ships that are strongly price elastic indicate that the European market has the potential to be successfully developed for citrus products. By expanding this market, production from the Florida citrus industry could be channeled abroad to relieve projected domestic surpluses. Total revenue to Florida exporters can be increased by increasing the sales volumes to these price elastic markets.

In order to obtain better estimations of demand parameters in the European market, different data sources will have to be used. Perhaps data that deal more directly with foreign retail markets would be more meaningful. A price index should also be used — to take inflation in the European countries into account. The results from the data used in this study are not conclusive enough to make any decisive observations concerning their use. Further research attempts should also include some analysis of demand in Eastern European countries. Along with rising per capital incomes in Poland and other countries, there has been a demand for a greater variety of goods in these countries. Exports of single strength grapefruit juice to East Germany in April, 1968, exceeded the entire export of this product to either Sweden, Denmark, or Switzerland for all of 1967. An investigation into the potential of this export market should be included in further research on Western Europe's demand situation. Advertising should again be included as an independent variable, because of possible increasing effects on demand.

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REVIEW OF LINE CHECK DATA SHOWING BACTERIAL CONTAMINATION IN PROCESSING FROZEN ORANGE CONCENTRATE

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Sanitation plays an important role in the processing of frozen concentrated orange juice (FCOJ). If an efficient sanitation program is not maintained, microorganisms, primarily lactic acid bacteria and yeast, take hold and produce off-flavors in the finished product (1, 3). Under favorable conditions, these organisms grow at an extremely rapid rate; thus it becomes imperative that sanitation be watched closely. The diacetyl test has been developed and is a very effective quality control tool in detecting insanitary conditions (5, 6). However, it is not a panacea for all microbiological problems that may develop as it only shows the presence of those organisms capable of producing diacetyl and/or acetylmethylcarbinol. In many cases it is desirable to know the total viable population in various phases of the processing operation. This is especially true of the finished product. With the advent of the FDA Good Manufacturing Practices, it is mandatory that the processor maintain records of the total microbial population of the finished product. Generally this is referred to as making plate counts. However, when juice from various processing operations is plated, this is referred to by the citrus industry as a "line check." For an effective biological control program, the diacetyl test should be used in conjunction with line checks. This enables the processor to detect microbial buildup in his processing operation, the source of contamination and determine the efficiency of each clean-up. Our company employs both of these tools on a routine basis during its processing operations.

In 1952, Minute Maid set up a comprehensive biological control program for all of its

processing plants. This consisted of making line checks from various processing operations, "mike" counts and more recently diacetyl tests. At first line checks were made daily, later twice each week. The data are recorded on special logs, and at the end of each month a line check status report is prepared from the tabulated results. These reports have been published since 1953 for January, February, April and May, the principal months of operation in processing FCOJ. It is from this information that this paper has been prepared.

Procedure

All line check samples were collected under aseptic conditions from various stages in processing FCOJ. They were pour plated on orange serum agar and the plates counted after 48 to 72 hr. of incubation at 30°C. All results (concentrate and finished product) were reported on a single strength juice basis (12° Brix).

Results

Minute Maid operated at one time or another during the interim between 1953-69 seven concentrate plants. Routine line checks were made at each location. However, for the sake of space only portions of the results from three plants are reported herein. Unless stated otherwise, all data are the average results for the location and/or year indicated. Table 1 shows contamination in processing FCOJ from extractors to the finished product from 1953 through 1969. The results are seasonal averaged plate counts obtained from three plants. As would be expected, evaporator feed juice counts were higher than extractor juice; the difference being the pick-up of contamination between these two points. Up to 1965 low temperature evaporators were employed; after this date TASTE (thermal accelerated short-time evaporator) units were used. Data shown (evap. pump-out) are average results from both types of evaporators. Finished product counts for all three plants were less than 10,000 org. per ml.

