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*RESEARCH ARTICLE*

# The content of monomeric anthocyanin in grape berries cultivated in the forest-steppe zone of the Altai territory

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Antocyanins are the most significant group of connections possessing a wide range of pharmaceutical activity among all biologically active agents. The results of the chemical analysis of grape berries cultivated in the forest-steppe zone of the Altai territory are given in the article. Three grades with the high content of anthocyanins (Zilga, Adehl, Hasanskij Bousa) are revealed. The carried-out correlation analysis has revealed interrelation between chemical indicators of berries and meteorological factors. The strong and average correlation between anthocyanins and the content of SS, sugars, titrable acids and AA is common for the grape types, which are characterized by black color, rounded shape and thin skin of berries.
The correlation analysis of meteorological indicators and the main biochemical factors (SS, sugar, titrable acidity, AA) allows to reveal the strong dependence of the majority of grape types on GTK and smaller dependence – on SAT.
**Keywords**: monomeric anthocyanin; grape berries; forest-steppe; Altai

## Introduction

Now around 80 % of all world medicines is received from vegetable raw materials, mainly fruits and berries (*Vaccinium, Cerasus, Solanum*, etc.) (Pirniyazov et al., 2003; Bowen-Forbes et al., 2010). The idea of creating phytomedicines attracts such countries as the USA, India, China and Russia (Taranova, 2011).

One of the sources of receiving biologically active agents, which cause therapeutic efficiency of medical medicines, is representatives of the type *Vitis* (Pirniyazov et al., 2003; Taranova, 2011; Muhametova et al., 2017). Grape is a valuable vegetable raw material which is used to extract from its berries the maximum of the polyphenols (especially anthocyanins) which have a lot of pharmacological anthocyanins such as the ability to increase elasticity of blood vessels, to improve visual acuity and have bactericidal effect (Coman et al., 2018; Wu et al., 2006). The high antioxidant activity of anthocyanins of grapes is very important for cancer therapy, atherosclerosis and other widespread serious illnesses (Yefremov, 2014; Ramalho et al., 2018).

Anthocyanins are the main painting pigments of plants, which give plants various colors – from yellow to amber. Saturation of color and the content of these pigments in grape depend on a grade and soil climatic conditions of its cultivation (Rustionl et al., 2015; Avidzba et al., 2015). Therefore the study of the content of anthocyanins in grape berries cultivated in the unstudied territories (Siberia, Yakutia, Far East) is an important and relevant task (Dmitruk et al., 2005).

Besides, accumulation of these pigments in berries *Vitis* allow to define direct and indirect correlations between different factors. This sort of information is of great interest for many researchers as it allows to optimize selection works on creating new types of fruits and berries (Dobrucka, Pivovarov, 2000).

Thus the purpose of our research was to study the content of monomeric anthocyanins in grape cultivated in the forest-steppe zone of the Altai territory and also to define correlations between different factors.

## Materials and methods

The material for our research is berries of 11 introduced types and hybrids of grapes from the Research Institute of Horticulture in Siberia collection. The key type is a zoned type Katyr. Samples of grapes were collected in the I-II decade of September (2014–2016, 2018) when grape is ripening.

The content of the soluble solids (SS) and titrable acids was determined by the standard technique (Arasimovich et al., 1972), sugars – in accordance with GOST 13192–73 (2011), ascorbic acid (AA, or vitamin C) – in accordance with GOST 24556–89 (2003).

The quantitative indices of monomeric anthocyanins in berries were defined according to GOST 53773 (2010) with use of the dual-beam SHIMADZUUV-1800 spectrophotometer with lengths of the waves equal to 510 nanometers and 700 nanometers. The concentration of anthocyanins was recalculated for tsianidin-3-glucoside, using value of coefficient of molar absorption, $\varepsilon$=26900 [mol • cm/dm$^3$]$^{-1}$.

Statistical data processing was carried out with the use of the Microsoft Excel 2010 program. Correlations between accidentally chosen factors were defined by a special correlation analysis (Armour, 1985).

