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SOME NEW ANALYTICAL INDICATORS OF PROCESSED ORANGE JUICE QUALITY, 1971-72[1]

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Abstract. **Juice Definition Program (JDP) studies started during the 1970-71 citrus season were continued using 30 chemical and physical analyses, state test extraction and commercial type variations of the original harsh and soft squeeze were used. Six samples each of 'Hamlin,' 'Pineapple' and 7 samples of 'Valencia' oranges were harvested at periodic intervals during their respective period of maturity in the 1971-72 season. Ranges and averages for the analytical indicators are reported. Quality comparisons are made of state test and light squeeze juices. A flavor prediction equation was found using multiple regression analyses. A correlation coefficient (r = .969) was found between flavor panel scores and predicted scores.**

Thirty samples of frozen concentrated orange juice selected at random from the production of 20 processing plants in Florida during the 1970-71 season were analyzed using 30 JDP chemical and physical analyses. Average, minimum and maximum values of each analysis are presented. A multiple regression analysis of the data resulted in a prediction equation for flavor that used 6 variables and gave a correlation coefficient (r = .904).

Distinguishing analytical characteristics are demonstrated between orange concentrate evaporator pumpout and orange pulp wash concentrate.

Data are summarized by presenting average, minimum and maximum values from the 30 JDP analyses on each of the 25 samples of orange concentrate and 27 samples of orange pulp wash concentrate produced in 7 Florida processing plants throughout the 1970-71 and 1971-72 citrus season.

I. SINGLE-STRENGTH JUICES EXPERIMENTALLY PRODUCED.

During the 1970-71 processing season (the first season) the Juice Definition Program (JDP) was begun, to investigate possible new indicators of processed orange juice product quality (1). The JDP was continued for a second season during 1971-72 for the purpose of gathering data on juices prepared using extraction methods which might be utilized by the industry. In the second season there was some modification in the original methods through looser extractor settings called hard and light the former being more nearly commercial than the harsh setting of the first year. The three orange varieties were more evenly represented in the processing runs of the second season to correct the varietal unbalance of the first season.

During the first season of the JDP, three extractor variations were employed (soft squeeze, harsh squeeze and state test (4)), only two were

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[1]The authors wish to acknowledge the excellent technical assistance of: L. C. Albright, J. E. Collins, F. H. Givens, Sharon Lovejoy, Bernice Mercer, Betty Murphy, Vernon Rhoades, Margaret Swift, Florida Department of Citrus and W. F. Schopke, Jr., Irene Pruner, and B. F. Wood, Agricultural Research & Education Center, Lake Alfred.

Cooperative research of the State of Florida Department of Citrus and Agricultural Research and Education Center.

reported (soft squeeze and harsh squeeze). It was noted during the first season JDP that flavor of the state test samples rated as well or slightly better than the soft squeeze samples. It was also noted that the single 'Hamlin' sample gave a better flavor with soft squeeze than the state test while 'Pineapple' and 'Valencia' samples appeared to produce very slightly better flavor with state test extraction as compared with soft squeeze. Because of the limited data of the first season JDP, it was decided to gather additional state test data during a second season and evaluate it before reporting.

Analyses for ammonium oxalate soluble pectin, glucose, fructose and ascorbic acid were discontinued and a pH analysis of samples using a Beckman zeromatic pH meter was added.

In other ways the experimental design and procedures (see Materials and Methods) of the second year generally agreed with that of the first year.

For space efficiency in the tables, hydroxide soluble pectin refers to sodium hydroxide soluble pectin and oxalate soluble pectin refers to ammonium oxalate soluble pectin.

Materials and Methods

'Hamlin,' 'Pineapple' and 'Valencia' oranges grown on rough lemon rootstock were used. 'Hamlin' and 'Pineapple' varieties were each harvested periodically 6 times and 'Valencia' 7 times through their respective producing seasons. The fruit was sized, the larger than 3-9/16″ diameter fruit and smaller than 2-1/4″ diameter fruit was eliminated and samples of uniform fruit size distribution were prepared for each of three extractor tests. Fruit and juice weight were recorded.

The following three basic extractions were made during each processing run; state test, FMC 091B (special test extractor), and both light and hard squeeze using a FMC 391 standard commercial extractor. The extractor settings of each of the three tests are shown in Table 1.

The juice from the light and hard squeezes was then finished. Weighings were made on both

Table 1. Extractor settings JDP 1970-71 and 1971-72 seasons[z]

	1970-71 Season		1971-72 Season				1970-71 and 1971-72 Seasons	
	Squeeze		Squeeze					
	Harsh	Soft	Hard		Light		State test	
Cups	3"	3"	3"	4"	3"	4"	3"	4"
Strainers	.090"	.040"	.040"	.040"	.040"	.040"	.025"	.025"
Orifice Tubes	1" WR	1" SR	1" WR	1 1/4"WR	1" SR	1 1/4"SR	1" SR	1" WR
ID and/or Restrictor	7/16"LR	1/2"BM	7/16"LR	1/2"LR	5/8"BM	9/16"LR	No mechanical restrictors[y]	
Upper Cutter	S	S	S	S	L	L	L	L

Note: WR - Window Tube
SR - Split Ring (No window)
LR - Long Restrictors
BM - Bell Mouth
L - Long
S - Short

[z] 1/8" Beam setting used throughout all tests.

[y] Pneumatic restrictor only on state test extraction (45 psi air).

the juice as well as finisher discharge pulp. A FMC 35 finisher (.20″ screen) was adjusted to produce discharge pulp of such juice content that 200 grams of the discharge pulp, when mixed with 200 grams distilled water and strained according to the FMC quick fiber test (5), would pass 200 grams of fluid through the screen. The state test extraction juices were unfinished.

The state test and the finished juices were deaerated in a chamber at approximately 28 inches of vacuum, flash pasteurized at 195°F, and rapidly cooled to 45°F in a plate heat exchanger. The cooled juice was filled into 12 fl. oz. citrus enamel lined cans, sealed and stored at 32°F until analyzed.

All orange juice samples were evaluated for flavor by an experienced panel of 11 or 12 members using a 9-point hedonic scale. All samples were analyzed for 30 chemical and physical characteristics, following procedures of the first season (1) by a team of co-workers. Table 2 lists analyses used.

Correlation matrices relating flavor with as many as 25 of the juice constituent variables were developed and linear multiple regression analyses were made using a G.E. time sharing computer (6).