A breakdown of the data by month of operation for Plant A are shown in Table 2. The highest extracted juice and evaporator feed counts for the midseason occurred in February. The later half of this month generally is the windup of this portion of the fruit supply. Historically, the last week of February, prior to the advent of the TASTE evaporators, was when the most serious spoilage outbreaks occurred (2). The results shown for April and May represent those obtained during the Valencia portion of the processing season. The highest counts for the year, except for the finished product, occurred in May. This is due to a combination of factors such as fruit maturity when the Valencia season is drawing to a close and warm weather with the temperature approaching 90°F each day.

The Big December Freeze

On December 12 and 13, 1962, Florida experienced the worst freeze of the century. The fruit was picked as rapidly as possible. During the month of January, 1963, all plants that could possibly process FCOJ were in operation. They operated 24 hr. a day and 7 days a week. In February little or no fruit was processed as all the midseason fruit had been handled the previous month. Valencias lasted for approximately a month and were processed in April.

The freeze caused physiological changes to occur in the oranges. Hesperidin, for example, appeared in the fruit as small white specks

Table 1. Contamination in processing FCOJ from extractors to finished product from 1953-69.

Plant	Year	Juice from extract.(1)	Evap. feed juice	Evap. pump-out	Finished product
			Avg. org. per ml		
A	53-69	50,000	60,000	7,000	7,000
B	53-65	66,000	107,000	4,000	4,000
C	55-69	33,000	54,000		2,000

Data avg. per station from 175 to 5,000 samples.

(1) Sampled before finishers.

Table 2. Contamination in processing FCOJ from 1953-69.

	PLANT A			
	January	February	April	May
		Avg. org. per ml		
From extractors (1)	27,000	41,000	28,000	50,300
Evaporator feed (1)	29,400	48,200	39,600	91,300
Pump-out (1)	3,100	2,200	4,100	7,500
Finished product (2)	2,100	5,401	1,300	1,900

(1) Avg. of 300 to 400 samples; (2) 1,500 to 2,100 samples.

Note: Juice from extractors sampled before finishers.

creating a processing problem. The effect of juice extracted from freeze-damaged fruit on the microbial population is questionable. The author personally examined sound oranges from the tree and drops from the ground and found the juice when extracted aseptically to be sterile, for all practical purposes. However, freeze-damaged fruit soon becomes extremely soft and thus is prone to splitting. When this occurs it readily becomes contaminated with microorganisms. Most processors experience difficulty in handling this type of fruit.

The effect of processing freeze-damaged fruit on microbial contamination is shown in Table 3. Extracted juice counts from 2 plants for January, 1962, are compared with those for January, 1963, the month following the freeze, and for April, the next month of operation. Plant A shows the freeze had little or no effect on microbial population. On the other hand, in Plant B the extracted juice counts were noticeably higher for January, 1963, than during any other period. This may have been due to the soft condition of the fruit that was being processed.

Effect of Stabilizing Temperature On Bacterial Contamination

During the infancy of the frozen concentrate industry, a serious quality problem in the form of gelation and separation was created by either not heating the juice or by insufficient heat treatment in the low temperature evaporators. The heating process, primarily to reduce enzyme activity, is referred to as stabilizing. The juice was either flash-heated prior to entering the evaporator or between stages of the unit. However, most processors used the latter method to heat their product. The stabilizing temperature was gradually increased from 150°F to 190°F or above.

Table 4 shows the effect of the stabilizing temperature on microbial contamination. Seasonal average product counts before stabilizing and from the stage after heat treatment are presented. Note a temperature between 150-155°F gave a reduction in total viable population of 80-96%, and 190°F, 98-99.4% Murdock et al. (4) in 1953 reported on the thermal resistance of bacteria and yeast in orange juice and concentrate. Of the organisms studied, these authors found yeast were the most heat resistant with the greatest thermal resistance in concentrate, rather than in single strength juice (0.53 min. at 150°F in single strength juice and 6.7 min. in 42° Brix orange concentrate).

