Agraarteadus
1 • XXXIV • 2023 39–43

Journal of Agricultural Science
1 • XXXIV • 2023 39–43

QUANTITY OF COLOURING SUBSTANCE IN GRAPES AND RAISINS FROM SEEDLESS HYBRID FORMS WITH COLOURED GRAPE JUICE (*Vitis vinifera* L.)

Venelin Roychev[1], Neli Keranova[2]

[1]Department of Viticulture, Faculty of Horticulture with Viticulture, Agricultural University, Plovdiv, Bulgaria
[2]Department of Mathematics and Informatics, Faculty of Economics, Agricultural University, Plovdiv, Bulgaria

Saabunud:
Received: 9.06.2022

Aktsepteeritud:
Accepted: 30.06.2023

Avaldatud veebis:
Published online: 15.08.2023

Vastutav autor:
Corresponding author: Neli Keranova

E-mail: nelikeranova@abv.bg

ORCID:
0000-0002-3938-748X (VR)
0000-0001-6050-6554 (NK)

Keywords: colouring substance, skins and grape juice, raisins, seedless colouring hybrid forms.

DOI: 10.15159/jas.23.02

ABSTRACT. A study of the amount of colouring substance in the skins and juice of grapes and raisins of seedless vine forms with coloured grape juice of six hybrid combinations was performed. It was found that most of the hybrid forms of all crosses were superior to the mother variety Alicante Bouschet in the amount of anthocyanins in the grape juice, and only a few ones have mathematically proven differences. Most of them do not differ from the parent variety in colour intensity and colour shade, as well as in the percentage of yellow, red and blue colour. The 'Alicante Bouschet' variety has a proven lower content of anthocyanins in the skins of grapes and raisins of several hybrid forms. There is a proven high or moderate positive correlation between the content of anthocyanins in the skins and the juice of the grapes and the intensity of the colour in the hybrid forms of most crosses. Approximately 47% of the increase in the intensity of the colour of the grape juice can be explained by an increase in the amount of anthocyanins, and only 27% of the reasons for the changes in the intensity of the colour of the grapes are due to factors that do not affect changes in the content of anthocyanins in them.

Introduction

The quantitative determination of the colouring substance of the different vine varieties with red skin of the grapes is important for their ampelographic characteristics and for oenological practice. It is known that their accumulation in the grapes depends on many factors – genotypic, physiological and environmental conditions. Anthocyanins are the most essential part of the colouring substance in grapes. They represent a large group of flavonoids that provide protection from solar radiation and UV radiation, have antioxidant action, protect against various pathogens, *etc.* (Fartzov *et al*., 1993; Adams, 2006; Biniari *et al*., 2020; Naiker *et al*., 2020; Yan Du *et al*., 2021).

Their location is in the vacuoles of the cells of the hypodermal layer of the skin of the grapes, but in the colouring varieties 'Alicante Bouschet', 'Gran Noir', 'Saperavi' and others – also in the cells of the juice and mesocarp of the grape. Anthocyanins are considered potential natural pigments that would replace synthetic colouring in various foods (Riberean-Gayon, 1959; Kantarev, 1973; Kennedy, 2008; Olivares *et al*., 2017; Fia *et al*., 2021). By condensation with other flavonoids and phenols, they form more complex polymers that have a strong influence on the oenological characteristics of wines (Singleton, 1988).

In wine production, these pigments are a key factor determining its colour, and are extremely important for the looks of table grapes (Ferreyra *et al*., 2020; Vergana *et al*., 2020). However, from an economic point of view, the data related to the production of seedless hybrid forms with red colour of the grape juice, suitable for fresh consumption and production of wines are particularly interesting. The aim of this study is to determine the technological and nutritional value of 'Alicante Bouschet' variety and seedless hybrid forms with coloured red juice of the grapes, by means of a comparative biometric characterization of the amount of colouring substance in their grapes. Such research into seedless hybrid forms with coloured grape juice is not found in the literature.

