# Intermittent Warming of Peaches and Nectarines Stored in a Controlled Atmosphere or Air[1]

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*Abstract*. Three peach [*Prunus persica* (L.) Batsch.] and one nectarine [*P. persica* var. *Nectarina* (Ait.) Maxim.] cultivars were stored in a controlled atmosphere (CA) or air at 0°C for 9 weeks. At 3- or 6-weeks intervals fruits from certain of these storage atmospheres were shifted to air at 18.3°C for 2 days and then returned to CA or air at 0°C. Fruits stored in CA retained better quality and had lower respiration rates than those stored in air. Within a given storage atmosphere fruit quality was often even better and respiration (of CA stored fruit) usually was further reduced when the temperature had been raised to 18.3° for 2 days during the 0° storage. Skin browning frequently developed during ripening at 18.3°. This disorder and decay remain serious problems for successful long-term storage.

Peaches and nectarines are extremely perishable and do not lend themselves to prolonged cold storage. At 0°C the storage life of most cultivars is 2 to 3 weeks. If held too long at or near 0° they are subject to chilling injury. Fruit so injured may appear normal when removed from cold storage, but do not ripen satisfactorily at high temp. They develop physiological or internal breakdown in which the flesh becomes dry and mealy or woolly (3). In more advanced stages the flesh may become badly discolored with a watery transluscent breakdown around the stone. Delayed storage (3, 4, 6, 7, 8), intermittent warming (2, 8), and controlled atmosphere (CA) storage (1) have been reported to reduce or delay development of this disorder.

Our purpose was to determine whether intermittent warming of peaches and nectarines while in CA or air storage would further reduce or delay internal breakdown and so increase the marketable life of the fruit.

## Materials and Methods

'Loring', 'Blake', and 'Rio Oso Gem' peaches and 'Regal Grand' nectarines were obtained on the day of harvest from commercial orchards in Maryland or Pennsylvania. They were brought to Beltsville and 40- to 50-fruit lots of each cultivar were randomized for 9 weeks storage under each of 12 storage conditions in either CA (1% $O_2$ & 5% $CO_2$) or air at 0°C. At 3- or 6-week intervals certain lots of fruits were shifted to air at 18.3° for 2 days and then returned to CA or air at 0°. All fruit were held a combined total of 7 days in air at 18.3°, either during or after storage, to provide equal times at ripening temp before final quality evaluations were made.

At harvest, fruit firmness ranged from 3.9 kg (8.5 lb.) to 7.7 kg (16.9 lb.), respiration rate from 48.8 to 56.0 mg $CO_2$/kg-hr and acidity (as malic acid) from 613 to 956 mg/100 ml. Respiration was measured over a 2 day period in air at 18.3°C after allowing the fruit to equilibrate in temp 1 day following harvest (1). Acidity was measured on fruits used for firmness measurements (1).

All fruit were in their respective test atmospheres of CA or air at 0°C within 3 days of harvest. Stainless steel chambers 218 l, Fig. 1 or metal drums 114 l, Fig. 2 were used as test chambers. The desired CA (1% $O_2$ + 5% $CO_2$) was obtained initially by flushing the sealed chambers containing the fruit with $N_2$ and adding $CO_2$. Air flow through the chambers was adjusted to provide the $O_2$ required for respiration and a flow of $N_2$ from a cylinder was used to adjust the $CO_2$ concentration when necessary. Flow rates varied from about 0.5 to 10 l per hr. The gas concn were monitored with an Orsat analyzer. The CA averaged 1.2% $O_2$ & 5.4% $CO_2$ during the test.

All fruit samples were dipped before storage in a suspension of benomyl (methyl-1-(butylcarbamoyl)-2-benzimidazole carbamate), at 100 ppm at 46°C for 2½ min., to reduce decay development (9).

The 4 warm-up treatments tested in the 3 atm were: no warm-up, warm-up after 3 weeks, after 6 weeks, and after both 3 and 6 weeks. The 3 atm were: CA, air, and a combination of CA and air. Quality and respiration of fruit from the combination CA and air treatments were intermediate between those of fruit stored in CA or in air for the entire test period. Only data from treatments where all storage was in CA or in air are reported.

Fruit respiration rates were measured on duplicate samples of 5 fruit over a 2 day period in air at 18.3°C after storage (1).

Internal appearance of the fruit was rated on a 10-fruit subsample; fruits were cut in half crosswise to the suture. A scale of 5 to 1 was used with 5 excellent and 1 very poor. A total score was obtained for each lot of fruit by multiplying the number of fruits in each class by the numerical rating, adding these numbers and multiplying by 2 so that 10 fruit with no internal disorder would have an internal appearance rating of 100. Acidity (as malic acid) was determined on fruit used to evaluate internal condition (1).

Cultivars were treated as replicates and data were processed by analysis of variance and the means compared by Duncan's multiple range test (5).

## Results and Discussion

Respiration rates of peaches and nectarines from CA were significantly lower than from air storage (Table 1). Intermittent warming tended to further reduce the respiration rate. The reduction was significant only between the non-warmed and warmed CA fruit.

