EFFECTS OF THE TEST HOUSE EXTRACTOR MODIFICATIONS UPON THE YIELD OF ORANGE JUICE IN COMMERCIAL PRACTICES

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ABSTRACT

A description of the evolution of the present citrus test house extractor equipment and procedures is presented. Comparisons of juice yields since the introduction of the FMC 091B test house extractor in 1967-68 with the four prior years are made for early-midseason oranges and for valencias. It is concluded that there has been little or no reduction in juice for early-midseason oranges, but a definite reduction in valencia juice. It is recommended that procedures should be so organized that Canners may recover about 90% of the juice for early-midseason fruit and 95% of the juice for valencias that is extracted by the test house extractor. These percentages probably approximate the relative amounts of good, usable juice.

INTRODUCTION

Beginning with the 1965-66 season a quality improvement program was initiated within the Florida citrus industry in an effort to upgrade the quality of all orange juice products. Specifically, the use of pulp washed solids was prohibited in retail and institutional pack of frozen orange concentrate, a standardized sampling device was installed at all test houses to assure uniform samples from each load of fruit, and a maximum allowable recovery by any processor was put into effect. Although the old test house extractors continued to be used, 95% of the actual juice recovered by these machines was reported to the citrus grower. The canner was allowed to recover 105% of the juice reported to the grower, and could not average more than 105% for any two week period. At the same time, an accelerated research program was undertaken to determine a satisfactory test house extractor.

At the end of the 1966-67 season, it was decided to adopt the FMC Model 091B as a standard test house extractor, although it was recognized that there was a bias when seedy fruit were extracted. While the machine looks very much like the commercial FMC extractor, in fact, it operates on a somewhat different principle and effectively acts not only as an extractor, but also as a finisher in the test house.

During the 1967-68 season, the machine was operated under 16 to 18 pounds pressure, the grower received a report of 95% of the weight of juice actually extracted, and the canner was allowed 105% recovery.

As a result of in-plant experience and experimental research it was clearly evident that the seed bias was important and could be reduced only by a major increase in pressure which in turn resulted in overextraction and the necessity to adopt a factoring procedure in order to properly identify the amount of good, usable juice.

Therefore, since 1968-69 the machines have been operated at 45 pounds pressure and a factoring procedure has been used to compensate for overextraction and to equalize the relationship between early-midseason oranges and valencias. Thus, the pounds of juice reported to the grower were hoped to represent equivalent weights regardless of variety. Factors and tolerances have varied since that time and are set for the early varieties at an 87% correction factor and a 102% recovery for the fall of 1971. There will be consideration of the factor in December and again when valencia processing season begins.

This entire program was established in an effort to give every grower the same report regardless of the plant to which his fruit was delivered and to force the processor to produce high quality products by some reduction in yield. The following discussion is an effort to analyze the results of the program, and on the basis of these results to make recommendations for future action.

It should be remembered that during the period from 1965-66 through 1970-71 relatively severe freezes occurred on January 31, 1966; January 26, 1968; December 26, 1968; February 4, 1970; November 24 and 25, 1970; and January 20, 21 and 28, 1971, making it extremely difficult to interpret the yields obtained in this period, but these are the only data available, and it is essen-

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tial to analyze them as carefully as possible in order to make valid recommendations for the future.

In order to understand present recoveries, it was recognized that some base for comparison must be used. The USDA Statistical Reporting Service has been analyzing the internal quality of oranges since 1963-64. All analyses have been run on the FMC 091 extractor which was one of the test house machines in use prior to the adoption of the 091B in 1967. Identical settings have always been used with this machine so that results from one year to the other should be comparable.

In addition, although a 105% recovery factor was established in 1965, since no change was made in the actual test house extractor, the 1965-66 and 1966-67 seasons may be mathematically corrected and may be considered as a part of a four year control period for statistical purposes, insofar as juice volume is concerned. The pounds solids recovery is invalid since pulp washing was discontinued for practical purposes in the latter two years.

Thus, the 4 years from 1963-64 through 1966-67 may serve as a base period for considering the results of the four subsequent years, 1967-1971.

Table 1 shows the correction factors that were used in reporting internal quality to growers, the allowed canner percent recovery, and the actual pounds of solids recovered by the canners. The first two years are really not comparable to the others since they include solids obtained by pulp washing over and above the full amount reported to growers. Thus, on early and midseason oranges in 1965-66 the real percentage recovery (102.3% x 95% = 97.2%) was reduced to approximately 97.2% of the value actually recovered in the test house as compared with the 103.7 and 105.1 the two preceding years. The elimination of pulp washing appeared to have reduced the total yield by approximately 6 or 7 percentage points. A slightly greater reduction occurred in the case of valencias.

