

Assessment of apricot color and quality changes using color indices

Petrisor Cristina

Research and Development Station for Fruit Tree Growing Baneasa, Bdv. Ion Ionescu de la Brad, No.4, Sect.1, Bucharest, Romania

*Corresponding author. Email: crisstop@yahoo.com

Abstract In apricot fruit, establishing the optimal harvest time is crucial, since fruit quality potential are closely related to the ripening stage at harvest. Stage of maturation is usually estimated by fruit color through parameter L^* , a^* , b^* . The goal of this study was establish feasibility of different chromatic indices for apricot color and quality determination and their relationship with pigments and ethylene concentration. Color changes during apricot ripening were the result of significant changes in the values of a^* , h° , $(a^*/b^*)^2$, $(1000a^*/L^*b^*)$, $(180 - h^\circ/L^* + C^*)$. Chroma and lightness were not a good parameters to express apricot ripeness because narrow range of variation and small differences between stages of maturation and even between varieties. Relationship between b^* , L^* , C^* and total carotenoids content were very weak. For ripened apricot fruits a^* , h° and chromatic indices could be used as objective ripening indices.

Key words

apricot, chromatic parameters, carotenoids, color index

Color is considered to be one of the most important external factors of fruit quality, as the appearance of the fruit greatly influences consumers [10].

The study of the variability of the apricot color is important for quality control to determining appropriate maturity, processing, consumption and for selection of the best cultivar intended to be accounted. The importance of this feature in fruit quality requires the need for its rapid and accurate quantification. Recently, visible reflectance spectroscopy was successfully used to quantify in a non-destructive terms pigment content and fruit color.

Although, different apricot varieties have been investigated in terms of color by some researchers in the world [5;11;13;15;16] however an extensive research as to chromatic indices, and their correlation with pigments and ethylene have not been investigate until now.

Some colorimetric studies [1;4] shown that the ratio a^*/b^* and $(a^*/b^*)^2$ were good indicators in order to express color changes and lycopene content of tomatoes. Also, other authors [9] proposed an color index $(2000a^*/L^*C^*)$ for determining color of tomato and they compared this with other color indices used in literature in relationship to color.

Some authors [8] proposed the use of the formula $1000a^*/L^*b^*$ as a color index that may be used consistently to indicate color and maturity of citrus fruit. Later, Olmo et al., 2000 using this color index, found that is important to color monitor during ripening of fruits grown under temperate conditions. Other researchers [2] has proposed a color index for red grapes and investigated usefulness of this to

classify the red grapes depending on their external color. This index showed a good linearity with the visual colour of the fruits and distinguished between sample groups of different external color.

Also, another authors [6] proposed the use of a chromatic index $L^*(b^*-a^*)/100$ to identify progress of olive fruit maturation.

This study was carried out to establish feasibility of using color indices from literature for evaluating color, ripening and quality of different romanian apricot cultivars.

Material and Methods

The biologic material consisted of three Romanian apricot cultivars: Rares with extra-early maturation, Carmela with early maturation and Excelsior with medium maturation. Fruits of all cultivars were harvested at two maturity stage (half-ripe and ripe) from experimental orchard of Research Station Baneasa. At least 30 fruits were harvested from at least five different trees for each cultivar and they were pooled.

In order to determine the colour parameters, work was performed on samples containing 15 fruits for every cultivars, each fruit being analyzed upon two side (the more colourful and the lesser colour side) in the equatorial zone of fruit. Each fruit was measured twice on each side, to establish the average of colour parameters.

Surface color of the individual apricots fruit was determined by measuring L^* , a^* , b^* value with a portable chromameter HunterLab Mini Scan XE Plus

calibrated to white standard reflective plate using Illuminant D65, and with a measuring area of 32 mm in diameter.

The coordinates a^* and b^* were used to compute the hue angle $h^\circ = \tan^{-1} \frac{b^*}{a^*}$ and $C^* = \sqrt{a^{*2} + b^{*2}}$ and chromatic indices a^*/b^* , $(a^*/b^*)^2$, $(1000a^*/L^*b^*)$, $(180-h^\circ/L^*+C^*)$, $(2000a^*/L^*C^*)$.

Total carotenoids content were determined from pulp and peel by measuring the absorbance at $\lambda=450\text{nm}$ of acetone extract with UV-VIS spectrophotometer using the procedure described by [14]. Results were expressed as mg carotenoids/100g fresh weight.

The measurement of C_2H_4 concentration was carried out following the closed-system method at 20°C [3]. Apricots were placed in hermetic glass containers (1500mL) equipped with rubber sampling ports. Three replicates were prepared from each maturity stage. Concentration of C_2H_4 was determined in accordance with the method of [7] using a Fisons GC 9000 series gas chromatograph with a flame ionization detector EL980 and a Chrompack CP-Carboplot P7 column (inside diameter 0.53mm, length 10 m). The temperature of the oven was 60°C and the detector temperature was 100°C . The carrier gas used was H_2 . The values were expressed in $\mu\text{L } C_2H_4 \text{ kg}^{-1}\text{h}^{-1}$.

