fruit the roadside stand owner recommended the use of 22-lb. boxes for firm fruit and 10-lb. boxes for ripened fruit.

Locating a local source of bulk fruit would be one of the first steps a PYO owner would need to take if he is to expand his operation. Madison County, Florida, about 25-30 miles from the PYO used in this study, could be a source for bulk purchasing since there are over 3,000 acres of peaches and nectarines. In 1983, fruits which received postharvest treatment of hydrocooling with fungicide(s) and brushing were sold in 25 or 38-lb. boxes in the Madison area. Prices ranged from $0.16 to $0.40/lb., depending on time of season and fruit grade. Postharvest treated fruit would virtually eliminate the sorting costs and cost of boxes and increase storability but would add transportation costs. If the cost of sorting and boxes is removed, the average cost per pound of saleable fruit is about $0.035. This $0.035 added to the $0.16/lb. cost from the grower plus nominal transportation costs could net the owner over $1,000, assuming sale of about 17,000 lb. at $0.27/lb.

Since almost all surveyed customers would purchase other fruits and nuts, it would seem a small operator within 10-20 miles of his potential market would profit by selling a diversity of produce. The roadside market could be a feasible alternative for large growers to market their produce, especially fruit too ripe to ship or when the usual market price drops.

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EFFECTS OF POSTHARVEST TREATMENTS ON RIPENING, CAROTENOIDS AND QUALITY OF CANNED 'BABYGOLD 7' PEACHES[1]

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Abstract. **Postharvest ripening treatments (ethephon, fungicides, and/or storage conditions) of immature, 'Babygold 7' peaches** [Prunus persica **(L.) Batsch**] **accelerated ripening and color development and produced fruits of highest quality as measured by various quality parameters. Peaches contained more carotenoid than tree-ripened fruit and were practically decay free. Lycopene accumulation was stimulated and detected for the first time in tissue treated with 2-(4-chlorophenylthio)-triethylamine hydrochloride (CPTA). Postharvest ripening produced fruit of comparable or better quality for canning than peaches harvested at optimum maturity and canned. Peaches held at 41°C and 90% relative humidity (moist hot-air rooms) for 24 hr before ripening at 27°C and 90% relative humidity after dipping in 250 ppm ethephon for 1 min produced one of the most efficient methods of fruit ripening for canning.**

Mechanical harvesting could reduce production costs of peaches, but this once-over operation results in harvesting fruit differing widely in maturity. A method to ripen immature fruit acceptably could improve recovery of mechanically harvested fruit. Although there is considerable information on the effects of postharvest conditions on quality of freestone peaches, information on the effects of storage conditions on postharvest ripeness and quality of fresh nonmelting type clingstone peaches and on the canned fruit is meager (4, 6).

Ethylene is the hormone responsible for ripening in most fruits (1). Application of 2-(4-chlorophenylthio)-triethylamine hydrochloride (CPTA), a bioregulator, was found to affect carotenoid biosynthesis in a number of tissues (2).

The objective of this study was to evaluate the effects of postharvest treatments with 2-chloroethylphosphonic acid (ethephon), CPTA, fungicides, and ripening temperatures on ripening, color development and quality of fresh, and canned immature 'Babygold 7' non-melting clingstone peaches.

Materials and Methods

'Babygold 7' peaches were mechanically harvested in commercial orchards in South Carolina. Thirty fruit were separated according to chlorophyll content into 3 maturity categories based on optical density differences ΔOD (700-730 nm): immature ($\Delta OD > 0.8$); medium ripe ($0.4 < \Delta OD \leq 0.8$); and ripe ($\Delta OD \leq 0.4$) using a Neotec (IQA Neotec Corp.) spectral instrument. These fruit were then used to calibrate the FMC Spectrasort, which scans 80% of the surface area of each peach and sorts on the basis of its greenness. This instrument was used to separate automatically the remaining fruit into these 3 maturity categories.

A number of postharvest treatments were used for ripening the immature but full-size peaches. Each treatment consisted of 20 lots of uniform-size fruit replicated 10 times.

Method 1. Fruit was immersed for 1 min into aqueous solution of 250 ppm ethephon with 0.05% Tween-20. The controls were dipped in water with wetting agent. Following dipping, the fruit was air-dried and placed at either 24 or 27°C and 90% relative humidity for 4-6 days to ripen.

Method 2. Peaches were dipped for 1 min into aqueous solution of 250 ppm ethephon and after 30 min of air drying were dipped for 1 min in 2500 ppm CPTA adjusted to pH 9 with NaOH; 0.05% Tween-20 was used in each solution. The controls were dipped in water with wetting agent. Treated fruit was kept at 27°C and 90% relative humidity for ripening.

