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The quality comparison of different Jerusalem artichoke (*Helianthus tuberosus* L.) cultivars tubers

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The aim of this study was to evaluate the quality of different Jerusalem artichoke cultivars tubers grown in a Lithuanian ecological farm. Jerusalem artichoke tubers of three cv. 'Albik', 'Rubik', 'Sauliai' were grown in the Petras Tiknevičius ecological farm in 2011. The agrochemical indexes of soil and the chemical composition of tubers have been identified. According to our results, cv. 'Sauliai' tubers have been the most productive – the average weight of one tuber was 26.1 g. 'Albik' tubers accumulated the highest amount of dry matter and crude protein – 23.21 ± 0.44% and 7.79 ± 0.5% DM, respectively. 'Rubik' tubers accumulated the most crude fiber and crude ash – 4.28 ± 0.18% DM and 6.75 ± 0.14% DM, respectively.

Key words: Jerusalem artichoke, yield, chemical composition

INTRODUCTION

The Jerusalem artichoke (*Helianthus tuberosus* L.), which is also called the sun choke, sun root, topinambur or earth apple, is an Angiosperm plant species of the Composite family and a warm-season species of sunflower native to temperate regions of North America and it has been grown in Europe since the 17th century. This interesting and useful crop with a beautiful name "ground-pear", due to the high ecological plasticity, and thus high efficiency as a valuable dietary product, is very attractive to cultivation (Zubr, 1988). J. artichoke as species is highly competitive, quickly shading the soil surface and creating a zone of captured resources, thereby repressing the growth of most other species. Tubers and tops of this crop have a universal value. The tubers of Jerusalem artichoke typically comprise about 80% water, 15% carbohydrate, and 1–2% protein. They contain various minerals, especially rich in iron (0.4 to 3.7 mg 100 g^{-1}), calcium (14 to 37 mg 100 g^{-1}) and potassium (420–657 mg 100 g^{-1}) (Whitney, Rolfrs, 1999; Kocsis et al., 2008). The amount of iron in Jerusalem artichoke tubers is about three times bigger as compared with that of potato tubers. Protein in Jerusalem artichoke tubers comprises around 1.6–2.4 g · 100 g^{-1} of fresh weight. Protein and nitrogen levels remain relatively constant in the tubers during development. Jerusalem artichokes are recommended for diabetic patients (Taper, Roberfroid, 2002; Tungland, 2003).

The tubers of J. artichoke, containing up to 20% of inulin and unique on equation vitamin-mineral complex, are valuable foodstuff with high treatment and prophylactic potential (Baker et al., 1990).

In Russian Federation, demand for new varieties of J. artichoke has increased search of a new initial material for breeding. The following aims – precocity, high yield, suitability for production of fructose, inulin, ethanol, medical products, biologically active additives and forage – are very important. Therefore, research on genetic resources of this crop has increased in N. Vavilov Institute of Plant Industry (Rodrigues et al., 2007).

Yet Timiryazev attributed to the artichoke one of the most intensive field crops capable of absorbing carbon from the air and release oxygen. And this is the way to the creation of effective green belts around industrial centers (Dzabiev, 2003).

The aim of this study is the chemical composition of different cultivars of Jerusalem artichoke (*Helianthus tuberosus* L.) tubers grown in Lithuania.

MATERIALS AND METHODS

Plant material

Field experiments on three Jerusalem artichoke (*Helianthus tuberosus* L.) cv. 'Albik', 'Rubik', 'Sauliai' were carried out at the Petras Tiknevičius organic farm in 2011, which is in the Varėna District (south of Lithuania). The soil of the experimental site according to the FAO-UNESCO soil classification is *Haplic Dystri Arenosols*.

The main soil properties are as follows: soil pH_{KCl} 6.7–7.5, available phosphorus (P_2O_5) 101–232 kg^{-1}, available potassium (K_2O) 65–98 mg kg^{-1}.

One factor field experiment was conducted. The size of original fields was 20 × 5 = 100 m^2, as well as that of accounting fields was 20 × 2.3 = 43 m^2, in 4 repetitions. The tubers of Jerusalem artichoke were planted on the first decade of May, where distance between plants was 30 cm and interlinear distance was 70 cm, and harvested in October.

In the repetitions variants were distributed at random. Samples for laboratory analyses were made up of 6 kilograms.

