It is noteworthy that the wax-coated grapefruit stored at 20°C, 55% R.H., had shrinkage and internal CO_2 similar to packinghouse fruit in cold storage (14°C, 90% RH). This suggests that grapefruit with wax-based coatings has less need of refrigeration than the same fruit with shellac or resin coatings.

Valencia oranges from packinghouses had rate of weight loss about four times that of fruit coated with wax microemulsion K123B, and three times that of fruit with one layer of K123B and a second layer of high-gloss shellac-resin coating (Table 3). The wax microemulsion used in this case contained petroleum wax as the hydrocarbon wax, whereas microcrystalline wax was the hydrocarbon source in the water-vapor barrier used for the data of Table 1.

Application of coatings did increase light reflectance of the fruit surface (Table 2). Highest values of reflectance were obtained when the second coating contained shellac and resin. However, such coatings elevated internal interior CO_2 and reduced O_2 values - whether the shellac and resin coatings were the only coating applied (see values for packinghouse fruit in Tables 1 and 2) or applied as second layer (Table 2). In both cases, the ratio of CO_2 to O_2 is markedly higher than for fruit not coated or coated only with wax microemulsion.

Table 2. Properties of Valencia oranges with wax or layered coatings compared with packinghouse fruit coated with resin waxes. Fruit was stored one week at 20°C, 75% Relative Humidity.

Treatment		Shrinkage	Internal Gas		Ethanol	Gloss[z]
Coating	P.H.	(%/day)	O_2(%)	CO_2(%)	(ppm)	(G.U.)
None (unwashed)	ARS	0.56	19.3	2.1	573	—
None (washed)	ARS	0.73	17.7	3.1	656	4.6
K123B	ARS	0.18	12.3	6.3	910	5.8
K123B-RS[y]	ARS	0.22	4.4	13.3	1990	7.9
R1[w]	A	0.57	6.1	13.4	2975	5.0
R1	B	0.55	2.8	11.5	1556	5.7
R1	C	0.74	2.4	10.5	1757	5.0
R4	D	0.70	5.8	11.3	2127	5.1
SOL	E	0.88	4.6	11.0	1610	5.5
SOL	F	0.51	7.9	6.6	2512	5.7
R2	G	0.59	5.6	11.0	2093	4.2
R5	H	0.59	6.7	9.9	1556	5.7
$LSD_{0.05}$		0.04	5.2	2.7	250	0.9

[z]Measured within 2 days after acquisition or coating of the fruit.
[y]First coating was microemulsion K123B; second was high-gloss coating RS; application rate for each was 0.5 ml/fruit.
[w]See Table 1.

The ethanol content of juice from fruit with the high-gloss coating was virtually the same (2,000 ppm) as packinghouse fruit, which was much higher than fruit not coated or coated only with wax microemulsion (Table 2). Ethanol content as high as 2000 ppm should indicate that some flavor deterioration may have occurred, although flavor analysis was not included in this study. Ke and Kader (1990) found a significant decrease in flavor of Valencia oranges when ethanol had risen to 2000 ppm; Ahmad and Khan (1987), working with mandarin, found the same result.

Thus, layered coatings with a shellac outer coating did solve one of the problems associated with high-gloss coatings, that is, relatively high weight loss of the coated fruit. Such a coating did not, however, solve the flavor problems associated with inhibition of gas exchange by these coatings, because gas exchange was inhibited about the same whether the high-gloss coating was applied as only coating (as in the packinghouses) or as second coating in our laboratory. By contrast, coatings consisting of two wax layers kept weight loss low with much less inhibition of gas exchange.

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POSSIBLE QUARANTINE TREATMENTS FOR FLORIDA AGRICULTURAL FOOD COMMODITIES

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Abstract. **The availability and need for quarantine treatments for agricultural commodities produced in Florida were examined. The most important quarantine pest in Florida is the Caribbean fruit fly, *Anastrepha suspensa* (Loew), and quarantine treatments exist for grapefruit, orange, tangerine, mango, carambola, and guava infested with this fly. Other treatments could potentially be used for other fruits. Some fruits presently have no potential quarantine treatments for Caribbean fruit fly. Quarantine treatments are also available for**

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a few other pests, such as pecan weevil, *Curculio caryae* (Horn), sweetpotato weevil, *Cylas formicarius elegantulus* (Summers), and sugarcane borer, *Diatraea saccharalis* (Fabricius). Quarantine treatments have not been researched for other pests, such as the papaya fruit fly, *Toxotrypana curvicauda* Gerstaecker, and the annona seed borer, *Bephratelloides cubensis* (Ashmead).