Method 3. Peaches were kept at 41°C and 90% relative humidity for 24 hr before ripening at 24 or 27°C under 90% relative humidity. Certain lots of fruit were dipped for 1

[1]Mention of growth and bioregulators in this paper does not constitute a recommendation for use by the U.S. Department of Agriculture.

min into aqueous solution of ethephon with 0.05% Tween-20 before being placed at 27°C and 90% relative humidity.

Method 4. Fruit were dipped for 1 min in 52°C water containing 2,6-dicloro-4-nitroaniline (Botran) (75% WP) plus benonayl (Bonlate) (50% WP) at 908 g each per 378.5 liters of water. Treated fruit was then ripened at 24 or 27°C under 90% relative humidity.

Following ripening, fresh fruit was assessed for fruit color, texture, soluble solids, pH and total titratable acidity (3) and data reported are the means of 20 measurements. Color of skin and flesh were measured by the Hunter Color and Color Difference Meter with an L, a and b readout. Color was determined as a 3 dimensional characteristic with 2 chromatic attributes, hue and saturation, designated by θ and r in polar coordinates with $\theta = \tan^{-1} b/a$ and $r = (a^2+b^2)^{1/2}$.

Fruit from each treatment were processed as canned halves, stored at 21°C for 24 months and then evaluated for quality. A 10-point hedonic scale (10 = excellent, 1 = poor) was used for sensory evaluation by a 10 member trained panel.

Carotenoids in raw and canned product were extracted and analyzed (5). Optical density of an aliquot of the hexane extract was determined at 450 and 502 nm (7). The results were expressed as mg total carotenoids/100 g fresh weight.

Results and Discussion

Postharvest treatments on the ripening of immature peaches. Postharvest treatments with ethephon, ethephon followed by CPTA, and/or ripening temperatures enhanced fruit color, as indicated by decreased hue angle for skin (ground) and flesh color, and increased soluble solids as compared to the control (tree-ripened) fruit (Table 1). Peaches treated with ethephon and CPTA developed an orange color and exhibited the greatest decrease in hue angle in skin and flesh color. Ripening at 24 rather than at 27°C increased the hue angle reading in the first quadrant, indicating that the peaches became light yellow. With postharvest ripening, an intensity of saturation was exhibited. Saturation was proportional to the strength of a given color.

Fruit softening was enhanced compared with immature fruit and the total acid (expressed as % citric) generally decreased with application of ethephon. Peaches placed in 41°C and 90% relative humidity prior to the ripening temperatures and ethephon dipping were significantly more acceptable than the tree-ripened fruit by the sensory panelists and had a very low incidence of decay (data not shown).

The significant decrease in the hue angle readings indicates chlorophyll destruction and carotenoid production. Carotenoid analyses corroborate this idea (Table 4). No internal breakdown or brown discoloration of the pit cavity followed any of the postharvest treatments during the 4-6 day ripening period.

Effects of postharvest ripening methods on peach processing quality. Postharvest ripened peaches canned and stored for 24 months at 21°C produced fruit of comparable or better quality than peaches harvested at optimum maturity and canned. This was verified by measuring quality parameters (Table 2) and by sensory evaluation (Table 3).

The various treatments affected color development even after processing. This was exhibited by the decrease in hue angle and the increase in intensity of saturation as compared to the control. The best postharvest ripening treatment was method 3 (41°C + 90% relative humidity for 24 hr, a 1 min ethephon dip (250 ppm) and storage at 27°C + 90% relative humidity). Sensory evaluation of appearance, color, texture, taste and overall acceptability ratings of this treatment was about 7 on a 10 point hedonic scale, while that of the control canned peaches averaged ca. 6.0 (Table 3). Brown rot was consistently reduced by this treatment which had the highest percent of soluble solids and better texture. All treatments produced peaches with a higher % soluble solids and citric acid than those of tree ripened fruit. Four to 6 days were needed for postharvest ripening of immature peaches to obtain a canned product of high quality.

Table 1. Effects of postharvest treatments on ripening of immature Babygold 7 clingstone peaches as measured by various quality parameters.

