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THE CONTENT OF PROTEIN AND OF AMINO ACIDS IN JERUSALEM ARTICHOKE TUBERS (*HELIANTHUS TUBEROSUS* L.) OF RED VARIETY ROTE ZONENKUGEL

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Introduction. Jerusalem artichoke (*Helianthus tuberosus* L.) is grown primarily for its edible tubers, which were first cultivated by native Americans before the arrival of the Europeans. Unlike most tubers, but in common with other members of the Asteraceae, the tubers store fructans instead of starch. Fructans are non-digestible carbohydrates considered functional food ingredients because they affect body processes in ways that result in better health and in many diseases prevention. However, the Jerusalem artichoke deserves attention not only because of the content of fructans, recent studies also indicate a high protein content, including essential amino acids.
Material and methods. The aim of the work was to establish the content of protein and amino acids in Jerusalem artichoke tubers (*Helianthus tuberosus* L.) of red variety – Rote Zonenkugel. The content of protein was estimated by Dumas method. The amino acids composition was analysed with ion-change chromatography with postcolumn derivatisation and detection of ninhydryn reaction with automatic amino acids analyser.
Results. The assessed liophylisate was characterised by high protein content (6.36%) in comparison to chicory (which is the main industrial source of fructans) and to commonly consumed potatoes. There was shown a few times higher content of essential amino acids (also of methionine) in comparison to chicory and potato. The examined essential amino acids were present in very advantagenous proportions.
Conclusions. In Jerusalem artichoke tubers of Rote Zonenkugel variety of the high content of protein was established in comparison to other plant sources. The high content was found of amino acids with special stress on essential amino acids (esp. sulphur ones).

Key words: Jerusalem artichoke (*Helianthus tuberosus* L.), protein and amino acids' content

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INTRODUCTION

Jerusalem artichoke (*Helianthus tuberosus* L.) belongs to *Asteraceae* family and is still little known, although as cultivated plant has a long tradition. Grown for centuries, the Jerusalem artichoke (*Helianthus tuberosus* L.) was first a source for human food, and later was used in animal feed [Ben Chekroun et al. 1996]. Its cultivation is not difficult, because it is resistant to frost periods, dry periods and poor soils. It is a decorative plant which is high (2.5-3.5 m) and has flowers similar to these of sunflower, but a bit smaller. The seeds cannot mature in Poland so the plant is multiplied by under earth stalk tubers [Burdzenia 2001]. These tubers are the source of fiber, also fructans, best known and the most appreciated components of Jerusalem artichoke tubers.

The proved advantageous influence of high fiber diet in prophilaxis of many diseases caused looking for food rich in alimentary fiber. There is observed a meaningful growth of food enriched in soluble fiber obtained from vegetables and fruit and also from other raw plant materials [Dziugan et al. 2006].

Although the high fructans content is the cause why Jerusalem artichoke tubers are used for obtaining functional food, also the high biological value of proteins and balanced amino acids composition of this plant tubers is worth to underline.

One of the basic and most important nutritive substances are proteins which play an important role in metabolism of each alive organism. Proteins are the mechanical support of cells and tissues; they enchance the origin or/and breakdown of covalent linkages; they generate in cells and tissues motions. They are the building material of tissues and biologically active components (i.e. enzymes and hormons) [Ciborowska and Rudnicka 2007, Gawęcki and Hryniewski 2005, Alberts et al. 2007].

There is a small evidence in literature concerning the content of amino acids in Jerusalem artichoke tubers. Cieślik [1998] showed the high content of essential amino acids in Jerusalem artichoke tubers of three new varietes: Topstar, Gigant and Violet de Rennes. The highest essential amino acids content was fund in Topstar variety. There was established the high content of sulphur amino acids in tubers of all varieties [Cieślik 1998].

AIM OF WORK

The objective of this work was to establish the content of protein and amino acids in Jerusalem artichoke tubers (*Helianthus tuberosus* L.) of red variety – Rote Zonenkugel.

MATERIAL AND METHODS

The research material were Jerusalem artichoke tubers (*Helianthus tuberosus* L.) of red variety – Rote Zonenkugel grown up in Gaj near Cracow (Poland) in 2005. Therefore, in the present study, we investigated protein and amino acids content in a new variety that so far has not been tested. The average sample of 3-5 kg was liophilised and then the total solids, proteins and individual amino acids contents were assessed. All analysis were performed in triplicate repetition.

