ENHANCEMENT OF COLOR IN RECONSTITUTED JUICE BY NATURAL MEANS

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ABSTRACT

The addition of natural pigment granules, or chromoplasts, isolated from the juice of 'Murcott' oranges or 'Dancy' tangerines to reconstituted orange juice of pool color was found to increase the magnitude of the Hunter Color Difference Meter "a" value, indicating an increase in the redness of the juice, and giving a product of improved color and appearance.

The chromoplasts were isolated by centrifugation of the extracted citrus juices. They may be washed with water if necessary. The supernatant fluid, decanted after the fresh juice was centrifuged once, would contain recoverable soluble solids.

INTRODUCTION

Color has been recognized for many years as an important characteristic of citrus juices and considerable effort and study has gone into the development of practical methods for measurement and evaluation of color in orange concentrate and reconstituted juices produced commercially in Florida. The Hunter Color Difference Meter was found to be a reliable instrument for measuring color variations and changes which take place in processed citrus products (1, 2, 3, 8). A nomograph for the relationship between the USDA visual color scores and the Hunter "R_d" and "a" values has been prepared (4) which permits the objective Hunter values to be interpreted in terms of the visually determined color scores.

The significance and importance of color to consumer preference of reconstituted orange juice was clearly demonstrated at the World's Fair during the summer of 1965. Ceco Marketing Consulting and Research, Inc., (CMCR, Inc.) an independent research organization working with the Florida Citrus Commission, conducted a consumer taste survey on frozen concentrated orange juice (FCOJ) at the Florida Pavillion of the Worlds Fair. Color was found to be one of the most influential factors affecting juice preference. The results of the color tests have been summarized (5) as follows: (a) as color increases overall preference increases, (b) a juice having a visual color score of 36 was least preferred while one with a color score of 39 was most preferred, and (c) color strongly affected the judgment of consumers on other characteristics of the juice. On the basis of their findings, CMCR, Inc. recommended that the industry do everything possible to raise the color of the juice naturally, preferably by more than one color point.

During the 1963-64 citrus season Huggart *et al.* (4) determined color scores for 164 cans of FCOJ collected semi-monthly during December through June from 21 Florida plants. Of these samples, 43% were given a color score of 36 or less, 51% were scored 37, and only 6% were scored 39. On the basis of these figures, it appears that most of the orange juice presently on the market is not as highly colored as the consumer would prefer.

Since most of the color of citrus juices is localized in pigment granules or chromoplasts which can be isolated by centrifugation, it seemed reasonable to attempt several experiments to determine whether or not chromoplasts could be isolated from fruits of rich color and used to enhance the color of FCOJ. The results of this study are presented in this report.

EXPERIMENTAL METHODS

Isolation of chromoplasts.—Juice was extracted from 300 g (whole fresh weight) of 'Dancy' tangerine or 'Murcott' orange fruits with a Silex Juicit, and filtered through 4 layers of cheesecloth. The filtered juice was then centrifuged in a Servall RC-2 at 4000 X gravity for 10 minutes. With tangerine juice this force was sufficient to centrifuge all of the chromo-

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plasts out of suspension, giving a clear, opalescent supernatant fluid and a pellet containing the chromoplasts. The supernatant fluid after centrifugation of 'Murcott' juice, however, was yellow. The pellet was found to consists of several layers of particulate material of different color. A layer of brown material was found at the bottom of the pellet with the red and orange chromoplasts above that, topped with a layer of yellow chromoplasts. The yellow chromoplasts were absent from tangerine juice.

The supernatant fluid was removed by decantation, and the chromoplasts were resuspended in tap water without disturbing the brown material which adhered to the walls of the centrifuge tube. This brown substance was discarded. The chromoplasts were then washed twice by recentrifugation in tap water to remove acids and other juice components. Prior to the final centrifugation, the chromoplast suspension was distributed equally in 6 centrifuge tubes. Thus, each tube contains the equivalent of 50g of whole fruit. Water was decanted from the final pellet and the tube was allowed to drain.

Addition of chromoplasts to orange juice.—A 6 ounce can of commercial concentrated orange juice was reconstituted with tap water and divided into 4 equal portions. Appropriate amounts of the packed chromoplasts were then resuspended in the juice. A mortar and pestle were used to thoroughly disperse the particles in a small volume of juice before adding them to the remainder. The addition of the chromoplasts in one centrifuge tube to the reconstituted juice from one-fourth 6 ounce can of concentrate is equivalent to adding the 'color' from the juice of 200 g of whole fresh fruit to juice reconstituted from one 6 ounce can of concentrate.

