Color measurement in fruits and vegetables: Measure Citrus Color Index (CCI), Ripening Index (RI), Tomato Color Index (TCI) and do more with Sensegood Spectrophotometer

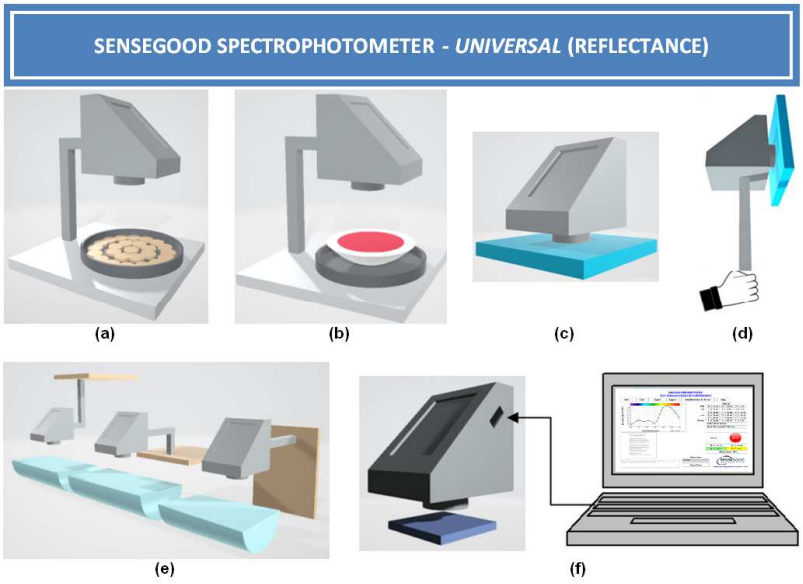
Photo: Wonderful nature – rainbow for a healthy life: Satisfying colors of fruits and vegetables.
Source: wallpaperaccess.com

Importance of color in fruits and vegetables:

Fruits and vegetables are nature's boon to human. One can judge if the fruit is ripped or not by looking at its color. Color of the fruits and vegetables can also be associated with their freshness. One of the basic improvements of quality of any fruit or vegetable is proper sorting and handling. Separating the ripe fruits from the over-ripe and unripe fruits would allow the "good fruits" (with adequate shelf life) to be shipped to fresh market while the less desirable, the green and the over ripe fraction, could be send to a processing plant where quality could be enhanced by appropriate bio-processing techniques. [1] Consider an example for apple; color and size of apple are most important criteria among other quality parameters estimated *by consumer*. [2]- [6]

Sensegood spectrophotometer for color quality management in fruits and vegetables:

Sensegood spectrophotometer is an analytical color measurement instrument that is widely accepted in industry and research fraternity. It comprehensively evaluates the color attributes of various samples, including solids, liquids, powders and pastes. Large viewing area (sensor's field of view) and rotating sample platform averages out sample and produces accurate repeatable color attributes. As a result, consistency can be maintained and quality standards can be met with less waste, time, and effort.



- ✓ Benchtop/ Tabletop: (a) (b) (Rotating sample platform)
- ✓ Handheld/ Portable: (c) (d)
- ✓ Online/ In-process: (e)

- ✓ Solid: (a) (c) (d) (e)
- ✓ Liquid: (b) (e)
- ✓ Paste: (b) (e)
- ✓ Powder: (a) (b) (e)

- ✓ Contact measurement: (c) (d)
- ✓ Non-contact measurement: (a) (b) (e) (Adjustable height)

Works with:
- ✓ 5V adapter (cell phone charger)
- ✓ Power bank
- ✓ Computer/ Laptop (f)

- ✓ Averaging
- ✓ Auto repeat measurement mode
- ✓ Color match percentage
- ✓ Color indices (whiteness, yellowness, …)

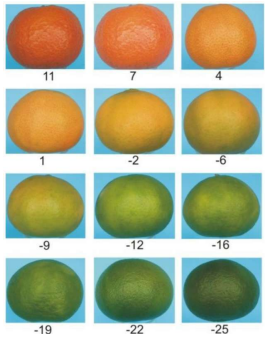
- ✓ *SensegoodSmart* – computer interface software utility

Sensegood spectrophotometer for measuring color indices:

A practical application where the inspection of the color is needed is the assessment of fruits to determine the need of post harvest treatments. Fruits are harvested manually, then loaded in boxes and transported to a packing house, where the fruits are sorted.

Citrus scores:

Fruit sorting focuses on classification by color. For citrus fruits like mandarin; orange colored fruits go directly to market, orange–green undergo a 24 hour degreening process and green fruit is processed for 72 hour degreening. Various citrus scores are used in the citrus industry to determine the harvesting date or to decide which fruit should undergo a degreening treatment.



