COLOR MEASUREMENT OF GRAPEVINE (*VITIS VINIFERA L.*) ACCESSIONS INFLUENCED BY THE LENGTH OF COLD STORAGE

Grapevine berry color measurement

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Abstract

Color is one of the most important phenotypic characters of the table grape cultivars, which has high importance in the consumer's preference. This morphological trait is variable and not consistently uniform within a cultivar or even a bunch. Between harvest and consumption fruits are stored for several weeks which time is influencing the color of the berry. In this study 10 grapevine accessions ('Agaphante', 'KM98', 'Korai piros veltelini', 'Korona', 'Pinot gris', 'Pozsonyi', 'Ros de Minis', 'Tramini piros', 'T9', 'Zenit') were collected from the germplasm collection of the Research Institute for Viticulture and Oenology of the National Agricultural Research and Innovation Centre of Kecskemét. The samples were investigated by ColorLite Sph 850 spectrophotometer. The color of 30 berries per accessions were measured in 3 replicates per berry. The aim of this study was to evaluate the color uniformity and the effect of cold storage. L*, a*, b* values of each accessions were evaluated after the sampling and until a visible reduction in the quality of the grapes, at most 4 weeks with 1-week intervals from the harvest. Results showed that there is a significant difference among the cultivars in the L*, a*, b* values. The length of cold storage also has a significant effect on the color of the accessions as the values are changing in some cases of the 1-week storage period.

Keywords: *Vitis vinifera* L., berry, color, L*a*b*

Introduction

The consumers' preference is depending on the appearance not only in case of table grape varieties but many horticultural crops. Numerous researches are dealing with this question. Although, the color of crops is a subjective factor, yet for the consumers this factor stands almost always on the first place of the many characteristics determining the appearance of the fruits and vegetables (LÓPEZ CAMELO AND GÓMEZ, 2004). JEMISON (2008) alludes the skin color of potato tubers as the most important feature in the aspect of consumers' preference. For example, in Kenya the white colored sweet corn is more favoured than the higher carotenoid containing yellow sweet corn (DE GROOTE AND KIMENJU, 2008). In case of bell peppers the green variants are the most marketable, while the red, yellow and orange cultivars take a minor part of the market (FRANK, 2001). According to the research by LOPEZ CAMELO AND GÓMEZ (2004) the most determinative characteristic of tomato cultivars is the color. CLIFF ET AL (2002) found that the apples with red skin color are the most merchantable, while the green ones are less pleasing for the consumers. The color has so high influence that in many cases green apples with better content values are less preferred (HAMADZIRIPI, ET AL2014). In case of cherry cultivars, it can be said that the darker the skin color is, the higher the number of the consumers (CRISOSTO AND CRISOSTO, 2003). The color has also an accentuated place of the quality influencing factors of date cultivars (ISMAIL ET AL, 2001) and the consumers' choice about the edible flowers (KELLEY ET AL, 2001).

Table grape cultivars possess many special features of quality. These refer mainly to the appearance of the fruit: attractiveness of the berries and the bunches, berry shape, and bunch compactness are the most important. Uniform color of the berry or berries within the bunches is also not negligible characteristic (BÉNYEI and LŐRINCZ, 2005). In the regard of color table and wine grape cultivars are usually divided into 3 groups: white, red, and blue. There are, nevertheless, a large number of shades materializing, for instance the green, greenish-yellow, yellowish-green, light yellow, even the amber berries are listed as white colored cultivars. All shades of red, including the bluish-red are listed into the red colored cultivars. Blue colored cultivars could be light reddish-blue, dark blue and black, as well (KOZMA, 1968). For the red color anthocyanins are responsible mainly (LIAO et al, 1992; MAZZA ET AL, 1995). Among anthocyanins there are other coloring matters in grapevine such as β-carotene, different xanthophylls and chlorophyll- derived compounds which affect not only the color of the wine but wine flavour, as well (MENDES-PINTO et al, 2005). The appearance of the berries is also influenced by the thickness of the wax layer (CSEPREGI and ZILAI, 1955). In the consumers' aspect the uniform berry color is highly important. For example, greenish spots make an unripened feeling, furthermore the fully ripened green berries are unliked, also. The russeting

– which is a typical attribute of the white grapevine cultivars – could have a negative effect too on the estimation of the yield (KOZMA, 1968).

