TEMPERATURE MANIPULATION IMPROVES POSTHARVEST QUALITY OF A MID-SEASON PEACH

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ABSTRACT

*Mid-season peach (*Prunus persica (L.) *Batsch cv Majestic) fruit of five maturity stages, from red suture to red, full soft, were subjected to warming treatments before and during storage at 5C. Intermittent warming and delayed storage accelerated softening in red suture, half and full red hard fruit. The treatment effect was greater with less mature fruit. Treatment had no effect on soluble solids concentration, total phenolics, or titratable acidity. 'Majestic' peaches could be held at 5C up to four weeks if harvested at the half red or full red hard stage and held at room temperature for 24 h before storage.*

INTRODUCTION

Fresh market peaches are harvested when hard and well before fully ripe to prevent bruising during transport and marketing. The sweetness, flavor and texture of peaches is adversely affected by this harvesting practice. Fruit quality is especially poor if peaches have not reached threshold maturity when harvested. Consumers want red, firm peaches when purchasing fruit, yet also consider peaches with a high soluble solids concentration (%SSC) or a high ratio of SSC to titratable acidity to be of superior flavor (Crisosto 1996a). Peach cultivars differ widely in accumulation of red color, %SSC, and softening rates during ripening (Crisosto

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1996b). This variability is why consumers ranked peaches the most objectionable and erratic in quality of all fruits in supermarkets (Bruhn *et al.* 1991; Bruhn 1995), and has led to a decline in consumer purchase of peaches (Epperson *et al.* 1992).

The recommended storage temperature for most peaches is 0C (Hardenburg *et al.* 1986). Peach storage life depends on maturity stage and cultivar, and ranges from one week at 5C to five weeks at 0C (Crisosto 1996b). Some peach cultivars, such as 'Elberta', develop chilling injury at 0C and must be stored at 5C (Boyes 1952). Other peach cultivars are very prone to chilling injury at 2 or 5C, which appears as brown discoloration under the peel or in the flesh (Crisosto 1996a). Texture changes, such as a sensory lack of juiciness or mealiness (woolliness), loss of flavor, and flesh translucency can also occur in chill-injured fruit. Late season peaches are generally regarded as being more sensitive to chilling injury, but response varies with cultivar, growing region, and year.

In Texas, commercial production of peaches does not meet consumer demand (Lyons *et al.* 1989). Most peaches are sold locally or within the state and desirable fruit are firm, fully blushed, sweet and juicy. Growers are interested in expanding peach production and marketing fruit within and outside Texas. Peaches from Texas are available from April into August, encompassing wide climatic and environmental conditions. Additionally, most Texas peach growers store fruit at 5C rather than at 0C to avoid coil condensation and freezing in coolers.

Temperature manipulation can prevent chilling injury in peaches. Ben-Arie *et al.* (1970) reported that a 24 h delay in cold storage prevented subsequent chilling injury at 2C. Anderson (1979) found that warming peaches at 18C for 48h after one to two weeks storage at 5C prevented internal breakdown after four weeks total storage. However, the effectiveness of either of these treatments depends on cultivar and maturity stage (Lill *et al.* 1989).

'Majestic' freestone peaches are large, firm, fully red, and mature in late June in central and west Texas. The objective of our experiment was to identify a maturity stage and temperature manipulation treatment in a mid-season peach that would best maintain quality after storage at 5C.

MATERIALS AND METHODS

Plant Material

'Majestic' peaches were harvested throughout the canopy from forty, 5-year old trees grown at the Texas A&M Agricultural Experiment Station, Stephenville, TX on a windthorst fine sandy loam following practices recommended for peach trees in Texas (Lyons *et al.* 1989). Trees were given alternate sprays of Benlate and Captan fungicides following the recommended schedule for Texas.

