Biochemical evaluation of the assortment of pumpkin vegetable crops for the creation of functional food products

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Abstract. It is known that vegetables are sources of vitamins, biologically active substances, antioxidants and other vital micronutrients. In particular, pumpkin vegetable crops (zucchini, squash) contain all the necessary mineral salts, vitamins, trace elements, pectin substances, ascorbic acid and not too many sugars. Varieties of vegetable crops are characterized by a diverse biochemical composition and are suitable to various degrees for obtaining processed products for therapeutic, preventive and functional purposes. The article considers the assortment of zucchini and squash by yield and the most important indicators of the biochemical composition of the fruit: the content of dry substances, sugars, vitamin C; the accumulation of nitrates in the fruit. High water content of zucchini and squash fruits (94-96%), low sugar content (1.5-3.5%) were found. Squash has a higher yield (25-90 t / ha), compared to zucchini (4-11 t/ha). Nevertheless, zucchini contain 3-4 times more vitamin C in the fruit and accumulate 3-4 times less nitrates than squash, having almost 10 times more of vitamin value. At the same time, squash is 2-3 times less than zucchini, accumulating nitrates. Of the 7 studied varieties of zucchini, the hybrid Belogor F1 and the variety Tsukeshib were distinguished, which have high yield, high fruit quality and vitamin value. Of the 15 studied varieties of squash, the varieties Perlinka, Pyatachok and Tabolinsky were identified, which have high yields, high fruit qualities and vitamin value, and weakly accumulate nitrates.

1. Introduction
It is known that vegetables are the most important sources of vitamins C, P, E, some B vitamins, provitamin A, beta-carotene, trace elements, carbohydrates and phytoncides, so the consumption of vegetables reduces the deficiency of many biologically active substances necessary for human health.

Vegetables and fruits, which are a powerful regulator of human health, play a particularly important role in obtaining functional products. The variety of types and forms of fruit, berry and vegetable crops containing a complex of various biologically active compounds makes it possible to create new effective products that have a beneficial effect on human health [1-4].

In breeding, much attention is paid to the creation of varieties and hybrids with high fruit quality, high content of biologically active substances and antioxidants, which can be used to create dietary, therapeutic, and preventive food products [5].
One of the main tasks facing breeders is the selection of plant sources of biologically active substances, the creation of varieties of vegetable crops with high nutritional value [6].

A wide variety of varieties of vegetable crops obtained by breeders allows you to choose varieties with a specific biochemical composition that allows you to use these varieties for processing and obtaining functional food products with specified properties [4, 7]. Moreover, with the help of agrotechnical techniques, such as fertilizers, you can purposefully affect the biochemical composition of fruit, berry and vegetable plants, and hence the functional value of their processed products [2].

Zucchini and squash are a bushy variety of hard-barked pumpkin (Cucurbitapepo L.); they belong to the so-called vegetable pumpkins, which consume young ovaries for food [8]. The fruits of zucchini, used in food, contain almost all the vital salts, vitamins and trace elements for the human body, are characterized by a high content of water and a low content of sugars. The fruits of squash contain sugars, ascorbic acid, fiber, pectin substances, and mineral salts. Zucchini and squash are fried, boiled, stewed, stuffed, but most of all they are suitable for canning.

The aim of the work is to give a comparative assessment of the biochemical composition of fruits in different varieties of zucchini and squash and to identify varieties that have a complex of economically valuable characteristics and vitamin value, suitable for processing in the production of functional products.

2. Materials and methods

The study of varieties of vegetable crops was carried out in 2006-2018 at the experimental plots of the Federal State Budgetary Scientific Institution FNTSO, in the Ramensky district of the Moscow region. The agrotechnological assessment of the assortment of vegetable crops was carried out at the Bykovo Experimental Production Enterprise in the Moscow Region and on the basis of farms in the Tambov region.