Nowadays the descriptor list of the International Organisation of Wine and Vine (OIV, 2009) is used for the description of the grapevine accessions, in which 6 colors refers to the berry (OIV 225), which are the *greenish-yellow* (Chasselas B), the *rosé* (Chasselas Rosé Rs), the *red* (Chasselas Rouge Rg), the *grey* (Pinot gris), the *dark purplish-red* (Cardinal Rg) and the *bluish-black* (Pinot N). After all, numerous shades of the given colors could appear, therefore the development of a quantitative standard could be an important step for the market, because of the fact that the berry skin color primarily affects the consumers' choice (CLIFF et al., 1996; ZEPPA et al., 1999; ROLLE et al., 2011).

There are numerous dimensions measuring color, for example XYZ, Yxy, CMY, CIE L*a*b*, CIE L*u*v*. L*a*b* (lightness, red/green and yellow/blue chromaticity coordinate) can be measured by different spectrophotometers, such as the ColorLite sph850 spectrophotometer (ColorLite GmbH, Katlenburg-Lindau, Germany), which measures the color of solid material based on reflection, while the color of liquids based on transmission. This device was applied in many studies to evaluate color of agricultural products, such as pepper (BARANYAI et al., 2011), citrus (GOULAS and MANGANARIS, 2012), orange (GARNACHO et al., 2012) and apricot (FIRTHA et al., 2010).

Grapevine as most of the fruits and vegetables is usually stored from the harvest until selling, most of the cases the transport takes longer time. In addition consumers store them further until consumption. Consequently, the effect of storage is a significant factor. According to CHIRONI ET AL. (2017) long-term cold storage has an effect on the different attributes of table grapes such as general appearance, color, turgidity, consistency, crispness and so on and so forth.

The aim of this experiment was to evaluate the color of different grapevine accessions (table and wine grapes) influenced by the length of cold storage.

Materials and Methods

Berry samples were collected in the Research Institute for Viticulture and Oenology of the National Agricultural Research and Innovation Centre (Kecskemét, Hungary). Grapevine accessions 'Agaphante', 'KM98', 'Roter Velteliner', 'Korona', 'Pinot gris', 'Pozsonyi', 'Ros de Minis', 'Traminer', 'T9', 'Zenit' were investigated. Bunches were harvested in 2019 in full ripeness. Thirty berries of each accessions were collected from several bunches and stored in plastic boxes until the color measurements. Measurements were carried out 4 times with 1-week intervals. Between the measurements the samples were stored on +6.0 ±0.3°C degrees in

28.2±0.7% RH refrigerator, the conditions were verified by a DataLogger. Color of the berries were measured by a ColorLite sph850 spectrophotometer. The spectrophotometer was calibrated by two ethalons, a BAM white ceramic ethalon and a white acril ethalon. Three replicates were carried out of each berry in every week to minimize noise. The final L*a*b* values were the average of the three repetitions per berry. The effect of the storage on the color was also investigated based on the color index calculated of the L*a*b* values (100×a*/L*×B*) (GOULAS and MANGANARIS, 2012). Furthermore, the changes of the L*a*b* values were investigated by analysis of variance (ANOVA), Dunn's post hoc test, which were carried out in the PAST 3.12 (HAMMER et al., 2001).