Materials and Methods

Characteristics of photometric analysis

The study used skins and juice from grapes and raisins of seedless hybrid forms with coloured grape juice (colouring) (F1), obtained as a result of sexual hybridization between the seed colouring vine variety – 'Alicante Bouschet' (P1) and the seedless (P2) – 'Russalka 1', 'Kondarev 6', 'Beauty Seedless', 'Kondarev 10', 'Russalka 3', 'Russalka'. The grapes from the experimental vines were harvested at technological maturity (at 21–22% sugars), for three consecutive seasons. An average sample was collected in three replicates of 100 g of berries from the grapes of 'Alicante Bouschet' and each hybrid form in the different crosses at technological maturity. All indicators in the study were determined based on the analyses of dry skins and coloured juice. Anthocyanins in the skins of grapes and raisins were determined after preliminary extraction, and in the juice – directly, by photometry at a wavelength λ = 520 nm with a photocolorimeter "Specol" (Roychev *et al*., 2020). The intensity of colouring is expressed by the optical density of the experimental samples, measured with a photocolorimeter at λ = 420 nm and λ = 520 nm. The following values are taken as peak levels for yellow colour – λ = 420 nm, for red – λ = 520 nm and for blue – λ = 620 nm.

Statistical methods

To prove the existing differences between the amounts of the individual components of the colouring substance in 'Alicante Bouschet' and the hybrid forms, single-factor analysis of variance and LSD-test at a level of statistical significance of 0.05 were applied. The correlations between the studied biochemical parameters were established by applying correlation analysis. Graphic images were constructed, visualizing the interaction between the amount of anthocyanins and the intensity of the colour of the juice and the skins. The compiled regression models present the established relations in an analytical form. The tools of MS Excel and IBM SPSS were used for the mathematical data processing.

Results and Discussion

The comparative evaluation of the content of anthocyanins in the grape juice shows that 'Alicante Bouschet' has statistically proven differences only with the hybrid form 29/27 from cross I, and 29/66 and 29/68 from cross II (Table 1).

Table 1. Comparative assessment of the colouring substance in the grape juice of 'Alicante Bouschet' and the studied seedless hybrid vine forms

