Nutritional value of promising raspberry varieties

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Abstract. Raspberry is a crop, characterized by a valuable chemical composition, which determines the wide spectrum of its utilization not only as a fresh fruit, but also as a plant raw material for the food industry. The purpose of the paper is to make an integrated assessment for the fruit of promising raspberry varieties from genetic pool of FSSI "I.V. Michurin FSC” for nutrient and biologically active substances content and mineral elements. The object of investigation was 18 raspberry fruit varieties. The varieties are promising for cultivation in the Central Black Soil region of Russia. Chemical analyses of fruit were carried out with the use of spectrophotometric, chromatographic (HPLC), atomic absorption methods. As it was found, the significant variation in chemical composition indicators turned to be dependent on varietal features. The raspberry fruit accumulated 2.9–3.9% of dietary fibre, 0.34–1.3% of protein, 13.6–31.1 mg/100g of vitamin C, 0.2–83.6 mg/100g of anthocyanins, 0.14–0.90 mg/100g of niacin, 0.1–0.9 mg/100g of resveratrol, 0.2–3.1 mg/100g of piceid, 118.8–388.0 mg/100g of potassium, 0.29–0.97 mg/100g of iron. A high level accumulation of ascorbic acid was found in Gerakl, Evrazia, Zhar-ptitsa, Peresvet varieties; anthocyanins – in Evrazia, Gerakl, Polka, Rubinovoe ozherel'e; resveratrol and piceid – in “Zhelty gigant” and “Rubinovoe ozherel'e” varieties. The studied varieties are recommended as edible fresh fruit and for the consumption in the frozen form. Preventive food production is also appropriate.

1. Introduction
The fruits and berries with a low energy value have a number of vital carbohydrates, organic acid, as well as vitamins and phenolic compounds providing antioxidant protection of the organism against stressors of life and development of most non-infectious diseases leading to reduced working capacity and shortened human life [1-4].

Raspberry is one of the most popular crops. This is due to its ability to grow in various climatic zones, ten of berry-like plants have tendency to frost killing, rotting, and can be damaged by late-spring and early-fall frosts. Sometimes they suffer from a lack of a moisture in hot summer. The raspberry is distinguished by early fruiting, regular fruitage. And because of the late terms of flowering, it can hardly be damaged by frosts. Raspberry has a long-term flowering period, due to which only very few flowers are damaged and this does not affect the productivity. The raspberry fruit is one of the promising sources for functional food. The raspberry fruit are very soft with dry substances content at the level of 10-23% [5]. Organic acids are the components that affect the taste of raspberries, mainly citric, malic, oxalic and succinic acids. Values of total acidity are in the range from 0.5 to 2.8% in terms of citric acid [6, 7]. In yellow-fruited raspberries the content of β-carotene is 9.9 ml/100g. In red-fruited raspberries it was 0.28 ml/100g [8]. The accumulation of ascorbic acid in fruit...
varies within 5-40 mg/100g [9]. The total content of tocopherol is 14.0-36.0 mg/100g, of which γ-
tocopherol – 5.4-19.7 mg/100g and α-tocopherol – 0.07-2.1 mg/100g [10]. It was found that raspberry
fruit are characterized by a high-level accumulation of polyphenolic compounds from 142 to 758
mg/100g in terms of gallic acid. The main representatives of phenolic compounds in raspberry fruit are
ellagic acid, gallic acid, caffeic acid, epicatechin, quercetin, lambertianin, kempferol [11, 12]. In
addition, raspberries tend to accumulate such important polyphenolic compounds as anthocyanins due
to their presence the fruit have P-vitaminous and antioxidant properties and they are suitable for
freezing and technological processing. Depending on the variety and place of cultivation,
thanthocyanidins can be found in raspberries, especially cyanidin-3-sophoroside (41.2-62.0 mg/100g)
and cyanidin-3-glucoside (10.1-15.2 mg/100g) [13, 14].

