Frost Damage to Walnut Kernels

low temperatures during harvest season may cause injury to kernels resulting in chemical changes that produce rancidity

L. L. Claypool and Paul Esau

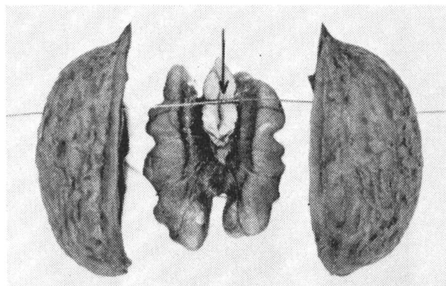
Late harvested walnuts in some areas of northern California—though not a common occurrence—have suffered considerable freezing injury to walnut kernels.

Recent heavy plantings of walnuts have been made in areas subject to frost at harvest time. As a result, serious harvest problems may be encountered in seasons when nuts mature late or when freezing temperatures occur in late October or early November. Since 1940, freezing weather has occurred in Lake County—for example—at harvest time in 1946, 1948, 1949, 1953, 1954, and 1955. In 1946 and 1948, weather conditions were particularly conducive to frost damage. In 1946, temperatures of 25°F or below were recorded on several days in late October and early November. Subfreezing temperatures—below 28°F—were recorded at instrument shelter level as early as late October, lasting one to nine hours.

Frost Conditions

For acute danger of damage by frost, several conditions must coincide: *1*, temperatures below 28°F; *2*, conditions favoring radiation, such as a clear night and a low dew point; *3*, at least partial defoliation of the tree; and *4*, high moisture content of the nuts.

Conditions favoring radiation and defoliation of the trees facilitate freezing, but temperatures below 28°F and high moisture content of the nuts may be—in themselves—sufficient for freezing to occur. When freezing temperatures occur during harvest time, the moisture content of the nut is likely to be high enough to result in kernel injury.



Walnut separated into its increment parts to show position of thermocouple junction—arrow—in kernel.

In slow freezing it is generally assumed that damage results from rupture of the cell walls by ice crystals. All later signs of damage are the result of this injury to the cells. Damage shows itself in several ways, depending on the condition of the kernel. The earliest sign of frost damage, regardless of kernel condition, is a darkening of the skin—the pellicle—of the meat. When fully mature frozen nuts are placed in storage in the 32°F–68°F range and exposed to spontaneous loss of moisture, no visible change in the texture and color of the meat occurs. However, exposure of mature frozen nuts to high temperature soon after freezing—as maintained in dryers—produces an oily appearance of the meat. Immature kernels after freezing show signs of internal collapse and become rubbery in texture. These outward changes are followed by odor and taste changes. The more rapid flavor changes of frozen kernels than of those not frozen are the result of chemical changes that occur in the oil. These changes may be oxidative or enzymatic, or both, and are known collectively as rancidity. A normal walnut kernel contains two protective devices that retard rancidity: *1*, the oxidative changes are retarded by an efficient antioxidant; and *2*, an effective barrier prevents the enzymes from attacking the oil. In a frozen kernel both systems are disturbed and these protective devices are removed. This allows rancidity to develop quite rapidly, depending somewhat on the temperature at which the nuts are held.

Influence of Moisture Content

Under controlled laboratory conditions, the freezing point of walnuts was related to moisture content. These results were an aid to interpreting data collected in the field at Davis on nights sufficiently cold to freeze walnuts.

During harvest the moisture content of kernels may range from 20% to above 40%, depending upon the degree of separation of the nuts from the hulls and

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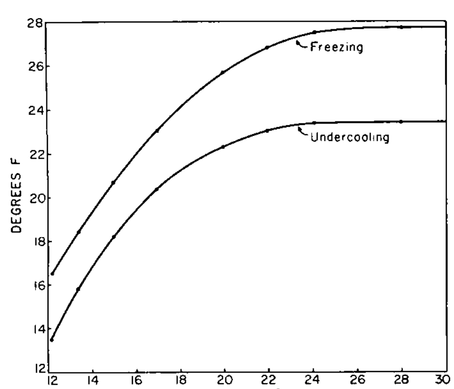
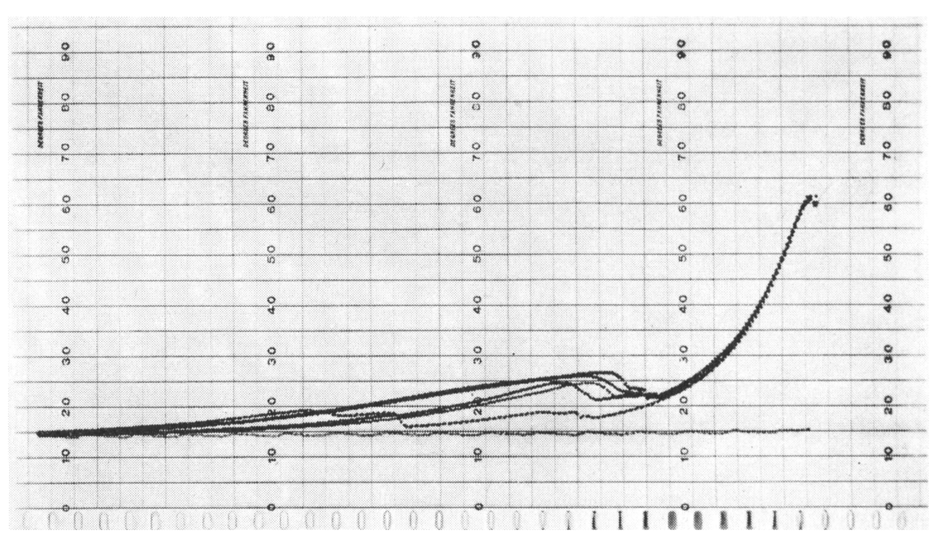
Freezing point and undercooling of walnut kernels in relation to moisture content.



