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Effects of *Granucol* activated carbons on sensory properties of sea-buckthorn (*Hippophae rhamnoides* L.) wines

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Abstract: The paper introduces some experimental data on activated carbons of Granucol series that can improve the colour of sea-buckthorn wines and stabilize them during storage. Such treatment is necessary because sea buckthorn contains reactive phenolic compounds that trigger non-enzymatic oxidative browning in sea-buckthorn wine. A direct regulation of the amount of phenolic compounds can improve sensory characteristics of sea-buckthorn wines, as well as increase their shelf-life. The research featured table dry wine made of 10 varieties of sea buckthorn grown in the Altai region. The chromatic characteristics were studied according to the existing guidelines of the International Organization of Vine and Wine (OIV, France). The index of yellowness served as an additional indicator for the colour assessment of the sea-buckthorn wines. Another objective indicator of colour assessment was the index of the displacement of the colour of x and y coordinates that corresponded with the green-red and yellow-blue chromatic axes. When 20–60 mg/100 ml of Granucol activated carbon was used during the winemaking process, it significantly improved the harmony of the sea-buckthorn wines. In particular, it had a positive effect on the colour characteristics. Granucol carbon reduced such unfavourable taste characteristics as excessive roughness (the total amount of polyphenolic compounds fell by 1.5–2 times) and significantly improved the aroma by erasing the yeasty and fusel odours.

Key words: Sea-buckthorn wines, activated carbon, colour stability, chromatic characteristics, browning

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INTRODUCTION

In the Altai region, researches on the industrial use of sea-buckthorn berries began almost simultaneously with the cultivation of the plant. Nowadays, sea buckthorn covers enough acreage to allow for its industrial processing. There have been *in vitro* and *in vivo* studies of sea-buckthorn products (juices, jam, oil, etc.) on humans and animals. These nutrition and pharmaceutical products proved to have an anti-inflammatory, antitumoural, and antisclerotic effect on a living organism [1, 2]. As a rule, such preventive and therapeutic effect is attributed to phenol, vitamins, mineral substances, amino acids, fatty acids, and phitosterols. Sea buckthorn contains up to 11 satureted as well as mono- and polyunsarurated fatty acids. In addition, the berries contain α- and γ-tocopherols and α-tocotrienol, as well as some phitosterols, including campesterol, β-sitosterol, Δ^5-avenasterol, cycloartenol, and gramisterol, which have a strong antioxidant effect [3, 4]. Sea-buckthorn berries are known to contain a large amount of cartienoids and their ethers, such as astaxanthin, zeaxanthin, zeaxanthin-palmitate, α-, β-, and γ-carotenes, cis-β-carotene, β-cryptoxanthin, lycopene, lutein-palmitate-myristate, and other biologically active compounds [5–9].

Nevertheless, the huge potential of sea-buckthorn is hardly used for fruit wine production because of a high oil content in sea-buckthorn berries. Thus, the berries are difficult to process, and the resulting drinks are sensory unstable [10].

According to the previous research [11], the low stability of sea buckthorn wine is probably connected with high-reactive substances of the phenol origin in its composition. The substances are prone to copolymerization and condensation reactions; as a result, the drinks tend to be of dark colour. A high concentration of phenol substances proved to be an essential feature of sea-buckthorn berries. Sea-buckthorn flavonoids are represented by catechins, leucoanthocyanins, prosyanidins, flavan-3-ol, and, to a lesser extent, by flavones. Also, the berries contain coumarins and tanning substances [12–16]. Nevertheless, the polyphenols are able to inhibit the formation of Maillard reaction products. Presumably, the mechanism can be explained by the fact that some polyphenols might interact with the intermediate products of the Maillard reaction: polyphenolic amides obstruct the reaction and result in sugar and amino acid degradation products of dark colour.

The phenol compounds of grape and fruit wines affect such sensory properties as colour and taste [18–20]. Excessive phenol compounds make white wines rough and harsh. Usually, the rough taste is attributed to the tanning substances [21–23], e.g. prosyanidins. The effect of polyphenols on the colour of white wines is determined by both enzymic and nonenzymic oxidation when exposed to oxygen. As a result, the wine acquires amber colour, which may turn dark-brown if exposed to oxygen for too long. Such changes of colour are inappropriate for table wines [20].