Form	Anthocyanins mg dm^{-3}	Colour Intensity IC	Colour shade NO	Yellow %	Red %	Blue %
Alicante Bouschet	572.53	16.72	0.68	34.87	54.00	11.13
I – 'Alicante Bouschet' × 'Russalka 1'						
29/13	737.04 n.s.	13.88 n.s.	0.66 n.s.	35.50 n.s.	56.86 n.s.	7.64 n.s.
29/24	602.01 n.s.	14.85 n.s.	0.66 n.s.	36.22 n.s.	56.42 n.s.	10.02 n.s.
29/27	748.92 *	22.79 n.s.	0.76 n.s.	36.45 n.s.	48.58 n.s.	14.97 n.s.
29/56	541.77 n.s.	10.19 *	0.79 n.s.	38.33 n.s.	49.40 n.s.	12.27 n.s.
29/57	633.64 n.s.	15.45 *	0.89 n.s.	38.71 n.s.	44.04 n.s.	17.25 n.s.
II – 'Alicante Bouschet'× 'Kondarev 6'						
29/62	405.13 n.s.	12.63 n.s.	0.67 n.s.	35.04 n.s.	53.84 n.s.	11.12 n.s.
29/66	313.39 *	8.39 *	0.77 n.s.	36.76 n.s.	48.31 n.s.	14.94 n.s.
29/68	1058.49 *	18.62 n.s.	0.57 n.s.	32.00 n.s.	57.38 n.s.	10.62 n.s.
III – 'Alicante Bouschet'× 'Beauty Seedles'						
30/2	534.31 n.s.	12.22 n.s.	0.65 n.s.	34.82 n.s.	55.27 n.s.	9.91 n.s.
30/3	823.64 *	14.62 n.s.	0.65 n.s.	35.26 n.s.	54.92 n.s.	9.82 n.s.
30/8	595.30 n.s.	13.95 n.s.	0.70 n.s.	35.09 n.s.	51.33 n.s.	13.58 n.s.
30/9	949.08 *	19.97 n.s.	0.60 n.s.	33.05 n.s.	55.83 n.s.	11.11 n.s.
30/10	469.80 n.s.	11.51 n.s.	0.73 n.s.	36.75 n.s.	51.74 n.s.	11.50 n.s.
30/24	585.86 n.s.	14.16 n.s.	0.79 n.s.	36.63 n.s.	48.07 n.s.	15.30 n.s.
IV – 'Alicante Bouschet'× 'Kondarev 10'						
31/9	633.97 n.s.	12.27 n.s.	0.55 n.s.	30.74 n.s.	57.91 n.s.	11.35 n.s.
31/22	655.12 n.s.	14.28 n.s.	0.94 n.s.	40.75 n.s.	43.58 n.s.	15.66 n.s.
31/26	316.74 *	11.39 n.s.	0.70 n.s.	35.39 n.s.	53.64 n.s.	9.97 n.s.
31/29	388.92 *	8.38 *	0.77 n.s.	37.79 n.s.	50.95 n.s.	11.27 n.s.
31/36	581.28 n.s.	17.19 n.s.	0.74 n.s.	36.61 n.s.	49.44 *	13.95 n.s.
31/40	867.46 *	18.36 n.s.	0.43 n.s.	28.38 n.s.	66.00 n.s.	5.62 n.s.
31/41	756.31 *	15.72 n.s.	0.79 n.s.	37.83 n.s.	48.29 n.s.	13.88 n.s.
V – 'Alicante Bouschet'× 'Russalka 3'						
31/57	481.88 n.s.	12.54 n.s.	0.52 n.s.	29.44 n.s.	57.46 n.s.	13.10 n.s.
31/58	336.48 *	10.42 *	0.58 n.s.	28.68 n.s.	51.91 n.s.	19.41 n.s.
31/65	585.07 n.s.	11.96 n.s.	0.53 n.s.	29.45 n.s.	55.57 n.s.	14.98 n.s.
VI – 'Alicante Bouschet'× 'Russalka'						
32/9	631.13 n.s.	12.94 n.s.	0.63 n.s.	32.91 n.s.	53.87 n.s.	12.88 n.s.
32/11	563.20 n.s.	11.88 n.s.	0.71 n.s.	32.71 n.s.	47.14 n.s.	20.18 *

n.s. – there are no proven differences in significance level 0.05, * – significant at $p < 0.05$

In cross III – 30/3 and 30/9 stand out with higher levels of anthocyanins, which determines the presence of statistical differences between them. In IV hybrid combination 31/26 and 31/29 are distinguished by proven lower values of this indicator, compared to the parent variety, and 31/40 and 31/41 – with higher than it. Only in 31/58 in the cross V the differences between the compared values were proved, as the hybrid form has a lower content of anthocyanins in the grape juice, and in the VI cross – there are no significant differences.

Most of the hybrid forms are superior to the parent variety in absolute values of this indicator. Most of them do not differ from 'Alicante Bouschet' in the intensity of colour and colouring shade, as well as in the percentages of yellow, red and blue colour in the juice of the grapes.

According to the comparative assessment, 'Alicante Bouschet' has a proven lower content of anthocyanins in the skins of the grapes – 942.66 mg dm^{-3} from the hybrid forms 29/27 – 1513.18 mg dm^{-3} – I, 30/3 – 1372.97 mg dm^{-3} and 30/9 – 1578.48 mg dm^{-3} – III, 31/40 – 1549.66 mg dm^{-3} and 31/41 – 1498.58 mg dm^{-3}– IV (Table 2).

