TOMATO PRODUCTS SPECTROPHOTOMETER STUDIES

In March 2008, Agricultural Marketing Service, Specialty Crops Inspection Division (SCI) in cooperation with the University of California, Davis (UCD) completed a study of the Minolta Konica CR410 spectrophotometer for use in the evaluation of "color" in tomato products. The study was initiated to consider additional instruments for approval at the request of instrument suppliers. SCI currently maintains a list of approved instruments including the Hunter Lab D25-D2 series; Agtron M400, M500, and E5M Colorimeters; and BYK Gardner models XL20, XL23, XL-805, and Colorgard 2000/05.

The study compared the Hunter Lab Scan XE from Hunter Lab and the UCD reference spectrophotometer (Hunter Lab Scan 5100) to the Minolta Konica model number CR410.

Samples of commercially prepared tomato products were purchased from grocery stores in the Davis, Sacramento, Vacaville, CA and Reston, VA areas. The illuminant used for the color study was CIE illuminant C. The standard observer was 1931, 2 degrees Standard Observer.

As a result of the study and determinations made by SCI, the following spectrophotometers and the equations associated with each instrument are approved for the calculation of the color score for products covered by the U.S. Standards for Grades of Canned Tomato Sauce, Tomato Juice, Tomato Juice from Concentrate, Tomato Paste, Tomato Puree, Concentrated Tomato Juice, and Tomato Catsup.

List of Approved Spectrophotometers

Minolta Konica model number CR410

- Tomato Sauce Score: $TSS = -51.231 + 1.463\ a + 13.986\ b - 1.021\ b^2$
- Tomato Catsup Score: $TCS = -50.28 + 9.956\ a - 0.263\ a^2 - 2.76\ b$
- Tomato Juice Score: $TJS = 25.51 + 1.406\ a - 2.97\ b$
- Tomato Paste and Puree Score: $TPS = -1.345 + 1.253\ a + 7.733\ b - 0.574\ b^2$

  where a and b are from Hunter L, a, b values.

BYK Gardner Color View

- Tomato Sauce Score: $TSS = -227.607 + 1.154\ a + 33.615\ b - 1.278\ b^2$
- Tomato Catsup Score: $TCS = -59.387 + 5.635\ a - 0.0990\ a^2 + 0.414\ b$

- Tomato Juice Score: TJS = 95.652 + 0.956 a - 11.840 b + 0.379 b^2
- Tomato Paste and Puree Score:
  TPS = -2.63270 + 13.822 log b - 7.422 log L + 0.0234 a - 1.002 b + 0.295 L

  where L, a, and b are readings reported by the instrument.

HunterLab ColorFlex 4500L

- Tomato Sauce Score: TSS = -153.100 + 1.187 a + 22.332 b - 0.864 b^2
- Tomato Catsup Score: TCS = -80.888 + 8.355 a - 0.144 a^2 - 1.194 b
- Tomato Juice Score: TJS = 25.963 + 0.989 a - 1.787 b
- Tomato Paste and Puree Score: TPS = -81.582 + 1.069 a + 15.390 b - 0.591 b^2

  where a and b are readings reported by the instrument.

Hunter D25A-9000

- Tomato Sauce Score: TSS = -180.263 + 1.145 a + 26.413 b - 1.012 b^2
- Tomato Catsup Score: TCS = -99.999 + 9.532 a - 0.166 a^2 - 0.936 b
- Tomato Juice Score: TJS = 25.715 + 0.956 a - 1.748 b
- Tomato Paste and Puree Score: TPS = -58.296 + 1.093 a + 12.120 b - 0.480 b^2

  where a and b are readings reported by the instrument.

Hunter Lab Scan XE

- Tomato Sauce Score: TSS = -149.176 + 1.139 a + 21.608 b - 0.826 b^2
- Tomato Catsup Score: TCS = -81.964 + 8.321 a - 0.142 a^2 - 1.129 b
- Tomato Juice Score: TJS = 25.114 + 0.939 a - 1.638 b
- Tomato Paste and Puree Score: TPS = -40.926 + 1.061 a + 9.473 b - 0.376 b^2

  where a and b are readings reported by the instrument.

List of Previously Approved Spectrophotometers (Initial Study)

The below equations are used for the calculation of color score for the previously approved colorimeters for tomato products. These equations are based on Hunter a and b values referenced in the initial study by USDA at UC Davis entitled, "Color Scoring Tomato Products Objectively", by George Marsh, James Buhlert, Sherman Leonard, Teri Wolcott and Julie Heil, Dept. of Food Science and Technology, University of California, Davis, July 15, 1980.

Hunter D25-D2 Colorimeter

- Tomato Sauce Score: TSS = -154.39 + 1.1142 a + 22.596 b - 0.86736 b^2
- Tomato Catsup Score: TCS = -74.937 + 7.5172 a - 0.1278 a^2 - 0.8051 b
- Tomato Juice Score: TJS = 29.600 + 0.8835 a - 1.8553 b
- Tomato Paste and Puree Score: TPS = -46.383 + 1.0211 a + 10.607 b - 0.42198 b^2

where a and b are readings reported by the instrument.

Agtron M400 and M500 Colormeters

- Tomato Sauce Score (tentative): TSS = -25.002 + 1.5234 R - 0.0092174 R^2 - 0.25817 G
- Tomato Catsup Score (tentative): TCS = -5.3411 + 1.0309 R - 0.00745 R^2 - 0.15663G
- Tomato Juice Score: TJS = 28.629 + 0.1428 R - 0.24197 G + 0.14176 B
- Tomato Paste and Puree Score: TPS = 20.850 + 0.828 R - 0.004335 R^2 - 0.283 G + 0.312 B

R = Red, G = Green, B = Blue

Agtron E5M Colorimeters

- Tomato Sauce Score (tentative): TSS = 38.936 - 0.45231 (E5M Reading)
- Tomato Catsup Score: TCS = *No equation is available for an accurate color score for catsup.*
- Tomato Juice Score: TJS = 40.898 - 0.35759 (E5M reading)
- Tomato Paste and Puree Score: TPS = 54.250 - 0.005265 (E5M Reading)^2

For Tomato Paste and Puree having a brown or burnt visual appearance the Agtron E5M meter reading yields accurate "substandard" scores.

BYK Gardner XL20, XL23, XL-805, and Colorgard 2000/05 Colorimeters

- Tomato Sauce Score (tentative): TSS = -193.20 + 1.0211 a_L + 27.649 b_L - 1.0175 b_L^2
- Tomato Catsup Score: TCS = -40.511 + 4.7767 a_L - 0.07791 a_L^2 - 0.56986 b_L
- Tomato Juice Score: TJS = 34.094 + 0.71464 a_L - 1.7883 b_L
- Tomato Paste and Puree Score: TPS = -46.383 + 1.0211 a_L+ 10.607 b_L - 0.42198 b_L^2

where a_L and b_L are readings reported by the instrument.

"SCI moving forward in the 21st Century using technology, innovation, and old fashioned hard work"