Mandarin ripening stages
Image source: Ref [8]

Sensegood spectrophotometer acquires color of citric fruits like orange, mandarin, lemon, grapefruit; analyses and represent as Citrus Color Index (CCI). Along with CCI, it also provides values for Citrus Number (CN) and Citrus Red (CR). Sensegood spectrophotometer's firmware works on citrus score algorithm developed by United States Department of Agriculture (USDA). [7]

L*=+55.54, **a*= -14.22**, b*=+29.16	L*=+63.93, **a*= +25.54**, b*=+46.95
Citrus Color Index **CCI: -8.78**	Citrus Color Index **CCI: 8.51**
Citrus Number **CN: 20.90**	Citrus Number **CN: 54.92**
Citrus Red **CR: -46.30**	Citrus Red **CR: 153.05**
Ripening index: **a/b = -0.49, b/a = -2.05**	Ripening index: **a/b = 0.54, b/a = 1.84**

Photo: Determine citrus scores in orange fruit using Sensegood spectrophotometer.

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Tomato color index:

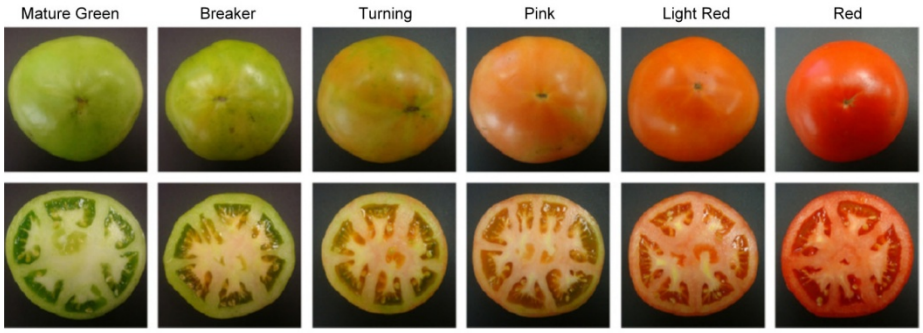


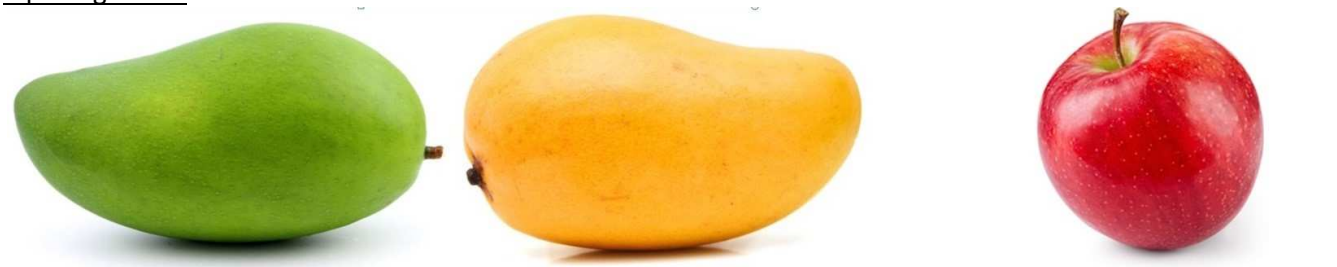
Photo: Tomato ripening stages. Image source: Ref [9]

Color in tomato is the most important external characteristic to assess ripeness and postharvest life, and is a major factor in the consumer's purchase decision. Tomato Color Index (TCI) is the measure of tomato ripening. Sensegood spectrophotometer acquires tomato color and presents result in terms of TCI.

L*=+56.82, **a*= -10.41**, b*=+39.35	L*=+40.50, **a*= +33.97**, b*=+31.58
Tomato Color Index **TCI: -9.00**	Tomato Color Index **TCI: 36.17**
Citrus Color Index **CCI: -4.66**	Citrus Color Index **CCI: 26.56**
Citrus Number **CN: 26.68**	Citrus Number **CN: 75.15**
Citrus Red **CR: -20.92**	Citrus Red **CR: 279.61**
Ripening index: **a/b = -0.26, b/a = -3.78**	Ripening index: **a/b = 1.08, b/a = 0.93**

Photo: Determine tomato color index (TCI) using Sensegood spectrophotometer.