Table 2. Comparative assessment of the content of the colouring substance in the skins of grapes and raisins in 'Alicante Bouschet' and the studied seedless colouring hybrid vine forms

Form	Anthocyanins mg dm^{-3}	Colour Intensity IC	Colour Shade NO	Yellow %	Red %	Blue %	Raisins anthocyanins mg/g
Alicante Bouschet	942.66	6.65	0.72	35.91	50.02	14.07	34.83
I – 'Alicante Bouschet' × 'Russalka 1'							
29/13	1017.34 n.s.	5.28 n.s.	0.72 n.s.	33.87 n.s.	47.52 n.s.	18.61 n.s.	43.63 n.s.
29/24	821.14 n.s.	6.09 n.s.	0.56 *	33.36 n.s.	60.23 *	6.14 *	15.40 *
29/27	1513.18 *	7.79 n.s.	0.66 n.s.	33.37 n.s.	51.00 n.s.	15.63 n.s.	52.82 *
29/56	737.30 n.s.	3.65 n.s.	0.73 n.s.	34.11 n.s.	47.06 n.s.	18.83 n.s.	32.94 n.s.
29/57	910.52 n.s.	3.65 n.s.	0.68 n.s.	33.56 n.s.	49.35 n.s.	17.09 n.s.	30.84 n.s.
II – 'Alicante Bouschet' × 'Kondarev 6'							
29/62	1042.08 n.s.	6.42 n.s.	0.80 n.s.	37.14 n.s.	46.47 n.s.	24.20 *	33.16 n.s.
29/66	433.17 n.s.	2.39 *	0.83 *	37.43 n.s.	44.90 n.s.	17.67 n.s.	25.89 n.s.
29/68	1045.61 n.s.	6.30 n.s.	0.87 *	41.93 *	48.77 n.s.	9.30 n.s.	38.13 n.s.
III – 'Alicante Bouschet' × 'Beauty Seedless'							
30/2	995.23 n.s.	5.58 n.s.	0.75 n.s.	34.29 n.s.	45.74 n.s.	19.97 n.s.	39.28 n.s.
30/3	1372.97 *	7.03 n.s.	0.77 n.s.	35.84 n.s.	46.60 n.s.	17.57 n.s.	40.05 n.s.
30/8	1017.05 n.s.	5.70 n.s.	0.66 n.s.	32.79 n.s.	49.96 n.s.	17.24 n.s.	43.69 n.s.
30/9	1578.48 *	8.54 n.s.	0.67 n.s.	33.16 n.s.	50.03 n.s.	16.81 n.s.	43.74 n.s.
30/10	646.28 n.s.	3.76 n.s.	0.76 n.s.	35.44 n.s.	46.40 n.s.	18.16 n.s.	53.55 *
30/24	1150.43 n.s.	9.73 n.s.	0.84 *	37.22 n.s.	44.54 *	18.24 n.s.	56.75 *
IV – 'Alicante Bouschet' × 'Kondarev 10'							
31/9	801.57 n.s.	4.02 n.s.	0.73 n.s.	35.84 n.s.	49.25 n.s.	14.91 n.s.	58.84 *
31/22	1300.34 n.s.	9.07 n.s.	0.87 *	37.59 n.s.	43.32 *	19.09 n.s.	64.90 *
31/26	604.08 n.s.	5.08 n.s.	0.69 n.s.	34.32 n.s.	50.37 n.s.	15.32 n.s.	24.52 n.s.
31/29	818.53 n.s.	4.18 n.s.	0.77 n.s.	34.95 n.s.	45.11 n.s.	19.96 n.s.	42.82 n.s.
31/36	1003.23 n.s.	7.37 n.s.	0.85 *	38.67 n.s.	45.57 n.s.	15.75 n.s.	46.53 n.s.
31/40	1594.66 *	10.78 *	0.53 *	28.30 *	53.05 n.s.	18.64 n.s.	43.22 n.s.
31/41	1498.58 *	7.90 n.s.	0.69 n.s.	33.32 n.s.	48.36 n.s.	18.33 n.s.	45.65 n.s.
V – 'Alicante Bouschet' × 'Russalka 3'							
31/57	922.78 n.s.	5.17 n.s.	0.75 n.s.	34.21 n.s.	46.10 n.s.	19.69 n.s.	51.25 *
31/58	817.35 n.s.	4.35 n.s.	0.70 n.s.	34.33 n.s.	49.06 n.s.	16.61 n.s.	33.94 n.s.
31/65	1262.05 n.s.	7.40 n.s.	0.71 n.s.	35.01 n.s.	49.64 n.s.	15.35 n.s.	39.31 n.s.
VI – 'Alicante Bouschet' × 'Russalka'							
32/9	1380.21 n.s.	8.16 n.s.	0.67 n.s.	35.05 n.s.	52.84 n.s.	12.11 n.s.	55.66 *
32/11	823.29 n.s.	4.54 n.s.	0.73 n.s.	35.84 n.s.	49.89 n.s.	14.27 n.s.	23.18 n.s.

