Современная наука и инновации. 2024. № 3. С. 76-83.
ТЕХНОЛОГИЯ ПРОДОВОЛЬСТВЕННЫХ ПРОДУКТОВ

Modern Science and Innovations. 2024;(3):76-83.
TECHNOLOGY OF FOOD PRODUCTS

Научная статья
УДК 615.322
https://doi.org/10.37493/2307-910X.2024.3.7

Спектрофотометрический метод оценки цвета экстрактов из *Sorbus Aucuparia*

Ксения Николаевна Нициевская[1*], Светлана Владимировна Станкевич[2], Елена Валерьевна Бородай[3]

[1, 2, 3] Северо-Кавказский федеральный университет, г. Ставрополь, Россия
[1] nitsievskayakn@sfsca.ru; https://orcid.org/0000-0002-7302-106X
[2] sveticstank@yandex.ru; https://orcid.org/0000-0002-5157-2004
[3] borodayev@sfsca.ru; https://orcid.org/0000-0003-4350-085X
*** Автор, ответственный за переписку:** Ксения Николаевна Нициевская, nitsievskayakn@sfsca.ru

Аннотация. *В статье представлено описание метода спектрофотометрии. Объектами исследований использовались экстракта из вегетативных частей и плодов рябины красной (Sorbus aucuparia) в процессе научного исследования были выбраны диапазоны растворителя с кислой средой, нейтральной и щелочной. Исследование оптических свойств экстрактов проверяли посредством использования спектрометрии, с помощью прибора КФК-2. В процессе работы изучали опытные образцы экстрактов по следующим показателям: интенсивность цвета (I, е.д.), оттенок цвета (T, е.д.), хроматографическая структура (%) и содержание суммы антоцианов (в пересчете на цианидин-3,5-дигликозид, %). В результате экспериментальных исследований была проведена математическая обработка данных с расчетом средних значений и стандартного отклонения. Анализ количественных данных исследования цвета и прозрачности образцов показал зависимость между показателем интенсивность цвета (I, е.д.) и содержанием антоцианов (в пересчете на цианидин-3,5-дигликозид, %), что с увеличением оптической плотности при длине волны λ=440, 540 и 670 нм возрастает содержание антоциановых комплексов в исследуемых экстрактах Sorbus aucuparia. Согласно анализу и обработке данных рекомендовано использование в качестве растворителя воду с щелочной средой для выделения антоциановых соединений при исследование синего компонента (λ= 670 нм) определил содержание свободных антоцианов в хинонной форме.*

Ключевые слова: плоды рябины красной, Sorbus aucuparia, интенсивность цвета, антоцианы

Для цитирования: *Нициевская К.Н., Станкевич С.В., Бородай Е.В. Спектрофотометрический метод оценки цвета экстрактов из Sorbus aucuparia // Современная наука и инновации. 2024. № 3. С. 76-83. https://doi.org/10.37493/2307-910X.2024.3.7*

Research article

The spectrophotometric method for evaluating the color of extracts from *Sorbus Aucuparia*

Kseniya N. Nitsievskaya[1*], Svetlana V. Stankevich[2], Elena V. Boroday[3]

[1, 2, 3] North-Caucasus Federal University, Stavropol, Russia
[1] nitsievskayakn@sfsca.ru; https://orcid.org/0000-0002-7302-106X
[2] sveticstank@yandex.ru; https://orcid.org 0000-0002-5157-2004
[3] borodayev@sfsca.ru; https://orcid.org/0000-0003-4350-085X
*** Corresponding author:** Kseniya N. Nitsievskaya, nitsievskayakn@sfsca.ru

Abstract. *The article describes the method of spectrophotometry. Materials and methods. The objects of research were extracts from vegetative parts and fruits of red mountain ash (Sorbus aucuparia). In the process of scientific research, solvent ranges with acidic, neutral and alkaline media were selected. The study of the optical properties of the extracts was verified by using spectrometry, using the KFK-2 device. In the course of work, experimental samples of extracts were studied according to the following indicators: color intensity (I, e.d.), color shade (T, e.d.), chromatographic structure (%) and the content of the sum of anthocyanins (in terms of cyanidin-3,5-diglycoside, %). As a result of experimental studies, mathematical data processing was carried out with the calculation of average values and standard deviation. Analysis of quantitative data on the color and transparency of samples showed a relationship between the color intensity index (I, e.d.) and the content of anthocyanins (in terms of cyanidin-3,5-diglycoside, %), that with*

an increase in optical density at a wavelength of λ=440, 540 and 670 nm, the content of anthocyanin complexes in the Sorbus extracts under study increases aucuparia. According to the analysis and data processing, it is recommended to use water with an alkaline medium as a solvent for the isolation of anthocyanin compounds in the study of the blue component (λ= 670 nm) determined the content of free anthocyanins in quinone form.

