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PEEL DISORDERS OF FLORIDA CITRUS AS RELATED TO GROWING AREA AND COLOR-ADD FORMULATIONS

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Abstract. **As a result of several killing freezes in the citrus growing areas of Florida, packinghouses in the northern part of the state have drawn more heavily on the southern part of the state as their source of fruit. Coincidentally with this shift have come more reports from packinghouse managers of problems in getting uniform applications with their color-add process. Examinations of irregularly colored fruit revealed injuries to the rind. Tests of several chemicals representative of those used in color-add concentrate indicate that some have the potential for causing rind injury. Of these pine oil, which is a component of most comercial concentrates, consistantly caused severe injury under most test conditions.**

During most of the citrus producing season in Florida the natural color of the fruit is pale. Color-adding has been used in Florida to increase consumer acceptance of the fruit (9). In the usual color-add operation the fruit is passed through a tank that consists of a flat roller conveyor with perforated flood pans above. The dye is provided to the packinghouse as a concentrate requiring dilution with water. The concentrates available in Florida carry instructions that the product be diluted with 250 to 300 parts water for application (10).

Application time and temperature is limited to 4 minutes at 120°F (49°C) for oranges and 2.5 minutes at 115°F (46°C) for 'Temples' and tangelos (1, 10, 14). These conditions have not been found to be phytotoxic to citrus (12). Lower temperatures or shorter treatment times drasticaly reduce the intensity of color obtained. The color intensity is also affected by pH and water quality (10, 14, 17).

The Florida citrus fruit law provides that the Department of Agriculture shall examine products used for the processing of citrus and that if any ingredient in said product is found to be injurious to "fruit or its keeping qualities, then such composition shall not be used on citrus fruit and the manufacturer shall be denied the license hereinafter required." The law also provides that the fruit should not be colored more deeply than is natural for the variety, and defines these colors in Munsell color, notation (1).

After the freezes of the 1983-4 and 1984-5 citrus seasons the authors noted an increase in reports of irregular color in color-added fruit. Most of these reports came from interior, as opposed to Indian River, packinghouses north of State Highway 60 and involved the color-add products of all licensed suppliers (6). Fruit that was identified as to source had all come from groves in the southern portion of the state.

The fruit examined had areas that were a darker orange to red color and some of these areas were marked by a shrinking of the tissues around the oil cells. These tissues were more deeply colored as were areas that had not degreened uniformly or had been damaged prior to the color-add process.

Except for the location of the packinghouses reporting problems, no pattern was discernable. This is, in part, due to the packinghouse maxim "the hotter the market, the smaller the problem". When prices are good and fruit demand high, fruit defects are more easily overlooked by the buyers. Packers then are less likely to hear of, or be concerned about processing defects. Conversly, when demand is low, buyers are quick to find fault in order to get a lower price from the packer.

A further complication is that few shippers retain samples of the fruit shipped. Therefore, since the fruit may be two to five days in transit, the fruit on which there are reported problems is long gone from the packinghouse and any reported problem cannot be checked on available fruit. Packinghouses also do not keep detailed records on the outcome of individual lots of fruit. With this in mind the authors examined two avenues as possible causes of this increase in complaints.

The first was to examine the potential for injury from color-add ingredients. The other was to examine trends in coloring fruit and in changes in the sources of that fruit. Climate has a dominant effect on fruit quality (3, 13); therefore comparisons were made in the climate of areas of fruit origin.

Color-add concentrates used in Florida are solutions of Citrus Red No. 2 dye in a petroleum solvent with emulsifiers to disperse the solution in water. Each formulation also uses a cosolvent to improve the solubility. The most common of these is pine oil.

Materials and Methods

Ingredients. Ingredients commonly found in color-add formulations were tested to determine the potential of each to injure fruit when used under conditions for color-add use. The ingredients tested were emulsifiers, solvents and pine oil.