Results and Discussions

The experimental results of color parameters and chromatic indices at different ripening stage of apricots are shown in table 1. It can be seen that a increase in the a^* , b^* , C^* and a decrease in the h° and L^* parameters which corresponding with advancing of ripening apricot color changed from green to orange or orange-red.

The decrease of lightness (L^* value) reflects the darkening of apricots color and this was observed at Excelsior and Carmela cultivars (table1).

The red-green component (a^* value) increased for all cultivars studied, denoting loss of green color related to the disappearance of chlorophyll. This parameter has high values for Carmela cultivar which implies a strong degree of red materialized by specific color of this fruit which presents on one side of fruit red- carmine color covers.

The blue-yellow component (b^* value) changed very little during apricot ripening (table 1), although not significant, values were higher from half-ripe stage.

Our results shown that the value of h° (hue angle) is a useful indicator of maturity stage, as it decreases linear throughout ripeness from value between 70-75 (corresponding green-yellow color) to value between 50-65 (corresponding deep orange or orange-red color) showing that apricots change from green to yellow-orange, deep orange or orange-red.

The C^* values increased among maturity stage, that indicate a marked intensity and uniformity of color. However narrow range of variation of this parameter and a little difference between maturity stage and even among cultivars, suggested that, this color parameter is less useful for determining of color modification and maturity stage during fruit ripening.

The range of color values is representative of apricot species and is in agreement with results obtained previously in apricot [5; 12; 15].

Values of chromatic indices a^*/b^* and $(a^*/b^*)^2$ increased during fruit ripening in all cultivars studied and generally is less than unity. In the same way, varies other calculated chromatic indices used in this study, their values ncreasing with increasing percentage of orange color.

Regarding chromatic indices $180-h^\circ/L^*+C^*$ small differences were observed both between maturation stage and even between cultivars. So, this color index did not significant colour differences during apricot fruit ripening and between cultivars.

Carotenoids pigment content increases with advancing maturity, especially in the later stage of maturation to values: 2.5 mg/100g fresh weight (Rares cultivar), 5.8 mg/100g fresh weight (Carmela cultivar) and 3.5 mg/100g fresh weight (Excelsior cultivar). The highest total carotene content was found in Carmela cultivar which was up to two times greater as compared with the rest of studied cultivars and has a intense orange color covered on one side with red-carmine. So, total carotenoids content of the apricot fruit studied were found to be different depending on cultivar. Mean values of total carotenoids were similar to those reported by other researchers [5;15;17]

In case of early cultivar Carmela, determined an increase three times of ethylene concentration (table 2) in ripe stage than half ripe stage. Among the cultivars studied, extra-early cultivar presents the lowest production of ethylene (table2), so this variety is a slow ripening in terms of emission of ethylene. We can observed that, the cultivar with mid season (Excelsior) presents generally lower values of fruits ethylene concentration than early cultivar and greater than extra-early cultivar. We can conclude that this cultivar have a slowly development of maturation supported by production of ethylene.

Table 1

Variation of color parameters and chromatic indices in apricot cultivars studied

Cultivars	Maturity stage	L*	a*	b*	C*	h°	a*/b*	$(a^*/b^*)^2$	$\frac{1000a^*}{L^*b^*}$	$\frac{180-h}{L^*+C^*}$	$\frac{2000a^*}{L^*C^*}$
Rares Extra-early season	Half-ripe	65.67	10.20	48.04	49.16	78.05	0.21	0.044	0.32	0.88	6.31
	Ripe	66.55	22.52	50.49	55.33	65.93	0.44	0.19	6.7	0.93	12.23
Carmela Early season	Half-ripe	62.21	17.14	48.64	51.56	70.62	0.35	0.12	5.66	0.96	10.12
	Ripe	52.25	34.41	49.12	56.07	48.65	0.70	0.49	13.40	1.21	23.49
Excelsior Mid season	Half-ripe	71.08	12.51	52.55	54.02	76.61	0.23	0.052	0.33	0.82	6.51
	Ripe	67.36	27.26	48.31	55.48	60.57	0.56	0.31	8.37	0.97	14.58

Table 2

Variation of total carotenoids content and production of ethylene in apricot cultivars studied

Cultivars	Maturity stage	Total carotenoids mg/100g fresh weight	Production of ethylene $\mu\text{L kg}^{-1} \text{h}^{-1}$
Rares Extra-early season	Half-ripe	2.1	0.15
	Ripe	2.5	0.16
Carmela Early season	Half-ripe	2.5	0.15
	Ripe	5.8	0.44
Excelsior Mid season	Half-ripe	1.73	0.13
	Ripe	3.5	0.26

Was observed in all apricot varieties studied very good correlation between a* value and carotenoids pigments ($R^2 = 0.90$) and good correlation between h° and carotenoids pigments ($R^2 = 0.80$) (data unshown)

Chromatic indices, we studied in this experiment were not used as indices for ripening apricot until present except a*/b* [16]. The a*/b* and $(a^*/b^*)^2$ ratio which has been proposed by several authors [1;4;9] as suitable for establish the degree of ripeness of tomatoes showed a high degree of correlation ($R^2 = 0.85$) with total carotenoid pigments and moderate degree of correlation ($R^2 = 0.70$) with ethylene concentration of apricot studied in this experiment. The discriminating power shown by that color indices a*/b* and $(a^*/b^*)^2$, allows us to separate, the evaluated apricot cultivars according to their appearance and degree of maturation.