n.s. – there are no proven differences in significance level 0.05, * – significant at $p < 0.05$

Hybrid forms predominate in which there are no proven differences with the parent variety, both in terms of colour intensity and the colouring shade, as well as in the percentages of yellow, red and blue colour.

In terms of the amount of anthocyanins in raisins, 'Alicante Bouschet' – 34.83 mg g^{-1} is proven to be superior to 29/24 – 15.40 mg g^{-1} and inferior to 29/27 – 52.82 mg g^{-1} – I, 30/10 – 53.55 mg $g^{-1}$and 30/24 – 56.75 mg g^{-1}– III, 31/9 – 58.84 mg g^{-1} and 31/22 – 64.90 mg g^{-1}– IV, 31/57 – 51.25 mg g^{-1} – V, 32/9 – 55.66 mg g^{-1} – VI. In the other hybrid forms the colouring substance is close to that of the parent variety.

There is a significant positive relation (0.655) between the content of anthocyanins in the juice of the grapes and the intensity of the colour in the hybrid forms from the cross 'Alicante Bouschet' × 'Russalka 1' as well as negative one- with the percentage of red colour (–0.345), and in 'Alicante Bouschet' × 'Kondarev 6' there is a strong, positive correlation between anthocyanins in the juice and the colour intensity (0.735) and a weak positive correlation – with the red colour (0.338).

The forms of the hybrid combination 'Alicante Bouschet' × 'Beauty Seedless' are also characterized by a high positive correlation between anthocyanins in the juice and colour intensity (0.882), and in 'Alicante

Bouschet' × 'Kondarev 10' and 'Alicante Bouschet' × 'Russalka 3' it is proven to be moderately positive (0.671 and 0.527). There is a moderate negative relation between the amount of anthocyanins in the juice and the blue colour in 'Alicante Bouschet' × 'Russalka 3' (–0.462) and 'Alicante Bouschet' × 'Russalka' (–0.446).

The content of anthocyanins in the skins of the grapes is in a very strong, positive relation with the colour intensity in all hybrid combinations: 'Alicante Bouschet' × 'Russalka 1' (0.836), 'Alicante Bouschet' × 'Kondarev 6' (0.998), 'Alicante Bouschet' × 'Beauty Seedless' (0.798), 'Alicante Bouschet' × 'Kondarev 10' (0.860), 'Alicante Bouschet' × 'Russalka 3' (0.987) and 'Alicante Bouschet' × 'Russalka' (0.995). There is a proven moderate positive relation in the red colour of the skins in 'Alicante Bouschet' × 'Kondarev' (0.571), 'Alicante Bouschet' × 'Russalka 3' (0.693) and 'Alicante Bouschet' × 'Russalka' (0.535). The correlation with the blue colour in 'Alicante Bouschet' × 'Russalka 3' (–0.446) and Alicante Bouschet × Russalka (–0.718) is negative.

Figure 1 shows the influence of anthocyanins on the colour intensity of the grape juice in all studied hybrid forms with the parent variety 'Alicante Bouschet'.