Results and Discussion

The analytical data for both light and soft squeezes are summarized in a series of tables showing average, minimum and maximum values for each analytical method used. 'Hamlin' data are shown in Table 2, 'Pineapple' data in Table 3 and 'Valencia' data in Table 4. A seasonal summary including all three varieties is shown in Table 5. A seasonal summary of data on state test samples for all three varieties is shown in Table 6.

The major difference in the settings of harsh and hard squeezes of the two seasons was strainer tube size (Table 1). The addition of a 4″ cup to the second season settings with the accompany-

Table 2. Hamlin summary - JDP analyses 1971-72

	Light squeeze			Hard squeeze		
	Avg.	Min.	Max.	Avg.	Min.	Max.
Glycosides - mg/100 ml	84	76	95	138	127	152
Limonin - ppm	2.1	0	5.0	6.9	0	12.5
Cloud - % light transmission	34.0	29.2	39.0	22.1	21.0	24.5
Sinking pulp - %	9.2	8.0	10.0	12.7	12.0	14.0
Alcohol insoluble solids - g/100 ml	.293	.270	.313	.400	.353	.439
Water insoluble solids - mg/100 g	137.0	99.6	180.3	218.5	162.6	270.2
Water soluble pectin - mg/100 g	18.7	14.4	21.8	32.8	26.4	39.1
Hydroxide soluble pectin - mg/100 g	44.9	37.1	49.8	55.3	49.1	65.2
Total pectin - mg/100 g	63.7	58.0	69.7	88.5	77.9	96.1
Serum viscosity - cps	1.49	1.39	1.56	1.88	1.72	2.01
Protein - g/100 ml	.108	.093	.118	.131	.120	.140
Calcium - mg/100 ml	2.4	2.0	3.5	3.4	2.8	5.0
Sodium - mg/100 ml	.35	.22	.48	.42	.35	.61
Potassium - mg/100 ml	227	206	271	220	202	240
Magnesium - mg/100 ml	10.7	9.2	11.1	11.1	10.8	11.9
Ash - g/100 ml	.384	.367	.418	.387	.367	.414
Total sugars - g/100 ml	8.06	7.26	8.95	7.91	7.17	8.91
Sucrose - g/100 ml	4.19	3.69	5.09	3.91	3.15	4.64
Chemical oxygen demand - ppm	197	80	340	229	95	375
Aldehydes - ppm	13.6	9.2	19.0	16.2	10.3	23.2
Oxygenated terpenes - ppm	4.1	3.5	5.0	5.8	4.3	7.5
Color score - ECS	34.1	33.4	35.2	32.9	32.3	34.0
Citrus red - CR	23.2	20.7	27.7	19.7	16.3	23.6
Citrus yellow - CY	69.3	65.7	72.7	64.2	61.2	68.3
Brix - degrees	10.6	9.1	11.6	10.6	9.2	11.6
Acid - % by wt.	.87	.77	.95	.79	.69	.85
Ratio - Brix/acid	12.3	9.6	14.9	13.6	11.0	16.9
pH	3.5	3.3	3.8	3.6	3.3	3.9
Oil - % by vol.	.006	.005	.007	.011	.010	.011
Flavor - scores	5.5	4.3	6.4	4.3	2.7	6.3

Table 3. Pineapple summary - JDP analyses 1971-72

	Light squeeze			Hard squeeze		
	Avg.	Min.	Max.	Avg.	Min.	Max.
Glycosides - mg/100 ml	100	94	106	142	136	155
Limonin - ppm	1.3	0	7.5	1.3	0	5.0
Cloud - % light transmission	22.1	19.5	26.5	15.2	14.0	17.5
Sinking pulp - %	11.9	10.0	13.5	18.7	16.0	22.0
Alcohol insoluble solids - g/100 ml	.362	.316	.390	.524	.471	.584
Water insoluble solids - mg/100 g	172.5	148.4	234.4	282.9	238.6	377.8
Water soluble pectin - mg/100 g	23.5	12.0	28.3	50.5	21.6	65.2
Hydroxide soluble pectin - mg/100 g	47.0	42.0	49.1	54.6	42.0	61.1
Total pectin - mg/100 g	70.5	56.6	77.4	105.1	63.6	119.5
Serum viscosity - cps	1.74	1.55	1.82	3.01	2.45	3.50
Protein - g/100 ml	.142	.121	.160	.170	.142	.192
Calcium - mg/100 ml	3.3	2.2	4.0	4.8	3.3	6.2
Sodium - mg/100 ml	.60	.28	1.04	.66	.36	.90
Potassium - mg/100 ml	292	235	320	277	239	292
Magnesium - mg/100 ml	12.0	10.8	13.6	11.5	10.8	12.0
Ash - g/100 ml	.487	.410	.518	.478	.416	.542
Total sugars - g/100 ml	9.15	7.44	9.77	9.09	7.32	10.51
Sucrose - g/100 ml	4.75	3.82	5.13	4.61	3.70	5.43
Chemical oxygen demand - ppm	350	235	490	398	260	515
Aldehydes - ppm	24.5	14.6	31.1	31.0	18.2	39.4
Oxygenated terpenes - ppm	9.2	5.8	11.3	11.0	7.7	14.3
Color score - ECS	35.7	34.9	36.8	34.9	34.0	36.0
Citrus red - CR	28.3	24.9	32.2	25.6	21.6	29.3
Citrus yellow - CY	76.4	73.4	80.5	73.6	71.0	77.6
Brix - degrees	12.6	10.8	13.5	12.7	10.8	13.6
Acid - % by wt.	1.00	.95	1.05	.94	.91	1.00
Ratio - Brix/acid	12.7	10.6	13.9	13.6	11.6	14.8
pH	3.7	3.6	3.7	3.6	3.6	3.7
Oil - % by vol.	.014	.009	.016	.028	.022	.031
Flavor - scores	5.8	4.1	6.6	4.3	2.3	5.0

ing orifice tube and restrictor differing slightly from those used with the 3″ cup in the first season was not considered a major difference since approximately 10% of the fruit was handled by the 4″ cups. According to Table 7 listing yields, the .040″ size strainer tube used in the second season hard squeeze delivered about 10% less pulpy unfinished juice to the finisher than did the .090″ size strainer tube used in the first season harsh squeeze. Even with less yield delivered to the finisher in the second season it was noted that hard squeeze finished yields were up, about 10% for 'Hamlin' and 'Pineapple' and 25% for 'Valencia,' over the harsh squeeze of the previous year. This phenomenon was explained by considering that for both years all finisher discharge pulp dryness was carefully controlled to a quick fiber of 200. This allowed more juice to be lost with the heavier pulp load of the first season than with the lighter pulp load of the second season.