Resveratrol is one of the best representatives of stilbenoid group. It is characterized by strong
antioxidant properties. Piceid (resveratrol-3-α-β-glicoside) is one of the most famous derivatives of
resveratrol. According to literary data, the most important sources of stilbenoids are the fruit of grape,
sweet cherry, blueberry [15]. There is a lack of information about accumulation of the compounds in
raspberry fruit. Thus, the research on identifying the appropriate raspberry varieties is relevant.
Change of physical and technical characteristics in fruit and berry production is determined by various
factors such as a variety, cultivation technology, area of growing, stage of maturation, harvest time,
conditions of storage and postharvest technologies [16-18].

2. The purpose of the study
The purpose of the present study was in integrated appreciation of raspberry varieties from FSSI “I.V.
Michurin FSC”. The attention was paid to the content of nutritional and biologically active substances,
mineral elements.

3. The object of the study
The fruits of 18 raspberry varieties were regarded as biological objects of the investigations. There
were usual varieties of raspberry (Mirazh, Meteor, Scromnitsa, Zheldy gigant, Peresvet, Patritsia,
Beglyanka, Maroseyka) and remontant ones (Oranzhevoye chudo, Polka, Polana, Evrazia, Zolotaya
osen, Gerakl, Rubinovoye ozherel’e, Bryanskoye divo, Zhar-ptitsa, Elegantnaya) from genetic pool of
the FSSI “I.V. Michurin FSC”. The varieties are promising for cultivation in the Central Black Soil
region of Russia.

4. Materials and methods
Chemical analyses of the fruit were carried out according to the standard methodical
recommendations: mass fraction of dry substances (or moisture) was determined by drying out to the
constant weight at a temperature of 105°C according to GOST 28561-90 [19]; fermentative method –
according to the Manual of Russia 4.1.1672-03 [20]; mass fraction of protein – by the GOST 26889-86
[21]. The definition of organic acid, resveratrol and piceid, was carried out with the use of the
photometric method in the conditions of reserved phase HPLC Agilent 1100 (Agilent Technologies,
USA), ascorbic acid – titration with the solution of 2.6-Dichlorophenol-indophenol sodium salt
derhydrate. Total flavonols were determined by the spectrophotometric method, total anthocyanins – by
pH-differential spectrophotometry with the use of spectrophotometer Shimadzu “UV-1800”
(Shimadzu Corporation, Japan) [20, 22]. Statistical processing of results was done using Software
package SPSS 20/0 (“IBM”, USA).

5 Discussion of the results
The water content in juicy raspberry fruit is within 86.2-92.0%. More water was accumulated in the
fruit of the varieties: Bryanskoye divo, Rubinovoye ozherel’e (table 1). The range of ash elements was
from 0.33% (“Bryanskoye divo”) to 0.61% (“Mirazh”). The differences of varieties by this character
increased almost two times. The raspberry does not belong to high protein products. The protein
content in the studied varieties ranged greatly from 0.34% (“Polana”) to 1.67 (“Mirazh”) at an average
value of 0.93%. The protein accumulation with its indices higher 75th percentile is observed in "Evrazia", "Maroseyka", "Mirazh" and "Rubinovoye ozherel'e" varieties.

The consumption of raspberry fruits (250 g) provides a daily need in proteins (75 g) on the whole by 3.1%. The total number of nutritional fibers in the fruits of the studied varieties ranged from 2.9% ("Maroseyka") to 3.9% ("Gerak", "Zhar-ptitsa"), the variations in the content were 1.3 times more depending on the variety. The highest accumulation of the nutritional fiber of no less than 3.7% was found in 4 varieties from the studied 18 varieties "Gerakl", "Zhar-ptitsa", "Oranzhevoye chudo", "Mirazh". As a result of the data obtained, insoluble nutritional fiber is dominant in raspberry (68.6%). The necessary daily norm for consumption of nutritional fiber is 20 g [23]. 100 g of raspberry fruit provides the human organism by 11.7% of such components.