Two types of emulsufiers are commonly useds. One is of the group classified as ethoxylated alkyl phenols. We selected Triton X-100 as typical of this class as it is readily available to formulators. The other type, known as glycerol esters, was exemplified by Tween 80 (11).

The principle purpose of the solvents in a color-add formulation is dilution. The solvent selected by the formulator needs to have a boiling range between 150 and 200°C in order to reduce the loss from evaporation during its use in the heated color-add tank.

Commercially available solvents are mixtures of aromatic and aliphatic hydrocarbons. For our examinations we used an aromatic solvent sold by the Ashland Oil company

under the name Hi-Sol 10. The claimed aromatic content is from 96% to 100%. The aliphatic solvent used was Shell Sol 71, a product of the Shell Oil Company. This had a claimed aliphatic content of 100%.

Two types of pine oil are available to formulators, steam distilled and synthetic. Steam distilled, or natural, pine oil is obtained by distillation of aged pine stumps in the southeastern United States. Synthetic pine oil is produced by the acid-catalyzed hydration of pinene (4). The pine oils used in these tests were Hercules Yarmor 302 (natural) and Union Camp Unipine 85 (synthetic).

The materials were tested by immersing fruit in solutions. The emulsifiers were used alone in the tests. To the petroleum solvents and pine oil, Triton X-100 was mixed at the rate of 25% of the total weight of the mixture in order to get an emulsion. Fruit were immersed for 4 minutes at 120°F, then held for 24 hrs. for examination. Prior to immersion, each fruit was wrapped with a single band of plastic tape to protect a portion of the surface from contact with the chemicals and provide an area for comparison of the effect of the treatment. The results are summarized in Table 1.

Climate. The effect of climate was analyzed by comparing the regional production of fruit during the 1977-78 season and the 1987-88 season with the regional packing during the same seasons (2, 5, 6, 7, 8). For this purpose the state was divided into three regions; northern, southern and east coast (Figure 1). The acreage in production and the number of cartons packed (Table 2) in each area were compared (Table 3). The climatological conditions of the northern and southern areas were compared by examining published reports from one station in the southern area and two in the northern area (Table 4).

The amount of fruit subjected to the color-add process was determined for each year between 1968 and 1988 (Fig. 2). The use of color-add in the three area of the state were also compared (Table 5).

Results and Discussion

Of the ingredients examined only pine oil showed a potential for fruit injury, and injury occured at levels far above what would be found in commercial color-add. An examination by the senior author of the color-add prod-

Table 1. Effect of chemical treatments.

Treatment	No.[z]	Conc.[y]	% Injured by Variety		
			Hamlin	Pineapple	Valencia
Triton X-100	2	10	0	0	0
Tween 80	2	10	0	0	0
HiSol 10[x]	6	20	0	0	0
Shell Sol 71[x]	6	20	0	0	0
Yarmor 302[x]	6	20	100	100	100
	4	15	100	100	100
	4	10	100	100	100
	4	5	0	0	0
Unipine 85[x]	6	20	100	100	100
	4	15	100	100	100
	4	10	100	100	100
	4	5	0	0	0

[z]= Number of times each variety was challanged with each chemical, 4 fruit per challange.
[y]= grams per liter.
[x]= Mixture of 75% material and 25% Triton X-100.

