

Preventing enzymatic softening of canned apricots

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Canned, unpeeled apricot halves are subject to softening disorders, which destroy the integrity of the fruit flesh. When the cans are opened, one, a few, or all of the halves may be completely macerated, or they may appear normal but disintegrate upon handling. The inability to detect the problem before the can is opened results in a significant number of dissatisfied customers, even if the fraction of affected cans is small.

Initially, softening after canning was believed to be a single problem. At least two problems were differentiated, however, by work at Davis by L. L. Claypool, Department of Pomology, and Bor S. Luh, Department of Food Science and Technology.

Softening caused by acid hydrolysis is detectable immediately after canning, does not increase with time, and characteristically affects only one or a few halves. Such halves are from fruits with a high natural acidity (low pH). They are softened more by heating than are fruits of slightly higher pH, presumably because constituents in the walls of fruit tissue cells are hydrolyzed. Lower canning temperatures, shorter cooking periods, or both, decrease but do not cure the disorder. The problem is avoided, however, by determining the acidity of fruit samples, diverting high-acid fruit to nectar, and using only fruit lots with pH values of about 3.5 or higher for packs of fruit halves.

The second type of softening, not detectable immediately after canning, may in time affect all halves in a can. The cause seems to be an enzymatic action that slowly liquefies the pectic materials binding the fruit cell walls together. After several months, a fraction of the halves are softened, and at that time enzymatic softening can be confused with acid hydrolysis. Enzymatic softening, however, continues until all fruit halves have softened. The resulting product is highly objectionable to the consumer.

Previously, all pectolytic enzymes were believed to be completely inactivated by heating (212° F for 20 minutes) during canning. In Australia, softening of canned fruit was associated with a high incidence of *Rhizopus* rot in the raw product. It was demonstrated that heat during canning killed the fungus but did not inactivate all pectolytic enzyme activity of fungal origin. The low enzyme activity remaining was sufficient to soften the fruit during the months between canning and consumption.

Studies at Davis confirmed that traces of pectolytic activity were detectable after juice from apricots rotted by *Rhizopus stolonifer* had been heated at 212° F for 20 minutes. Heat treatment also failed to inactivate pectolytic enzymes from isolates of *Rhizopus arrhizus* and *Gilbertella persicaria*, which produce similar rots. Other fungi may possibly produce pectolytic enzymes that are similarly heat resistant and contribute to the disorder.

The enzymatic activity necessary to disintegrate fruit halves in a No. 303 can was quantitated using juice obtained from apricot fruits rotted by *R. arrhizus*. After filtration, aliquots of juice in the amounts of 25, 2.5, 0.25 and 0.025 ml were added to cans of apricot (Blenheim and Tilton) halves in syrup before lidding and cooking. These showed that even the smallest quantity of juice, essentially no more than a single drop, retained sufficient activity after canning to soften the fruits noticeably within about 7½ months (see graphs).

Preventing softening

A simple, inexpensive treatment was sought that would inactivate pectolytic enzymes produced by any fungus present.

A more rigorous heat treatment (higher temperatures, longer periods, or both) was ruled out by the tendency of apricot fruits to disintegrate with excessive cooking. Additionally, activity detected after autoclaving (250° F) for 20 minutes indicated that complete inactivation would require unrealistic heating.

A chemical treatment of fruit or fruit halves was sought, therefore, to inhibit or destroy enzymes in fungal lesions or contaminating juice. Because known enzyme inhibitors would likely be unacceptable as food additives, chemicals capable of enzyme destruction were evaluated.

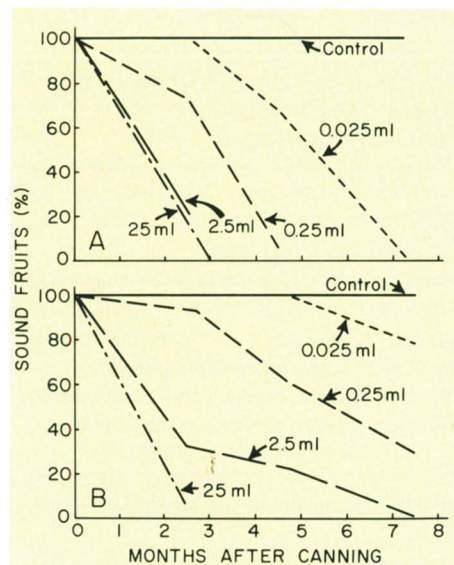
In preliminary laboratory tests, chemicals that destroyed enzyme activity included bases (sodium hydroxide, potassium hydroxide, ammonium hydroxide) and acids (hydrochloric acid). Attention was centered on a chemical already used widely in the food industry, sodium hydroxide (NaOH, or lye).

In canning tests started in 1975, fruit halves were dipped in NaOH solutions of a wide range of concentrations for ½ minute to 5 minutes, followed by an immediate water rinse. Into each can

INCIDENCE OF SOFT FRUIT ONE YEAR AFTER PRECANNING TREATMENT OF APRICOT HALVES WITH NaOH SOLUTIONS OF INDICATED NORMALITY AND DWELL PERIODS*

Treatment	NaOH concentrations	Time minutes	Total halves average number per can	Soft halves
Uninoculated control	not dipped		26 ± 2.1	0
Inoculated control	not dipped		23 ± 0.8	23 ± 0.8
Inoculated	0.1 N	2	22 ± 0.6	1 ± 1.5
	0.1 N	5	25 ± 1.9	0.25 ± 0.5
	0.5 N	1	23 ± 1.3	1 ± 1.5
	0.5 N	2	23 ± 1.5	0
	1.0 N	0.5	21 ± 2.1	0
	1.0 N	1	23 ± 1.2	0

* Data are averages of four replications of Blenheim fruit halves.