The objects of research:

Varieties of squash (Cucurbitapepo L. var. ovifera L.): Fuete (K), Bingo-Bongo, Gosha, Disc, Zolotoy, Zontik, Oranzhevyy, Perlinka, Pirouette, Pyatachok, Solnyshko, Tobolinsky, Cheburashka, PattiGreenTint, Whitecustard.

Varieties and hybrids of zucchini (Cucurbitapepo L. var. giraunotia Duch.): Gribovskie 37 (K), AdayaF1, Aeronaut, BelogorF1, Beloplodnye, Kveta MS, Tsukesha.

We studied the indicators of the yield of varieties, the content of dry substances, sugars, vitamin C (ascorbic acid) and nitrates in the fruits. Definition of yield vegetable plants was carried out according to the method of the All-Russian Institute of Crop Production (1986); dry matter content was determined by drying according to GOST 28561-90; sugar content – Bertrand and GOST 8756.13-87; the content of ascorbic acid using fluorimetrical method; the nitrate using colorimetric method [4, 6, 9-12].

To determine the relationships between the indicators of the biochemical composition of fruits, the relative coefficients were calculated:

The coefficient of the vitamin value of the fruits of the K\textsubscript{VC} is expressed as the ratio of the content of vitamin C in the fruits to the content of nitrates, according to the formula:

\[ K_{VC} = B/N, \]

where B is the content of vitamin C in the fruit; N is the content of nitrates.

The biological meaning of the coefficient of vitamin value of fruits – the higher the coefficient, the higher the vitamin value and environmental safety of products.

Sugar-vitamin coefficient K\textsubscript{SV} is expressed as the ratio of the content of sugars in fruits to the content of vitamin C, according to the formula:

\[ K_{SV} = C/B, \]

where C is the content of sugars in fruits; B is the content of vitamin C.

The biological meaning of the sugar-vitamin coefficient of fruits – the lower the coefficient, the higher the vitamin value and dietary usefulness of the products [3, 8, 11].

The integral score of the complex of quality indicators of K\textsubscript{INT} varieties was determined as the sum of the indicators reduced to a common denominator, according to the formula:

\[ K_{INT} = (b_1 + b_2 + b_3 + b_n) : n, \]
where \( b \) is the score of specific indicators, \( n \) is the number of indicators.

We bring the score of specific indicators to a common denominator, taking the maximum value of each specific indicator as the highest score (5 points). At the same time, the significance of individual indicators is leveled (not taken into account), so this assessment is valid only within the limits of a specific experience.

Legend:
1 - yield of varieties;
2 - dry matter content;
3 - sugar content;
4 - Vitamin C content;
5 - nitrate content;
6 - vitamin-nitrate coefficient;
7 - sugar-vitamin coefficient.

The dispersion analysis of the experimental material was carried out according to B. A. Dospekhov (1985).

3. Results and discussion

Table 1 shows data on the yield, nutritional and vitamin value of 7 varieties of zucchini, the control variety was the Gribovskie 37 variety.

| Varieties, hybrids | Yield, t / ha | Content | Coefficients |
|--------------------|--------------|---------|--------------|
|                    |              | dry substances, % | sugars, % | vitamin C, mg% | nitrates, mg% | vitamin-nitrate | sugar-vitamin |
| Gribovskiiy 37 (K) | 6,53         | 5,13    | 3,47       | 26,8 | 16,8 | 1,60 | 0,13 |
| Adai F1            | 3,80         | 5,00    | 3,57       | 24,9 | 15,1 | 1,65 | 0,14 |
| Aeronaut           | 7,20         | 4,60    | 3,13       | 26,1 | 22,8 | 1,14 | 0,12 |
| Belogor F1         | 8,33         | 5,07    | 3,37       | 25,3 | 16,2 | 1,56 | 0,13 |
| Beloplodnye        | 9,30         | 4,63    | 3,47       | 23,9 | 16,2 | 1,48 | 0,15 |
| Kveta MS           | 4,80         | 4,83    | 3,23       | 22,0 | 11,6 | 1,90 | 0,15 |
| Tsukesha           | 11,33        | 4,80    | 3,40       | 24,8 | 18,2 | 1,36 | 0,14 |
| LSD05              | 1,56         | 0,08    | 0,04       | 1,5  | 0,6  | 0,15 | 0,02 |