The territory of the Altai Region is characterized by sharp and continental climate, severe winter, hot and short summer (Makarova, 2017). The degree of moisture and heat conditions of this zone was determined with the help of hydrothermal coefficient of G.T. Selyaninov (GTK) and the sum of active temperatures above 10 °C (SAT) (Losev, 1994). According to the data about weather conditions presented by the Research Institute of Horticulture in Siberia, in 2014 (GTK = 1.3, SAT = 2245 °C) and 2018 (GTK = 1.2, SAT = 2308.9 °C) there were rather humidified and warmer weather conditions. In 2016 (GTK = 1.1, SAT = 2657.8 °C) there were insufficiently humidified and hot weather; in 2015 (GTK = 0.9, SAT = 2529 °C) – poorly humidified and hot. The total amount of rainfall in May-August was 295 mm in 2014; 231.7 mm in 2015; 297.8 in 2016 and 254.1 mm in 2018.

## Results

The content of anthocyanins in grape types with black berries cultivated in the forest-steppe zone of the Altai territory in 2018 has changed from 83.49 to 208.74 mg/dm$^3$ with average variation of V=19 %. The minimum quantity of anthocyanins was observed in berries of two grades – Amurskij 35 and Agat donskoj (83.49 mg/dm$^3$) that was at the level of control value (Fig. 1). Above the average level on 50 mg/dm$^3$, and control – three grades – Zilga, Adehl (166.99 mg/dm$^3$) and Hasanskij Bousa accumulated anthocyanins (208.74 mg/dm$^3$) twice.

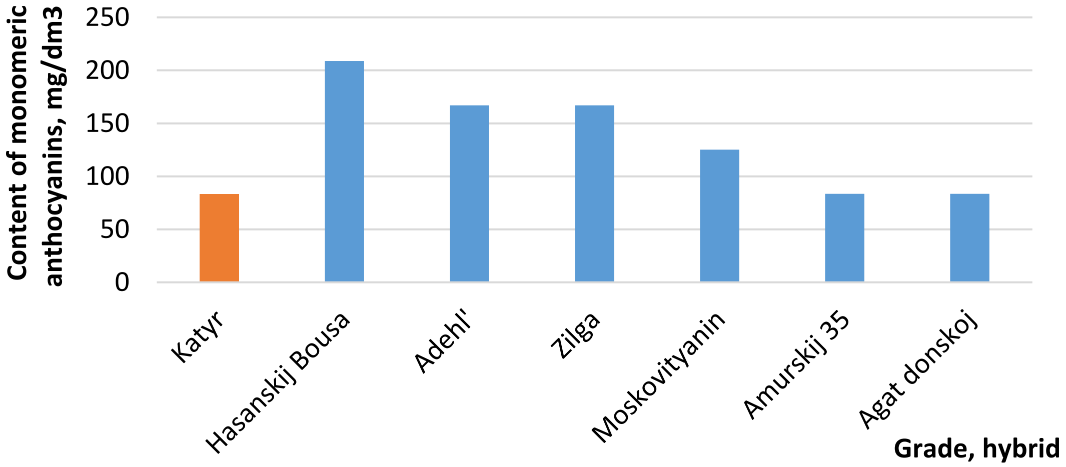


**Figure 1**. The content of monomeric anthocyanins in black berries of grapes, 2018

**Table 1**. Correlations between the content of anthocyanins and the key biochemical indicators of grape berries of various colors, form and thickness of their skin

| Indicators | Soluble solids, % | Sugar, % | Titrable acidity, % | Ascorbic acid, mg/100 g |
|---|---|---|---|---|
| | | Black berries | | |
| Anthocyanins, mg/dm$^3$ | **+0.92** | **+0.41** | **+0.71** | **+0.83** |
| | | White berries | | |
| Anthocyanins, mg/dm$^3$ | +0.03 | -0.39 | **+0.78** | **+0.84** |
| | | Pink berries | | |
| Anthocyanins, mg/dm$^3$ | -0.45 | -0.48 | -0.96 | -0.12 |
| | | Berries of an oval form | | |
| Anthocyanins, mg/dm$^3$ | **+0.57** | -0.27 | **+0.63** | **+0.75** |
| | | Berries of rounded shape | | |
| Anthocyanins s, mg/dm$^3$ | **+0.61** | **+0.46** | **+0.32** | **+0.53** |
| | | Berries with a thin skin | | |
| Anthocyanins, mg/dm$^3$ | **+0.67** | +0.29 | **+0.56** | **+0.96** |
| | | Berries with a thick thin skin | | |
| Anthocyanins, mg/dm$^3$ | **+0.63** | **+0.37** | +0.03 | **+0.43** |

The spectrophotometric data on optical density (A) of pink and white types of grape are 0.002–0.005 and 0.005–0.042, which is less than the norm (0.2–0.1). It indicates lack of these pigments in a thin skin of light grape berries that is confirmed by the research of L. Rustionl et al. (2015).