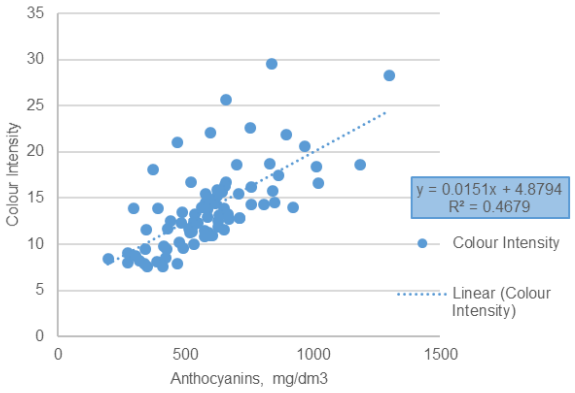

Figure 1. Influence of the content of anthocyanins in the juice of the grapes on the colour intensity in all studied seedless hybrid forms

Both in the individual crosses and in the group analysis of the hybrid forms of all combinations, the intensity of the juice colour tends to increase in parallel with the increase in the amount of anthocyanins in it.

This is proved not only by the slope of the trend line, but also by the positive coefficient in front of the independent variable in the presented regression equation. Given the value of the coefficient of determination, it should be assumed that 47% of the change in the intensity of the colour of the grape juice can be explained by changes in the content of anthocyanins in it.

The relation between the content of anthocyanins in the skins of the grapes and the intensity of the colour in all studied hybrid forms was modelled by a linear regression equation (Figure 2). The coefficients prove the positive relation between these two indicators, which determines the beneficial effect of the high content of anthocyanins in the skins on the intensity of their colour. According to the calculated coefficient of determination, less than 27% of the dispersion of the intensity of the colour of the skins is explained by factors other than the anthocyanins in them.

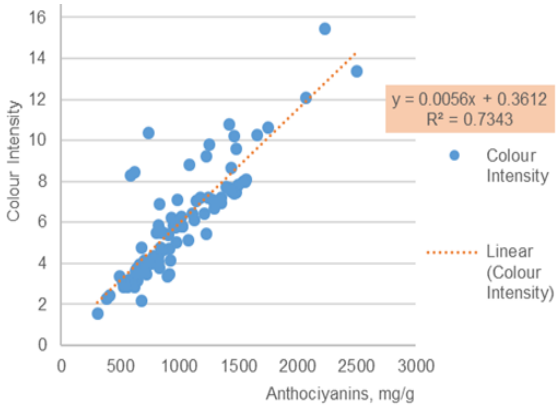

Figure 2. Influence of the content of anthocyanins in the skins of the grapes on the colour intensity in all studied seedless hybrid forms

Conclusions

The majority of the studied seedless colouring hybrid forms of all crosses are superior to the mother variety 'Alicante Bouschet' in the amount of anthocyanins in the juice of the grapes, and only a few differences are mathematically proven. Most of them do not differ from the parent variety in colour intensity and colour shade, as well as in the percentage of yellow, red and blue colour. The 'Alicante Bouschet' variety has a proven lower content of anthocyanins in the skins of the grapes than the hybrid forms 29/27, 30/3, 30/9, 31/40 and 31/41. Hybrid forms predominate in which there are no proven differences with the mother variety, both in terms of colour intensity and colour shade, and in the percentages of yellow, red and blue colour. The amount of anthocyanins in raisins is higher than 'Alicante Bouschet' in 29/27, 30/10, 30/24, 31/9, 31/22, 31/57 and 32/9. In the other hybrid forms the colouring substance is close to that of the mother parent variety. There is a proven high or moderate positive correlation between the content of anthocyanins in the juice of the grapes and the intensity of the colour in the hybrid forms of most crosses, and in some of them - negative or slightly positive between the anthocyanins and the red colour, and moderately negative with the blue colour. The amount of anthocyanins in the skins of the grapes is in a very strong, positive relation with the intensity of the colour in the seedless colouring forms of all hybrid combinations. Approximately 47% of the increase in the intensity of the colour of the grape juice in hybrid forms can be explained by an increase in the amount of anthocyanins. Only 27% of the reasons for the changes in the colour intensity in the skins of the grapes are due to factors which have no influence over the content of anthocyanins in them.

Conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

Authors contributions

Authors contributed equally to the manuscript.

References

Adams, D. 2006. Phenolics and ripening in grape berries. – American Journal of Enology and Viticulture, 57(3):249–256.

Biniari, K., Xenaki M., Daskalakis, I., Rusjan, D., Bouza, D., Stavrakaki, M. 2020. Polyphenolic compounds and antioxidants of skin and berry grapes of Greek *Vitis vinifera* cultivars in relation to climate conditions. – Food Chemistry, 30(1):125518. DOI: 10.1016/j.foodchem.2019.125518

Fartzov, K., Hadjuyski, L., Aljakov, M. 1993. Counter-radiation efficacy of Enoviton Granules produced from Cabernet sauvignon wine. – Journal of Wine Research, 4:119–124.

Ferreyra, S., Antoniolli, A., Bottini, R., Fontana, A. 2020. Bioactive compounds and total antioxidant capacity of cane residues from different grape varieties. – Journal of the Science of Food and Agriculture, 100 (1):376–383.

Fia, G., Bucalossi, G., Proserpio, C., Vincenzi S. 2021. Unripe grapes: an overview of the composition, traditional and innovative applications, and extraction methods of a promising waste of viticulture. – Australian Journal of Grape and Wine Research, 28:8–26. DOI: 1111/ajgw.12522

Kantarev, I. 1973. Research on some phenolic compounds (anthocyanins and tannins) in some dye varieties of vines and wines obtained from them. – Dissertation. Plovdiv, 191 p.

Kennedy, J. 2008. Grape and wine phenolics: Observations and recent finding. – Ciencia e Investigacion Agraria, 35(2): 107–120. DOI: 10.4067/S0718-16202008000200001

Naiker, M., Anderson, S., Johnson, J.B., Mani, J.S., Wakeling, L., Bowry, V. 2020. Loss of trans-resveratrol during storage and ageing of red wines. – Australian Journal of Grape and Wine Research, 26 (4):385–387. DOI: 10.1111/ajgw.12449

Olivares, D., Contreras, C., Munoz, V., Rivera, S., Gonzales-Aguero, M., Retamales, J., Defilippi, B. 2017. Relationship among colour development, anthocyanin and pigment-related gene expression in 'Crimson Seedless' grapes treated with abscisic acid and sucrose. – Plant physiology and biochemistry, 115:286–297. DOI: 10.1016/j.plaphy.2017.04.007

Riberean-Gayon P. 1959. Recherches sur les anthocyanes des vegetaux. Application au genre *Vitis*. – Thse, Dr. Sc. Plus., Paris. Rev., Gn. Bot., 66:531 – 636.

Roychev, V., Tzanova, M., Keranova, N., Peeva, P. 2020. Antioxidant content and antioxidant activity in raisins from seedless hybrid vine varieties with coloured grape juice. – Czech Journal of Food Sciences, 38 (6):410–416. DOI: 10.17221/160/2020-CJFS.

Singleton, V.L. 1988. Wine Phenols. Wine Analysis. Modern Methods of Plant Analysis book series (MOLMETHPLANT, volume 6) Berlin, pp. 173–218.

Vergana, A., Torrealba, M., Alcalde, J., Perez-Donoso, A. 2020. Commercial brassinosteroid increases the concentration of anthocyanin in red tablegrape cultivars (*Vitis vinifera* L.). – Australian Journal of grape and wine research, 26(4):427–433. DOI: 10.1111/ajgw.12457

Yan, D., Xingyan, L., Xiaolin, X., Xinyu, C., Xueyan, R., Qingjun, K. 2021. An investigation on polyphenol composition and content in skin of grape (*Vitis vinifera* L. cv. *Hutai* No.8) fruit during ripening by UHPLC-MS2 technology combined with multivariate statistical analysis. – Food Bioscience 43. DOI: 10.1016/j.fbio.2021.