Postharvest treatments[z]	Ripening or treatment time	Hunter color values: Skin Hue angle ($\tan^{-1}b/a$)	Skin Saturation index $(a^2+b^2)^{1/2}$	Flesh Hue angle ($\tan^{-1}b/a$)	Flesh Saturation index $(a^2+b^2)^{1/2}$	Texture (Magness-Taylor) (kg)	Soluble solids (%)	Titratable acidity[y] (%)
Immature		97.5°	18.4	82.0°	30.3	7.1	9.1	0.4
Tree-ripened	—	65.8°	23.5	71.1°	32.4	5.4	10.9	0.4
24°C + 90% RH	4-6 days	77.7°	23.0	70.7°	32.8	5.5	10.9	0.4
24°C + 90% RH E 250 ppm	4-6 days 1 min	70.5°	24.2	67.4°	32.6	4.9	10.8	0.4
27°C + 90% RH	4-6 days	72.8°	23.0	68.1°	33.2	5.6	11.3	0.4
27°C + 90% RH E 250 ppm	4-6 days 1 min	64.7°	25.2	65.6°	36.0	5.4	11.3	0.3
27°C + 90% RH E 250 ppm + CPTA 2500 ppm	— 1 min 1 min	55.9°	25.3	65.0°	33.7	5.4	11.8	0.3
41°C + 90% RH 27°C + 90% RH E 250 ppm	24 hr — 1 min	65.8°	25.4	66.1°	34.9	5.6	11.0	0.3
41°C + 90% RH 27°C + 90% RH	24 hr —	67.2°	25.8	65.7°	34.3	5.5	11.1	0.3
41°C + 90% RH 24°C + 90% RH	24 hr —	72.2°	25.0	68.5°	34.7	5.0	12.0	0.4

[z]E, ethephan; CPTA, 2-(4-chlorophenylthio)-triethylamine hydrochloride.
[y]Expressed as percent citric acid.

Table 2. Effects of postharvest ripening methods on quality of canned Babygold 7 non-melting clingstone peaches as measured by various quality parameters.

Postharvest treatment[z]	Hunter color values: Hue angle ($\tan^{-1}b/a$)	Hunter color values: Saturation index $(a^2 + b^2)^{1/2}$	Texture (shearforce) gm-cm	Soluble solids (%)	Titratable acidity[y] (%)
Tree-ripened	69.2°	35.3	5.8 X10⁴	24.0	0.3
Tree-ripened and stored at 2°C	74.1°	33.4	6.0 X10⁴	24.5	0.4
24°C + 90% RH	71.0°	34.8	6.1 X10⁴	24.5	0.4
24°C + 90% RH Botran + benomyl + Hot water	69.9°	34.4	5.7 X10⁴	24.7	0.5
24°C + 90% RH E 250 ppm	68.9°	35.2	6.3 X10⁴	26.0	0.4
27°C + 90% RH	68.8°	35.4	6.5 X10⁴	24.8	0.4
27°C + 90% RH Botran + benomyl + Hot water	66.2°	35.6	8.0 X10⁴	25.6	0.4
27°C + 90% RH E 250 ppm	65.5°	36.1	6.6 X10⁴	25.5	0.4
27°C + 90% RH E 250 ppm + CPTA 2500 ppm	64.9°	36.3	7.4 X10⁴	25.4	0.4
41°C + 90% RH 27°C + 90% RH E 250 ppm	67.2°	35.6	7.4 X10⁴	28.2	0.3
41°C + 90% RH 27°C + 90% RH	67.5°	35.9	7.2 X10⁴	26.6	0.4
41°C + 90% RH 24°C + 90% RH	69.8°	36.3	7.2 X10⁴	27.3	0.4

[z]Fruit were stored at 21°C for 24 months following postharvest ripening treatments. E, ethephan; CPTA, 2-(4-chlorophenylthio)-triethylamine hydrochloride).
[y]Expressed as percent citric acid.

Table 3. Sensory evaluation[z] of postharvest ripened canned Babygold non-melting clingstone peaches.

Postharvest treatment[y]	Appearance	Color	Texture	Taste	Overall acceptance	Total
Tree-ripened	6.9	5.5	6.3	6.0	5.6	30.3
24°C + 90% RH	7.5	7.1	5.8	4.4	4.9	29.7
24°C + 90% RH Botran + benomyl + hot water	6.6	7.1	6.7	5.0	5.1	30.5
24°C + 90% RH E 250 ppm	7.0	7.4	6.4	5.5	5.8	32.1
27°C + 90% RH Botran + benomyl + hot water	5.8	7.2	7.2	5.2	5.8	31.2
27°C + 90% RH E 250 ppm	7.4	7.1	7.0	6.8	6.9	35.2
27°C + 90% RH E 250 ppm + CPTA 2500 ppm	6.7	7.8	5.6	5.7	6.5	32.3
41°C +90% RH 27°C + 90% RH E 250 ppm	7.3	7.4	7.3	6.9	6.8	35.7
41°C +90% RH 27°C + 90% RH	7.0	8.0	6.7	6.6	6.8	35.1
41°C +90% RH 24°C + 90% RH	7.7	7.4	7.1	6.8	7.0	36.0

[z]Based on the following rating scale: 10-excellent; 7-8-9-very good; 4-5-6-good; 2-3-fair; 1-poor.
[y]Fruit were stored at 21°C for 24 months following postharvest ripening treatments. E, ethephan; CPTA, 2-(4-chlorophenylthio)-triethylamine hydrochloride.

