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COMMERCIAL, CANNED GRAPEFRUIT JUICES PRODUCED IN FLORIDA, 1973-74 THROUGH 1982-83 SEASONS

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Abstract. **From the 1973-74 season through the 1982-83 season 1039 samples of commercial, canned grapefruit juices were collected from Florida processing plants. These samples were analyzed for °Brix, % acid, naringin and flavor. °Brix/% acid ratio was also calculated from each sample. The average flavor score for all samples was found to be 5.9 which falls in the "like slightly" flavor category. Flavor scores have shown a steady decline over the 10-yr period, whereas, naringin has increased over the sample period.**

In 1973 the Florida Department of Citrus initiated the grapefruit quality improvement program of which the survey of commercial, canned, single-strength grapefruit juice was a part. One of the goals of the program was to determine chemical and physical parameters which could be used in an objective determination for flavor. As a result of the study, a number of publications (1, 2, 3, 6, 7) have been written on the effects of °Brix, acid, °Brix/% acid ratio, naringin and limonin on flavor of canned grapefruit juice.

The commercial product known as canned grapefruit juice is grapefruit juice that has been subjected to heat sterilization (canning) and is usually 1 of 2 forms: 1) Grapefruit juice prepared from unconcentrated, undiluted liquid extracted from mature grapefruit. 2) Grapefruit juice from concentrate.

In addition, there is a third form at present in which concentrated grapefruit juice ingredient may be added to form [1] above for adjustments without label declaration provided the concentrated grapefruit juice ingredient added does not constitute more than 15% of the grapefruit juice soluble solids in the finished food.

Also, the Federal Standard of Identity description for grapefruit juice allows the addition of not more than 10% by volume of unfermented juice obtained from mature hybrids of grapefruit (4).

Methodology has also undergone significant changes especially with regard to limonin determination (3, 5), thus limonin determination will not be discussed in this paper. Only those factors for which analytical procedures have remained constant over the 10 seasons studied will be reviewed. It is the purpose of this paper to present data reviewing the quality of commercial, canned grapefruit juice produced in Florida during the 1973-74 through 1982-83 seasons and to serve as a possible data base for improving canned grapefruit juice.

Materials and Methods

Samples of commercial, canned grapefruit juice were collected on the first and fifteenth of each month from Florida processing plants by United States Department of Agriculture Processed Foods Division supervising inspectors. Samples were normally collected between the months of November and June and delivered to the Citrus Research and Education Center in Lake Alfred where they were analyzed and evaluated for flavor within 1 week of production, thus minimizing any degradation of quality due to storage.

Each sample was analyzed for °Brix by hydrometer, % acid by titration with standardized NaOH and calculated as anhydrous citric acid and naringin by the Davis Test (D.T.) (1). Flavor was evaluated by an experienced 10-12 member taste panel using a nine point hedonic scale, where 9 = like extremely, 5 = neither like nor dislike, 1 = dislike extremely, etc. Any known sugar added samples, which make up under 5% of the total commercial canned grapefruit juice pack, were not included in the program. Of the 1039 samples analyzed only 121 or 11.6% of the sample were known to be reconstituted product. The largest group of reconstituted samples consisted of 37 juices which were acquired during the 1982-83 season when Florida processors were allowed to pack reconstituted product at 9°Brix. A regression analysis of all the data was run in order to determine a regression equation for flavor.

Results and Discussion

Table 1 gives the maximum, minimum and average values for the quality characteristics of commercial, canned, grapefruit juice packed in Florida during the 1973-74 through 1982-83 seasons. Of particular interest is the average °Brix. Florida grade standards stipulate (8) that the minimum total soluble solids of unsweetened single strength grapefruit juice in the can not be less than 9°Brix. The average °Brix was 10.23% (Table 1). Naringin by the Davis Test was found to have the largest range in values with a minimum of 350 ppm and a maximum of 1509 ppm. The average flavor score for all samples was 5.9 which falls in the middle of the "like-slightly" flavor category.

Table 1. Maximum, minimum and average values for some quality analysis of commercial, canned grapefruit juices packed during the 1973-74 through 1982-83 seasons.

	Maximum	Minimum	Average
°Brix	15.30	8.60	10.23
% Acid	1.65	0.75	1.17
°Brix/% acid Ratio	12.80	7.05	8.85
Naringin (D.T.) ppm	1509	350	722
Flavor score	7.6	2.9	5.9

The yearly average values for the quality factors studied are shown in Table 2. Only during the 1979-80 and 1982-83 season did the average °Brix fall below the 10% level. During the 1982-83 season the Florida processors were allowed to pack reconstituted grapefruit juice at 9°Brix minimum for the first time. New FDA grapefruit juice standards of identity effective July 1, 1983 call for a 10°Brix minimum for the reconstituted product. Percent acid and °Brix/% acid Ratio showed the most fluctuation during the 10-season period. Percent acid was at its lowest during the 1982-83 season where the average value was 1.04% and ratio correspondingly was at its highest during the same season. Naringin has shown a steady increase in value with the exception of the 1978-79 season where the average value was determined at 639 ppm, some 91 ppm lower than

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Table 2. Average quality factors for commercial, canned grapefruit juices: 1973-74 through 1982-83.

