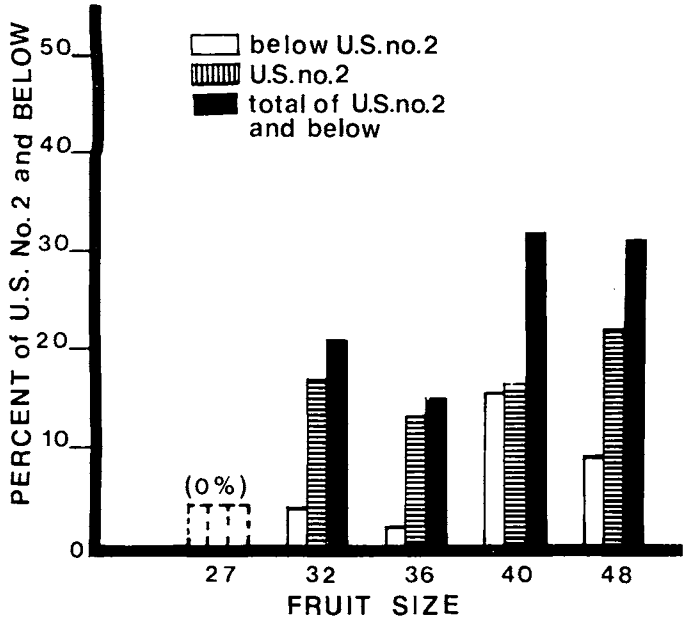

Fig. 3. Internal freeze damage (drying) in Florida commercial grapefruit, measured by U.S. Grade Standards, in four commercial shipments arriving in Japan during April 1977. Separators were used at packinghouses.

did not pass through a separator averaged 42% U.S. No. 2 or below, with lots ranging from 13 to 71% U.S. No. 2 or below. Generally, the larger the size of the fruit, the less was the internal freeze damage (Figs. 2 and 3).

Eleven lots of fruit were cut and inspected in a single commercial shipment that arrived in Tokyo during May 1977. Two lots graded 0% U.S. No. 2 or below and one lot graded 75% U.S. No. 2 or below; the average was 16% U.S. No. 2 or below.

Conclusions

Internal freeze damage (drying) progresses after grapefruit are picked and packed, during refrigerated storage or extended transit periods. Consideration should be given to setting more stringent standards for grapefruit that show freeze damage at packing, especially for those destined for export or storage. Consideration also should be given to the judicious use of frozen-fruit separators for grapefruit when freeze damage is present, even though separators do not eliminate, but only reduce the incidence of freeze-damaged fruit. Generally, the larger the size of the fruit, the less is the internal freeze damage.

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CHARACTERISTICS OF WASTEWATER FROM CITRUS PACKINGHOUSES USING FROZEN FRUIT SEPARATORS[1]

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Abstract. **Oil-emulsion and water frozen citrus fruit separators were used extensively in citrus packinghouses following the freeze of January 1977. Wastewater samples from 2 packinghouses, one with an oil-emulsion and the other with a water separator, were analyzed for COD, BOD, and settleable, total, volatile, and fixed solids. Phenolic residues, methylene blue active substances (MBAS), and turbidity were also determined. Wastewater from the packinghouse using the oil separator had high COD and BOD readings, while the wastewater from the packinghouse using a water separator exhibited lower values in the same tests. The presence of oil separator fluid in wastewater drastically changed its physical properties. Coagulated solids in oily wastewater tended to float to the top, while that in non-oily waste sank to the bottom.**

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[2]The authors express appreciation to Mr. Ben Wood and Mr. Perry Cooper for excellent technical assistance.

Following the January 1977 freeze, a 10-day embargo on the sale and transportation of fresh citrus fruit was instituted by the Florida Citrus Commission (5). The purpose of this ban was to protect the consuming public as well as the citrus industry against use of citrus fruit which may have been damaged by freezing. The order further stipulated that no fresh citrus fruit damaged by freezing shall be sold or offered for sale, except to processing plants for the purpose of conversion into processed citrus products or by-products. Therefore, fruit shipped in fresh fruit channels must meet rigorous standards for freeze damage.

Such restrictions necessitate the use of frozen fruit separators in citrus packinghouses to eliminate freeze-damaged fruit from reaching the consumer. There are 2 principal types of separators, namely water and oil (3, 7), both work on the principle of separation based on differences in specific gravity between freeze damaged and non-damaged fruit. Oil separators utilize an emulsion of purified mineral oil and water to separate sound fruit, which sink onto a roller conveyor, from freeze-damaged fruit which float and are removed from the emulsion on another conveyor. Water separators rely on the greater buoyancy of damaged fruit when either dropped into or released below a moving stream of water (7). Grierson and Hayward (3) published extensive evaluation of the 2 types of separators following the 1957 freeze in Florida.

