Table 2. Effect of temp change on yeast population in 65°Brix orange concentrate.

Strain A Laboratory Study Product held 2, 4, 6 days at 30° and 40°F and 1 wk. at 0°F						
Days	Bef.	Aft.	% Dec.	Bef.	Aft.	% Dec.
	30°F Org/ml x 10^3			40°F Org/ml x 10^3		
2	640	260	59	480	280	42
4	550	290	47	550	460	16
6	450	320	29	460	310	33

Table 3. Effect of temperature change on yeast population.[z]

58°Brix orange blend	
Before treatment Original level of contamination	After treatment 2 days at RT (50-60°F) and 2 wks. at 0°F)
Yeasts per ml	Yeasts per ml
240-3000	12-825

[z]15 — 5 gal. drums of product examined before and after treatment.

45°Brix concentrate at any temp investigated below 40°F. At this temp 1 strain grew in 2 months and the other 2 in 3 months. Mold was detected in 45°Brix concentrate after 12 months at all temp investigated below 40°F. A slight brown discoloration was noted after 7 months at 30°F but was not evident in 15°F or 0°F samples. Yeast did not grow in 65°Brix concentrate at any temp over extended periods of storage. Mold growth was noted in 65°Brix concentrate after 12 months at all temperatures investigated above 0°F. A slight discoloration was observed at 30°F and 40°F after 15 months but not at 15°F or 0°F.

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ORANGE JUICE COLOR MEASUREMENT USING GENERAL PURPOSE TRISTIMULUS COLORIMETERS[1]

BRADLEY A. EAGERMAN[2]

IFAS Agricultural Research and Education Center, Lake Alfred, FL 33850

Abstract. **Several general purpose colorimeters were found which under the proper sample presentation conditions could successfully be used for orange juice color measurement in place of the special purpose Hunterlab citrus colorimeter. Correlations of better than 0.98 were achieved for multiple regression equations for Agtron abridged spectrophotometer, sphere collector colorimeters, and 0-45° viewing colorimeters as compared with the citrus colorimeter color scores for 150 samples. This paper presents the methods used, regression equations, and possible reasons why certain sample presentation methods were more successful than others.**

Color has a psychological impact on the flavor of a number of food products. The effect visual color has on orange juice flavor was shown in a large scale consumer study at the New York World's Fair (3). As a result of this, the USDA grade standards allot up to forty points out of a possible one hundred for color when determining the commercial grade of orange juice (12). This is equal to the consideration accorded to the subjective flavor score for a juice.

[1]Florida Agricultural Experiment Stations Journal Series No. 592.

[2]Current address: Liquid Carbonic Corporation, 3740 West 74th Street, Chicago, IL 60629.

The author would like to thank Magnuson Engineers and Hunter Associates Laboratories for use of their instruments and technical suggestions in this work.

The desire to determine juice color with an objective instrumental method, rather than a visual method led to the development by Hunter Associates Laboratories of the Citrus Colorimeter (CC) (9). The exploratory work and subsequent testing of the CC was done by Wenzel and Huggart (4, 5, 7, 13, 14, 15). They developed the multiple correlation equation (8) which has been adopted as the official color score method (11).

The major disadvantage of the Hunterlab citrus colorimeter is the calibration procedure. The State of Florida and the USDA inspection service requires all instruments used for color measurement to be annually brought to a central location, checked against a series of juices, adjusted to agree with a designated "master" instrument, and then a plastic calibration tube is given an assigned color score for routine, in-plant calibration. This type of calibration procedure is not feasible for instruments scattered over various parts of the world. Also, these plastic tubes fade from constant exposure to light and age. Transporting instruments could affect their optical alignments. Thus instruments which can be calibrated using stable, reproducible, and transportable reference standards would be preferred over the current method.

