consumption of fruit juices and soda pop alternatives in Canada and the United States, the aseptic packaging system may provide a viable alternative to drum storage of citrus concentrate products.

Summary and Implications

For the small citrus processor or potential concentrate processor, the issue of how to store bulk citrus concentrate is paramount in managerial decision-making. Not only are there alternative containers (drums, tanks, aseptic packaging) but also alternative forms or Brix levels and alternative refrigeration or temperature levels. A generalized comparison of technical and economic considerations for citrus concentrate storage in drums, tank farms, and the bag-in-box concept indicated little economic differentiation in total investment for each storage alternative over the expected economic life of the facility. Economic, operational, and managerial efficiencies gave tank farms and the bag-in-box incentive advantages over drum storage. However, due to the experimental nature of the aseptic bag-in-box, tank farm storage seems more appropriate for commercial concentrate storage. The major considerations of product handling and transport characteristics, product standardization and quality control, storage space utilization, and the relative investment costs of storage and warehousing were presented for each system as to their relative advantages and disadvantages, with principal emphasis in drum and tank storage. Due to the operational efficiencies of tank farms, this storage method appears most appropriate for firms with bulk citrus concentrate.

There are four processed citrus faces in the supermarket—the frozen goods (FCOJ), the diary case (chilled or pasteurized single-strength), the canned goods (pasteurized products), and the beverage section (juice drinks and soda pop alternatives). Processor and merchandising managements must monitor consumer consumption and demographic patterns of trends of these four product lines as they pertain to the firms' storage of citrus concentrate. Managerial participation in financial, labor, procurement, and marketing decisions should also assist the evaluation of appropriate concentrate storage needs and methods tailored to the firm and to the product.

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EFFECT OF FINISHING VARIATIONS ON QUALITY AND YIELD OF JUICE FROM FROZEN ORANGES[1]

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Abstract. **During the 1980-81 season 5 harvests of 'Pineapple' and 4 of 'Valencia' oranges were extracted similarly and tested with both soft- and hard-finishing variations. All harvests except the first two for 'Pineapples' were made after the January 13, 1981 freeze. Single strength juice samples were analyzed for physical, chemical and organoleptic characteristics. Reported results include correlation matrices and a statistical summary. Results showed finisher-setting variation produced no significant differences in juice flavor. A flavor prediction equation for all varieties and treatments was determined with a coefficient of determination (r^2) value of 0.770.**

During the Juice Definition Program (JDP) (1, 2, 3) initiated by the Florida Department of Citrus in the early 1970's, numerous analyses were made of the constituents, and characteristics of single-strength orange juice in an effort to determine a means of measuring "over extraction" and determine several factors that showed substantial differences between high and low juice recoveries, which were also significantly associated with flavor score. Only limited information on the direct effect of finishing was reported and freeze

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damaged fruit was not studied. The purpose of this paper, therefore, is to report on the effects of soft- and hard-finishing on the quality of the juice produced from 'Pineapple' and 'Valencia' oranges, most of which had some freeze damage.

Materials and Methods

The fruit used in this study was harvested from a central Florida grove by a commercial harvesting crew. During the course of the season, with the first harvest made in December 1980 and the final harvest in May 1981, 5 harvests of 'Pineapple' and 4 of 'Valencia' oranges were made. This study originally was designed to determine the effects of finishing on the quality of orange juice, but the January 13, 1981 freeze presented a unique opportunity of studying finisher variations and freeze-damaged effects also. Each harvest was comprised of 30 boxes of fruit which were delivered to the packinghouse at the Agricultural Research and Education Center in Lake Alfred. The fruit was washed, sized, with fruit 2 5/8"-3 1/4" in diameter (size 125 to 64) selected for the study and randomized into 2, 10-box samples. Prior to extraction fruit sample weights were determined and recorded. The fruit samples were extracted on an FMC Model 291 Citrus Juice Extractor using typical commercial settings shown in Table 1. The extracted juice and pulp were then

Table 1. Extractor settings.