Titratable acidity of peaches and nectarines from CA was significantly higher than from air storage (Table 2). Intermittent warming showed a trend toward increasing the acidity but the differences were not significant.

The internal appearance of peaches and nectarines (Fig. 3) from CA was rated significantly higher (better) than from air storage (Table 3). All intermittent warming treatments improved this rating significantly for air-stored fruit whereas only the 3 and 6 weeks warming treatment significantly improved the internal appearance rating of CA fruit.

A formal taste panel evaluation was not conducted but flavor was evaluated by the authors when the internal appearance was rated. Those ratings indicated that fruit with an internal appearance rating of 70 or higher had acceptable flavor. Fruit with higher appearance ratings usually had better flavor.

Decay was partially controlled but not eliminated by the benomyl dip. Decay averaged 7.3 to 22.8%, but there were no significant differences due to storage treatment. Brown rot caused by *Monilinia fructicola* was the principle decay organism but others were also

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Fig. 1. CA storage tests with peaches in stainless steel chambers.

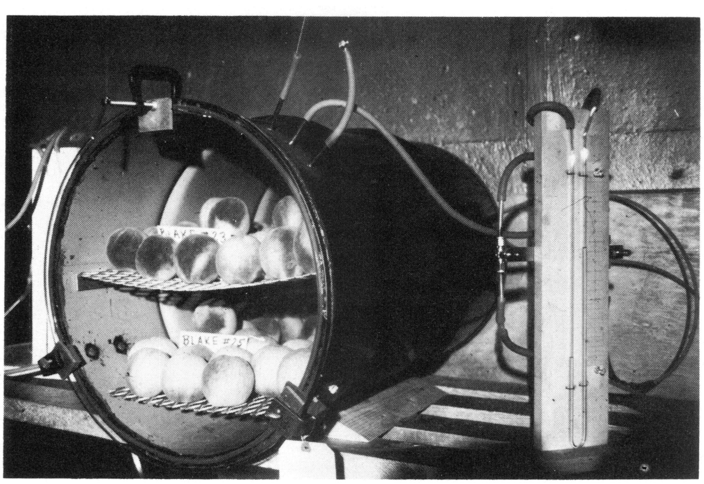

Fig. 2. CA storage tests with peaches in metal drum.

present. These included *Botrytis*, *Alternaria*, *Penicillium*, and yeast species.

Skin injury was a second serious problem on peaches and nectarines. The injury varied with cultivars both in kind and degree. In 'Loring' and 'Blake' it appeared as a reticulated brown pattern on the

Table 1. Respiration rates of peaches and nectarines in air at 18.3°C after 9 weeks storage with or without intermittent warming.[z]

| Warm-up period (2 days in air at 18.3°C) | Storage atmosphere at 0°C | | Average |
|---|---|---|---|
| | CA | Air | |
| | ($mg\ CO_2/kg\text{-}hr$) | | |
| None | 53 b | 60 c | 57 b |
| After 3 weeks | 47 a | 61 c | 54 ab |
| After 6 weeks | 45 a | 57 bc | 51 ab |
| After 3 & 6 weeks | 44 a | 54 bc | 49 a |
| Atmosphere average | 47 a | 58 b | — |

[z] Mean separation by Duncan's multiple range test, 5% level.

Table 2. Titratable acidity of peaches and nectarines after 9 weeks storage with or without intermittent warming.[z]

| Warm-up period (2 days in air at 18.3°C) | Storage atmosphere at 0°C[y] | | Average |
|---|---|---|---|
| | CA | Air | |
| | (mg/100 g) | | |
| None | 589 a | 319 b | 454 a |
| After 3 weeks | 546 a | 364 b | 455 a |
| After 6 weeks | 584 a | 417 b | 501 a |
| After 3 & 6 weeks | 629 a | 424 b | 527 a |
| Atmosphere average | 587 a | 381 b | — |

[z] Acidity was measured after a total of 7 days ripening in air at 18.3°C during the warm-up treatments or after storage.
[y] Mean separation by Duncan's multiple range test, 5% level.