Measurement of color.—The reconstituted orange juices with added chromoplasts were analyzed for lightness "R_d", redness "a", and yellowness "b" with the Hunter Color Difference Meter. Color scores were then determined by means of the nomograph relating the "R_d" and "a" values to the USDA visual scores for oranges juice as previously described by Huggart *et al.* (4).

Results and Discussion

The addition of chromoplasts isolated from the highly colored juice of 'Dancy' tangerines or 'Murcott' oranges to a reconstituted commercial juice having a low color score increased

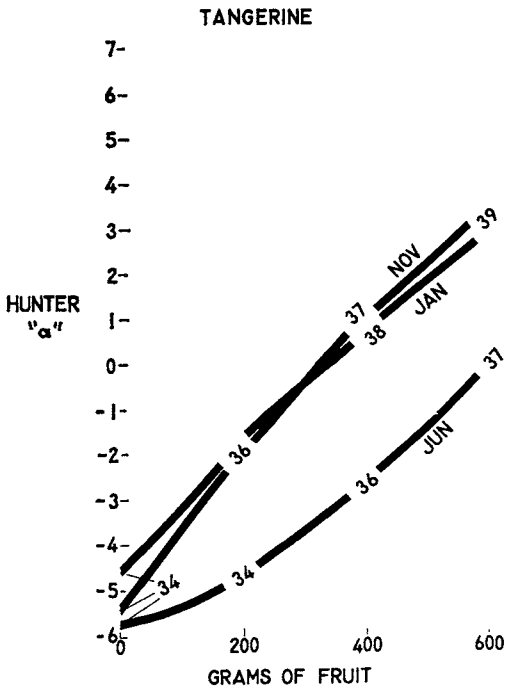

Figure 1.—Effect of adding chromoplasts isolated from juice of 'Dancy' tangerines harvested in November, January, or June to reconstituted concentrated orange juice of poor color. The Hunter "a" value is plotted as a function of the grams of whole fruit from which chromoplasts were obtained for addion to 24 ounces of reconstituted concentrate. Numbers on the graph are the USDA visual color scores.

the HCDM "a" value, indicating an increase in the redness of the juice. The treated juice was judged much more appealing in color than the untreated and no change in flavor was detected.

Figure 1 shows the results that were obtained in 3 separate experiments with chromoplasts isolated from 'Dancy' tangerines. Addition of chromoplasts isolated from juice from the equivalent of 200 g of whole fruit harvested in November or January, to juice reconstituted from one 6 ounce can of concentrate increased the USDA visual color score by 2 points. Chromoplasts isolated from late season (June), cold-damaged fruit were more orange than red, and considerable brown material was found in the juice.

The effect of adding chromoplasts from 'Murcott' oranges to a juice of poor color is shown in Figure 2. In February, fruits at the stage of color-break were harvested from young trees not yet in commercial production. The fruit in this grove were subsequently damaged

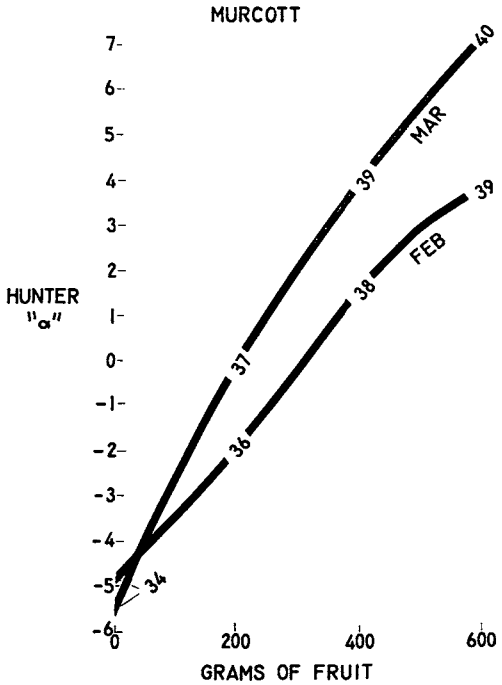

Figure 2.—Effect of adding chromoplasts isolated from juice of 'Murcott' oranges harvested in February or March to reconstituted concentrated orange juice of poor color. The Hunter "a" value is plotted as a function of the grams of whole fruit from which chromoplasts were obtained for addition to 24 ounces of reconstituted concentrate. Numbers on the graph are the USDA visual color scores.

so severely by the freeze that they could not be used again. The fruit used in March were obtained from another commercial grove and appeared to be ripe and without freeze damage. Chromoplasts isolated from the ripe 'Murcott' oranges were very effective in improving the color score of the poor color juice. Chromoplasts from the juice of only 400 g of equivalent whole fruit were required to raise the color score of 24 ounces of reconstituted concentrate from 34 to 39.