The content of protein was estimated by Dumas method [PN-EN ISO 14891:2004]. Sample 0.5 g of the lyophilisate was collected to tin foil and closed. The principle of determination consists in the thermal decomposition of sample in the combustion tube at high temperatures (from 900-1200°C) in an atmosphere of oxygen. Nitrogen compounds contained in the test sample are converted into molecular nitrogen, which is then determined quantitatively using a thermal conductivity detector. The nitrogen content is calculated using a microprocessor. The final result was obtained as a percentage of nitrogen, and expressed the protein content after using typical conversion factors.

The amino acid analysis was performed by Moore and Stein method. Liquid-phase hydrolysis of powdered samples was performed in 6M HCl containing 0.5% phenol at 110°C for 24 hours under an argon atmosphere. The hydrolysates were lyophilised, dissolved in an appropriate volume of dilution buffer and filtered through a 0.45 μm syringe filter before applying to the amino acid analyzer. Sulphur-containing amino acids were analysed as oxidation products obtained by performic acid oxidation (18 hours at 4°C) followed by standard hydrolysis procedure with HCl. Amino acids were determined by ion-exchange chromatography with post-column derivatization with ninhydrin using an automatic amino acid analyzer according to standard protocol of manufacturer (Ingos, Czech Republic) [Amino acid... 2007, Davidson 2003, Smith 2003, Carne 2003, Darbre 1986].

RESULTS AND DISCUSSION

In Jerusalem artichoke tubers the total solids average level was 24.17% and in liophylisate the average amount was 96.80%. The average content of protein in liophylisate of Jerusalem artichoke tubers was 6.36%.

Cieślik et al. [2000] found the protein content from 5.5 to 12.5 g·100 g^{-1} of total solids, 7.6 g·100 g^{-1} at average, in Jerusalem artichoke tuber. The values of cited range were also found by Florkiewicz et al. [2007]. The assessed protein content in Albik and Rubik varieties ranged from 6.7 to 7.7 g·100 g^{-1} of total solids – the similar amount of assessed component was found. That value was higher than in potatoes or other tuberroot vegetables as carrot or celery [Kunachowicz et al. 1998]. Protein concentration of tubers of 19 wild and cultivated genotypes was examined by Seiler at three growth stages. The genotype Iowa 1 at the vegetative stage had the lowest protein of 6.18 g·100 g^{-1} d.m., while the highest was reported in Minnesota 1 at the fruiting stage with 12.98 g·100 g^{-1} d.m. [Seiler 1990]. In general, protein concentration increased with increasing maturity and the higher content of protein may be due to translocation of nitrogen from leaves and stem to tubers later in the season.

There was also observed a small decrease of proteins content in tubers stored in soil during winter [Florkiewicz et al. 2007]. Concerning the amount of protein nitrogen the Jerusalem artichoke is similar to potatoes but the protein has a high biological value. The amount of protein in fresh tuber mass ranged from 0.8 to 1.4 g·100 g^{-1} [Cieślik and Filipiak-Florkiewicz 2000].

Among the examined varieties (Violet de Rennes, Topstar, Gigant, Onta, Colambia, Hel, Fuseau & Sakhaliński) the highest protein content was found in tubers of Violet de Rennes variety. It was found that higher protein content was present in tubers cultivated in 1998 than 1997 [Cieślik et al. 2000]. Sawicka [2004] reported high content of

protein in tubers of Kulista Czerwona IHAR (Spherical Red) and Swojecka Czerwona (Familiar Red).

Cieślik et al. [2000] among the assessed varieties found the highest content in Fuseau tubers (8.5 g·100 g^{-1} of total solids at average). The smaller protein content was measured in Topstar, Hel, Sachaliński and Columbia varieties. The content of protein dropped with plant growing up (8.1 g·100 g^{-1} of total solids for tubers harvested in September to 7.4 g·100 g^{-1} in tubers harvested in October). Whereas in tubers harvested after winter soil storage the second growth of protein level was observed (up to 8.1 g·100 g^{-1} of total solids) [Florkiewicz et al. 2007].