The intent of the changes in hard squeeze extractor settings was to produce a better quality hard squeeze juice, one which would simulate some commercial juices or be closer to commercial products than the harsh squeeze juices of the first season. This was accomplished since Table 5 shows a second season average of 4.6 flavor points for the hard squeeze samples. This was an improvement over the 2.7 flavor point average for the harsh squeeze samples of the first season.

The intent of the light squeeze extractor settings using less restriction in the orifice tubes and a long upper cutter (Table 1) was to produce a softer squeeze and to decrease the unfinished juice yield and thus if possible produce an improved quality light squeeze juice. These objectives were not accomplished (Table 7).

The net result of extractor changes between the two seasons was to produce a light squeeze juice virtually identical to the soft squeeze juice of the previous season and to produce a near commercial hard squeeze with less difference in consistency with its light squeeze counterpart

Table 4. 'Valencia' summary - JDP analyses 1971-72

	Light squeeze			Hard squeeze		
	Avg.	Min.	Max.	Avg.	Min.	Max.
Glycosides - mg/100 ml	77	70	88	112	90	146
Limonin - ppm	0	0	0	0	0	0
Cloud - % light transmission	25.2	23.5	27.2	16.8	15.5	17.5
Sinking pulp - %	8.5	7.5	9.5	11.9	10.0	14.0
Alcohol insoluble solids - g/100 ml	.324	.306	.353	.440	.424	.465
Water insoluble solids - mg/100 g	133.0	124.0	160.4	186.5	166.8	209.0
Water soluble pectin - mg/100 g	24.7	19.7	34.3	40.9	33.2	47.7
Hydroxide soluble pectin - mg/100 g	37.5	23.3	57.3	39.9	28.1	45.3
Total pectin - mg/100 g	62.2	47.3	91.6	80.8	66.2	93.0
Serum viscosity - cps	1.71	1.59	1.77	2.14	2.01	2.26
Protein - g/100 ml	.127	.116	.151	.144	.130	.158
Calcium - mg/100 ml	2.3	1.3	2.8	3.3	1.9	3.9
Sodium - mg/100 ml	.39	.37	.42	.52	.42	.68
Potassium - mg/100 ml	253	222	270	247	215	261
Magnesium - mg/100 ml	10.5	8.8	11.7	11.0	9.5	12.0
Ash - g/100 ml	.484	.428	.537	.479	.405	.539
Total sugars - g/100 ml	9.59	8.86	10.72	9.59	8.91	10.64
Sucrose - g/100 ml	4.75	4.37	5.75	4.73	4.23	5.61
Chemical oxygen demand - ppm	468	375	515	493	425	560
Aldehydes - ppm	24.0	20.8	28.7	32.7	27.0	39.6
Oxygenated terpenes - ppm	6.3	5.4	7.5	8.8	7.2	12.0
Color score - ECS	38.5	38.2	38.9	37.3	37.1	37.5
Citrus red - CR	39.6	36.9	41.5	34.1	32.4	35.3
Citrus yellow - CY	85.4	84.5	86.2	82.9	81.4	84.7
Brix - degrees	12.3	11.9	12.8	12.4	12.0	12.9
Acid - % by wt.	.91	.77	1.17	.87	.71	1.08
Ratio - Brix/acid	13.8	10.2	16.4	14.5	11.1	17.7
pH	3.7	3.4	3.9	3.7	3.4	4.0
Oil - % by vol.	.016	.014	.019	.039	.035	.043
Flavor - scores	6.0	5.2	6.8	5.0	4.3	5.3

than the difference between the two squeezes of the first season. The analytical data representing the light and hard squeezes was not as polarized as the data of the soft and harsh squeezes of the first season. This lesser separation between the second season light and hard squeeze data resulted in fewer significant single correlations of various analyses with flavor than were reported for the first season comparisons. However, the computer was utilized to produce a linear multiple regression flavor prediction equation with 8 variables (equation No. 1, Table 8), and a correlation coefficient (r = .951). This compares most favorably with the correlation coefficients of the equations developed from the more "academic data" of the first years' experiments.

It was noted that, as for the previous year, limonin appeared as a significant indication of juice quality. However, it was also noted that approximately 2/3 of the experimental samples contained no limonin. In these samples the limonin variable would be useless in a prediction equation so a multiple regression analysis was made using the same data, but withholding the limonin data. An 11 variable prediction equation (No. 2, Table 8) was developed with a correlation coefficient (r = .969) somewhat better than for equation No. 1. There were four variables common to both equations, Brix, serum viscosity, glycosides, and magnesium. Observed and predicted flavor scores for all light and hard squeeze samples, using equations No. 1 and No. 2, are shown in Table 9.

Figures 1, 2, and 3 show graphical representation of cloud, COD, and flavor data, respectively when plotted vs time. Early maturity 'Hamlins' showed the largest % light transmission difference between light and hard squeeze (Fig. 1). November light squeeze 'Hamlin' juice exhibited nearly double the % light transmission as the hard squeeze for the same period.

COD, when plotted vs time, showed a constant 2 to 3 fold increase through each varietal season (Fig. 2). This is the expected pattern, but is contradictory to the data for the first season.