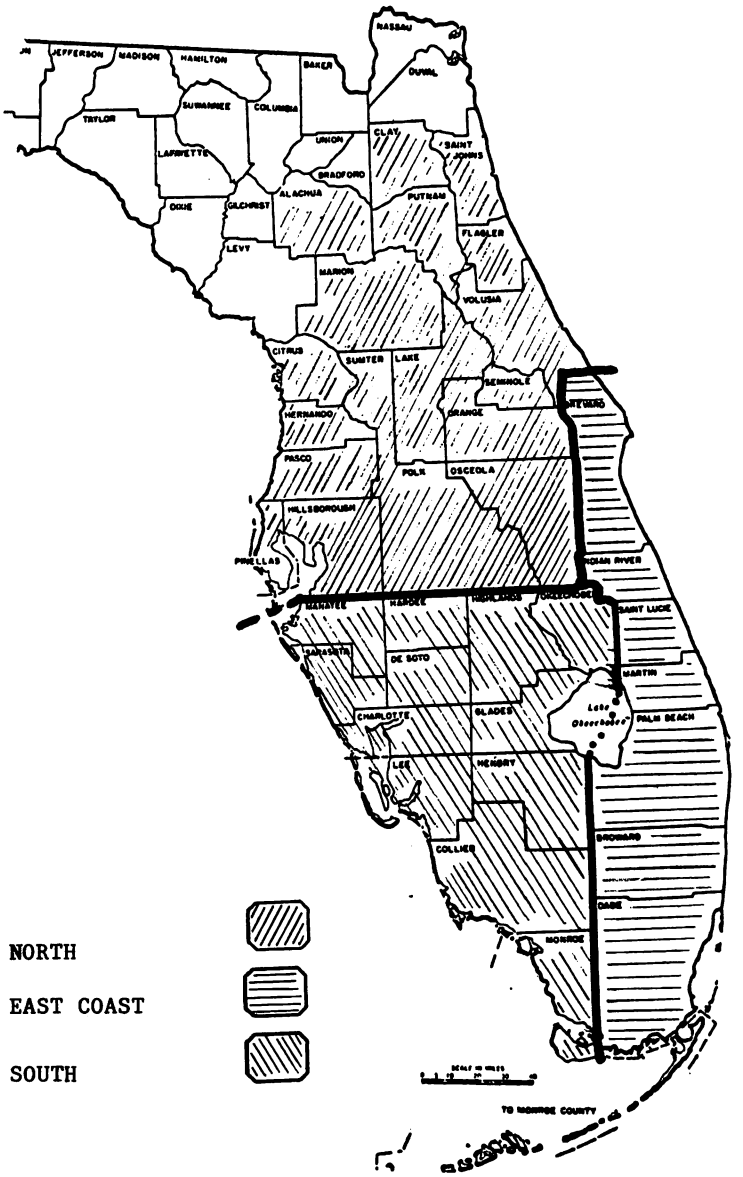

Fig. 1. Florida growing and packing areas.

Table 2. Listing of Counties in the 3 Citrus Packing areas of Florida.

Northern	Southern	East Coast
Alachua[z]	Charlotte[z]	Brevard
Citrus[x]	Collier[z]	Broward[z]
Duval[y]	Desoto[y]	Dade[x]
Flagler[z]	Glades[z]	Indian River
Hernando[z]	Hardee	Martin
Hillsborough	Hendry[x]	Palm Beach[y]
Lake	Highlands	St. Lucie
Marion	Lee[z]	
Orange	Manatee	
Osceola	Okeechobee[z]	
Pasco	Sarasota[y]	
Pinellas		
Polk		
Putnam[y]		
Saint Johns[z]		
Seminole		
Sumter		
Volusia		

[z]= Counties not shipping citrus in 1987-8 or 1977-8
[y]= Counties shipping citrus in 1977-8 and not 87-8
[x]= Counties shipping citrus in 1987-8 and not 77-8

Table 3. Changes in Citrus Production and Packing by Area.

	1978	1988	Difference %	Percent of Total 1978	Percent of Total 1988
Northern Area					
Total Acres[z]	425,262	192,360	−54.8	51.2	27.6
Oranges Packed	20,538,921	17,430,805	−15.1	79.8	75.2
Southern Area					
Total Acres[z]	199,782	276,645	+27.8	24.0	39.6
Oranges Packed	2,667,494	2,443,032	−8.4	10.4	10.5
East Coast					
Total Acres[z]	206,191	228,924	+9.9	24.8	32.8
Oranges Packed	2,528,731	3,301,601	+23.4	9.8	14.3

[z]= All varieties of citrus.

ucts licensed by the state of Florida for the 1986-87 season found that all contained varying amounts of pine oil. Of those products licensed for 1987-88 all but one had pine oil (6).