Activated carbon can improve the sensory characteristics of sea-buckthorn wines. In fact, activated carbon of Granucol series is often used to improve the taste and colour of grape wine [32, 33]. This brand of carbon can be used for different technological purposes. For instance, Granucol GE adsorbs unwanted taste and smell; Granucol FA is used to remove the reddish tint in young wine; Granucol BI can lower the amount of phenol and monomer substances. Fruit wine industry has developed a lot of ways to improve such indices of must as sugariness or acidity. However, there are little experimental data on how to lower and stabilize polyphenols, in spite of the fact that it is polyphenols that are responsible for the harsh and rough taste, as well as browning during storage.

Eye appeal is an important aspect that determines the reaction of customers when they choose wines and winy beverages of an unfamiliar trademark [34]. Thus, competitiveness requires that local wines should be attractive without losing their shelf stability. Appearance can be objectively assessed by analysing chromatic characteristics, e.g. colour intensity, tint, and coordinates in the CIE Lab system [35–40]. By determining the chromatic properties of wine and winy beverages, it is also possible to measure its yellowness, since yellowness has recently been introduced into control practice for many nutrition products. It characterizes the change in colour of a test sample from clear or white toward yellow [41–43].

The research objective was to analyse the effect various amounts of Granucol activated carbon produce on the polyphenols content and the chromatic and sensory characteristics of dry sea-buckthorn wine.

STUDY OBJECTS AND METHODS

The research featured dry wine materials of sea buckthorn (Novost Altaya variety) harvested in 2014 in Barnaul at M.A. Lisavenko Research Institute of Siberian Gardening. The initial amount of polyphenols was 480 ± 4.5 mg/dm^3. The wine materials were produced by submerged cap fermentation with the help of Oenoferm yeast, race LW 317-28 (Erbslöh Geisenheim AG, Germany). Clarification of the wine material was performed using 2.0–2.5 g/dm^3 of bentonite. The final filtration of the wine materials was made with the help of a SEITS-KS80 filter-paperboard. The ageing time of the wine material was 42 weeks at 5 ± 1°C. The general amount of SO$_2$ was 80 mg/dm^3. Granucol carbon (Erbslöh Geisenheim AG, Germany) was applied in rising concentrations from 10 to 150 mg/100 ml at 10 mg/100 ml intervals.

The mass concentration of general phenolic substance was determined according to the colourimetric method with the Folin-Ciocalteu reagent [44–46] on the spectrophotometer PE-5300VI (Ecros, Russia). The samples were preliminary diluted by 100.

The optic and chromatic characteristics of the samples before and after activated carbon treatment were determined in accordance with the methodic recommendations compiled by the OIV [47, 48] with the help of a UV-1800 spectrophotometer (Shimadzu, Japan).

Based on the spectral characteristics of the wine materials, we calculated:

– the value of colour intensity (I) represented by the sum of absorption values of the wine materials at the wave lengths of 420, 520, and 620 nm:

$$I = A_{420} + A_{520} + A_{620}; \tag{1}$$

– the value of wine material colour tint (N) represented by the ratio of absorption value at the wave lengths of 420 and 520 nm:

$$N = A_{420} / A_{520}; \tag{2}$$

– the value of yellowness (G, %) according to the formula introduced in [49]:

$$G = \frac{(1.28X - 1.06Z)100}{Y}, \tag{3}$$

where X, Y, and Z are coordinates of colour in the CIE system:

$$X = 0.42 \cdot T_{625} + 0.35 \cdot T_{550} + 0.21 \cdot T_{445}, \tag{4}$$

$$Y = 0.20 \cdot T_{625} + 0.63 \cdot T_{550} + 0.17 \cdot T_{495}, \tag{5}$$

$$Z = 0.24 \cdot T_{495} + 0.94 \cdot T_{445}, \tag{6}$$

where T_{625}, T_{550}, T_{445}, and T_{495} are coefficients of transmittance relative to distilled water at the corresponding wave lengths, %.

