

The Borax Treatment of Citrus Fruit for Prevention of Decay

H. R. Fulton, U. S. Bureau of Plant Industry, Washington, D. C.

Practically all of the decay of Florida citrus fruit after leaving the tree is either blue mold rot or stem end rot. The control of these two forms of rot is a factor of prime importance in the successful marketing of the crop of any season. For stem end rot five methods of control have proved more or less effective as follows: (1) Pruning out of dead wood, the breeding ground for the two fungi that produce stem end rot. Pruning is more effective against *Diplodia* than *Phomopsis* stem end rot, but on the whole must be rated as probably not more than 50% effective. (2) Spraying the young fruit with bordeaux oil emulsion for melanose control cuts out about half of the stem-end rot in the matured fruit after picking, and is more effective against *Phomopsis* than against *Diplodia*. (3) Disbuttoning, properly carried out, is over 95% effective against both forms of stem-end rot, and may be accomplished during the precoloring process by maintaining humidity above 90% with temperature between 80° F. and 90° F. (4) Prompt handling. Both types of stem-end rot are relatively slow in starting on the fruit after picking, and seldom cause appreciable loss in less than ten days or two weeks from the tree unless temperatures are abnormally high. (5) Low temperatures

greatly prolong the development period of both types of stem-end rot, and are very effective in the successful marketing of fruit subject to this decay. To a large extent this merely postpones decay, and shifts the burden of loss to the buyer. It will be noted that two of the foregoing control measures, pruning out dead wood and spraying for melanose control, are in the hands of the grower of the fruit; the other three measures, disbuttoning, prompt handling, and subjecting to low temperature, are in the hands of the shipper.

Effective control of blue mold rot in the past has involved three things: (1) careful handling at every stage to prevent the breaks in the skin necessary for blue mold infection. (2) keeping the surface of the fruit as dry as possible, so as not to have continuous moisture long enough for blue mold spores to sprout and grow. (3) temperatures low enough to greatly retard the growth of the blue mold fungus, which means about 45° F., some ten degrees lower than an effective temperature for stem-end rot control.

For a long time fruitless search has been made for a satisfactory chemical agent that will control these rots. For several years the U. S. Bureau of Plant Industry has been investigating blue mold

control by fungicides, following a different line of attack from those previously used. It was found that dipping the citrus fruit in 5% solution of borax (40 pounds borax in 100 gallons water) protects it against blue mold decay to a marked degree. Leaving a certain amount of the borax sediment on the fruit makes the treatment more effective, and subsequent brushing of the surface-dry fruit, as in packing house polishing, does not materially lessen the effectiveness. Increase in temperature of the solution and prolonging the exposure to the warm borax up to the limit of tolerance of the fruit increase the effectiveness very materially. The treatment is highly effective even 24 to 36 hours after the fruit has been subjected to blue mold infection. A very fortunate and entirely unexpected development in the testing of the borax treatment is its very high effectiveness against both types of stem-end rot, after either hot or cold applications.

COLD BORAX TREATMENT

In packing house operations the simplest and least expensive type of installation is for the cold borax treatment. All that is necessary is a small tank with a conveyor, through which the fruit may pass after being washed and scrubbed, and before entering the drier; or else a sprinkling device that will wet the fruit thoroughly with the borax solution after it has been scrubbed and before it is dried. In the latter case, the borax spray is caught in a pan and recirculated by means of a rotary pump. The solution, if kept reasonably clean, may be used for a week or two without renewal. Attention must

be given to maintaining its proper strength. In cool weather, if the temperature falls below about 68° F., the saturation point will be lowered to less than 5% for borax, and it will be necessary to use some means of keeping the temperature above 68° F. in order to maintain a full 5% strength. If water brought in on the surface of the fruit from the scrubbers tends to dilute the solution, a slight addition of borax from time to time will be necessary to maintain the proper strength. Concentrations of solution up to 10% do not injure the fruit, but leave a too conspicuous sediment, and are only slightly more effective than 5% solution. With the 5% cold treatment the polishing brushes take off occasional blotches of unsightly sediment, and the fruit has a good appearance after treatment, even though the surface carries an inconspicuous coating of fine borax crystals sufficient to protect against later infection. In extensive laboratory tests on commercially handled fruit of inferior grade, held after treatment at 70° F. with high humidity,—conditions that would give every chance for rot to develop,—it has been found on the average that something over 50% of the blue mold decay and almost 75% of stem-end rot are prevented, over a two to three weeks' marketing period. These degrees of effectiveness have been fully maintained in commercial shipments. The cost is only a fraction of a cent a box. One dollar per car is ample to cover all costs of the cold borax treatment. About 50 packing houses have used it during the past season in Florida.