Although 105% recovery was permitted from 1965-66 through 1969, on early and midseason oranges, the highest recovery of any year was in 1967 and for early and midseason oranges was

TABLE 1

STATISTICS ON PERCENT RECOVERY FOR POUNDS SOLIDS BY CANNERS FOR THE LAST EIGHT YEARS

	Early-Midseason Oranges			Valencia Oranges		
Year	Correction Factor	Allowable Canner Recovery	Actual % Recovery to March 1 On lbs. solids	Correction Factor	Allowable Canner Recovery	Actual % Recovery March 1 to Season end On lbs. solids
63-64	0	-	103.7*	0	-	105.6*
64-65	0	-	105.1*	0	-	106.9*
65-66	95%	105%	102.3***	95%	105%	103.7***
66-67	95	105	103.1***	95	105	103.9***
67-68**	95	105	102.5	95	105	103.8
68-69	88 & 90	105	102.3	90	105	104.2
69-70	88	104	102.6	90	104	103.6
70-71	86 & 88	102	101.3	90 & 91	102	102.1

* Pulp washing allowed

** Standardized 091B test house extractor installed in all plants

*** Average about 97 to 98% of amount actually extracted as compared with 104 to 107% in the two previous years with pulp washing

TABLE 2

A COMPARISON OF CANNER ACTUAL POUNDS SOLIDS PERCENT RECOVERY DURING NOVEMBER, JANUARY - FEBRUARY AND MAY FOR LAST FOUR YEARS

Canner Report #	Approx. date	1967-68 Corr. factor	1967-68 % Rec.	1968-69 Corr. factor	1968-69 % Rec.	1969-70 Corr. factor	1969-70 % Rec.	1970-71 Corr. factor	1970-71 % Rec.
5	11/7	-	-	-	-	88	104.8	86	102.3
6	11/14	-	-	-	-	88	102.2	86	102.3
7	11/21	-	-	88	105.4	88	102.0	86	102.7
8	11/28	-	-	88	102.3	88	101.5	86	99.6
Avg.					103.9		102.6		101.7
Avg. percent of test house*					91.4		90.3		87.5
17	1/23	95	103.4	90	102.7	88	103.2	88	102.2
18	1/30	95	102.6	90	101.8	88	103.6	88	101.6
19	2/6	95	102.0	90	102.3	88	101.8	88	102.1
20	2/13	95	102.7	90	102.3	88	103.8	88	100.0
Avg.			102.8		102.1		103.1		101.5
Avg. percent of test house*			97.7		91.9		90.7		89.3
32	5/8	95	103.7	90	104.6	90	103.5	90	102.6
33	5/15	95	104.5	90	104.5	90	104.0	90	103.2
34	5/22	95	104.9	90	104.2	90	104.8	91	102.4
35	5/29	95	104.0	90	104.4	90	103.7	91	102.4
Avg.			104.3		104.4		104.0		102.7
Avg. percent of test house*			99.1		94.0		93.6		92.9

*% OF TOTAL SOLUBLE SOLIDS EXTRACTED IN TEST HOUSE BEFORE FACTORING WAS ACCOMPLISHED

TABLE 3

A COMPARISON OF JUICE RECOVERY BETWEEN HAND REAMING AND VARIOUS TEST EXTRACTOR SETTINGS

Extractor	Hamlin % Juice Recovery	Hamlin % Difference	Hamlin Comparative Lbs. Juice	Pineapple % Juice Recovery	Pineapple % Difference	Pineapple Comparative Lbs. Juice	Valencia % Juice Recovery	Valencia % Difference	Valencia Comparative Lbs. Juice	Factor Differential Val & PA.
Hand Ream*	55.56	0	50.00	55.56	0	50.00	55.56	0	50.00	0
091	49.43	-6.13%	44.49	55.58	+ .02%	50.02	53.44	-2.12%	48.10	+3.1%
2701	57.28	+1.72	51.55	60.70	+5.14	54.63	57.07	+1.51	51.36	+3.0
091B 16#	50.04	-5.52	45.03	55.16	- .40	49.64	53.07	-2.49	47.76	+2.1
091B 45#	55.82	+ .26	50.32	59.18	+3.62	53.26	55.22	- .34	49.70	+4.0

*A HYPOTHETICAL ORANGE AT 50 POUNDS OF JUICE

only 103.1. Theoretically, the canners could have averaged much higher. For some reason they did not attain their full potential. It was not the percentage recovery factor which limited them, but rather their effort to maintain a quality product.

