Blended fruit wines based on stevia essence

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Abstract. The introduction of new technology of enhanced biological value fruit wine production using the vegetable sugar substitute (concentrated stevia essence) in food and processing industry plants will permit to enlarge the range of Russian wine products manufactured from domestic natural fruit raw material. Besides, the using of domestic raw materials in the technology of enhanced biological value fruit wine production will permit to solve the import dependency problem and to replace the foreign wine products with domestic high quality competitive products, as well as to reduce the product costs which may be achieved by the partial replacement of sugar by the sugar substitute made of stevia. The natural plant sugar substitute stevia was used instead of sugar in order to reduce the energy density of fruit wines. The stevioside is resistant to thermal conditioning and it has a low decomposition level in different pH levels. The study of quality and bioavailability of wine specimen was made with use of standard methods. The analysis of fruit wine specimen bioavailability showed that blended wine based on black currant and blackberry is more replete with vitamins, minerals, and organic acids. The elaborated blended wines are valuables because they contains plant raw materials which are harmonically combined with each other and complement one another, making antioxidant effects. They are capable to slow aging and to improve metabolism as well as to prevent illnesses and to boost the immune system. The use of stevia essence as a sugar substitute in fabrication of demi-sweet fruit currant and blackberry blended wines permits to produce low-calorie wines with equal palatability.

1. Introduction

In the latest time, the table wines fabricated from various fruit raw materials have become popular in the Russian Federation. But they are predominantly the wines of foreign manufacturer. The percentage of table fruit wines from all the fruit wines produced in Russia is only 5%. At that, the most of them are manufactured from reconstituted juice concentrates which are very often low quality. At the same time, in the most of climatic zones of Russia, there are large plantations of fruits which can serve as a raw material for wine fabrication.

The use of berries as a regional raw material in the fabrication of enhanced biological value fruit wines as a functional food may be of current importance now. It concerns wild harvests as well as cultivated berries. The fruits and berries contain nutrients (vitamins, minerals, antioxidants, etc.) and the use may permit to fill the gap of components entering into the human organism [3, 6].

Usually the harvesting of fruit raw materials takes place in July – September. It’s caused by a bulk berry maturing and the optimal accumulation of biologically active substances. The use of such raw
material creates problems with food preservation and non-transportability. That is why the making by local producers seems to be the most rational.

The availability of domestic fruit law material in the region of Nizhny Novgorod, in the Mari El Republic, in Udmurtia, in Mordovia, and in some other regions permits to enlarge the production of enhanced biological value fruit wines which would be competitive in the consumer's market of the region of Nizhny Novgorod. It will help to solve the problem of food security of the region and to provide the inhabitants with high quality and safe products.

Like juices, the fruit wines fabricated from natural raw materials contain organic acids, mineral and flavourings and other nutrients, which are healthy for human organism [5]. The curative properties of many fruits and berries are well known. But it’s typical of the fruit wines too.

According to the statistics, Russian consumer prefers demi-sweet wines in which there is a lot of sugar. It is established that now the abundant number of carbohydrates relative to recommended dietary allowance enter into the human organism [1, 2].

That is why the elaboration of a new enhanced biological value fruit wine production technology with the replacement of saccharose by a vegetable sugar substitute is of grand importance now. A natural sweetener (concentrated stevia essence) is suggested for using as a sugar substitute.

The purpose of this study is to elaborate a new enhanced biological value fruit wine production technology with use of the sugar substitute (stevia).

2. Materials and methods
The following raw materials were chosen as study subjects of wine production: fresh berries of raspberries, blackberry, black currant, red currant.

The sugar substitute stevia instead of sugar was used in order to reduce the energy value of the produced fruit wines. The stevioside is resistant to thermal conditioning and it has a low decomposition level in different pH levels. The research made by specialists of scientific Research Institute of Nutrition of the Russian Academy of Medical Sciences showed that if the stevioside is consumed regularly the index of sugar, radionuclides and cholesterols in the body decreases, the cell regeneration and the blood coagulation are improved, the blood vessels strengthen, the growth of neoplasms decelerates, lipid, protein, and water-salt metabolisms are restored.

Analyzing the technical information concerning the technological properties of different forms of stevia sugar substitutes (leaves, syrups and essences) the authors make the decision to use a concentrated stevia essence manufactured by the ООО “Steviya” (Republic of Crimea) due to technical standard ТУ 9199-001-00833266-2016 for the production of enhanced biological value fruit wines.

2.1. The organoleptic indicator determination
The methods of organoleptic analyzes of the products include the determination of appearance (clarity, the presence of crust), of color, of aroma (bouquet), tasting by the sense organs. The organoleptic examination of fruit wine specimen was made according to the state standard ГОСТ 32051–2013 “Wine products. Methods of organoleptic analysis”.