Maturity Stages

Peach maturity stages are widely variable, and must be determined for each cultivar and production region (Crisosto 1996b). We selected peaches at five stages based on several years of observations of the maturation patterns of 'Majestic' peaches in North Central Texas near Stephenville. 'Majestic' develops full red coloration (blush) and softens with ripening. Maturity stages used and firmness at harvest were red suture, (112N firmness; 116 g/fruit) one half red (95N; 161 g/fruit), fully red, hard (68N; 183 g/fruit), red firm (32N; 240 g/fruit), and red soft (19N; 242 g/fruit). Fruit from the first three ripeness stages were harvested on July 7 and red firm and red soft peaches were harvested July 28, 1994. Fruit at red hard and red firm stages most closely corresponded to the threshold mature and firm ripe stages defined for South Atlantic peaches (Delwiche and Baumgardner 1983).

Storage Treatments

Peaches in each ripeness stage were subjected to three treatments, consisting of immediate storage at 5C for one to four weeks (control), one day storage at 20C followed by storage at 5C, 90% RH for one to four weeks (DS); and immediate storage at 5C for two weeks, followed by one day warming at 25C then another 2 weeks at 5C (IW). Fruit given intermittent warming reached 18C after 6 h and 23C after 24 h. Four boxes, each containing 35-40 fruit, were used per treatment per ripeness stage. From these replicates, five fruit were sub-sampled at random for each storage interval for fruit analyses.

Fruit Analyses

Visual color was quantified on each peach on the mid center of the cheek having the most blush, using a Hunter D25-2 color difference meter (Hunter Assoc. Lab., Inc. Fairfax, VA) and expressed as value (L), color (°hue) and saturation (chroma) (Setser 1984). Firmness of the mid center of one peeled cheek per fruit was measured with an Effigyi penetrometer (Magness-Taylor), 8.1 cm probe. Percent extractable juice was determined by a modified method of von Mollendorff *et al.* (1992) to estimate mealiness of peaches. Each peach was quartered, 50 g tissue pureed using an Oster puree blender, then centrifuged at 8,600 g for 14 min. The supernatant was decanted and weighed, and percent puree/g tissue and percent juice/g tissue determined. Supernatants were combined within replicates and held at -20C for later determination of percentage soluble solids concentration (%SSC), percentage titratable acidity (%TA), and total phenolics content. For % TA, a 10 mL sample was combined with 90 mL water and titrated to pH 8.1, and percentage acidity calculated using meq malic acid. Soluble solids concentration was determined as percent Brix with an ABBE-3L refractometer. Total phenolic-content was determined with Folin-Denis reagent, following the method of Swain and Hillis (1959).

Statistics

The experiment was arranged as a split plot with storage week as the main plot and maturity stages and storage treatments as subplots. Data were subjected to analyses of variance and means separated by Ryan-Einholdt-Gabriel-Welsch (Schlotzhauer and Littell 1987). Standard error of the means were presented where interactions were not significant.

Peach Quality Changes During Storage

Fruit harvested at red firm or red soft stages became very soft (flesh resistance of < 8N) after one to two weeks storage and remaining fruit were discarded. No differences among storage treatments were found within these maturity stages (data not shown). In the whole study, only two peaches had decay.

Peaches harvested at less mature stages and stored continuously at 5C for up to 4 weeks changed little in color, measured as lightness/darkness, redness, greenness, or intensity (Table 1). The ratio of a/b, the red-to-green value found useful in predicting tomato redness, increased until two weeks storage in red suture and until one week storage in half red peaches and did not differ among treatments. The hue of red suture and full red hard fruit was not affected by storage treatment and averaged 56.5° and 34.2°, respectively, over all weeks of storage (data not shown). Weight loss was about 2% per week regardless of maturity stage or treatment, with cumulative weight loss by the fourth week of 9.0, 9.6 and 9.8% for red suture, half and full red hard fruit, respectively (data not shown).

Week of storage, but not warming treatment, affected composition of fruit harvested at red suture, half red or full red hard stages (Table 1). The % SSC declined slightly in stored red suture fruit. Percentage TA declined with storage and the rate of change was greater for fruit harvested less mature. The ratio of SSC/TA increased with storage with all maturity stages and was highest in full red hard fruit stored four weeks. Total phenolics and pH tended to increase with storage in half and full red hard fruit (121 to 194 μg/mL caffeic acid; 3.60 to 4.40 pH).

