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ORIGINAL RESEARCH PAPER

# DEVELOPMENT AND ANALYSIS OF FRUIT BEVERAGES WITH ANTIOXIDANT PROPERTIES

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**Abstract**: The interest for developing functional beverages by using fruits is increasing every day. This article presents an improved technology for the production of fruit beverages that does not use primary deep heat treatment of raw materials. The obtained beverages were analyzed regarding several physical indicators, content in compounds that possess antioxidant properties and a sensorial assessment. Beverages obtained from chokeberry, hawthorn and rose hip, had the highest levels of biologically active substances and strawberries, blackberries, black currant and cherry, the highest overall rating for the sensorial analysis. All the developed beverages have great market potential due to their content in bioactive compounds and their appeal to consumers.

**Keywords**: *antioxidants, fruit beverages, functional products, sensorial analysis, technology*

## INTRODUCTION

Nowadays, the use of fruits used for production of functional products has grown. Black currant, chokeberry, and fox grapes (*Vitis labrusca L.*) are some of the fruits that grow in the Tambov region that are stable and provide high crop yields every year [1, 2].
For a long time, Michurinsky State Agrarian University has been engaged in the selection of apple trees that have a high content of anthocyanins in leaves and pulp, the so-called "red-leaved" or "red-pulped" apple trees. These are one of the most adaptive crops for the CBS zone. Their use in processing was insufficiently studied, since the products obtained from these fruits are significantly different from traditional ones [3, 4].
Fruits are great sources of various biologically active compounds, such as: vitamins, polyphenolic compounds, organic acids, sugars, macro- and micronutrients, dietary fibers and other compounds that are required for daily synthesis and construction of cells, as well as for normal metabolic processes and other functions in the human body [3 – 7].
The research regarding functional foods and dietary supplements is constantly increasing nowadays, due to their importance in maintaining human health [8]. The developments of new and improved processing technologies and analysis methods for products that possess antioxidant properties have proven to be beneficial for the expansion of both food and pharmaceutical industries [9 – 12].
Due to the presence of a wide range of biologically active substances, fruits like: black currant, grapes, chokeberry, rose hips and others, have the ability to strengthen the immune system and increase the defenses of the human body due to their antioxidant properties [1, 2, 7, 9].
The chemical composition of fruits used as raw materials determines the products taste, aroma and especially color because of several technological operations performed in the manufacturing of food products [4, 13, 14].
The aim of this study is to obtain beverages from fruits acquired locally by using an innovative technology, and to analyze them regarding the content in biologically active substances that possess antioxidant properties alongside with the sensorial analysis in order to establish their benefits.

## MATERIALS AND METHODS

Experimental studies were conducted in the "Functional Nutrition Products" laboratory from the Michurinsky State Agrarian University in 2017-2018.

### *Preparation of drinks*

The raw material used were: wild hawthorn, chokeberry Chernookaya variety, rosehip Vitamin variety, apples with red pulp (hybrid 87-3-2), fox grapes (*Vitis labrusca* L.), gooseberries Russian yellow variety, garden strawberries Zephyr variety, blackberries Agaveam variety, black currant Zelenaya dymka variety and cherry Molodezhnaya variety.
In order to obtain the pulp, grapes, gooseberries, and black currant were squeezed after jelly production, and the other fruits were crushed. Water at a temperature of 40 °C was

poured on the resulting pulps and kept for 1 - 2 hours, until 2.5 - 3% of the soluble solids were extracted. The mixture was filtered and heated. Sugar was added until the soluble solids were 10 - 14 %, depending on the acidity of the mixture and the taste. The obtained drinks were poured into 0.33 L glass bottles and pasteurized at 85 °C.

***Analysis methods***

*Titratable acidity of fruits*

5 mL of sample were diluted with purified water and titrated with 0.1N NaOH solution in the presence of phenolphthalein as an indicator. The results were expressed as percentage of total acidity [15].

*Determination of soluble solids*

The refractive index of the analyzed solution is measured on a refractometer at a temperature of 20.0 ± 0.5 °C. The mass fraction of soluble solids (in terms of sucrose) obtained as a result of the study shows that the solutions are soluble in solids on a refractometer scale [16].

*Quantification of ascorbic acid in fruits*

5 mL of sample were inserted into a titration flask with 10 mL of 2N HCl, diluted to 50 mL with distilled water. 1 mL freshly prepared 1 % starch solution and 0.1N KI solution were added. The mixture was titrated with a 0.1N $K_2Cr_2O_7$ solution to a persistent blue color. The results were calculated considering that 1 mL 0.1N $K_2Cr_2O_7$ solution corresponds to 8.806 mg ascorbic acid and they were expressed as mg ascorbic acid in 100 mL of beverage [17].