Meteorology

Weather conditions of the Varėna Meteorological Station observations were as follows. Spring in 2011 was compared with the perennial 1924–2011 data. The days were very warm but the nights were cool. In the first half of April the weather was rainy and in the second half it was dry and serene. Precipitation was 42 percent of the multi-annual average. Temperature was very variable in May. Precipitation was 90 percent of the multi-annual average. When Jerusalem artichoke was growing, the weather was damp.

Summer was warm and rainy. The average temperature in the summer months was 1.7 °C warmer than permanent. The weather was very dry and unusually warm in the first half of June. The weather was very warm, windy and dry. Evaporation of moisture was increased from plants and soil. Precipitation during the month dropped to 71 percent of the multi-annual average. This prevented the Jerusalem artichoke stems and tubers from growing very well. July was rainy and warm. Precipitation was 154 percent of the multi-annual average. Moisture and heat supplies were sufficient to develop tubers. The weather was warm (0.7 °C more than the multi-average) and precipitation was 140 percent of the multi-annual average in August. Growth conditions of Jerusalem artichokes were favorable for sugar accumulation in the tubers.

Autumn was warm and dry. The weather was warm and rainy in September. Precipitation was 105 percent of the multi-annual average. There was dry and warm weather in October. It was favorable for sugar accumulation in tubers. In general, the year 2011 was favorable for growing Jerusalem artichokes.

Analytical methods

Quality indicators of soil (pH, amount of available potassium, phosphorus) and some chemical composition of Jerusalem artichoke tubers were determined by standard methods:

– dry matter – ISO 751:2000;

– crude fiber – Weender (LST EN ISO 6865:2001);

– crude protein – LST 1497:97;

– crude ash – LST 1539:1998.

The investigations of soil and tubers were carried out in the Laboratories of Food Raw Materials, Agronomic and Zootechnical Research and Department of Horticulture, Agronomy Faculty, Aleksandras Stulginskis University.

Statistical analysis

The research data was statistically processed using Microsoft Excel 2003 and by calculation of the mean standard deviation of the measurement. Three pairs of values were used to calculate correlation. Correlation coefficient R was calculated to determine the correlation of indexes. The calculated correlation coefficients were evaluated by the Fisher criterion. Significant differences were determined at 95% probability level.

RESULTS AND DISCUSSION

Jerusalem artichoke is a little sensitive to soil reaction and can grow when the soil pH is 5.0–7.4. The sufficient rate of potassium as well as available phosphorus is more than 150 mg kg^{-1}. According to our research results, the soil, where tubers where grown, was rich in phosphorus but too little rich in potassium. Phosphorus plays an important physiological role in development of plants. This element participates in synthesis of carbohydrates and proteins during the process of Jerusalem artichoke tuber formation. Cellular nuclear ferments and CO ferments contain various phosphorus compounds. Phosphorus is also necessary for synthesis and metabolism of organic materials (Cieslik, 1998; Buivydaitė et al., 2006).

Mostly plants lack potassium in soils of light granulometric structure, which have received little potassium fertilization but have been enriched with ammonium fertilizers. Potassium activates photosynthesis, synthesis of macromolecular carbohydrates cellulose and vitamins, strengthens hydration of cytoplasm, improves metabolism, stimulates accumulation of proteins and regulates the ratio of non-protein nitrogen and proteins. The amount of mobile potassium and mobile phosphorus not exceeding 150 mg kg^{-1} soil is a sufficient norm for plants. When soil lacks potassium, plant leaves curl up and deform, yellow spots occur, plants start dying (Buivydaitė et al., 2006; Zhong et al., 2009).

The yield of tubers depends not only on climatic conditions, soil type, cultural practices, and harvest period but also on the quality of the plant and especially the choice of cultivars, having high production in fructose, a correct choice of cultivar is the first necessity for the improvement of this crop (Kays, Nottingham, 2008).

Jerusalem artichoke tuber's size and shape depend on the soil. These results were reflected in the yield obtained. The tuber size and number tend to be inversely related. 'Sauliai' cv. was the most productive – in average 26.1 ± 0.5 g, 'Rubik' cv. – in average 13.6 ± 0.2 g, 'Albik' cv. – in average 11.3 ± 0.4 g per one tuber.

If you compare those results with the yield of late varieties grown in Russia, Hungary and Lithuania, the most productive was cv. 'Interes' (Russia) – in average 44.33 g per one tuber (Dzabiev, 2003).

Jerusalem artichoke contains a sufficiently large amount of dry matter (20%), among which 80% contained a polymer – fructose – inulin (Saengthobpinit, Sajjaanantakul, 2005).