Evaporator Contamination

Table 5 shows microbial activity in processing FCOJ in a Buflovak-Howard bank of evaporators in comparison with a Kelly unit. The Buflovak-Howard combination consisted of three 2-stage Buflovak units in series with one 2-stage Howard evaporator. The Kelly was a 4-stage unit. All product was stabilized at 150°F in between effects using a plate-type heat exchanger. The microbial buildup in both units prior to the heat exchanger was comparable, 45% versus 52% for the Kelly unit. There was

Table 3. Contamination prior to and after December, 1962 freeze.

	EXTRACTED JUICE (1)		
	Plant A	Plant B	
	Avg. org. per ml		
Jan., '62	79,000	72,000	Year prior to freeze
Jan., '63	60,000	238,000	After Dec., '62 freeze
Apr., '63	47,000	80,000	

Data for each month avg. of 10 to 17 samples.

(1) Sampled before finishers.

Table 4. Effect of stabilizing temperature on microbial contamination in low temperature evaporator.

	PLANT B			
	Heat treatment between evap. stages			
Year	Stab. temp. °F	Before stab.	After stab.(1)	% Reduction aft. stab.
		Avg. org. per ml		
1953	150	65,000	13,000	80
1954	150	85,000	5,000	94
1955	155	79,000	12,000	85
1956	155	52,000	2,000	96
1957	190	82,000	400	98.5
1958	190	126,000	2,000	98
1959	190	169,000	1,000	99.4

Data for each year avg. of 90 to 180 samples.

(1) Sampled from stage after stabilizer.

Table 5. Comparison of microbial activity in processing FCOJ in low temperature evaporators. Data 1954 season

Source of sample	Buflovak-Howard Avg. org. per ml	Buflovak-Howard % Change from evap. feed	Kelly Avg. org. per ml	Kelly % Change from evap. feed
Evap. feed	53,000		52,000	
Stage bef. stab.	77,000	45 (+)	79,000	52 (+)
Stage aft. stab.	26,000	51 (-)	5,000	90 (-)
Evap. pump-out	19,000	64 (-)	3,000	94 (-)

All averages weighted; 79 to 82 samples per station.

a greater reduction in counts in the stage after the heat exchanger in the Kelly unit than in the Buflovak-Howard bank of evaporators.

In 1965 the high temperature TASTE (thermal accelerated short-time evaporator) was installed in several of our plants. In these units juice is held for a short time between 195-200°F. Contamination in concentrating orange juice in a low temperature unit versus a TASTE evaporator is shown in Table 6. Seasonal average plate counts show that product leaving the TASTE unit is commercially or virtually sterile. This is in direct contrast to the low temperature evaporator, as the data indicate.

In this summation of data, cutback juice has not been mentioned due to the lack of space. However, the level of contamination of cutback juice follows closely with that reported for extractor juice.

Table 6. Evaporator contamination. Low temperature versus TASTE.

Low temp. (1) Year	Evap. feed	Pump-out	TASTE Year	Evap. feed	Pump-out
	Avg. org. per ml			Avg. org. per ml	
1960	42,000	12,000	1965	78,000	<100
1961	71,000	2,000	1966	78,000	<100
1962	50,000	7,000	1967	23,000	<100
1963	53,000	3,000	1968	24,000	<100
1964	52,000	7,000	1969	43,000	<100

(1) Juice stabilized at 190°F between effects.
Data for each year avg. of 50 to 170 samples.

The data presented herein is only a small portion of voluminous material collected from 1953 through 1969. Only the interesting aspects have been reported.

Summary

Data obtained from line checks made over the past 16 years show contamination in processing FCOJ (frozen concentrated orange juice) from the extractors to the finished product. The highest plate counts during the midseason portion of the pack occurred in February, and for the processing year in May.

The data are inconclusive regarding the microbiological contamination occurring in juice extracted from freeze-damaged fruit. One plant showed higher plate counts on extracted juice the month after the freeze while another plant did not.

The effect of different stabilizing temperatures on microbial contamination in a low temperature evaporator is shown. Two types of low temperature evaporators processing FCOJ are compared in regard to microbial contamination. Product leaving the high temperature (TASTE) evaporator is practically sterile.

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