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EQUIVALENT COLOR SCORES FOR FLORIDA CONCENTRATED ORANGE JUICE FOR MANUFACTURING AND CANNED ORANGE JUICE

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Abstract. **Visual color scores and Citrus Colorimeter Citrus Red and Citrus Yellow readings were obtained on 3,629 samples of concentrated orange juice for manufacturing and 416 samples of canned orange juice produced in 9 commercial plants during the 1969-70 season. Although a regression equation derived from a statistical analysis of this data failed to discriminate between juices having a weak or a strong yellow color, it was found that the Color Scores of samples, which included both red and yellow color components, could be adjusted to reflect the correct color classification. Equivalent Color Scores were found to agree well with reported visual scores for both canned orange juice and concentrated orange juice for manufacturing. A few misclassified samples appeared at all color levels indicating that there was no bias in this method toward juices of deep, medium or pale color.**

The importance of color in juices (1) was brought out in a consumer survey test at the New York World's Fair where it was found that juice enhanced by the addition of artificial color was reported to have, "better body," be "sweeter," and have "more flavor" than juice reconstituted from the same concentrate without added artificial color.

The premium Florida product, Frozen Concentrated Orange Juice (FCOJ), must have a rich deep orange color. Only choice midseason and late season oranges, predominantly 'Pineapple' and 'Valencia' varieties respectively, produce juice of this color.

Traditionally, light colored juices from early varieties of fruit have been used by the processor to prepare concentrated orange juice for manufacturing (COJFM) or canned orange juice (COJ). In recognition of this difference in color quality, the citrus industry has given additional score points to pale orange colored products. To extend the usefulness of the Citrus Colorimeter from the measurement of FCOJ to all orange juice products, it was necessary to develop a method of measuring the color of these products.

The purpose of this paper is to compare objective and subjective color scores obtained from concentrated orange juice for manufacturing and canned orange juice. A method of relating colorimeter readings obtained from COJFM and COJ products to their respective visual scores is presented.

Materials and Methods

During past years, Florida Frozen Concentrated Orange Juice has been scored for color with plastic standard comparator tubes developed by the USDA and the citrus processors. There are 6 tubes in use (5). They have been selected as being the best visual match for the range of colors found in orange juice varying from pale yellow to deep orange. The Hunterlab Citrus Colorimeter (HCC) (3), which is capable of measuring translucent orange juice color in values that can be related accurately to subjective color scores has been successfully applied to the measurement of Florida FCOJ. Huggart, Wenzel and

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Martin (2) presented an equation and a nomograph for determining objective color scores that were equivalent to USDA subjective scores.

During the 1969-70 citrus processing season, the Consumer and Marketing Service (CMS), USDA, Winter Haven, supplied the authors with data of: (a) USDA visual color scores, and (b) Citrus Red (CR) and Citrus Yellow (CY) instrument readings determined with the Hunterlab Citrus Colorimeter for COJFM and COJ. These data were obtained by USDA inspectors during the examination and grading of the products as they were processed in 9 commercial plants opting to buy and use the HCC on a trial basis as recommended by the Florida Canners Association. Data were obtained on 3,629 samples of concentrated orange juice for manufacturing and 416 samples of canned orange juice. The data for the COJFM was reduced to 365 representative samples using a random starting point, then including the data in sequence from each 10th tabulation.

Inspection Aid No. 81. The range of 10 orange colors indicated by Inspection Aid No. 81 (7) and the OJ comparator standards, starting with the color, "not as good as OJ 6" and going through the color, "equal to OJ2," are representative of orange juice colors from Florida grown fruit. Two of the categories are combined when FCOJ colors are determined visually. It is thus possible to indicate 8 different juice colors for FCOJ using visual score points. Four of the 10 categories are combined when colors of canned juice or concentrate for manufacturing are determined (6, 8), thus it is possible to indicate only 6 different juice colors for these two products. Upon visual examination of the COJFM and COJ samples, it was found that some of the samples in the lighter colored groups could be subdivided into additional groups of colors. This presented a situation in which COJFM and COJ juice colors were not adequately described by appropriate score points. As a result, an equation limited to these scores was found to be unsatisfactory.

Color Score. The Hunter Citrus Colorimeter has been used in the laboratory to measure CR and CY color components of canned juice and orange juice for manufacturing. The Color Score (CS = 22.510 + 0.165 CR + 0.111 CY) for these products can be calculated using the CS equation or determined from a CS nomograph. Measurements of the CR and CY values of these products appeared to "fit" in the FCOJ color score nomograph when extrapolated down to light colored juices, although it was noted that some of the ordinates shifted toward a less yellow color than might have been expected had the CR, CY curve for FCOJ been extended.

Results and Discussion

The Florida Department of Citrus recognized the Hunterlab Citrus Colorimeter (HCC) and amended its Regulation 105-1.19 to state that, "Effective October 1, 1972, the Colorimeter shall be used exclusively to determine the Color Scores for frozen concentrated, canned concentrated and pasteurized orange juices and for orange juice from concentrate" (4).