In tubers of red variety Rote Zonenkugel the highest content of amino acids was found. The results of amino-acids levels estimations are presented at chromatograms (Fig. 1 and 2). Arginine was the most prevalent among all amino acids in the tubers

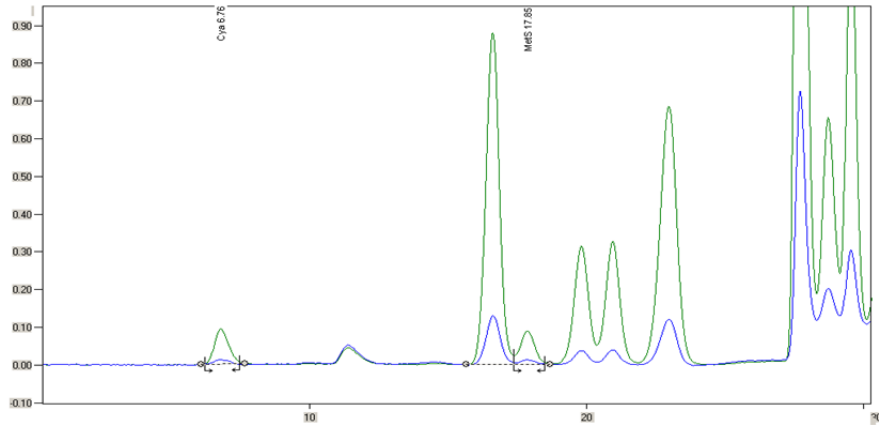

Fig. 1. The chromatogram of sulphur amino-acids content in assessed liophylisate of Jerusalem artichoke tubers

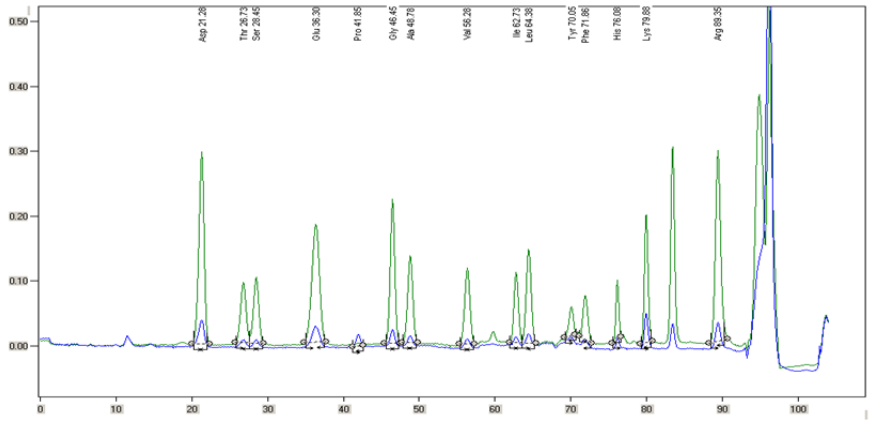

Fig. 2. The chromatogram of amino-acids content (without sulphur amino-acids) in assessed liophylisate of Jerusalem artichoke tubers

of the Jerusalem artichoke (*Helianthus tuberosus* L.), whereby the contents of all the essential amino acids was high and Aleknaviciene et al. [2009] received a similar result. Regarding the content of nonessential amino acids Aleknaviciene et al. [2009] found 2-times higher content of glutamic acid, slightly higher content of alanine and serine, and significantly lower content of aspartic acid (about 400 mg·100 g^{-1} d.m.). According to their results the amounts of essential amino acids in Albik cultivar were slightly higher than in the tubers of Rubik and Swojecka cultivars. Jerusalem artichoke is not well known, although the content of nutrients in the tubers is significantly higher than in the commonly consumed potato or chicory, which is a major source of fructans. The comparison of amino acids composition of Jerusalem artichoke tubers, potato tubers and chicory is presented in Figure 3.