Reference to valencias for the same period shows that the closest the canners on the average could come to 105% recovery was in 1968-69 when they averaged 104.2. Since they could never average over 105%, coming within less than 1% of the maximum is probably about as high as could be expected. This is suggestive that they were recovering all that they could do within the limits of the artificial and arbitrary limits placed upon their production. It is further suggestive that there was no reduction in squeeze on valencia oranges to maintain quality, but only to remain legal. Since the tolerance did not permit the canners to exceed 105% in any three week period, they could approach the 105% on a seasonal basis, but it would be impossible to ever attain it.

In 1969-70 when the allowable recovery was reduced to 104% on early-midseason oranges, recovery still remained at only about 102.6% whereas on valencias, the canners did come within 0.4% of the maximum allowable. This corroborates the thesis in the above paragraph and is strongly suggestive that collectively, the canners are very competent to manage their plants so that they can come very close to whatever legal limit is permitted. This is contrary to the claims that have often been made that a tolerance of several percentage points is required for them to remain legal. Therefore, if tolerances are necessary, a tolerance as small as 1% would be practical and would result in no hardship to the canners.

TABLE 4

CORRELATIONS BETWEEN INSPECTION SERVICE POUNDS OF JUICE AS REPORTED TO GROWERS AND FLORIDA CANNERS YIELDS FOR SS JUICE AND CHILLED JUICE BY MONTHS

SEASON	OCT. -NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY
1963-64	.21	.09	.80	-.33	.93*	.76	.83
1964-65	.17	-.83	.10	.13	.67	.86	.61
1965-66	-.18	.14	.50	.94*	.77	.33	.20
1966-67	-.44	.20	.86*	.67	.88	.94*	.89
1967-68	.11	.86*	.99**	.26	.67	.13	.65
1968-69	.72	.99**	.56	.99**	.93*	.91*	.99**
1969-70	.92**	.89	.26	.60	.89*	.85	.93*
1970-71	.68	.50	.93*	-.03	-.62	.97*	.88*

* SIGNIFICANT AT 95%

** SIGNIFICANT AT 99%

In 1970-71, when canners were allowed to average yields over the entire season, the entire season did not reach 102%, but valencias actually averaged more than 102%. In effect, the canners made up on valencias what they failed to obtain on early-midseason oranges.

This latter statement is further borne out by the selected data shown in Table 2. Here data for the last four years are shown for pounds solids recoveries in November; late January and early February; and in May. Very little concentrate is actually run in November, but these figures show that the recovery on early oranges was close to the tolerance for only one week in 1968 and 1969, but when the allowable recovery dropped from 88 to a factor of 86% in 1970, canner recovery was very close to the allowable 102%. For midseason oranges in January and February the canners did not approach the allowable recovery except in 1970-71 when they got a 101.5% in those four weeks as compared with the allowable of 102%. Actually they could have recovered 104% in a given week and nothing close to this was attained. This further corroborates that even when the best fruit is being run, early-midseason oranges are such that the allowable recovery is not being obtained by the canners and that the restraint is due to quality and not to an arbitrary standard. Apparently at 45 pounds pressure in the test house, quality limitation restricts maximum yields on early and midseason oranges to about 91% of the actual juice extracted in the test house.

In the case of valencias a somewhat different picture is disclosed. Canner averages were exactly at the tolerance of 104 in 1969-70, and they exceeded this tolerance in one week. They were within 0.6% of the tolerance in 1968-69. They exceeded the tolerance by 0.7% on the average in

TABLE 5

CORRELATIONS BETWEEN INSPECTION SERVICE POUNDS OF JUICE AS REPORTED TO GROWERS AND FLORIDA CANNERS YIELDS FOR SS JUICE AND CHILLED JUICE ON A CUMULATIVE SEASON TO DATE BASIS