At the 20% level, when used as directed, the pine oil content of the dye solution would be about 0.5 gm/L. Of those formulations containing pine oil none was found to have as much as 20% in the concentrate. Under the conditions of the test no fruit injury was observed at the level of 3.75 gm/L (Table 1). Based on these observations, no injury from pine oil would be expected on normal fruit until the color-add was used at levels above 8 times the recommended dilution.

Since the 1977-78 citrus season, the production of citrus has shifted to the south. Table 2 shows that of the 18 northern counties reporting citrus producing acreage, 39% did not have operating citrus packinghouses in the 1987-88 season while of the 11 southern counties 64% did not. The 7 east coast counties had little change during the period examined. Table 3 shows that while the citrus production in the northern counties fell by over 50% during the 10-year period, the amount of oranges shipped by packers in this area fell by only 15%. Increased production in the southern area with a simultaneous drop in the amount of oranges shipped by southern packinghouses made up most of the difference.

Over the past 20 years there has been an increase in the use of color-add. While production of oranges has remained fairly constant, the use of color-add has gone from less than 30% of the crop in 1967-68 to nearly 55% in 1986-87 (Figure 2). When comparing 1977-78 with 1987-88 (Table 5) the use of color-add can be seen to be have increased in both the northern and southern areas of the

Table 4. Comparison of climatological conditions.

Station	Cold[z] Min	Cold[z] Max	Cold[z] Avg	Heat[y] Min	Heat[y] Max	Heat[y] Avg[x]
Northern Station "A"[w]	388	734	523	3124	3539	3324
Northern Station "B"[v]	651	1107	889	2774	3316	3088
Southern Station[u]	322	572	440	3281	3842	3542

[z]= Number heating degree days accumulated per year. See text.
[y]= Number cooling degree days accumulated per year. See text.
[x]= During 5 year period 1982-87 minimum, maximum and average number of degree days per year.
[w]= Clermont; Elev. 125, Lat. 28.29 N, Long. 81.47 W
[v]= Lisbon; Elev 68. Lat. 28.52 N, 81.47 W
[u]= Moore Haven Lock; Elev. 35, Lat 26.50 N, Long. 81.05 W

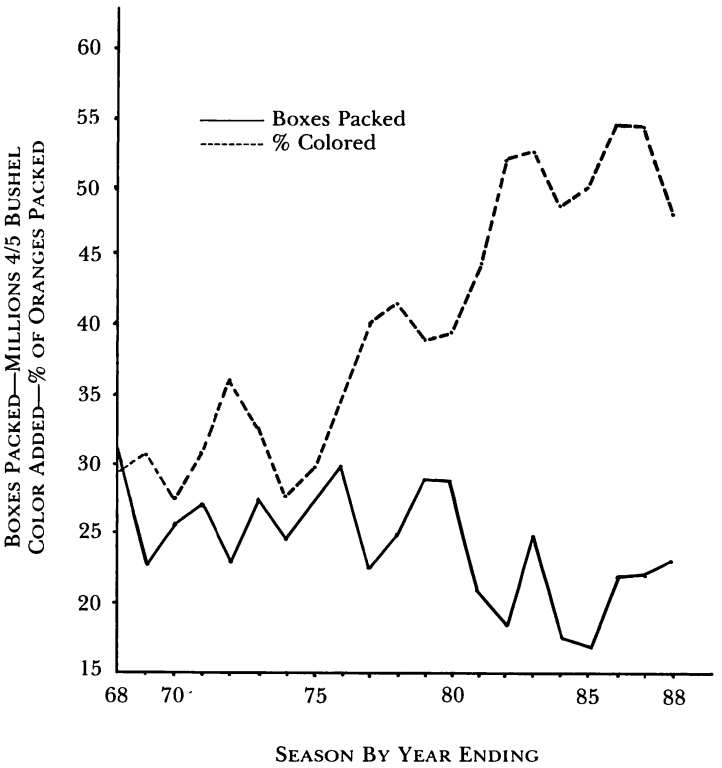

Fig 2 Oranges packed vs. percent color-added.

state while the east coast had a decrease which was mostly due to a decrease in oranges packed.