To analyse the effect of Granucol carbons on the sensory characteristics of sea-buckthorn wines, different amounts of the activated carbon were added into the processed and aged wine materials and stirred for two hours. Finally, the wine was filtered from carbon. After that, the samples were tested for mass concentration of polyphenols and the optic characteristics of wine materials.

RESULTS AND DISCUSSION

Fig. 1 shows the dynamic changes in the amount of the phenolic compounds in the wine material according to the concentration and type of Granucol carbon.

Fig. 2 shows that the usage of Granucol carbon reduced the polyphenol concentration in the sea-buck-

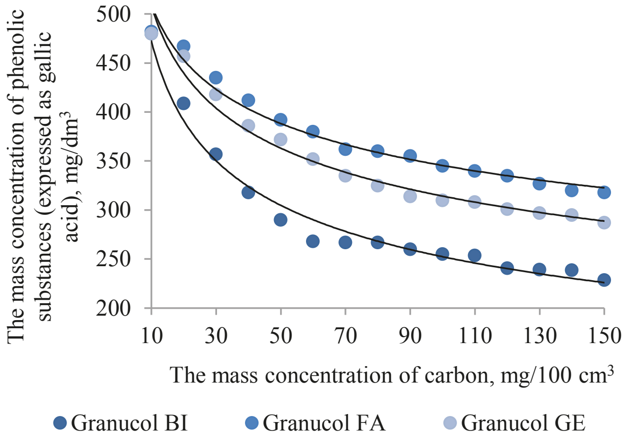


Fig. 1. Effects of the mass concentration of the phenolic substances in the sea-buckthorn wine material on the concentration and type of Granucol carbon.

thorn wine material. Granucol BI demonstrated the best results. In general, this type of carbon helped lower the amount of phenolic substances in the sea-buckthorn wine by 2.1 times when the maximum carbon amount was 150 mg/100 ml. Granucol FA and Granucol GE also lowered the amount of polyphenols. However, they were less effective and reduced the amount of polyphenols only by 1.52 and 1.56 times, respectively. Fig. 2 shows the empiric isotherms of phenolic substances adsorption by different activated Granucol carbons.

We calculated the specific adsorption by the following formula:

$$A = \frac{C_0 - C}{m} \cdot V, \tag{7}$$

where C_0 is the mass concentration of phenolic substances in the starting wine material, mg/dm^3;

C is the mass concentration of phenolic substances in the processed wine material, mg/dm^3;

m is the mass of the used sorbent, mg; and

V is the volume of the processed solution, dm^3.

Here we can see that the most effective concentration of Granucol BI was 20–60 mg/dm^3. Probably, this type of carbon absorbs the phenolic substances that exhaust the media due to their monomer nature.

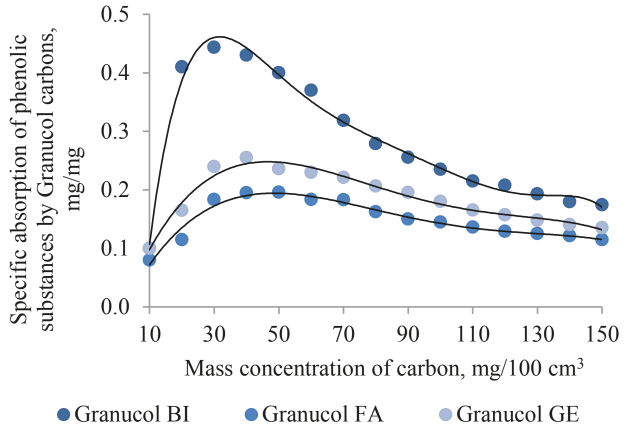


Fig. 2. Isotherms of adsorption of phenolic substances in sea-buckthorn wine material by different types of Granucol carbons.