SEASON	NOV. 30	DEC. 31	JAN. 31	FEB. 28	MAR. 31	APR. 30	MAY 31
1963-64	.21	.45	.61**	.56**	.54**	.69**	.66**
1964-65	.17	-.27	.17	.45*	.39*	.47**	.79**
1965-66	-.18	.24	.46	.68**	.77**	.83**	.78**
1966-67	-.44	-.13	.23	.68**	.74**	.84**	.91**
1967-68	.11	.38	.60*	.81**	.82**	.81*	.78**
1968-69	.72	.95**	.98**	.96**	.96**	.96**	.96**
1969-70	.92**	.89**	.86**	.94**	.95**	.90**	.91**
1970-71	.68	.81**	.73**	.86**	.86**	.91**	.91**

* SIGNIFICANT AT 95%

** SIGNIFICANT AT 99%

1970-71, and actually in one week were as high as 103.2 throughout the industry. The conclusion is inescapable that legality not quality limited valencia recovery to 94% or less of the actual juice extracted in the test house. Thus, the correction factors and the tolerance levels between early-midseason and valencia varieties are not properly adjusted. There is good reason to believe that the canners are extracting every drop of good juice that they possibly can obtain from early-midseason oranges and this may well not represent the very best juice on occasion. Whereas, in the case of valencias they are bumping the tolerance continuously, actually exceeding it under the rules that were permitted in 1970-71, and on occasion they are having to throw away good juice in order to remain legal.

As already noted, these figures suggest that, on the best midseason fruit available, canners are able to recover only approximately 91% of the total juice extracted at 45 pounds pressure. However, on valencias they can easily obtain 94%, and probably could attain 95% with no adverse effect upon quality, but these latter figures cannot be demonstrated since legal requirements prohibited this type of recovery at least on an average basis. What individual plants recovered is not public information.

Blair* in unpublished work recommended that the difference in the correction factor between early-midseason oranges and valencias should be at least a 4%. Thus, if 88 were correct for early-midseason oranges, 92% would be correct for valencias. The recovery data in Table 2 suggests that a 5% differential or 93% might be more proper for valencias.

The author had an opportunity to examine raw data collected by Blair in the test house extractor program. Comparisons were made between hand reaming and recovery from various extractors when these two operations occurred on the same day for hamlins or pineapples or valencias. Because of the scarcity of the data and an inability to compare one variety with another, no effort was made to establish statistical significance for these figures, but Table 3 shows a hypothetical situation to illustrate the relative difference in percent recovery for the three varieties as affected by the original test house extractor, the FMC 091; the Automatic Machinery 2701 extractor, currently in use in packinghouses; and the present test house extractor FMC 091B at 16 pounds and at 45 pounds pressure, the latter situation being what is actually used in test houses today.

No decision has ever been made on what should represent a standard from which to make comparisons, but since hand reaming is the one form of extraction that has been in use for many, many years, it might be considered that it is the best base. If this be done, it will be noted that hamlins and valencias appear to act in a similar manner as affected by various test house extractor procedures. Whereas, pineapples follow an entirely divergent pattern. Since there is no way to determine what percentage of the early and midseason crop is seeded, it is necessary to consider pineapples, parson browns, hamlins, and many other varieties together and handle them all on the same basis. This is unfortunate, but unless individual loads can be properly identified by variety, an extremely unlikely situation, it is necessary that these varieties be handled in a similar manner. These data clearly indicate in the right hand column of Table 3 that the factor differential between valencia and pineapples at 45 pounds pressure does calculate out to 4 percentage points so that 90% on midseason oranges and 94% on valencias would apparently be comparable, at least insofar as comparison with hand reaming is concerned. Actual practice as noted in Table 2 would be suggestive that the differential should be 5% rather than 4% and that 90% for midseason and 95% for valencias might be a more proper designation, if a 100% recovery factor were allowed. The differential in the test house is not necessarily indicative of what happens with two different types of extractors used under many different sets of circumstances in actual processing facilities. There is no question that it is easier to get juice out of a valencia and that it stands more abuse in the extraction process than is the case with early-midseason oranges.

Inspection Service Versus Canner Recovery

One opportunity for comparison is between the juice reported to the grower by the inspection service and the Florida Canners' reported recovery for the combination of single strength canned juice and chilled juice.

Table 4 shows correlation between the weekly juice values reported by the Inspection Service to growers and the combined weekly recovery reported by the Florida Canners Association on a monthly basis for the past 8 years. A few months

*The author wishes to acknowledge the cooperation of Mr. J. G. Blair of the Florida Citrus Commission staff for making data available for this report.

contained 5 weeks rather than 4 so that in 5 week months a lower correlation coefficient may be significant. When the 4 year base period, 1963 through 1967, is considered, it will be noted that for early and midseason oranges, which would represent the months through February, on only two occasions were significant correlations found and in some months a negative correlation resulted. Similarly, for the valencia period, March through May, only 2 months were found to be significantly correlated.

