Vapor-Heat Against Fruit Fly

variable factors affect injury to citrus and avocados in sterilization tests for control of fruit fly insects

Walton B. Sinclair and D. L. Lindgren

Eggs and larvae of fruit flies are destroyed by vapor-heat sterilization but the treated fruit may be injured. The kind and amount of injury depend on the tolerance of the fruit to saturated atmospheres at 110F and 120F for specified lengths of time.

To determine to what extent the vapor-heat method can be applied to California-grown citrus and avocado fruits—without injuring the fruit, lowering the composition or altering the flavor of the juice—a series of investigations was initiated at Riverside.

The effect of vapor-heat treatments on the fruit is markedly influenced by the variety of the fruit, the environment in which it is grown, the degree of maturity, and the quality of the fruit at the time the experiments are performed. All of these factors are highly important in the successful operation of the vapor-heat process for sterilizing citrus fruits against fruit fly larvae and eggs.

Citrus fruits—Valencia and navel oranges, grapefruit, and lemons—for the experiments were obtained from packing houses in the different citrus-growing districts of California. Each experimental sample consisted of from 10 to 30 boxes of orchard-run fruit. The fruit was treated in the picking boxes without cleaning or segregation.

Avocado fruit samples—Fuerte and Dickinson varieties—consisted of from 10 to 30 flats. The fruit was treated in the packed flats with the tops removed.

Treatments

The vapor-heat investigation required a room with equipment to control the heat, relative humidity, and circulation of the air in the room where the fruits being treated were exposed to saturated vapor, and the temperature gradually raised over a period of eight hours until the temperature at the center of the fruit reached 110F. This temperature was held for an additional 8¾ hours. Saturated vapor was maintained for the entire period of 16¾ hours. In the latter part of the investigations, the approach period—the eight hours required for the sample to reach 110F—was considerably reduced. The mortality of the eggs and larvae of the various fruit flies is dependent upon the latent heat released when water vapor is condensed on the surface of the fruit.

In some of the experiments, the sterilization process was performed by a modified vapor-heat method commonly called the quick-run-up method. The same principle of heat transfer is involved, but this method consists essentially in exposing the commodity to saturated vapor at 120F and subsequently removing the product when it reaches an internal temperature of 119F. As shown by other investigators, the mortality of the oriental fruit fly was complete at 119F.

The chief advantages of the quick-run-up method are that the time of exposure of the commodity to high temperatures is greatly reduced, and that the time required for the product to reach 119F depends on the heat capacity of the chamber and the size of the load. With citrus and avocado fruits, approximately four hours were required to reach this temperature.

Fruit Injury

The external physical injury of the heat-treated fruit was determined by observing each individual fruit in both the control and treated samples. Observations were made on the treated samples between 24 and 48 hours after removing them from the heating room. The samples were run through the regular packing-house procedures and, subsequently, placed in storage for observation of evidence of external and internal breakdown of the fruit.

The influence of the variable factors such as fruit variety, environment, and maturity is definitely manifested in the response of the navel orange variety to heat sterilization. Navel oranges grown in the Covina and Glendora districts of California have extremely soft and tender peels. As a result of the excessive soil moisture and of rainy weather, the peel becomes turgid and highly susceptible to checks and cracks. This condition is conducive to injury by the heat-sterilization treatments. Consequently, navel oranges from these two areas were severely injured by the vapor-heat treatments. On the other hand, navel oranges from the Riverside and Redlands districts have much tougher peels and, consequently, navels from these two areas withstood the heat treatments much better than fruit from the other two districts.

The amount of injury which occurred on late navels—April 7 to May 16, 1950—was highly significant at the 1% level. Other sterilization experiments showed that early maturing navels—January 2 to April 26, 1951—withstood the heat treatments better than the late season fruit. The total injury noted for the 110F and 120F treatments was barely significant at the 5% level.

The surface injury on the lemons was not quite as great as on the navel oranges, but the lemons did not store as well as the navels, for internal breakdown in the lemons occurred at ordinary temperatures on the packing floor.

Injuries to Valencia oranges and grapefruit were also influenced by the variable factors. Both overmature Valencia oranges and grapefruit were injured by the heat-treatment processes, but high-quality fruit of both of these varieties could withstand the heat treatments without physical injury to the surface of the peel. As far as physical injury to the peel is concerned, the experimental data obtained in this investigation demonstrated that Valencia oranges and grapefruit could successfully withstand the vapor-heat treatments better than either the navel orange or lemon varieties. In fruits which were susceptible to injury, the rind collapse and internal breakdown were usually of sufficient magnitude to cause losses to growers by increasing the number of defective fruits and by reducing the storage life of the fruit.

As a result of the heat treatments, a marked reduction occurred in the titratable acidity and the ascorbic acid of navel and Valencia oranges, grapefruit, and lemons. This decrease in free acidity of the treated fruit was accompanied by a corresponding increase in the pH—relative acidity-alkalinity—of the juice.

The soluble solids of the treated fruit had a tendency to be slightly lower than those of the control fruit.