	1973-74	74-75	75-76	76-77	77-78	78-79	79-80	80-81	81-82	82-83
°Brix	10.40	10.30	10.28	10.22	10.19	10.46	9.96	10.57	10.11	9.61
% Acid	1.16	1.17	1.14	1.12	1.20	1.22	1.20	1.27	1.18	1.04
°Brix/% acid Ratio	9.13	8.87	9.07	9.06	8.57	8.70	8.38	8.41	8.68	9.35
Naringin (D.T.) ppm	598	665	658	794	730	639	800	853	865	812
Flavor score	6.3	6.3	6.1	5.6	5.7	6.0	5.9	5.6	5.7	5.4
No. of samples	168	110	121	99	100	113	96	73	79	80

the previous season and 161 ppm lower than the following season. During the 1973-74 season the average value was determined at 598 ppm, while during the 1982-83 season that value had climbed to 812 ppm despite being the season on which canned juice was being packed at its lowest °Brix.

Flavor scores have shown a steady decrease over the 10-season period as shown in Fig. 1. During the 1973-74 and 1974-75 seasons flavor scores averaged 6.3 which is at the upper end of the "like slightly" flavor category. During the 1982-83 season the average score was 5.4 which constitutes the upper end of the "neither like nor dislike" flavor category.

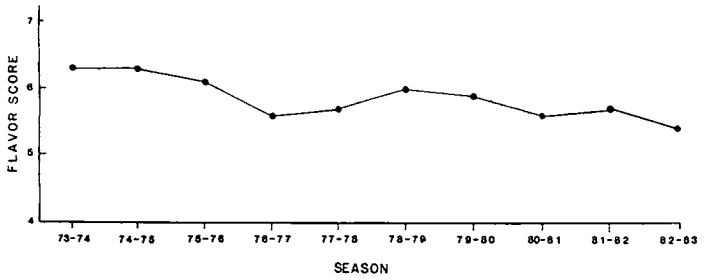

Fig. 1. Flavor score vs. season of commercial, canned grapefruit juices packed during the 1973-74 through 1982-83 seasons.

The frequency by percentage of the flavor values is shown in Table 3. The flavor scores for all samples fell within the six categories shown. The range of the average flavor scores for each flavor category is also indicated. It is evident from this table that the majority of all samples (50.24%) fell within the "like slightly" flavor category. Another 24.73% of the samples tasted fell within the "like moderately" flavor category and approximately the same percentage number of samples (21.55%) fell within the "neither like nor dislike" flavor category. Just over 3% or 32 samples were judged to be in the dislike flavor categories.

Table 4 is a list of the most common adverse comments made by the taste panelist. "Sour (tart)" and "too bitter" are the most prevalent comments made. "Metallic off flavor", which could be due to slow cooling of the product in the can, is also made frequently and contributes to the low flavor scores given by the panelist to this product.

Table 3. Frequency by percent of the flavor values for commercial, canned grapefruit juices packed during the 1973-74 through 1982-83 seasons.

Flavor	No. of samples	% of samples
Like very much (7.5-8.4)	4	0.39
Like moderately (6.5-7.4)	257	24.73
Like slightly (5.5-6.4)	522	50.24
Neither like nor dislike (4.5-5.4)	224	21.55
Dislike slightly (3.5-4.4)	28	2.70
Dislike moderately (2.5-3.4)	4	0.39

Table 4. Most common adverse flavor comments of commercial, canned grapefruit juices packed during the 1973-74 through 1982-83 seasons.

Sour (tart)
Too bitter
Heated off flavor
Metallic (tinny) flavor
Stale off flavor
Weak flavor
Stored can taste
Heated aroma

The data were analyzed statistically for correlation of flavor with the other analytical values for quality. The correlation coefficients obtained are shown in Table 5. °Brix and °Brix/% acid Ratio correlated positively with flavor at the 1% level of significance, while naringin by the Davis test was found to correlate negatively with flavor at the 1% level. Naringin also had the highest correlation coefficient.

Table 5. Correlation coefficients of flavor scores to various quality factors of commercial, canned grapefruit juices packed during the 1973-74 through 1982-83 seasons.

°Brix	0.217[z]
% Acid	−0.070
°Brix/% Acid Ratio	0.244[z]
Naringin (D.T.)	−0.274[z]

[z]Significant at the 1% level.

