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INNOVATIONS IN CITRUS WAXING—AN OVERVIEW

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Abstract. **Many factors are to be considered when the citrus packinghouse changes its method or type of wax process. These include the type of wax to be used and the market to which the fruit is to be shipped. Not all ingredients acceptable in the US are acceptable to all foreign market countries.**

Uniformity of coverage as well as the quantity of wax on the fruit can be a factor on how well the fruit holds up on the way to market. Over waxed fruit may develop off flavors, under waxed fruit will shrink (los weight) excessively. The applicator used is the single most important factor in uniformly applying the wax coating.

When fungicides are incorporated into the wax, allowances must be made for the rate at which the wax is applied and the fungicide concentration adjusted accordingly.

The comparative costs of ingredients will affect the formulators decisions on which products to offer and this will affect the cost to the packinghouse. Cost and a sure supply of ingredients will also be a factor to the packinghouse. New wax ingredients, new methods of application and adjustments in traditional ideas about citrus waxing may be necessary.

The appearance of citrus at the marketplace is often the only quality that affects the price paid and the potential for reorders. For this reason the packinghouse manager is usually very concerned with the coating that he uses on his fruit.

Since there are many different suppliers offering coatings, and each supplier often offering several different coating products, the question of which product is best is of concern to the packinghouse manager. Since there is no single answer to this question, we will consider several factors that affect that decision.

The desired end result of citrus waxing is to give the fruit a good shine that will last through the marketing process as well as to reduce weight loss by the fruit to the maximum extent possible without harming the fruit.

It has sometimes been said that citrus waxing is more art than science. This idea, which is in part true, has been furthered by the complexity of the waxing process and the failure of many scientists and laymen alike to differentiate between the various types of waxes. The differences between wax types and applicator types as well as their affect on the quality of the final product will be considered here.

The coatings used for citrus are usually called 'waxes' although modern products commonly available contain little if any wax of any kind (8, 37). The reason for this is that the earliest citrus coatings in commercial use were composed of waxes (1, 4, 5, 6) and this term has been since applied to all postharvest citrus coatings regardless of their composition.

In the history of citrus waxing, advances in the method of application are related to advances in formulation. As new methods of application are developed, new formulations are developed to take advantage of them. On the other hand as new 'wax' products are developed advances in application technology take place.

Types of Waxes

Solvent Wax

The most commonly used wax in Florida is the so called solvent wax (15). It is called such because it is based upon one or more resins dissolved in a petroleum solvent. The solvent will be different for each different formulation but they will have some characteristics in common. A typical solvent blend will be composed of 70-80% aliphatic hydrocarbons, up to 25% aromatic hydrocarbons and may include solvents such as acetone, ethyl acetate, etc. The blend will boil or distill between 200°F and 300°F for the most part and the lower boiling fractions will have a slightly higher proportion of the aliphatic hydrocarbons than the higher boiling portions.

In this solvent will be dissolved either a synthetic resin (coumarone-indene) or the calcium salt of a natural wood rosin that has been previously hydrolyzed with dimer acids. The latter resin in used almost exclusively for fruit destined for the Japanese market (22). Both types of resin formulation will also contain one or more plasticizing and/or leveling agents to assist in forming a shiny, flexible film on the surface of the fruit.

An important requirement of solvent waxes is that the fruit must be completely dry before waxing, whereas water waxes do not. Water waxes do require drying after application (16, 20, 24, 25, 26, 37). These two operations seem to require about the same amount of energy in Florida operations.

Water Waxes

There are two basic types of water based waxes, emulsion based and resin solution. Although these represent two entirely different types of product they are often confused in the literature or are lumped into a single designation; "emulsion wax", "water emulsion wax" or "water wax" (8, 37). The differences between these types of wax are such that there are differences not only in their use, but also their affect on the fruit (13).