Model:	FMC Model 291 @ 75 rpm
Cup size:	3"
Orifice rube:	7/16" long bore
Strainer tube:	.040" long
Beam setting:	3/4" down

finished on an FMC Model 35 juice finisher modified for pneumatic control of pulp discharge pressure, fitted with .020" screens and operated at a speed of 400 rpm. The finisher discharge pressure was adjusted to produce a soft-finish (Avg 214 quick fiber) and a hard-finish (Avg 118 quick fiber), according to the FMC Quick Fiber Test (5), on duplicate fruit samples. Finished juice weights were recorded and the % yield determined. Juice samples for analysis were canned, frozen, and kept at −8° F until evaluated.

Twelve analytical quality indicators were evaluated for each sample. The analyses, the procedures for which are in common use in the citrus industry and have been previously referenced (1, 2, 3) except the analyses for limonin (6) and optical density (absorbance) which is the equivalent to the inverse log of the light transmission of the juice, are listed in Table 2. All juice samples were evaluated for flavor by a

Table 2. Analytical methods used in quality determination.

°Brix	Flavor
% Acid	Color number
°Brix/% Acid ratio	Optical density
% Sinking pulp	Total glycosides (mg/100 ml)
Viscosity (cps)	pH
Limonin (ppm)	Recoverable oil

11 to 12-member experienced taste panel using a 9-point hedonic scale where 9 = like extremely, 5 = neither like nor dislike, 1 = dislike extremely, etc. Stepwise multiple linear regression analysis of the data was made using flavor as a dependent variable.

Results and Discussion

When the quality of juice is discussed, flavor is given prime consideration. A number of objective measurements were made to determine differences which could be attributed to finisher variations on juice, also whether these differences would produce any significant correlations with the subjective flavor measurements. Tables 3 and 4 illustrate the

Table 3. Summary all varieties.

Variable	Avg.	Min.	Max.	Std. Dev. Range
°Brix	11.3	10.1	12.9	10.4 - 12.2
% Acid	0.88	0.51	1.20	0.69 - 1.07
°Brix/% Acid ratio	12.8	9.3	21.4	10.2 - 16.8
% Sinking pulp	12.2	7.0	23.0	7.7 - 16.7
Viscosity (cps)	1.88	1.44	3.61	1.22 - 2.54
Limonin (ppm)	4.2	1.0	6.3	2.5 - 5.9
Flavor	5.0	3.9	6.0	4.4 - 5.7
Color number	36.0	34.6	37.3	35.2 - 36.9
Optical density	0.46	0.15	0.76	0.27 - 0.65
Glycosides (mg/100 ml)	119.8	86.8	151.1	100.1 -139.5
pH	3.7	3.4	4.1	3.5 - 3.9
% Oil	0.022	0.014	0.047	.012- .032
% Yield	45.8	32.1	58.2	37.7 - 53.9

Table 4. Summary of all varieties by finisher treatment.

Variable	Soft Avg.	Soft Min.	Soft Max.	Hard Avg.	Hard Min.	Hard Max.
°Brix	11.3	10.1	12.9	11.3	10.1	12.7
% Acid	0.88	0.51	1.18	0.88	0.52	1.20
°Brix/% Acid ratio	12.8	9.7	21.4	12.8	9.3	20.7
% Sinking pulp	11.4	7.0	20.0	13.1[a]	8.0	23.0
Viscosity (cps)	1.90	1.44	3.61	1.86	1.46	3.41
Limonin (ppm)	4.0	1.0	6.3	4.4	1.4	6.0
Flavor	5.0	3.9	5.8	5.0	4.1	6.0
Color number	36.1	34.9	37.3	36.0	34.6	37.2
Optical density	0.46	0.22	0.66	0.46	0.15	0.76
Glycosides (mg/100 ml)	117.7	86.8	143.7	121.4	97.5	151.1
pH	3.7	3.4	4.1	3.7	3.5	4.0
% Oil	0.022	0.014	0.042	0.020	0.014	0.047
% Yield	44.2	32.1	55.7	47.5[a]	37.1	58.2