By the organoleptic indicators the table fruit wines have to be clear, without crust and inclusions, without alien tones in the aroma and tasting. The opalescence is allowed in the specimen of fruit wine.

The quality measures result in tasting points [4]. The general assessment was made by a 10-point scale: clarity - 0.5, color - 0.5, bouquet- 3.0; typicality - 1.0, tasting - 5.0. 9 experts, representatives of teaching staff of the chairs “Technologies of production, conservation and processing of plant cultivation products” and “Commodity research and proceeding of animal husbandry products” of Nizhny Novgorod State Agricultural Academy, make the examination of organoleptic indicators.

2.2. The physicochemical parameter determination
The experimental base of the study was the equipment of the laboratories of the Department of proceeding technologies of Nizhny Novgorod State Agricultural Academy, such as the laboratory of
special exam of consumer goods; laboratory of commodity research and food and non-food product homogeneous group examination; laboratory of microbiology, and interdepartmental teaching analytic laboratory.

The number of minerals and organic acids in the specimen of fruit wines was defined with measuring instruments and testing technique of the accredited laboratories.

3. Discussion of the results
The results of fruit wine specimen organoleptic indicator examination with comparison of black-currant and blackberry fruit wines based manufactured by the traditional technology (based on sugar) and by the author technology (with use of stevia essence) is represented in tables 1 and 2. The appearance of specimen of wine manufactured with the use of concentrated stevia essence is shown in figure 1.

Table 1. Taste panel score of fruit wine specimens, points

| Wine                        | Performance indicator |       |       |       |       | Total, points |
|-----------------------------|-----------------------|-------|-------|-------|-------|---------------|
|                             | Clarity | Color | Aroma | Tasting | Typicality |               |
| Control specimens (sugar)   |         |       |       |         |           |               |
| Black-currant               | 0.5     | 0.5   | 2.9   | 4.8     | 1.0     | 9.7           |
| Black currant, red currant, | 0.5     | 0.5   | 2.7   | 4.3     | 0.9     | 8.9           |

Specimens (concentrated stevia essence)

| Black-currant               | 0.5     | 0.5   | 2.9   | 5.0     | 1.0     | 9.9           |
| Black currant, red currant  | 0.5     | 0.5   | 2.7   | 4.3     | 0.8     | 8.8           |

Making the examination of black-currant wine the tasters noted that it has a higher organoleptic points than the red currant wine because this berry has a more strong aroma and a more strongly pronounced tasting then red currant. That is why the black-currant wine totally received 9.7 (control specimens) and 9.9 points (experimented specimens).

Table 2. Taste panel score of blackberry wine specimens, points

| Wine                        | Performance indicator |       |       |       |       | Total, points |
|-----------------------------|-----------------------|-------|-------|-------|-------|---------------|
|                             | Clarity | Color | Aroma | Tasting | Typicality |               |
| Control specimens (sugar)   |         |       |       |         |           |               |
| Blackberry                  | 0.5     | 0.3   | 1.5   | 3.0     | 0.4     | 5.7           |
| Raspberries-blackberry      | 0.5     | 0.5   | 3.0   | 4.0     | 1.0     | 9.0           |

Experimented specimens (stevia essence)

| Blackberry                  | 0.5     | 0.3   | 1.5   | 3.2     | 0.4     | 5.9           |
| Raspberries-blackberry      | 0.5     | 0.5   | 3.0   | 4.0     | 0.9     | 8.9           |
The examination of blackberry wine showed that blended wines with raspberries addition has higher points than blackberry wine in all the parameters excepting clarity (the point by this parameter was equal in all the specimens). The blended fruit wine received the highest points.

The specimens of black-currant and blackberry wine fabricated with use of stevia essence received less points in the parameter clarity. The natural sugar substitute provoked a longer sweet and unusual afterglow.

![Figure 1. The appearance of fruit wines with stevia essence: (a) - «Black-currant»; (b) - «Black-currant - red currant»; (c) - «Blackberry»; (d) - «Raspberries - blackberry»](image)

The physicochemical parameters of blackberry and black-currant wine experimented specimens are represented in tables 3 and 4.

