

Impact of Weather Conditions on the Variability of the Biochemical Composition of Fruit of *Oxycoccus Macrocarpus* Ait.Pers. Introduced In Belarus

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Abstract: The article presents the results of a two-year comparative study of the biochemical composition of fruit of six *Oxycoccus macrocarpus* cultivars newly introduced in Belarus — ‘Stevens’, ‘Bain Favorit’, ‘Hiliston’, ‘Holistar Red’, ‘Stankovich’, and ‘WSU 108’ — based upon 14 indicators in seasons that are contrasted in terms of the moisture regime. It is established that the favorable combination of weather conditions in 2016 contributed to the increasingly active accumulation of free organic, ascorbic and hydroxycinnamic acids, soluble sugars, true anthocyanins, catechins, and flavonols in fruit, by 8-62 %, compared with the rainless season of 2015. Furthermore, the sugar-acid index went up by 15 %, which indicates an improvement in the organoleptic properties of fruit, amid a reduction, by 9-33 %, of the content of leucoanthocyanins, dry and pectic substances, and tannins. Based upon the findings of the comparative analysis of the variability levels of the biochemical composition of cranberry fruit during the two-year observation cycle, it is established that the accumulation of dry substances, ascorbic and hydroxycinnamic acids, as well as the total amount of anthocyanin pigments and bioflavonoids was characterized by the least marked interseasonal differences; whereas the most conspicuous differences were reported for the sugar-acid index and content of soluble sugars, pectic substances, leucoanthocyanins, and flavonols. Within the taxonomic range of large cranberry, ‘Stankovich’ showed most resistance of its biochemical composition to overall weather factors; while ‘Bain Favorit’ and especially ‘Hiliston’ were characterized by least resistance.

Keywords: *Oxycoccus macrocarpus*, large cranberry, fruit, biochemical composition, organic acids, carbohydrates, bioflavonoids, variability, interseasonal differences.

Date of Submission: 07-07-2017

Date of acceptance: 22-07-2017

I. Introduction

A critical aspect of introduction research associated with the study of *Oxycoccus macrocarpus* cultivars is the comparative evaluation of the biochemical composition of fruit within a multi-year observation cycle that gives a clear picture of not only its genotypic peculiarities, but also the degree of dependence of the content of active substances on a season’s hydrothermal regime, which to a great extent determines their organoleptic properties. The consideration of this aspect of the response reaction of large cranberry to the integrated effect of meteorological factors is deemed highly relevant, because, as our studies show, the extremely unstable weather conditions during the vegetation and fruit ripening period typical of Belarus’s region produces a marked impact on the rate of accumulation of compounds and therefore seriously adjusts the nutritive and vitamin value of products [1]. The analysis of this issue allows identifying the cranberry cultivars that have most potential in terms of not only the taste properties of their fruit, preconditioned by the peculiarities of their biochemical composition, but also the degree of resistance of its separate components to the integrated effect of meteorological factors in the introduction area.

II. Materials And Methods

Six cultivars of *Oxycoccus macrocarpus* had been selected as objects of the study: ‘Stevens’(st), ‘Bain Favorit’, ‘Hiliston’, ‘Holistar Red’, ‘Stankovich’, and ‘WSU 108’. Research was carried out in 2015 and 2016 at the Experimental Station of the Central Botanical Garden of the National Academy of Sciences of Belarus located in the Gantsevichy District of the Brest Region (N 52° 74', E 26° 38'), in the central agro-climatic region of the country with peat ameliorated soil developed on cotton grass sphagnum peat of high peatbogs, with hemic peat, pH_{H2O} equals 4.0. The years of the study were characterized by pronounced contrasting weather conditions of the vegetation period — season 2015 was mostly characterized by moderate temperatures with a substantial shortage of moisture, whereas season 2016 was notable for its hotter weather with moderate and sometimes excessive precipitation. The comparative evaluation of the biochemical composition of fruit was conducted based upon a broad range of indicators with the use of routine methods for the acquisition of analytical information [2-8]. All of the determinations were made with a three-time biological repeatability. The data were statistically processed with 95 % confidence interval.