Florida has pests which do not occur in many of the places where markets (actual or potential) for Florida's agricultural produce exist. Whenever the quarantine authority in an importing country or state determines that a pest possesses a potential risk of establishment, a quarantine is placed on that pest, and commodities which might harbor it are prohibited from entering without undergoing a certified treatment proven to kill virtually all individuals of the pest. Of the quarantine treatments currently used for Florida commodities, methyl bromide fumigation may be banned by the year 2000 as it is purported to be an ozone depleter, and alternative treatments need to be developed. Other quarantine treatments are presently used for some Florida commodities. Some treatments have been thoroughly researched; however, certification has not been requested. With other commodities and pests, sufficient research has been conducted to indicate that the treatment would probably work; however, it has not been proven effective at the high level of precision needed to ensure virtually 100% mortality of the pest. Other commodities have no present or potential quarantine treatments. Some have simply not been studied, while others have proven difficult.

Proving that something is 100% certain is a statistical impossibility. Therefore, quarantine authorities demand a level of probability very slightly under 100% that a treatment will not leave survivors. For example, the U.S. Department of Agriculture, Animal and Plant Health Inspection Service (APHIS), demands a mortality level of 99.9968% (one survivor of 31,250 treated individuals) for treatments involving fruit flies (Shannon, 1994). However, Couey and Chew (1986) showed that to ensure 99.9968% mortality of an organism at the 95% confidence level, there must be no survivors of 93,613 individuals treated, and this has usually been the standard goal APHIS uses for confirming a quarantine treatment for fruit flies. Japan often demands that 30,000 individuals be subjected to a treatment with no survivors before the treatment is approved.

The objectives of this work were to collect and summarize information on insect quarantines placed against Florida agricultural commodities used for human consumption, evaluate the feasibility of quarantine treatments for each case, and indicate where quarantine treatment research is needed.

Materials and Methods

Plant quarantine manuals and similar sources from different countries and states were searched for quarantines of Florida commodities used for human consumption (fruits, vegetables, nuts, and sugarcane). We selected only those quarantine problems which we felt represented possible markets for Florida commodities. Literature and unpublished information on quarantine treatments of Florida quarantine pests were studied for their possible application. Primary attention was given to the ability of the commodity to tolerate the treatment; if the treatment kills the pest but also damages the commodity it is not a viable treatment. Methyl bromide was not considered for possible future treatments because it may be banned in the near future and the trend is to market agricultural produce without the use of postharvest fumigants.

Results and Discussion

Quarantine treatments for Florida agricultural commodities were divided into three groups: 1) certified treatments presently being used or permitted to be used; 2)

Table 1. Quarantine treatments for Caribbean fruit fly in Florida agricultural commodities for human consumption.

Commodity	Treatment	Reference
Grapefruit	0.6-2.2°C for 14-24 days[z]	Ismael (1989)
Grapefruit	Fly-free zones[z]	Riherd et al. (1994)
Grapefruit	Irradiation; 50 Gy + 1.1°C for 5 days[y]	von Windeguth & Gould (1990)
Grapefruit	≥43.3°C air (100% RH) until center ≥43.3°C for 50 min[y]	Hallman et al. (1990)
Grapefruit	Air at 48°C until center ≥44°C[y]	Sharp (1993)
Grapefruit	Irradiation; 150 Gy[x]	von Windeguth & Ismail (1987)
Citrus[w]	40 g/m³ methyl bromide 2 hr at 24-29°C[z]	(C. Riherd, Fla. Dept. Agr., personal communication)
Lime	Non-host[y]	Hennessey et al. (1992)
Mango	Water at 46.1°C for 65-90 min[z]	Anon. (1990a)
Mango	48°C air until center ≥44.5°C[y]	Sharp (1992)
Mango	Irradiation; 75 Gy[x]	von Windeguth (1986)
Carambola	1.1°C for 15 days[z]	Gould & Sharp (1990)
Carambola	Water at 46°C for 45 min[y]	Hallman & Sharp (1990)
Carambola	Irradiation; 50 Gy[y]	Gould & von Windeguth (1991)
Carambola	Air at 48°C until center ≥44°C[y]	Sharp & Hallman (1992)
Carambola	Air at ≥46°C (100% RH) until center ≥46°C for 35 min[y]	Hallman (1990)
Guava	Water at 46.1°C for 35 min[z]	Gould & Sharp (1992)
Guava	Air at 48°C for >50 min[x]	(W. Gould, USDA, personal communication)
White sapote	1°C for 15 days[x]	Hallman (1993)
Canistel	1°C for 15 days[x]	(G. H., unpublished data)