Results

Analysis of the L*a*b* values individually and color index (100×a*/L*×B*) was investigated. Results showed that L* is the most sensitive to the length of the cold storage. The value of all accessions was significantly changed. In some cases, ('KM98') the value was decrease only after the 3rd week of storage, in other cases ('Pinot gris') the change was started after the 1st week of storage. The values of a* were the less variable among the tree color components. For example, in the case of 'Pinot gris', 'Ros de Minis', 'Pozsonyi', Korai piros veltelini' and 'Traminer' the values were not changing. High variability was observed in the values of b*, where the change was significant except 'KM98' and 'Korona'. Significant difference of all the 3 values was observed in the case of 'T9', 'Zenit' and 'Agaphante'. Results showed that in case of 'KM98', 'Ros de Minis', 'Zenit', 'Pozsonyi','Korai piros veltelini', 'Agaphante' and 'Traminer' the cold storage had no effect on the color index. This value (100×a*/L*×B*) was significantly changed only in some cases ('Pinor gris', 'T9', 'Korona') caused by the length of the storage. The accession 'T9' showed the highest sensitivity among all and all values were significantly changed during the storage (Table).

Table: Significant differences of the different indeces based on the analysis of variance

Cultivar	Week after harvest	L*	a*	b*	ci
KM98	1	25,59 ± 0[b]	3,16 ± 1,13[a]	0,18 ± 1,14	-52,38 ± 263,75
	2	25,39 ± 1,9[b]	4,07 ± 1,13[b]	-0,18 ± 1,3	-11,09 ± 58,51
	3	26,06 ± 1,34[b]	3,43 ± 1,2[a]	0,07 ± 1,36	4,23 ± 35,54
	4	23,45 ± 1,92[a]	3,55 ± 1,05[ab]	0,15 ± 1,46	7,15 ± 86,91
Pinot gris	1	19,76 ± 3,69[c]	2,3 ± 0,91	-1,18 ± 0,97[a]	-20,23 ± 74,94[a]
	2	15,08 ± 2,19[a]	2,54 ± 1,29	0,36 ± 0,94[b]	11,27 ± 150,13[b]
	3	15,3 ± 2,01[a]	2,79 ± 1,33	1,23 ± 0,94[c]	17,82 ± 12,54[b]

	4	16,84 ± 1,98[b]	2,32 ± 1,08	0,66 ± 0,84[bc]	58,33 ± 338,91[b]
Ros de Minis	1	26,18 ± 2,4[c]	1,66 ± 1,33	3,3 ± 1,98[a]	1,13 ± 19,01
	2	22,93 ± 2,15[a]	2,09 ± 1,53	4,23 ± 1,69[a]	3,06 ± 2,8
	3	24,09 ± 2,09[b]	1,91 ± 0,99	5,38 ± 1,46[b]	1,72 ± 1,23
T9	1	21,32 ± 2,64[c]	-0,14 ± 0,4[a]	-3,65 ± 0,91[a]	0,13 ± 0,71[a]
	2	19,56 ± 2,47[b]	-0,76 ± 3,42[a]	-2,65 ± 1,06[b]	2,33 ± 10,75[a]
	3	16,92 ± 2,12[a]	-0,03 ± 0,21[b]	-2,84 ± 1,08[b]	0,1 ± 0,57[a]
	4	20,64 ± 1,22[c]	-0,36 ± 0,22[c]	-1,85 ± 1,09[c]	2,13 ± 3,71[b]
Zenit	1	24,05 ± 1,63[c]	0,58 ± 0,79[a]	6,5 ± 1,4[a]	0,35 ± 0,52
	2	21,38 ± 1,11[a]	0,73 ± 0,74[ab]	8,49 ± 1,43[b]	0,38 ± 0,42
	3	22,65 ± 1,88[b]	1,11 ± 0,9[a]	8,48 ± 1,36[b]	0,56 ± 0,45
Pozsonyi	1	23,96 ± 2,11[b]	2,66 ± 1,58	2,07 ± 1,84[a]	-3,95 ± 59,4
	2	22,19 ± 1,73[a]	3,21 ± 1,32	1,88 ± 1,93[ab]	10,28 ± 49,48
	3	21,41 ± 2,38[a]	3,31 ± 1,38	2,84 ± 2[bc]	4,57 ± 19,15
	4	21,38 ± 1,91[a]	2,68 ± 1,46	3,32 ± 2,43[c]	5,74 ± 7,9
K.p. veltelini	1	23,07 ± 2,62[b]	1,24 ± 0,98	5,06 ± 2,28[a]	1,06 ± 0,69
	2	21,85 ± 2,7[ab]	1,02 ± 0,76	5,17 ± 1,64[a]	0,96 ± 0,71
	3	21,02 ± 1,51[a]	1,28 ± 0,98	6,55 ± 1,63[b]	0,98 ± 0,77
Agaphante	1	22,22 ± 2,05[c]	4,85 ± 0,89[b]	-1,45 ± 1,37[a]	-22,23 ± 78,15
	2	20,5 ± 2,5[b]	4,16 ± 1[a]	-0,86 ± 1,47[ab]	22,99 ± 252,28
	3	20,99 ± 2,27[bc]	3,97 ± 0,93[a]	-0,51 ± 1,01[b]	19,79 ± 547,58
	4	19,9 ± 2,1[a]	4,14 ± 0,89[a]	-0,29 ± 0,84[b]	-2,24 ± 74,69
Korona	1	25,62 ± 1,53[b]	-0,03 ± 0,81[a]	8,98 ± 1,75	-0,04 ± 0,35[a]
	2	24,58 ± 1,77[a]	0,12 ± 0,89[a]	10,13 ± 2,14	0,03 ± 0,33[a]
	3	24,85 ± 1,75[ab]	0,91 ± 1,06[b]	9,87 ± 2,41	0,36 ± 0,4[b]
Traminer	1	22,28 ± 2,47[b]	3,4 ± 1,38	2,87 ± 1,82[a]	-0,26 ± 48,83
	2	20,71 ± 3,25[b]	3,68 ± 1,67	4,2 ± 1,95[b]	5,37 ± 3,79
	3	20,44 ± 2,28[a]	4,15 ± 1,46	5 ± 1,9[b]	4,79 ± 2,94