Resin solution waxes. These are also called simply resin waxes and are composed of a solution of one or more of several alkali soluable resins or resin like materials. Shellac, protein (corn, soy, milk, etc.) natural gums, tall oil or wood rosins, and any of various natural gums and resins modified with organic and mineral acids and/or glycerol are some of these products. These resins are dissolved with the aid of an alkali (ammonium hydroxide, morpholine, sodium hydroxide, etc.) and alcohols, glycerine or proplyne glycol may be added to aid in dissolving the resins. The formula may also contain various organic acids, wetting agent and oils that act as leveling agents and plasticizers. These latter ingredients may have more effect on the performance of the finished wax than any other single ingredient.

Recently introduced into the Florida citrus industry is a special class of resin wax, the concentrate wax. Concentrate waxes are to be applied at a rate using 1/2 to 1/4 the volume of wax per box that standard resin and emulsion waxes are intended. Part of their advantage lies in their lower water content which results in faster drying and better shine with less solids on the fruit. Diluting these waxes destroys this advantage. These waxes are much higher viscosity than standard waxes and so require special handling.

Emulsion waxes. These are composed of a natural wax such as carnauba, paraffin, etc. or a synthetic wax such as oxidized polyethylene emulsified in a soap (anionic system) or a detergent (nonionic system). The properties of emulsion waxes vary not only with the ingredients but also with the method of manufacturer which will affect particle size and distribution in the emulsion. One class of emulsion waxes, storage wax, is not applied to improve the appearance of the fruit but only for increasing the storage life. These waxes have no additives for shine. In order to increase the shine on an emulsion wax, formulators add solutions of the same ingredients used in resin solution waxes. The resulting emulsion wax will actually be composed of from 50 to 80% emulsion and the balance resin solution (2).

One thing that all water waxes have in common is that they require clean, dry, fruit in order to give their optimum shine, drying, shrinkage control, etc. If the fruit is not clean then it should be slightly damp in order for the wax to adhere to it. Another effect of not having clean fruit that is also well dried after waxing will be poor resistance to rewetting or water spotting (sweating). In this effect water partially dissolves the wax or just gets under it then, when the water dries again, white spots are left due to air bubbles under the wax film.

Other Waxes

Bar waxes. Also called slab waxes, these are composed of mixtures of waxes cast into bars or slabs. These bars are then pressed to the underside of the first brushes of wax applicator and as the fruit pass over they pick up wax. Subsequent brushes spread and polish the wax (37). These waxes are mostly paraffin with small amounts of other waxes mixed in.

Paste/Oil Waxes. These waxes are applied in a similar manner except that the wax is usually dripped onto an overhead brush which then brushes the wax onto the fruit. These waxes are mainly composed of various melting point paraffins blended to give the desired viscosity, and are essentially the same as the products used to wax vegetables (31, 32).

Neither bar wax nor the paste/oil waxes are used in significant quantities in Florida at this time.

Comparison of Waxes

Table 1 lists the major solvent and water wax types with their normal use. Also listed are the optimum shrinkage control for these. Some waxes, due to their nature or their type of applicator do not usually reach the optimum level in commercial practice. Applications that would give optimum shrinkage control might result in reduced plant capacity or many equipment cleaning problems.

Table 1. Comparison of wax types, application rates and shrinkage.

Wax Type	Normal application Rate, Boxes/gal.[z]	Shrinkage[y] Optimum	Usual
Solvent Wax			
Coumarone-indene	65-75	65-75	70-80
Wood Rosin, Calcium	60-70	65-75	70-85
Water Waxes			
Emulsion, Polyethylene	120-150	55-65	55-65
Emulsion, wax	120-150	60-70	60-70
Resin, Normal strength	130-170	65-75	65-75
Resin, Concentrate	300-500	65-75	75-85

[z]Based on average product use on oranges. Box is 90 1-3/5 Bushel.
[y]For average of all varieties.

In Table 2 each of the waxes discussed is ranked for each of six qualities that are of importance in selecting a wax. The numerical rank given each is as compared to the average of the other waxes in the list. The differences may overlap from one applicator/wax combination to another.