The correlations between chromatic index $180-h^\circ/L^*+C^*$ with ethylene concentration and carotenoids pigments were weak for all apricot

cultivars studied. But the other two chromatic indices studied ($1000a^*/L^*b^*$) and ($2000a^*/L^*C^*$) had good correlation coefficients in range ($R^2 = 0.70-0.78$) for ethylene and carotenoids but only in case of Rares and Carmela cultivars. The Excelsior cultivar had very low correlation coefficients in range $R^2 = 0.35-0.56$ (data unshown).

Conclusions

Chroma was not a good parameter to express apricot ripeness. Also, L* parameter had the same limitations as chroma. The chromatic index $180-h^\circ/L^*+C^*$ did not separate the fruits of different maturity stage and color, as clearly as the a*/b* ratio and the other chromatic indices.

From CIELAB color feature a* and h° and from chromatic indices $1000a^*/L^*b^*$, $2000a^*/L^*C^*$ and a*/b* ratio are those visible changes during ripening process and they are most feasible indicators

for color quantification distinguish different stages of maturity of apricot studied.

The high R^2 obtained for the relationships between total carotenoid concentration or ethylene concentration and some color values and chromatic indices, demonstrate that these parameters were good to apricot quality determination.

Literature cited

1. Arias R., Lee T.C., Logendra L., Janes H. 2000. Correlation of lycopene measured by HPLC with the L^* , a^* , b^* color readings of hidroponic tomato and relationship of maturity with color and lycopene content. J. Agric. Food Chem. 48:1697-1702
2. Carreno J., Martinez A., Almela L., Fernandez - Lopez J.A. 1995. Proposal of an index for the objective evaluation of colour of red table grapes. Food Research International 28(4):373-377
3. Chambroy Y., Souty M., Jacquemin G., Gomez R.M., Audergon J.M. 1995. Research on the suitability of MAP for self-life and quality improvement of apricot fruit. Acta Hort. 384:633-638
4. D'Souza M.C., Singha S., Ingle M. 1992. Lycopene concentration of tomato fruit can be estimated from chromaticity values. HortScience 27(5):465-466
5. Drogoudi P.D., Vemmos S., Pantelids G., Petri E., Tzoutzoukou C., Karayianis I. 2008. Physical characters and antioxidant, sugar and mineral nutrient contents in fruit from 29 apricot (*Prunus armeniaca* L.) cultivars and hybrids. J. Agric. Food Chem. 56:10754-10760
6. Garcia J.M., Youshi K. 2005. Nondestructive and objective methods for the evaluation of maturation level of olive fruit. Eur. Food Res. Technol. 221:538-541
7. Golias J., Novak J. 1985. Determination of ethylene by gas chromatographic enrichment technique with a flame ionization detector. J. Chromatogr. 346:43-52
8. Jimenez-Cuesta M., Cuquerella J., Martinez-Javega J.M. 1981. Determination of color index for citrus fruit degreening. Proc Int. Soc. Citriculture 2:750-753
9. Lopez Camelo A.F., Gomez P.A. 2004. Comparison of color indexes for tomato ripening. Hort. Bras. 22(3):534-537
10. Olmo M., Nadas A., Garcia J.M. 2000. Nondestructive methods to evaluate maturity level of oranges. J. Food Sci. 65(2):365-369
11. Petrisor C., Radu G.L., Balan V. 2009. An optical reflectance nondestructive method for studying apricot fruit color. Rev. Chimie 60(8):770-773
12. Petrisor C., Bălan V., Bărbulescu A. 2007. Physical and chemical attributes of extra-early ripening apricots. Acta Hort. 760:491-495
13. Petrisor C., Balan V., Tudor V. 2006. Evolution of colour during maturation of different Romanian apricot cultivars. Acta Hort. 717:369-372
14. Rodriguez-Amaya D.B. 2001. A guide to carotenoid analysis in food. ILSI Press Washington, 45
15. Ruiz D., Egea J., Tomas-Barberan F.A., Gil M.I. 2005. Carotenoids from new apricot (*Prunus armeniaca* L.) varieties and their relationship with flesh and skin color. J. Agric. Food Chem. 53(16):6368-6374
16. Ruiz D., Reich M., Bureau S., Renard C.M.G.C., Audergon J.M. 2008. Application of reflectance colorimeter measurements and infrared methods to rapid and nondestructive evaluation of carotenoids content in apricot (*Prunus armeniaca* L.). J. Agric. Food Chem. 56:4946-4922
17. Sass-Kiss A., Kiss J., Milotay P., Kerek M.M., Markus M.T. 2005. Differences in anthocyanin and carotenoid content of fruits and vegetables. Food Res. Int. 38:1023-1029.