However, since the introduction of the standardized test house extractors, early and midseason results correlated significantly in 5 of the 16 monthly periods and valencias in 7 of the 12 possible periods. Thus, the relationship between Inspection Service report figures and Canners juice recovery appears to have been improved since the introduction of the test house extractor. This may be due to the extractor, but more probably is related to the limitation on Canner recovery. The fact that Table 1 suggests that canners have been able to recovery closer to the maximum allowable for valencias than for early-midseason fruit, lends credence to this latter explanation. The more erratic results on early-midseason oranges have to be related to the nature of the extractors and the unknown mix of seedy and seedless fruit.

Table 5 shows correlations for the accumulated yields throughout the season. Thus, as the season progressed and more figures were obtained, correlation coefficients become statistically significant, but there is again a distinct improvement since the introduction of the standardized test house extractor.

Comparison of USDA Internal Quality of Field Run Oranges With Canner and Inspection Service Yield Figures

Table 6 shows for early-midseason oranges the correlation coefficients determined between the figures reported by the Statistical Reporting Service on internal quality obtained on the first of October, November, December and January and both the Inspection Service reported yield to growers and the canners combined juice recovery figures. Both of the latter are accumulated recoveries to March 1. The 4 year periods* before and after the introduction of the test house extractor and the combined 8 years are compared. There is no statistically significant relationship between any of the dates and any of the recovery figures. This is disturbing and appears to suggest that the Statistical Reporting Service figures taken from early and midseason oranges in the field do not relate to the juice recovered at processing plonts. The situation appears to be somewhat improved with new test house extractor procedures, but not sufficiently to render the figures statistically significant.

When a similar comparison is made for valencias (Table 7), the Statistical Reporting Service data correlates significantly with the canners figures during the last four years for all four monthly samplings. The relationships with the Inspection Service reported figures are not as high. As in the preceding table, correlations in the period prior to the introduction of standardized test house extractors were not as high as since that date. The best relationship appears to be for the fruit sampled on April 1.

Relationships Between Brix Reported by the Statistical Reporting Service and by the Inspection Service

Since juice recovery was supposed to be reduced by the quality improvement program, and since USDA Statistical Reporting Service figures do not always relate to actual recovery, correlations for Brix were determined in the same manner as for juice. These data are shown in Tables 8 and 9. It was hoped that an analysis of Brix relationships would perhaps suggest whether comparisons between the USDA reported figures in the field and the figures reported from processing plants are subject to valid comparisons. Brix should not have been affected by changes in test house procedures. Table 8 compares data for early-midseason oranges and the data is handled in two ways. In one instance the Brix reported by the Statistical Reporting Service for early and midseason oranges is weighted on the basis of 1/1 or equal values given for early and midseason oranges. In the second comparison, the ratio between the two varieties is based on the actual number of groves of each sampled on the individual dates. Thus, on January most of the groves were midseason rather than early oranges and the specific figures is weighted more heavily with midseason oranges.

Neither procedure for either the four year or the eight year periods are found to be significant. This seems most strange and places considerable doubt upon the validity of attempting to project figures reported by the Statistical Reporting Serv-

*In 1965-66 and 1966-67 Inspection Service reports were corrected from 95% to 100% to be directly comparable to the two preceding years. In succeeding years, corrections were also made on the basis of legal recovery allowed.

TABLE 6

A COMPARISON OF CORRELATIONS BETWEEN JUICE YIELDS FOR EARLY AND MID-SEASON ORANGES AS REPORTED BY STATISTICAL REPORTING SERVICE ON OCT. 1, NOV. 1, DEC. 1, AND JAN. 1, AND CUMULATIVE JUICE YIELDS FOR SS JUICE AND CHILLED JUICE AS REPORTED BY FLORIDA CANNERS ASSOCIATION AT THE END OF FEB., AND CUMULATIVE JUICE YIELDS FOR ALL PROCESSED ORANGES AS REPORTED BY THE INSPECTION SERVICE[1] AT THE END OF FEB.

