Olive Freeze-Injuries

effects of cold, radiation, dew, wind, and other conditions studied

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Minimum temperatures that olives can endure without freezing were investigated at Davis and Winters.

Frozen olives can not be used for pickling but are still suitable for oil extraction.

Olive fruits, immediately after freezing, assume a dark-green, water-soaked appearance. The injury occurs in spots or completely covers the fruit, usually extending to the pit. Occasionally, fruits which appear normal externally are frozen around the pit. Several days after thawing, the injured flesh becomes dark brown.

Microscopic examination shows that the cells of the frozen fruits are plasmolyzed, the protoplasm existing as a solid clump in the center of the cell rather than adhering to the cell wall as in unfrozen fruits. The oil droplets are retained in the cells as the cell walls are not disrupted.

There is no difference in oil content between frozen and nonfrozen olive fruits. Mission olive fruits frozen at 15° F for 16 hours had 17.0% oil after thawing, while unfrozen Mission olives had 16.6% oil. However, frozen olives left on the tree will lose a considerable amount of moisture eventually, thus showing an apparent increase in oil content. Olives frozen early in the winter will have a lower oil content than if the freezing occurs late in the winter.

To determine how long olive fruits can endure subfreezing temperatures without injury, a refrigerated chamber was used which could be adjusted to the desired temperature. For accurately recording the fruit temperature in each test, iron-constantan thermocouples were inserted into sample fruits and connected to an electronic recording instrument.

In each test, lots of 20 to 40 fruits were used which were left attached to shoots 12 to 18 inches long. Tests revealed that fruits left on shoots freeze in the same manner as fruits on the tree while fruits detached from the shoot are more resistant to freezing injury.

The endurance tests showed that olive fruits undercool considerably before ice crystals start forming. After freezing begins, the temperature rises immediately to 24° to 27° F, and occasionally to 29° F. However, ice crystals must form before injury occurs. In many tests fruits undercooled 8° to 10° F below their freezing point, but when allowed to warm up to room temperature showed no evidence of freezing injury.

In another test green Mission fruits attached to shoots were exposed for varying lengths of time to three temperatures: 22°, 24°, and 27° F. Thermocouples were inserted in sample fruits and the duration of exposure was calculated from the time the fruit actually reached the indicated temperature.

Before the fruits were placed in the freezing chamber, half of them were sprayed lightly with an atomizer containing water plus a wetting agent. The other half was left dry. The former treatment tried to simulate dew conditions.

The dry fruits proved much more resistant to freezing than the wet fruits. Dry fruits required exposure for one hour at 22° F before any freezing occurred and for three hours before an appreciable amount took place. This shows that the fruits can go considerably below their freezing point due to undercooling, but as no ice crystals formed, no freezing resulted.

Wet fruits froze more readily. Three hours at 27° F, or one-half hour at 24° F caused about 5% of the fruits to freeze. One-half hour at 22° F caused 80% of the fruits to freeze. However, even when wet fruits were held at 22° F for six hours, 15% of them failed to freeze. Although well under their freezing point such fruits were undercooled and, after removal from the freezing chamber, warmed up to room temperature without ice crystals forming or injury appearing.

The rate of warming from previous subfreezing temperatures appears to have little effect on the development of freezing injury. Fruits detached from stems, were placed in a 15° F chamber for three hours. One group, warmed up rapidly at 100° F, showed 5% of the fruits frozen. A second group, warmed up at room tem-

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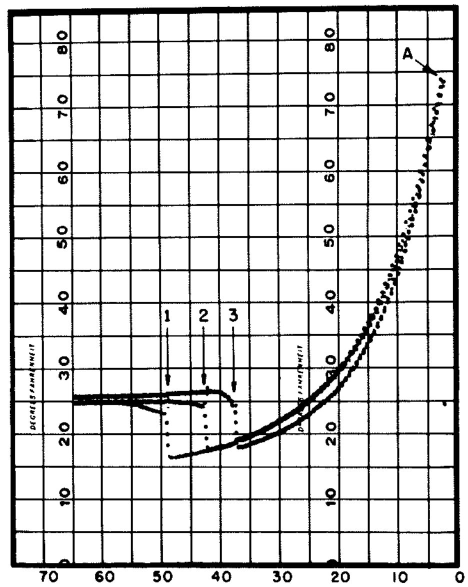

Temperatures of three sample olive fruits as printed by a recording potentiometer attached to thermocouples in the fruits. The fruits were placed in a 15° F chamber at "A." They undercooled below their freezing point, but when ice crystals started forming in the fruits their temperature rose immediately to the freezing point. Black fruit started freezing at "1", red fruit at "2", and green fruit at "3."