Presently, the United States standards for grades of orange juice state that "Color may be determined by any colorimeter, approved by the U. S. Department of Agriculture, which gives values equal to the USDA Orange Juice Color Standards (12)". At present, the Hunterlab D45 citrus colorimeter is the only colorimeter thus approved. The purpose of the study presented in this paper was to determine if other, commercially available colorimeters would meet the above stated criteria.

Materials and Methods

The basic plan employed was to examine a number of possible sample presentation methods on instruments using a variety of optical designs, and select the best ones for further consideration. Thus, through successive screening tests, an original 150 different instrument and presentation combinations were reduced to 12 which were used to measure 150 reconstituted commercial frozen concentrated orange juice samples. These samples, which were collected as part of other studies (1, 2), were from 22 different commercial plants and produced in four different crop seasons. The samples were selected at random from those which were available. The samples ranged in color number (CN) from 34.2 to 39.2 with a mean of 37.10 and a standard deviation of 1.05. This range would encompass over 99% of the retail orange juice. Also tested were some juices of various cultivars, and they ranged in CN from 33.0 for a 'Hamlin' juice to 44.3 for a 'Honey Tangerine'[3] juice.

The instruments used in this study employed most of the major viewing configurations produced by all manufacturers. Selection of instruments was based upon those which were available for use.

The following instruments were used in this work:

(1) Agtron M-500-A Abridged Reflectance Spectrophotometer (Agtron) (Magnuson Engineers, Inc., San Jose, CA).

(2) Hunterlab D25D1A Color and Color Difference Meter with 0-45° viewing optic head (A head).

(3) Hunterlab D25D2P Color and Color Difference Meter with sphere viewing optic head (Sphere).

(4) Hunterlab D45D2 Citrus Colorimeter, operated with the specified test tube adaptor (CC), and as a 0-45° tristimulus colorimeter (0-45) (Hunter Associates Laboratories, Fairfax, VA).

(5) Kollmorgen KCS-10 Color Eye, Signature Model (Color Eye) (Macbeth Division, Killmorgen Corp., Newburgh, NY).

The following sample presentation methods were tried on one or more instruments at some stage of the work. All sample presentation methods were not tried on all instruments due to limitations imposed by instrument design.

(1) Optical glass cuvettes of 2.5, 5, 10, 12.5, and 20 mm path length (A. H. Thomas Co. and Fisher Scientific Co.) backed with white, grey, or black cardboard reflectors of approximately 90%, 40% and 5% reflection, respectively.

(2) Total and diffuse transmission and reflection for all listed cell sizes.

(3) Round plastic sample cup with an optical glass bottom (Magnuson Engineers, Inc.) used with spacer rings painted black which give a sample depth of 6.3, 10, 12.5, 18.8 and 25.4 mm and polished aluminum spacer rings to give sample depth of 10 and 12.5 mm. These rings were backed with plastic reflectors of 0, 24, 33, 52 or 90 percent reflection (Magnuson Engineers, Inc.) or a diffusely reflecting stainless steel disc of about 40% reflection.

Calibration for all the Hunterlab instruments and for the Color Eye was done by checking for uniformity of measurement throughout the color solid with various colored calibrated tiles or glass, and then standardizing with the calibrated white ceramic tile provided with the instruments. The Agtron is calibrated using plastic discs of various gray shades. By selecting discs slightly lighter and darker than the extreme samples to be measured, a scale expansion is accomplished, allowing small color differences to be made larger, thereby increasing the instruments sensitivity to small color changes. The calibration discs used for the last phase of this work were as follows: Blue 0-10, Green 24-52, Red 33-63, Yellow 33-63. The numbers are the percentage reflectance of the discs. With these limits, the measured samples covered 35% of the full scale blue range, 60% of the green, 50% of the red, and 55% of the yellow. Without the expansion feature, the range would have been: 4%, 17%, 15% and 17%, respectively.

All analyses and data conversions were done using a General Automation minicomputer. Statistical regression analysis was done using a stepwise multiple regression program available on the system.

[3]A reputed tangor previously known as 'Murcott.' Ed.