| Variety                      | Ash  | Water | Protein | Nutritional fiber | Total |
|------------------------------|------|-------|---------|-------------------|-------|
|                             |      |       |         | insoluble         |       |
| Beglyanka                    | 0.60 | 86.2  | 0.83    | 2.1               | 0.9   | 3.0 |
| Bryanskoye divo              | 0.33 | 89.7  | 0.84    | 2.0               | 1.5   | 3.5 |
| Gerak                        | 0.40 | 88.9  | 1.00    | 3.0               | 0.9   | 3.9 |
| Evrazia                      | 0.40 | 86.3  | 1.33    | 2.1               | 1.4   | 3.5 |
| Zhar-ptitsa                  | 0.35 | 86.3  | 0.86    | 2.1               | 1.8   | 3.9 |
| Zhelty gigant                | 0.57 | 86.4  | 0.72    | 2.5               | 1.0   | 3.5 |
| Zolotaya osen                | 0.34 | 88.7  | 0.75    | 2.4               | 1.0   | 3.4 |
| Maroseyka                    | 0.55 | 88.3  | 1.16    | 2.2               | 0.7   | 2.9 |
| Meteor                       | 0.62 | 85.3  | 0.83    | 2.8               | 0.8   | 3.6 |
| Mirazh                       | 0.61 | 86.8  | 1.67    | 3.1               | 0.6   | 3.7 |
| Oranzhevoye chudo            | 0.60 | 87.4  | 1.04    | 2.6               | 1.2   | 3.8 |
| Patritcia                    | 0.59 | 86.5  | 0.81    | 2.4               | 0.9   | 3.3 |
| Peresvet                     | 0.60 | 85.0  | 0.72    | 2.9               | 0.5   | 3.4 |
| Rubinovoye ozherel'e         | 0.49 | 89.3  | 1.15    | 1.9               | 1.5   | 3.4 |
| Scromnitsa                   | 0.52 | 87.1  | 0.83    | 2.7               | 0.9   | 3.6 |
| Elegantnaya                  | 0.40 | 85.2  | 1.05    | 2.2               | 1.3   | 3.5 |
| Polka                        | 0.45 | 92.0  | 0.83    | 1.9               | 1.6   | 3.5 |
| Polana                       | 0.31 | 88.8  | 0.34    | 2.2               | 1.3   | 3.5 |
| Mean                         | 0.49 | 87.5  | 0.93    | 2.4               | 1.1   | 3.5 |
| Standard errors              | 0.03 | 0.43  | 0.07    | 0.09              | 0.09  | 0.06|
| Median                       | 0.51 | 87.0  | 0.84    | 2.3               | 1.0   | 3.5 |
| Percentile                   |      |       |         |                   |       |
| 25th                         | 0.39 | 86.3  | 0.80    | 2.1               | 0.9   | 3.4 |
| 75th                         | 0.60 | 88.8  | 1.08    | 2.7               | 1.4   | 3.7 |

The citric acid is dominant in raspberry fruit, its accumulation ranges from 466 mg/100g ("Beglyanka") to 1750 mg/100g ("Polka"), see table 2. The malic acid content is significantly lower and it ranged from 7.4 mg/100g ("Beglyanka") to 63.0 mg/100g ("Polana"). The highest total accumulation of acids was observed in "Evrazia", "Polka", "Polana" varieties.

The level of ascorbic acid accumulation was averagely 21.7 mg/100g ranging from 13.6 mg/100g ("Mirazh") to 31.1 mg/100g ("Gerakl"). As for ascorbic acid content – the highest (over the 75th percentile) is observed in "Evrazia", "Zolotaya osen", "Zhar-ptitsa", "Peresvet", "Gerakl", taking into account daily need for vitamin C (60.0 mg/100g) [24]. Thus, there are no obvious differences in accumulation of ascorbic acid between usual varieties and the remontant raspberry varieties. Average accumulation of vitamin C in the usual group of fruitage was 19.8±1.69 mg/100g, but there were 23.3±1.48 mg/100g in the group of remontant varieties.
The niacin (vitamin PP) content in the investigated varieties ranged from 0.14 mg/100g ("Zhar-pititsa") to 0.90 mg/100g ("Mirazh", "Maroseyka"), averagely – 0.44 mg/100g. The following varieties "Mirazh", "Maroseyka", "Patritsia" can be isolated as the best ones for accumulation of niacin. The consumption of 250 g of raspberry fruit provides the need in this vitamin by no more than 5.5%.

