Assessment of the biochemical composition and technological properties of Far Eastern dessert pumpkin varieties for the production of functional products

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Abstract. The article presents the analysis results of the breeding suitability of two Far Eastern pumpkin varieties, Nadezhda and Vnuchka, according to key biochemical, consumer and technological indicators, with a view to their possible use as functional food products. The results show that the biochemical parameters of these varieties’ fruits are unstable and varied depending on the hydrothermal conditions of the year. Both varieties are high in vitamins with an average ascorbic acid content of 10.12 mg% (Nadezhda) and 11.71 (Vnuchka) mg%. The total sugar content in both varieties is almost equivalent, with an insignificant difference of less than 1%. However, the Nadezhda variety has a higher yield. It was found that both studied varieties are suitable for the production of functional products according to the main test indicators in the conditions of the Middle Amur region. Nevertheless, the Nadezhda variety is characterised by shorter periods favourable for processing raw pumpkin materials of 1–2 months after harvesting, while the Vnuchka variety can be processed 1–4 months after.

1. Introduction
A priority state project of the Russian Federation is to improve the quality of life of its citizens by maintaining health and working capacity. Providing good nutrition is particularly important to achieve these goals, including the development and production of various functional food products that contribute to preserving and strengthening health [1]. Particular attention has been given to developing new balanced products enriched with ingredients, such as multicomponent food products with desired properties, that increase the products’ nutritional and biological value [2].

In developing the food and processing industry in Russia, it is necessary to take into account advances in nutrition science concerning food production technology. In particular, Russian nutritionists should consider the deficiency of micronutrients in food fortification, which is unsafe for health. Micronutrients include vitamins, minerals and trace elements that are found in food in very small quantities (milligrams or micrograms). While not sources of energy, they participate in the assimilation of food, regulation of functions, implementation of growth processes and adaptation and development of organisms.

Food products processed from fruit and vegetables that contain antioxidants, such as ascorbic acid, tocopherols, carotenoids and polyphenols, help reduce the harmful effects of free radicals on living organisms [3, 4]. Pectin and carotene offer particularly useful properties for food products, as they activate humans’ beneficial microflora. The main sources of pectin and carotene are apple and pumpkin fruits [1]. Pumpkin occupies a special place among vegetable crops, being widely used for...
food and feed purposes, as a raw material in the canning, confectionery and vitamin industries and as a high-value raw material with equal nutritional and biological values that corrects the human nutritional balance [5–7].

A balanced combination of proteins, carbohydrates, sugars, vitamins, organic acids and enzymes has a beneficial effect on the human body. Pumpkins contain 5–30% dry matter, 1.5–20% starch, 0.1–0.15% fat, 0.70–0.95% fibre, 0.2–1.4% pectin, 10–14% sugars, 1.8–16.0 mg% carotene and approximately 15 mg% ascorbic acid. Pumpkin is an excellent raw material for the production of dietary foods. Pumpkin is a source of pectin, which is in various forms: insoluble in water, which is part of the cell walls, water-soluble, contained in the protoplasm of cells [1, 8, 9].

The nutritional value of pumpkins as raw materials for functional products indicates that the fruit could be used for drinks and desserts to treat respiratory diseases. The resulting high-protein foods, with high Ca content and vitamins A, C, E and group B, would help increase organism immune defence, reduce the inflammatory process and intoxication and have a beneficial effect on the epithelium of the respiratory tract, protecting its microflora.

The industry requires that the fruit of a particular type of raw plant material have good technological qualities. It further necessitates that the varieties and hybrids used have high yields and other characteristics that determine the profitability of their cultivation and processing in the conditions of the growing place, ensuring high quality of the products [5].

Therefore, the purpose of our research is to assess whether dessert pumpkin varieties of Far Eastern breeding are suitable for functional food products according to key biochemical and technological indicators.

2. Materials and methods
This study considers Nadezhda and Vnuchka pumpkins, two varieties of local breeding, zoned in the Far Eastern region. The pumpkin crop was accounted at the end of September to assess the biological ripeness of the fruit, with diseased specimens culled. Sampling of the fruit and preparation for laboratory analysis was performed according to GOST 7975-2013. The quantity of dry matter, mass fraction of fat in the dry matter and mass fraction of crude fibre in the dry matter were determined using the gravimetric method, while the total sugar content was assessed with the Bertrand method. The spectrophotometric method was used to assess the carotene content in the dry matter, phosphorus and nitrogen. The potassium was assessed with flame spectrophotometry and vitamin C with the titrimetric method. Protein was examined using the spectrophotometric method with Nessler’s reagent and according to the following state standards: GOST 54951-2012, GOST 31675-2012, GOST 13496.17-95 and GOST 13496.15-2016.

To determine the technological properties of the studied pumpkin varieties, the ratio of the individual parts of the fruit was calculated, with the peel, pulp and placenta with seeds separated. Variability of productivity and fetal weight (coefficient of variation) was calculated according to Dospekhov [10].