The highest amount of dry matter was established in Jerusalem artichoke tubers 'Albik', the smallest one in 'Rubik'. The amount of dry matter fluctuated from 19.26 to 23.21% (Table). According to other researches, the amount of dry matter is also very similar and in average it fluctuated about 22.0% (Dzabiev, 2003).

The crude fiber content in tubers fluctuated from 3.49 to 4.28% DM. The most crude fiber was accumulated by 'Rubik' tubers (Table). According to the Russian research, the amount of crude fiber in their studies was significantly lower: the average amount was about 1.0% (Dzabiev, 2003).

Quality indexes of some tubers were calculated by correlation. The research data show a strong statistically reliable dependency between crude fiber and dry matter, statistically significant dependence at 95 percent probability level (Fig. 1).

But the research data do not show dependency between crude protein and dry matter. Strong correlation was established between dry matter and crude ash, statistically significant dependence at 95 percent probability level (Fig. 2).

According to our results, the low correlation coefficient between crude fiber and crude ash, statistically significant dependence at 95 percent probability level were calculated (Fig. 3).

The essential difference from other vegetables is that Jerusalem artichoke is manifested in its high content of tubers of the protein (3.2% of dry matter), represented by eight amino acids, including essentials which are synthesized only by plants and not synthesized in humans: arginine, valine, histidine, isoleucine, leucine, lysine, methionine, tryptophan, phenylalanine (Tungland, 2003).

Jerusalem artichoke tuber's crude protein accumulated was 5.12–7.79% DM. 'Albik' tubers accumulated the highest amount of crude protein (Table). According to the Russian research, the

Table. **Chemical composition of Jerusalem artichoke tubers**

Varieties	Dry matter, %	Crude fiber, % DM	Crude ash, % DM	Crude protein, % DM
'Albik'	23.21 ± 0.44	4.10 ± 0.39	5.5 ± 0.17	7.79 ± 0.50
'Rubik'	19.26 ± 0.32	4.28 ± 0.18	6.75 ± 0.14	6.74 ± 1.60
'Sauliai'	22.84 ± 0.35	3.49 ± 0.02	4.58 ± 0.16	5.12 ± 0.09