In connection with the presence of the recessive genes, suppressing the formation of anthocyanin pigments, the yellow-colored varieties of raspberry (Beglyanka, Zhelty gigant, Oranzhevoye chudo, Zolotaya osen) contain a little of anthocyanin pigments. Differences in accumulation of the given substances between the varieties are very significant; their content in Polka variety is 13.1 times more than that in Patrisia variety. The analysis of the investigated assortment revealed that the varieties Gerakl, Evrazia, Polka (62.4-83.6 mg/100g fresh fruit) occurred to have dark colored berries with high accumulation of anthocyanins. Taking into account the average content of anthocyanins in raspberry fruit (37.5 mg/100g) and daily norm of consumption of these substances (50 mg) [25], we found that the consumption of 100 g of red raspberries is sufficient for daily need in anthocyanins by 75.0%. The accumulation of flavonoids in the studied varieties with inter varietal differences (7 times) was averagely 23.2 mg/100g. The content of flavonoids with ery rutin component was over 30 mg/100g in 7 studied varieties (Maroseyka, Meteor, Mirazh, Oranzhevoye chudo, Patritsia, Peresvet, Scromnitsa), and such result totally covered the adequate level of their consumption.

| Variety              | Citric acid | Malic acid | Vitamin C | Niacin | Total anthocyanins | Flavonoids (by rutin) |
|----------------------|-------------|------------|-----------|--------|-------------------|-----------------------|
| Beglyanka            | 466         | 7.4        | 18.5      | 0.30   | -                 | 12.6                  |
| Bryanskoye divo      | 1035        | 12.0       | 20.7      | 0.22   | 48.7              | 37.3                  |
| Gerakl               | 1250        | 17.0       | 31.1      | 0.18   | 62.4              | 38.0                  |
| Evrazia              | 1540        | 14.5       | 28.2      | 0.18   | 83.0              | 42.9                  |
| Zhar-pititsa         | 933         | 11.0       | 27.7      | 0.14   | 42.5              | 21.1                  |
| Zhelty gigant        | 973         | 17.0       | 18.0      | 0.50   | -                 | 7.9                   |
| Zolotaya osen        | 1310        | 20.0       | 24.6      | less than 0.1 | less than 0.1 | 6.0                   |
| Maroseyka            | 1246        | 19.0       | 19.0      | 0.90   | 15.0              | 28.7                  |
| Meteor               | 670         | 16.8       | 15.0      | 0.50   | 10.0              | 25.4                  |
| Mirazh               | 1144        | 15.0       | 13.6      | 0.90   | 14.5              | 12.3                  |
| Oranzhevoye chudo    | 1083        | 2.4        | 21.6      | 0.56   | 0.2               | 7.9                   |
| Patritsia            | 868         | 10.8       | 24.0      | 0.80   | 6.4               | 17.9                  |
| Peresvet             | 1298        | 32.0       | 28.2      | 0.75   | 44.3              | 21.2                  |
| Rubinovoye ozherel’e| 1480        | 16.5       | 19.4      | 0.19   | 55.6              | -                     |
| Scromnitsa           | 1241        | 34.4       | 22.0      | 0.55   | 9.5               | 13.4                  |
| Elegantnaya          | 1370        | 13.0       | 21.1      | 0.25   | 41.0              | 31.6                  |
| Polka                | 1750        | 31.0       | 15.4      | 0.21   | 83.6              | -                     |
| Polana               | 1670        | 63.0       | 23.8      | 0.28   | 46.1              | 46.9                  |
| Mean                 | 1185        | 19.6       | 21.7      | 0.44   | 37.5              | 23.2                  |
| Standard errors      | 78.11       | 3.21       | 1.16      | 0.07   | 7.02              | 3.29                  |
| Median               | 1244        | 16.7       | 21.4      | 0.30   | 42.5              | 21.2                  |
| Percentile 25th      | 989         | 12.3       | 18.6      | 0.21   | 12.3              | 12.5                  |
| Percentile 75th      | 1355        | 19.8       | 24.5      | 0.56   | 52.2              | 33.0                  |

The investigations for macro- and microelements in raspberry fruit showed significant intervarietal differences in the content of mineral substances (table 3). Thus, the potassium content in the fruit of "Zhelty gigant" variety was 3.3 times more than that in "Polka" fruit. Higher accumulation of potassium was found also in "Maroseyka" and "Mirazh" vs. The difference between max. ("Mirazh") and min. ("Polka") accumulation of iron in the raspberries of the analyzed varieties reach 4.6 times. A
high level of iron content was observed also in the "Zhelty gigant" variety. One portion of raspberry fruit (250 g) provides daily need in mineral substances in the following value: iron – by 10.8%, potassium – by 17.0%, calcium – by 9.8%, magnesium – by 16.0%, zinc – by 5.8%.