	Oct. 1		Nov. 1		Dec. 1		Jan. 1	
	Can.	Insp.	Can.	Insp.	Can.	Insp.	Can.	Insp.
1963-67	.008	.399	-.176	.316	-.755	.520	-.469	.864
1967-71	.731	.695	.569	.507	.845	-.167	.774	.716
1963-71	.454	.564	.198	.219	.345	.436	.548	.574

1 Corrected to 100% after 1965-66 (see text)

ice in the field to what the canners will actually recover in-plant. It also strongly suggests that any conclusions on the effect of the quality improvement program should not use Statistical Reporting Service data as a base.

In the case of valencias (Table 9), the figures are improved and for the eight year period are highly significant for both field data collected on the first of April and the first of May. This is again suggestive that valencia comparisons are most statistically valid and that there is something radically wrong with procedures for handling early and midseason oranges.

Discussion

There seems little question that the general consensus of the Florida citrus industry is that the quality improvement program has been a success. It has provided uniform sampling and testing procedures in all processing plants. Frozen orange concentrate has enjoyed an increasing demand and a maintenance of uniformly good quality that appears to be a direct result of the over-all quality program.

However, there has been major confusion on the part of industry decision makers as to how best to adjust actual extractor settings, and factoring and recovery tolerances in a manner to be fair to both the grower and the processor while at the same time permitting maximum recovery of good, usable juice. A major problem is the inability of the industry to determine what is good, usable juice. Data reported at the 1971 Processor Days at both the USDA and the Experiment Station are strongly suggestive that there will be objective testing procedures available within a very few years to properly define good, usable juice, and to identify juice that has been abused by over-extraction procedures. However, until that day arrives it is necessary to make arbitrary decisions that are as valid as possible with currently available data. Information has been scarce and many decisions have been made on the basis of self-interest, ignorance, or an attempt to get a consensus from a group of people, very few of whom, could really justify the decision that was being made. This is not said to be critical, but rather to face the facts as they currently exist. This indecision has been reflected by periodic changes in operation factors and is amply demonstrated in the data above when the erratic results between varieties is noted.

Although hamlins and valencias have similar recovery characteristics from various extractors, actually in-plant recoveries in November on early oranges as compared with May on valencias are very suggestive that the results in-plant are en-

TABLE 7

A COMPARISON OF CORRELATIONS BETWEEN JUICE YIELDS FOR VALENCIA ORANGES AS REPORTED BY STATISTICAL REPORTING SERVICE ON FEB. 1, MAR. 1, APR. 1, AND MAY 1, AND CUMULATIVE JUICE YIELDS FOR SS JUICE AND CHILLED JUICE AS REPORTED BY THE FLORIDA CANNERS ASSOCIATION, AND JUICE YIELDS FOR ALL PROCESSED ORANGES AS REPORTED BY THE INSPECTION SERVICE[1], FOR THE PERIOD FROM MARCH 1, TO THE END OF THE SEASON

	Feb. 1		Mar. 1		Apr. 1		May 1	
	Can.	Insp.	Can.	Insp.	Can.	Insp.	Can.	Insp.
1963-67	.43	.43	.934	.93	.970*	.998**	.920	.955*
1967-71	.979*	.909	.981*	.984*	.997**	.926	.991**	.921
1963-71	.771*	.757*	.817*	.838**	.885**	.864**	.863**	.846**

1 Corrected to 100% after 1965-66 (see text)

* Significant at 95%

** Significant at 99%

tirely different from experimental procedures. It is probable that this lies in a difference in actual maturity and that oranges in November lack the full bodied flavor of a more mature orange, and also contain off flavor components which are minimized by reduced extraction procedures. It has been amply demonstrated that certain flavor characteristics, some of which are bitter in nature, are more apt to be present in immature fruit regardless of variety and much softer squeeze must be used with the resulting lower recovery on oranges which are relatively immature, as compared with a fully matured fruit. The actual recoveries by canners lend credence to this hypothesis because recoveries during November have generally been well below the tolerance provided. Similar results have been obtained following freezes. There seems no question that the average canner is making a real effort to maintain a quality product, but it is also a fact that when maturity is satisfactory, the average canner will make effort to get the maximum recovery permitted by regulation.

The data presented here support the thesis by Blair that the factoring mechanism should require at least a 4% spread between valencia and midseason oranges.

Consideration of the data presented here does not give any support to the conclusion that the quality improvement program has actually reduced the juice yield for canners on early and midseason oranges. This may be true, but the data is so erratic and confusing that no conclusions are possible, and since canners have not been recovering the maximum allowable, it is suggestive that juice yields have not actually been reduced. It seems far more reasonable to believe that yields on early and midseason oranges represent very close to the maximum possible with reasonably good quality, and probably do not represent any real reduction within the industry.