[a]Difference at 95% level of significance.

results of this study based on the total data accumulated and the effect of finisher treatment on both varieties. As shown in Table 3, flavor scores indicate that a majority of samples fell within the range 4.4-5.7 or between the upper end of the "dislike slightly" and the lower end of the "like slightly" flavor categories respectively. Statistical correlation showed no significant differences between flavor scores of soft- and hard finished juices. Significance for all comparisons was determined at the 95% or greater level of significance. Fellers et al (4) observed similar results using non-freeze damaged fruit during the 1972-73 and 1973-74 JDP extractor/finisher studies. Following the January 13, 1981 freeze, taste panel evaluations showed flavor scores to decline steadily with a slight recovery occurring after April 30th. This decline in flavor scores is clearly illustrated in Fig. 1.

Statistical analysis of determined yield did not produce any significant correlations with flavor, although as shown in Table 4, hard-finish produced 7.5% more juice than soft-finish which was determined to be a significant difference. The only other factor found to be significantly different between soft- and hard-finisher treatments was % sinking pulp at the 95% level.

Limonin was determined by the immunoassay procedure developed by Mansell (6). In previous studies of this nature,

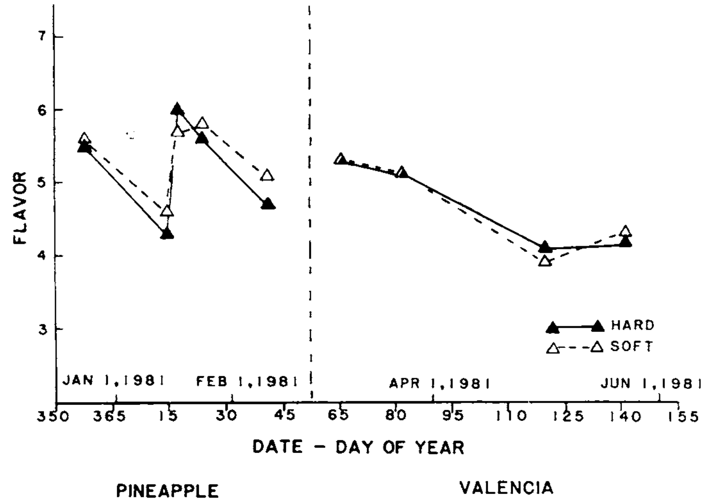

Fig. 1. Flavor vs Time of Harvest.

limonin was shown to produce significant negative correlations with flavor score (1, 2, 3), however, in this study, limonin produced a significant positive correlation with flavor in 'Valencia' juice; that is, juices with the highest limonin content received the highest flavor scores. Overall limonin contents were lower in 'Valencia' juices than those found in juice from the 'Pineapple' variety. Limonin, however, produced no significant flavor correlation in juice from 'Pineapple' oranges, a seedy variety. Limonin values, as normally occur, were found to decrease in the juice as the season progressed.

The absence of a significant correlation between flavor and limonin in the 'Pineapple' variety, in addition to the other analytical characteristics studied, can be seen on a varietal basis in Table 5. The data indicated the flavor from

Table 5. Simple flavor correlations of various analytical characteristics by variety.

Variable	Pineapple	Valencia
°Brix	0.062	−0.796[a]
% Acid	−0.040	0.632
°Brix/% Acid ratio	−0.070	−0.878[b]
% Sinking pulp	0.027	0.623
Viscosity (cps)	0.655[a]	0.618
Limonin (ppm)	0.528	0.867[b]
Color number	−0.193	0.681[a]
Optical density	0.718[a]	−0.804[b]
Glycosides (mg/100 ml)	0.445	−0.850[b]
pH	0.015	−0.805[b]
% Oil	−0.049	−0.820[b]
% Yield	0.067	0.847[b]

[a]95% Level of significance.
[b]99% Level of significance.