[z]Treatment presently used or at least certified for use in some country or state.
[y]Research for treatment essentially completed; however, certification has not been requested.
[x]Treatment would probably work; confirmatory research needed.
[w]Grapefruit, orange, tangerine, and lemon.

Table 2. Quarantine treatments for pests other than the Caribbean fruit fly in Florida agricultural commodities for human consumption.

Commodity	Pest	Treatment	Reference
Blueberry	Blueberry maggot	32 g/m^3 methyl bromide^z	Anon. (1990c)
Blueberry	Plum curculio	32 g/m^3 methyl bromide^z	Anon. (1990c)
Sweetpotato	Sweetpotato weevil	Methyl bromide fumigation^z	Anon. (1993)
Sweetpotato	Sweetpotato weevil	Irradiation; 300 Gy^x	(J. L. Sharp, USDA, personal communication)
Sweetpotato	Sweetpotato weevil	2-4% O_2; 40-60% CO_2 for 7 days^x	Delate et al. (1990)
Pecan	Pecan weevil	−18 to −11°C for 7 to 14 days^z	Anon. (1988)
Pecan	Pecan weevil	60°C water for 5 min.^{z}	Anon. (1988)
Pecan	Pecan weevil	Steam at 5 lb/in^2 for 3 min^z	Anon. (1988)
Sugarcane	Sugarcane borer	−10°C for 48 hr^z	(O. Sosa, USDA, personal communication)
Sugarcane	Sugarcane borer	Water at 52°C for 20 min^x	Sosa (1990)
Sugarcane	Sugarcane borer	Water at 25°C for 72 hr^x	Sosa (1990)

^{z}Treatment presently used or certified.
^{x}Treatment would probably work; confirmatory research needed.

treatments for which the research has been essentially completed, but for which certification has not been requested, and 3) treatments which would probably work, but for which confirmatory research has not been done. For many other commodities, virtually no relevant research toward developing quarantine treatments has been done.

Quarantine treatments for Caribbean fruit fly, *Anastrepha suspensa* (Loew), the most important quarantined pest of agricultural food commodities in Florida, are presented in Table 1. Table 2 presents treatments for other pests found in Florida. Some of these treatments have problems. Irradiation at the doses recommended for fruit flies often leaves some larvae alive, although sterile. Inspectors finding these larvae have no method presently for determining if the larvae will not reproduce. Sweetpotatoes fumigated with methyl bromide must be quickly processed because they begin to decompose rapidly. The potential controlled atmosphere treatment for sweetpotatoes (Delate et al., 1990) can only be applied to cured sweetpotatoes, because it damages uncured sweetpotatoes.

Many agricultural commodities grown in Florida currently have no potential quarantine treatments. Treatments have not been examined for many Caribbean fruit fly hosts, such as atemoya, mamey, Japanese persimmon, kumquat, loquat, pomegranate, sapodilla, Surinam cherry, and papaya (Anon., 1990b). Papaya is also a host of the papaya fruit fly, *Toxotrypana curvicauda* Gerstaecker, in Florida; no research on quarantine treatments for this pest has been done. Avocados are hosts of the Caribbean fruit fly; but no treatment has yet been found that does not damage avocados. No quarantine treatment research has been done on the annona seed borer, *Bephratelloides cubensis* (Ashmead), a pest of the fruits of many species of *Annona*, such as atemoya and sugar apple. Alternative treatments to methyl bromide are needed for blueberry infested with blueberry maggot, *Rhagoletis mendax* Curran, and plum curculio, *Conotrachelus nenuphar* (Herbst). Virtually any of the existing quarantine treatments could be improved by simplifying them, making them more economical and reducing damage to the commodity from the treatment.