Keywords: fruits of red mountain ash, Sorbus aucuparia, color intensity, anthocyanins

For citation: *Nitsievskaya KN, Stankevich SV, Boroday EV. The spectrophotometric method for evaluating the color of extracts from Sorbus aucuparia. Modern Science and Innovations. 2024;(3):76-83. https://doi.org/10.37493/2307-910X.2024.3.7*

Introduction. When creating food systems, special attention is paid to the formation of organoleptic abilities, which are most often the promotion of goods on the market. Appearance and color are the first things that the consumer market makes a choice before [1].

In the authors' work, color is described as a qualitative characteristic of light, for visualization of visual sensation [2, 3]. Recently, instrumental methods of assessment have been applied to the study of the indicators "color" and "transparency", where color is decomposed into a luminous flux with wavelengths in the range from 190 to 780 nm [4-8].

Foreign researchers believe that traditional organoleptic assessment of color characteristics is subjective and dependent on the taster's experience, as well as external lighting factors [9]. Therefore, a method of quantitative analysis of intensity in color addition is proposed [10].

In the article by N.S. Anikina and other co-authors, a calculation method is proposed for the analysis of three components at different wavelengths: red (λ = 540 nm), yellow (λ = 440 nm) and blue (λ = 670 nm). The presence of each color is characterized by the decomposition products of phenolic compounds, such as yellow color, the content of tannins (tannins) and anthocyanin, red - free anthocyanins (in the form of flavylium cations and anthocyanin-tannin complex) and the blue component - free anthocyanins in quinone form or combinations of tannins and anthocyanins [11].

The aim of the work is to study the color characteristics of extracts from different parts of Sorbus aucuparia and their dependence on the content of anthocyanins.

Materials and research methods. The objects of the research were extracts obtained from dry vegetative parts (leaves and branches) and fruits of red rowan (Sorbus aucuparia). Purified water was used as a medium for dissolving (solvent) the studied plant raw materials and reducing the error of the research, the acidity of the aqueous medium was regulated using a 1% solution of citric acid (pH = 1.98 units) and 1% sodium bicarbonate (pH = 9.1 units). Purified water was obtained in accordance with the requirements for type II water according to GOST 52501-2005 "Water for laboratory analysis" (by filtration through the UPVA-159 unit, Belgorod, Russia). The plant materials were collected in the Novosibirsk region in dry weather, the collection period was September 2022. The raw materials were dried: leaves and branches by natural drying (T = 20 ± 2 ° C, humidity 75%), fruits by convective drying (drying oven with forced ventilation "Binder", Germany) (T = 55 ± 3 ° C, convection 100%), the raw materials were dried until the moisture content in the final product was 6.0 ± 1.0% (using the Chizhov method). The samples were stored at a temperature of t = 20 ± 3 ° C, air humidity W = 67 ± 2%.

For the study, samples of plant materials were taken in dry crushed form (fraction diameter ≈ 0.5 cm) crushing was carried out in a laboratory mill LM 201 of the company "Plaun" (Russia, Moscow) and in the form of extracts. For the studies, extracts were prepared from crushed plant materials by mixing the sample with a solvent in the ratio of 1:20 (g: ml). Extraction was carried out for 180 and 240 min at a temperature of 60±2 °C in a water bath of the company "Loip" (Russia, St. Petersburg).

The coding of the samples was carried out in the following sequence and is presented in Table 1.