III. Results And Discussion

The differences of weather conditions of the period of ripening and formation of the biochemical composition of fruit of the *Oxycoccus macrocarpus* cultivars under analysis in 2015 and 2016 had a marked impact on the rate of accumulation of certain compounds. This can be vividly illustrated by the averaged quantitative characteristics of their biochemical composition during the years of observation (Table 1) for the entire range of cultivars, which integrate the genotypic component. Apparent are the marked interseasonal differences of the indicators, caused by the influence of the hydrothermal regime of the vegetation period on the content of certain compounds in fruit. The more favorable combination of weather conditions in the second season contributed to the more active accumulation of free organic, ascorbic and hydroxycinnamic acids, soluble sugars, true anthocyanins, catechins, and flavonols in fruit, by 8-62 %, compared with the previous rainless season, and increase in the sugar-acid index by 15 %, which indicates an improvement in the organoleptic properties of fruit. At the same time, positive changes in the biochemical composition of cranberry fruit was accompanied by the reduction, by 9-33 %, of the content of dry and pectic substances, and tannins, as well as leucoanthocyanins. Furthermore, the said shifts in the composition of P-vitamin content of cranberry fruit during the second year of observation did not have a reliable effect on the total amount of bioflavonoids.

Table 1

Averaged parameters of accumulation of active substances in dry matter of fruit during observation years, within the taxonomic range of the introduced *Oxycoccus macrocarpus* cultivars

Indicator	2015	2016	Interseasonal differences, % (2016/2015)
Drymatter, %	13.5	13.0	-
Freeorganicacids, %	22.8	24.6	+7.9
Ascorbicacid, mg%	438.6	488.7	+11.4
Hydroxycinnamicacids, mg%	621.9	683.7	+9.9
Solublesugars, %	28.7	37.4	+30.3
Sugar-acidindex	1.3	1.5	+15.4
Pecticsubstances, %	7.9	5.3	-32.9
Trueanthocyanins, mg%	2013.5	2520.0	+25.2
Leucoanthocyanins, mg%	5190.7	4069.9	-21.6
Total of anthocyanin pigments, mg%	7204.2	6589.9	-8.5
Catechins, mg%	1473.7	1740.4	+18.1
Flavonols, mg%	927.2	1501.6	+62.0
Toyal of bioflavonoids, mg%	9605.1	9831.9	-
Tannins, %	3.04	2.56	-15.8

Note: A dash (-) means that no Student's t-test statistically significant differences are observed at p <0.05

To identify the degree of dependence of the analyzed indicators on the integrated effect of weather conditions during the vegetation period, a comparison was conducted, within the taxonomic range, of the levels of their variability within the two-year observation cycle. We applied the variation factor values (V, %) of the characteristics under analysis, which show the level of their dependence on meteorological factors, i.e. the higher the variation factor, the stronger the dependence, and vice versa. In this study, we applied the G. Zaytsev scale [9], which provides for five groups of characteristics: very low variation level (V<7 %), low (V=8-12 %), medium (V=13-20 %), high (V=21-40 %), and very high (V>41 %). The comparative analysis of data from Table 2 showed very broad ranges of variance, within the two-year observation cycle, of variation factors of the quantitative characteristics of the biochemical composition of large cranberry fruit. This implied various degrees

of dependence on the hydrothermal regime of the season and made it possible to designate the analyzed characteristics, as well as cultivars of the introduced variety showing the most and the least degree of this dependence. At the same time, Table 3 shows that the variability of most of the indicators of the biochemical composition of *Oxycoccus macrocarpus* fruit within the two-year observation cycle was to a great degree determined by the genotype of the plants. The most stable characteristics with a very low degree of variability accounted for 14 % ('Hiliston' and 'Stankovich') to 43 % (in 'Bain Favorit' and 'Holistar Red') of the total. The 'Bain Favorit' cultivar had no characteristics with the low variability level, whereas in 'Stankovich', the share was at 43 %. A less dramatic contrast of cultivar differences was observed for the characteristics of the biochemical composition of fruit with the average variability level — from 14 % in 'Bain Favorit' and 'WSU 108' to 29 % in 'Stevens' and 'Stankovich'. The share of indicators with the high variability degree varied within the range of cultivars from 14 % in 'Holistar Red' and 'Stankovich' to 36 % in 'Bain Favorit' and 'Hiliston'. When it comes to the indicators with the very high variability level, their insignificant share (less or equal to 7 %) was reported only for three cultivars — 'Bain Favorit', 'Hiliston' and 'Holistar Red', whereas the rest of the cultivars showed no characteristics with this variability degree.

