Studies show that kiwifruit can be successfully canned, but that frozen, sliced kiwifruits are closest to fresh fruit in appearance and flavor.

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A new crop for California:

kiwifruit

The kiwifruit (*Actinidia chinensis* Planch), a native of south central China, grows on a large, woody, deciduous vine. In 1906 it was introduced into New Zealand under the name of "Chinese gooseberry," and during the next quarter century New Zealand nurserymen selected large-fruited seedlings, which became commercial varieties. When New Zealand first began to export the fruits commercially in 1953, the name was changed to "kiwi," because the fruits superficially resemble New Zealand's native bird, the kiwi.

In 1935 the U.S. Plant Introduction Station at Chico, California, received plants of a large-fruited variety from a New Zealand grower of Chinese gooseberries. These plants are the ancestors of most of the 'Hayward' variety kiwifruit plants growing in California today, and even after 40 years, the parent vine is still fruiting. In 1974 kiwifruit became the internationally accepted name of the fruit, replacing Chinese gooseberry and kiwi.

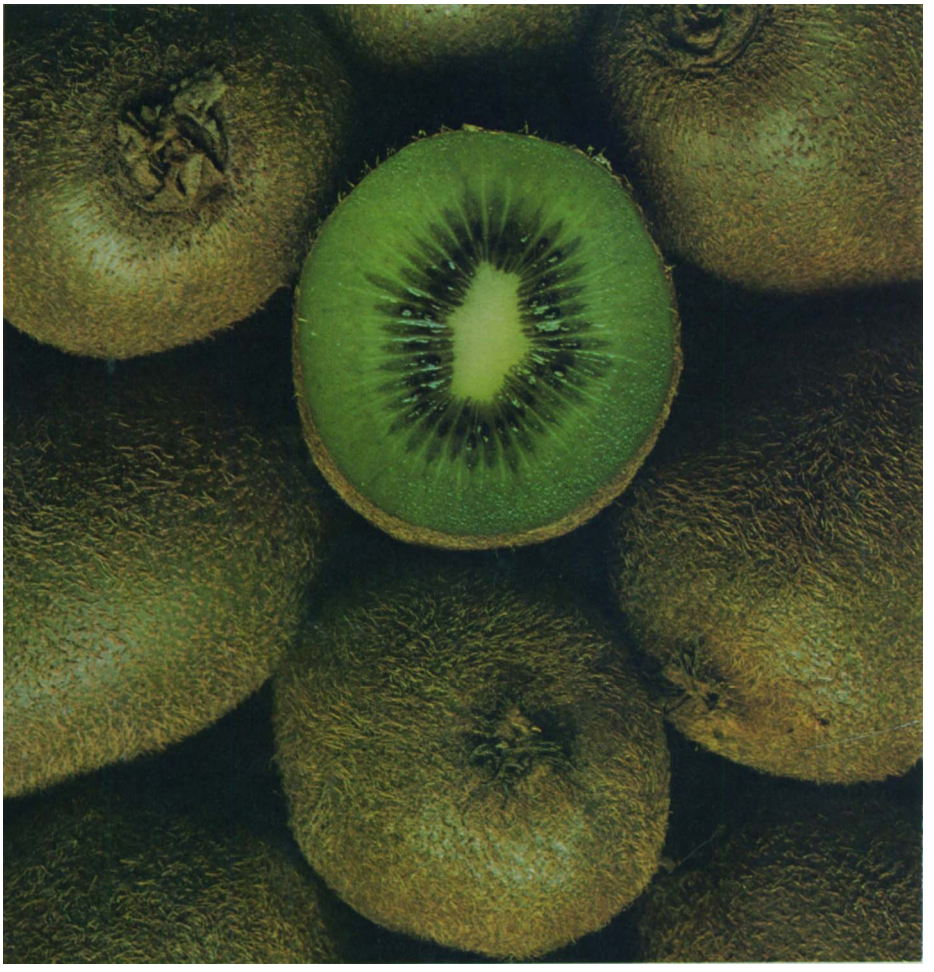
In the 1960s the Chico Plant Introduction Station developed cultural methods for the kiwifruit, and growers were encouraged to experiment with new plantings. Two growers imported several thousand plants from New Zealand in the mid-1960s to establish the first kiwifruit vineyards in California. Limited nursery production began in Chico in about 1960, and nurseries devoted solely to kiwifruit production began in Gridley in 1966. By 1970 approximately 50 acres were growing in Kern and Butte counties.