**Table 3.** The physicochemical parameters of blackberry and black-currant wine experimented specimens

| Wine name                  | Ethanol volume ratio, % | Total sugars, g/dm³ | Mass concentration of titratable acids in terms of malic acid, g/dm³ |
|----------------------------|-------------------------|---------------------|---------------------------------------------------------------------|
| Control specimens (sugar)  | 9.8, 70.22              | 12.3                |
| Black-currant              | 9.7, 70.23              | 14.5                |

| Experimented specimens (concentrated stevia essence) | Ethanol volume ratio, % | Total sugars, g/dm³ | Mass concentration of titratable acids in terms of malic acid, g/dm³ |
|-----------------------------------------------------|-------------------------|---------------------|---------------------------------------------------------------------|
| Black-currant                                       | 9.8, 0.22               | 13.3                |
| Black-currant-red currant                           | 9.7, 0.26               | 15.5                |

The ethanol volume ratio in the control and experimented specimens of blended and unblended black-currant wine was equal.

The mass concentration of titratable acids in terms of malic acid in the black-currant blended wine specimen was a little higher – by 2.2 g/dm³ in control as well as in the experimented specimens.
The ethanol volume ratio in the control and experimented specimens of blackberry unblended and blended wine was 9.2% and 9.5% (a little higher) respectively (table 4).

**Table 4.** The physicochemical parameters of the blackberry wine specimens

| Wine name                | Ethanol volume ratio, % | Total sugars, g/dm³ | Mass concentration of titratable acids in terms of malic acid, g/dm³ |
|--------------------------|-------------------------|---------------------|---------------------------------------------------------------|
| Control specimens (sugar) |                         |                     |                                                               |
| Blackberry               | 9.2                     | 71.12               | 9.8                                                           |
| Raspberries-blackberry   | 9.5                     | 70.13               | 7.9                                                           |
| Experimented specimens (concentrated stevia essence) |                         |                     |                                                               |
| Blackberry               | 9.2                     | 0.29                | 10.7                                                          |
| Raspberries-blackberry   | 9.5                     | 0.25                | 9.3                                                           |

According to the standard the ethanol volume ratio value in the fruit wines may be from 6.0 to 15.0%. The discrepancy between the results of two parallel determinations within the limits of repeatability and relative error amounted to 0.03% (at that the reference value is 0.10%).

The mass concentration of titratable acids in terms of malic acid in the blackberry blended wines was a little lower - by 1.9 g/dm³ in the control specimen and by 1.4 g/dm³ - in the experimented specimen.

The sugar volume in stevia essence wines is minimal. But the stevia essence which was added to the dry wine made the wine sweet tested. The discrepancy between the results of two parallel determinations within the limits of repeatability and relative error amounted to 0.3% (at that the reference value is 1.2%).

The standard do not regulate the quantity of vitamins, minerals, and organic acids but this index characterizes the biological value of the wine.

The results of stevia essence of fruit wine experimental specimen biological value are represented below. The blackberry and black-current unblended wine specimens served control specimens (table 5).

**Table 5.** The quantity of vitamins in the stevia essence fruit wine specimens, mg/l

| Vitamins  | Indicators               | Black-currant (control) | Black-currant-red currant | Blackberry (control) | Raspberries-blackberry |
|-----------|--------------------------|-------------------------|---------------------------|----------------------|------------------------|
| C         |                          | 18.8                    | 22.94                     | 15.8                 | 18.98                  |
| β-carotene|                          | 0.15                    | 0.17                      | 0.07                 | 0.1                    |
| B₁        |                          | <0.01                   | 0.030                     | <0.01                | 0.030                  |
| B₂        |                          | 0.05                    | 0.15                      | 0.05                 | 0.33                   |
| B₃        |                          | <0.5                    | <0.5                      | <0.5                 | <0.5                   |
| B₆        |                          | <0.02                   | <0.02                     | <0.02                | <0.02                  |
| PP        |                          | <0.5                    | <0.5                      | <0.5                 | <0.5                   |

It was established that there were three time more thiamine and lactoflavin in the blended black-current- red currant wine than in the control specimen of the unblended raspberries-blackberry. The index of β-carotene is a little higher (by 0.02mg/l) in the blended wine. Besides, the index of ascorbic acid is higher by 4.14 mg/l.

The index of thiamine and lactoflavin in the raspberries-blackberry blended wine is higher (3 and 6.6 time respectively) in comparison with the -blackberry unblended wine (control).
The β-carotene index is inconsiderably higher (by 0.03 mg/l) in comparison with the control specimen.

The ascorbic acid index in the blackberry wine control specimen was 15.8 mg/l. It is by 3.18 mg/l lower than in that of raspberries-blackberry blender wine. The blackberry and black-currant blended wine specimens suggested by the author are more replete with minerals than the control specimens of unblended wines (table 6, figure 2).