Table 1 – The code of the extract samples

Sample code	Type of raw material	Solvent environment	Duration, min
p.0/180	fruit	neutral	180
p.0/240		neutral	240
p.k/180		sour	180
p.k/240		sour	240
p.s./180		alkaline	240
p.sh/240		alkaline	180
l.0/180	leaves	neutral	180
l.0/240		neutral	240
l.k/180		sour	180
l.k/240		sour	240
l.sh/180		alkaline	180
l.sh/240		alkaline	240
v.0/180	branches	sour	180
v.0/240		sour	240
v.k/180		alkaline	180
v.k/240		alkaline	240
v.sh/180		sour	180
v.sh/240		sour	240

The extraction study was carried out using optical methods: measuring the optical density (D, units), transmittance (T, %) and absorption coefficient (ε, units) using a KFK-2 photoelectric concentration colorimeter (ZOMZ, Russia). Blue (λ=440 nm), green (λ=540 nm) and red (λ=670 nm) light filters were used in the work. Distilled water was used as a comparison solution.

The color intensity (I, units) taking into account all pigments was expressed according to formula (1) [1,11,12]:

$$I = D_{440} + D_{540} + D_{670} \quad (1)$$

Where D – optical density of the absorption spectrum, rel. units,

It was established that color intensity I less than 0.10 characterized the extracts as weakly colored, from 0.11 to 0.30 as moderately colored, from 0.31 to 0.50 as well colored, and more than 0.51 as intensely colored [11].

The proportion of red color in the color composition was determined as the dA (%) indicator using formula (2) [14]:

$$dA(\%) = (1 + \frac{D_{440}+D_{670}}{2*D_{540}}) *100 \quad (2)$$

The color shade (T, units) was expressed according to formula (3) [1,11,12]:

$$T = \frac{D_{440}}{D_{540}} \quad (3)$$

Where D – optical density of the absorption spectrum, rel. units,

The chromatographic structure (%) was calculated using formula (4) [1]:

$$D_{440,540,670}(\%) = \frac{D_{440\ 540\ 670}}{I} * 100 \quad (4)$$

Mathematical data processing using regression analysis was performed using the MS Excel program, the experiments were carried out in triplicate. The adequacy of the regression equations was checked using Fisher's F-criterion. The significance of the regression coefficients was assessed using Student's t-criterion.

The following indicators were taken as controlled parameters of the extracts: active acidity (pH, units), upper limit of thermodynamic stability of the solution (ϕst), temperature (t, °C), absorption coefficient (ε, units), transmittance coefficient (T%), color intensity (I, units), color shade (T, units), chromatographic structure.

Determination of anthocyanins.

The volume of extracts in the amount of 0.5-1.0 cm3 was placed in a measuring test tube, 10 cm3 of 1% hydrochloric acid solution was added and kept in a water bath at 40-45 °C for 20 minutes. After cooling, the contents were filtered through a paper filter and the optical density of the solution was measured on a spectrophotometer at wavelengths of λ = 510 nm and 670 nm (in the spectra, detection of a green and red light filter). As a comparison solution, use a 1% hydrochloric acid solution.

The content of the sum of anthocyanins (in terms of cyanidin-3,5-diglycoside, %) is calculated using formula (5) in % of dry matter [13]:

$$X, \% = \frac{(D_{510} - 0{,}33 * D_{670}) * V}{453 * m * (100 - W)} \quad (5)$$

V - volume of extract, cm3; 453 - specific absorption index of cyanidin-3,5 - diglycoside; $D_{490,670}$optical density of absorption spectrum, rel. units; m - weight of plant material in extract, g.

Research results and their discussion. The studied samples differed in optical density indices, and therefore in the calculated characteristics – color intensity, color shade. Unlike the work of Nilova L.P. and other co-authors [14], and Rozhnov E.D. [12], the research was conducted not only in a neutral and acidic environment, but also in an alkaline one. The study of extracts from various initial plant materials was analyzed according to several indices, presented in Table 2.