Table 4. Carotenoids and color of postharvest ripened and canned Babygold 7 non-melting, clingstone peaches.

Postharvest treatment[z]	Ripening or treatment time	Fresh fruit: Relative O. D. intensity of carotenoids: Crude carotene (450 nm)	Fresh fruit: Relative O. D. intensity of carotenoids: Lycopene (502 nm)	Fresh fruit: Tristimulus Color: Hue angle ($\tan^{-1}b/a$)	Fresh fruit: Tristimulus Color: Saturation index $(a^2 + b^2)^{1/2}$	Canned fruit: Relative O. D. intensity of carotenoids: Crude carotene (450 nm)	Canned fruit: Relative O. D. intensity of carotenoids: Lycopene (502 nm)	Canned fruit: Tristimulus Color: Hue angle ($\tan^{-1}b/a$)	Canned fruit: Tristimulus Color: Saturation index $(a^2 + b^2)^{1/2}$
Immature	—	0.66	0.06	82.0°	30.3	—	—	—	—
Tree-ripened	—	0.81	0.06	71.1°	32.1	0.63	0.05	69.2°	35.3
24°C + 90% RH E 250 ppm	4-6 days 1 min	0.97	0.11	67.4°	32.6	0.53	0.10	68.9°	35.2
27°C + 90% RH	4-6 days	0.92	0.11	68.1°	33.2	—	—	68.8°	35.4
27°C + 90% RH E 250 ppm	4-6 days 1 min	1.09	0.13	65.6°	36.0	0.68	0.13	65.5°	36.1
27°C + 90% RH E 250 ppm + CPTA 2500 ppm	 1 min 1 min	1.34	0.26	65.0°	33.7	0.64	0.15	64.9°	36.3
41°C + 90% RH 27°C + 90% RH E 250 ppm	24 hr 1 min	—	—	66.1°	34.9	0.67	0.12	67.2°	35.6
41°C + 90% RH 27°C + 90% RH	24 hr	1.20	0.13	65.7°	34.3	0.67	0.12	67.5°	35.9
41°C + 90% RH 24°C + 90% RH	24 hr	0.92	0.11	68.5°	34.7	0.52	0.09	69.8°	36.3

[z]E, ethephan; CPTA, 2-(4-chlorophenylthio)-triethylamine hydrochloride.

The Botran-benonyl-hot water treatment at 24°C ripening temperature produced peaches with the highest citric acid concentration (data not shown). The ethephon-CPTA treatment had the smallest hue angle indicating that these peaches had more orange-yellow color than any other treated fruit.

Tree-ripened fruit subjected to a corresponding period (14 days) of cold storage at 2°C adversely affected the quality but still yielded a fairly satisfactory product. Cold storage did not improve the canning quality of 'Babygold 7' peaches and should be used only when necessary to relieve peak-season canning loads.

Carotenoids and color in fresh and processed peaches. Carotenoids increased with ripening temperature, ethephon and CPTA application to 'Babygold 7' peaches (Table 4). Ripening temperatures of 27°C enhanced the yellow color development as compared to ripening at 24°C. Carotenoid content of postharvest ripened 'Babygold 7' peaches ranged from 1.3 to 2.7 mg/100 g fresh weight.

Increased lycopene accumulation was associated with the various ripening temperatures and especially when the fruit was treated with ethephon and CPTA (Table 4). Lycopene accumulation was greatest in peach tissue treated with CPTA. Minor amounts of lycopene were found in the untreated fruit but the lycopene in treated fruit increased about 4.5 times. When heat processing was applied to 'Babygold 7' peaches for canning, there was a decrease in the content of total carotenoids and in lycopene.

Color is one of the most important qualities of peaches from the standpoint of canning. A uniform, bright yellow could be obtained from fruit which ripened under treatments at 27°C + 90% relative humidity, ethephon 250 ppm, and 41°C + 90% relative humidity, with and without ethephon with subsequent storage at 27°C + 90% relative humidity.

There seemed to be a relationship of hue angle to carotenoids in the flesh of the postharvest ripened fruit, but this relationship was not consistent in the canned product (Table 4). There was no apparent relationship between saturation index and total carotene content. The hue angle for the flesh of postharvest ripened 'Babygold 7' peaches correlated well with the hue angle for the canned peaches.

The most efficient method for ripening of canning peaches was pretreatment at 41°C and 90% relative humidity (moist-hot-air rooms) for 24 hr, dipping in 250 ppm ethephon for 1 min, and ripening at 27°C and 90% relative humidity. This method provides a potential commercial technique and may also provide some reduction of decay.

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