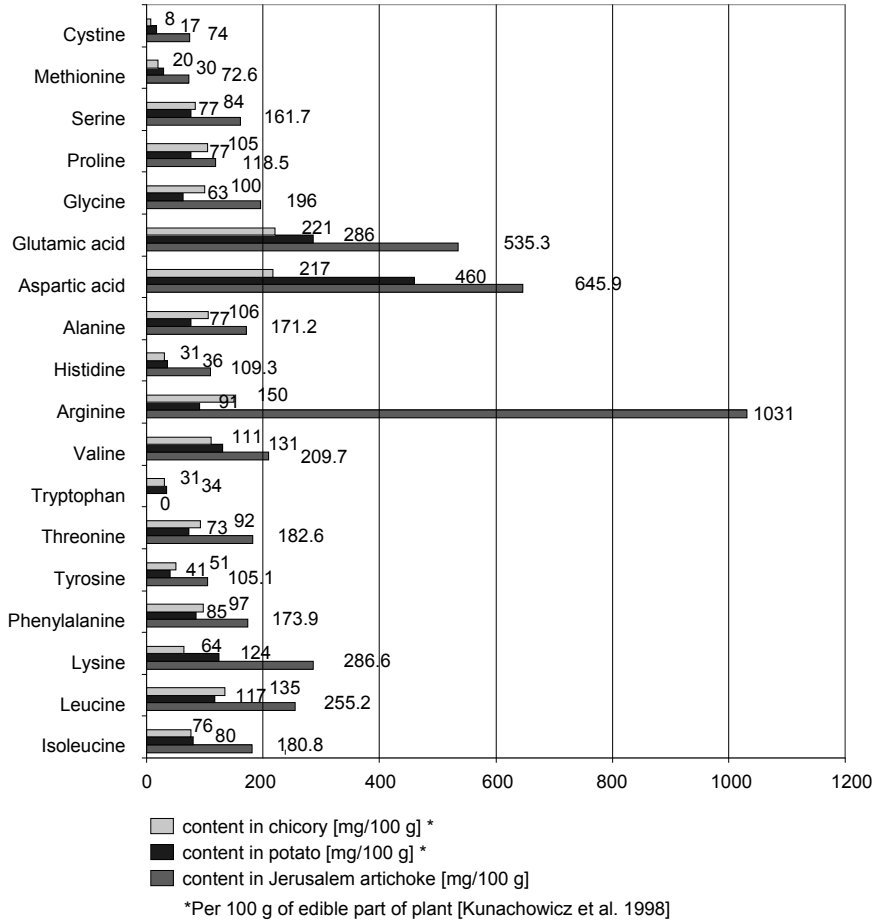

Fig. 3. The comparison of amino-acids composition of Jerusalem artichoke tubers, potato tubers and chicory

More than four times higher content of sulphur amino acids was observed in comparison to potato and chicory. Thanks to such a great amount of sulphur amino acids Jerusalem artichoke can be connected in diet with legumes seeds, which are poor in those amino acids. This can have a special meaning in Asia countries where soy bean is the main source of protein. In comparison to potato the Jerusalem artichoke tubers contain twice the amount of metionine. Because metionine is a restrictive amino acid in potatoes and green vegetables the Jerusalem artichoke tubers can be incorporated into meals with above named vegetables to improve the amino acids assimilation.

In Jerusalem artichoke tubers, over 2-times higher content of all essential amino acids was measured in comparison to their contents in chicory and potato. Reference to chicory stems results from the fact that it is the most important industrial source of fructans. The potato is a very commonly consumed vegetable, and some portion may be substituted for Jerusalem artichoke to enrich and vary the diet.

Cieślik [1998] showed the high content of essential amino acids in Jerusalem artichoke tuber of Topstar, Gigant and Violet de Renes varieties. In comparison to standard protein the very advantageous proportions in amino acids composition were obtained in Jerusalem artichoke tubers. The highest content of essential amino acids had Topstar variety [Cieślik 1998]. The tubers of Rote Zonenkugel variety were characterised by a lower content of essential amino acids than varieties assessed by Cieślik, but still that value was comparable to FAO/WHO standard protein (Table 1).

Table 1. The content of essential amino-acids in Jerusalem artichoke tubers of Rote Zonenkugel variety in comparison to standard protein FAO/WHO, mg·g^{-1} protein

Amino acid	Amino acid composition of	
	standard protein FAO/WHO	Jerusalem artichoke tubers Rote Zonenkugel variety
Histidine	19	17
Isoleucine	28	29
Leucine	66	40
Lysine	58	45
Methionine + Cystine	25	23
Phenylalanine + Tyrosine	63	44
Threonine	34	29
Tryptophan	11	–
Valine	35	33
Sum of essential amino-acids	339	260

Source: FAO/WHO 2007.

