THE USE OF ARSENIC ON CITRUS FRUIT FOR PROCESSING

A REVIEW

GRAY SINGLETON
Salada-Shirriff-Horsey Inc.
Plant City

The purpose of this paper is to bring up to date, in one place, much of the bibliography of arsenic as related to the culture of citrus fruit; to comment briefly on some of the references cited and to discuss some work not heretofore published.

Miller, Bassett and Yothers (18) have made a detailed study of the effects of arsenic when applied to citrus. Their references to previous work is the most complete list that I have seen. I have taken the liberty of using their list and adding work published since 1933, when their bulletin was written.

It is not likely that we will ever know who first used arsenic on citrus. In the early days of agriculture in Florida lead arsenate and paris green were practically the only insecticides available and it seems reasonable to suppose that, when insects attacked citrus trees or fruit, the grower applied anything, including derivatives of arsenic, in an effort to kill the pest.

It was not until the organization of the Florida State Horticultural Society that we had a forum where such matters as the use of insecticides could be discussed and recorded. At the meeting of the Society held in 1894 a round table discussion of citrus insecticides (5) brought out statements that a number of orange growers had been using a proprietary insecticide called Thrip Juice. Yothers (17) states that this preparation, when analyzed later, contained 2.2% arsenic, calculated as the metal. This would be 10.12% calculated as lead arsenate.

The growers had noticed that the acid in the fruit was reduced (5) and maturity was hastened when Thrip Juice was used. Dr. Yothers paper reads, in part, as follows:

“For many years it has been known to at least a few Florida citrus growers that sprays containing arsenic would “sweeten” by largely eliminating the acid content. It is not known to us who was the first grower to discover this phenomenon. While there may have been several growers before 1894 who knew of the effect of arsenicals, we only have definite information about one.

“Some time before 1894 Mr. F. G. Sampson, Boardman, Florida, used Thrip Juice to kill scale insects. Again between 1904 and 1910 Mr. J. A. Farnbach used the same spray for scale insects in Mr. Sampson’s grove. An analysis of this spray, made several years later, showed that it contained 2.2% arsenic as metallic arsenic. While there is no proof that the material used in 1894 and in 1904 to 1910 was of the same composition, we surmise that it was identical. According to Mr. Farnbach’s observation, the application of this spray rendered the fruit insipid and he claimed that arsenic was the cause of the great change in the fruit. The laborers nearly ate up the crop before the fruit had colored. Mr. Farnbach’s statement is verified by another man who had been on the grove throughout the past 35 years.”

Miller, Bassett and Yothers (18) state as follows:

“Soon after arsenic was first used on citrus in Florida—in 1893, by Lyman Phelps—it was found that the fruit on arsenic sprayed trees matured more quickly than other fruit.”

H. W. Marsh stated before the Florida State Horticultural Society (5) in 1894 that Mr. J. E. Wilbur, of South Lake Weir, and Mr. Tilson, of Orange Bend had shipped fruit a month earlier than usual by spraying with Thrip Juice.

Arsenic was not very effective for scale on citrus so, when oil emulsion became available, arsenic was dropped as a spray and was nearly forgotten.

Time passed and the growers noticed that the first shipments to reach the market at the start of a new season brought better prices than crops harvested later. This brought on a race to be the first to ship. There were no maturity laws. Packing houses shipped when they pleased.

Finally the market refused to accept Florida fruit and maturity laws had to be passed to restore the confidence of the buyers in
the eating quality of our fruit. (6) (7) (8). When the ratio of soluble solids to acid became the basis for estimating maturity, low acid became important. Under the new laws certain growers in Manatee county were able to ship fruit a month or six weeks ahead of the other counties.

As this time I was chemist for the Independent Chemical Co. I had never heard of Thrip Juice or arsenic sprays. The Company operated a phosphate mine and six fertilizer plants. Our customers frequently sent me samples for analysis. The Company made no charge for this service. I thought nothing of it when four of our customers sent in samples at about the same time. Three of these samples were lead arsenate. One was lime.