'Valencia' juice was more sensitive to the analytical characteristics studied than juice from the 'Pineapple' variety. Viscosity and optical density both produced a significant flavor correlation in juice made from 'Pineapple' oranges, however, only optical density was determined to give a statistically significant flavor correlation common to both varieties.

An indication of the effects of the freeze on fruit maturity and other characteristics, and in turn, their effects on flavor, can also be seen in Table 5. As previously discussed and shown in Fig. 1, flavor scores declined following the freeze until the end of April. As a result of this downward trend in flavor and the normal pattern found in the other juice characteristics studied as fruit matured, a number of anomolies were realized. It must be kept in mind that flavor deterioration was possibly due to frozen juice sacs splitting, allowing the juice to be contaminated with bitterness compounds and other undesirable constituents outside the sac instead of the usual brief exposure to these constituents at the time of juice extraction. Also as juice content dropped in the fruit, the concentration of undesirables in the juice became greater. As the data show, in the 'Valencia' variety, °Brix, ratio, and pH along with ratio in the 'Pineapple' variety produced negative flavor correlations in the juice, and variables such as limonin and viscosity showed positive flavor correlations in both varieties. In 'Valencia' juice, % yield was shown to produce a highly significant positive flavor correlation. Oranges harvested early in the study showed less flavor deterioration due to the freeze than oranges harvested at a later time.

As previously mentioned only % sinking pulp and % yield produced significant differences between soft- and hard-finisher treatments on the combined varietal data, though, none of the variables studied were found to produce a significant difference in both the 'Pineapple' and 'Valencia' varieties. As illustrated in Table 6, % sinking pulp

Table 6. Average values for finisher variations by variety.

Variable	Pineapple Soft	Pineapple Hard	Valencia Soft	Valencia Hard
°Brix	11.0	10.9	11.8	11.7
% Acid	0.79	0.78	1.00	0.99
°Brix/% Acid ratio	13.9	14.0	11.8	11.9
% Sinking pulp	12.6	14.8[a]	10.0	11.0
Viscosity (cps)	2.22	2.14	1.49	1.51
Limonin (ppm)	4.8	5.3	3.0	3.4
Flavor	5.4	5.2	4.7	4.7
Color number	35.6	35.5	36.8	36.5
Optical density	0.36	0.38	0.59	0.58
Glycosides (mg/100 ml)	112.4	117.7	124.3	126.2
pH	3.8	3.8	3.6	3.7
% Oil	0.017	0.017	0.028	0.028
% Yield	48.2	51.3[a]	39.1	42.7

[a]Difference at 95% level of significance.

and % yield were the only parameters found to show significant differences between the treatments in 'Pineapple' orange juice, however, none were found in 'Valencia' juice. All significant differences found between soft- and hard-finishing were found at the 95% level of significance. Only slight differences were found in the flavor scores between soft- and hard-finishing within a given variety, although apparent differences were determined between the 'Pineapple' and 'Valencia' juices with 'Pineapple' juices receiving overall higher flavor scores.

The following flavor prediction equation was developed:

$$\text{Flavor Score} = 8.33 + (0.93 \times \%\ \text{Acid}) + (0.66 \times \text{viscosity}) - (0.48 \times {}^\circ\text{Brix}).$$

In summary, a study into the effects of hard- and soft-finisher treatments on the juice extracted from mostly freeze-damaged 'Pineapple' and 'Valencia' orange varieties was made and data statistically evaluated. Results showed that hard-finishing produced an average 7.5% more juice, however, no statistically significant differences were found in flavor scores between the hard- and soft-finishes within varieties.

Flavor scores declined after the freeze, however, fruit maturity and other juice characteristics studied followed normal development patterns, thus giving rise to a series of anomolies, such as significant positive flavor correlations determined with limonin and viscosity.

Limonin values obtained using an immunoassay procedure produced no statistically significant differences in content between soft- and hard-finisher treatments of juice in either variety. Significant flavor correlation with limonin was found in the 'Valencia' variety, although overall limonin contents were lower in 'Valencia' juice than limonin contents found in juice from the 'Pineapple' orange variety.