Freezing of walnut kernels under laboratory conditions. Note the abrupt rise in temperature to the freezing point when ice crystals begin to form.



GLADIOLUS

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covered corms were grown again in 1955 and produced an excellent flower crop.

The yield of cormels and small corms —sizes No. 5 and No. 6—from the original two-thirds bushel was two bushels. These were hot-water treated and replanted the following year by the first grower. During the second year, the 10 bushels of cormels obtained by the second grower represented a ratio of 15:1 of the original two-thirds bushel stock. On this basis, multiplication of clean stocks from small lots of treated cormels would appear easy and rapid.

Advantages

There are numerous advantages of the hot-water treatment of gladiolus cormels. Bigger corms and a much higher yield of cormels are produced and most corms produced the first year are of blooming size.

Clean corms yield a higher flower cut and flowers are produced from smaller size corms when they are disease free. Furthermore, the same planting stock may be used for a number of seasons.

The hot-water treatment enables the growing of several varieties which demand a high price, but which have been unprofitable since planting stocks have become infested with disease. Also, treatment preserves rare varieties or new crosses and makes possible a more rapid increase.

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upon the length of time nuts have been so separated. If the moisture content of the kernels is above 25%, they will freeze at 28°F plus or minus 1°F. Mathematical curves showing the freezing point and degree of undercooling of hulled nuts of different moisture contents are shown in the graph in column 1, page 7. The graph in columns 2 and 3 on the same page shows a portion of a recorder chart of laboratory frozen walnuts. As the moisture content is reduced, the freezing point is lowered. Experimentally, no freezing could be produced at 10°F when the moisture content fell below 12%.

The undercooling curve reflects a phenomenon that may or may not occur to the same degree in nature. In this case, conditions favorable to radiation assume a role of consequence. A low dew point and dry ground may retard freezing and cause undercooling. Dew deposit or any other condition that promotes formation of ice crystals on the shell assists freezing without undercooling when the temperature of the kernel falls below its freezing point. The undercooling is of practical importance to the grower, for undercooling without freezing does not damage the kernel.

The degree to which a walnut may undercool is not predictable. As much as 10°F of undercooling was recorded in laboratory experiments. However, the majority of undercooling minima fell in the 0°F–4°F range. All data on walnuts frozen under field conditions fell in the latter range. The duration of undercooling is also unpredictable. Experimental values range from zero to 15 minutes, but conditions in an orchard might be somewhat different. The thermocouple is a foreign body in a kernel and, as such, it acts as a focal point where freezing may be initiated. The duration of undercooling may be greater under field conditions than under experimental conditions if no ice crystals form on the nut surface.

Influence of the Hull

When an early frost occurs, a substantial part of the crop may be on the trees with hulls intact to a varying extent. The moisture content of an intact hull or one just beginning to split is about 86%. This high moisture content favors freezing of the nut. Experimental freezing of intact hulls shows that the freezing point is the same as that for kernels of high moisture content, that is, 28°F plus or minus 1°F. The hull also may or may not pass through the undercooling stage before freezing, but whatever happens to the hull will affect the nut. If the temperature of the hull after undercooling rises above the freezing point, the nut will not freeze. But the kernel will freeze in the same instant if the hull freezes. Attempts to induce independent freezing of the hull and of the nut by creating a moisture-proof barrier between the hull and the shell failed.

The condition of the hull may serve as an indicator as to whether or not frost damage has occurred. A frozen hull breaks down quite rapidly. The hull of experimentally frozen walnuts became dark and mushy in 24 hours, staining the shell.

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ALMONDS

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copper chelate in 100 gallons of water produced an average kernel weight of 1.07 grams and no kernel shrivel. The copper content of the hull was 2.7 ppm—parts per million—and the copper content of the kernel was 7.3 ppm. The average kernel weight from trees not treated was 0.75 gram with 42% shrivel; the copper content of the hull was 1.4 ppm and 6.8 ppm in the kernel.

Experimental Treatments

Copper materials were applied both to the soil and to the leaves. Twenty pounds of copper sulfate applied in a trench around the base of a tree produced a marked response in the amount of new shoot growth and an improvement in leaf color. Applications of one pound of copper sulfate mixed with the soil at planting time, however, did not produce a response during the first year. Three pounds of copper sulfate applied to the soil around an extremely dwarfed older tree also produced a decided improvement in the condition of the tree.

During April 1955, spray applications of one pound of copper chelate per 100 gallons of water were made to a number of trees in the area. These sprays produced a marked response in the amount of shoot growth, an improvement in leaf color, and an increase in the copper content of the leaves. Marked response was also produced in the color and copper content of the leaves of Marianna plum grafts which had been placed on some of the trees.

The treatments were experimental applications designed to show whether or not copper deficiency was present. Experiments are underway to determine dosages which will serve to correct the deficiency and which will not be injurious to the trees in this orchard.

Varying Conditions

Response to any particular treatment does not always occur. Variations in soil type, growing conditions, species of tree, and perhaps rootstock are influential in the amount of response to various treatments.

At the present time it appears that, in California, the distribution of copper-deficient trees—of all species—is restricted to comparatively quite small areas in different districts.

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