I knew nothing of what was going on until several years later when two of the customers who had sent in samples of lead arsenate came to me, separately, and told me that they were in trouble. Their groves, both owned and leased, were dying. Both told the same story. They had hired men to steal spray material from spray crews on Terra Ceia island. These were the samples that were sent to me. The sample of lime, I was told later, was from 2,000 pounds that was supposed to have been stolen from the same crews. The grower paid $2.00 per pound for the lime.

I was told that the spray crews on Terra Ceia were using 300 gallon spray tanks. They dissolved 4 pounds of lead arsenate in the desired amount of 32 degree lime-sulfur solution before putting the lime-sulfur in the tank. They diluted to 300 gallons for use. The growers who came to me said that they had used 7 to 8 pounds of lead arsenate to 100 gallons of spray on the theory that if a little was good, a great deal should be much better. They wanted to make very sweet fruit which they could mix with cheap, sour fruit which they could buy. The mixture of sweet and sour fruit would pass the maturity test but most of the mixture was not fit to eat. Now, some of these groves were dying and the growers wanted help—quickly.

I examined the groves and found that some had been killed back to limbs two inches in diameter. Other groves, sprayed in the same way with the same amount of arsenic, showed no damage. I could find but one variable. The unhurt groves had been sprayed with bordeaux.

Analysis showed that there was practically no arsenic in the roots, trunks, large limbs or fruit on any of the groves. Arsenic was accumulating in the young growth in the damaged groves. When the concentration of arsenic, calculated at \( \text{AS}_2\text{O}_3 \), reached two parts per million total arsenic, the new growth died. There was little or no arsenic being deposited in the new growth of the trees that were sprayed with bordeaux. Test trees in the damaged groves were sprayed with 4-4-50 bordeaux. Accumulation of arsenic in the new growth slowed down and stopped. The new growth quit dying. The trees recovered. These same groves are still being sprayed with arsenic every year but they are in fine condition after 35 years of arsenic sprays.

It appears that bordeaux is in some ways connected with tree recovery. Why this should be, I do not know. Some chelating agent might be better.

It is quite likely that a large part of the arsenic used on citrus groves is wasted in one or more of three conditions that can make the arsenic ineffective. These conditions are:

1. Putting arsenic into the spray in an insoluble form.
2. Mixing soluble arsenic into a spray which makes the arsenic insoluble.
3. Applying arsenic to groves which are in a hungry or dormant condition.

The last condition listed probably wastes more money than any other practice. Only water-soluble arsenic is effective in speeding up the respiration rate of the tree. (18) making it actually live faster and mature its fruit earlier. This acceleration metabolism does not occur at the optimum rate unless the tree is in a healthy, vigorous condition. Putting arsenic on a hungry tree does more harm than good. The increased respiration puts a strain on the tree that results in a condition similar to that of an overworked and underfed horse. Much of the trouble that has been caused by arsenic has been due to the spraying of trees which had not been prepared to speed up their rate of living. For best results an application of nitrate should be put on shortly before spraying or dusting with arsenic.

In the literature we note variations in the results of different investigators which may be due to differences in the preparation of trees to receive the spray. Some growers apply the
arsenic two or three weeks after the May fertilization with good results.

We now come to the processors and the problems that he faces where arsenic is concerned. The outstanding problem lies in the fact that all growers want to ship to fresh market in September. They use arsenic accordingly. The processor wants early fruit and he wants it to have arsenic but when he buys fruit for sections in January or February he does not want fruit that should have been picked in October. It is too soft. It breaks down in the can and goes to mush.

The processor does not want mixed fruits for sections and will not buy it if he knows it. Fruit that has been held too long after it was mature is often mixed with fruit that will not pass the maturity test. The overripe fruit mixed with green fruit sets up processing problems that have not been solved. The temperature and scalding time may be right for one but cannot be right for both. The strength and temperature of lye solution may be right for one but cannot be right for both. The result is usually a compromise which results in soft, mushy sections and green, ricey sections in the same can. This does not encourage the consumer to eat more citrus.

The ideal situation, from the point of view of the processor, is to have a graduated program where varying amounts of arsenic are applied so that the crop can move to market in an orderly way without getting overmature. When all of the growers try to ship during the first few weeks of the season a few will make it, but the vast majority will hold their fruit until it is overmature and starts to drop from the tree. Then the grower cuts the price to move it quickly.