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COLOR AND CLOUD STABILITY IMPROVEMENT OF CARROT JUICE

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Abstract. **A large percentage of the carrots harvested in Florida each year are unsuitable for the fresh market, but are otherwise sound and could be processed into a valuable juice due to the high β-carotene content. A study was conducted to improve the color and cloud stability of carrot juice since these problems can limit quality. Carrot juice discolored and clarified quickly unless the carrots were heated (90-95°C) prior to juice extraction. Heating whole carrots was more effective than heating milled carrots for improving color, but juice from carrots heated whole tended to clarify quickly if citric acid was not added. The addition of citric acid prior to juice extraction (acidification from pH 6 to 5 or 4) significantly improved color and cloud stability. A commercial pectinase/hemicellulase preparation added before extraction also improved juice color. The overall extraction of β-carotene into the juice was low (ca. 20%).**

A significant portion of the total carrot crop harvested in Florida each year never reaches the fresh market due to various defects such as size and shape (Bates and Koburger, 1974). These reject carrots are otherwise sound and could be utilized in various ways, but are usually either discarded or severely under-utilized as animal feed. Carrots have a high β-carotene content (Senti and Rizek, 1975), and the potential for carrot juice as a natural source of β-carotene and coloring agent appears to be good, especially since natural carotenes reportedly have a demand which exceeds supply.

Carrot juice is currently being produced by a company in Florida, but poor color and cloud stability often limit the quality (Stephens et al., 1971; Bates and Koburger, 1974). Blanching carrots, especially in acid, has been reported to improve color and cloud of heat processed (canned) juice (Stephens et al., 1971; Bates and Koburger, 1974; Kim and Kim, 1983), but timing and extent of acidification need further investigation. Carrots are known to have pectinesterase (PE) activity (Lee et al., 1979), which could lead to the precipitation of pectin in carrot juice with subsequent loss of cloud. Poor color is probably due to low β-carotene extraction, co-precipitation of β-carotene during cloud loss, or enzymatic and oxidative discoloration.

Research has also indicated that various commercial enzymes such as pectinases and/or cellulases increase extraction of juice from carrots (Sreenath et al., 1986; Foda et al., 1985; Anastaskis et al., 1987), but the impact of enzyme treatment on color extraction and cloud stability remains unclear. The most valuable component of carrot juice is probably β-carotene, but the amount of β-carotene extracted during pressing has not been reported and would probably be rather low (Imeri and Knorr, 1988). The objectives of this research were to evaluate the effects of acidification, heat, and enzyme treatments on the color and cloud stability of carrot juice, and to determine the extent of β-carotene extraction in carrot juice.

Materials and Methods

Study 1—Effects of Heat and Acidification

Carrots were obtained from a local market, lye-peeled in 10% sodium hydroxide at 60°C for 2 min, and thoroughly washed. A portion was heated in a steam tunnel to an internal temperature of 93°C, cooled in water, and milled in a hammer mill (1/8″ screen). These conditions were sufficient to inactivate pectinesterase (data not shown). The milled carrots were then either acidified to pH 5 or pH 4 with a 50% citric acid solution or left non-acidified (control). The other portion of carrots was milled before heating and either acidified to pH 5 or 4 with a 50% citric acid solution or left non-acidified (control). The milled carrots were then heated to 93°C in a small stainless steel steam-kettle and cooled. The milled carrots were then extracted by placing in a press cloth and pressing in a small hydraulic press. The experiments were replicated 3 times.

Color of the juice was measured using a HunterLab Color Difference Meter (model D25-2). The turbidity or cloud of the juice was determined by measuring the absorbance at 660 nm (A_{660}) using a spectrophotometer. A portion of the juice was placed at 2°C for 2-3 days and the absorbance at 660 nm again determined to measure the extent of clarification or cloud loss. All data were subjected to analysis of variance using SAS, and least significant difference (0.05 level) was used to separate means.

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