Table 2. Rank comparison of wax types.

Wax Type[z]	Shine[y]	Durability[x]	Drying	Shrinkage[w]	Clean-Up[u]	Cost[v]
	Rank by Property					
Solven C-I[t]	1	4	3	6	8	8
Solvent CaResin	2	5	4	5	9	9
Resin, NS	3	3	8	4	6	6
Resin, Conc.	4	6	7	9	7	4
Polyethylene Emul.[t]	5	1	5	2	4	5
Wax-Emulsion	6	2	6	3	5	7
Paste/oil	7	7	2	8	3	3
Bar	8	8	1	7	2	2
Storage Emul.	n/a	n/a	9	1	1	1

[z]C-I = Coumarone-indene.
NS = Normal strength.
[y] Initial shine.
[x]Lasting ability of initial shine.
[w]Modified by ability to reach optimum.
[u]Ease of cleaning or lack of carry over onto equipment.
[v]Based on cost per box treated.
[t]These waxes by nature are not acceptable under current Japanese regulations.

Durability refers to the lasting quality of the initial shine. Shine may be lost due to scuffing or breakdown of the film due to dusting, powdering or rewetting. Dusting is the effect of abrading some of the surface from the film leaving it intact. Other than formulation problems this can be due to a rough surface due to poor application often from using too high a pressure or from air currents in the waxer. This causes droplets of wax to partially dry in the air before it reaches the fruit, thus not leveling out on the surface. Powdering or fracturing is a breakdown of the wax film where it separates from the fruit and can also be a formulation problem. More commonly it is due to either dirty fruit or excessive shrinkage, that is the fruit shrinks away from the wax (21). Rewetting which often resembles powdering has already been discussed to some extent. This problem is, more often than not, a formulation problem and is aggravated by juices from rotting fruit either in the carton or from rotten fruit having broken up in the waxer.

Wax Applicators

If the wax is not properly applied even a very good wax formula will give inferior results. The wax applicator used depends upon the type of wax and the supplier as these are often supplied by the wax formulator on a loan or lease basis. The differences between solvent wax applicators are small but those between water wax applicators may be large.

Solvent Wax

The applicator for solvent wax has changed little since the mid 1940's (33, 34). Basicly a conveyor with turning rolls carry the fruit through a chamber in which the wax is applied. Application is done through fine oil burner nozzles above the fruit. The nozzles are mounted in the center of an air duct that directs the wax onto the turning fruit. This air stream is directed around the fruit by being drawn through the rolls by a partial vacuum formed below the conveyor by a large exaust fan. The fruit is rapidly dried on open conveyor (20, 37) with unheated fans. Improvements have been directed toward increasing the coverage of the fruit by directing wax from a second set of nozzles (different angle) and or modifying the conveyor rolls to turn the fruit more while in the wax path.

Solvent waxes are usually applied at about 70 Florida boxes (90 lb.) per gallon of wax. (Table 1). Wax application rates are controlled by the selection of the nozzle orifice and by varying the pressure. If an excessive nozzle pressure is used, over 70 psi., or the various air moving blowers are out of balance dusting can become a problem.

Water Wax

A simular type of nozzle as is used with solvent wax is also used to apply most water waxes. These waxes are sprayed onto the fruit over a bed of brushes. For optimum results these brushes should be composed of at least 50% horse-hair (16) in order to help spread wax over the fruit. For most water waxes a minimum of 8 brushes should be used. The wax should be applied near the middle of such a brush bed. With concentrate waxes the brush bed should have at least 10 brushes with at least 6 after the point of application.

One of the objectives of the wax applicator is to deliver a uniform amount of wax to each fruit. Since fruit progresses through the waxer by being pushed by fruit behind it, movement is usually not uniform. In most waxers the fruit is found to move more slowly down the sides of the waxer and faster through the middle.