It is my firm conviction that all grapefruit shipped or processed before the first of April should have some arsenic. We could greatly increase the utilization of grapefruit if we could furnish to the consumer a product without too much acid and without the harsh, bitter naringen which sends the customer looking for other juices and other fruits. But we do not want all of it to be ready in September. We need good fruit through the entire season and we will realize the maximum return for both fresh and processed fruit when we have a graduated spray program that will get our fruit ready as we need it. Our experiment stations can work out such a program and it could give us much better fruit. They now have most, or all, of the data needed.

Up to this point we have been considering grapefruit because it is legal to use arsenic to speed up the maturity of this fruit. It is not legal on oranges or tangerines. The reason for this difference in the law lies in the fact that we are not likely to produce insipid grapefruit by the use of arsenic. It is practically impossible to do so. On the other hand, oranges and tangerines require only a small amount of soluble arsenic to make them insipid. The danger is not in the insipid fruit itself but in the fact that a little fruit with a 35 to 1 ratio can be mixed with a large amount of 6 to 1 ratio and, if there is enough juice, the mixture will pass the maturity test. It will not pass the taste test of the customer who eats one fruit at a time and who does not like, and will not buy, oranges or tangerines with a 6 to 1 ratio. The processor wants only medium ratios, neither high or low.

Before it became illegal to use arsenic on oranges and tangerines it was common practice to dust the tops of the trees lightly with 5% lead arsenate in lime-sulfur dust. If the trees are dusted evenly from top to bottom the dew and rain will bring too much dust down to the lower branches. The lower fruit becomes insipid while the top fruit is still sour. By putting all of the dust on the top third of the tree a fairly uniform maturity may be secured.

It is most unfortunate that the mixing of arsenated fruit with unarsenated can be used to move fruit into the fresh market and processing plants before the unarsenated portion is mature. If this could be controlled by inspection in the grove, as it is in Texas, we could greatly improve the eating quality of mid-season oranges and tangerines.

Arsenic improves the color of the juice of seedling oranges and tangerines so much that the juice of seedlings is fairly comparable to that of valencias. The juice of tangerines changes to the deep red color of Clementines. The best flavored oranges and tangerines that I have tasted were dusted very lightly in early June with 5% lead arsenate in lime-sulfur dust.

One of the most useful effects of arsenic on oranges is to dust valencias when they start splitting. The acid in the fruit is already
formed and the arsenic has no effect on the ratio or flavor.

It will be noted that the last two references cited (27 and 28) are written for the grower as well as the scientist. They tell him the how much, when and how of the use of arsenic. They tell him what to expect under given conditions.

It should be remembered that the juice content Law is one of the limiting factors in legal maturity of citrus fruit and that a small amount of arsenic, properly used, will bring the brix-acid ratio in line before the juice content is ready. With this in mind it is increasingly important that we use more arsenic in small quantities to make our mid-season fruit more acceptable to the consumer who does not like bitter, sour grapefruit. This is more important than early maturity.

The scientist will appreciate the great accuracy of Dr. Longfield-Smith’s modification of the Gutzeit Method (28) for arsenic determinations. This is important because, at most, the chemist is working with only a few parts per million. The sharply defined stains resulting from this modification make it possible to read results to a small fraction of a part per million.

**Summary**

The processor wants good juice and sections through the entire season and not just for the first few weeks only. A very small amount of arsenic, properly applied, improves the palatability of grapefruit products through March, and some seasons, even later.

**Acknowledgments**

The Author wishes to express his sincere appreciation for assistance rendered by:

Dr. B. A. Porter, Chief
Fruit and Vegetable Insects
Research Branch
United States Department of Agriculture
Beltsville, Maryland

and

Dr. Howard Baker, Entomologist
Fruit and Vegetable Insects
Research Branch
United States Department of Agriculture
Beltsville, Maryland.

Without the assistance of Dr. Porter and Dr. Baker in furnishing excerpts from publications now out of print, much of this paper could have not been written.

G. S.

**BIBLIOGRAPHY**

Literature Cited by Miller, Bassett and Yonthers (18)

Other References