Table 2 – Study of color characteristics

Samples	***I*, e.d [1]**	**calculation dA% [2]**	**T, e.d. [3]**	$D_{440}(\%)$[4]	$D_{540}(\%)$[5]	$D_{670}(\%)$[6]	**Anthocyanins [7],%**
fruit							
p.0/180	0.20±0.01	21.37±1.07	1.53±0.08	46.80 ±2.34	30.54±1.53	**22.66± 1.13**	0.008±0.001
p.0/240	0.20±0.01	21.05±1.05	1.50±0.08	46.73 ±2.34	31.16±1.56	**22.11± 1.11**	0.007±0.001
p.k/180	0.08±0.00	21.30±1.07	**1.74±0.09**	**53.33 ±2.67**	30.67±1.53	16.00± 0.80	traces
p.k/240	0.08±0.00	21.78±1.09	**1.78±0.09**	**52.98 ±2.65**	29.80±1.49	17.22± 0.86	traces
p.s./180	**0.35±0.02**	20.40±1.02	1.38±0.07	44.93 ±2.25	32.46±1.62	**22.61± 1.13**	**0.020±0.001**
p.sh/240	**0.36±0.02**	19.79±0.99	1.29±0.06	43.66 ±2.18	33.80±1.69	**22.54± 1.13**	**0.021±0.001**

leaves							
l.0/180	0.26±0.01	23.46±1.17	2.29±0.11	61.90±3.09	27.08±1.35	11.03± 0.55	0.016±0.001
l.0/240	0.28±0.01	21.03±1.05	1.84±0.09	57.35±2.87	31.18±1.56	11.47± 0.57	0.010±0.001
l.k/180	0.20±0.01	25.31±1.27	**2.65±0.13**	**65.33±3.27**	24.62±1.23	10.05± 0.50	0.006±0.001
l.k/240	0.20±0.01	26.11±1.31	**2.87±0.14**	**67.95±3.40**	23.68±1.18	8.37± 0.42	0.007±0.001
l.sh/180	**0.39±0.02**	17.73±0.89	1.04±0.05	40.82±2.04	39.29±1.96	**19.90± 0.99**	**0.039±0.002**
l.sh/240	**0.42±0.02**	18.23±0.91	1.01±0.05	38.28±1.91	37.80±1.89	**23.92± 1.20**	**0.047±0.002**
branches							
v.0/180	0.34±0.02	22.24±1.11	1.58±0.08	45.86 ±2.29	28.99±1.45	**25.15± 1.26**	0.009±0.001
v.0/240	0.37±0.02	20.42±1.02	1.29±0.06	41.89 ±2.09	32.43±1.62	**25.68± 1.28**	0.010±0.001
v.k/180	0.04±0.00	28.71±1.44	**3.47±0.17**	**73.20±3.66**	21.09±1.05	5.71± 0.29	traces
v.k/240	0.04±0.00	27.17±1.36	**3.13±0.16**	**70.65±3.53**	22.55±1.13	6.79± 0.34	traces
v.sh/180	**0.39±0.02**	17.99±0.90	1.07±0.05	41.34 ±2.07	38.50±1.93	**20.16± 1.01**	**0.027±0.001**
v.sh/240	**0.43±0.02**	18.54±0.93	1.02±0.05	37.65 ±1.88	36.94±1.85	**25.41± 1.27**	**0.036±0.002**

Note: [1] Color intensity, units according to formula (1); [2] share of red color in color addition % according to formula (2); [3] color shade, units according to formula (3); [4,5,6] Chromatographic structure (%); [7] anthocyanins in terms of cyanidin-3,5-diglycoside, % according to formula (5)

Sorbus aucuparia fruit extracts in different solvents had different color characteristics. Thus, the "color intensity (I, units)" index when processed in an alkaline medium showed the highest quantitative result and the samples can be described as "well colored", while in an acidic medium the transition of coloring pigments is lower by ≈ 4.5 times compared to an alkaline medium and ≈ 2.5 times, the samples were described as "weakly colored". According to formula 5, the constituent element when assessing the content of anthocyanins plays a numerical value at λ = 670 nm. It was noted that with a high content of red pigments (D_{670} (%)) in alkaline fruit extracts (samples p/sh.180 and p.sh/240), there was a high content of anthocyanins (in terms of cyanidin-3,5-diglycoside, (%)) - in comparison with the control sample, it is higher by ≈ 2.5 times.

Samples of extracts from leaves and branches of *Sorbus aucuparia* in different solvents also had higher color characteristics in a medium with sodium bicarbonate. When comparing all *Sorbus aucuparia extracts* with each other, the maximum release of anthocyanins was noted in the leaves (sample l.sh/240) was ≈0.05%, in the branches (sample v.sh/240) ≈ 0.04%, in the fruits (sample p.sh/240) 0.02%.

