Evaluation of potato tubers of Nevsky variety and selection hybrids by amino acid composition

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Abstract. Potato protein is recognized as one of the most valuable plant proteins due to its high content of essential amino acids. Changes in the metabolic composition of potato tubers during low temperature storage can affect their nutritional value. In the course of study, the amino acid composition of potato tubers was determined, differing in the color of the pulp stored at a temperature of 2 °C for 7 months. The research included the study of 3 hybrids of potato and potato variety of standard Nevsky, hybrid 10.76.1 with red peel, others with yellow peel. With increasing storage time, the total protein content and especially the amino acid content increased. The determination of amino acids was carried out according to "M-04-38-2009" with the system of capillary electrophoresis "Drops-105", the starch content – by specific gravity (GOST 7194-81); reducing sugars – according to the Sumner method; crude protein – according to the Kjeldahl method, GOST 13496.4-93; nitrate content – by ion-metric, according to GOST 29270-95. Biochemical analysis of potato tubers allows us to highly evaluate of the hybrid 10.76.1 with red peel according to the EAA amino acid composition index with an indicator of 61.6 to 63.1 % and taste with an indicator 7.9 to 6.5 points and the ratio of starch/protein with an indicator of 14.0 to 15.7, which is higher than similar indicators of the Nevsky standard.

1. Introduction

Amino acids of plants occupy a central place in the metabolism. At present, more than 150 amino acids have been found in free and bound form in living organisms [1].

The composition of potato proteins contains 18 amino acids, including 9 essential ones: tryptophan, leucine, isoleucine, valine, threonine, lysine, methionine, phenylalanine, histidine [2, 3]. Humans and animals cannot synthesize essential amino acids and must receive them ready-made as part of food. Proteins in which at least one of the named acids is absent are considered as inferior. The biological value (EAA index) of potato tuber proteins ranges from 60 to 92 % and averages 85 % (chicken egg is taken as EAA for 100 %) [4]. Protein content in potatoes is relatively low – 0.7–4.6 %, (on average
2 % of wet weight), but in many areas potato consumption reaches 150 kg or more per person per year. Therefore, potato as a source of protein is of great importance in nutrition.

According to A.S. Vechera, M.N. Goncharik (1973) [5] varietal differences were more pronounced in the content of non-protein nitrogen than protein. In general, protein nitrogen in potatoes is 1.5–2.5 times more than non-protein. This coincides with data obtained in other countries, according to which the ratio of protein, amine, and amide nitrogen in potatoes is 6:3:1.

The amino acid composition of proteins in different varieties of potatoes is identical, only the quantitative content of individual free amino acids changes. The content of free amino acids in potatoes of different varieties ranges from 973 to 2329 mg %. The predominance of alanine was found to be 96–248 mg %, histidine + lysine – 84–228 mg %, the content of glutamic acid to be 88–376 mg %, the content of phenylalanine to be 63–82 mg % of dry weight. The total amount of amino acids depends on the growing conditions [6]. The maximum amino acid content is achieved in the flowering phase of potatoes. Amino acids indirectly affect the taste and aromatic properties of potatoes. The ratio of amino acids to sugars is one of the reasons for the different taste of potato tubers [7]. During storage, the amount of amides and free amino acids in tubers increases, the amount of arginine, histidine, lysine, leucine, phenylalanine and proline increases, while the amount of methionine, isoleucine, alanine, glycine and tyrosine decreases. An increase in the amount of amino acids/amides and a decrease in starch during storage lead to a deterioration in the taste of potatoes.

2. Materials and methods
The starting material for the research was potato tubers of breeding hybrids M 11.58, 12.2.8, 10.76.1 and the zoned Nevsky potato variety (standard).

The studies were carried out at the Center for Collective Use of the Federal State Budget Scientific Institution Federal Scientific Center of BST RAS. For analysis, one tuber was taken in 3-fold repetition. In tubers were determined: starch content – by specific gravity (GOST 7194-81); reducing sugars – according to the Sumner method; crude protein – according to the Kjeldahl method, GOST 13496.4-93; nitrates – ion-metric according to GOST 29270-95. The taste of boiled potatoes was determined organoleptically on a 9-point scale: 9 – excellent, 7 – good, 5 – satisfactory, 3 – fresh, 1 – bad (unpleasant, bitter).

The determination of amino acids was carried out two weeks after digging potatoes and at the end of March according to "M-04-38-2009" on the system of capillary electrophoresis "Drops-105".

3. Discussion of the results
The analysis of experimental data showed that during the last months of storage (as in our case, April) in early varieties of potatoes, the content of individual amino acids and their total amount usually increases (table 1). Thus, in spring tubers of the Nevsky medium variety, an increase in the content of most amino acids was noted in the spring, such as lysine, tyrosine, phenylalanine, leucine-isoleucine, methionine, valine, proline, threonine and alanine, with a total amount of 6130 mg %. In the autumn period (after harvesting), the content of the listed amino acids in freshly harvested potatoes was 2–3 times lower, and their total amount was 4260 mg %.

Trends similar to the standard (Nevsky variety) were noted for two hybrids 10.76.1 and M 11.58, and only for hybrid 12.2.8 another direction is observed in the amino acid content at different analyzed times, which may be related to the ripeness group of the hybrid. It should also be noted that the content of individual amino acids and their total amount in the tubers of hybrids were slightly lower compared with those of the standard, which can be associated with both, nutrition, growth conditions as well as biological characteristics of the objects of study.