HOT BORAX TREATMENT

Preliminary laboratory tests have shown increased effectiveness of the borax treatment with progressive rise in temperature when the fruits are allowed to remain for several minutes in the hot solution. For several years in California lemons and to some extent oranges, have been washed for four or five minutes in water at 115 to 120° F. for the control of brown rot. It was thought that this experience in California would be a fair guide for the tolerance of citrus fruits for the hot borax bath, and our first tests were made at 120° F. with exposure for five minutes. The internal temperature of the fruit in such brief treatment was not greatly raised, and the quality of the fruit was not adversely affected. Under the rather moist holding conditions maintained in the tests so as to promote rot, the hot treated fruit maintained a normal plump appearance, with however a distinct surface deposit of sediment or grey bloom. This hot treatment increased the effectiveness to over 90% for blue mold rot, and to about 80% for both forms of stem-end rot. The hot borax treatment is being tried in two or three packing houses in this state. In some cases an "aged" appearance has developed in the fruit after hot treatment; it has been found advisable to try lowering the temperature to 106 or 108° F., and to remove some of the borax with a 2½% borax spray or a water spray as it leaves the borax tank. This procedure is being tried extensively in California. Experimental tests have shown that each of these changes is in the direction of lessened effectiveness of the hot treatment,

and the combined result would probably give an effectiveness intermediate between the cold borax dip and the 5-minute bath in 5% borax at 120° F. The fruit so treated has been arriving at market in a generally satisfactory condition, as has that from a number of packing houses in which the cold dip is used. Whether severe shipping conditions would show material difference between the cold and the moderately hot treatments remains to be seen. It is still too soon for a final conclusion as to the exact temperature and concentration and degree of removal of borax deposit that will give the highest degree of effectiveness with due regard to highly attractive appearance of the fruit on the market. It is not unlikely that discriminating buyers will not object to a little borax on the fruit for the same reason that some people like to have visible evidence that apples have been sprayed — to have assurance of good 'keeping quality.

An installation for the hot treatment must include a tank of sufficient size to give approximately 5 minutes in the hot borax solution; a device to keep the fruit properly submerged and to insure a slow enough passage through the solution; suitable heat piping in the tank, and a boiler or other means for supplying the heat. The cost is greater than for the cold treatment on account of more expensive installation, fuel, attention to operation and regulation, and larger amount of borax thrown away in renewal of the solution, when necessary, in the larger tank. Even with these items figured in the hot borax treatment ought not to cost more than two or three dollars a car when the

equipped unit is working at full capacity.

Under Florida conditions, with stem-end rot to be considered as well as blue mold rot, and with little difference between hot and cold treatments in effectiveness against the former, it may be that the cold treatment will meet most of the requirements for ordinary shipping conditions, and certainly offers a convenient and inexpensive means of trying out the method. Under very trying shipping conditions the added effectiveness of the hot borax treatment would certainly be desirable; but this treatment must not be pressed to the point of market loss from sediment or aged appearance. Ordinary hard water as well as soft water has been used satisfactorily for the cold borax treatment. Even with the hot treatment it seems unlikely that chemical reactions taking place between the borax and the dissolved mineral salts in the water would materially lower the percentage of effective borax, or produce enough sediment to form an unusual objectionable surface deposit. There is some evidence that surface deposit sometimes becomes gradually more prominent with ageing of the solution in the tank after using a week or ten days, even in the cold treatment. To keep tab on the strength of solution, hydrometer and temperature readings are taken, and the corresponding borax percentage

Member: I would like to ask about the drying of this fruit. Does the test show there is any difference in drying after the borax is used, and is there any difference between the hot and cold?