The yield of zucchini varieties varied from 3.80 to 11.33 t / ha. It significantly exceeded the control variety Gribovskie 37 hybrid Belogor F1 (8.33 t /ha), varieties Beloplodnye (9.30 t/ha) and Tsukesha (11.33 t/ha). The yield of the Adaya F1 and Kveta MS varieties was significantly lower than that of the control variety.

The dry matter content indicator is very important for products intended for processing. The highest dry matter content was observed in the control variety Gribovskie 37 and the hybrid Belogor F1. In other varieties, this indicator was significantly lower than the control.

The sugar content was highest in the control varieties and varieties of Adaya F1 and Beloplodnye (3,47 is 3.57%). In other varieties, this indicator was significantly lower than the control.

The content of ascorbic acid in the fruits of zucchini during the study period was generally quite high – 22.0-26.8 mg% (almost 2 times more than in apples). The highest content of vitamin C was in the control variety and in the varieties Belogor F1 and Aeronaut (25.3-26.8 mg%); in other studied varieties – significantly lower than the control.
Thus, we see that all indicators of the nutritional value of zucchini were the highest in the control variety Gribovskie 37, with the exception of low yield, which makes it economically unprofitable to grow this variety on an industrial scale.

The accumulation of nitrates in fruits is a negative indicator. The least accumulated nitrates in the fruits of the variety Kveta MS (11.6 mg%), lower than the control indicators, were also in the hybrids Adaya F1 and Belogor F1.

Calculations of the coefficients of the vitamin value of the varieties showed that, in general, this indicator was quite high in zucchini. The highest level was found in the Kveta MS variety (above the control – 1.90), as well as in the Gribovskie 37, Adaya F1 and Belogor F1:F1 varieties (at the control level).

But the sugar-vitamin coefficient of all varieties of zucchini was very low, which characterizes this culture as highly dietary. There were no significant differences between the varieties in this indicator.

Table 2 shows data on the yield, nutritional and vitamin value of 15 varieties of squash, the control variety was the Fuete variety.

### Table 2. Yield and nutritional value of fruits in the varieties of squash (CucurbitapepoL. var. oviferaL.), on average for 3 years

| Varieties, hybrids | Yield, t / ha | Content | Coefficients |
|--------------------|--------------|---------|--------------|
|                    |              | dry substances, % | sugars, % | vitamin C, mg% | nitrates, mg% | vitamin-nitrate | sugar-vitamin |
| Fuete (K)          | 38.7         | 5.93     | 2.67        | 8.65        | 44.5         | 0.19            | 0.31         |
| Bingo-Bongo        | 36.3         | 4.59     | 2.38        | 6.49        | 47.5         | 0.14            | 0.37         |
| Gosha              | 29.7         | 3.94     | 1.64        | 4.22        | 42.7         | 0.10            | 0.39         |
| Disc               | 68.0         | 6.07     | 2.36        | 4.27        | 26.7         | 0.16            | 0.55         |
| Zolotoy            | 14.3         | 3.97     | 1.98        | 5.95        | 49.8         | 0.12            | 0.33         |
| Zontik             | 67.7         | 4.08     | 2.16        | 4.96        | 35.9         | 0.14            | 0.48         |
| Oranzhevyy         | 25.0         | 5.22     | 2.21        | 4.47        | 54.8         | 0.08            | 0.49         |
| Perlinka           | 49.3         | 5.77     | 2.51        | 7.72        | 22.6         | 0.34            | 0.32         |
| Pirouette          | 41.3         | 4.63     | 2.38        | 7.68        | 27.1         | 0.28            | 0.31         |
| Pyatachok          | 83.0         | 4.90     | 2.66        | 7.88        | 35.8         | 0.22            | 0.34         |
| Solnyshko          | 25.3         | 5.28     | 1.77        | 6.36        | 40.3         | 0.16            | 0.28         |
| Tobolinsky         | 48.3         | 5.73     | 2.14        | 7.87        | 30.5         | 0.26            | 0.27         |
| Cheburashka        | 90.0         | 4.48     | 2.62        | 5.57        | 34.6         | 0.16            | 0.47         |
| PattiGreenTint     | 49.7         | 5.80     | 2.25        | 6.06        | 52.3         | 0.12            | 0.37         |
| Whitecustard       | 38.0         | 5.34     | 2.11        | 6.44        | 39.7         | 0.16            | 0.33         |
| LSD05              | 4.8          | 0.42     | 0.28        | 0.92        | 1.8          | 0.02            | 0.02         |