Several types of applicators are found in use in Florida and many of these are listed below along with their advantages and disadvantages.

Manifold. One or more banks of nozzles mounted in a fixed position over the brush bed. This type of applicator has the advantage of requireing no mechanical attention but since many nozzles are used to deliver the wax each must be smaller than on other types of applicator and hence more subject to plugging. One method to combat this is to use a timer to operate solenoids which interrupt the wax flow from the nozzles every few seconds. This allows for the use of larger nozzles but can contribute to irregular nozzle output because turbulence in the manifold reduces the effective pressure along its length. One such instalation, using the same size nozzle at each of four positions, was found to put out less wax at each nozzle as it was farther from the source. The nozzle nearest the wax source was putting out twice the wax that the nozzle farthest from the source. This could be overcome by careful nozzle selection using smaller nozzles closer to the wax source and larger ones farther away.

Travelling nozzles. By using fewer nozzles and having them move across the width of the brush bed less wax is delivered over any one section of the waxer bed. This allows for the use of a larger nozzle for any given volume of fruit. There are four distinct types of travelling nozzle applicator and are referred to here as "beam slider", "swinging arm", "lawn sprinkler" and "eliptical chain" with reference to the manner which the nozzle is carried across the brush bed.

1. The beam slider has a nozzle that is mounted on a block which slides back and forth across the brush bed on a rail. The movement of the block is accomplished by a chain drive. The chain runs continuously in one direction and reversal of the block is by means of a mechanical switch. This type of applicator is cheap to build but because the block must stop to change direction at each end of its travel more wax is delivered along the sides of the waxer than to the middle with subsequent over waxing along the sides and/or under waxing in the middle. This type of applicator also moves too slowly to adequately wax fruit at higher volumes as some fruit will often go through the waxer while the nozzle is over another part of the brush bed. Equipment from various suppliers will vary and some will be better than others in this regard.

2. Swing arm applicators have the nozzle mounted at the end of an arm which then swings back and forth across the brush bed. Often two or three such arms will be mounted so that each covers a smaller portion of the bed. These are generally mechanically reliable but since the arms pause slightly at the end of each swing, as mechanical slack is taken up, they have problems similar to the beam slider as far as coverage is concerned. This is averaged out some when more than one arm is used and when adequate brushes follow the point of application.

3. Lawn sprinklers are so called because their appearance is something like a rotary lawn sprinkler. Nozzles are mounted on each end of a "T" which then rotates over a portion of the brush bed. The units in operation here in Florida usually have two of these sprinklers (4 nozzles) and each is equipped with valves so that one of each pair of nozzles may be shut off. This type of applicator lays down a circle of wax over a portion of the brush bed. The fruit does not receive a uniform wax coating and is often over waxed in order to make sure that all fruit is adequately waxed. Much of this wax subsequently tracks off onto dryer rolls and other equipment.

4. In the eliptical chain applicator the nozzle is mounted on a chain that travels around two horizontally mounted sprockets. The nozzle travels quite rapidly and so makes several passes over the fruit as it crosses the brush bed. This type of applicator comes closest to applying a uniform amount of wax across the width of the brush bed. Its main

disadvantage is that it requires more mechanical attention than many other applicators and because of its high speed of operation its wax supply lines are subject to considerable wear. Unless this type of applicator is cared for regularly it can be the source of many problems.

All of the above applicators have some problems in common. The nozzles used have a fixed orfice and have only a small lattitude of volume output with changes in pressure, usually less than 2 to 1 over the practical range of operating pressures. If the pressure is increased too high a great deal of fog is produced and, if the wax is a quick drying wax, this could be a cause of dusting. Even when used at moderate pressures air currents can blow the fine wax spray away from the fruit. The latter problem can be minimized by enclosing the waxer. The first problem can be handled by changing nozzles each time the process rate is changed. In many houses where the fruit volume and varieties are changed many times this is often neglected and the house operates on a compromise where some fruit is under waxed and others are over-waxed.