Equivalent color scores. Since random CS values calculated from the COJ and COJFM sample CR and CY measurements, when properly adjusted to reflect the appropriate number of extra points given for these products, agreed very well with the reported visual scores, it was decided to try an adjusted "Equivalent Color Score" (ECS) as a means of determining visual score of these products. A nomograph was prepared by extrapolating the FCOJ CS equation down to include pale juice colors found in COJFM and COJ products. The range of CS values and, "Adjustment," which, when applied to CS scores, convert them to Equivalent Color Scores for COJFM and COJ is shown in Table 1. The points to be added for this conversion are obtained from USDA Inspection Aid No. 81. Pale yellow juices that would score 33 or 34 points for FCOJ are given 2 points when packed as COJFM or COJ and would have an equivalent color score of 35 or 36 points respectively as shown in Table 1.

Table 1. Equivalent color scores for concentrated orange juice for manufacturing (COJFM) and canned orange juice (COJ).

Color number[z,y]	Color score for FCOJ[z]	Adjustment for COJ and COJFM[z,x]	Equivalent color score for COJ and COJFM[z]
32.5-33.4	33	+2	35
33.5-34.4	34	+2	36
34.5-35.4	35	+1	36
35.5-36.4	36	+1	37
36.5-37.4	37	+1	38
37.5-38.4	38	0	38
38.5-39.4	39	0	39
39.5-40.4	40	0	40

[z] As designated in Regulation 105-1.19, Sec. (1) (r), State of Florida, Department of Citrus, Lakeland (4).

[y] Calculated from citrus red (CR) and citrus yellow (CY) readings obtained with Hunter citrus colorimeter (2) using the following equation:
Color number = 22.510 + 0.165 CR + 0.111 CY.

[x] Differences between USDA visual color scores for frozen concentrated orange juice, canned orange juice or concentrated orange juice for manufacturing as specified in United States standards for grades of these products (6, 7, 8).

Juices of medium orange color are given 1 point and deep orange colored juices are given equal scores.

Misclassified samples. CS values were calculated from the CR and CY measurements obtained by the CMS from the "in-plant" samples. The number of ECS samples appearing in each color classification was compared with the number of samples observed by the USDA inspectors to be in the respective groups. The percentage of samples falling into each of the respective color groups, both adjusted, or observed, is reported in Table 2. Using this system, 7.2% of the COJFM samples and 6.8% of the COJ products were misclassified. The largest percentage of samples misclassified, 3.6% in the COJFM juices observed to be 37, was not repeated in canned juices. This suggests that there might be a slight bias in the number of COJFM samples reported to score 37 points, the minimum score acceptable for COJFM Future Contracts. Extrapolation of the CS equation to include pale yellow juice colors does not result in misclassified samples. The percentage of misclassified samples in the color groups of the two products appears to be largely due to random error between the two methods of determining score. There is no definite trend or pattern toward greater misclassification in the paler colored juices.

Table 2. Comparison of equivalent color scores with USDA visual color scores for concentrated orange juice for manufacturing and canned orange juice.

USDA color score points	USDA visual color score[z] Samples-%	Equivalent color score Samples-%	Misclassified[y] Samples-%
Concentrated orange juice for manufacturing n = 365			
36	7.4	7.7	+0.3
37	28.8	25.2	-3.6
38	32.6	33.1	+0.5
39	31.2	32.6	+1.4
40	0.0	1.4	+1.4
Total	100.0	100.0	7.2
Canned orange juice n = 416			
35	1.4	3.6	+2.2
36	62.5	61.1	-1.4
37	15.4	13.9	-1.5
38	19.0	20.0	+1.0
39	1.7	1.2	-0.5
40	0.0	0.2	+0.2
Total	100.0	100.0	6.8

[z] Obtained by USDA inspectors by comparison of color of orange juices with USDA plastic Orange Juice (OJ) Color Standards (5, 6, 7, 8).

[y] Plus and minus signs indicate that the percentage of samples was greater or less than that for the visual scores.

COJFM and COJ prediction equations. Prediction equations relating color measurements to visual scores used in evaluating COJFM and COJ colors were derived for each product separately and for both products considered as a group. Details of the methods used in deriving prediction equations for orange juices have been reported by Huggart, Wenzel and Martin (2).

The best fitting regression equation derived form "in-plant" data included both COJFM and COJ results, but excluded the yellow color component as it did not contribute significantly to visual score and was omitted for statistical reasons. The regression equation follows:

$$\text{Visual score} = 32.5341 + 0.1495\ CR.$$

This equation explained 90.1% of the variation between visual score and CR readings.

When predicted scores for the 781 COJFM and COJ samples selected in this study were compared with observed scores, 145 of the 781, or 18.6% of the samples were misclassified. From visual examination, it was found that misclassified juices were bright yellow. When both CR and CY coordinates were plotted on the FCOJ color score nomograph, the unusually high CY readings were great enough to place the samples in the next higher score point group. From this observation, it was concluded that a measure of the yellow component would be necessary for correct colorimeter evaluation of concentrated orange juice for manufacturing and canned orange juice.

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