Table 2

Average values of variation factors (V, %) of the quantitative characteristics of the biochemical composition of fruit of the introduced *Oxycoccus macrocarpus* cultivars, within the two-year observation cycle

Indicator	'Stevens'	'Bain Favorit'	'Hiliston'	'Holistar Red'	'Stankovich'	'WSU 108'
Drymatter	1.5	1.1	5.2	2.2	8.8	1.1
Freeorganicacids	13.9	3.4	27.8	3.4	10.9	4.9
Ascorbicacid	20.8	2.7	30.2	7.4	14.7	4.1
Hydroxycinnamicacids	9.9	3.8	11.4	10.4	11.7	10.9
Solublesugars	29.2	23.4	11.0	13.1	9.4	25.4
Sugar-acidindex	15.7	17.0	13.7	10.1	18.9	30.3
Pecticsubstances	32.1	30.1	56.1	36.2	10.1	20.2
Trueanthocyanins	19.8	33.6	24.7	4.1	1.3	13.8
Leucoanthocyanins	15.8	6.3	33.1	24.0	22.3	10.4
Total of anthocyanin pigments	3.9	16.0	14.6	14.4	16.2	2.3
Catechins	8.9	37.0	5.7	6.0	8.5	31.0
Flavonols	21.0	43.7	21.7	48.3	32.8	33.8
Bioflavonoids	1.4	23.1	8.4	5.9	6.2	7.9
Tannins	5.9	4.7	17.5	17.3	18.2	8.4
Average	14.3	17.6	20.1	14.5	13.6	14.6

Table 3

Proportion of indicators of the biochemical composition of fruit of introduced *Oxycoccus macrocarpus* varieties with various degrees of variability within the two-year observation cycle, %

Variability level (V, %)	'Stevens'	'Bain Favorit'	'Hiliston'	'Holistar Red'	'Stankovich'	'WSU 108'
Very low (< 7)	29	43	14	43	14	28
Low (8-12)	14	0	21	14	43	29
Average (13-20)	29	14	22	22	29	14
High (21-40)	28	36	36	14	14	29
Very high (>41)	0	7	7	7	0	0

The data presented in Table 2 show that the cultivars 'Bain Favorit' and especially 'Hiliston' had the highest integrated level of the variability of the biochemical composition of *Oxycoccus macrocarpus* fruit within the two-year observation cycle evaluated based upon average weighted variability indicators of all of the characteristics under analysis in their entirety, whereas 'Stankovich' had the lowest variability level. This suggested that the biochemical composition of the fruit of the cultivar 'Stankovich' his most resistant to weather conditions, whereas the cultivars 'Bain Favorit' and especially 'Hiliston' are least resistant.

Notably, during the observation years, the variability level of a specific characteristic in the large cranberry cultivars under analysis, as a rule, did not maintain its correspondence to any area of the accepted scale, which unambiguously attested to its pronounced dependence on a season's hydrothermal regime. In this connection, with a view to determining the degree of this dependence it was deemed advisable to apply the averaged — within the taxonomic range and two-year observation cycle — values of variation factors of the analyzed characteristics of the biochemical composition of the fruit, see Table 4. This analysis showed that

interseasonal differences were least significant (within the very low variability level) for only one characteristic — the content of dry substances in fruit. Low variability levels during the observation period were reported for the accumulation of free organic and hydroxycinnamic acids, tannins, as well as consolidated figures for the accumulation of anthocyanin pigments and bioflavonoids. At the same time, medium variability levels were shown for the content of ascorbic acid, soluble sugars, proper anthocyanins, catechins, and the sugar-acid index within the two-year observation cycle. The variability level was high only for pectic substances and flavonols. Our earlier studies in the same region with a different set of cultivars [1] had similar findings regarding the variability pattern for the time series of the characteristics of biochemical composition of large cranberry fruit, which is apparently a specific peculiarity of the response reaction of cranberry plants to change in weather conditions of the vegetation period. To identify the sequence of the analyzed characteristics in the ascending order of their variability, which indicates stronger dependence on a season's hydrothermal regime, each of their positions was determined in accordance with the increase in the values of variability factors specified in Table 4. Based upon the premise that the first five rows are occupied by the characteristics with the lowest, and the last five rows, by those with the highest level of dependence on abiotic factors, it follows from the table that for large cranberry, the least explicit interseasonal differences were reported for the content of dry substances in fruit, as well as ascorbic and hydroxycinnamic acids, as well as the total amount of anthocyanin pigments and bioflavonoids; whereas the most conspicuous differences were reported for the content of soluble sugars, pectic substances, leucoanthocyanins, and flavonols, as well as the sugar-acid index.