*Quantification of flavonoids*

In a 25 mL volumetric flask 5 mL of fruit drink, 5 mL of a $CH_3COONa$ 100 $g \cdot L^{-1}$ solution and 3 mL of an $AlCl_3$ 25 $g \cdot L^{-1}$ solution were added, shaken, and brought to mark with water and left for standing 15 minutes. The absorption was determined at 430 nm. The calibration curve was constructed by using a rutin standard solution and the results were expressed as mg flavonoids in 100 mL of beverage [18].

*Quantification of anthocyanins*

In a 50 mL volumetric flask 10 mL of buffer solution *p*H = 1 and 1 mL of fruit drink were added, and the flask was brought to mark with buffer solution *p*H = 1. In another 50 mL volumetric flask, 10 mL of buffer solution *p*H = 4.5 and 1 mL of fruit drink were added, and the flask was brought to mark with buffer solution *p*H = 4.5. Both flasks were stirred and left to stand for 5 minutes in the dark. The absorption of the two solutions was determined at 520 nm and 700 nm. The content of anthocyanins was calculated with the following formula: Anthocyanins = $A \cdot M \cdot d \cdot 100/e \cdot l$; where $A=(A_{520nm} - A_{700nm})_{pH=1} - (A_{520nm} - A_{700nm})_{pH=4.5}$, M is the molecular weight of cyanidin-3- glucoside, d is the dilution factor, e is the molar extinction coefficient and l is the path length of the cell. The results were expressed as mg anthocyanins in 100 mL beverage [19].

*Determination of catechins*

0.8 mL of fruit drink was taken in two tubes. 4 mL of a 1 % solution of vanillin in concentrated hydrochloric acid were poured into one of them and the volumes were adjusted to 5 mL in both tubes with concentrated hydrochloric acid. A test tube without vanillin was used as a control. In the presence of catechins in the sample, pink, raspberry or orange-red colour is formed. After 5 min, the intensity of the coloured solutions was measured spectrophotometrically at 504 nm. The quantitative content of catechins in the sample was determined by a calibration curve constructed using the (±) catechin standard solution [20].

All results were obtained in triplicate. All the used reagents were analytical grade, and the purity of the analytical standards was 99% for rutin and 98% for (±) catechin.

*Sensory analysis*

The sensory analysis was performed in accordance with the "Technology of storage and processing of fruits and vegetables with the basics of standardization" according to E.P. Shirokova [21, 22].

## RESULTS AND DISCUSSION

Beverages obtained from gooseberries, fox grapes and black currant had the highest acidity of all the obtained beverages and the lowest *p*H value. The acidity of the beverages is proportional to the one in the fruits used for their developing (Table 1).

The energy value of the beverages was proportional with the soluble solids content, thus beverages obtained from black currant, strawberries and chokeberries had the highest soluble solids content and the highest energy value (Table 1).

***Table 1.*** *Physical and chemical indicators and energy value of functional fruit beverages*

| Fruit used for obtaining beverage | Soluble solids, [%] | *p*H | Total acidity, [%] | Energy value, [kcal /100 g] |
|---|---|---|---|---|
| Wild hawthorn | 10.2 | 3.1 | 0.20 | 40.0 |
| Chokeberry | 13.5 | 3.0 | 0.34 | 54.0 |
| Rosehip | 11.5 | 3.5 | 0.27 | 46.0 |
| Hybrid red pulp apple | 11.6 | 3.0 | 0.17 | 46.4 |
| Fox grape | 12.3 | 2.9 | 0.38* | 49.2 |
| Gooseberry | 11.6 | 2.6 | 0.57 | 46.4 |
| Strawberry | 13.7 | 2.8 | 0.27 | 54.8 |
| Blackberry | 12.3 | 2.8 | 0,20 | 49.2 |
| Black currant | 14.4 | 2.7 | 0.34 | 57.6 |
| Cherry | 11.1 | 2.9 | 0.27 | 44.4 |

* The calculation was carried out on grape acid

Further studies were carried out in order to study the chemical composition of the obtained beverages, thus several compounds that possess antioxidant properties were analyzed (Table 2).