TABLE 1.
EFFECT OF RIPENESS STAGE AND STORAGE AT 5C ON CHANGES IN 'MAJESTIC PEACHES'

		Color					Composition		
		L	a	b	a/b	Chroma	SSC	TA	SSC/TA
Ripeness stage	Weeks of storage						----(%)----		
Red suture	0	57.3a	5.5c	30.9a	0.21c	32.4a	13.2a	1.00a	12.8e
	1	52.9a	11.4b	28.5a	0.44b	32.4a	13.4a	0.89b	15.0d
	2	57.2a	12.9b	30.8a	0.61a	35.4a	12.9ab	0.70c	18.4c
	3	56.2a	17.1a	30.1a	0.68a	36.4a	12.6b	0.57d	22.1b
	4	56.2a	15.7ab	30.1a	0.67a	35.0a	12.6b	0.44c	28.6a
Half red	0	52.7a	19.7b	28.2a	0.72c	34.9b	12.4b	0.98a	12.4d
	1	45.3b	25.1a	23.3b	1.17a	35.0b	13.2a	1.00a	13.2d
	2	52.5a	21.9b	23.6a	0.90b	36.5ab	12.4b	0.55b	22.5c
	3	47.3b	26.1a	27.4b	1.23a	36.3b	13.3a	0.48b	27.7b
	4	49.8ab	26.3a	26.2b	1.13ab	38.3a	12.4b	0.40c	31.0a
Full red, hard	0	43.0a	32.6a	21.4a	1.63a	39.4a	13.1a	0.94a	13.9d
	1	41.9ab	31.7a	20.5a	1.61a	38.1a	12.4b	0.60b	20.7c
	2	38.6b	26.4b	17.4b	1.55a	31.7b	11.9b	0.58a	22.4c
	3	42.5a	29.4ab	20.7a	1.54a	36.5a	12.9ab	0.42d	30.7b
	4	41.9ab	31.0a	20.8a	1.57a	37.6a	13.2a	0.34c	38.8a

•Means separated within columns and ripeness stage by REGWF, P≤0.05.

Delayed Storage and Intermittent Warming Effects on Peach Quality

Intermittent warming affected peach composition only in fruit harvested at red suture, half red, or full red hard stages, and only in hue, juice pH, flesh resistance to puncture, and percent extractable juice.

Color expressed as degrees hue, was more yellow (52°) in half red peaches stored continuously at 5C (control) after three weeks storage than for IW fruit (37°). Hue did not change significantly with warming treatment in red suture or full red hard fruit (data not shown). Juice pH was slightly lower in IW peaches (4.0-4.2) after four weeks storage compared with control fruit (4.2-4.4).