So, if in the tubers of the Nevsky variety (standard) the total amino acid content was 6130/4260 mg % in spring / autumn, then in hybrids it was lower and ranged from 4260/3700 mg % (10.76.1) to 3680/3650 (M 11.58). The relative content of essential amino acids (EAA index) was a stable value that varied in a rather narrow range with an indicator 57.3 to 60.0 % (hybrid M 11.58) to 63.1/61.6 % (hybrid 10.76.1).
Table 1. Amino acid composition of tubers of potato, 2018

| Indicators          | M 11.58 | 12.2.8 | 10.76.1 | Nevsky |
|---------------------|---------|--------|---------|--------|
|                     | spring  | fall   | spring  | fall   | spring  | fall   |
| Arginine            | 300     | 290    | 200     | 250    | 220     | 230    |
| Lysine *            | 210     | 340    | 200     | 280    | 230     | 240    |
| Tyrosine            | 190     | 200    | 200     | 280    | 230     | 240    |
| Phenylalanine *     | 210     | 210    | 200     | 320    | 250     | 250    |
| Gis tidin *         | 140     | 140    | 140     | 130    | 120     | 170    |
| Leucine-iso-leucine * | 540   | 570    | 510     | 670    | 700     | 640    |
| Methionine *        | 180     | 150    | 100     | 150    | 440     | 160    |
| Valin *             | 330     | 390    | 230     | 360    | 390     | 330    |
| Proline             | 360     | 220    | 300     | 240    | 330     | 250    |
| Threonine *         | 500     | 420    | 530     | 460    | 520     | 450    |
| Serine              | 190     | 320    | 220     | 380    | 250     | 240    |
| Alanine             | 300     | 210    | 310     | 240    | 300     | 230    |
| Glycine             | 230     | 220    | 220     | 330    | 240     | 230    |
| Amount of Amino Acids | 3680 | 3650   | 3420    | 4160   | 4260    | 3700   |
| EAA, %              | 57.3    | 60.0   | 57.6    | 58.7   | 63.1    | 61.6   |

Note: * – Essential amino acids

In autumn measurement of amino acids in samples of freshly harvested potatoes relative content of essential amino acids in the tubers of hybrids exceeded the standard: the EAA_{10.76.1} 61.6 % > EAA_{M11.58} 60.0 % > EAA_{12.2.8} 58.7 % > EAA_{Nevsky} 55.6 %. In the analysis of tubers after storage (spring) only hybrid 10.76.1 of the EAA-index (63.1%) is significantly superior to the standard 60.3 %, which is possibly associated not only with biological characteristics, but also with storage conditions.

An increase in the amount of amino acids during storage positively correlates with deterioration in taste in potatoes [8].

Table 2. Biochemical indicators of potato tubers

| Name of indicator   | Nevsky  | 10.76.1 | 12.2.8 | M 11.58 |
|---------------------|---------|---------|--------|---------|
|                     | spring  | fall    | spring  | fall    | spring  | fall    |
| Dry matter, %       | 21.3    | 23.5    | 21.0    | 22.5    | 21.9    | 23.5    |
| Starch, %           | 15.7    | 17.7    | 15.4    | 17.0    | 16.3    | 17.7    |
| Reducer. Sugar %    | 0.45    | 0.09    | 0.35    | 0.07    | 0.40    | 0.03    |
| Taste in points     | 5.1     | 7.0     | 56.5    | 67.9    | 7.5     | 7.7     |
| Protein, %          | 1.40    | 1.35    | 1.10    | 1.08    | 1.40    | 1.38    |

During culinary processing the tested hybrids both in autumn (7.7–9.0) and spring (6.5–7.5) exceeded the standard (Nevsky) 7.0/5.1point.

In spring, after prolonged storage in tubers of the Nevsky variety, the sum of amino acids increased by 1.44 times compared to autumn, and the taste rating decreased from 7.0 to 5.1 points. Similarly to the Nevsky variety, tendencies of change in indicators were noted in the hybrid 10.76.1, with a spring increase in the total amount of amino acids by 1.15 times, the taste of tubers decreased from 7.9 to 6.5 points.

The ratio of starch/protein, which determines taste, was always wider in autumn (after harvesting) in all tested variety samples and decreased by spring: for the standard from 13.1 to 11.2; for a hybrid 10.76.1 – from 15.7 to 14.0; for a hybrid 12.2.8 – from 12.8 to 11.6 and for the hybrid M 11.58 – remained at almost the same level 18.7 and 18.5.

The content of reducing sugars, the presence of which affects the quality of processed fried products, was low in all varieties in autumn 0.03–0.09 %, and increased after prolonged storage (spring) to 0.35–0.45 %.
4. Conclusion
Thus, the biochemical analysis of potato tubers makes it possible to highly evaluate the hybrid 10.76.1 with red peel according to the EAA index of amino acid composition 61.6-63.1 % and taste 7.9/6.5 points, the ratio of starch / protein 14.0-15.7, which is higher than the similar indicators of the standard (Nevsky): EAA 60.3/55.6 %, taste 7.0/5.1 points, starch / protein 11.2-13.1.

The other two hybrids 12.2.8 and M 11.58 exceeded the standard in terms of dry matter / starch content and taste. However, they were inferior in terms of total amino acid content and EAA index.

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