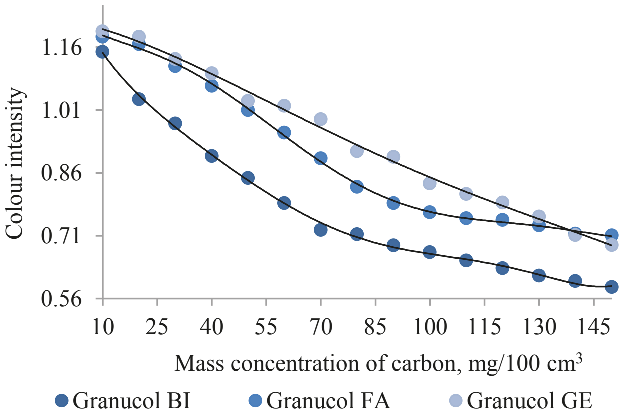


Fig. 3. Effects of the concentration and type of Granucol carbons on the colour intensity.

The optical properties of wine material help determine its quality, age, and technological peculiarities. For instance, one can define the age and composition by the colour of wine. Any deviations from the colour norm mean that the wine in question is defective.

A Shimadzu UV-1800 spectrophotometer was used

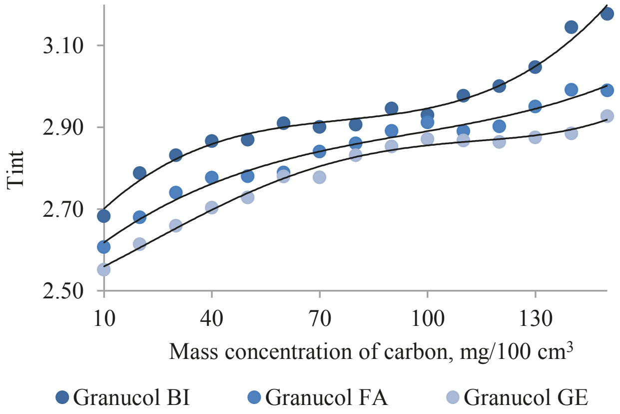


Fig. 4. Effects of the concentration and type of Granucol carbons on the tint of the wine material.

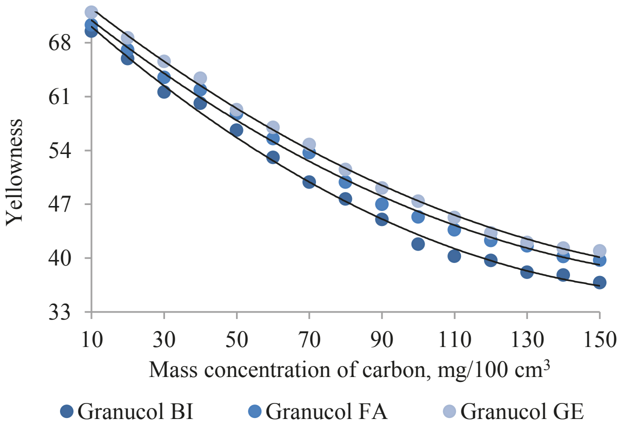
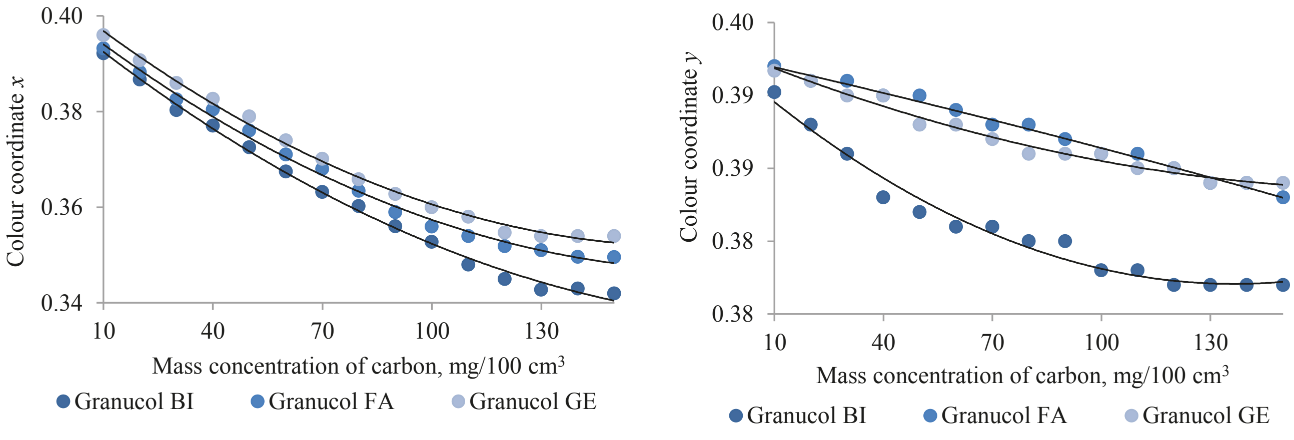


Fig. 5. Effects of concentration and type of Granucol carbon on the yellowness of the sea-buckthorn wine material.