Production and marketing

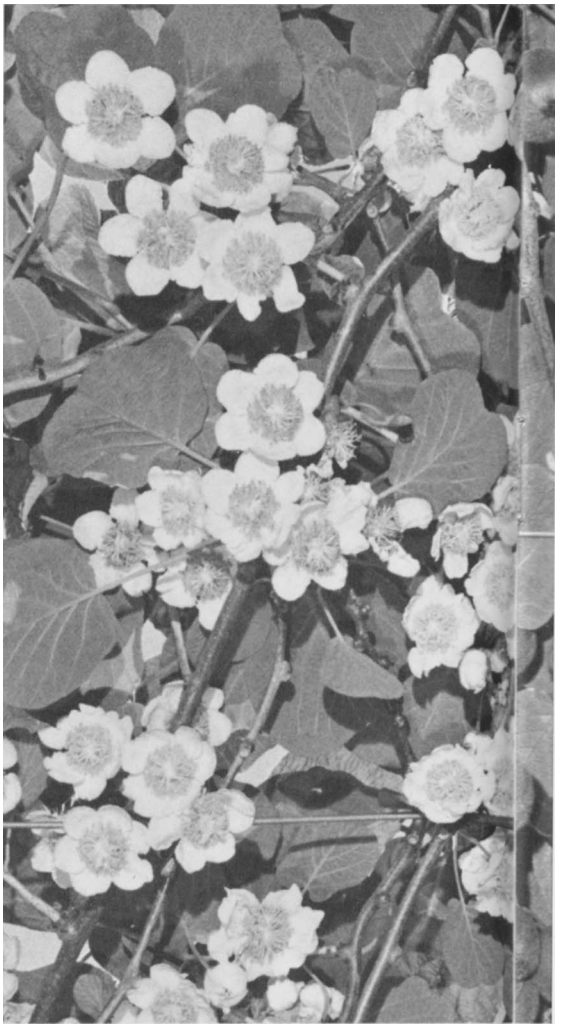
Information on age and size of plantings was obtained in a recent survey of 160 growers, representing 750 acres in 26 California counties. Most of the plantings, by growers who responded to the survey, were made in 1974 and 1975—164 and 260 acres, respectively, compared with 72 acres planted in 1973 and 85 acres during 1967-72. Plantings were primarily in sizes of 1 to 3 acres (38 growers in 1975, 21 in 1974), although in 1975, 14 growers planted 4 to 7 acres, 4 planted 8 to 13, and 5 planted over 14 acres.

Considerable kiwifruit acreage was not covered by this survey. It is presently estimated that more than 1,200 acres have already been planted in small commercial lots of 2 to 25 acres from Chico south to San Diego; however, about 100 acres are bearing (4 years and older). The 1975 kiwifruit production was only 120 tons, but acreage already planted in California could produce 3,000 to 4,000 tons of fruit by 1980, compared to the 6,000 tons now being produced in New Zealand. Full-bearing, 10-year-old kiwifruit vineyards produce 4 to 7 tons per acre.

Kiwifruit vines are planted in rows 15 feet apart. Vines are spaced 18 to 20 feet apart in the rows and are trained



Kiwifruit . . .



Kiwifruit flowers (left) and fruit (right) on overhead pergola.

on strong trellises 6 feet high. Because the plants are dioecious, 10 to 12 percent of the total planting must be pollenizers to ensure pollination by wind and by insects, primarily bees. Vines require protection from strong winds, prefer well-drained orchard soils, and need frequent irrigation.