The calculated characteristic “color shade” (T, units), with a ratio of wavelengths λ=440 and 540 nm (more often used to study flavonoids of various natures) indicated the maximum transition in the branches and amounted to ≈ 3.3 units for treatment for 180 and 240 minutes within the error limits, thereby indirectly indicating the preservation of phenolic compounds.

Analyzing the data in Table 1, high values were noted for the studied indicators, this fact indicates the preservation of phenolic compounds during drying. When assessing the chromatographic structure D_{440} (%) nm determined high values in an acidic environment, in comparison with neutral and alkaline in fruits 1.2 times, in branches ≈ 1.8 times.

Conclusion. Comparative analysis showed that there is a relationship between the color intensity index (I2, units) and the content of anthocyanins (in terms of cyanidin-3,5-diglycoside, %), so with an increase in optical density at a wavelength of λ = 440, 540 and 670 nm, the content of anthocyanins in the studied Sorbus aucuparia extracts also increases.

The aim of the work was to study the color characteristics of extracts from different parts of Sorbus aucuparia and their dependence on the content of anthocyanins. During the analysis and generalization of the obtained data, the parameters for evaluating the extracts using different solvents (neutral, acidic and alkaline) revealed significant differences when using the solvent medium and the type of plant material (fruits, leaves, branches). According to the analysis and processing of the data, it is recommended to use water with an alkaline medium as a solvent for the extraction of anthocyanin compounds. A transition in an acidic medium of phenolic compounds in red (λ = 540 nm) and yellow (λ = 440 nm) color was noted, according to the literature [11], it can be assumed about the transition of tannins and other polyphenolic compounds of the anthocyanin-tannin complex. The study of the blue component (λ = 670 nm) and the calculation of anthocyanins (in terms of cyanidin-3,5-diglycoside, %) determined the content of free anthocyanins in the quinone form.

ЛИТЕРАТУРА

1. Школьникова М. Н., Рожнов Е. Д. Физические методы исследования в объективной оценке внешнего вида напитков из растительного сырья // Ползуновский вестник. 2023. № 1. С. 151–163. https://doi.org/10.25712/ASTU.2072-8921.2023.01.019
2. Compendium of international analysis of methods – OIV Chromatic Charac-teristics. Method OIV-MA-AS2-11. Determination of chromatic characteristics according to CIELab. [Электронный ресурс]. URL: http://www.oiv.int/public/medias/2478/oiv-ma-as2-11.pdf (accessed: 26.02.2024).
3. Precise color communication. Color control from perception to instrumentation. 2007. 62 p. [Электронный ресурс]. URL: https://www.konicaminolta.com/about/network (accessed: 20.02.2024).
4. Плотникова Л. В., Нечипоренко У. Ю., Плотникова Н. А., Успенская М. В., Ишевский А. Л. Оптические методы в исследовании масляных экстрактов и шротов растительного сырья // Научный журнал НИУ ИТМО. Серия «Процессы и аппараты пищевых производств». 2017. № 3. С. 33–42. https://doi.org/10.17586/2310-1164-2017-10-3-33-42
5. Nechiporenko AP, Melnikova MI, Nechiporenko UYu, Plotnikova LV, Uspenskaya MV. Optical properties of oil extracts and residues of medicinal and aromatic herbs // Izvestiya Vuzov. Prikladnaya Khimi-ya i Biotekhnologiya (Proceedings of Universities. Applied Chemistry and Biotechnology). 2018. Vol. 8. No. 4. P. 6–12. https://doi.org/10.21285/2227-2925-2018-8-4-6-12
6. Ревина А. А., Геворгиз Р. Г., Лозинина С. С., Железнова С. Н., Тхан Т., Павлов Ю. С., Нехорошев М. В., Рябушко В. И. Оптические свойства и радиационная стабильность экстрактов морской диатомеи Cylindrotheca closterium (Ehrenb.) Reimann et Lewin // Сорбционные и хроматографические процессы. 2016. Т. 16. № 2. С. 173–182.
7. Макаров А. С., Яланецкий А. Я., Лутков И. П., Шмигельская Н. А., Шалимова Т. Р., Максимовская В. А., Кречетова В. В. Цветовые характеристики виноматериалов для розовых и красных игристых вин // Магарыч. Виноградорство и виноделие. 2017. № 3. С. 44–47.
8. Стародубцева М. Н., Потапова Е. А. Получение компонентов для производства безалкогольных тонизирующих напитков // Инновации в пищевой биотехнологии.

