Chemical composition of a seed kernel of a pumpkin produced in the Central Chernozem region of Russia

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Abstract. Seeds are the by-product in the cultivation of pumpkin. They are characterized by a high level of mineral substances and essential oils. However, the level of accumulation of biologically active components of seed kernel varies greatly among pumpkin varieties depending on climatic cultivation zones. Pumpkin varieties – Vitaminnayanaya, Michurinskaya sladkaya, Kubyshka, Muskatnayanaya, Aport – are taken as the objects of study. The chemical analysis of pumpkin seed kernels was carried out in accordance with generally accepted methodological recommendations. It was found that the sodium content in pumpkin seed kernel in the varietal section varies within the range of 5.07-17.6 mg/100 g, potassium – 554.8-767.1 ml/100g, calcium – 156.6-989.0 ml/100g, magnesium – 125.5-323.8 ml/100g, iron – 2.31-6.92 ml/100g, copper – 0.384-0.697 ml/100g, zinc – 4.80-7.43 ml/100g. The kernels of pumpkin seeds of the Michurinskaya sladkaya variety are characterized by high level of calcium – 989 ml/100g. Pumpkin seed kernels zoned in Tambov Region are rich in essential linoleic acid (52.59-63.87%), polyunsaturated oleic acid (11.70-27.35%), tocopherol (90-140 ml/100g). According to the content of linoleic acids, the highest indicators were found in seeds of Aport varieties – 63.87%, oleic acids – Muskatnayanaya (27.35%). The high content of tocopherol is typical for seeds of the Michurinskaya sladkaya variety – 140 ml/100 g. The obtained data on the chemical composition of pumpkin seed kernels indicate their promising use in the creation of functional food products and biologically active additives.

1. Introduction

In the modern world, the food industry has an important task – to provide the population with food products that meet not only the requirements of the current regulatory and technical documentation, but also make it possible to increase the resistant properties of the human body exposed to adverse environmental factors, including in pandemic conditions. It is functional food products that contribute to the prevention of diseases related to nutrition, therefore it is necessary to expand the raw material base of the sources of functional ingredients, including those of plant origin [1-3].

Pumpkin is an annual herbaceous plant of the cucumber family. Large-fruited pumpkin (Cucurbita maxima) and summer or common pumpkin (Cucurbita pepo) are widely cultivated. Pumpkin fruit is a juicy multi-seeded pumpkin with yellow flesh with a diameter of 15 to 40 cm. Pumpkin fruits are processed in significant volumes in order to produce juices, squash and jam, and are also used at forage enterprises to prepare feed for farm animals. Secondary oil-containing products are pumpkin
seeds having high oil content [4, 5].

Seeds make up 0.75 5% of the pumpkin weight. About 200-300 pumpkin seeds and sometimes up to 700 kg are collected from 1 hectare of arable land. Seeds are flat, elliptical, 10-12 mm long. They have two shells – external, woody, yellowish-white and internal film, greenish-gray. The seeds are without an endosperm, kernel – with large wide cotyledons, seed shell makes on average 20-32% of seeds weight, and the mass of 1000 dry seeds is 140-350 g [3, 7, 8].

Due to its composition and, more importantly, the specific range of fats, pumpkin seed kernels are considered a valuable dietary component. In some countries, they are served as an appetizer, mainly after salting and frying. Pumpkin seed kernels are also used as additives to confectionery and bakery products. Pumpkin seed oil (especially produced from shell-free seeds) is used both in food (as salad oil) and in the pharmaceutical industry [1, 6, 9].

With oil as the main component (which in many cases is 50% of the total weight), pumpkin seeds are considered a valuable source of protein and fat. Pumpkin seed oil includes fatty acids: palmitic (C 16:0), stearic (C 18:0), oleic (C 18:1) and linoleic (C 18:2) [5]. However, the level of accumulation of biologically active components in a kernel varies greatly among pumpkin varieties depending on climatic cultivation zones. It should be noted that data on the biochemical composition of pumpkin seed kernel zoned under the conditions of the Central Chernozem region of the Russian Federation are not presented in the literature.

The purpose of this study was a comprehensive assessment of seed kernels of pumpkin varieties grown in Tambov Region of the Russian Federation. The attention is paid to the content of food and biologically active substances, mineral elements.

The objects of study include the most promising varieties of pumpkin – Vitaminnaya, Michurinskaya sladkaya, Kubyshka, Muskatnayanaya, Aport grown at the experimental site of the experimental farm of Michurinskaya State Agrarian University in accordance with the recommendations of Skrypnikov Yu.G., Professor, Doctor of Agricultural Sciences [1].

2. Materials and methods
Chemical analyses of fruits were carried out in accordance with the generally accepted methodological recommendations: food fibers by enzymatic-gravimetric method according to GOST R 54014-2010; total protein content according to GOST 26889-86; fatty acid composition – gas capillary chromatography as per GOST R 51483-99; fat content – extraction of fats with chloroform-methanol mixture by Folch method; content of sodium, potassium, calcium, magnesium – according to GOST 33462-2015; iron, copper, zinc – according to GOST EN 14084-2014; total content of tocopherols – according to the methodological manual P 4.1.1672-03. Statistical processing of the results was carried out using the SPSS 20/0 software package (IBM, USA).

