COMBINING CA STORAGE WITH INTERMITTENT WARMING

EXTENDS THE STORAGE LIFE OF PEACHES AND NECTARINES

STABY

R. E. Anderson, R. W. Penney, and W. L. Smith, Jr.
ARS, U.S. Department of Agriculture, BARC-West
Beltsville, Maryland 20705

ANDERSON '77

Peach quality deteriorates with time in storage. One of the principal manifestations of this deterioration is internal breakdown, a serious physiological disorder which ultimately terminates the market life of peaches and nectarines. Most peach and nectarine cultivars can be stored 2 to 4 weeks at 0°C but only for about a week at 5° (6). With longer storage at either temperature internal breakdown often occurs. This type of breakdown is considered to be a form of chilling or low temperature injury and usually is not apparent until fruit so injured are transferred to higher temperature for ripening. Even after ripening, injured fruit may appear normal externally and only show breakdown symptoms when they are cut open. This form of chilling injury occurs more rapidly at 5° than at 2.5° and more rapidly at 2.5° than at 0° (6).

Various methods have been tested to reduce breakdown and prolong the storage life of peaches and nectarines. CA storage is one such method. In our tests, some results of which were reported at the previous CA conference here at Michigan State, we found that a CA of 1% O_2 + 5% CO_2 at 0°C delayed the development of internal breakdown and maintained fruit quality of some peach and nectarine cultivars 2 to 3 times longer than air storage at 0°C (1,2). In recent years a number of other investigators have reported the results of their studies on the CA storage of peaches and nectarines. Several (7,9,10) but not all (13) of these investigators reported CA to be more favorable than air for storing these fruits.

Another method of delaying breakdown of peaches and nectarines is to warm the fruit periodically during storage or intermittent warming (IW) (3,5). In this warming treatment the fruit are usually warmed at room temperature (18-20°C) for 1 to 3 days at intervals of 1 to 4 weeks during storage at 0°. After warming, the fruit are returned to 0°. Warming appears to be the simplest method, thus far tested, for reducing internal breakdown.

Since both CA storage and intermittent warming delay breakdown, we combined CA (1% O_2, 5% CO_2) with IW. Fruit were stored at 0°C in either CA or air; and at intervals of 3 and 6 weeks, samples of CA- and air-stored fruit were warmed and returned to 0°C. After 9 weeks at 0° the fruit were transferred to about 18-20° till ripe and then evaluated for internal breakdown. The fruit were cut in half at right angles to the suture and rated on the basis that 100 indicates no breakdown and 20 very severe breakdown. The results were very promising (3).

Fruit stored in air at 0°C with no warming (Air-NW) had very severe breakdown, as indicated by the low rating of 22 (Table 1). Fruit from CA with no warming (CA-NW) and those from air that were intermittently warmed (Air-IW) had ratings of 78 and 72, respectively. These fruit had little breakdown and were considered to have acceptable quality. Fruit that had been stored in CA and were intermittently warmed (CA-IW) had a rating of 98, which was significantly better than that of CA or IW alone. They had no breakdown and were of excellent quality.

We also measured the titratable acidity and respiration of these fruit. Acidity was measured because it is related to flavor, and its loss or retention should provide an objective measure of a change in flavor. Respiration was measured because it is an objective measure of fruit metabolism. Injured tissues usually show an increase in respiration; and since chilling can cause injury, fruit with the higher respiration rates probably have the more severe injury (8).

We found titratable acidity of peaches and nectarines from CA-NW to be higher than that of fruit from air-NW (Table 1). Intermittent warming maintained the acidity at a higher level than that of the nonwarmed fruit, but the difference was not significant.

Respiration of the CA-NW fruit was lower than that of the air-NW fruit (Table 1). Warming reduced the respiration rates of both CA- and air-stored fruit but significantly so only for the CA-stored fruit. Thus, the CA-IW fruit had the lowest respiration rate. This indicates that least injury occurred in these fruit, and most injury occurred in the air-NW fruit.

It appears from these results that either CA-NW or air-IW were about equally effective in reducing internal breakdown and maintaining fruit quality longer than regular air storage. However, the combination of CA-IW maintained the quality of peaches and nectarines better than CA or IW alone for 9 weeks (3).