Dr. Fulton: If anything, the cold borax solution dries more rapidly than the

looked up in a reference table. An effective strength of solution must be maintained and excessive concentration avoided. Intelligent supervision is required for this.

It must be remembered that even small amounts of borax in the soil affect growing plants of various kinds to a serious degree, and the disposal of waste borax solution must be watched with this in mind. The addition of hydrated lime to the borax solution some hours before the tank is emptied will convert much of the soluble borax into an insoluble form and lessen the chance of its injuring vegetation.

Whether or not the borax treatment will completely replace any of the older methods of controlling either blue mold rot or stem-end rot remains to be seen. At its best it is not 100% perfect, and the part of wisdom is to go slowly in modifying established methods of control and note carefully the effects under all sorts of conditions,—to regard this new chemical method of control as an additional fighting unit in the warfare against these destructive rots of citrus fruits. Its use gives promise of extending the market range for citrus fruit, and of increasing consumer-satisfaction, as well as of lessening losses from rot in transit.

water. The hot solution certainly dries very much more rapidly than water.

Mr. Warner: I would like to ask regarding the methods of heating that water. What methods have you?

Dr. Fulton: I am going to ask Mr. Andrews to answer that if he will.

Mr. Andrews: Recently I have been to California. It takes considerable heat to carry on 110° or 112° treatment. In the Winter Garden houses, for instance, we have as high as a 15 horse-power boiler, which on cold days is working to capacity to maintain 120 degrees. In California, where they have natural gas, they generally use low pressure steam boilers. There were about twenty houses using them, of maybe 5 to 8 and 10 H. P. It will develop that for a six car house you would have to have a 6, 8 or 10 H. P. boiler to hold the water at 106 or 108°, and be sure you are going to protect your fruit on a cold day.

Two or three things we have observed in a practical application might be of interest. This white deposit on fruit that Dr. Fulton speaks about. If we put borax through our washers we find the rolls get a little whitish appearance. Sometime ago in Winter Garden, the deposit was so bad that they were going to discount the fruit on the New York market on account of the white deposit. We had to spend a day to boil those rollers and get the mixture off. If you have a wooden roller, run the drier for 8 or 10 revolutions, and spray with warm water, and you get that deposit off.

We have found in buying borax — there is a fine pulverized form that you buy for household use. If you throw that into a tank for the cold borax treatment, it takes a long time to dissolve. It is much better to take a crystal form, one-quarter inch in diameter. Then the water can circulate through the crystals, and they will dissolve away and go in the solution much quicker.

Member: This might be of interest. We put in a hot borax plant in December. Previous to putting it in we were getting on the average of 5% to 10% decay under ice, and since putting in the plant we have shipped in the neighborhood of 75 cars with less than 1% decay, using the hot treatment. It took exactly five minutes for the fruit to go through and in heating the solution to 105°, the fruit got in dry — it burned the fruit up. After shipping 8 or 10, we cut it down to 85° of 5% solution. That held up 14 days. One sample out of ten would be 100% perfect, and I have found only one decayed orange at the end of fourteen days in any sample that we have had. We never had any trouble with borax on the fruit, but we still get reports on its being aged and dry when only heated at 85°. At another house we tried the cold borax, with no results. In this house here, it is washed, and goes in at 85°, and from there into the drier and through the polisher.

At the Clearwater house, after trying out this cold borax solution, without results, I put in what is called an alkali special by-product. We were shipping under ice with decay, but since using that we ship getting 1% decay, while a neighboring house, shipping under ice, is getting more decay than we are.

I am still using one solution in one house, and the other in the other. In heating the water at Valrico I use two gasoline drums, with an ordinary cast-iron coil, and have a circulating pump to pump the water out and back into the vat. On a warm day, I keep water at 85°. I made a 5% solution, and at 85°, by

using an ordinary hydrometer, I tested it with that, in order to find what I knew was 5% solution.

The other is about a 2% alkali Special; I buy it at Mr. Skinner's place at Dunedin.

Mr. Chase: I was in California the latter part of January or the first part of February, and I visited some of the packing houses out there that are using the borax solution. California fruit is troubled with blue mold. Our trouble comes mostly from stem-end decay, so we can't confuse the California experiments with Florida experiments. One of the big packing houses of the California Exchange was one of the first houses to make a trial test of the borax solution. Last August or September they shipped 37 cars and out of the 37 cars there were 30 cars that went through without any decay whatsoever. There was a 1% decay discovered in the balance 7 cars. Those cars moved under ventilation.