Table 6. The quantity of micro- and macroelements in the stevia essence fruit wine specimens, mg/l

| Mineral elements | Black-currant (control) | Black-currant-red currant | Blackberry (control) | Raspberries-blackberry |
|------------------|-------------------------|---------------------------|----------------------|------------------------|
| Natrium          | 35                      | 11.6                      | 45                   | 10.6                   |
| Magnesium        | 5.2                     | 76                        | 61                   | 96                     |
| Potassium        | 23.8                    | 176                       | 129                  | 135                    |
| Calcium          | 6.0                     | 136                       | 45                   | 103                    |
| Manganese        | 0.66                    | 0.97                      | 0.9                  | 1.6                    |
| Iron             | 1.1                     | 1.8                       | 3.9                  | 0.2                    |
| Copper           | <0.01                   | <0.01                     | 0.08                 | 0.07                   |
| Zinc             | 0.3                     | 0.6                       | 0.7                  | 0.6                    |
| Phosphorus       | 9.6                     | 144                       | 84                   | 68                     |

The quantity of potassium, calcium and phosphorus in Black-currant-red currant blended wine specimens is higher by 7.4; 22.7; 15 time respectively relative to the unblended wine control specimen.

Moreover, the blended wine specimen is remarkable for its higher quantity of magnesium, manganese, iron, zinc. But the natrium quantity is an exception. Its quantity in the unblended wine is by 23.4 mg/l lower than in that of the control specimen. The copper quantity is equal in both specimens – lower than 0.01 mg/l.

![Figure 2](image_url)
The quantity of magnesium, potassium and calcium was higher relative to the control specimen by 35; 6; 58 mg/l respectively.

The quantity of organic acids in the concentrated stevia essence fruit wine specimens is shown in the table 7. The research data show that the dominating substance in the researched wine specimens is citric acid. Tartaric acid is absent in the control specimen but it forms in the Black-currant- red currant blended wine. It is a result of must fermentation. Malic, siccine and lactic acids also predominate in the blended wine specimen. Their quantity in the black-currant- red currant wine is higher by 0.55; 0.9; 0.11 g/dm³ respectively relative to the control specimen value.

Table 7. The quantity of organic acids in the stevia essence fruit wine specimens, g/dm³

| Organic acids     | Black-currant (control) | Black-currant-red currant | Blackberry (control) | Raspberries-blackberry |
|-------------------|--------------------------|----------------------------|----------------------|------------------------|
| Tartaric acid     | 0.25±0.05                | 0.25±0.05                  | 1.2±0.2              | 0.19±0.04              |
| Malic acid        | 0.35±0.07                | 0.9±0.2                    | 0.37±0.07            | 0.44±0.05              |
| Citric acid       | 4.1±0.8                  | 11±2                       | 5±1                  | 6±1                    |
| Siccine acid      | 0.6±0.1                  | 1.5±0.3                    | 0.8±0.2              | 0.9±0.2                |
| Lactic acid       | 0.39±0.08                | 0.5±0.1                    | 0.99±0.21            | 0.29±0.06              |
| Acetic acid       | 0.41±0.08                | 0.17±0.2                   | 0.35±0.07            | 0.72±0.1               |
| Sorbic acid       | -                        | -                          | 100±20               | 8±2                    |

The sorbic acid quantity in the black-currant wine specimens is not established. The acetic acid quantity in the blended wine is lower by 0.35 g/dm³. It is favorable for wine qualitative characterization persistency.

The quantity of the main organic acids in the blackberry wine specimens is equal. However, a higher level of sorbic acid in the blackberry control specimen (100±20 g/dm³) is noted. It is 12.5 time higher than in that of the raspberries-blackberry blended wine specimen. The quantity of acetic acid in the raspberries-blackberry specimen is 0.37 g/dm³ higher.

So, it is established by the results of fruit wine specimen biological value assessment that raspberries and blackberry black-currant blended wines.

The analysis of fruit wine specimen bioavailability showed that blended wine based on black currant and blackberry is more replete with vitamins, minerals, and organic acids (exceptive raspberries-blackberry wine in which the organic level is the same or lower). Undoubtedly, the blended wines thanks to their chemical composition may benefit the human organism if they are consumed in moderate quantity.

4. Conclusion
The elaborated blended fruit wines are valuables because they contain plant raw materials which are harmonically combined with each other and complement one another, making antioxidant effects. They are capable to slow aging and to improve metabolism as well as to prevent illnesses and to boost immune system. They drive to the improvement of the digestion, of the cardiovascular system; they improve the emotional state and may be recommended for persons with diseases of the endocrine system. The use of stevia essence as a sugar substitute in fabrication of demi-sweet fruit black-currant and blackberry blended wines permits to produce low-calorie wines with equal palatability.

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