Effect on Flavor

The vapor-heat treatments altered the taste of the citrus fruits and produced off-flavors which could be detected by

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Use of Iron Chelates

supplying plants with iron through soil treatment limited to high-value plantings

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Use of chelating agents—especially the new compound Fe 138—to correct iron chlorosis by effectively supplying iron to plants has proved promising in a series of experiments.

All plant species tested—but not all individual plants—responded to treatment, and some of the individuals within species did respond with retreatment.

Treatment responses in the field have lasted from two to six months. Woody plants treated late in the summer have given good responses. Responses are more difficult to obtain for large trees than for small trees and shrubs. Some large trees required several months following treatment to become green.

None of the polyamine polyacetate chelates—of which EDTA is the best known—tested in the experiments has proved as efficient in correcting iron chlorosis by soil applications in California as in Florida. The reasons for this difference have been intensively studied.

Absorbed by Plants

Iron chelates supply iron to plants by being absorbed as a single molecule by the plant. Present evidence suggests that the chelate also helps effect translocation of iron in plants. The mechanism of release of the iron from the chelate within the leaf or the ultimate fate of the chelating agent in a plant is poorly understood.

The chelating agent, DTPA, has been a better source of iron for plants in many, but not all, calcareous soils than has either EDTA or HEEDTA. All three of these agents can be toxic.

Iron chlorosis in California almost always occurs in basic calcareous soils. Iron is precipitated as the hydroxide from chelates in basic solutions. In simple systems such as nutrient solutions this reaction proceeds very slowly, but in a clay suspension at alkaline pH—relative acidity-alkalinity—values above seven—neutral—the reaction proceeds rapidly. Apparently clay catalyzes the hydrolysis reaction by which iron is precipitated. In addition, the chelated molecule itself is fixed to a considerable extent under either basic or acid conditions in some soils, and this appears to be related to the amount and kind of clay in the soil. The mechansim of this fixation is not known, but reaction rates indicate it is not a simple exchange reaction. Soil organic matter, moderate amounts of salt in the soil, or soil microorganisms have very little effect upon the solubility of iron chelates in the soil.

Other Agents Studied

Additional chelating agents of the same family of compounds as EDTA that are capable of keeping iron soluble in basic solutions better than does EDTA have been studied. These were disappointing because they also were fixed on the clay portion of the soil, as was EDTA. Fixed iron chelate is a poor source of iron to plants as compared to soluble iron chelate. Within limits, iron chelate fixation in soil usually varies with the rate applied. Application of iron as the EDTA chelate at the rates of 40, 160, 320, 1,280, and 2,560 pounds iron per acre of soil to samples of Dublin silt loam containing 57% calcium carbonate, resulted in 85, 74, 68, 42, and 32% of fixation in 72 hours. These values represent the summation of both methods of fixation. Even the 40-pound rate is of doubtful economy for orchard operation. Smaller application rates in the field have proved ineffective, while in the laboratory such low rates are almost completely fixed within 24 hours. Rates beyond 160 pounds iron per acre have often been toxic.

The decreasing rate of fixation of chelated iron with increasing application rates does not necessarily imply that the soil becomes saturated. Some clay minerals did not exhibit a change in per cent of fixation with increasing application rate in the range studied.

New Chelates

Among a number of new chelating compounds supplied by the chemical industry one, an aromatic amine, designated Fe 138, appears especially promising for use in calcareous soils. There is little precipitation of iron from this chelate in calcareous soils during extended periods. In fact, this chelate performs the prodigious feat of solubilizing iron in calcareous soils. It has effectively supplied iron to a number of plant species and corrected chlorosis. It appears to be much less toxic to plants than is EDTA. The evidence obtained to date indicates Fe 138 is not readily decomposed by microorganisms and is not absorbed appreciably by the clay fraction of the soil. Although these data are highly encouraging, it must be emphasized that extensive testing will be required to evaluate the chelating compound.

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the taste test. The heat treatments destroyed the fresh delicate flavor of the navel orange, and the loss of flavor and the reduction in acidity of the fruit gave the treated navels a flat taste.

The off-flavor in the lemons was considerable. The treated lemon samples which exhibited internal breakdown during subsequent storage developed extremely bad off-flavors.

Off-flavors could be detected in grapefruit and Valencia oranges, but they did not occur or develop in the storage of these fruits to the same degree as they did in the navels and lemons.

Injury to Avocados

The avocados tested—Fuerte and Dickinson varieties—would not tolerate a 16-hour treatment in a saturated atmosphere at 110F or the 120F temperature of the quick-run-up method.

All avocados were damaged by the vapor-heat treatments. The injury to the fruit consisted of off-flavors, rancid odor, and darkening of the interior. These injuries were intensified on storing the fruit at 50F for one week. The high, moist temperatures of the vapor-heat treatments appeared to inactivate the enzyme systems of the avocado fruits to the extent that treated fruit failed to ripen normally. In storage, the treated fruits were readily attacked by fungi, and consequently deteriorated very rapidly.

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