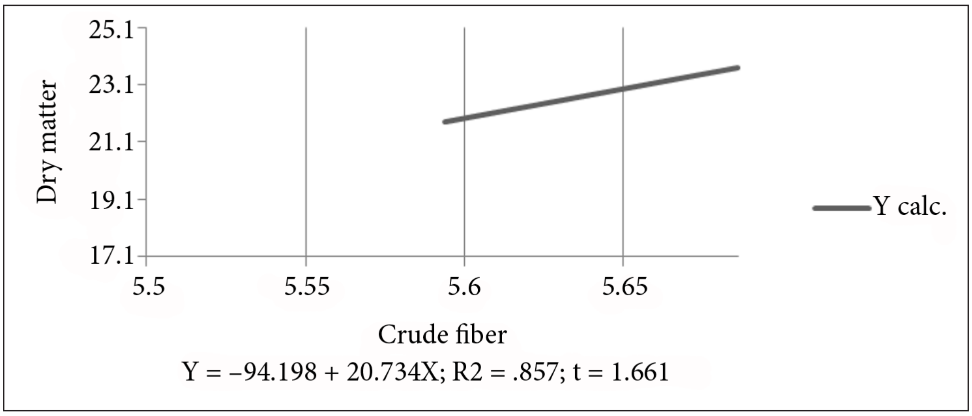

Fig. 1. *Crude fiber and dry matter correlation of Jerusalem artichoke tubers*

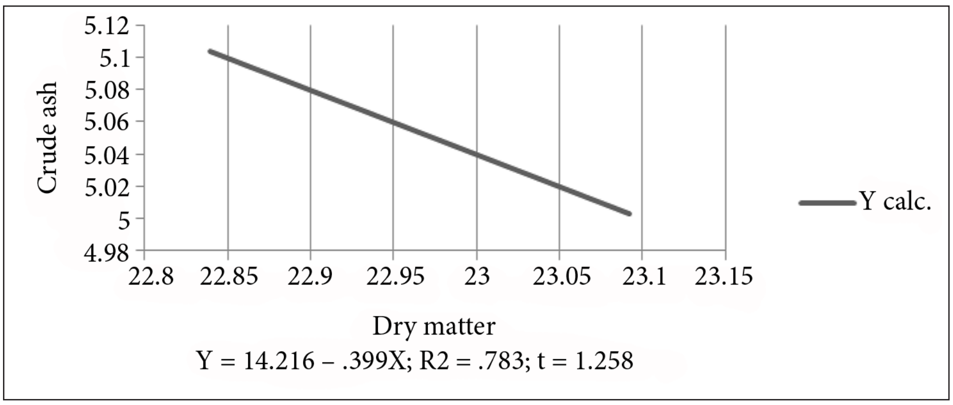

Fig. 2. *Dry matter and crude ash correlation of Jerusalem artichoke tubers*

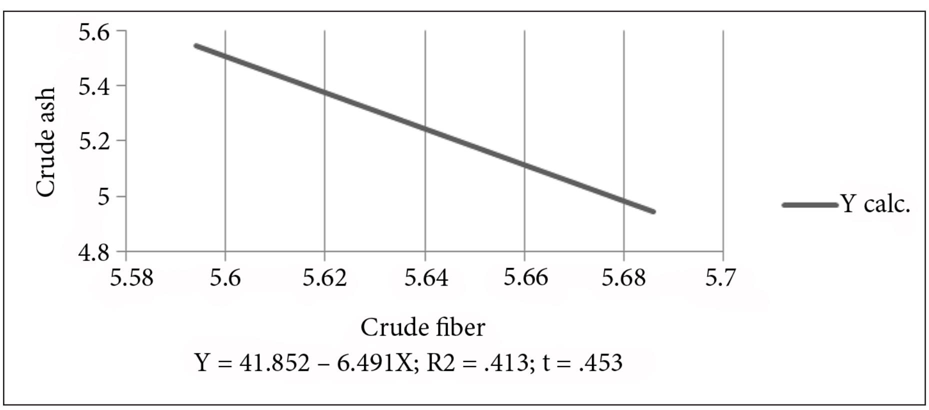

Fig. 3. *Crude fiber and crude ash correlation of Jerusalem artichoke tubers*

amount of crude fiber in their studies was significantly lower: the average amount was about 2.2% (Dzabiev, 2003).

According to our results, the correlation coefficient was not established between crude fiber and crude protein.

CONCLUSIONS

The most productive was cv. 'Sauliai' – the average weight per one tuber was 26.1 g. 'Albik' tubers accumulated the highest amount of dry matter and crude protein – 23.21 ± 0.44% and 7.79 ± 0.50% DM, respectively. 'Rubik' tubers accumulated the biggest amount of crude fiber and crude ash – 4.28 ± 0.18% DM and 6.75 ± 0.14% DM, respectively. The smallest amounts of crude fiber, crude ash and crude protein were established in 'Sauliai' tubers – 3.49 ± 0.20% DM, 4.58 ± 0.16% DM and 5.12 ± 0.09% DM, respectively.

The research data show a strong statistically reliable dependency between crude fiber and dry matter and between dry matter and crude ash. A low correlation coefficient is between crude fiber and crude ash. None correlation is established between crude protein and dry matter, and between crude fiber and crude protein.

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SKIRTINGŲ VEISLIŲ TOPINAMBŲ (*HELIANTHUS TUBEROSUS* L.) GUMBŲ KOKYBĖS RODIKLIŲ PALYGINIMAS

Santrauka

Tyrimo tikslas – įvertinti skirtingų veislių topinambų gumbų kokybę. Trys topinambų gumbų veislės: 'Albik', 'Rubik', 'Sauliai' buvo augintos Petro Tiknevičiaus ekologiniame ūkyje 2011 metais. Nustatyti dirvožemio agrocheminiai rodikliai ir topinambų gumbų vidutinis svoris bei jų cheminė sudėtis. Remiantis tyrimo rezultatais, topinambų veislė 'Sauliai' buvo produktyviausia – vidutiniškai vieno gumbo svoris buvo 26,1 g. Nustatyta, kad didžiausi kiekiai sausųjų medžiagų ir žalių baltymų sukaupta 'Albik' veislės gumbuose – atitinkamai 23,21 ± 0,44 % ir 7,79 ± 0,50 %. Didžiausi kiekiai žalios ląstelienos ir žalių pelenų sukaupta 'Rubik' veislės gumbuose – atitinkamai 4,28 ± 0,18 % ir 6,75 ± 0,14 %.

Raktažodžiai: topinambų gumbai, derlius, cheminė sudėtis