Results and Discussion

All of the 12 methods included in the last phase of this work, correlated with the current method with a multiple correlation coefficient (R) better than 0.980. Table 1 lists some of the best methods found for each instrument. Although the use of the citrus colorimeter optical head as a 0-45 tristimulus colorimeter gave the best numerical R, it was not significantly different from the best Agtron or Hunter Sphere methods.

Table 1. Instruments and viewing conditions which gave the best correlations to the citrus colorimeter color scores.

Instrument	Mode	Viewing Conditions: Cell thickness (mm)	Reflective backing	Multiple correlation coefficient
Agtron (M-500-A)	0-45° Narrow band Filter collection	12.5	Grey	.988
Hunterlab (D25D2P)	Sphere D[z]	20	Grey	.992
	Sphere T[z]	10	Grey	.992
	Sphere D[z]	20	Black	.990
Hunterlab D45D2	0-45°	10	White	.994
	Receptor 1″ from sample	10	Grey	.994
		12.5	White	.990
		20	Grey	.988

[z]D = Diffuse reflection; T = Total reflection (diffuse plus specular).

All of the methods listed in Table 1 scored over 97% of the samples within 0.3 scale units of the CC measurement. This variation is less than that which visual assessment could reproducibly achieve (5). Table 2 lists the equations which gave the correlations listed in Table 1 and the standard error of the estimate for each equation.

Table 2. Multiple regression equations of fit for some of the best correlating methods.

Instrument	Cell (mm)	Backing	Std. error of estimate
0-45	10	White	0.097
CN = 35.9061 −1.1235 Y + 1.4021 X − 0.7565 Z[z]			
0-45	10	Grey	0.101
CN = 38.2021 −1.0914 + 1.3383 X −0.8098 Z			
Sphere (diffuse)	20	Grey	0.125
CN = 26.9955 −0.0782 L + 0.1541 a′ + 0.2705 b′[y]			
Sphere (total	10	Grey	0.129
CN = 45.2316 −0.4319 L + 0.3932 a + 0.6476 b[x]			
Agtron	12.5	Grey	0.132
CN = 41.1986 −0.0913 Blue −0.0728 Green + 0.0654 Red + 0.0256 Yellow[w]			

[z]C.I.E. Y, X, Z color scale.
[y]Hunter transmission scale, where a′ = 10 x a/L and b′ = 10 x b/L.
[x]Hunter L, a, b color scale.
[w]Agtron filters within the spectral range of the colors listed.

The citrus colorimeter was designed for use with a translucent product. Thus, when used as a 0-45 colorimeter it had the greatest sized sample port and photo receptor relative to the light beam size of the instruments tested, and had the receptor located close to the sample. According to Hunter (1), for translucent and other light scattering materials, a large sample port and photo receptor allow collection of scattered light which would otherwise be trapped or lost. By this same reasoning, the significant difference ($P < .01$) in correlation found in earlier screening tests between the citrus colorimeter used as a 0-45 colorimeter (0-45) and the Hunter A head (A head), which is a 0-45 colorimeter, is probably due to the location of the photo receptor one inch from the sample in the 0-45 and three inches from the sample in the A head. Fig. 1 gives a representation of the optical arrangement used in those two instruments. As can be seen from this figure, some of the scattered light which is collected on a receptor located one inch from the sample is not collected on the receptor three inches from the sample. The Agtron also has the photo receptor located one inch from the sample.