To determine just how long breakdown could be delayed and quality maintained by this storage technique, we included storage periods of 9, 15 and 20 weeks in recent tests. In 17 out of 18 tests over a 3-year period both Redskin and Rio Oso Gem peaches and Regal Grand nectarines were again found to retain good quality with practically no breakdown through 9 weeks storage in CA-IW. The one test where breakdown did occur was conducted on more mature Redskin fruit (8.6 lbs at harvest). This we believed to be, at least in part, a factor in its shorter storage life. In all 18 tests fruit stored in air-NW had severe breakdown after 9 weeks storage. Fruit quality and the extent of breakdown after 15 and 20 weeks storage in CA-IW varied among cultivars. In 8 of 10 tests on Rio Oso Gem little breakdown occurred and quality remained good through 20 weeks. In the other 2 tests the maximum storage life was 9 and 15 weeks because of breakdown. Internal breakdown in Redskin and Regal Grand varied even more after 15 and 20 weeks. Redskin peaches retained fair to good quality through 15 weeks in 3 of 4 tests but after 20 weeks it had moderate to severe breakdown and poor quality. Regal Grand sometimes had little breakdown and retained good quality through 20 weeks but in others was only fair after 15 weeks (unpublished data). Reasons for this variation are being investigated. Figure 1 shows the typical internal appearances of Rio Oso Gem peaches from air-NW and CA-IW storage.

Table 1. Effects of storage atmosphere and intermittent warming on internal breakdown, titratable acidity and respiration of peaches and nectarines stored 9 weeks at 0°C (Anderson and Penney, lit. cit. 3).

Variable measured	Storage atmosphere	Treatment during storage NW[1]	IW[1]
		Breakdown ratings[2]	
Internal breakdown[3]	CA[4]	78 b[5]	98 a
	Air	22 c	72 b
		Mg/100 g	
Titratable acidity[3]	CA	589 a	629 a
	Air	319 b	424 b
		Mg CO_2/Kg-hr	
Respiration[3]	CA	53 b	44 a
	Air	60 c	54 bc