This is not true in the case of valencias. There has been a continual struggle on the part of the processor to keep within the required tolerance on valencia recoveries throughout most of the past

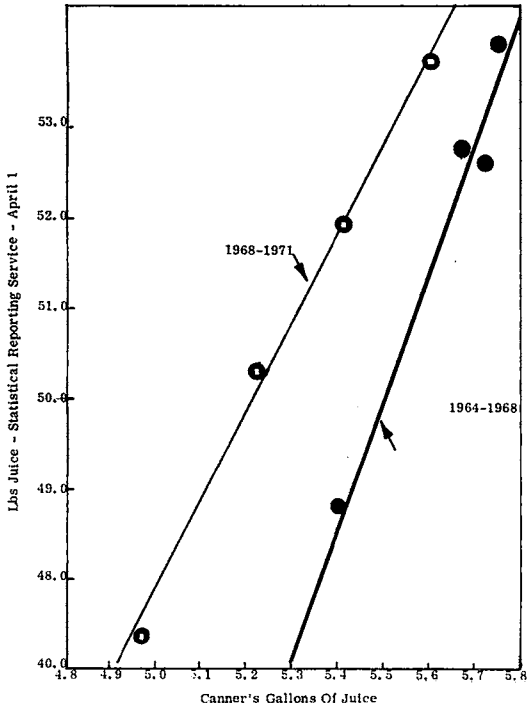
TABLE 8

A COMPARISON OF CORRELATIONS BETWEEN BRIX FOR EARLY AND MID SEASON ORANGES AS REPORTED BY USDA STATISTICAL REPORTING SERVICE ON OCT. 1, NOV. 1, DEC. 1, AND JAN. 1 AND INSPECTION SERVICE CUMULATIVE BRIX AS OF THE END OF FEBRUARY

		Oct. 1	Nov. 1	Dec. 1	Jan. 1
E/M = 1/1	1963-67	.014	.774	.786	.831
	1967-71	.505	.525	.751	.711
	1963-71	.392	.472	.536	.580
E/M = USDA RATIO	1963-67	.037	.797	.767	.813
	1967-71	.529	.516	.765	.711
	1963-71	.399	.484	.562	.600

Figure 1

Relationship Of Canners Juice Yield & Statistical Reporting Service Lbs. Of Juice On April 1, For 4 Years Before And After The Use Of The 091B Test House Extractor



four years. Figure 1 shows two regression lines which relate the April 1st pounds of juice figures reported by the Statistical Reporting Service with the gallons of juice recovered by canners in the plants. This compares the four year period before the standardized test house extractor and the four years since.

Both regression lines are statistically significant and the difference between them represents the amount of reduction that has taken place in valencia juice yields with the advent of the quality improvement program. There is a serious question whether this reduction is fully justified particularly since no comparable reduction can be shown for early and midseason fruit. It makes an excellent case for the conclusion that the yield on valencias should be permitted to be increased and there should probably be some further tightening of restrictions on early and midseason oranges so that recoveries are more comparable for all varieties. It is the author's belief that since the immature fruit processed in November represents a small percentage of the total and that since processing in large volume rarely begins before mid-December a lower correction factor could be used early in the season, with some adjustment upward about mid-December and with a further adjustment upward in the range of additional 4% and preferably 5% on valencias.

TABLE 9

A COMPARISON OF CORRELATIONS BETWEEN BRIX FOR VALENCIA ORANGES AS REPORTED BY USDA STATISTICAL REPORTING SERVICE ON FEB. 1, MAR. 1, APR. 1, AND MAY 1, AND INSPECTION SERVICE CUMULATIVE BRIX FOR VALENCIAS

	FEB. 1	MAR. 1	APR. 1	MAY 1
1963-67	.603	.740	.416	.946*
1967-71	.990**	.941	.942	.663
1963-71	.662	.736*	.931**	.801**

* SIGNIFICANT AT 95%

** SIGNIFICANT AT 99%

Furthermore the data is suggestive that the so-called tolerance which the canners have insisted they must have in order to remain legal need be on more than 1%, and that this is particularly true if they are permitted to have the actual recovery based on a relatively long period of time. Although current regulations call for 102% average on a cumulative basis for the entire season, it would be far better to have the season separated into two parts, and for the first portion of the season to end around March 15th, with a second cumulative period to be set up for valencias. Since during 1970-71 processors tried to make up on valencias what they failed to get on early and midseason oranges, real justification for such a policy exists.