A recent innovation introduced into Florida is the air nozzle. This nozzle receives the wax at low pressure then uses a stream of air to atomize it for application. These nozzles have a wide range of volume that may be delivered without adverse effect. Some as high as a 20 to 1 ratio of highest output to lowest without reducing their ability to apply the wax properly.

Air nozzles are especially good at applying the high viscosity concentrate waxes, but they also work well on regular water waxes.

When used properly these nozzles give excellent trouble free operation but, as is more often the case, when used poorly they are extremely troublesome and erratic. The industry has much to learn about air nozzles but, for the time being, they appear to have much to offer in solving some of the common problems for wax application. There are many styles of air nozzles available and it is possible that the 'perfect' one has not been tried or, if it has, possibly it has only been used by those not equipped to take full advantage of it.

Shrinkage Control

In addition to improving the appearance of the fruit the wax coating is needed to replace the natural wax that has been removed by the washing process (8, 37). In doing this the film needs to retard water loss while, at the same time, allowing near normal respiration to take place (9). If respiration is interferred with too much, then off flavors will develop in the fruit (3, 10, 11, 12, 29). The lower acid fruits such as tangerines and murcotts are especially sensitive to this.

One method of controlling the wax coating is by measuring the weight loss of fruit that has been washed but not waxed and comparing it to the weight loss of waxed fruit (3). Some workers use unwashed fruit for the comparison base, this method will give different results but is also a valid method. The use of unwashed fruit is not practical in Florida because of the high rate of decay from stem end rot. Table 3 shows the method used for the figures in this paper other workers using their own methods would have to develop their own standards.

To determine shrinkage, fruit is weighed on the first day of the test, then again 5 days later. The percentage of weight loss is calculated for the washed and waxed fruit. The percent loss of the waxed fruit is then divided by the percent loss of the washed only fruit. This figure is then multiplied by 100 and referred to as "% Shrinkage Ratio".

For all resin waxes the minimum safe ratio would be

Table 3. Typical Shrinkage Control Test.
Shrinkage Control Test: Valencia Oranges.

Sample	Weight 4/6-81	Weight 4/11-81	% Loss	Ratio %
Washed	4253	4094	3.74	—
Waxed	4326	4220	2.45	65.5

about 55% before off flavors could be a problem (solvent and water resin waxes). Polyethylene emulsion waxes allow for the ratio to be as low as 40% without off flavors (10, 12, 13) and wax emulsion are between these two. Varieties sensitive to off flavor development should be kept 5-10 percentage points higher. Table 1 gives the optimum shrinkage ratio for each type of wax as well as the normal range found in a good commercial application. Concentrate resin waxes and solvent waxes are normally found to have a shrinkage higher than optimum. Concentrate waxes due to the thinner coating and solvent waxes due to the problem of getting complete coverage on all fruit. Thick skinned varieties, such as grapefruit often have a ratio about 10 percentage points higher than other varieties with the same wax coating. Excessive shrinkage will result in loss of revenue when the fruit is sold by weight and can also result in deformation of the fruit, fracturing of the wax film (powdering) and loss of gloss (21).

Fungicides

Citrus water waxes may also be used as the vehicle for postharvest fungicides (7, 18, 28). Solvent waxes may also be used but have met with mixed success and generally have not been as effective as water waxes for this purpose (19, 30). The most obvious reasons for incorporating fungicides in the shipping wax are the ease of application (no additional equipment is needed) and, the reduction in the amount of water put on the fruit that will subsequently need to be removed.