3. Results and Discussion
The findings show that the shape of the studied fruits is flat-round and the colour of the pulp is orange (table 1). Both varieties of pumpkin are fragrant and juicy, but the Nadezhda variety has a rich, sweet taste.

| Table 1. | Tasting assessment of pumpkin dessert fruits by organoleptic indicators. |
|----------|--------------------------|--------------------------|
| Indicators | Pumpkin variety |  |
| Fetal shape | Nadezhda | Vnuchka |
| The main coloration of the fruit surface | flat-rounded | flat-rounded |
| Coloration of fruit pulp | light grey | dark green with light green-grey |
|  | stripes |
|  | Orange |
|  | Orange |
The bark thickness of both varieties is thin, averaging 3.70 mm in the Nadezhda variety and 3.20 mm in the Vnuchka variety (table 2). The varieties have an average pulp thickness of 3.91 cm (Nadezhda) and 2.13 cm (Vnuchka). The mass fraction of placenta with seeds averaged 12.30% and 14.45% in the Nadezhda and Vnuchka varieties, respectively. The share of peeled pulp without peel was 77.00% in the Nadezhda variety and 71.60% in the Vnuchka variety.

| Indicators                                      | Pumpkin variety | Nadezhda | 2018 | 2019 | Average | Vnuchka | 2018 | 2019 | Average |
|------------------------------------------------|-----------------|----------|------|------|---------|---------|------|------|---------|
| The height of the fruit, cm                    |                 |          |      |      |         |         |      |      |         |
| The largest transverse diameter of the fruit, cm |                 |          |      |      |         |         |      |      |         |
| Bark thickness, mm                             |                 |          |      |      |         |         |      |      |         |
| The thickness of the fruit pulp, cm            |                 |          |      |      |         |         |      |      |         |
| The height of the fetal chamber, cm            |                 |          |      |      |         |         |      |      |         |
| Fetal camera diameter, cm                      |                 |          |      |      |         |         |      |      |         |
| Placenta mass with seeds, kg                   |                 |          |      |      |         |         |      |      |         |
| Peel weight, kg                                |                 |          |      |      |         |         |      |      |         |
| Mass of pulp without peel, kg                  |                 |          |      |      |         |         |      |      |         |

Laboratory studies of the fruits showed that their biochemical parameters changed depending on the hydrothermal conditions of the year. Hydrothermal coefficient (HTC) is the ratio of the total precipitation to the sum of the temperatures reduced by 10 times and is used as an indicator of the plant’s need for moisture [11]. The Nadezhda variety showed the best indicators in 2018 (HTC = 2.1) in terms of the mass fraction of moisture (87.70%), mass fraction of fat in the dry matter (1.90 %), carotene content in the dry matter (193 mg/kg), dry matter (3.74% abs. dry.), total sugar (7.52%), vitamin C (10.4 mg%), phosphorus (0.67% abs. dry.) and potassium (1.99% abs. dry.) (table 3). However, the Vnuchka variety presented an increase in indicators in 2019 (HTC = 2.5) compared with the previous year, exhibiting the following values: dry matter (2.0% abs. dry.), total sugar (0.44%), vitamin C (by 3.56 mg%), phosphorus (0.09 % abs. dry.), and nitrogen (by 0.04% abs. dry.).

Both varieties are high in vitamins with an average content of 10.12 mg% (Nadezhda) and 11.71 mg% (Vnuchka) of ascorbic acid. The total sugar content in the varieties is similar, with an insignificant difference of 0.64%. In both years, the Nadezhda variety led in indicators such as mass fraction of moisture, mass fraction of fat in the dry matter and carotene content in the dry matter and potassium, while the Vnuchka variety was significantly more enriched with nitrogen.

| Indicators                                      | Pumpkin variety | Nadezhda | 2018 | 2019 | Average | Vnuchka | 2018 | 2019 | Average |
|------------------------------------------------|-----------------|----------|------|------|---------|---------|------|------|---------|
| Mass share of moisture, %                       |                 |          |      |      |         |         |      |      |         |
| Mass fat in dry matter, %                       |                 |          |      |      |         |         |      |      |         |
| Mass share of raw fiber in dry matter, %        |                 |          |      |      |         |         |      |      |         |
| Carotene content in dry matter, mg/kg           |                 |          |      |      |         |         |      |      |         |
Dry substance, % abs. dry.      3.74  11.90  7.82  2.74  13.9  8.32
Total sugar, %               7.52  6.08  6.80  5.96  6.36  6.16
Vitamin C, mg %               10.4  9.84 10.12  8.02 15.40 11.71
Phosphorus P₂O₅, % abs. dry.  0.67  0.43  0.55  0.50  0.52  0.51
Potassium K₂O, % abs. dry.   1.99  2.56  2.28  1.61  2.01  1.81
Nitrogen, % abs. dry.        0.96  0.12  0.54  0.97  0.16  0.56

The Nadezhda variety (4.89 kg/plant) stood out in terms of productivity over the years studied (figure 1), with an average fruit weight of 3.33 kg. The coefficient of variation was 10.5–16.2% for productivity and 2.74–2.48% for weight of the foetus. However, it should be noted that the Vnuchka variety belongs to a small-fruit portioned variety; the average weight of the foetus was 1.09 kg with a variation coefficient of 4.44–15.66%.

![Figure 1. The productivity of dessert pumpkin varieties.](image)

4. Conclusion
In this study, experimental data on the biochemical composition, technological and consumer properties of dessert pumpkin varieties of Far Eastern breeding in the Middle Amur Region were obtained to examine the varieties’ suitability for use in functional food products.

The Nadezhda variety is more productive than the Vnuchka variety, providing 1.55–5.00 kg more raw material per plant. The tasting assessment of the pumpkin fruits according to organoleptic indicators of consumer properties revealed that the appearance, colour and aroma of both varieties satisfy consumers’ aesthetic values. Nevertheless, the Nadezhda pumpkin has a more saturated sweet taste than the Vnuchka pumpkin, and its overall tasting score was 1.6 points higher.

Biochemical studies of the fruits showed that the Vnuchka variety is characterised by a high content of vitamin C (11.71 mg%) and is more enriched with nitrogen (0.57% abs. dry.), but it is inferior to the Nadezhda variety in terms of the mass fraction of moisture, mass fraction of fat in dry matter, carotene content in dry matter and potassium.

This studies have shown that in the Middle Amur region, favourable periods for processing pumpkin raw materials are the first 1–2 months after harvesting for the Nadezhda variety and 1–4 months after harvesting for the Vnuchka variety.
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