Сборник тезисов VII Международной научной конференции студентов, аспирантов и молодых. Кемеровский государственный университет. 2019. Т. 2. С. 132–133.
9. Остроухова Е. В., Пескова И. В., Луткова Н. Ю. Исследование сенсорных профилей белых столовых вин из винограда сорта Мускат белый // Магарач. Виноградарство и виноделие. 2015. № 4. С. 44–46.
10. Абрамова И. М., Поляков В. А., Савельева В. Б., Сурин Н. М., Приёмухова Н. В. Определение цветности спиртных напитков с использованием спектрофотометрического метода анализа // Пиво и напитки. 2015. № 1. 40–42.
11. Аникина Н. С., Червяк С. Н., Гниломедова Н. В. Методы оценки цвета вин // Обзор. Аналитика и контроль. 2019. Т. 23. № 2. С. 158–167. https://doi.org/10.15826/analitika.2019.23.2.003
12. Рожнов Е. Д., Рыбакова И. А. Перспективы использования антоцианов черники в составе смарт-упаковки // Агропродовольственная экономика. 2023. № 5. С. 27–39.
13. Масленников П. В., Чупахина Г. Н., Скрыпник Л. Н., Федураев П. В., Полтавская Р. Л. Содержание антоциановых и каротиноидных пигментов в лекарственных растениях // Электронный журнал «Вестник МГОУ». 2013. № 11. С. 1–14.
14. Nilova L. P., Ikramov R. A., Malyutenkova S. M. The effect of microwave heating on the optical characteristics of berry extracts // Bulletin of the VGUIT. 2019. Vol. 81. No. 1. P. 218–224. https://doi.org/10.20914/2310-1202-2019-1-218-224

REFERENCES

1. Shkol'nikova MN, Rozhnov ED. Physical methods of investigation in objec-tive evaluation of the appearance of drinks from plant raw material. Polzunovskiy vestnik. 2023;(1):151-163. (In Russ.). https://doi.org/10.25712/ASTU.2072-8921.2023.01.019
2. Compendium of international analysis of methods – OIV Chromatic Charac-teristics. Method OIV-MA-AS2-11. Determination of chromatic characteristics according to CIELab [Electronic resource]. Available from: http://www.oiv.int/public/medias/2478/oiv-ma-as2-11.pdf (accessed: 26.02.2024).
3. Precise color communication. Color control from perception to instrumentation. 2007. 62 p. [Electronic resource]. Available from: ttps://www.konicaminolta.com/about/network (accessed: 20.02.2024).
4. Plotnikova LV, Nechiporenko UYu, Plotnikova NA, Uspenskaya MV, Ishevskii AL. Optical methods in the study of oil extracts and meals of vegetable raw materials. Processes and Food Production Equipment. 2017;(3):33-42. (In Russ.). https://doi.org/10.17586/2310-1164-2017-10-3-33-42
5. Nechiporenko AP, Melnikova MI, Nechiporenko UYu, Plotnikova LV, Uspenskaya MV. Optical properties of oil extracts and residues of medicinal and aromatic herbs. Izvestiya Vuzov. Prikladnaya Khimi-ya i Biotekhnologiya (Proceedings of Universities. Applied Chemistry and Biotechnology). 2018;8(4):6-12. https://doi.org/10.21285/2227-2925-2018-8-4-6-12
6. Revina AA, Gevorgiz RG, Lozinina SS, Zheleznova SN, Tkhan T, Pavlov YuS, Nekhoroshev MV, Ryabushko VI. Optical properties and radiation stability of extracts of the marine diatom Cylindrotheca closterium (Ehrenb.) Reimann et Lewin. Sorbtsionnye i khromatograficheskie protsessy (sorption and chromatography processes). 2016;16(2):173-182. (In Russ.).
7. Makarov AS, Yalanetskii AYa, Lutkov IP, Shmigel'skaya NA, Shalimova TR, Maksimovskaya VA, Krechetova VV. Color characteristics of wine materials for red and rosé sparkling wines. Magarach. Viticulture and Winemaking. 2017;(3):44-47. (In Russ.).
8. Starodubtseva MN, Potapova EA. Obtaining components for the production of non-alcoholic tonic drinks // Innovations in food biotechnology. In Collection of abstracts of the VII International scientific conference of students, postgraduates and young people. Kemerovo State University. 2019;2:132-133. (In Russ.).
9. Ostroukhova EV, Peskova IV, Lutkova NYu. A study of sensory profiles of table wine materials made from the grape ‘white muscat’. Magarach. Viticulture and Winemaking. 2015;(4):44-46. (In Russ.).