CONCLUSIONS

1. In Jerusalem artichoke tubers of Rote Zonenkugel variety, the high content of protein was established in comparison to other plant sources.

2. The high content of amino acids was found with special stress on essential amino acids (esp. sulphur ones).

SUMMARY

Proteins are a particularly important substance of human cells and play an important role in human nutrition. The amino acid content, their proportions and digestibility by humans characterise protein's biological value. Proteins consist of 20 amino acids, but the most important are essential amino acids which the human body needs to take from food. Jerusalem artichoke (*Helianthus tuberosus* L.) is alternative, not very common, agricultural product containing components significant for human nutrition. Although this vegetable is appreciated mainly due to the high fructans content, it is also important for significant amount of essential protein. The tubers of Rote Zonenkugel variety are characterised by a high protein content (6.36%). Above four times higher content of sulphur amino acids and over 2-times higher content of all essential amino acids in comparison to their contents in chicory and potato was measured. That value was comparable to FAO/WHO standard protein. Jerusalem artichoke (*Helianthus tuberosus* L.) is valued not only for its nutritious and medicinal qualities but also for simple cultivation, therefore it is a widely accessible source of proteins.

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Rozporządzenie Ministra Rolnictwa i Rozwoju Wsi z dnia 27 czerwca 2007 w sprawie metodyki postępowania analitycznego w zakresie określania zawartości składników pokarmowych i dodatków paszowych w materiałach paszowych, premiksach, mieszankach paszowych i paszach leczniczych [Minister of Agriculture and Rural Development dated 27 June 2007 on the methodology of analysis for the determination of nutrients and feed additives in feed materials, premixes, compound feeds and feed treatment; in Polish].

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ZAWARTOŚĆ BIAŁKA I AMINOKWASÓW W BULWACH TOPINAMBURU (*HELIANTHUS TUBEROSUS* L.) ODMIANY CZERWONEJ ROTE ZONENKUGEL

Wstęp. Topinambur (*Helianthus tuberosus* L.) jest uprawiany głównie dla jadalnych bulw podziemnych, które rodzima ludność Ameryki wykorzystywała jeszcze przed przybyciem Europejczyków. Podobnie jak u innych przedstawicieli rodziny *Asteraceae*, w topinamburze materiałem zapasowym nie jest skrobia, lecz fruktany. Fruktany to nietrawione przez człowieka węglowodany o właściwościach funkcjonalnych. Dlatego mają korzystny wpływ na zdrowie i znajdują zastosowanie w profilaktyce wielu chorób. Topinambur zasługuje na większe zainteresowanie nie tylko ze względu na zawartość fruktanów. Zawiera on także znaczne ilości białka, w tym aminokwasów egzogennych. Celem pracy było oznaczenie zawartości białka i aminokwasów w bulwie topinamburu (*Helianthus tuberosus* L.) czerwonej odmiany Rote Zonenkugel.

Materiał i metody. Zawartość białka oznaczono według zasady Dumasa [PN-EN ISO 14891: 2004]. Skład aminokwasowy analizowano metodą chromatografii jonowymiennej z postkolumnową derywatyzacją i detekcją reakcji ninhydrynowej, z użyciem automatycznego analizatora aminokwasów.

Wyniki. Otrzymany liofilizat charakteryzował się wyższą zawartością białka (6,36%) w porównaniu z cykorią (która jest głównym źródłem fruktanów produkowanych na skalę przemysłową) czy powszechnie spożywanymi ziemniakami. Stwierdzono kilkukrotnie większą zawartość aminokwasów egzogennych (również metioniny) w stosunku do cykorii i ziemniaków. Wykazano zawartość aminokwasów egzogennych w bardzo korzystnych proporcjach.

Wnioski. W bulwach topinamburu czerwonej odmiany Rote Zonenkugel stwierdzono dużą zawartość białka w porównaniu z innymi źródłami roślinnymi. Wykazano wysoką zawartość aminokwasów, ze szczególnym uwzględnieniem aminokwasów egzogennych (w tym siarkowych).

Słowa kluczowe: topinambur (*Helianthus tuberosus* L.), zawartość białka i aminokwasów

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