Since the presence of oil-emulsion seemed to adversely affect the quality of packinghouse wastewater, physical and chemical analyses were conducted on effluents from packinghouses with water and oil separators. Differences in coagulatability with ferric chloride of the 2 types of effluents were also studied.

Materials and Method

Grab samples of final discharged wastewater were obtained from 2 citrus packinghouses between March and May, 1977. Samples were collected from the following key locations in the packinghouse utilizing an oil-emulsion separator: A. rinse water after fruit emerged from oil separator, B. rinse water after fruit was washed with FMC Fruit Cleaner, C. rinse water following color-add application, and D. final composite effluent. Analyses were started within one hr after collection without the addition of preservatives.

Each sample was tested, at least twice, for settleable, total, fixed, and volatile solids. Turbidity, pH, chemical oxygen demand (COD), biochemical oxygen demand (BOD), total phenols, and detergent content expressed as methylene blue active substances (MBAS) were also measured. All tests were conducted according to Standard Methods for the Examination of Water and Wastewater (6) with the exception of the total phenols determination, where sodium ortho-phenylphenol was used as a standard instead of phenol (4). Standard and short COD determinations were carried out as described by Crandall et al. (2).

Coagulation tests were conducted on 500 ml samples of wastewater with 0, 10, 20, 40, 80, and 160 ppm $FeCl_3$. The test was conducted according to Process Design Manual for Suspended Solids Removal of the U.S. Environmental Protection Agency (1). Varying amounts of 2% $FeCl_3$ were added and the samples were stirred using a 6-position stirrer (Phipps and Bird Inc., Richmond, Va.) for 2 min at 100 rpm, followed by 3 min at 30 rpm. The samples were then allowed to stand for 30 min to allow settling of the floc. Turbidity was measured using Hach 2100-A turbidimeter. Data were expressed as formazine turbidity units (FTU). Best coagulation was obtained with 140 ppm $FeCl_3$ and the latter level was used on samples collected from points A, B, C, and D described above.

Results and Discussion

Effluent from the packinghouse with an oil separator was milky in color due to the presence of emulsified separator fluid. It was also higher in total and volatile solids, turbidity, COD, and BOD (Table 1), but low in fixed solids and MBAS.

Table 1. Physical and chemical characteristics of citrus packinghouse wastewater with water or oil-emulsion frozen fruit separator.

Test	Type of fruit separator	
	Water	Oil
Total solids (mg/liter)	300	733
Fixed solids (mg/liter)	150	103
Volatile solids (mg/liter)	150	630
Settleable solids (ml/liter)	0.3	0.2
pH	7.4	7.2
Turbidity (FTU)	60	420
COD (mg/liter)	340	2120
BOD (mg/liter)	80	625
Phenol (mg/liter)	2.7	—
MBAS (mg/liter)	8.4	2.4

Most of the solids in oily effluent floated to the surface, probably as a result of low specific gravity. The solids sank to the bottom of the effluent from the packinghouse which employed frozen fruit water separator.

Table 2. Physical and chemical properties of wastewater samples collected from various points in packinghouse utilizing an oil-emulsion separator.

Test	Sampling Point[z]			
	A	B	C	D
Total solids (mg/liter)	1310	1350	1015	690
Fixed solids (mg/liter)	373	322	315	200
Volatile solids (mg/liter)	937	1028	700	490
Settleable solids (ml/liter)	4.5	7.5	negligible	0.1
pH	7.0	7.1	7.9	7.4
Turbidity (FTU)	55	95	180	320
Short COD (mg/liter)	9940	4040	2500	2940
Long COD (mg/liter)	—	3860	—	3760
BOD (mg/liter)	—	400	—	530
Phenols (mg/liter)	—	—	0.87	1.6
MBAS (mg/liter)	7	11.9	1.4	2.8

[z]A = water rinse following oil separator; B = water rinse following wash with detergent; C = water rinse after color-add dip; D = final discharge.

High COD and BOD values in oily wastewater were attributed to the presence of oil (Table 1). This resulted in an increased load of pollutants per unit vol of wastewater.

Most Florida packinghouses rely on municipal wastewater treatment facilities. Excessive oil present in discharged effluent changed its physical and chemical characteristics and this could result in difficulty in treating wastewater by some municipal systems, which may lead to possible shut down of packinghouse operations.

Table 2 lists the physical and chemical characteristics of effluents obtained at various sampling points in a packinghouse which used an oil-emulsion frozen fruit separator. It was not possible to conduct BOD determinations on samples A and C, or phenol determinations on samples A and B (Table 2), due to excessive turbidity resulting from the presence of oil and/or Citrus Red No. 2 dye. Total solids were high in effluents collected from all sampling points. Most of the solids, however, were organic in nature as evidenced by high volatile solids content.