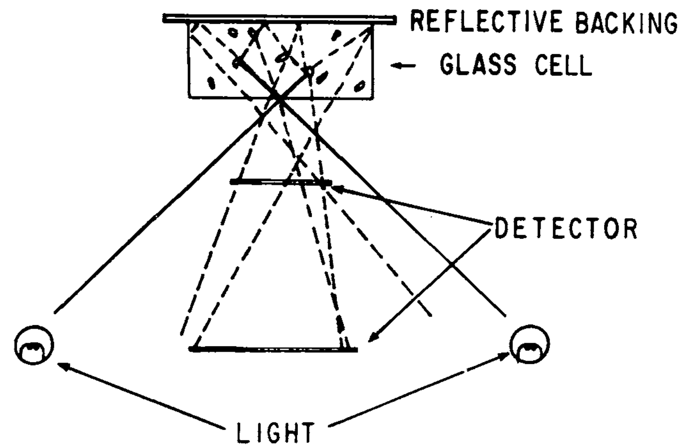

Fig. 1. A stylized representation of the advantage of 0-45 colorimeter with the photoreceptor located one inch from the sample versus three inches from the sample.

The sphere collector may include or exclude specular component, or gloss. In Table 1, total reflection means specular plus diffuse components, while diffuse reflection means specular component excluded or matte reflection. A sphere collector is in design the best instrument for light scattering materials, as the photocell collects all of the light which enters from the same port (Fig. 2). However, for the instruments used, the illuminated area was almost as large as the sample port, so some of the scattered light was lost by not being able to reenter the sphere (10).

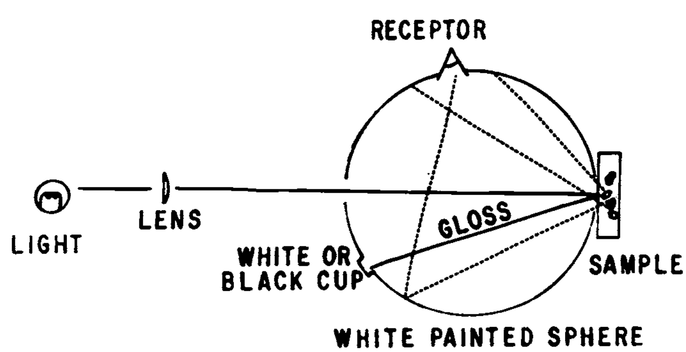

Fig. 2 A stylized representation of an integrating sphere collector.

The selection of calibration discs for use with the Agtron depends upon the reflectance range of the samples under the viewing conditions employed. The calibration discs employed in this work were not the same as those in the work reported by Huggart *et al.* (6). If all other factors were constant, the values could be adjusted mathematically to common calibration points. However, there was a difference of about 12 units in the reflective backing discs used, and there is no exact way to compensate for that difference. The multiple regression correlation coefficients calculated from two different sets of at least 100 samples each, were not significantly different from each other. The differences in method between the two studies is that the earlier work used a 52% reflectance plastic disc trimmed so as to fit inside the sample cup as the reflective backing, while this study used a sandblasted stainless steel disc of 40% reflectance for the backing. Both studies used a 12.5 mm polished aluminum spacer ring.

Conclusions

Successive screening of a large number of possible sample presentation methods to select those which correlated best with the currently approved method to allow the following general conclusions to be made.

1. Transmission measurements on commercial orange juice are not reproducible in any thickness cell tested probably due to the variability in the amount of pulp, and the size of pulp particles.
2. For reflectance style measurements, the sample thickness must be great enough for the sample to appear translucent rather than transparent. Five mm was too thin, while 10 mm gave good results. For the upper limit, 20 mm gave good results while 25.4 mm is about the limit of light penetration for most of the colorimeters.
3. The gray reflective backing was the backing most frequently yielding the highest correlation coefficients. This is probably because the current instrument method uses a sandblasted steel backing, so that it could correlate well with the visual method which uses a medium gray painted background.
4. The general rules as to which instrument designs would most likely give the best results for orange juice are those which are designed to be used for translucent materials. That is:

a) a large sample port and photo receptor relative to the incident beam illumination area (so as not to trap scattered light).

b) the receptor close to the sample, or a sphere collector (so as to collect the maximum scattered light possible).