10. Abramova IM, Polyakov VA, Savel'eva VB, Surin NM, Priemukhova NV. Determination of Chromaticity of Alcoholic Beverages by Using of Spectrophotometry Analysis Method. Pivo i napitki = Beer and drinks. 2015;(1):40-42. (In Russ.).
11. Anikina NS, Chervyak SN, Gnilomedova NV. Methods for evaluating the color of wines. The review (Analytics and Control). 2019;23(2):158-167. (In Russ.). https://doi.org/10.15826/analitika.2019.23.2.003
12. Rozhnov ED, Rybakova IA. Prospects for the use of blueberry anthocyanins as part of smart packaging. Agroprodovol'stvennaya ehkonomika = Agri-food economy. 2023;(5):27-39. (In Russ.).
13. Maslennikov PV, Chupakhina GN, Skrypnik LN, Feduraev PV, Poltavskaya RL. Content of anthocyanin and carotenoid pigments in medicinal plants // Russian Social and Humanitarian Journal. 2013;(11):1-14. (In Russ.).
14. Nilova LP, Ikramov RA, Malyutenkova SM. The effect of microwave heating on the optical characteristics of berry extracts. Bulletin of the VGUIT. 2019;81(1):218-224. https://doi.org/10.20914/2310-1202-2019-1-218-224

ИНФОРМАЦИЯ ОБ АВТОРАХ

Ксения Николаевна Нициевская – кандидат технических наук, доцент, ведущий научный сотрудник, Сибирский федеральный научный центр агробиотехнологий Российский академии наук (СФНЦА РАН), Scopus ID: 57214137007, https://orcid.org/0000-0002-7302-106X, nitsievskayakn@sfsca.ru

Светлана Владимировна Станкевич – кандидат сельскохозяйственных наук, доцент, старший научный сотрудник, Сибирский федеральный научный центр агробиотехнологий Российский академии наук (СФНЦА РАН), https://orcid.org/0000-0002-5157-2004, sveticstank@yandex.ru

Елена Валерьевна Бородай – старший научный сотрудник, Сибирский федеральный научный центр агробиотехнологий Российский академии наук (СФНЦА РАН), Scopus ID: 57216352786, https://orcid.org/0000-0003-4350-085X, borodayev@sfsca.ru

Вклад авторов: все авторы внесли равный вклад в подготовку публикации
Конфликт интересов: авторы заявляют об отсутствии конфликта интересов.

Статья поступила в редакцию: 14.08.2024;
одобрена после рецензирования: 11.09.2024;
принята к публикации: 14.10.2024.

INFORMATION ABOUT THE AUTHORS

Kseniya N. Nitsievskaya – Associate Professor, Siberian Federal Research Center of Agrobiotechnologies of the Russian Academy of Sciences, Scopus ID: 57214137007, https://orcid.org/0000-0002-7302-106X, nitsievskayakn@sfsca.ru

Svetlana V. Stankevich – Cand. Sci. (Econ), Siberian Federal Research Center of Agrobiotechnologies of the Russian Academy of Sciences, https://orcid.org/0000-0002-5157-2004, sveticstank@yandex.ru

Elena V. Boroday – Siberian Federal Research Center of Agrobiotechnologies of the Russian Academy of Sciences, Scopus ID: 57216352786, https://orcid.org/0000-0003-4350-085X, borodayev@sfsca.ru

Contribution of the authors: the authors contributed equally to this article.
Conflict of interest: the authors declare no conflicts of interests.

The article was submitted: 14.08.2024;
approved after reviewing: 11.09.2024;
accepted for publication: 14.10.2024.