Highest COD level was measured in rinse water applied to fruit emerging from the oil separator (Point A, Table 2). Further dilution along the packinghouse line resulted in a considerable drop in COD, from 9940 ppm in point A effluent to 2940 ppm in the final composite effluent, a drop of 70.4% (Table 2).

Phenolic content was lower in both oily and non oil-containing effluents (Table 1 and 2) in comparison with figures previously reported (4). This was due to use of a detergent which does not contain the fungicide *o*-phenylphenol, the main source of phenolic contamination in citrus packinghouse effluent (4).

Coagulation of oily wastewater discharge (Sample D, Table 2 and 3) with ferric chloride was achieved successfully with the addition of 140 ppm $FeCl_3$ (Table 3). However, the floc floated to the surface instead of settling to the bottom as is the case in aqueous effluents. In samples A and B (Table 3), turbidity was still high after flocculation due to the persistance of oil emulsion. In sample C (Table 3), there was no reduction in turbidity following coagulation with $FeCl_3$, probably due to the presence of color-add dye.

Conclusions

The use of oil emulsion separators in packinghouses for elimination of freeze damaged fruit drastically changes both physical and chemical properties of the wastewater.

Table 3. Turbidity of citrus packinghouse effluents taken at various points from a packinghouse which utilizes an oil separator before and after coagulation with 140 ppm $FeCl_3$.

Sample code	Sample description	Turbidity (FTU) Before flocculation	After flocculation
A	Rinse after oil separator	55	53
B	Rinse after wash with detergent	95	54
C	Color-add rinse	180	170
D	Final discharge	320	27

The presence of separator fluid results in high COD and BOD content. It also changes its coagulation and settling characteristics. Such a change may necessitate the application of special oil removal equipment prior to its discharge into municipal wastewater treatment facilities.

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PRELIMINARY SOLAR DRYING STUDIES OF SOME FLORIDA FRUITS AND VEGETABLES

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Abstract. **In preliminary experiments Florida grown fruits (peaches and mangos) and vegetables (carrots, celery, green peppers and parsley) were dried with forced ambient air circulation in an enclosed solar dryer using direct solar energy concentrated two- to three-fold by reflectors. Dried products were compared with similar products prepared in a conventional hot-air forced-draft dryer, and with commercial products. Comparisons were based on flavor, color, moisture content, restoration, and shrinkage.**

With increasing fossil fuel costs and decreasing dependability of their supply, alternative forms of energy might become economically feasible for food drying. Flink (5) discussed energy requirements in food dehydration and suggested that conservation of fossil fuels is the first recommended step. However, conservation alone probably cannot continue to compensate for the increasing costs of fossil fuels. Alternative energy sources such as solar could become more feasible and eventually necessary. Florida, with its abundant sunshine and nearly year-round production of fruits and vegetables could be a prime location for application of solar energy for food drying.

Traditional sun drying (direct radiation in the open air) has been practiced for many years and still continues. The food crop is either dried on the plant (grains and field peas), or is harvested, sorted, washed and spread in direct sunshine for drying (raisins and prunes). Problems with open air sun drying such as rain damage and insect infestation, have been discussed by many authors including Cruess (4), VanArsdel (9), and Szulmayer (8). Applying direct radiation, both Khan (6) and Lawand (7) used enclosed chambers with natural air circulation to solar-dry foods. Although their dryers reduced contamination and duration of drying compared with traditional open-air sun drying, air temperature, flow, and humidity were not controlled.

An experimental enclosed solar dryer, using solar radiation, concentrated two- to three-fold by reflectors, and having a forced draft air circulation system, has been designed and installed at our laboratory (2, 3). In these preliminary tests Florida grown fruits (peaches and mangos) and vegetables (carrots, celery, green peppers and parsley) were solar dried. Various quality factors for these solar dried products were compared with reference samples prepared by conventional hot air drying and with commercially available products.

Experimental

Produce and pretreatments

Florida grown carrots, celery, green peppers, mangos, parsley and peaches (May to July harvest) were sorted, washed and pretreated as follows:

Carrots. 1/8 in. (3 mm) and 1/4 in. (6 mm) thick slices were blanched for 5 min with steam at 214°F (101°C).

Celery. Celery leaf (leaves that are currently wasted in the packing of fresh celery) were pretreated the same as carrots. Celery stalk was also pretreated the same as carrots, except only 1/4 in. (6 mm) slices were used.

Green peppers. These were halved with core and seeds removed, then sliced into approximate 1/4 in. (6 mm) cubes. Half the green pepper cubes were soaked in 1.5% sodium metabisulfite for 5 min, and the other half were soaked in water.

Mangos. Fully ripened mangos (Tommy Atkins variety) were manually peeled, and the seed removed by making two slices from stem to stylar end. The two resulting sections of fruit were cut to produce 1/4 in. (6 mm) thick

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Mention of a brand name or trademark is for identification only and does not constitute endorsement by the U.S. Department of Agriculture over others which may also be suitable.