As shown in Tables 1 and 2, a substantial decrease in the Hunter "R_d" value, which is consistent with results observed in commercial juices (4), was also found when chromoplasts were added to the reconstituted juice. Changes in the Hunter "b" value were not of any consequence.

In preliminary experiments, chromoplasts were also obtained from the highly acidic calamondin fruits. However, their use was discontinued, because this fruit is not readily available and wide variation in juice color was

Table 1. Effect on color of orange juice with added 'Dancy' tangerine chromoplasts.

Amount color added	HCDM*			Visual color score
	R_d	a	b	
Control	36.1	-5.4	36.8	34
200**	35.2	-1.9	36.6	36
400**	34.2	1.0	36.5	37
600**	32.7	3.5	35.9	39

*Values obtained using 0.6 cm. viewing depth with Carrara plate.

**Grams of whole fruit needed to obtain chromoplasts to enhance the color of 24 ounces of reconstituted concentrated orange juice.

observed in fruit from different trees.

Although the practical and economic aspects of using isolated chromoplasts instead of whole juice or concentrate to increase the color score of FCOJ on a commercial basis has not been fully studied, some consideration has been given to these problems.

The primary disadvantages would be the availability of sufficient highly colored fruit at a reasonable price, the necessity for setting up a separate operation to isolate the chromoplasts, and the problem of finding a method of utilizing the supernatant fluid remaining after removal of the chromoplasts. A solution to these problems should be obtained before further study and work with chromoplasts is undertaken.

Some advantages to the use of isolated chromoplasts are also apparent. Since the chromoplasts represent about 10% of the total volume of whole juice, less space would be required for storage. The addition of chromoplasts to FCOJ to improve color would be unlikely to impart a tangerine or 'Murcott' flavor, since flavor constituents would be decanted with the supernatant fluid. It should also be noted that the chromo-

Table 2. Effect on color of orange juice with added 'Murcott' orange chromoplasts.

Amount color added	HCDM*			Visual color score
	R_d	a	b	
Control	34.8	-5.5	38.9	34
200**	32.5	-0.1	38.9	37
400**	30.7	4.1	38.8	39
600**	29.5	7.3	38.5	40

*Values obtained using 0.6 cm. viewing depth with Carrara plate.

**Grams of whole fruit needed to obtain chromoplasts to enhance the color of 24 ounces of reconstituted concentrated orange juice.

plasts isolated from citrus juice are the natural form in which the characteristic pigments of orange juice are found in the fruit.

Before concluding it should be mentioned that another method of enhancing color of orange juice by natural means (6, 7) has been developed. This other method involves the use of orange peel carotenoids in contrast to intact chromoplasts as presented in this paper.

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EQUIVALENT COLOR SCORES FOR FLORIDA FROZEN CONCENTRATED ORANGE JUICE*

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ABSTRACT

Color data obtained from the examination of 428 reconstituted commercial samples of frozen concentrated orange juice (FCOJ), collected from Florida processing plants during 2 citrus seasons were statistically analyzed. Correlation coefficients and a multiple regression equation were computed relating Hunterlab Citrus Colorimeter (HCC) Citrus Red (CR) and Citrus Yellow (CY) values to average visual color scores. The fit of the multiple regression equation was quite good and explained 97.1% of the observed variation (% R). Using this relationship a nomograph was constructed to estimate equivalent color scores from colorimeter values.

The range between the mean scores of 5 judges was 0.75 of a visual score point. When 5 instruments were compared in 4 tests, the ranges of CR means were equivalent to 0.34, 0.20, 0.15 and 0.08 of a score point.

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INTRODUCTION

In a statistical study in which an instrument, the Hunterlab D45 Citrus Colorimeter and its measurements, Citrus Red (CR) and Citrus Yellow (CY) are being evaluated, the existence of a high correlation between instrument color values and visual color scores must be established if instrument color values are to be an acceptable indication of average visual color scores. Differences in average performance among personnel composing a panel for judging color score must be determined. Subjective and objective methods of determining color of reconstituted frozen concentrated orange juice