3. Research results of pumpkin seeds chemical composition
The level of protein accumulation in seed kernels of the studied pumpkin varieties varied between 17.7-28.3% (Table 1). The highest level of protein accumulation is typical for Muskatnaya seed kernels. According to literary data, seed kernels of pumpkin varieties zoned in the Central Chernozem region are characterized by a lower level of protein accumulation compared to seed kernels zoned in the Krasnodar Territory [6], Poland and Austria [9].

The lipid content in seed kernels of studied pumpkin varieties varies within 43.4-58.7%. The studies revealed that the largest content of lipids in pumpkin seed kernels was found in Aport variety – 58.7%, Kubyshka (53.3%), Michurinskaya sladkaya (53%) and Muskatnayanaya (50.3%) slightly lag behind this indicator. The lowest content of fatty acids in pumpkin seeds was found in Vitaminnaya variety – 43.4%. The content of lipids in the kernels of pumpkin seeds grown in the Krasnodar Territory is 28-32%, Poland and Austria – 39-47%.

It was found that the content of dietary fibers in seed kernels of studied pumpkin varieties ranges within 6.6-8.4%, of which insoluble dietary fibers account for 68-91% of the total content, and soluble dietary fibers – 0.1-0.33%. The highest level of dietary fibers is typical for Vitaminnaya,
Michurinsky sladkaya and Kubyshka varieties. The highest level of insoluble dietary fibers is typical for Vitaminnaya and Michurinsky sladkaya, soluble dietary fibers – Kubyshka.

### Table 1. Chemical composition of pumpkin seed kernels

| Variety           | Fat, % | Protein, % (Nx6.25) | Food fiber (total), % | Insoluble dietary fiber, % | Soluble dietary fiber, % |
|-------------------|--------|---------------------|-----------------------|----------------------------|--------------------------|
| Vitaminnaya       | 43.4   | 27.9                | 8.1                   | 7.4                        | 0.7                      |
| Michurinskaya sladkaya | 53.0   | 26.2                | 8.4                   | 7.6                        | 0.8                      |
| Kubyshka          | 53.3   | 24.6                | 8.0                   | 5.4                        | 2.6                      |
| Muskatnayana      | 50.3   | 28.3                | 7.2                   | 5.1                        | 2.1                      |
| Aport             | 58.7   | 17.7                | 6.6                   | 5.2                        | 2.1                      |

According to studies conducted by Leila Rezig et al. (2019) [8], Mallek Ayadi et al. (2018) [9], Siddeeg et al. (2014) [10], Vasilyeva A.G. and Kruglova I.A. (2007) [6], El Adawy and Taha (2001) [11], Shevyakova L.V. and Bessonov V.V. (2018) [12], pumpkin seed kernels are characterized by high accumulation of potassium, calcium, zinc and phosphorus.

Sodium content in pumpkin seed kernels in the varietal section is found to vary within the range of 5.07-17.6 mg/100 g, potassium – 554.8-767.1 ml/100g, calcium – 156.6-989.0 ml/100g, magnesium – 125.5-323.8 ml/100g, iron – 2.31-6.92 ml/100g, copper – 0.384,-0.697 ml/100g, zinc – 4.80-7.43 ml/100g, which corresponds to the literature data (Table 2).

### Table 2. Content of macro- and microelements in pumpkin seed kernels

| Variety           | Sodium, mg/100 g | Potassium, mg/100 g | Calcium, mg/100 g | Magnesium, mg/100 g | Iron, mg/100 g | Copper, mg/100 g | Zinc, mg/100 g |
|-------------------|------------------|---------------------|-------------------|---------------------|----------------|------------------|----------------|
| Vitaminnaya       | 17.6             | 767.1               | 156.6             | 190.2               | 2.51           | 0.384            | 6.49           |
| Michurinskaya sladkaya | 5.07         | 554.8               | 989.0             | 125.5               | 2.31           | 0.554            | 4.80           |
| Kubyshka          | 9.63             | 590.0               | 171.0             | 208.0               | 6.92           | 0.697            | 7.31           |
| Muskatnayanaya    | 4.76             | 471.4               | 148.9             | 179.4               | 3.90           | 0.586            | 7.43           |
| Aport             | 9.95             | 451.5               | 227.5             | 323.8               | 3.49           | 0.452            | 6.34           |

The kernels of pumpkin seeds of Michurinsky sladkaya variety are characterized by high level of calcium – 989 ml/100g, which significantly exceeds the literary data.

The validity of the obtained results of fatty acid content in pumpkin seeds was checked using the Cochran’s Q Test. The comparison of the table values of the Cochran’s Q Test with the calculated results indicates the reliability of the obtained data from chemical studies of fatty acid composition (Table 3).

