Vitamin value assessment of fruits and berries in the Central Black Earth Region (CBER) by the level of biologically active substances in the wild analogues

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Abstract. The fruits of all wild plants were gathered in Tambov, Lipetsk and Voronezh regions. The following research methods were used: thermogravimetric, titrimetric, photometric. Fruit weight of cultivars is 2.8 (the cherry) – 54.2 (the strawberry) times bigger than the fetal weight of wild related species. The rowan, the apple, the pear, the plum, the hawthorn, the current, the blackberry, the raspberry and the apricot are in the range. The selection of fruit and berries of the Central Black Earth Region provided: the reduction of organic acid by a factor of 1.8-6.9 in the fruits of the apple, the pear, the hawthorn, the briar, the cherry, the blackberry, the raspberry, the guilder rose, the apricot; the rise of ascorbic acid by a factor of 1.5-10 in the fruits of the rowan, the apple, the briar, the blackberry, the raspberry, the guilder rose, the apricot; the rise of β-carotene by a factor of 1.5-10 in the fruits of the apples, the hawthorn, the briar, the cherry, the current and the blackberry; the rise of anthocyanins by the factor of 2-26.8 in the fruits of the rowan, the apple, the pear, the hawthorn, the briar, the black current, the blackberry, the guilder rose, the strawberry and the apricot; the rise of flavonols by the factor of 1.5-13.7 in the fruits of the apples, the hawthorn, the briar, the current, the blackberries, the raspberry, the guilder rose, the apricot; the percentage rise of solids by a factor of 1.5 in the fruits of the cherry and the apricot; the rise of tannins and colorants by the factor of 1.5-3.2 in the fruits of the rowan, the hawthorn and the apricot; the rise of tanninum by the factor of 3.1-3.5 in the fruits of the rowan and the hawthorn as well as increasing in the amount of carotenoids by the factor of 1.5 in the fruits of the raspberry. The rise of solids, carotinoids, tannins and colorants including tanninum content in the fruit and berries turned out to be the most complicated for research results of fruit and berry selection.

1. Introduction
There are always more prominent and inefficient, lagging plants in terms of biochemical fruit composition among the varieties and hybrids of fruit and berries. Consequently, the respond to the question how far selection of these or those fruit and berries has moved on and how fully they have realized their specific and varietal capacities is relevant. For instance, the leaves of sea buckthorn varieties are still richer in flavonoids, E and C vitamins than its berries [1]. The range of the strawberry BC3 possesses lots of improved properties (content of ascorbic acid, organic acid, phenol compounds, solids, fetal weight) regarding Fxa genotype and F1 generation [2].
Due to the high content of anthocyanins and phenol compounds the fruits of the blackberry varieties possessed greater antioxidant activity than the raspberry and the pine strawberry [3]. In the Ands conditions the bilberry contains high level of phenols, flavonoids, anthocyanins, lutein tannins and the blackberry had a high level of vitamin C and β – carotin [4]. The berries of highlands blackberry contain 290-1200 mg% of anthocyanins in the conditions of Costa-Rica [5]. In the conditions of South Korea the content of anthocyanins in the berries of the black raspberry were from 13 to 1070 mg% [6]. In the conditions of Bosnia and Herzegovina the berries of the raspberry contained 53.5-58.8 mg% of anthocyanins, 14-16.7% of solids, 164.5-416.2 mg% of phenol compound, 35.8-55.0 mg% of ascorbic acid [7]. In the conditions of Kyrgyzstan the fruits of the wild cherry-plum contained 1-2.3 % of organic acid, 16-30.2 mg % of ascorbic acid and 177-365 mg% of phenol compounds [8], and in the conditions of India the fruits of the wild Nepal plum contained 45.5 mg% of ascorbic acid [9]. By comparing these data with the cultivars of the plum it is obvious that the fruits of the wild cherry-plum and plum are less sour and contained the same ascorbic acid and phenol compounds. In the conditions of Turkey the berries of the blackberry varieties contained 142-342 mg% of anthocyanins [10]. The lower limit of this interval (144.54 mg%) coincided with the level of anthocyanins in the bilberry grown in the conditions of Tambov and Vologda regions [11]. The fruits of the elderberry sown in cultivation with the wild seeds in the conditions of Turkey were rich in anthocyanins (307-412 mg%), phenol compounds (360-447 mg%) and contained 26-38 mg % of ascorbic acid [12], and in the conditions of Lipetsk region the fruits of the wild elderberry contained less anthocyanins ( 139.5 mg%) but more ascorbic acid (140.8 mg%) [13]. The berries of red-fruit varieties of the gooseberry in the conditions of Serbia contained 186 mg% of anthocyanins and 62-140.4 mg% of ascorbic acid [14], but in the conditions of Tambov region the varieties of analogous colours contained 37.4 mg% of anthocyanins and 39.6 mg% of ascorbic acid [15]. The fruits of the apple varieties were the richest in flavonols (130mg% in the varieties of Orlik and Zvezdochka), pectin substances (5.88% in the variety of Gala) and iron (50 mg/ kg in the variety of Gala) [16]. Among the cherry varieties Vladimirskaya was the one of the richest in solids, ascorbic acid, anthocyanins, flavonols and catechins [17]. The purpose of our research was to compare the content of biologically active substances in the fruit and berries of the most widespread cultivated plants to the content of the same substances in the fruits of the wild analogues in the conditions of the Central Black Earth region.