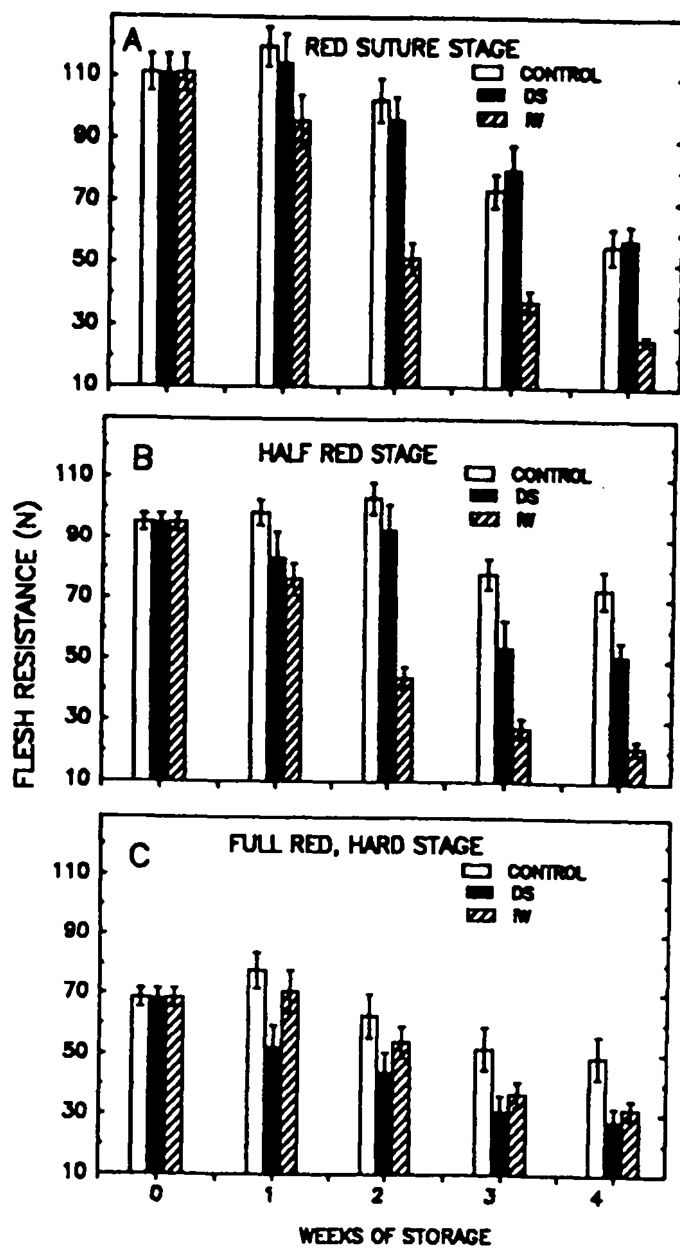

FIG. 1. FLESH RESISTANCE OF PEACHES HARVESTED AT THE RED SUTURE (A), HALF RED (B) OR FULL RED HARD RIPENESS STAGES (C)
Treatments are given in Fig. 1 legend.

DS fruit were softer than control fruit at half and full red hard stages, but not at the red suture stage (Fig. 1). Fruit at the red suture stage lost half their initial resistance to puncture after four weeks' storage (Fig. 1A). Fruit warmed after two weeks storage (IW) were markedly softer than those from the other treatments. The firmness changes in full red hard peaches were much less affected by warming treatment compared with half red fruit (Fig. 1C). Full red hard peaches given DS and IW treatments were softer than control fruit after three weeks' storage. Control fruit were firmer than DS or IW fruit and lost 20 N of firmness after four weeks' storage.

Half red fruit initially had 42% extractable juice/g tissue (Fig. 2A). After one and four weeks storage, control fruit had more juice than either delayed stored or intermittently warmed peaches. However, peaches that were warmed after two weeks storage had more extractable juice than other treatments. We were unable to express juice from red suture peaches.

Stored, full red hard fruit had less extractable juice than fresh fruit (Fig. 2B). IW peaches had more extractable juice after two weeks storage and less after three and four weeks storage than control fruit.

All full red hard peaches of control and IW treatments had chilling injury, exhibited as flesh browning, after two weeks storage at 5C. No peaches from the DS treatment exhibited browning. Peaches were not subjectively rated for woolliness, although we had attempted to quantify textural abnormalities by determining percent extractable juice.

DISCUSSION

Several methods have been used to determine peach maturity stages, including ground color, development of blush, firmness and SSC/TA (Delwiche and Baumgardner 1983; Robertson *et al.* 1993; Crisosto 1996b). In our study, flesh resistance to puncture best separated ripeness stages of 'Majestic' peaches.

Flesh browning was visible in firm full red peaches for control and IW but not DS treated fruit after two to four weeks' storage. However, the total phenolic contents of fruit from these treatments were similar (ca 200 μg/mL caffeic acid). Total phenolics in peaches include chlorogenic acid, which is oxidized by polyphenoloxidase (PPO) and causes peach mesocarp browning (Cheng and Crisosto 1995). In our study, control peaches may have had the same accumulation of chlorogenic acid but had enhanced PPO, causing flesh browning.