According to the obtained data, the fatty-acid composition of seed kernels of the studied pumpkin varieties includes the following (Fig. 1):

- saturated fatty acids: myristic (0.11-0.15%), pentadecanoic (0.01-0.03%), palmitic (12.20-18.79%), hexadecenoic (0.01-0.02%), heptadecenoic (0.04-0.15%), heptadecenoic (0.02-0.07%), stearic (4.90-6.55%);
- Omega-9-monounsaturated fatty acids: palmitoleic (0.10-0.15%), oleic (11.70-27.35%), gondoic (0.06-0.11%);
- Omega-6-polyunsaturated fatty acids: linoleic (52.59-63.87%), y-linoleic (0.12-0.61%);
- Omega-3-polyunsaturated fatty acids: iso-octadecadienoic (0.03-0.05%).

The obtained data on the level of fatty acid accumulation in pumpkin seed kernels are confirmed by the studies M. Ziaul Amin (2019) [13], Orsavova J. (2015) [14], Mallek-Ayadi et al. (2018) [9], Siano F. et al (2016) [15].
Table 3. Calculation of the Cochran’s Q Test

| Fatty acid and its index | Estimated Q-criterion | Tabulated value of Q-criterion |
|--------------------------|-----------------------|-------------------------------|
| Pentadecane 15:0         | 0.5684                | 0.68                          |
| Palmitin 16:0            | 0.6234                | 0.68                          |
| Hexadecenoic 16:1        | 0.5985                | 0.68                          |
| Palmitoleic 16:1 (9-cis) | 0.6759                | 0.68                          |
| Heptadecoic 17:0         | 0.5896                | 0.68                          |
| Heptadecanoic 17:1       | 0.6563                | 0.68                          |
| Stearic 18:0             | 0.6741                | 0.68                          |
| Oleic 18:1 (9-cis)       | 0.5874                | 0.68                          |
| Vaccenic 18:1 (11-trans) | 0.6145                | 0.68                          |
| Iso-octadecadienoic 18:2i| 0.6235                | 0.68                          |
| Linoleic 18:2            | 0.6544                | 0.68                          |
| γ-linoleic 18:3 (ω-6)    | 0.5874                | 0.68                          |
| Arachic 20:0             | 0.6489                | 0.68                          |
| Gondoinic 20:1           | 0.6321                | 0.68                          |
| Behenic 22:0             | 0.6756                | 0.68                          |
| Lignoceric 24:0          | 0.6589                | 0.68                          |

Figure 1. Structure of fatty acids in pumpkin seeds.

The content of oleic acid in pumpkin seeds varies between 11.70 and 27.35%. The largest content of oleic acid differs in seeds of Muskatnaya variety – 27.35%, significantly inferior in this indicator are the seeds of Vitaminaya variety – 16.78%, Michurinskaya sladkaya – 15.43% and Kubyshka – 14.51%.
The largest content of linoleic acid in seeds was noted in Aport variety – 63.87%, slightly inferior in this indicator is Michurinskaya sladkaya variety – 61.53%, Kubyshka – 59.91% and Vitaminnaya – 58.3%. The lowest content of linoleic acid was found in Muskatnaya variety – 52.59%.

Pumpkin fruit seeds have high content of Vitamin E – tocopherol, which varies within 90-140 mg/100g of the raw weight of the canopy (Fig. 2), which is significantly higher than the obtained data of tocopherol content in pumpkin seed kernels noted by Stevenson D.G. (2007) [16], Kim M.Y. et al. (2012) [9], M. Ziaul Amin (2019) [13], but consistent with the data of Vasilyeva A.G. and Kruglova I.A. (2007) [6]. It is a biocatalyst and is one of the strong antioxidants protecting polyunsaturated fatty acids, retinol and carotenoids from oxidation.

![Figure 2](image-url). Content of tocopherol in the kernel of pumpkin seeds.

The largest tocopherol content was found in pumpkin seeds of Michurinskaya sladkaya variety – 140 ml/100g. The lowest content of Vitamin E was noted in Vitaminnaya variety – 90 ml/100g.

4. Conclusion

Thus, based on the studies it was established that pumpkin seed kernels zoned in Tambov Region are rich in essential linoleic acid (52.59-63.87%), polyunsaturated oleic acid (11.70-27.35%), tocopherol (90-140 ml/100g), calcium (171.0-989.0 ml/100g) and magnesium (179.4-323.8 ml/100g), which indicates the prospect of using them in the creation of functional food products and biologically active additives. According to the content of linoleic acids, the highest indicators were found in the seeds of Aport varieties – 63.87%, oleic acids – Muskatnaya (27.35%). The seeds of Michurinskaya sladkaya variety are characterized by high content of tocopherol – 140 ml/100 g. The kernels of pumpkin seeds of Michurinskaya sladkaya variety are characterized by high calcium accumulation level – 989 ml/100 g.

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