Vines begin to leaf out in mid-March and flower in early May; the fruits are harvested in November. Since the kiwifruit is a subtropical plant, it freezes at temperatures of 29° F and below when in leaf, but a mature dormant vine may tolerate temperatures down to 10° F.

Kiwifruit vines are attacked by a few pests and diseases in California. These include root knot nematodes, omnivorous leaf roller, salt marsh caterpillar, oak root fungus, crown rot, and fruit decays caused by *Botrytis* and *Alternaria*.

Kiwifruits are harvested when they reach at least 8 percent soluble solids. When cooled to a 32° F core temperature within 12 hours after harvest, the fruits can be stored up to 6 months under commercial refrigeration. About 7 pounds of fruit are packed in a plastic tray enclosed within a perforated polyethylene bag to minimize moisture loss; this is placed in a wood or fiberboard box for shipment. The limited California production has been sold mainly in local markets, but some fruits have been exported to Japan and Holland.

The kiwifruit's external appearance is not particularly attractive. The fruit, which is about the size and shape of a chicken egg, has a relatively firm, greenish-brown skin densely covered with short brown hairs. But the flesh is an attractive emerald green color and has numerous small, jet-black, edible seeds arranged in a circular pattern around the center of the fruit. In cross-section, rays of lighter colored flesh spread from the center almost to the skin layer. Between each pair of adjacent rays (locule walls) are several seeds.

The New Zealand kiwifruit season, including storage, extends from May through November; California-grown fruits are available from November through April. Thus, when California produces enough to meet the existing demand, fresh kiwifruit will be available the year around.

Processing

With many newly introduced crops, production eventually exceeds the fresh-market requirement, and other outlets must be found for the surplus. Anticipating a future kiwifruit surplus, the Department of Food Science and Technology at Davis has studied four processing possibilities—freezing, canning, dehydrating, and juice extraction. With each method, the nutritional value of the processed product has been compared with that of unprocessed fruits.

Mature kiwifruit vine on 6-foot trellis.

Peeling. Because of their hairy skin, kiwifruits must be peeled before processing, except those to be used for juice. Two peeling methods were explored—one using lye solutions and the other using a gas flame. The latter proved impractical, but the lye treatment worked satisfactorily and was used in the research.

It was assumed that the lye, as a basic substance, might decrease the high concentration of ascorbic acid in the fruits. Surprisingly, a study showed that lye-peeled fruits retained a much higher concentration of this important vitamin than did hand-peeled fruits (103.78 mg ascorbic acid per 100 g edible fruit for lye-peeled, compared with 81.33 mg for hand-peeled fruits). It was determined experimentally that a greater concentration of ascorbic acid existed near the skin than in other parts of the fruit. Peeling by knife removed some of the fruit tissue along with the skin. The lye treatment, with temperature and concentration controlled, removed only the very thin skin membrane. Thus, not only was more ascorbic acid retained, but preparatory losses were less (9.02 percent weight loss in lye-peeled versus 13.72 percent in hand-peeled fruit).

Canning. Kiwifruits are stored at 32° F for 3 weeks to 3 months and then

allowed to soften at room temperature (65° to 70° F), just as Bartlett pears are handled for canning. Cold storage for at least 2 weeks is necessary to induce softening, which improves the flavor of kiwifruit whether they are canned or eaten fresh.

Fresh, partially softened, whole kiwifruits were peeled in a 15 percent lye solution for 90 seconds at boiling temperature (approximately 218° F). The fruits were removed from the solution, washed in cold water, trimmed by hand, and rinsed again. Then 19.5 ounces of fruits and 10.5 ounces of 33° Brix syrup were packed into No. 2½ cans, which were then vacuum sealed. The fruits were cooked in the cans at 212° F for 21 minutes and then were water-cooled before storage at room temperature.

Freezing. Caustic-peeled fruits, sliced transversely into approximately 1-cm-thick sections, were dipped for 3 minutes into a solution of 12 percent sucrose, 1 percent ascorbic acid, and 0.25 percent malic acid. The purpose of the dip treatment was to inhibit enzymatic and nonenzymatic changes during processing and storage. The slices were then frozen by one of two IQF (individually quick frozen) methods—in liquid Freon at -22° F, or in an air blast at -40° F. When frozen, the slices were packaged in polyethylene bags and stored at 0° F.