(a) (b)

Fig. 6. Effects of the concentration and type of Granucol carbon on the displacement of the coordinates *X* and *Y* (according to the CIE 1931 chromatic system of coordinates).

to measure the optical density of the wine material in cuvettes with a path length of 10 mm. To define the intensity and tint of the colour, the optical density was measured at the waves of 420 and 520 nm. To obtain the trichromatic coordinates, we calculated the transmittance at 445, 495, 520, and 650 nm. The results were calculated according to the OIV methods [41, 42].

The following dependency graphs feature the colour intensity, tint, and yellowness according to the concentration of Granucol carbons (Fig. 3, 4).

The physical-and-chemical analysis and simple visual observation proved that Granucol carbon lowered the colour intensity. A larger mass of Granucol carbon changed the colour of the wine material from intense amber to light yellow. Granucol FA and Granucol GE also reduced the intensity of colour. However, the wines visually maintained the brown tint, which made them less attractive.

Yellowness is another factor that characterises the state of wine and wine materials, but fixed standards have been established for grape wines only [43]. Currently, yellowness is not used for sea-buckthorn wines assessment or for fruit wines in general. Nevertheless, we calculated the index of yellowness of our samples. Fig. 5 shows the changes of yellowness according to the concentration and type of Granucol carbon.

Remarkably, Granucol BI proved to be the most effective type of carbon to improve the wine colour: not only did it lower the amount of phenolic substances, but it also improved it by making the wine more visually attractive. Granucol FA and Granucol GE also improved the colour and removed partly the brown tint, but their amounts were higher.

The trichromatic colour coordinates of wine (*xyz*) and the subsequent coordinates *X* and *Y* were calculated according to the CIE Lab system of coordinates. Granucol carbon changed the coordinate *X* (the chromatic green-red axis) and produced almost no change on the coordinate *Y* (the chromatic yellow-blue axis) (Fig. 6a and 6b).

The beneficial effect of Granucol carbon on the aroma and taste were also quite remarkable (Fig. 7).

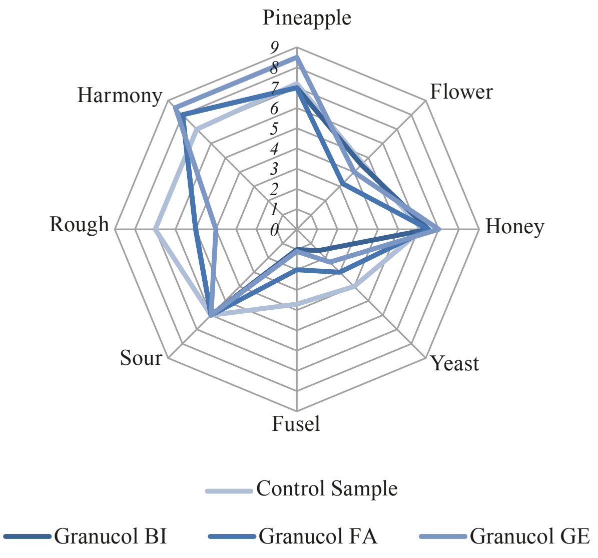


Fig. 7. Effects of Granucol carbon on the organoleptic properties of sea-buckthorn wine.

CONCLUSIONS

The present research proved that the activated carbon of the Granucol series can improve the sensory properties (taste and colour) of sea-buckthorn wine. The experiment demonstrated the effect of the concentration of carbons on the chromatic properties of wine. Granicol BI proved to be the most effective type of carbon to remove browning caused by oxidation, and Granucol GE greatly improved the sensory perception of taste and aroma.

CONFLICT OF INTEREST

The authors declare no conflict of interest related to this article.

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