Limited visual color measurements indicate that the best alternate methods correlated about as well with visual assessment as does the existing method ($r > 0.96$). However, the visual scores used were from one judge only, and as such, may not be equivalent to a larger panel. Thus further visual panel work is necessary to determine conclusively if any instrumental method agrees more closely to visual color judgments than other methods.

A disadvantage of most of the proposed methods is that optical glass cells cost much more than the glass test tubes used for the current method, and the use of separate backing plate is awkward to use. This latter problem could be alleviated by the construction of a stainless steel or aluminum cell with an optical glass for the measurement face.

The work presented here is believed to show conclusively that other photoelectric colorimeters can successfully measure orange juice color. None of the instruments tested cost more than the current price of the citrus colorimeter. The Agtron is substantially cheaper. However, the model tested here does not have output capability, so the color number equation must be solved manually. A new model, which will allow for preprogrammed equations, will be available by the time this article appears in print. The Hunterlab instruments used all have output capability.

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FLORIDA CANNERS RECOVERY FROM 1971-72 THROUGH 1976-77 AND RECOMMENDATIONS FOR FUTURE REGULATIONS

J. T. Griffiths and William J. Hepburn
Florida Citrus Mutual,
P. O. Box 89, Lakeland, Florida 33802

Additional index words. Concentrate, pulp washed; Concentrate, frozen orange; Solids, pulp washed; Extractor, testhouse; Factor, testhouse, Recovery, tolerance; Citrus, Orange.

Abstract. **The 6 years from 1971-72 through 1976-77 are analyzed according to reports from the Florida Canners Association and the Florida State Inspection Service to demonstrate the percentage recovery which canners were able to obtain as compared with the volume of juice or pounds solids reported to the grower. In addition, the amount of pulp washed solids for concentrate produced during those periods is compared with the amount of frozen concentrated orange juice produced. It is recommended that the canner tolerance of 102% can be reduced to 101% and that 3 weeks average recoveries as reported by canners form the basis for an objective test to trigger raising or lowering the testhouse extractor factor.**

In 1971, Griffiths (1) presented a paper covering results for the period from 1963 through 1971 on orange juice yields which had resulted from instituting a quality improvement program with substantial restrictions on canner recovery.

During the 1968-69 season the testhouse procedure was further modified by installing identical extractor and sampling procedures in all processing plants. The testhouse extractors were set to operate at 45 pounds of extractor pressure. This pressure resulted in the over extraction of the oranges and yielded something besides good, usable juice. Therefore, it was necessary to factor the results in terms of what was reported to the grower. In the initial stages, the canners were permitted to have a tolerance of 5% extra recovery over that reported to growers. This was modified in 1969-70 to 4%, and then in 1970-71 to 2%. The individual processor had to stay within the tolerance limit on a seasonal basis. Thus, he had to average less than 102% over the entire season, and could exceed 102% only for a limited number of weeks in sequence.

Comparisons of juice in oranges as reported by the Statistical Reporting Service on April 1st and then compared with the actual juice recovered by canners showed that the period from 1968 through 1971, as a result of the testhouse program, did result in substantially reduced yields by canners. The sales pattern and consumer response clearly indicated a substantial improvement in orange juice quality.

Griffiths (1) recommended that the recovery by canners should be reduced from 102% to 101% and he suggested specific correction factors by dates. These recommendations were never acted upon by the industry.

In the 1972-73 season, a further modification was made to require that the 102% recovery figure be calculated separately for early-midseason oranges for the period ending on approximately April 1st. The 'Valencia' period was also restricted to 102% for the balance of the season.

Current regulations permit a canner to recover over 104% in any one week, but in any 3 week period, the average must be below 104%. Actually, a canner can recover 103.9% on a continuing basis for a considerable period of time provided only that the average for that variety does not exceed 102%.

The factor for determining the juice yield to be reported to growers is recommended by a testhouse extractor committee composed of 2 representatives each from the Florida Citrus Commission, the Florida Canners Association, Florida Citrus Mutual, intermediate handlers, and Florida Citrus Packers. The committee meets on call of