Table 5. Summary all varieties - JDP analyses 1971-72

	Light squeeze			Hard squeeze		
	Avg.	Min.	Max.	Avg.	Min.	Max.
Glycosides - mg/100 ml	86	70	106	130	90	155
Limonin - ppm	1.1	0	7.5	2.0	0	11.3
Cloud - % light transmission	27.0	19.5	39.0	18.0	14.0	24.5
Sinking pulp - %	9.8	7.5	13.5	14.3	10.0	22.0
Alcohol insoluble solids - g/100 ml	.326	.270	.390	.454	.353	.584
Water insoluble solids - mg/100 g	147.1	99.6	234.4	227.1	162.6	377.8
Water soluble pectin - mg/100 g	22.4	12.0	34.3	41.4	21.6	65.2
Hydroxide soluble pectin - mg/100 g	42.8	23.3	57.3	49.4	28.1	65.2
Total pectin - mg/100 g	65.3	47.3	91.6	90.9	63.6	119.5
Serum viscosity - cps	1.65	1.39	1.82	2.33	1.72	3.50
Protein - g/100 ml[z]	.125	.093	.160	.148	.120	.192
Calcium - mg/100 ml	2.6	1.3	4.2	3.8	1.9	6.2
Sodium - mg/100 ml	.45	.22	1.04	.53	.35	.90
Potassium - mg/100 ml	257	206	320	248	202	291
Magnesium - mg/100 ml	11.0	8.8	13.6	11.2	9.5	12.0
Ash - g/100 ml	.453	.367	.537	.449	.367	.542
Total sugars - g/100 ml	9.0	7.3	10.7	8.9	7.2	10.6
Sucrose - g/100 ml	4.6	3.7	5.8	4.4	3.2	5.6
Chemical oxygen demand - ppm	345	80	515	379	95	560
Aldehydes - ppm	20.1	9.2	31.1	27.0	10.3	39.6
Oxygenated terpenes - ppm	6.5	3.5	11.3	8.5	4.3	14.3
Color score - ECS	36.2	33.4	38.9	35.2	33.9	37.5
Citrus red - CR	30.8	20.7	41.5	26.9	16.3	35.3
Citrus yellow - CY	77.5	65.7	86.2	74.1	61.2	84.7
Brix - degrees	11.9	9.1	13.5	11.9	9.2	13.6
Acid - % by wt.	.93	.77	1.17	.86	.69	1.08
Ratio - Brix/acid	12.9	9.6	16.4	13.9	11.0	17.7
pH	3.6	3.3	3.9	3.6	3.3	4.0
Oil - % by vol.	.012	.005	.019	.026	.010	.043
Flavor - scores	5.8	4.3	6.8	4.6	2.3	6.3

[z]The unit of the protein values for the first season (1970-71) was erroneously listed as mg/100 ml when published. The data were measured and recorded in units of g/100 ml. The second season data are reported in units of g/100 ml.

Flavor, when plotted by variety vs time of extraction, yields some interesting observations (Fig. 3). 'Hamlins' showed a steady improvement in flavor of the light and hard squeeze through the season. Both light and hard squeeze 'Hamlin' juices are unacceptable (below 5.0 flavor points) in November and both light and hard extraction juices from 'Hamlins' picked from the same grove block in February showed identical good acceptable flavor scores. 'Pineapple' juices of light and hard extraction were both unacceptable in the December extractions. The light squeeze 'Pineapple' flavor became acceptable in January and achieved good acceptance in late February, while the hard extracted 'Pineapple' juice, in opposition to the 'Hamlin' variety, only achieved minimal acceptance once during the season in late January, after which the flavor steadily decreased. The 'Valencia' produced barely acceptable juice from both light and hard extractions in mid-March. The light extracted juice improved to good acceptance in mid-April while the hard extracted 'Valencia' juice never achieved more than minimal acceptance.

Table 6, summarizing the state test juice JDP analyses, may be compared with other JDP juice analyses in Table 5. Of interest are comparisons between state test and soft squeeze averages such as the similarity of cloud, sodium, potassium, magnesium, ash, COD, aldehyde, color score, CR, CY, oil and flavor values and the differences of sinking pulp, alcohol-insoluble solids, water-insoluble solids, water-soluble pectin, sodium hydroxide-soluble pectin and total pectin values.

For both seasons, 'Pineapple' and 'Valencia' state test juices averaged slightly higher flavor than the soft or light squeeze juices, although not statistically different. For the same 2 years, 'Hamlins' averaged lower flavor in state test juice than for the light or soft squeeze juice; again,

Table 6. State test summary all varieties-JDP analyses 1971-72

	Avg.	Min.	Max.
Glycosides - mg/100 ml	94	70	117
Limonin - ppm	.90	0	7.5
Cloud - % light transmission	24.9	18.0	37.0
Sinking pulp - %	18.0	13.5	23.5
Alcohol insoluble solids - g/100 ml	.599	.449	.720
Water insoluble solids - mg/100 g	431.8	243.8	732.0
Water soluble pectin - mg/100 g	36.9	19.6	56.3
Hydroxide soluble pectin - mg/100 g	88.4	65.9	117.4
Total pectin - mg/100 g	125.3	96.1	155.9
Serum viscosity - cps	1.89	1.52	2.33
Protein - g/100 ml	.156	.110	.203
Calcium - mg/100 ml	3.4	1.4	5.6
Sodium - mg/100 ml	.50	.30	1.22
Potassium - mg/100 ml	256	204	310
Magnesium - mg/100 ml	11.1	9.2	12.5
Ash - g/100 ml	.456	.356	.589
Total sugars - g/100 ml	9.04	7.45	10.28
Sucrose - g/100 ml	4.64	3.75	5.56
Chemical oxygen demand - ppm	374	90	565
Aldehydes - ppm	21.4	9.2	35.4
Oxygenated terpenes - ppm	6.8	3.6	12.0
Color score - ECS	36.2	33.1	38.7
Citrus red - CR	31.4	19.9	41.5
Citrus yellow - CY	76.3	63.9	95.2
Brix - degrees	11.9	9.2	13.5
Acid - % by wt.	.90	.74	1.18
Ratio - Brix/acid	13.4	9.8	17.2
pH	3.7	3.3	4.0
Oil - % by vol.	.012	.005	.018
Flavor - scores	5.9	3.8	6.8

not a statistical difference (Table 7).

The findings of no statistical difference in flavor scores of juices commercially extracted and finished and state test juices with about 8% more yield and 60 to 80% greater pulp was unexpected and prompted some investigation into possible explanations for this fact. A comparison of extractor settings showed the following differences which may have an effect on flavor.

a. The state test extractor was equipped with a strainer tube with .025″ diameter holes while soft and light squeeze juices were produced on the commercial FMC 391 equipped with strainer tubes with .040″ diameter holes.

b. Pressure of squeeze was related to the diameter of the bore in the orifice tube or its restrictor, Table 1 shows a wide difference. The pressure inside the orifice tubes used with the state test machine was controlled at 45 psi by a pneumatic gate at the discharge end. The orifice tube used on the FMC 391 extractor was fitted with mechanical restriction to regulate the squeezing pressure. There were no measurements made to determine pressure within the FMC 391 extractor orifice tube.

c. The state test machine used long upper cutters and operated at about half the speed of the commercial extractor. These two factors are partially responsible for the low oil content of the state test juice, and possibly other beneficial flavor factors.

d. The stroke length of the state test extractor was approximately double that of the 391 extractor. This, together with the slower speed (c), meant that juice was expressed from each orange in the state test extractor over a greater time period, using a greater volume of orifice tube than occurred when the 391 commercial extractor was used. The effect of length of extraction period on flavor is not known.