The recording station in the southern growing area was generally warmer than the two northern stations (15) as expressed as heating and cooling degree days (Table 4). One heating (cooling) degree day is accumulated for each whole degree that the daily mean temperature is below (above) 65° F. Cooler growing conditions have been shown to produce fruit less susceptable to injury (3, 13).

Since the northern part of the state has suffered a loss in production but not a commensurate loss in the number of cartons of oranges packed or colored, this fruit has had to come mostly from the southern area. In addition, the use of color add has nearly doubled since 10 years ago. This means that packinghouses are color-adding fruit with which they have not had much experience. The increasing color-add use has not been accompanied by any general increase in the equipment used. The authors have ob-

Table 5. Changes in color-add use on oranges by packing area 1977,8 and 1987,8.

	1978	1988	% of Total Diff. %	% of Total 1978	% of Total 1979
Northern Area					
Packed	20,538,921	14,430,805	−15.1	79.8	75.2
Colored	9,290,844	9,921,211	+6.4	88.8	88.1
Southern Area					
Packed	2,667,494	2,443,032	−8.4	10.4	10.5
Colored	415,297	854,725	+51.4	4.0	7.6
East Coast					
Packed	2,528,731	3,301,601	+23.4	9.8	14.3
Clored	749,574	481,618	−35.7	7.2	4.3
TOTALS					
Packed	25,735,146	20,175,438	−21.6	—	—
Colored	10,455,715	11,257,554	+7.7	—	—

served that packers are attempting to make up for this lack of equipment by increasing the amount of concentrate that they put in their tanks and shortening the exposure time to well under 2 minutes.

Since pine oil has shown the ability to cause injury at high concentrations, it is recommended that formulators look for alternate materials to use in this application. It is also recommended that packers adhere more closley to the recommended use rates for color-add concentrates, and if deeper color is desired increase the exposure time rather than the concentration of the dye.

The causes of peel injury are many and complex (16). The injuries and discolorations noted by the authors appear to be closley related to growing area rather than to the use of color-add.

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"THE GUIDE": AN INDUSTRY RESPONSE TO NEW REGULATIONS

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Abstract. **Growers in Dade County, Florida, like their colleagues in other parts of Florida and the United States, have had to learn about and begin to comply with new or more stringent regulations which have been developed by governmental agencies at the federal, state, and local levels during the past 2-3 years. Local Cooperative Extension Service offices, the governmental agencies promulgating the regulations, and several trade organizations and trade journals have been active in the educational process. The Dade County Chapter of the Florida Foliage Association has compiled information on several current issues: pesticides, labor, hazardous materials, groundwater, safe nursery practices, 25 material safety data sheet (MSDS's), and upcoming topics. This has been published as a loose-leaf notebook entitled "The Self Help Guide to Regulatory & Information Agencies & Safe Nursery Practices", nicknamed "The Guide." The rationale, compilation process, possible future directions, and relevance of "The Guide" to other industries will be discussed.**

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Rationale

Government regulations affecting the agricultural sector have increased not only in number but also in complexity during the past few years. These regulations are of federal, state, and sometimes local origin. Some have arisen as rule making based on environmental legislation such as the Clean Water Act (8), the Safe Drinking Water Act (9), and the Endangered Species Act (14, 19), all enacted in the early 1970's. Others, such as the Occupational Health and Safety Administration's (OSHA's) Hazard Communication Standard (1) and the U.S. Environmental Protection Agency's (EPA's) Farmworker Protection Plan (6, 15) have been developed in response to concerns for