The fact that optical density was the only variable studied which gave a significant flavor correlation common to both 'Pineaple' and 'Valencia' varieties, coupled with results that increased yields from hard finish did not produce significant corresponding flavor correlations, indicated that under the conditions of this study, the effects of finishing were determined to be not critical to overall juice quality.

Finally, a flavor prediction equation with an r^2 value of 0.770 was developed.

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STUDIES ON THE INHIBITION OF ALTERNARIA CITRI IN STORED CITRUS FRUITS[1]

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Abstract. **During extended storage of citrus fruits for 3-4 months, a type of disease known as "Black-Rot" caused by** Alternaria citri **becomes a problem. Post-harvest treatments proved ineffective to control this type of decay. Now it has been demonstrated that the application of an antifungal complex (Antibiotic F), derived from a local strain of** Bacillus subtilis **AECL 69, on the cut stem-ends (in a radius of 2 cm) prior to storage significantly controls this disease in 'Valencia' oranges and 'Kinnow' mandarins. No residual bioactivity was detected from the peel and juice of the treated fruits after a storage period of 3-4 months at 4-5°C.**

In stored citrus fruits the major spoilage organisms were found to be *Penicillium digitatum, Penicillium italicum* and in 'Kinnow' mandarins, a type of soft rot caused due to *Erwinia citri* maculan was also observed (6). In extended storage of both oranges and mandarins, Black-Rot caused by *Alternaria citri* was also observed. In order to minimise postharvest losses in citrus fruits, several experiments were carried out in our laboratory using different postharvest treatments (1, 2, 4, 5).

None of these treatments and others reported from elsewhere (8) were effective in controlling Black-Rot in citrus fruits. The antifungal antibiotic F derived from a local strain of *Bacillus subtilis* AECL 69 was found quite effective against *Alternaria citri* in stored 'Valencia' oranges (7). Further in a detailed study, the effect of Antibiotic F on the inhibition of *Alternaria citri* in stored oranges and mandarins was investigated during 1979-81, the results of which are reported in this paper.

Materials and Methods

Stored citrus fruits decaying with 'Black-Rot' were collected and the causitive fungus, *Alternaria citri*, was identified by direct microscopic examination of blackened tissues. The infected tissues from oranges as well as mandarins were streaked on to malt extract agar (pH 6.5) and a dozen of pure culture isolates of *Alternaria citri* were maintained on malt extract agar slants and were tested against the killing effect of antibiotic F by cup plate technique.

To test the effectiveness of antibiotic F to control the postharvest decay of citrus by *Alternaria citri*, the mature fruits of *Citrus sinensis* Osbeck cv. 'Valencia' and *Citrus reticulata* Blanco cv. 'Kinnow' were procured from a private orchard, stem-ends cut to the shoulders, washed and dipped in aqueous suspension of thiabendazole (1000 ppm conc.) against *Penicillium* rots (5). The fruit skin portions around stem-ends were encircled (radius 2 cm) with a felt-tipped marker and the aqueous solution of antibiotic F (inhibition zone 25 mm against *A. citri*) was applied with the help of a sterilized pasteur pipette to the encircled skin area. This was repeated three times after an interval of five minutes. Plain water drops were applied to another lot of fruits that served as controls. After drying in normal air, the treated as well as nontreated oranges and mandarins were held in perforated cardboard boxes lined with newspaper (0.093 mm thick). The fruit containers were stored for 3 months (Kinnow), 3 and 4 months (Valencia) in a commercial cold storage (4-5°C) and then transferred to room temperature (25-30°C) for a week. The fruits were then cut across and the incidence of Black-Rot (also known as internal blackening) recorded.

For the residual effect of the antibiotic F, treated fruits 3 (3x3) were collected at random after a storage period of 4 months. The skin portion from 2 cm dia around the stem-ends were removed with a sharp sterilized blade and skin

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