The state test juice passed through the .025″ strainer tube hole as its sole screening treatment,

Table 7. Average Yield, Flavor and Pulp Comparisons 1970-71 and 1971-72 Seasons JDP.

	1970-71				1971-72			
	% Yield				% Yield			
	Unfinished	Finished	Flavor	% Pulp	Unfinished	Finished	Flavor	% Pulp
				Hamlin				
State test	53.10	-	5.8	15	62.65	-	5.4	18
Soft	51.88	48.08	6.3	9	-	-	-	-
Light	-	-	-	-	59.75	57.43	5.5	10
Harsh	78.45	58.50	2.8	22	-	-	-	-
Hard	-	-	-	-	72.55	63.36	4.3	13
				Pineapple				
State test	60.90	-	5.9	19	62.50	-	6.1	21
Soft	60.91	57.00	5.8	12	-	-	-	-
Light	-	-	-	-	60.69	56.94	5.8	12
Harsh	76.67	53.28	1.5	26	-	-	-	-
Hard	-	-	-	-	68.18	58.64	4.3	19
				Valencia				
State test	59.27	-	6.0	15	63.89	-	6.1	15
Soft	60.40	57.35	5.9	9	-	-	-	-
Light	-	-	-	-	61.76	58.79	5.9	9
Harsh	76.60	48.88	3.2	15	-	-	-	-
Hard	-	-	-	-	69.37	61.10	5.0	12

Table 8. Flavor Prediction Equations 1971-72 JDP Light and Hard Squeeze Juices.

Equation No. 1	Equation No. 2
$F = 0.388(Bx) - 36.638(O) - 1.189(SV) - 0.007(Gly) - 0.186(L) + 1.545(pH) + 0.023(Tp) - 0.177(Mg) - 0.801$	$F = 0.858(Bx) - 1.066(SV) - 0.101(OT) - 0.017(Gly) + 0.004(WIS) + 0.837(Su) - 24.405(Pro) + 0.057(NaSP) - 1.644(Na) + 0.438(Ca) - 0.230(Mg) - 2.174$
$(r = 0.951)$	$(r = 0.969)$

F = flavor, Bx = °Brix, SV = serum viscosity, OT = oxygenated terpenes, Gly = total glycosides, WIS = water insoluble solids, Su = sucrose, Pro = protein, NaSP = sodium hydroxide soluble pectin, Tp = total pectin, Na = sodium, Ca = calcium, Mg, = magnesium, O = oil, L = Limonin and pH = pH.

whereas the light squeeze juice from the commercial extractor passed through an .040″ strainer tube hole which admits much larger pulp rag and juice cell particles than the .025″ hole. The light squeeze juice rag-pulp mixture was then treated again by forcing it through an .020″ hole in a screen using a finisher screw in close tolerance with the screen.

As a consequence of extraction and finishing differences, the state test juice was found to have a comparatively high percentage of larger juice cell particles which have not suffered complete maceration (24% of state test juice particles are over 100 μ size). Commercial type juice is composed of more finely divided pulp-rag and juice cell particles (4% of light squeeze juice particles are over 100 μ size), basis determinations using a Coulter Particle Counter, Model T.

Flavor panelists indicated a fresh character for state test juice which seemed to be associated with the larger undisturbed juice cell particles. There had been some lack of preference for the heavy pulp content of the state test juices, but surprisingly was more than offset by good flavor ratings.

The consistently high flavor scores for state test juice were unexpected and initial attempts to account for this have not been completely satisfactory.

Table 9. Flavor Scores of JDP Samples 1971-72.

Observed	Predicted by Equation No. 1	Predicted by Equation No. 2	Observed	Predicted by Equation No. 1	Predicted by Equation No. 2
2.7	2.7	3.1	5.2	6.0	5.6
2.7	3.5	2.9	6.4	5.9	6.1
3.4	3.3	3.6	5.8	6.1	5.8
5.3	5.4	5.2	6.1	6.0	6.2
5.6	5.1	5.4	5.6	5.6	5.8
6.3	6.3	6.0	6.8	6.9	6.9
2.3	2.5	2.2	6.1	6.2	6.4
4.6	4.4	4.6	4.1	4.2	4.3
5.0	4.8	4.7	5.7	5.7	5.7
4.9	5.4	4.9	6.2	5.9	5.8
4.6	4.3	4.8	6.6	6.5	6.8
4.3	4.5	4.7	5.7	6.2	5.9
5.2	4.8	4.7	6.5	6.2	6.3
4.3	4.9	4.9	4.3	4.2	4.2
4.8	4.8	4.4	4.5	4.6	4.8
5.2	4.6	5.3	5.3	4.7	4.7
5.2	5.1	4.8	6.1	6.1	6.0
4.8	4.7	4.7	6.4	6.0	6.5
5.3	5.6	5.4	6.3	6.5	6.4

II. FROZEN CONCENTRATED ORANGE JUICE (FCOJ) — COMMERCIALLY PRODUCED.

Two flavor prediction equations were developed and reported as a part of the first season JDP (1). Although these equations clearly demonstrate that flavor scores of processed orange juice could be predicted with good statistical agreement (correlation coefficients $r = .979$ and $.984$), it was recognized that the significance of the equations were merely academic. The usefulness of these equations was naturally limited to juices prepared in the exact manner of our test juices (i.e. prepared samples). It became evident that the real value of a juice flavor prediction equation would come when such an equation could be successfully applied to samples of a commercial product produced by various processors. This experiment was designed to develop a flavor prediction equation for commercial FCOJ. A series of commercial FCOJ samples were analyzed as a part of the second season JDP to gather data for a commercially applicable FCOJ flavor prediction equation.