The yield of squash varieties was significantly higher than that of zucchini, and varied from 14.3 to 90.0 t / ha. It significantly exceeded the control variety of Fuete varieties Tobolinsky, Perlinka, PattiGreenTint (48.3-49.7 t/ha), Disk, Umbrella (67.7-68.0 t/ha), Pyatachok, Cheburashka (83,-90.0 t/ha). The yield of Gosha and Solnyshko varieties was significantly lower than that of the control variety.

The highest dry matter content was observed in the control variety Fuete and at the control level in the varieties Tobolinsky, Perlinka, PattiGreenTint. In other varieties, this indicator was significantly lower than that of the control.

The sugar content was the highest in the control variety Fuete (2.67), and at the control level - slightly lower in the varieties Perlinka, Pyatachok, Cheburashka (2.51-2.66%). In other varieties, this indicator was significantly lower than that of the control.

The content of ascorbic acid in the fruits of squash during the study period was generally significantly lower than in zucchini – 4.22-8.65 mg% (almost 3-4 times less than in zucchini). The
highest content of vitamin C was in the control variety Fuete (8.65 mg%) and in the varieties Perlinka, Pyatachok, Pirouette, Tobolinsky (7.68-7.88 mg%), in other studied varieties – significantly lower than the control.

Thus, we see that all indicators of the nutritional value of squash, as in the case of zucchini, were the highest in the control variety of Fuete, with the exception of low yield, which sharply reduces the economic efficiency of growing this variety.

Squash, unlike zucchini, accumulate significantly more nitrates in their fruits (from 22.6 to 54.8 mg%). Nitrates of the Perlinka, Pirouette and Disc varieties accumulated the least in the fruits (22.6-27.1 mg%), the indicators of the Zontik, Pyatachok, Solnyshko, Tobolinsky, Cheburashka and Whitecustard varieties were also lower than the control ones (30.5-40.3 mg%).

Calculations of the coefficients of the vitamin value of the varieties showed that, in general, this indicator was low in scallop squash, much lower than that in zucchini. However, this indicator varied greatly among the varieties of patissons. The highest level was found in the Perlinka variety – 0.34 (significantly higher than that in the control - 0.19), as well as in the Pirouette, Pyatachok, Tobolinsky varieties (0.22–0.28).

The sugar-vitamin ratio of all varieties of squash was 3-5 times higher than that of zucchini, which characterizes this culture as having high nutritional advantages, but less dietary than zucchini. The lowest sugar-vitamin coefficient was observed in the varieties Fuete (control), Perlinka, Pirouette, Solnyshko, Tobolinsky (0.27-0.32 - at the control level), which characterizes these varieties as having increased dietary value.