Ripening index:



L*=+50.98, a*= -16.12, **b*=+24.52**	L*=+67.12, a*= +16.18, **b*= +49.36**	L*=+45.41, **a*= +42.79**, b*= +21.95
Ripening index: **a/b = -0.66, b/a = -1.52**	Ripening index: **a/b = 0.33, b/a = 3.05**	Ripening index: **a/b = 1.95, b/a = 0.51**
Citrus Color Index **CCI: -12.90**	Citrus Color Index **CCI: 4.88**	Citrus Color Index **CCI: 42.93**
Citrus Number **CN: 17.88**	Citrus Number **CN: 46.96**	Citrus Number **CN: 77.54**
Citrus Red **CR: -61.66**	Citrus Red **CR: 102.93**	Citrus Red **CR: 312.27**

Photo: Determine ripening indices in mangoes and apples using Sensegood spectrophotometer.

Apart from citrus scores and tomato color index, Sensegood spectrophotometer is equipped with ripening indices. The a*/b* index represents the ratio of red-green and yellow-blue color components. Same way, reciprocal index b*/a* can also be considered depending on the color of fruit or vegetable.

Color measurement for sorting and grading:

Sensegood spectrophotometer helps in picking up even the slightest color difference. It helps in finding difference between two colors and shows result in percentage match.

Sensegood Spectrophotometer for color assisted grading and sorting of Eggplant or Aubergine or Brinjal

Photo: Determine color match percentage in fruits and vegetables using Sensegood spectrophotometer.

If matching is poor; below set threshold, Sensegood spectrophotometer provides audible alarm and display indication on LCD to alert operator. Hence operator can quickly react and take appropriate action. The information assists for the prompt corrective action toward sorting and grading. This surely results into improved product quality, consistency and market acceptability.

Abstract – Sensegood spectrophotometer usage guideline:

Fruits that turn orange-red from green:

In case of citrus fruits, use citrus scores to determine harvesting date or degreening treatment. However, citrus scores are specifically designed for citrus fruits, one can also consider ripening index and CIE a* color component value in general.

Tomatoes:

Use tomato color index (TCI) or ripening index or citrus red.

Fruits that turn yellow from green:

Use CIE b* color component value or ripening index or suitable citrus index.

Other fruits:

Use ripening index or any suitable value (L*,a*,b*,C*,h^0,u*,v*,CCT,X,Y,Z,x,y) or any of the indices that monotonically changes over ripening stages.

Fruits and vegetables in general:

Establish color tolerances and find match percentage to ensure color within limit.

Do more with Sensegood spectrophotometer:

Sensegood spectrophotometer also incorporates continuous auto measurement mode. In this mode, it wakes up at user selectable intervals, takes measurement, compares the sample color with the saved reference, displays percentage match, and alarms to the operator with beeping sound in case if the matching percentage is below preset threshold. It has provision for averaging option in normal mode as well as in auto repeat measurement mode.

Measured CIE L*a*b* values indicate strength of color parameters like: bright or dull, red – green and yellow – blue respectively. Measured color is also represented as reflectance graph, peak wavelength and color temperature on color touch LCD. Sensegood spectrophotometer is non-messy non-contact type instrument which has benefit of measuring sample's color from a distance. Because of this, sensor's optical assembly

remains scratch proof enabling long life in retaining calibration. Non-contact measurement avoids any sample contact and contamination on sensor measuring surface. Sensegood spectrophotometer is the versatile device that is engineered to work as handheld/portable, benchtop/table-top or in-process/online color measurement instrument.

SensegoodSmart utility:

Sensegood spectrophotometer provides computer interface software *SensegoodSmart* which lets you to convey numeric color data across all production plants that may be located at multiple places across the globe. SensegoodSmart utility enables user to store unlimited number of references to the computer. Any desired reference can be recalled and downloaded to Sensegood spectrophotometer whenever required. The utility provides all color related analytical information on single screen. This feature is even more desirable when using Sensegood spectrophotometer for in-process/online applications.

Other related reads:

On the other hand, natural food dye manufacturers also need control on color quality to maintain consistency. This topic is separately discussed in detail in Food dyes section.

Sensegood spectrophotometer helps fruit processors in managing color quality control in beverages like fruit juices and condiments like tomato ketchups. This topic is separately discussed in Beverages and pastes section.

Study cites that the color and method of packaging in fruits and vegetables influences consumer's willingness to buy. It can change consumer's perception by improving the appearance of fruits and vegetables or fruit juice packaging. [10] Check how Sensegood spectrophotometer can help in maintaining color consistency in your packaging.

References:

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[10] B. Dobrzański, and R. Rybczyński, "Influence of packing method on colour perception improving the appearance of fruits and vegetables", Research in Agricultural Engineering 54(2), January 2008. https://doi.org/10.17221/4/2008-RAE https://www.agriculturejournals.cz/publicFiles/01571.pdf

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