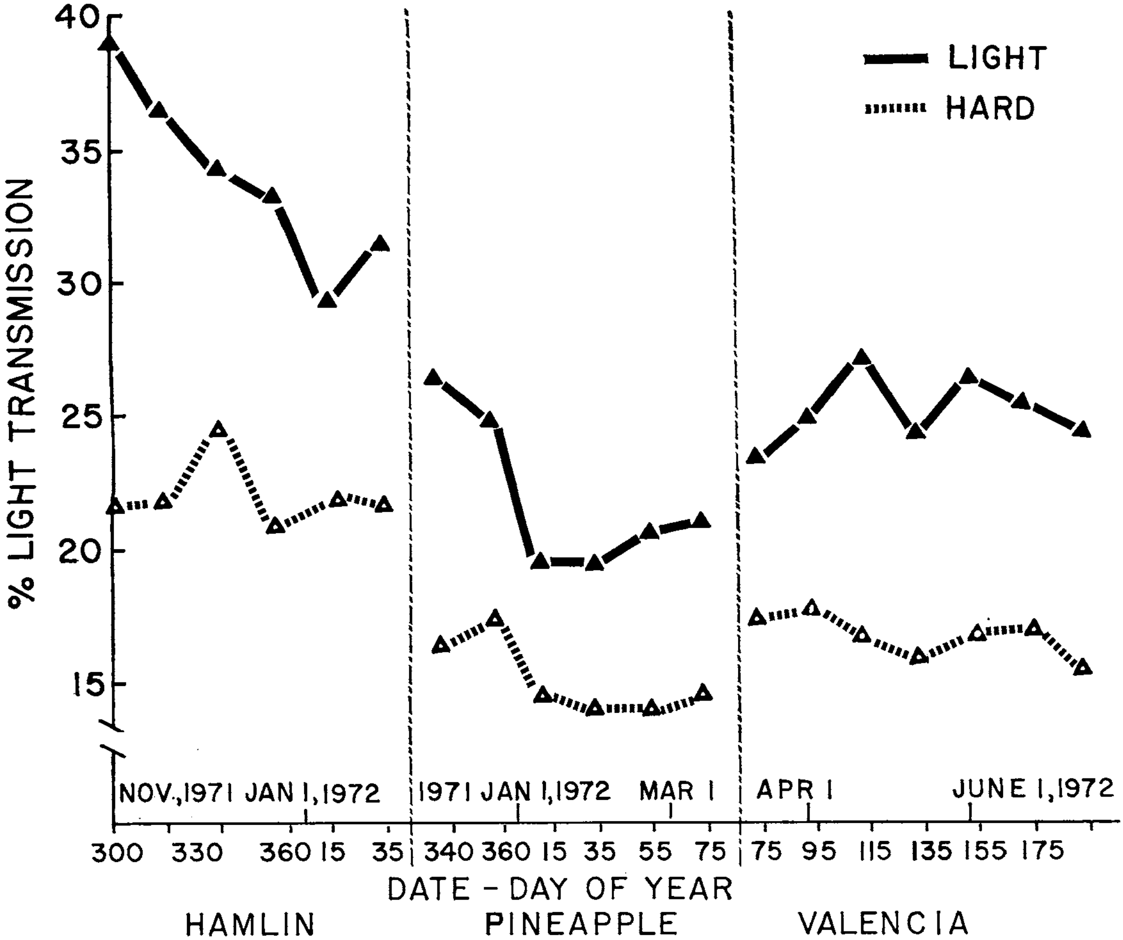

Fig. 1. Cloud (% light transmission) of light and hardsqueeze orange juice vs time.

Materials and Methods

Thirty samples (twenty-five 6-oz. cans and five 12-oz. cans) were drawn at random from Agricultural Research and Education Center (AREC) FCOJ survey samples collected from 20 FCOJ processors throughout the state, representing production from January through June 1971. Companion samples were reconstituted and evaluated for flavor within 2 weeks of packing by 10 to 12 experienced panelists using a 9-point hedonic scale.

The samples used in the experiment had been held at -8°F since collection. They were reconstituted to 12.8° Brix and analyzed for the 30 chemical and physical characteristics shown in Table 10, following the JDP analyses (1), by a team of co-workers.

The analytical data was analyzed by a stepwise linear multiple regression analyses using a G.E. time sharing computer. A maximum of 25 independent variables were permitted at one time.

Results and Discussion

The computer program automatically selected a combination of 6 variables giving the highest degree of significance contained in the data. These 6 variables are listed in Table 11 together with the multiple regression equation developed. Also shown in Table 11 are the observed subjective flavor scores reported by the taste panel evaluation together with the corresponding scores predicted by use of the regression equation developed using only objective analytical data from 6 analyses. The correlation coefficient ($r = .902$)