Per cent of Dry and Wet Green Olive Fruits Freezing at Three Temperature and Four Exposure Periods. Fruits Attached to Shoots. Mission Variety. Davis, California. Dec. 17, 1951.

Duration of exposure	Fruit temperature					
	*27° F Fruit condition		*24° F Fruit condition		*22° F Fruit condition	
	Dry	Wet	Dry	Wet	Dry	Wet
½ hour	0	0	0	5	0	80
1	0	0	0	5	10	70
3	0	4	0	11	55	90
6	0	36	0	28	65	85

* The fruits were allowed to cool to these temperatures before duration of exposure was recorded.

Effect of Fruit Maturity, Shaking, and Shoot Attachment on Percentage of Olive Fruits Frozen. Fruit Temperature—22° F for 3 Hours. Mission Variety. Winters, California. January 14, 1952.

Treatment	Total number of fruits	Number of fruits frozen	Per cent of fruits frozen
Different fruit maturities—Fruits attached to shoots			
Green fruit	43	33	77
Red fruit	61	17	28
Black fruit	22	2	9
Effect of shaking—Fruits attached to shoots			
Fruit shaken every ½ hour	38	38	100
Fruit not shaken	61	17	28
**Effect of shoot attachment*			
Fruits attached to tree	32	32	100
Fruits attached to shoots	99	99	100
Detached fruits	148	20	14

* 15° F for 2 hours.

in the surface 8″ to 10″ depth, which included the cultivated layer plus the soil from the furrows. Only a few slender roots penetrated the dense layers. There was no branching in the compact zone, but considerable branching in the more friable soil below.

Samples 21 to 24 were taken from a Sudan grass field on Yolo clay loam at Davis. They indicated compaction to a depth of 18″ with a resulting low infiltration rate. Sample 24, taken from below the 18″ depth, was only slightly more dense than is normal for this soil.

Root development in compact Yolo clay loam was studied in 60 core samples 4″ in depth. Two inches of loose sieved soil from the same location was placed on top of these cores, and beans, tomatoes, onions, sunflowers, and wheat were planted.

None of the crops had any appreciable number of roots in the compact soil, except wheat whose root diameter is smaller than that of the other plants. About 25% of the total wheat roots—by weight—grew in the compact layer.

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perature, showed 7% of the fruits frozen. A third group, warmed up very slowly in a box of insulating vermiculite, had 8% of the fruits frozen.

Maturity of the fruit has a marked effect on freezing injury, black fruit being more resistant to freezing than green fruit. This resistance apparently consists of the ability of the more mature fruit to undercool below its freezing point without ice crystals forming. However, there is little difference in the actual freezing point of olive fruits of different maturity.

To learn the effect of shaking the fruit on the incidence of freezing, a test was conducted in which the fruits were shaken at one-half hour intervals during a three-hour freezing period at 22° F. The shaking caused ice crystals to form in all fruits, with 100% of the fruits frozen, whereas only 28% of the undisturbed fruits were frozen. This would indicate that much greater freezing injury could be expected if olive fruits were shaken by winds or otherwise disturbed on the tree during a period when they were undercooled below their freezing point.

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American Cyanamid Co. Lederle Laboratories Division	1 pkg. folic acid—10 gm.
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In limited tests comparing the freezing injury of fruits of different varieties, little differences were found. The larger fruits, such as Sevillano or Ascolano, took longer to reach a given low temperature than did the smaller Mission fruits. However, the actual freezing point of the different varieties was about the same.

In the orchard, olive fruits are likely to be frozen during clear, cold, still nights, when conditions are favorable for radiation of heat from the olive fruits. The temperature of the olive fruits on such nights can be expected to be much lower than that recorded by a thermometer protected from radiation.

For example, on the night of December 8, 1951, a recording thermometer in a standard weather shelter at Winters recorded a minimum temperature of 31° F for about 1½ hours. In the same location another recording thermometer with an extended black bulb fastened above the shelter and exposed to the effects of radiation, recorded a minimum temperature of 24° to 25° F for seven hours.

Olive fruits on near-by trees probably endured temperatures similar to those recorded by the exposed thermometer. But an examination of several trees failed to show any frozen fruits. It is possible that the fruits undercooled below their freezing point without ice crystals forming. Or the olive fruits, being smaller than the thermograph bulb and more protected by the foliage, may not have radiated as much heat, and consequently may not have reached as low a temperature as recorded by the thermograph.

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