During the research, the degree of correlation between monomeric anthocyanins and the content of soluble solids, sugar, titrable acids and ascorbic acid was defined using coefficient of pair correlation (r). Grape types with black berries have strong (r >0.7) and average (r = 0.3–0.7) correlations between monomeric anthocyanins and all other studied factors (Table 1). Grape types with white berries (such as Tambovskij belyj, Kristall and Varduva) have high rates of correlations between factors «the content of anthocyanins» – «titrable acidity» (r = +0.78) and «the content of anthocyanins » – «content of AA» (r = +0.84). The group with pink berries is characterized by the absence of such correlations.

**Table 2.** Dependence of the content of the key biochemical indicators of grape berries on the sum of rainfall, SAT and GTK

| Indicators | Soluble solids, % | Sugar, % | Titrable acidity, % | Ascorbic acid, mg /100 g |
|---|---|---|---|---|
| | | "Katyr" | | |
| Sum of rainfall, mm | -0.10 | +0.32 | +0.40 | -0.23 |
| SAT* | -0.04 | +0.93 | -0.92 | -0.92 |
| GTK** | -0.15 | -0.85 | +0.92 | +0.89 |
| | | "Adehl" | | |
| Sum of rainfall, mm | -0.57 | -0.11 | -0.24 | -0.61 |
| SAT | +0.82 | +0.97 | -0.94 | -0.68 |
| GTK | -0.87 | -0.85 | +0.77 | +0.62 |
| | | "Amurskij" 35 | | |
| Sum of rainfall, mm | -0.14 | -0.91 | +0.51 | -0.25 |
| SAT | +0.68 | +0.09 | +0.68 | -0.91 |
| GTK | -0.45 | -0.14 | -0.38 | +0.88 |
| | | "Amurskij" 39 | | |
| Sum of rainfall, mm | -0.11 | -0.44 | +0.36 | -0.14 |
| SAT | +0.63 | +0.88 | -0.81 | +0.95 |
| GTK | -0.84 | -0.84 | +0.69 | +0.93 |
| | | "Varduva" | | |
| Sum of rainfall, mm | -0.58 | -0.16 | -0.06 | +0.88 |
| SAT | +0.24 | -0.001 | -0.80 | -0.62 |
| GTK | -0.1 | +0.27 | +0.56 | +0.67 |
| | | "Zilga" | | |
| Sum of rainfall, mm | +0.23 | +0.01 | -0.84 | -0.11 |
| SAT | +0.91 | +0.82 | -0.27 | -0.96 |
| GTK | -0.71 | -0.59 | +0.24 | +0.94 |
| | | "Kristall" | | |
| Sum of rainfall, mm | -0.22 | +0.50 | -0.14 | -0.86 |
| SAT | -0.05 | -0.21 | -0.19 | -0.35 |
| GTK | +0.29 | +0.54 | -0.14 | +0.28 |
| | | "Moskovityanin" | | |
| Sum of rainfall, mm | -0.13 | +0.10 | +0.32 | +0.54 |
| SAT | +0.49 | +0.67 | -0.94 | +0.73 |
| GTK | -0.74 | -0.59 | +0.24 | +0.94 |
| | | "Michurinskij rozovyj" | | |
| Sum of rainfall, mm | +0.28 | +0.13 | -0.39 | -0.56 |
| SAT | +0.82 | +0.73 | -0.78 | -0.71 |
| GTK | -0.56 | -0.46 | +0.8 | +0.67 |
| | | "Suvenir Vas'kovskogo" | | |
| Sum of rainfall, mm | -0.67 | -0.25 | +0.27 | +0.40 |
| SAT | -0.50 | +0.96 | +0.90 | -0.97 |
| GTK | +0.51 | -0.9 | -0.68 | +0.1 |
| | | "Tambovskij belyj" | | |
| Sum of rainfall, mm | -0.88 | +0.78 | -0.88 | -0.87 |
| SAT | +0.40 | -0.63 | +0.40 | +0.65 |
| GTK | -0.62 | +0.73 | -0.62 | -0.7 |
| | | "Hasanskij Bousa" | | |
| Sum of rainfall, mm | -0.27 | +0.54 | -0.59 | -0.29 |
| SAT | +0.91 | +0.52 | -0.79 | -0.89 |
| GTK | -0.81 | -0.19 | +0.67 | +0.86 |