SUMMARY AND CONCLUSIONS

1. The quality improvement program has resulted in standardized procedures for sampling and for testing fruit which have benefitted the entire industry.

2. With present test house extractors it is essential to use a hard squeeze and a factoring procedure in order to compensate for differences in yields between seedy and seedless varieties.

3. Data suggests that canners can very easily live within a tolerance of 1% as the extra allowable recovery. Therefore, it is to be recommended that the tolerance be set at only 101% on a cumulative basis with no two week period to be in excess of 103% and with the season divided into two halves ending with April 1 and the end of the season. Thus, it would be impossible to make up on valencias what has been lost on early-midseason or vice versa.

4. If a 101% recovery factor is permitted the processor, it would appear to be desirable to set correction factors as follows:

> 88% correction and 101% recovery to approximately December 15th. 89% factor and 101% recovery from December 15 to April 1st. 94% correction factor and 101% for the balance of the season, and with the 101% cumulative figure to be terminated with April 1st and again at the end of the processing season.

It is anticipated that these recommendations would give comparable yields to processors throughout the entire season, and that such yields would allow the maximum recovery of only good, usable juice.

5. At the earliest possible time objective criteria for the determination of good, usable juice

should be put into force by the Inspection Service and the recovery tolerance should be eliminated with the processor allowed to recover whatever amount of juice is good and usable under strict inspection supervision. Juice once labeled substandard should not be permitted to be ever reintroduced into a retail product, but should be forced into beverage base products.

6. Increased automation and objective recording of data in test houses should be carried forward as rapidly as practically possible.

FURTHER STUDIES OF ETHANOL AND ACETALDEHYDE IN JUICE OF CITRUS FRUITS DURING THE GROWING SEASON AND DURING STORAGE

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ABSTRACT

Further studies of ethanol content of citrus juice during the season, as an additional measure of maturity, showed marked varietal differences. As the season progressed, ethanol concentration in juice increased in all varieties, but at maturity Robinson tangerines and Temple oranges had lowest ethanol contents, Marsh grapefruit intermediate, and Valencia and Pineapple oranges had highest ethanol contents.

During storage in controlled atmospheres with carbon dioxide (CO_2) concentrations ranging from 10% to 30%, the ethanol content of juice of Marsh grapefruit increased with CO_2 concentration, with length of time of exposure to CO_2, and with total time of storage. Acetaldehyde content of juice, although much lower than ethanol content, increased in a similar manner.

INTRODUCTION

The ethanol and acetaldehyde contents of juice of Hamlin and Valencia oranges increase during the growing season, affording a measure of maturity in addition to the solids-acid ratio (4). These studies were extended to include other kinds of citrus fruits—Robinson tangerines, Temple and Pineapple oranges, and Marsh grapefruit.

Citrus fruits do not ripen or improve in flavor after harvest (1) and should, therefore, be stored under conditions that preserve the characteristics of freshly harvested fruit. The effects of certain storage conditions are reflected in changes in ethanol concentration in juice (4), so the determination of this component may provide a means of assessing the metabolic activity of the fruits during storage.

In a recent review by Wilkinson (8), several instances of CO_2 injury to stored products, including apples, were cited. Other fruits such as blackberries, cherries, and strawberries are apparently not as susceptible as apples to CO_2 injury, and the beneficial use of CO_2 in the transport and storage of cherries, plums, and the soft fruits has been reviewed by Smith (6). Ethanol and acetaldehyde accumulate in apple tissue damaged by CO_2, and Thomas (7) attributed the damage largely to acetaldehyde, although Smith (6) considered its presence only symptomatic of a metabolic imbalance. Brooks and McColloch (2) found that short-term exposure of grapefruit to CO_2 atmospheres avoided some of the physiological disorders associated with chilling injury.

MATERIALS AND METHODS

For the study of seasonal changes, Temple and Pineapple oranges and Robinson tangerines were harvested at weekly intervals from groves in the Central Florida area; biweekly harvests were made of Valencia oranges and Marsh grapefruit from the Indian River area near Wabasso, Florida. Harvests were begun before the usual commercial shipping period for all fruits except Valencia oranges. Data for this variety were previously reported (4); the present study included a period extending 2 months beyond April, the midpoint of normal commercial shipping (1). All fruits were from commercial groves. Samples of the composite juice of 10 fruits were analyzed within 1 day of harvest for ethanol, acetaldehyde, solids, acid, and pH.