The U. S. Department of Agriculture had two very good men in charge of the work at that point — Mr. Lon Hawkins and Mr. Barger, and they gave me all their data, and showed me all their machinery and equipment. They advise a temperature of 110°, and they keep the solution hot. They were under the impression that it would be advisable to have the hot solution here, but from the experiments that have been carried on in the Florida packing houses, and the appearance of fruit at destination, I am rather of the opinion that it would be rather dangerous for Florida to make use of the hot solution. I also am of the opinion that it is too hot. If it went up to 110°, which they thought in Califor-

nia would be the desirable temperature, I think it would be too hot. 85 degrees would be all right. They thought at that time it would be necessary to have a hot solution in order to bring about a penetration of the borax solution, but I have found out since that they have been unable to find any penetration. They are trying to determine now whether there is a penetration, and a benefit from that penetration.

There were a number of other interesting matters I ran across in California that would be of great interest to the Florida growers. I visited Mr. Shammel, at Riverside. Mr. Shammel, we all know, has done more in citrus bud selection than anyone else, I suppose, in this country. I ran across him first in 1911, when he was beginning his work. After that they permitted him to carry on some very extensive experiments in Riverside, and the results of those experiments show that the bud runs through to the parent tree; that is if it has good qualities they are perpetuated in the bud; if they have bad they also are perpetuated in the bud. Mr. Shammel showed me some trees that were the result, purposely, of defects in the parent tree, that came out in the bud. If they were shy bearers, it showed up, in the bud. If they were extensive bearers it showed up in the bud, and I feel that the knowledge gained by Mr. Shammel would be of inestimable value to the Florida Citrus Industry. I brought that matter up to Mr. Shammel to see if his services could not be assigned to Florida for a period, so we could get the benefit of his knowledge, and perfect some mistakes that I know are going to be very

expensive, unless something along those lines is done. Mr. Shammel seemed to think that if possibly strong enough appeal went up to headquarters he could be transferred from California, and the Florida citrus industry would get the benefit, and I would like to see if something could not be done along those lines at this meeting.

Mr. Skinner: Prepare a resolution, and bring it in a little later in the day, please.

Member: I would like to ask about the time during which the fruit is saturated, —whether he has experimented with a lesser period.

Mr. Fulton: Yes, we have simply wet the fruit with a cold solution, and will bring just about as good results as soaking for four or five minutes, provided the wetting is thorough. With the hot solution it is necessary for the fruit to be in something like five minutes, in order to get the skin warmed up, and get the benefit from the temperature.

Mr. B. C. Skinner: What is the effect of the borax on the drying of the fruit? I believe he was answered that the fruit dried more readily with it than without it, and that is contrary from what we get from the machinery end. Complaints are that if we put borax on we can't get the fruit dry. I was wondering if Mr. Andrews had any experience in the Winter Garden house on the drying end of it.

Mr. Andrews: With the cold borax I

believe we have noticed that it dries a little bit slower; with the hot borax, the heat that is applied to the skin of the orange furnishes the heat of evaporation, and while the Winter Garden drier is very inefficient on account of being rebuilt, we are able to get it dried, except on a very cloudy morning, but with the cold borax I believe there is cause for complaint on a little slower dry.

Dr. Fulton: In making my statement a while ago I was thinking about the drying where there is an equal amount of moisture. Ordinarily when the borax treatment is used I find the fruit comes in with more moisture on it, because ordinarily more or less of the surplus moisture is taken off.

Mr. Barney: Do you heat the air that you pass through the drier?

Mr. Andrews: It has been tried. Arcadia tries cooling the air, which serves the same purpose. They put lots of ice before the fan, and wring the moisture out before it goes in. Winter Garden now has a heating arrangement to heat the air.

Mr. Warner: I don't quite understand about the ageing effect.

Dr. Fulton: That ageing effect is puzzling us also. It is still in the investigation stage.

Mr. Allen: Does this borax in any way affect the eating qualities of the fruit?

Mr. Skinner: Not at all.