2. Materials and methods
The research was held in 2012-2019. The fruits of all the wild and cultivated plants were gathered in Tambov, Lipetsk and Voronezh regions. Biochemical analysis of the materials was conducted on the base of three laboratories: the laboratory of biochemistry of Michurinsk State Agrarian University, the laboratory of microbiology and chemistry of Michurinsk affiliate of the Russian University of cooperation and the research agrochemical laboratory of Yelets State University. The fruits were analyzed in relation to main vitamins. The content of solids was measured by thermogravimetric method [18], total acidity was measured by titrimetric method in terms of the malic acid [19], carotin was calculated by photometric method [20], the content of ascorbic acid was calculated by iodometric method [21], anthocyanins were calculated by photometric method [22], the content of flavonols and catechins were measured by L.I. Vigorov and A.Y. Tribunskaya’s method [23], the amount of tannins and colorants were measured by titrimetric method [24], the content of tanninum was calculated by titrimetric method [25], the amount of carotinoids was calculated by photometric method [26].

3. Results and discussion
We should note that the fruits of the wild species differ from cultivars in terms of flavour. For instance, the fruits of the wild black currant are sweeter and the fruits of the rowan and the cherry are less sweet but more acerb and bitter than the fruits of cultivated analogues. The weight of the wild fruits and berries are less than the weight of the cultivated analogues but the content of vitamins in cultivated plants is much lower than in the wild relatives (table 1).
Table 1. Qualitative indicators of assessed wild plants.