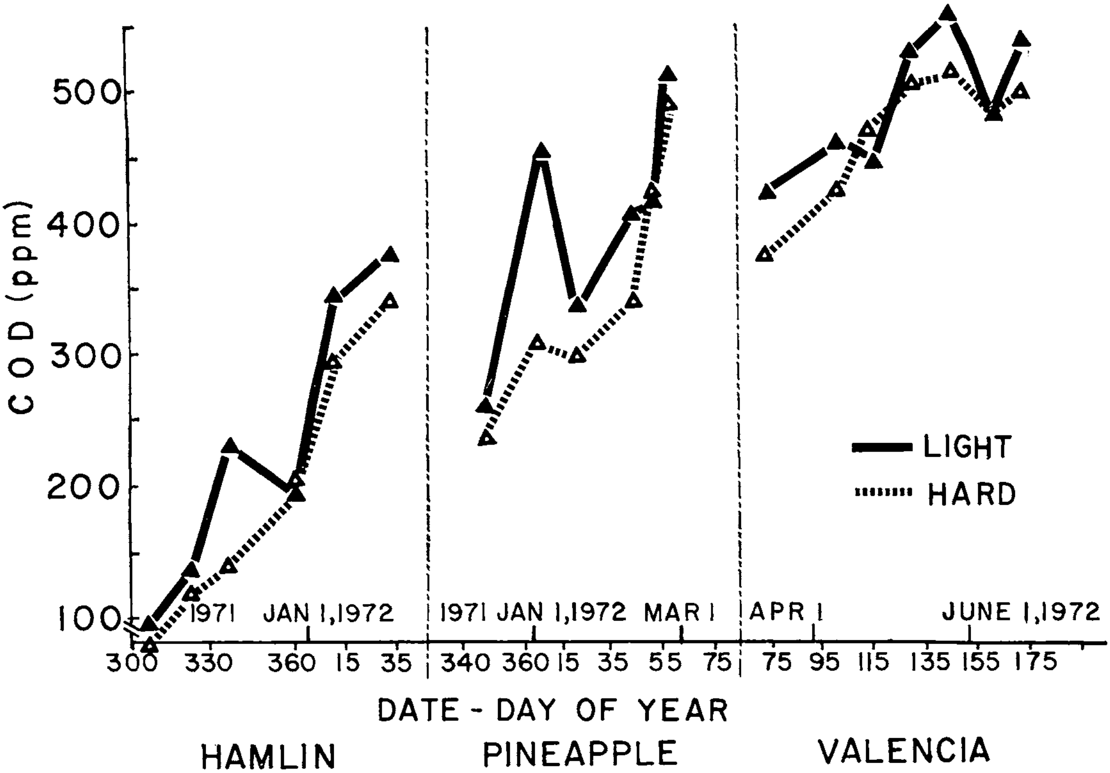

Fig. 2. Chemical oxygen demand of light and hard squeeze orange juices vs. time.

Table 10. FCOJ Summary - JDP analyses.

	Avg.	Min.	Max.
Glycosides - mg/100 ml	117	97	145
Limonin - ppm	0	0	0
Cloud - % light transmission	16.7	14.0	19.5
Sinking pulp - %	10.6	8.0	13.0
Alcohol insoluble solids - g/100 ml	.437	.367	.521
Water insoluble solids - mg/100 g	169.5	131.4	207.4
Water soluble pectin - mg/100 g	46.3	29.2	76.2
Hydroxide soluble pectin - mg/100 g	37.9	25.4	66.6
Total pectin - mg/100 g	84.1	58.7	108.8
Serum viscosity - cps	2.09	1.70	2.70
Protein - g/100 ml	.142	.117	.163
Calcium - mg/100 ml	2.9	2.2	3.6
Sodium - mg/100 ml	.88	.57	1.60
Potassium - mg/100 ml	266	251	278
Magnesium - mg/100 ml	12.2	10.9	13.6
Ash - g/100 ml	.461	.430	.497
Total sugars - g/100 ml	9.78	8.71	10.31
Sucrose - g/100 ml	4.80	3.74	5.23
Chemical oxygen demand - ppm	78	10	315
Aldehydes - ppm	10.4	5.0	19.7
Oxygenated terpenes - ppm	7.3	5.2	12.6
Color score - ECS	37.2	35.9	39.0
Citrus red - CR	34.4	28.3	41.0
Citrus yellow - CY	81.4	77.8	88.2
Brix - degrees[z]	45.0	44.6	45.7
Acid - % by wt.[z]	3.05	2.70	3.48
Ratio - Brix/acid	14.8	13.0	16.6
pH	3.8	3.7	3.9
Oil - % by vol.	.015	.011	.020
Flavor-scores	6.5	5.1	7.6

[z]Multiple regression analysis basis samples reconstituted @ 12.8°Brix.

Table 11. FCOJ flavor scores - predicted and observed[z].

Observed	Predicted	Observed	Predicted
6.7	6.6	6.1	6.4
6.4	6.4	7.0	6.8
6.1	5.9	7.0	6.8
6.2	6.4	6.4	6.6
7.1	7.0	7.1	7.2
6.3	6.1	7.6	7.5
7.0	6.9	5.5	5.4
6.7	6.8	5.8	6.2
6.6	6.6	6.3	6.6
6.6	6.8	7.0	6.7
5.1	5.4	6.1	6.6
7.5	7.2	6.9	6.7
6.8	6.6	6.5	6.3
6.9	7.0	6.5	6.9
6.3	5.8	5.4	5.4

[z]FCOJ flavor prediction equation.

$$F = 3.8(Ac) + .942(Ts) - .655(Na) + .918(Ca) + .02(Tp) - .045(Gly) - 4.452$$

F = flavor
Ac = % acidity
Ts = total sugars
Na = sodium
Ca = calcium
Tp = total pectin
Gly = total glycosides

(r = .902)

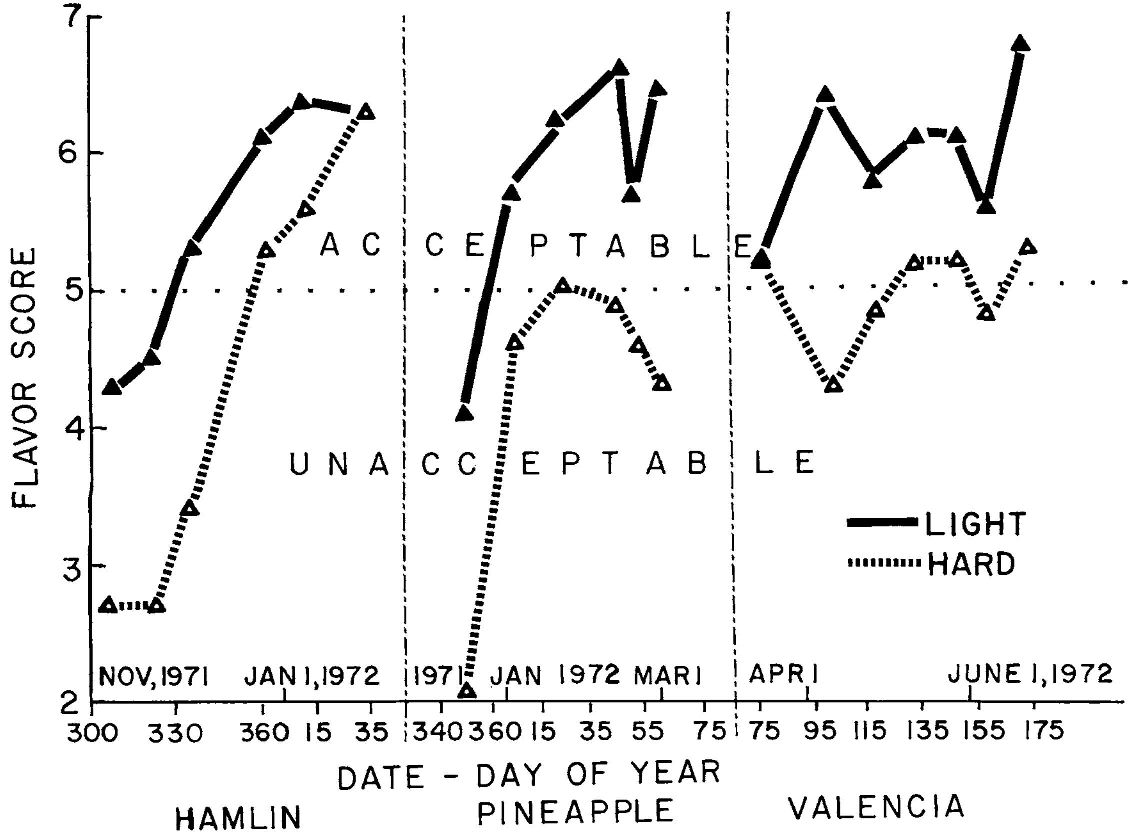

Fig. 3. Flavor score of light and hard squeeze orange juices vs. time.

for these results showed that the equation predicted approximately 81% of the variations in flavor.