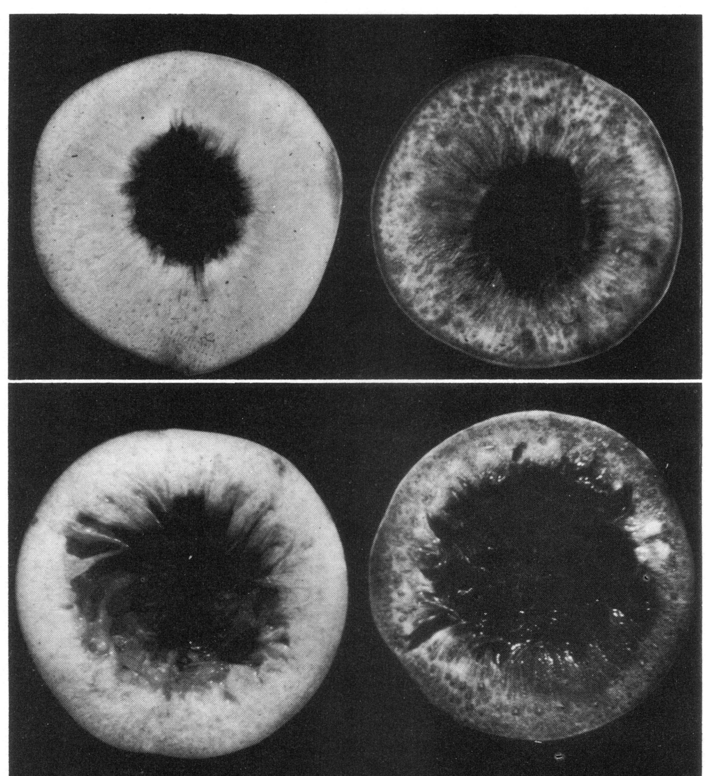

Fig. 3. 'Blake' peaches (top) and 'Regal Grand' nectarines (bottom) after 9 weeks storage at 0°C plus ripening in air at 18.3°C (CA-left, air-right).

Table 3. Internal appearance of peaches and nectarines after 9 weeks storage with or without intermittent warming.[z]

| Warm-up period (2 days in air at 18.3°C) | Storage atmosphere at 0°C[y] CA | Air | Average |
|---|---|---|---|
| | (rating) | | |
| None | 78 b | 22 d | 50 b |
| After 3 weeks | 84 ab | 43 c | 64 ab |
| After 6 weeks | 89 ab | 43 c | 66 ab |
| After 3 & 6 weeks | 98 a | 72 b | 85 a |
| Atmosphere average | 87 a | 45 b | — |

[z] Ratings (100 = excellent) were made after a total of 7 days ripening in air at 18.3°C during the warm-up treatments or after storage.
[y] Mean separation by Duncan's multiple range test, 5% level.

skin along with some skin cracking. The injury appeared as a brown spotting in 'Rio Oso Gem' and 'Regal Grand' but it was not as severe in either of these as in 'Loring' and 'Blake'. In all cultivars skin injury was absent in air-stored fruit that were not warmed. All air-stored fruit, however, had a dull appearance probably due to internal breakdown. These injuries did not occur on the non-warmed peaches stored in CA but they did occur on nectarines. The cause of the skin injuries was not determined, but, since it was absent in the unwarmed peaches from CA or air, it may have been due to extra handling and moisture condensation that occurred when they were shifted during warm-up. Gradual warming and less handling might help solve this problem.

If control of decay and skin injury can be improved CA storage with intermittent warming should be better for peaches and nectarines than continous 0°C storage in CA or in air.

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# Tire Fabric Waste as Mulch for Fruit Trees


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*Abstract*. The fabric portion of used tires was evaluated and compared with hay as a mulching material for fruit trees. Results indicated that fabric and old hay produced similar effects on soil moisture, soil temperature, soil density and penetration, and weed and tree growth. The fabric in contrast with old hay was more attractive to mice and slowed spring bud break. Tire fabric does not contribute significant amounts of plant nutrients to the soil, nor does it contain any toxic elements.


The beneficial effects of mulching on fruit trees has been well documented. Hay, straw, manure, sawdust, seaweed, paper, polythene and other organic and inorganic materials as mulches have been the subjects of experimentation (3, 4, 7, 14, 16). The chief benefits of mulching derive from increased soil moisture and a decrease in soil temperature fluctuations. The soil structure beneath a mulch improves and, in some cases, the decomposition of the mulch adds plant nutrients to the soil (6). In this study the fabric portion of used tire carcasses from which the reclaimable rubber had been separated was tested as a mulch for apple, peach and cherry trees and its several possible effects were examined. The purposes of this study were to explore the feasibility of using the fabric waste as a source of mulch material for orchards, and incidentally to seek a partial solution to the problem of waste disposal.

## Materials and Methods

Experiments were initiated in the University orchard during the fall of 1972 involving 108 five-year old 'McIntosh' apple trees (54 on MM106 and 54 on M.7 rootstocks); 36 three-year old 'McIntosh' apple trees on M.9; and 84 three-year old peach trees. In addition, 36 mature apple trees, randomly selected, were treated in a commercial orchard, Milton, Ontario. Old hay mulch was included for comparison with tire fabric and both treatments were compared with the non-mulched control. Each tree was considered as an experimental unit in randomized blocks with differing numbers of replications in each case. The mulch was 15 cm deep and extended out from the trunks for a radius of about 75 cm. None of the trees in the experiments had been mulched previously.

*Fabric waste properties*. Tire fabric waste was analyzed for rubber content, carbon black, various organic compounds, heavy metals and essential plant nutrients to determine its possible detrimental or beneficial contribution to the soil environment. These analyses were conducted by an independent laboratory through the co-operation of Uniroyal Ltd., Elmira, Ontario.


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