*Note:* SAT* – sum of active temperatures, GTK** – hydrothermal coefficient

The berries of grapes of oval and rounded shape have an average degree of correlations between the content of anthocyanins in the thin skin and SS (according to r = +0.57 and r = +0.61) and titrable acids (according to r = +0.63 and r = +0.32). The coefficients of correlation are in limits 0.3–0.7 for factors «the content of anthocyanins » – «the content of sugars» (r = +0.46) in berries of rounded shape and for factors «the content of antotsians» – «content of AA» (r = +0.53) in berries of oval shape. The accumulation of monomeric anthocyanins in grape types with thin and a thick skin depends at an average on the content of SS, sugar, acids and vitamin C. High coefficients of correlation (r = +0.96) are noted between such factors as «the content of anthocyanins » – «content of AA» in berries with thin skin. Some scientists (Begalieva et al., 2015) said that grape berries with high sugar content contain more phenolic connections including anthocyanins. Our data shows that the content of anthocyanins correlates more with SS, titrated acids and vitamin C; and less – with sugar. The results of the level of influence of such meteorological indicators as the GTK, SAT and the sum of rainfall, on biochemical structure of grapes are presented in table 2.

Z.K. Begalieva, O.K. Vlasova, S.A. Magadova (2015) say that high heat conditions and smaller amount of precipitation cause accumulation of phenolic connections in grapes. The correlation analysis has revealed strong influence of GTK on the contentsin of titrable acids in 25 % of all grape types (r = +0.77...+0.92), sugar – in 33 % (r =-0.84...-0.9), SS – in 42 % (r =-0.71...-0.87) and AA – in 50 % (r = +0.86...+0.94). 21 % of genotypes have an average negative correlation between GTK and all other studied factors. 25 % have an average positive correlation. 17 % of genotypes do not have close correlations between the main biochemical indicators of grape berries and GTK. SAT above 10 °C has a considerable impact on biochemical structure of grape berries. 48 % of all grape types have a correlation coefficient higher than 0.7 (according to r = +0.73... +0.97, r = -0.71...-0.96 and r = -0.78...-0.94) between SAT and the content of sugar, AA and titrable acids. 4 grape types Hasanskij Bousa (r = +0.91), Adehl (r = +0.82), Zilga (r = +0.94) and Michurinskij rozovyj (r = +0.82) are characterized by the accumulation of SS in berries simultaneously with the increase of heat. 25 % of all grape types were under the influence of active temperatures of average force on all biochemical indicators. 13 % of all types do not have such influence. Unlike GTK and SAT, the correlation coefficient between the sum of rainfall and the key biochemical indicators of berries was low: only 8 % of genotypes have r >0.7, 21 % – r = 0.3–0.7 and 23 % – r<0.3. The total number of rainfall during the period from May to August for four years of research work did not influence on biochemical structure of 21 % of all grape types.

## Conclusions

The high content of anthocyanins in 3 grape types cultivated in the forest-steppe zone of the Altai territory has been found out. In group with black coloring of berries The maximum content of anthocyanins is among such grape types with black berries as Zilga, Adehl (166.99 mg/dm$^3$), Hasanskij Bousa (208.74 mg/dm$^3$). Such types as Moskovityanin, Amurskij 35 and Agat donskoj are below average level (131 mg/dm$^3$).

It was not revealed that berries with pink (Michurinskij rozovyj, Suvenir Vas'kovskogo, Amurskij 39) and white (Tambovskij belyj, Kristall, Varduva) thin skin do not have anthocyanins.

The strong and average correlation between anthocyanins and the content of SS, sugars, titrable acids and AA is common for the grape types, which are characterized by black color, rounded shape and thin skin of berries.

The correlation analysis of meteorological indicators and the main biochemical factors (SS, sugar, titrable acidity, AA) allows to reveal the strong dependence of the majority of grape types on GTK and smaller dependence – on SAT.

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