| The name of the plant                        | Latin name                                      | Average fruit weight, g | The content of substances, % |
|---------------------------------------------|------------------------------------------------|-------------------------|------------------------------|
| The rowan                                   | Sorbus aucuparia L.                             | 0.28                    | 22.5 3.03 1.71 1.66          |
| The rowan varieties                         | Sorbus aucuparia L.                             | 1.2                     | 21.46 3.0 5.44 5.2           |
| The crab apple                              | Malus sylvestris (L.) Mill.                    | 19.35                   | 15.97 2.35 2.99 1.24         |
| The apple varieties                         | Malus domestica Borkh.                         | 118.8                   | 11.23 0.7 0.65 0.14          |
| The choke pear                              | Pyrus communis L.                               | 26.44                   | 20.0 0.6 1.18 0.62           |
| The pear varieties                          | Pyrus communis L.                               | 150.0                   | 14.75 0.3 0.11 0.05          |
| The blackthorn                              | Prunus spinosa L.                               | 1.74                    | 20.73 3.48 2.29 1.34         |
| The plum varieties                          | Prunus domestica L.                             | 40.0                    | 20.6 10.2 0.18 0.1           |
| The blood-red hawthorn                      | Crataegus sanguinea Pall                        | 2.82                    | 23.53 1.67 2.6 0.68         |
| The hawthorn varieties                      | Crataegus sanguinea Pall                        | 7.32                    | 19.8 1.12 4.07 2.41         |
| The briar                                   | Rosa canina L.                                  | 2.7                     | 33.61 3.11 10.64 4.16        |
| The briar varieties                         | Rosa canina L.                                  | 3.5                     | 24.45 0.45 12.1 5.2          |
| The sour cherry                            | Cerasus vulgaris Mill.                          | 1.74                    | 10.79 2.68 0.86 0.8         |
| The cherry varieties                        | Prunus cerasus L.                               | 4.93                    | 16.02 1.53 0.47 0.41        |
| The black currant                           | Ribes nigrum L.                                 | 0.43                    | 14.56 4.15 2.1 0.83         |
| The black currant varieties                 | Ribes nigrum L.                                 | 2.55                    | 15.9 3.01 0.26 0.1           |
| The European blackberry (the brambleberry)  | Rubus nessensis W. Hall.                        | 0.96                    | 12.73 3.35 1.81 0.87       |
| The blackberry varieties                    | Rubus subgen L.                                 | 12.2                    | 15.73 1.0 1.2 0.7            |
| The European raspberry                      | Rubus idaeus L.                                 | 0.85                    | 16.26 2.96 0.82 0.56        |
| The raspberry                               | Rubus idaeus L.                                 | 8.5                     | 10.0 1.61 0.7 0.45          |
| The guilder rose                            | Viburnum opulus L.                              | 0.54                    | 20.46 2.06 1.6 1.33        |
| The guilder rose varieties                  | Viburnum opulus L.                              | 0.58                    | 17.0 2.71 1.6 1.3           |
| The wild strawberry                         | Fragaria vesca L.                               | 0.39                    | 13.6 1.67 1.25 1.2          |
| The hill strawberry                         | Fragaria viridis Weston                        | 0.6                     | 12.87 0.84 1.1 0.83        |
| The pine strawberries varieties             | Fragaria × ananassa (Duchesne ex Weston)       | 27.1                    | 11.82 1.1 0.86 0.73        |
|                                          | Duchesne ex Rozier                             |                         |                              |
| The apricot                                 | Prunus armeniaca L.                             | 7.0                     | 10.8 1.4 0.08 traces        |
| The apricot varieties                       | Prunus armeniaca L.                             | 57.14                   | 15.0 0.3 0.2 traces         |

The varietal forms of cultivated fruit and berries as a rule are bigger than their wild relatives. The excess varies from 2.6–2.8 times (the hawthorns and the cherry) to 54.2 (the strawberry). The fruits of the briar and the guilder rose remained the same size as their wild analogues. The selection provided the rise of the solids only in the fruits of the cherry and the apricot – by 1.5 times. As a result of selection organic acids content in the fruits of the apple, the pear, the hawthorn, the briar, the cherry, the blackberry, the raspberry and the apricot decreased. This rate remained constant in the fruits of the rowan, the black currant, the guilder rose, the strawberry and it even increased in the fruits of the plum by 2.9 times. The research selection progress in terms of the amount of tannins and colorants are very poor. This rate managed to rise only in the fruits of the rowan (by 3.2 times), the apricot (twice), and the hawthorn (by 1.5 times). The rate remained constant or even became lower in the fruits of the rest compared to the wild species. The content of the prominent tannin substance, that is tanninum, managed to rise only in the fruits of the rowan (by 3.1 times) and the hawthorn (by 3.5 times).

Due to the long-term selection the content of ascorbic acid in the fruits of cultivated varieties rose from 1.5–2.2 times (the apple, the raspberry, the apricot, the blackberry) to 10 times. The rate of this
biologically active substance (BAS) remained at the level of the wild relatives or even lower in the fruits of the pear, the plum, the hawthorn, the cherry, the black currant, and the strawberry (table 2).