Table 4

Average values of variability factors of the biochemical composition of fruit of *Oxycoccus macrocarpus* cultivars within the taxonomic range in the two-year observation period and their positions, in the ascending order of the degree of their dependence on abiotic factors

Indicator	Variability level (V, %)	Position in the range, in the ascending order of the degree of dependence on abiotic factors
Drymatter	3.3	1
Freeorganicacids	10.7	4
Ascorbicacid	13.3	7
Hydroxycinnamicacids	9.7	3
Solublesugars	18.6	11
Sugar-acidindex	17.6	10
Pecticsubstances	30.8	13
Trueanthocyanins	16.2	8
Leucoanthocyanins	18.7	12
Total of anthocyanin pigments	11.2	5
Catechins	16.3	9
Flavonols	33.6	14
Bioflavonoids	8.8	2
Tannins	12.0	6

IV. Conclusion

The comparative study of the biochemical composition of fruit of six *Oxycoccus macrocarpus* cultivars newly introduced in Belarus — ‘Stevens’, ‘Bain Favorit’, ‘Hiliston’, ‘Holistar Red’, ‘Stankovich’, and ‘WSU 108’ — based upon 14 indicators in seasons that are contrasted in terms of the moisture regime showed that the favorable combination of weather conditions in 2016 contributed to the more active accumulation, in comparison with the rainless season of 2015, of free organic, ascorbic and hydroxycinnamic acids, soluble sugars, proper anthocyanins, catechins, and flavonols in fruit, by 8-62 %, and increase in the sugar-acid index by 15 %, which indicates an improvement in their organoleptic properties. At the same time, the content of leucoanthocyanins, dry and pectic substances, and tannins went down by 9-33 %. The comparative analysis of the levels of variability of indicators of the biochemical composition of cranberry fruit within the two-year observation cycle established that the least explicit interseasonal differences were reported for the accumulation of dry substances, and ascorbic and hydroxycinnamic acids, as well as the total amount of anthocyanin pigments and bioflavonoids; whereas the most marked differences were identified for the sugar-acid index, the content of soluble sugars, pectic substances, leucoanthocyanins, and flavonols. Within the taxonomic range of large cranberry, the cultivar ‘Stankovich’ showed the highest resistance of its biochemical composition to weather factors, while ‘Bain Favorit’ and especially ‘Hiliston’ turned out to be the least resistant cultivars.

References

- [1] Rupasova, Zh. A. et al. (2011). Formation of the biochemical composition of *Ericaceae* cultivar fruit when introduced to Belarus. Minsk: Belaruskaya navuka, 307.
- [2] Marsov, N. G., (2006) Phytochemical studies and biological activity of lingonberry, cranberry and blueberry. – Diss. of the cand. of pharm. sciences., 200.
- [3] Andreev, V. Y., Kalinkina G. I., Kolomic N. E., Isaikina N. V. (2013) Methods of definition of antocians in fruits of Aronia chokeberry. *Farmacia*, 3, 19-21.
- [4] Ermakov, A. I., et al. (1987). Methods of biochemical research of plants. Moscow: VO Agropromizdat, 430.
- [5] GOST 8756.2-82 (1982), Methods of definition of solids. M: Publishing house of standards, 5.
- [6] The State pharmacopoeia of the USSR. (1987). Vol.1. The general methods of the analysis, Moscow: Medicine, 286-287.
- [7] Pleshkov, B. P. (1985) Practical course in plant biochemistry. Moscow: Kolos, 110-112.
- [8] Skorikova, J. G. and Shaftan E.A. (1968) Technique of anthocyanins definition in fruits and berries. Sverdlovsk, 451-461.
- [9] Zaytsev, G. N. (1973) Technique of biometric calculations. Mathematical statistics in experimental botany. Moscow: Science, 256.

IOSR Journal of Biotechnology and Biochemistry (IOSR-JBB) is UGC approved Journal with Sl. No. 4033, Journal no. 44202.

Zhanna Rupasova. "Impact of Weather Conditions on the Variability of the Biochemical Composition of Fruit of *Oxycoccus Macrocarpus* Ait.Pers. Introduced In Belarus." IOSR Journal of Biotechnology and Biochemistry (IOSR-JBB) 3.4 (2017): 48-52.