Packinghouses that are exporting citrus will usually use thiabendazole (TBZ) as it is acceptable to most countries receiving Florida's citrus, whereas benomyl has many restrictions placed upon it (27). In order to meet the State of Florida minimum requirements for fungicides a packer may use TBZ at 1000 ppm in his shipping wax (23). Unfortunately this does not give optimum decay control (7, 35, 36). Part of the reason for this is that the rate of application when a fungicide is applied in a wax is tied to the rate of wax application. Compared to the common practice of applying water suspensions at 60 to 80 boxes per gallon of suspension, water waxes are applied at the rate of 125 to 200 boxes per gallon. To get the equivalent fungicide treatment it is logical that the concentration of fungicide be increased accordingly. A test of this was made during the 1980-81 processing season. The results are summarized in Table 4. The results of this trial was that when the fungicide was applied at similar rates (boxes of fruit per pound of fungicide), the decay control was the same.

Benomyl is also used in wax but we do not recommend it for several reasons. First, the material available is coarser than TBZ and is more likely to plug nozzles. Second, benomyl decomposes rapidly in many citrus waxes and loses effectiveness (14, 17).

The Future

It appears that commercial pressure will be responsible for great improvement in water waxes. Solvent waxes are becoming more expensive as the international price of

Table 4. Decay control of Valencia oranges with thiabendazole.

Treatment[z]	Rate-Boxes/ Gal.	Boxes/ pound TBZ	Decay at 4 weeks[y]
1000 ppm/water	150[x]	17,600	26
1000 ppm/water	75[x]	8,900	12
2000 ppm/NS Resin A	94	5,600	11
4000 ppm/Resin Conc.	272	8,150	11
2000 ppm/NS Resin B	188	11,250	10
2000 ppm/Wax Emulsion	100	5,990	12
2000 ppm/NS Resin C	118	7,068	16
2000 ppm/NS Resin D	110	6,600	8[w]

[z]Fungicide concentration/vehicle.
[y]Number decayed/100 after 3 weeks at 35°F and one week ambient.
[x]Two different levels used by different suppliers. 75 bxs/gal. more usual.
[w]Formulation contained high percentage of alcohol which may have affected decay.

petroleum products rise. In addition to this each of the two resins currently in use are obtainable only from a single source in the United States.

On the other hand, the raw materials for water waxes are available from many sources. This is especially true of the 'natural' products used in preparing waxes for fruit destined for Japan (22).

With many ingredients available and many ways of incorporating them into a formulation there are literally millions of possible combinations. The life of a typical wax formulation with a company that is aggressively seeking to compete in the Florida market is about 3 years for a top product. The first year it is introduced, the second the other suppliers are trying to better it and the third year competitors are easing it out. Some products persist either because they are priced much lower than their competition or possibly because their supplier is not strongly commited to product development. Fortunately for the industry competition is getting more keen at this time. Four years ago solvent wax had 80% of the market and only two major companies were actively supplying waxes to users. Today solvent wax has dropped to about 50% of the wax used and there are four major companies and one smaller company competeing to provide waxes to the industry. This competition will naturally bring about improvements in the traditional waxes.

It is possible entirely new methods will change the industry. Experiments are now being conducted in many alternate ways to handle fresh citrus (21). Storage waxes could, for example, be applied here then washed off at the receiving country and a packout (shine) wax be applied. Controlled atmosphere or other storage methods might finally become practical (29).

Since uniformity of application is so important this area is likely to see great improvement. Although equipment improvements will make even larger changes in waxing they will be slower in coming because they take longer to prove out. To test a wax, one could make a change to the new formula and back within an hour. To test an applicator the changes could take days.

This does not mean that improvements will not come, as breakthroughs are possible at any time. At this time, for example, one company is running trials on a manifold system that uses a 'computer' to control the wax application. If this type of unit proves successful that company will have a big advantage in the market.

There is a great incentive to develop improved applicators as these are often provided with a tie to the suppliers wax. This means that the one who supplies the applicator will most likely be selling the wax.