Melting flesh, freestone peaches soften by conversion of protopectin to water soluble pectins during ripening (Robertson *et al.* 1993). Woolliness is a textural abnormality caused by prolonged low temperature storage and is expressed in nectarines as a loss of extractable juice (von Mollendorffet *et al.* 1992, 1993). In our study, percent extractable juice generally declined with ripening and storage

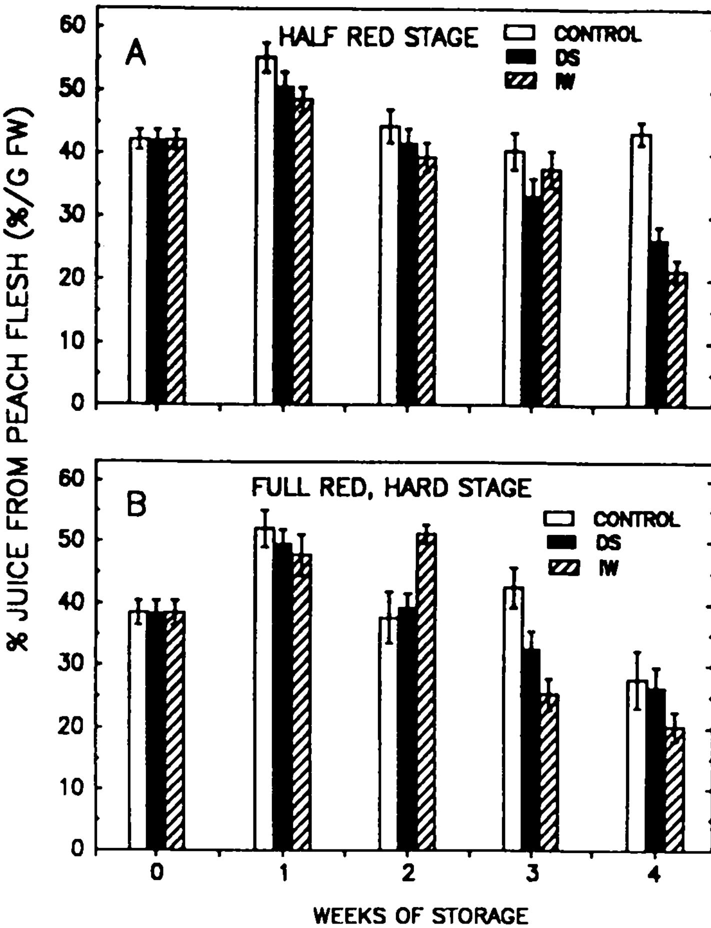

FIG. 2. JUICE EXTRACTED FROM PEACHES HARVESTED AT HALF RED (A) OR FULL RED HARD (B) RIPENESS STAGES AND HELD AT 5C FOR 4 WEEKS
Treatments are given in Fig. 1. legend. Values represent means of 20 fruit, ± SE.

time, perhaps due partially to water loss. Buescher and Furmanski (1978) reported peaches had a 14% loss in extractable juice after four weeks at 1C. In our study, peaches lost about 12 to 20% in extractable juice, even in peaches with no visible chilling injury. Extractable juice data did not clearly demonstrate woolliness or chilling injury as defined by browning in 'Majestic' peaches. Stored half red and red suture fruit from the control treatment were very firm, indicative of abnormal softening.

Intermittent warming increased the softening rate of red suture and half red 'Majestic' peaches held at 5C but had less effect on the more ripe, fully red hard fruit. Our data indicate that 'Majestic' peaches harvested fully red but hard can be held for one week at 5C before visible chilling injury (flesh browning) occurs. Holding these fruit at 25C for 24 h prior to storage prevented chilling injury and extended storage life to three or four weeks. Less mature fruit (half red) held for four weeks at 5C did not have flesh browning but had abnormal softening, indicating chilling injury. Delayed storage or intermittent warming accelerated softening and red coloration of half red peaches. Intermittent warming may be effective if applied at weekly, rather than biweekly, intervals.

In conclusion, 'Majestic' peaches harvested at half or full red hard maturity stages and held at 20C for 24h could be held 2 to 3 weeks at 5C. Red suture peaches were able to soften if given intermittent warming treatments but were smaller and less juicy than half or full red peaches. Half red peaches could be held three to four weeks at 5C if given delayed storage or intermittent warming treatments. Full red hard peaches given a delayed storage treatment could be held two to three weeks at 5C.

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