III. ORANGE PULP WASH CONCENTRATE AND ORANGE PUMPOUT CONCENTRATE—COMMERCIALLY PRODUCED.

Orange pulp wash concentrate has been a production item for well over a decade. During this time it has often been the center of controversies in drafting and following quality and identity standards of citrus products (7). It was felt there was a need for a study to illuminate the conforming or distinguishing characteristics of pulp wash concentrate and non-pulp wash pumpout concentrate. For this reason this comparative study of these two products was initiated in 1970, employing Juice Definition Program (JDP) analyses (1) performed by a team of co-workers.

Materials and Methods

A two season comparative study of constituents of orange pulp wash concentrate and non-pulp wash concentrate was concluded at the end of the 1971-72 season. A total of 52 samples were supplied by 7 cooperating Florida concentrate plants and were analyzed for 34 constituents or physical characteristics shown in Table 12, following JDP analytical methods.

Fourteen of the pulp wash concentrate samples were paired with 14 corresponding pumpout concentrate samples each pair having been produced by the same plant on the same day and from the same fruit. Thirteen additional pulp wash concentrate samples and 11 additional pumpout concentrate samples did not include sample pairs with common fruit origin.

Twenty-four samples were produced between December 1970 and June 1971 while 28 samples were produced between February 1972 and July

Table 12. Orange pulp wash concentrate and orange pumpout concentrate - Summary of JDP analyses 1970-71 and 1971-72 seasons[z].

	Orange pulpwash conc.			Orange pumpout conc.			Significance
	Avg.	Min.	Max.	Avg.	Min.	Max.	
Glycosides - mg/100 ml	217	166	276	130	87	204	**
Limonin - ppm	.9	0	5	.3	0	2.5	N.S.
Cloud - % light transmission	11.8	8.0	21.0	16.7	12.0	28.5	**
Sinking pulp - %	7.0	1.0	20.6	10.4	8.0	13.5	**
Alcohol insoluble solids - g/100 ml	.450	.255	.572	.437	.363	.520	N.S.
Water insoluble solids - mg/100 g	42.6	1.2	140.8	163.7	109.0	235.6	**
Water soluble pectin - mg/100 g	118.9	55.6	216.3	43.2	29.8	69.5	**
Oxalate soluble pectin - mg/100 g[y]	3.2	0	12.7	15.3	10.0	21.6	**
Hydroxide soluble pectin - mg/100 g	22.2	0	151.4	31.1	21.6	44.3	N.S.
Total pectin - mg/100 g	136.4	57.7	285.3	80.6	59.2	105.6	**
Serum viscosity - cps	8.40	2.92	25.30	2.34	1.92	3.51	**
Protein - g/100 ml	.091	.061	.119	.153	.110	.188	**
Calcium - mg/100 ml	5.3	2.7	20.0	3.2	2.0	5.3	**
Sodium - mg/100 ml	2.66	.84	10.7	1.38	.78	5.60	**
Potassium - mg/100 ml	272	214	327	257	180	310	N.S.
Magnesium - mg/100 ml	13.2	10.2	23.0	11.6	10.0	13.6	**
Ash - g/100 ml	.506	.364	.614	.458	.306	.521	**
Total sugars - g/100 ml	9.77	9.10	10.36	9.98	9.59	10.32	*
Sucrose - g/100 ml	4.84	4.52	5.49	5.05	4.54	5.51	**
Glucose - g/100 ml[y]	2.21	2.09	2.36	2.16	2.03	2.24	N.S.
Fructose - g/100 ml[y]	2.78	2.57	2.89	2.81	2.69	2.93	N.S.
Ascorbic acid - mg/100 ml[y]	40	27	49	44	33	54	N.S.
COD - ppm	.8	0	15	.4	0	5	N.S.
Aldehydes - ppm	2.4	0	7.7	1.3	0	7.8	N.S.
Oxygenated terpenes - ppm	4.6	1.9	13.0	3.8	1.3	7.6	N.S.
Color score - ECS	33.5	31.4	37.2	37.2	34.9	38.9	**
Citrus red - CR	22.0	15.3	25.4	34.3	18.8	43.8	**
Citrus yellow - CY	66.9	57.2	73.1	80.7	65.8	95.3	**
Brix - degrees - (conc.)	48.43	30.35	60.78	63.72	51.68	69.77	**
Acid - % by wt. - (conc.)	2.55	1.48	3.99	4.05	3.25	5.13	**
Ratio - Brix/acid	19.5	16.4	34.7	16.0	12.4	21.1	**
pH	4.0	3.9	4.5	3.9	3.8	4.1	*
Oil - % by volume	.008	0	.024	.006	0	.023	N.S.
Flavor - score	3.6	1.0	4.7	5.0	3.8	6.6	**

**Significant at 99% confidence level.
*Significant at 95% confidence level.
N.S. = Not significant.

[z]Samples reconstituted @ 12.8°Brix.
[y]1970-71 data only.

1972. Twenty-five samples were from midseason varieties and 27 samples were from 'Valencias.' Twenty-seven samples were pulp wash concentrates and 25 samples were pumpout concentrates. Samples were kept frozen after production, thawed, and reconstituted to 12.8° Brix for analysis.

Results and Discussion

Table 12 lists the analytical methods employed with the average, minimum and maximum for pulp wash and for pumpout products. The statistical difference between the pulp wash and non-pulp wash data is also indicated for each analytical method. Twenty-one of the 34 analyses produced data with significant difference at the 99% confidence level. Two analyses showed a difference at the 95% confidence level while 11 analyses showed no significant difference between pulp wash and pumpout.

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