| Name of the plant | Ascorbic acid | β-carotin | Amount of carotinoids | Anthocyanins | Flavonols | Catechins |
|-------------------|--------------|-----------|-----------------------|--------------|-----------|-----------|
| The rowan         | 42.68        | 4.0       | 12.41                 | 12.18        | 255.0     | 1.8       |
| The rowan varieties | 187.65     | 5.2       | 14.18                 | 122.9        | 431.52    | 347.71    |
| The crab apple    | 21.12        | 0.03      | 1.03                  | 0.7          | 26.94     | 0.79      |
| The apple varieties | 32.35      | 0.11      | 0.6                   | 3.37         | 36.23     | 2.58      |
| The choke pear    | 11.0         | 0.16      | 1.0                   | 2.24         | 66.2      | 15.81     |
| The pear varieties | 5.5         | 0.05      | 0.33                  | 5.0          | 98.8      | 151.88    |
| The blackthorn    | 20.24        | 1.11      | 5.01                  | 127.33       | 165.8     | 25.0      |
| The plum varieties | 11.21       | 0.19      | 0.57                  | 18.0         | 380.0     | 187.5     |
| The blood-red hawthorn | 25.53     | 1.2       | 6.36                  | 31.14        | 198.0     | 65.0      |
| The hawthorn varieties | 26.75     | 3.23      | 1.9                   | 168.5        | 123.0     | 545.7     |
| The briar         | 614.0        | 15.98     | 16.1                  | 46.5         | 152.3     | 26.0      |
| The briar varieties | 6175.9     | 50.65     | 14.0                  | 370.4        | 2095.5    | 1132.3    |
| The sour cherry   | 119.68       | 0.4       | 1.8                   | 120.87       | 124.18    | 181.95    |
| The cherry varieties | 18.53      | 0.6       | 0.9                   | 165.1        | 135.35    | 103.9     |
| The black currant | 136.6        | 0.01      | 3.46                  | 138.55       | 171.04    | 2.41      |
| The black currant varieties | 163.14     | 0.1       | 0.11                  | 353.2        | 241.2     | 373.75    |
| The European blackberry | 17.6      | 0.02      | 5.5                   | 124.19       | 198.0     | 0.81      |

The content of β-carotin in the fruits of some cultivars is also higher than in the fruits of their wild relatives: by 1.5 times (the cherry) – 10 times (the currant and the blackberry). But total quantity of carotinoids managed to rise only in the fruits of the raspberry by 1.5 times.

The content of blue colorants of antioxidant nature that are anthocyanins are higher in the fruits of most assessed cultivars than in the fruits of their wild analogues. This excess varies from 2-2.8 times (the pear, the currant, the strawberry, the guilder rose) to 26.8 times (the apricot).

The level of yellow colorants from the group of vitamin P flavonols rose only in the fruits of some species. This excess is from 1.5-2.3 times (the apple, the pear, the rowan, and the plum to 13.7 times (the briar).

In the process of long-term selection the content of catechins in the fruits of most cultivars became higher than in the fruits of their wild relatives. This excess varies from 2.4-3.3 times (the apple, the guilder rose, the apricot) to 827 times (the raspberry).

4. Conclusion
As a result of long-term selection of cultivars of the Central Black Earth region the weight of fruit and berries increased compared to the fruits of the wild relative species by a factor of 2.8 (the cherry)-54.2 (the strawberry). The fruits of the rowan, the apple, the pear, the plum, the hawthorn, the currant, the
blackberry, the raspberry and the apricot are in the range. The fruit weight of the briar and the guilder rose still remained constant contrary to selection.

The selection of cultivars of the Central Black Earth region provided: the reduction of organic acid by a factor of 1.8-6.9 in the fruits of the apple, the pear, the hawthorn, the briar, the cherry, blackberry, the raspberry, the guilder rose, the apricot; the rise of ascorbic acid by a factor of 1.5-10 in the fruits of the rowan, the apple, the briar, the blackberry, the raspberry, the guilder rose, the apricot; the rise of β-carotin by a factor of 1.5-10 in the fruits of the apples, the hawthorn, the briar, the cherry, the current and the blackberry; the rise of anthocyanins by the factor of 2-26.8 in the fruits of the rowan, the apple, the pear, the hawthorn, the briar, the black current, the blackberry, the guilder rose, the strawberry and the apricot; the rise of flavonols by the factor of 1.5-13.7 in the fruits of the apple, the rowan, the pear, the plum, the briar; the rise of catechins by a factor of 2.4-827 in the fruits of the apple, the rowan, the pear, the plum, the hawthorn, the briar, the current, the blackberries, the raspberry, the guilder rose, the apricot; the percentage rise of solids by a factor of 1.5 in the fruits of the cherry and the apricot; the rise of tannins and colorants by the factor of 1.5-3.2 in the fruits of the rowan, the hawthorn and the apricot; the rise of the tanninum by the factor of 3.1-3.5 in the fruits of the rowan and the hawthorn as well as increasing in the amount of carotenoids by the factor of 1.5 in the fruits of the raspberry.

The rise of solids, carotinoids, tannins and colorants including tanninum content in the cultivars turned out to be the most complicated task for research results in selection.

From all the assessed fruit and berries of the Central Black Earth region the largest number of biochemical characteristics managed to rise in the fruits of the rowan, the apple, the hawthorn, and the apricot while the strawberry and the guilder rose were the hardest to be changed by selection.

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