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REGULATORY ACTIONS AFFECTING THE USE OF ETHYLENE DIBROMIDE IN QUARANTINE FUMIGATION OF CITRUS FRUITS[1]

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Abstract. **Ethylene dibromide (EDB) is the only chemical approved for quarantine fumigation of citrus exported from Florida to other citrus producing states and to Japan. Fumigation is necessary to protect against the spread of the Caribbean fruit fly. The U. S. Environmental Protection Agency (EPA) has proposed banning the use of EDB in quarantine fumigation of citrus and tropical fruits and vegetables because it induced cancer in laboratory rats and mice. This ban, if carried out, would drastically curtail Florida's citrus export trade to Japan and thus might precipitate severe marketing problems for domestic grapefruit. Restrictions imposed by California Occupational Safety and Health Administration (Cal/OSHA) on exposure to EDB has resulted in halting citrus shipments from Florida to California. Concentrations of EDB at fumigation stations were generally low but higher at port warehouses. EDB residues in orange and grapefruit component parts decline rapidly after fumigation. The rate of decline is temperature dependent.**

Ethylene dibromide (EDB) is used in agriculture as a preplant soil fumigant for many crops and as a postharvest fumigant for grain, fruits, nuts and vegetables. A joint report issued by USDA/State and EPA (15) estimated that 14,837,100 pounds (6,729,995 kg) of EDB was used in the U. S. in 1978. Of that amount, only 83,500 lbs (37,875 kg) of EDB was used for quarantine fumigation of various commodities.

During the 1980-81 citrus season, nearly 6.5 million 4/5-bushel (approximately 18 kg) cartons of grapefruit were shipped to Japan (8). Its value was approximately $78 million at destination. Grapefruit exports from Florida to Japan represented 20.0% of all fresh grapefruit shipments, domestic and export, and 62.9% of all grapefruit exports in the 1980-81 season (8).

All citrus destined for export to Japan or other citrus producing areas must be fumigated with EDB to protect importing regions from possible introduction of the Caribbean fruit fly, *Anastrepha suspensa* (Loew). Postharvest fumigation against the Caribbean fruit fly commenced in 1974 and continues to date. Initially, it was conducted inside semi-trailer vans, loaded with packed citrus cartons (2, 12). In 1975, fumigation stations were constructed where loaded semi-trailer vans are placed inside 9000 ft^3 (255 m^3) chambers and fumigated with EDB (3). Research trails (3) indicated than an EDB dosage of 6.5 to 8 oz/1000 ft^3 (6.5-8 g/m^3) for 2 hr was required to assure 99.9968% (Probit 9) mortality of immature flies.

This paper reviews the regulatory actions on the use of EDB and presents data on EDB levels at Florida's 2 fumigation stations, 2 port warehouses and in various components of fumigated fruit.

Regulatory actions affecting the use of EDB

The current Federal permissible exposure limit for EDB is 20 ppm in any 8 hr workshift with a 30 ppm ceiling concentration and an acceptable maximum peak of 50 ppm for a brief period, not to exceed 5 minutes. As a result of a 1974 "Memorandum of Alert" issued by the National Cancer Institute regarding preliminary findings on the carcinogenicity of EDB, the Environmental Defense Fund petitioned EPA to investigate and cancel or restrict the use of EDB (16). In 1975, the office of Pesticide Review of EPA placed EDB on a list of chemicals to be further investigated (16).

In 1977, the EPA published a notice of Rebuttable Presumption Against Registration and Continued Registration (RPAR) of all pesticides containing EDB (7). This was based on preliminary evidence that EDB was a carcinogenic and mutagenic agent and also capable of producing adverse reproductive effects. The EPA invited users and/or registrants of EDB to submit evidence that the use of the chemical was not hazardous. In 1980, EPA issued its Position Document 2/3 (PD 2/3) in which they responded to comments submitted in response to the RPAR notice and proposed the cancellation of use and registration of EDB as a quarantine fumigant for citrus and for tropical fruits and vegetables by July 1, 1983 (16). As an alternative, EPA proposed that gamma irradiation be substituted for EDB.

The State of Florida, Department of Citrus (DOC), issued a rebuttal (13) to the EPA on the grounds that:

1. EDB is used safely in the quarantine fumigation of citrus,

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