| Table 3. Content of macro-and microelements in raspberry fruit, mg/100g |
|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|-----------------------------|
| Variety                  | Na  | K   | Ca   | Mg  | Fe  | Cu  | Zn  |
| Beglyanka                | 2.25| 231.1| 46.1 | 23.4| 0.59| 0.100| 0.396|
| Bryanskoye divo          | 2.55| 157.5| 46.9 | 15.6| 0.47| 0.021| 0.365|
| Gerakl                   | 1.91| 162.3| 49.0 | 14.1| 0.49| 0.024| 0.533|
| Evrazia                  | 2.78| 134.0| 30.8 | 11.7| 0.43| 0.016| 0.327|
| Zhar-pitsa               | 3.53| 155.9| 26.2 | 16.3| 0.46| 0.016| 0.464|
| Zhelty gigant            | 0.98| 388.0| 30.5 | 29.7| 0.97| 0.089| 0.377|
| Maroseyka                | 2.80| 358.5| 33.7 | 22.6| 0.69| 0.049| 0.286|
| Meteor                   | 1.43| 300.6| 34.6 | 67.7| 0.56| 0.057| 0.356|
| Mirazh                   | 1.00| 372.7| 41.5 | 34.4| 1.34| 0.059| 0.343|
| Oranzhevoye chudo        | 3.68| 224.7| 35.0 | 14.7| 0.50| 0.022| 0.269|
| Patriitia                | 1.32| 274.5| 35.0 | 31.0| 0.60| 0.076| 0.342|
| Peresvet                 | 1.06| 252.6| 58.5 | 66.3| 0.56| 0.055| 0.296|
| Rubinovoye ozherel’      | 3.99| 194.3| 44.9 | 14.7| 0.72| 0.027| 0.434|
| Scromnitsa               | 1.80| 282.2| 38.4 | 25.8| 0.49| 0.054| 0.242|
| Elegantnaya              | 4.11| 155.2| 47.4 | 23.1| 0.53| 0.038| 0.329|
| Polka                    | 2.57| 118.8| 26.9 | 11.4| 0.29| 0.023| 0.341|
| Polana                   | 2.47| 135.5| 29.4 | 10.5| 0.43| 0.020| 0.323|
| Mean                     | 2.37| 239.3| 38.5 | 25.5| 0.60| 0.044| 0.35 |
| Standard errors          | 0.25| 2.42 | 2.21 | 4.18| 0.06| 0.006| 0.02 |
| Median                   | 2.47| 224.7| 35.0 | 22.9| 0.53| 0.038| 0.342|
| Percentile 25th          | 1.43| 155.9| 33.0 | 14.7| 0.49| 0.022| 0.323|
| Percentile 75th          | 2.80| 228.2| 46.3 | 28.7| 0.62| 0.057| 0.377|

Investigations of the stilbenoids group, such as resveratrol and piceid, showed their content in raspberry fruit ranged from 0.1-0.9 mg/100g to 0.2-3.1 mg/100g, respectively. The highest accumulation of the given substances was found in "Zhelty gigant" (resveratrol – 0.6 mg/100g, piceid – 3.1 mg/100g) and Rubinovoye ozherele (resveratrol – 0.4 mg/100g, piceid – 1.8 mg/100g). Consumption of 250 g of raspberry fruit provides an adequate level (10 mg) of stilbenoids for the organism, namely resveratrol – by 12.5% [25].

6. Conclusion
Thus, the importance of raspberry fruit for healthy food and technological processing is obvious thanks to the presence of a complex of micronutrients. The raspberry is considered to be of highest value because it is a source of vitamin C, polyphenol compounds (anthocyanins) as well as mineral substances – potassium, iron. A portion of raspberry fruit (250 g) of the studied varieties provides a daily need in vitamin C by 96.2%, anthocyanins (red fruits forms) – by 187.5%, potassium – by 17.0%, iron – by 10.8%, soluble dietary fiber – by 43.8%, resveratrol – by 12.5%.

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