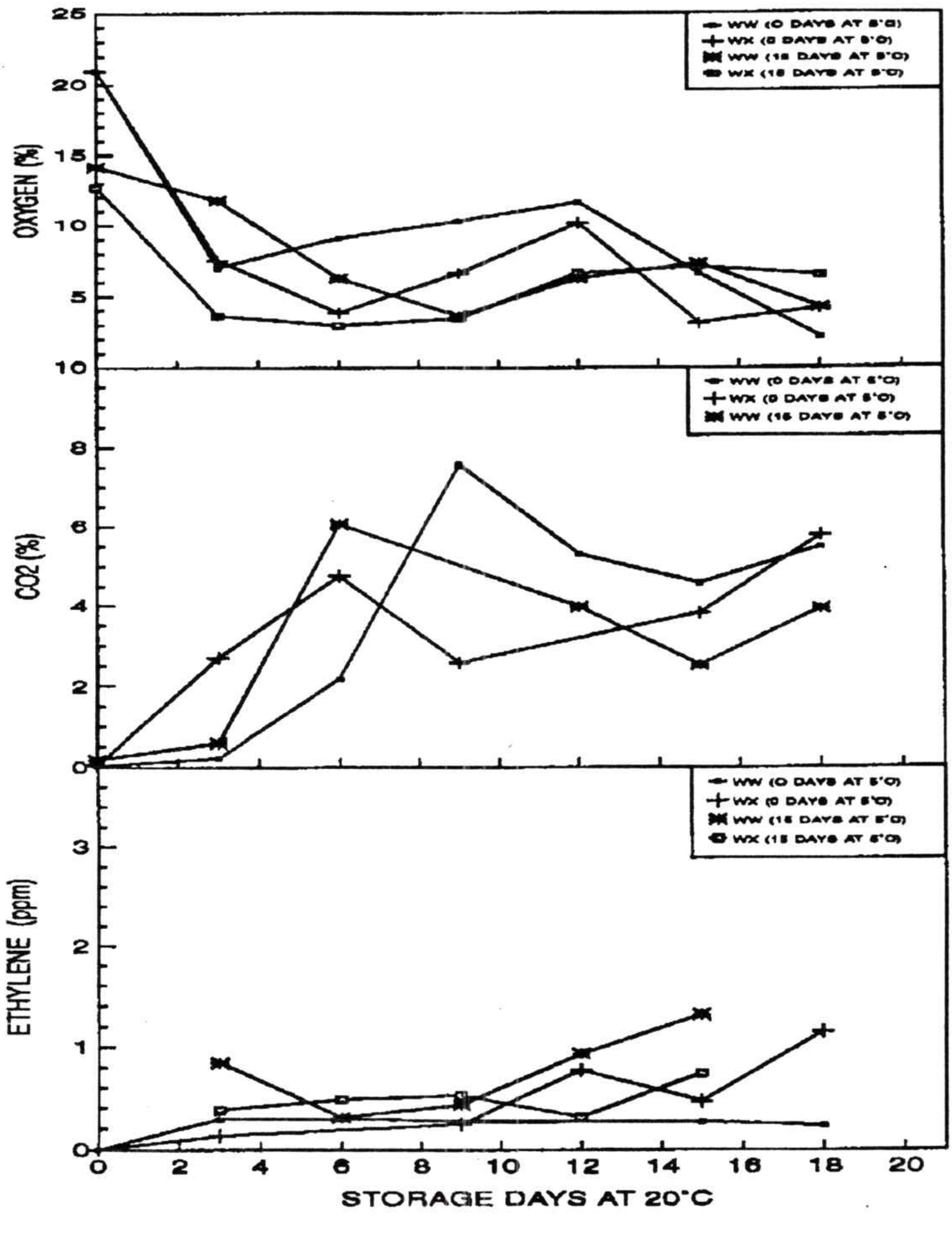

Figure 8. In package 0_2, CO_2 and C_2H_4 contents of MAP prickly pear (Opuntia amyclaea, T.) harvested in July, 1988, and stored at 5°C for 0 and 15 days. (WW) without glochids, (WX) waxed.