In summary, the flavor of commercial, canned grapefruit juices packed in Florida has shown a steady decline over the period studied. Naringin on the other hand has shown steady increases over the same period. °Brix remained relatively stable throughout the period dropping below the 10° level only during the 1979-80 and 1982-83 seasons.

A statistical evaluation of the data found that °Brix and °Brix/% acid Ratio correlated positively with flavor and naringin correlated negatively, all at the 1% confidence level.

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ENERGY CONTENT OF WASTE MATERIALS IN FLORIDA CITRUS PACKINGHOUSES[1]

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Abstract. **Waste products from Florida citrus packinghouses were quantified and evaluated for potential utilization as an energy source. For the solid products, samples were analyzed for ash, fuel carbon, gross heating value, moisture content, sulfur and volatile material. In addition, pruned citrus wood from freeze-damaged trees was analyzed. Since reduced moisture content enhances recoverable energy, samples were solar dried in flat plate collectors to determine expected minimum moisture content levels and the efficiencies of such direct solar drying. For a medium size packinghouse (10^6 cartons per year), recoverable energy estimates were: 4.4×10^8 kJ from fiberboard, 5.2×10^8 kJ from field debris and 5.7×10^8 kJ from combustible volatiles in solvent wax.**

An interest in becoming energy self-sufficient has evolved in the United States since the oil shortages of the 1970's. This theme is not only expressed at a national level but also holds for various industries. Fresh fruit packinghouses are one example, as many plants have prime seasonal markets and limited storage capabilities. Hence, economic losses would be extensive with interruptions of fossil fuel or electrical service.

One potential source of energy at packinghouses is in the waste materials associated with fresh fruit packing. Consolidating and combusting field debris, mutilated cartons, etc. would appear to be a straightforward approach as opposed to more complex gas or liquid fuel conversion processes. Although direct combustion would provide only process heat, typically through an on-site boiler, this technology (3, 4) is well-established and would allow limited portable fuels to be used in mobile equipment. In the future, a more extensive energy generation facility could incorporate cogeneration (12). A cogeneration topping cycle would provide heat and steam or both with secondary production of electricity. Such utilization of these waste materials would also be more socio-economically acceptable than consuming edible products or foodstuffs to sustain plant operations.

Drying of these waste materials enhances potential energy available via combustion. Dixit, et al. (3) reported difficulty with sustained combustion with greater than a 55% moisture content in wood. Burnett (2) cites boundary limits for self burning at $\leq$50% water, $\leq$55% non-combustibles and $\geq$25% combustibles. Solar energy has compatibility with such drying when scheduling is not critical. The waste materials could be dried and stored throughout the packing season and used only during fuel interruptions or at the end of a season.

Other researchers have investigated the direct energy in various crop residues: corn husks and stalks (10), apple and grape pomace (7, 13) and ginning wastes (5). Also, Vetter, et al. (15) classified and established the quantities of processing plant waste for the snack food industry. Research on citrus peel combustion for on-site energy utilization was reported by Kesterson, et al. (6).

Specific objectives of the research reported herein are to: 1) characterize the quantity, energy content and storage properties of citrus packinghouse waste products. 2) Analyze solar drying of such waste materials to increase recoverable energy.

Materials and Methods

The following waste materials were identified in Florida citrus packinghouses: fiberboard material, field debris and the solvent constituent in some wax formulations. An additional grove related waste material is the wood from pruning trees, especially after freeze damage. Of these materials, all but the solvent vapor were analyzed for their heating value.

Samples of fiberboard cartons and citrus debris, primarily leaves and twigs, were obtained from local packinghouses and at the Lake Alfred Citrus Research and Education Center (LA-CREC). For comparative purposes, field debris sampling was also undertaken at a citrus processing plant. For the LA-CREC samples, the mass of debris per pallet box was measured. Debris samples were shredded in a Fitzpatrick hammermill with a 1.75 cm screen. The material was then dried under vacuum at 60°C. Water additions were made to achieve various moisture contents. The samples were thoroughly mixed and allowed to equilibrate overnight before combustion pellets were formed.

Citrus wood from freeze-damaged trees was chipped to approximately 5 cm x 5 cm x 0.3 cm sized-pieces in the field with a Morbark 45 kw tree chipper. Fiberboard was hand cut into similar sized 5.0 cm square pieces. Moisture content for these materials was established by convective oven drying at 105°C for 48 hr.

To establish various combustion related properties of these solid waste materials, samples were analyzed by an independent laboratory (Thornton Laboratories, Tampa, FL). Their fuel analysis included percent ash, fixed carbon, sulfur and volatile matter plus gross heating value and moisture content.