Effect of adding indicated volumes of juice from apricots rotted by (A) *Rhizopus arrhizus* or (B) *R. stolonifer* to No. 303 cans of halves and syrup before canning. As determined by ability of the juice to liquefy citrus pectin, initial (before canning) activity was three times as great from *R. arrhizus* as from *R. stolonifer*.

Thinning Desertgold peaches increases fruit size

Dean D. Halsey

designated as inoculated were placed two fruit halves that had received the same treatment as the other halves in the can, but each of which had a *Rhizopus arrhizus* lesion about the diameter of a dime. In tests reported here, the fruit skin over the lesion was ruptured by hand rubbing to give the NaOH solution more ready access to the enzyme within the rotted flesh.

The table gives results from several promising treatments one year after the fruits were canned. Treated fruit halves, other than the two containing dime-sized fungus lesions, were generally similar in texture to untreated, uninoculated fruit. The two inoculated halves, by contrast, generally became obviously soft within 6 to 12 months after canning.

NaOH concentrations higher than 1 N often partially removed skin from the halves or, in some cases, caused a gel formation in the syrup. Even at 1 N, contact times evidently should not exceed about 1/2 to 1 minute. Below 0.1 N NaOH, treatments were effective only when the halves were soaked in the solution for several minutes.

Conclusions

Later studies have shown that most of the enzyme activity associated with fungal lesions can be physically removed by fruit-washing procedures. A water spray from multiple jets breaks open lesions as fruits roll beneath, thus allowing a following dip or spray of NaOH solution to contact and destroy the remaining enzymes more effectively.

It thus appears that a satisfactory treatment will consist of a combination of a vigorous water-spray wash followed by a dip or spray of NaOH. Alternatively, a spray of NaOH solution, without a prior water spray, might be delivered by jets to rupture the larger fungal lesions and destroy the pectolytic enzymes in fungal lesions in a single operation. Success of the cold lye treatment will depend on maintaining the correct concentration of NaOH solution and contact time, followed by a thorough rinsing of the treated fruit.

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Each harvest begins about April 25 and continues for two weeks in the Coachella Valley. This district produces the first peach fruit of the season from California, but it is closely followed by other districts. Because the first shipments reaching market receive favorable prices, it is important to Coachella Valley growers that their peaches reach optimum market quality, particularly acceptable fruit size, as early as possible.

Many cultural operations, including proper pruning, fruit thinning, and limb girdling at pit hardening, are practiced to maximize fruit size. This experiment was conducted to evaluate the effect of reducing the number of flower buds at bud swell in January on fruit growth and final fruit size.

Vigorous, five-year-old Desertgold trees on Nemaguard rootstock were used for the experiment. A spray containing 2 percent thiourea was applied on January 20 at bud swell. The application was made as a dilute, full-coverage spray using 2.5 gallons per tree. In other areas of the world, this treatment has reportedly reduced flower buds.

Other procedures that possibly could increase fruit size were also evaluated. These included shortening the bearing shoots by one-half, removing about one-half of the flowers at 95 percent full bloom, removing every other fruit after normal hand thinning, and limb girdling.

The experiment was designed as a four-factorial, in which some level of every treatment was repeated with some level of every other, and no treatment was applied by itself. There was a total of 24 treatments in two randomized blocks.

Flower bud abortion due to thiourea treatment was apparent at 95 percent full bloom on February 9. In plots in which every other fruit was removed after normal thinning, removed fruit were counted and weighed. These data showed that, by pit hardening on March 12, the peaches were already larger on thiourea-sprayed trees (9.26 grams mean fruit weight, compared with 7.88 grams on unsprayed trees), and there were fewer fruit per tree (76 removed per

sprayed tree, 99 per unsprayed tree).

At harvest, thiourea-sprayed trees also had larger peaches (see table). Shortening of fruit wood, flower thinning, and girdling also increased fruit size, but additional fruit thinning over normal thinning did not.

Thiourea sprays at bud-swell offer a method of flower bud thinning that results in larger fruit at harvest. Shortening the fruit-bearing branches after the standard pruning and hand thinning flowers at bloom also increase fruit size. Removing every other fruit after normal hand thinning has little or no effect on final fruit size, indicating that thinning to fewer fruits per tree than is the normal commercial practice is not advisable. Girdling substantially increased fruit size and should be continued as a standard practice. The use of thiourea cannot be recommended at this time, because it is not registered for use on peach trees in the United States.

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SIZE OF DESERTGOLD PEACHES
AT HARVEST,
APRIL 27, 1976, COACHELLA VALLEY

Treatment	Mean fruit diameter* millimeters
Sprayed with thiourea	49.25 [‡]
Not sprayed	46.20
Normal pruning	46.37 [‡]
Normal plus shortening pruning	49.09
Normal thinning	46.95 [†]
Normal plus flower thinning	48.73
Normal plus every other fruit thinned	47.51
Girdled	50.90 [‡]
Not girdled	44.56

* Means of 30 fruit per tree.

[†] Significant at 5 percent probability level.

[‡] Significant at 0.1 percent probability level.