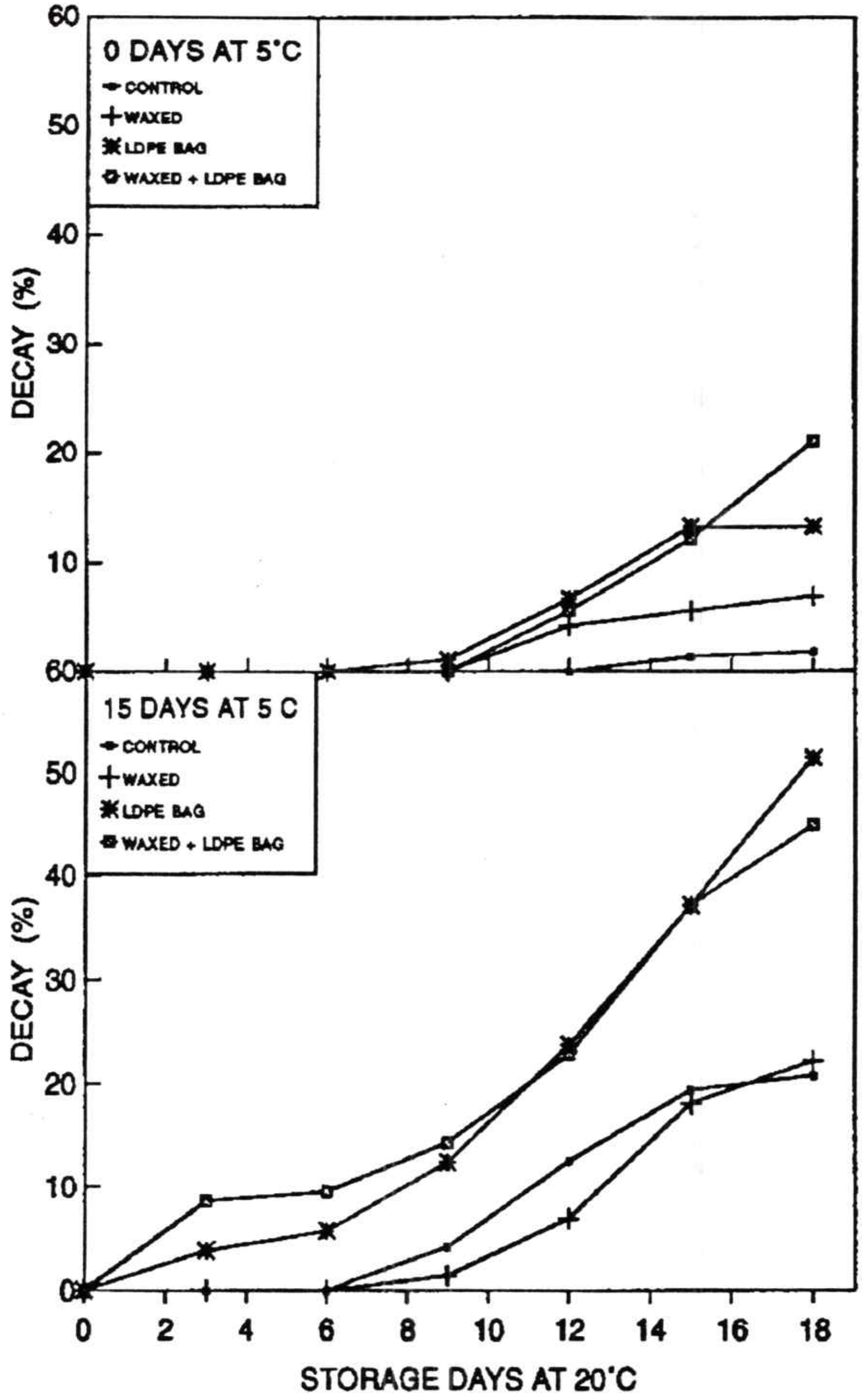

Figure 9. Decay incidence on prickly pear fruit (Opuntia amyclaea, T.) packed in low density polyethylene (LDPE) bags, harvested in July, 1988, and stored at 5° C for 0 and 15 days.

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