*Different letters within the same column mean significant differences according to Dunn's post hoc test ($p \leq 0.05$).

Discussion

The color is one of the most important characteristics of foods, especially of fruits and vegetables (BARRETT ET AL., 2010). Most of the cases long-term storage is necessary for the fruits and vegetables to get from the field to the market, even consumers store the bought crops in refrigerator for a couple of days. Several studies were born in this topic. According to OZTURK ET AL (2012) plum's color characteristics change during cold storage. The color of asparagus turns unacceptable without any special package during storage (ALBANESE ET AL., 2007). According to MA ET AL. (2016) home storage of the table is important part of the supply chain, in this way performance of the fruit during the time before consumption is necessary to be investigated. In their study CHIRONI ET AL. (2017) investigated the change of cluster color uniformity and berry color uniformity of 'Italia' and Red globe' grapevine cultivars and found that those are changing during the storage. In this study the color of 10 grapevine accessions'

berries were evaluated during long term cold-storage. Color value L* was the most variable among the 3 dimensions. All cultivars showed change in this dimension caused by the cold storage. Color value b* was changed also only in the case of a few cultivars ('KM9', 'Korona'). Color index (100a*/L*b*) introduced in GOULAS and MANGANARIS (2012) was investigated. The negative value of this variable refers to greenish, while the positive values to reddish tonalties of the samples. According the analysis of variance of the color index (100a*/L*b*) most of the accessions showed significant difference. In the case of 'T9' all variables were significantly changed during the cold storage. In most cases the values were negative during the 1st measurements ('KM98', Pinot gris', 'Pozsonyi', 'Agaphante', 'Korona' and 'Traminer') and turned to positive values during the cold storage in all cases. Condition of the accessions was also variable. In the case of 'Ros de Minis', 'K.p. veltelini', 'Korona', 'Traminer' after the third week samples lost the quality and it was not possible to repeat the measurements.

Our results showed that berry color of the grapevine is significantly change during the cold storage and this change is not uniform among the cultivars.

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