Table 3. Integral score assessment of the complex of indicators of zucchini varieties

| Varieties, hybrids | Indicators | K_{INT} |
|--------------------|------------|---------|
| Tsukeshia          | 5.0 4.7 4.8 4.6 3.2 3.6 | **4.32** |
| Belogor F₁         | 3.7 4.9 4.7 4.7 3.6 4.1 | **4.28** |
| Gribovskiy 37 (K)  | 2.9 5.0 4.9 5.0 3.5 4.2 | **4.25** |
| Beloplodnye        | 4.1 4.5 4.9 4.5 3.6 3.9 | **4.25** |
| Kveta MS           | 2.2 4.7 4.5 4.1 5.0 5.0 | **4.25** |
| Adai F₁           | 1.7 4.9 5.0 4.6 3.8 4.3 | **4.05** |
| Aeronaut        | 3.2 4.5 4.4 4.9 2.5 3.0 | **3.75** |

Table 4. Integral score assessment of the complex of indicators of the varieties of squash

| Varieties, hybrids | Indicators | K_{INT} |
|--------------------|------------|---------|
| Perlinka           | 2.7 4.9 4.7 4.5 5.0 5.0 4.2 | **4.43** |
| Pyatachok          | 4.6 4.1 5.0 4.6 3.2 3.2 4.0 | **4.10** |
| Tobolinsky         | 2.7 4.8 4.0 4.5 3.7 3.8 5.0 | **4.07** |
| Pirouette          | 2.3 3.9 4.5 4.4 4.2 4.1 4.4 | 3.97 |
| Fuete (K)          | 2.2 5.0 5.0 5.0 2.5 2.8 4.4 | 3.84 |
| Cheburashka        | 5.0 3.8 4.9 3.2 3.3 2.4 2.9 | 3.64 |
| Disc               | 3.8 4.3 4.4 2.5 4.2 2.4 2.5 | 3.44 |
| Whitecustard       | 2.1 4.5 4.0 3.7 2.8 2.4 4.1 | 3.37 |
| PattiGreenTint     | 2.8 4.9 4.2 3.5 2.2 1.8 3.6 | 3.29 |
| Solnyshko          | 1.4 4.5 3.3 3.7 2.8 2.4 4.8 | 3.27 |
| Bingo-Bongo        | 2.0 3.9 4.5 3.8 2.4 2.1 3.6 | 3.19 |
| Zontik             | 3.8 3.4 4.0 2.9 3.1 2.1 2.8 | 3.16 |
| Zolotoy            | 0.8 3.3 3.7 3.4 2.3 1.8 4.1 | 2.77 |
| Oranzhevyy         | 1.4 4.4 4.1 2.6 2.1 1.2 2.8 | 2.66 |
| Gosha              | 1.7 3.3 3.1 2.4 2.6 1.5 3.5 | 2.59 |
Table 3 shows the data on the integral score assessment of the complex of indicators of zucchini varieties. Table 3 shows that the highest integral score for the set of indicators was obtained for the Tsukesh variety and the Belogor F1 hybrid, which is also consistent with the analysis of individual indicators for the evaluation of zucchini varieties.

Table 4 shows the data on the integral score assessment of the complex of indicators of the varieties of squash. Table 4 shows that the highest integral score for the set of indicators was obtained for the varieties Perlina, Pyatachok and Tobolinsky, which is also consistent with the analysis of individual indicators for the evaluation of the varieties of squash.

4. Conclusion

High water content of zucchini and squash fruits (94-96%), low sugar content (1.5-3.5%) were found. Squash has a higher yield (25-90 t/ha), compared to zucchini (4-11 t/ha).

Nevertheless, zucchini contain 3-4 times more vitamin C in the fruit and accumulate 3-4 times less nitrates than squash, having almost 10 times more vitamin value. At the same time, squash is 2-3 times less than zucchini, accumulating nitrates.

The result of a comprehensive evaluation of the 7 studied varieties of zucchini included hybrid Belogor F1 and variety of Tsukesh with high yields, high quality fruit and vitamin value suitable for processing in the manufacture of functional foods.

On the set of studied economic and biological characteristics of the studied 15 squash varieties Perlina, Pyatachok and Tobolinsky with high yields, high quality fruit, vitamin and dietary value weakly accumulate nitrates, suitable for processing in the manufacture of functional foods.

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