1 NW = No warming. IW = Warmed 2 days in air at 18.3°C after 3 and 6 weeks storage.

2 Rating of 100 = no breakdown.

3 Breakdown and acidity determined after ripening at 18.3°C. Respiration in air at 18.3° after storage.

4 CA was 1% O_2 + 5% CO_2 (balance essentially N_2).

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

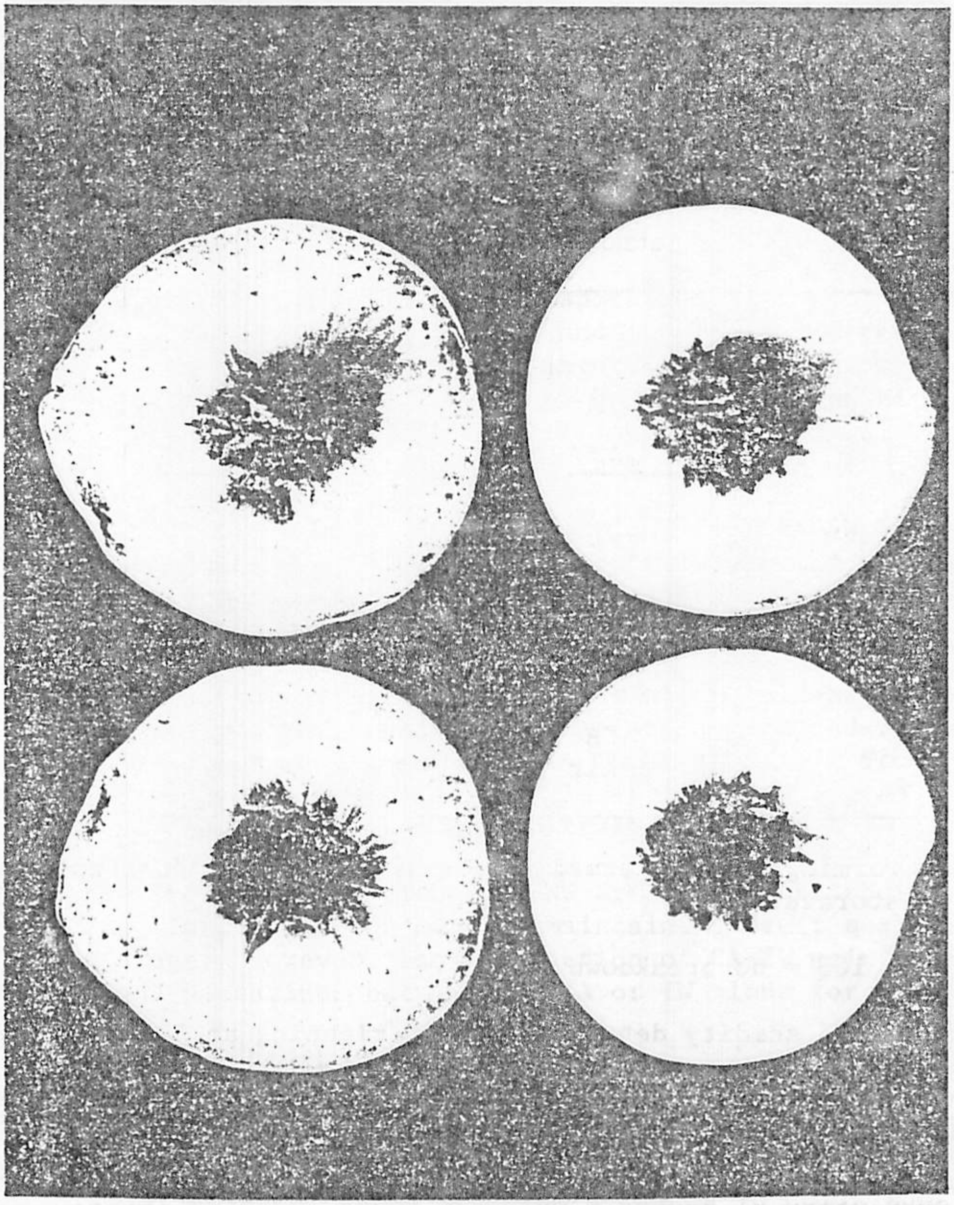

Figure 1. Rio Oso Gem peaches after 15 weeks storage at 0° plus ripening in air at 18-20°C. (Air-NW, left; CA-IW, right). The CA-IW fruit were warmed every 4 weeks during storage.

In some of our tests decay, mostly due to the brown rot organisms, was a serious problem. This decay was controlled in fruit dipped before storage in suspensions of 100 ppm benomyl at 46°C for 2-1/2 minutes (12).

Also in some tests a skin-browning type of injury occurred. We were unable to determine the cause of this injury but thought it might have been due to the extra handling of and moisture condensation on the fruit during the IW treatments. In later tests the fruit were warmed gradually, and this type of injury was essentially eliminated.

All of the foregoing tests were conducted on a laboratory scale, usually with only 50 to 100 fruit per sample. This past season we scaled up the size of the tests to determine whether or not our laboratory findings would stand up under commercial conditions.

Space was rented in a commercial, cold storage warehouse in Pennsylvania. For CA chambers we used pallet size plastic bags.1/ The bags were placed on wooden pallets to facilitate moving by fork-lift trucks for the warming treatments. Beneath the bags and on the inside bottom of each bag corrugated cardboard sheeting was placed to reduce abrasion and possible tearing of the plastic. A detailed report of this test has been submitted for publication (4).

Redskin and Marhigh peaches, about 100 38-lb cartons of each, were obtained from an orchard in Maryland. The fruit received the normal defuzzing, waxing and fungicide dip practiced at this packing shed. Twenty-four boxes of fruit were stored in each bag, and the CA fruit were to be warmed every 3 weeks at this warm up 1/2 of the IW samples were dipped in hot benomyl as a further decay control measure.

Our first inspection for breakdown was made after 6 weeks' storage plus a holding period of 18°C for ripening. Breakdown was quite severe in the Air-NW fruit; Redskin was rated 40 and Marhigh 33. Breakdown was essentially absent in the CA-IW fruit, as reflected by ratings of 89 for Redskin and 80 for Marhigh. These results confirmed our previous laboratory findings.

Unfortunately, decay was extremely severe, ranging from 52 to 95% and forced us to discontinue the test after this inspection. The causal organism of this decay was identified as *Mucor albo-ater* (11). In superficial observations, this decay may be confused with rhizopus decay. However, the most apparent distinction is that *Mucor* will grow at 0°C, whereas *Rhizopus* will *not* grow below about 7°. The hot benomyl treatment that effectively controlled brown rot during storage was ineffective in controlling *Mucor*.

1/ Donated by TransFRESH Corporation, Salinas, CA.

We believe that the decay-producing organism Mucor, which is not normally a problem with peaches, probably infected the fruit as they passed through the packing line. This was partially confirmed in other tests on fruit, from this orchard, which were selected from bulk bins as they entered the packing house. Fruit so selected did not develop decay due to Mucor.

Although decay limited the duration of these tests, there were several encouraging results. First, the sealed plastic bags maintained the desired O_2 and CO_2 levels quite well, and good temperature control was maintained within the bags. The CA-IW storage method reduced breakdown and maintained fruit quality much better than regular air storage. This leads us to believe that such bags may be useful to growers who wish to extend the marketing season of a small quantity of fruit--or to researchers who wish to extend their laboratory studies beyond the time limitations imposed by normal air storage. For larger scale CA-IW storage of peaches, the development of other techniques, equipment and facilities would likely be required.

This pilot scale test indicates the need for sanitary conditions in packing houses and the care required in selecting fruit from decay-free orchards, if possible, so that losses such as occurred in these studies could be avoided.

Summary

CA storage delayed the development of internal breakdown and maintained the quality of some peach and nectarine cultivars about 2 to 3 times longer than regular air storage.

Intermittent warming during storage also delayed the development of internal breakdown and maintained the quality of some peach and nectarine cultivars about 2 to 3 times longer than regular air storage.

The combined CA storage and IW treatments might thus be able to extend the market life of some peach and nectarine cultivars about 4 to 5 times that of such fruit in regular air storage.

Large, pallet-size plastic bags can be useful as test chambers to evaluate CA-IW under commercial conditions.

An effective decay-control treatment is essential for extended storage.

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