Dehydration. In preliminary experiments, fruits were dried at various temperatures. It was found that the lye-peeled, whole fruit could be dried to a good consistency, and darkening could be prevented, provided dehydrator temperatures were kept below 150° F. The dried product was quite acidic to the palate, but a pre-dip in a sugar solution before drying helped to improve the flavor.

Juice extraction. Overmature or irregularly shaped fruits that would not lend themselves to other processing methods were washed and put through a Model No. 3600 Brown Finisher. The finisher, fitted with a 0.01-inch screen, removed hairs and seeds as well as the skin, producing a rich green juice.

Observations. Canned kiwifruit stored for approximately 5 months were studied subjectively and analytically. Subjectively, it was found that canning had changed some fruit characteristics considerably, as compared with those of lye-peeled, unprocessed fruits. The canned fruits had changed from a light, bright green to a darker, yet not unsightly, dull green, and the texture was considerably less firm than that of raw fruits. Canned fruits had a much milder flavor than did fresh kiwifruits, and storage in syrup had made the fruits quite sweet. Although the flavor of the canned product was not similar to that of fresh kiwifruits, the taste was considered very pleasing, and more desirable to some judges than that of the fresh fruits. Analytically, canning was found to have little effect on the composition of the fruits (see table).

Frozen, sliced kiwifruits were closest to fresh fruit in appearance and flavor. The fruit slices, both frozen and thawed, maintained most of their textural integrity and bright green color. They also retained the fresh-fruit flavor characteristics but were judged less sweet. No off-flavor was detected, provided care was taken to freeze only fully ripe fruit. Freezing did not cause large compositional changes (see table).

Fresh and frozen kiwifruits were found to contain 66 calories per 100 grams edible portion, or 66 calories per fruit of 30 size and 52 calories for the 40 size. Canned fruit contained about 50 percent more calories than fresh fruit, due to the added sugar.

Kiwifruit juice was very pleasant to the taste and could be consumed as a single-strength juice. Because of its acidic nature, some consumers might want to add sugar or blend kiwifruit juice with other juices.

Summary

Results of the present study indicate that kiwifruit can be successfully preserved by canning or freezing. Frozen fruit slices maintained excellent quality after thawing and could contribute both color and taste to a fruit salad or dessert.

Even though the canned fruits had changed in color and flavor, as compared with fresh fruits, they were still considered very acceptable by the judging panel.

COMPOSITION OF EDIBLE PORTION OF FRESH, FROZEN, AND CANNED KIWIFRUITS

Constituent	Fresh	Frozen*	Canned
°Brix at 20° C	14.9	16.4	25.1
Moisture (%)	81.2	80.7	73.0
Ash (%)	0.45	0.53	0.45
Fat (Ether extract) (%)	0.07	0.08	0.06
Protein (%)	0.79	0.95	0.89
Carbohydrate (%)	17.5	17.6	25.5
Minerals (mg/100g sample):			
Calcium	16	18	23
Magnesium	30	27	30
Iron	0.51	0.51	0.40
Phosphorus	64	67	48
Vitamins:			
Vitamin A (I.U.)	175	117	155
Vitamin C (mg/100g sample)	105	218†	103
Thiamin (mg/100g sample)	0.02	0.01	0.02
Niacin (mg/100g sample)	0.50	0.22	0.40
Riboflavin (mg/100g sample)	0.05	0.03	0.02

* Fruit immersed in a solution of 1 percent citric plus 0.25 percent ascorbic acid 3 minutes before freezing.

† Due to pre-dip in ascorbic acid.

The vitamin C concentration in fresh kiwifruit and in expressed juice is especially high—more than twice that in oranges. The tartness due to the acidity makes the juice particularly desirable for blending with bland juices, such as those of pear and papaya, or for use as a single-strength breakfast drink.

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