***Table 2.*** *The content of biologically active compounds in fruit beverages (in 100 mL of beverage)*

| Fruit used for obtaining beverage | Anthocyanins [mg] | Catechins, [mg] | Flavonoids, [mg] | Ascorbic acid, [mg] | Ascorbic acid recommended daily intake satisfaction, [%] |
|---|---|---|---|---|---|
| Wild hawthorn | 13.8 | 7.5 | 58.3 | 25.52 | 32.0 |
| Chokeberry | 187.5 | 45.0 | 20.0 | 15.84 | 20.0 |
| Rosehip | 38.5 | 118.8 | 17.5 | 101.16 | 127.0 |
| Hybrid red pulp apples | 2.5 | 8.5 | 13.5 | 11.00 | 14.0 |
| Fox grape | 13.8 | 12.5 | 23.2 | 58.08 | 73.0 |
| Gooseberry | 4.1 | 18.8 | 17.0 | 38,70 | 49.0 |
| Strawberry | 4.7 | 3.8 | 15.9 | 2.61 | 4.0 |
| Blackberry | 101.0 | 42.5 | 19.9 | 3.55 | 5.0 |
| Black currant | 95.9 | 11.3 | 14.7 | 8.80 | 11.0 |
| Cherry | 19.7 | 2.5 | 25.0 | 4.42 | 6.0 |

The highest quantities of antioxidant compounds were found in fruit beverages obtained from rosehip, chokeberry, and fox grapes. The highest amount of ascorbic acid was determined for beverages obtained from rosehip, fox grape and gooseberry (Table 2).

The ascorbic acid recommended daily intake satisfaction was assessed for the developed beverages and in order to meet daily requirement of 15 % [7] the use of several volumes of beverage is required, like: wild hawthorn beverage - 47 mL, chokeberry beverage – 75 mL, rosehip beverage - 12 mL, hybrid red pulp apple beverage - 107 mL, fox grape beverage - 21 mL, gooseberry beverage – 31 mL, strawberry beverage - 375 mL, blackberry beverage - 300 mL, black currant beverage - 136 mL and cherry beverage – 250 mL.

The quantity of anthocyanins determined has a very important role in the functionality of the beverage due to its antioxidant properties and for the appealing factor for the consumer, because of the coloring properties that are very important in the appearance of the product. All the beverages were appealing and properly colored from pale yellow for wild hawthorn and gooseberries, orange for rosehips, pale red for apples and strawberries to deep burgundy in cherries, chokeberries, grapes, blackberries, and black currant. The highest amounts of anthocyanins were found in beverages with chokeberry, blackberry, and black currant: 95.9 mg in black currant, 101 mg for blackberry and 187.5 mg in chokeberry.

The sensorial evaluation of the products was carried out on a 10-point system, taking into consideration the coefficient of significance of the indicator (Table 3).

The beverages obtained were attractive for consumers regarding their appearance, taste, and smell. These characteristics are specific for each fruit.

Even though strawberries and hybrid red pulp apples do not possess significant quantities of antioxidant compounds, their specific aroma and taste (Table 3) qualifies them to be successful beverages and blends.

***Table 3.*** *Sensorial analysis of fruit beverages*

| Fruit used for obtaining beverage | Appearance, coefficient 0.35 | Color, coefficient 0.55 | Aroma, coefficient 0.40 | Taste, coefficient 0.70 | Overall rating |
|---|---|---|---|---|---|
| Wild hawthorn | 1.75 | 2.64 | 1.6 | 3.50 | 9.49 |
| Chokeberry | 1.75 | 2.75 | 2.0 | 3.36 | 9.86 |
| Rosehip | 1.70 | 2.75 | 1.9 | 3.36 | 9.71 |
| Hybrid red pulp apples | 1.57 | 2.48 | 2.0 | 3.36 | 9.41 |
| Fox grape | 1.68 | 2.75 | 2.0 | 3.50 | 9.93 |
| Gooseberry | 1.57 | 2.48 | 1.8 | 2.80 | 8.65 |
| Strawberry | 1.75 | 2.75 | 2.0 | 3.50 | 10.00 |
| Blackberry | 1.75 | 2.75 | 2.0 | 3.50 | 10.00 |
| Black currant | 1.75 | 2.75 | 2.0 | 3.50 | 10.00 |
| Cherry | 1.75 | 2.75 | 2.0 | 3.50 | 10.00 |

## CONCLUSION

Fruit raw materials were not subjected to deep heat treatment at the first stage according to our technology, thus decreasing the loss of several compounds that possess antioxidant properties.

Fruit beverages from crops such as rosehip, chokeberry and fox grapes were distinguished by high levels of biologically active substances and the beverages from cherries, strawberries, black currant, and blackberries were distinguished by their superior sensorial properties.

Due to their content in biologically active compounds and their satisfactory sensorial properties, all the beverages developed and analyzed by means of this research are proper for human consumption.

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