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Original scientific paper

NITROGEN AND SUGAR CONTENT VARIABILITY IN TUBERS OF JERUSALEM ARTICHOKE (*HELIANTHUS TUBEROSUS*)

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Several nutritive values for tubers of 114 Jerusalem artichoke (*Helianthus tuberosus*) populations were evaluated during 2006. The used material is a part of wild sunflower species collection at the Institute of field and vegetable crops and it is situated in Rimski Šančevi, Novi Sad. The samples were analyzed as fresh tubers on "Venema" automatic laboratory for alpha amino nitrogen, sodium and potassium content. Total sugar content was determined as the brix value on a refractometer. Total nitrogen was determined by the Kjeldahl method on dried samples.

Significant variability was found for all analyzed traits. Total nitrogen varied from 0,695 to 2,179% dry weight (mean 1,23%), alpha amino nitrogen content 0,012 to 0,118% fresh weight (m. 0,07%), potassium 0,231 – 0,452% fresh weight (m. 0,403%) and sodium 0,0003 – 0,0143% fresh

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weight (m. 0,007%). Total sugar content varied from 13,69 – 22,94% fresh weight (m. 19,14%).

Alpha amino nitrogen is an essential nutrient for animals so that it's presence in tubers of Jerusalem artichoke as food is positive. The protein content is similar to the one in potato and as such satisfactory for nutrition. The K/Na ratio is high which is useful, because an increased content of potassium in food can positively affect the reduction of Na/K ratio and lower systolic blood pressure by a significant amount in adults with mild hypertension. Inulin makes up to 80% of the total sugar content in the tubers of Jerusalem artichoke, and as a dietary fiber and a fructose polymer it positively influences digestion and sugar blood levels.

The obtained results suggest that selection of cultivars and populations with mnappropriate nutritive values is possible. Further research is needed to estimate the share of genetic in total variability and to determine whether the selection for new cultivars is justified.

Key words: α-amino nitrogen, *Helianthus tuberosus*, sunflower, total sugar, variability.

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INTRODUCTION

Helianthus tuberosus (Topinambour - local name) is a perennial sunflower species with origins in central North America. Because of high adaptability, topinambour can grow with low maintenance and irrigation, but in those conditions it quickly uses most of the soil resources and it is than necessary to prepare it for the next cultivar.

As a cultivated crop, topinambour has always been neglected in comparison to other more traditional crops. That was in part because the porpoise for which it was cultivated could be fulfilled in a easier way with other crops. It was cultivated on a larger scale only in a short period after the second world war in France because of potato shortages on approximately 150.000 ha.

Fresh topinambour tubers contain 80% water, 15% sugars and about 2% protein (KAYS and NOTTINGHAM, 2007). Sugars make up to 80% of tuber dry mass and the main carbohydrate is inulin which is a polymer of fructose, with a glucose unit at the end of the chain (CHEKROUN *et al.*, 1996). Due to the presence of inulin the tubers are also considered as good source of dietary fibers.

Tubers contain adequate amounts of macro and micro elements for use as cattle feed. Macro elements Ca, Mg, P and K are present in an appropriate amount, while there is a surplus of sodium compared to other root cultivars. While analyzing 19 topinambour genotypes, of which 9 wild and 10 cultivated, SEILER (1990) found significant differences in protein, macro and micro element content between genotypes while growing them in the same conditions. Tubers were found to be richer in iron (0,4-3,7 mg/100g fresh weight), calcium (14-37 mg/100g f.w.) and potassium (420-657 mg/100g f.w.) in comparison to potato (CIESLIK, 1998).

Proteins are present with about 5-10% of dry weight and they contain almost all essential amino acids. Essential amino acids lysine and methionine, can be found in tubers in larger content than in other similar root crops which is also why topinambour is considered as quality food (RAKHIMOV *et al*., 2003). Because of high adaptability and multiple tuber usability options, this species is becoming an interesting research subject and it is even labeled as a new cultivated crop.

MATERIALS AND METHODS

The topinambour collection was founded in the period between 1980. and 1991. The populations are grown in Rimski Šančevi locality, each in a separate parcel 0.8 by 3 meters. The soil is fertilized each year in spring with 85 kg/h of NPK fertilizer type 15:15:15. The whole collection is irrigated as needed to maintain maximum plant growth. At the end of the flowering stage the aboveground plant parts are removed.

At the end of the vegetation, tubers of 114 populations were dug by hand from three different parts of each parcel for repetitions. They were washed afterwards and immediately analyzed on a "Venema" automatic laboratory which is otherwise used for sugar beet quality analysis. It was used to determine the content of alpha amino nitrogen, Na and K. Total nitrogen was determined on dry samples using Kjeldahl method. The samples were dried on 60°C for 48h and ground afterwards. Total sugar content of the tubers was determined using a refractometer as the brix value which is in high positive correlation with inulin content as well as with total sugar content (BALDINI *et al*., 2004; VAN WAES *et al*., 1998). Brix is by definition a measurement of sugar mass in relation to the water in a sugar solution. To determine the brix value we used a digital refractometer (Schmidt+Haensch – DUR), with automatic temperature control for 20ºC. The data were analyzed using ANOVA and the mean values were compared using least significant difference (LSD) with significance of 0,05 and 0,01.

RESULTS AND DISCUSSION

Total nitrogen, α-amino-N, K, Na, K/Na ratio and total sugar content varied significantly among the genotypes.

The population collected in Montenegro TUB CG 16 had the lowest total nitrogen content (0,70%) while a wild genotype TUB 1628 had the highest (2,18%) (Tab.1.). Previous reports of N content in tubers at full maturity based on dry weight are 0,99-2,05% and on fresh weight 0,38% (SEILER, 1990; KAYS and NOTTINGHAM, 2007). The N content in tubers increases with maturity stages and the determined variability in the studied material is even larger than the previously reported values.

The average protein content (crude protein calculated by Kjeldahl N x 6,25) of tubers of all *H.tuberosus* genotypes at full maturity (7,84%) showed the same pattern as total N and it can be compared to some other more popular crops like dried potato

(8,3%), raw potato (2,1%) and raw turnip (1,9%) (SEILER, 1990). It seems that *H.tuberosus* has an adequate protein content for nutrition (Tab.1.).

The α-amino-N content increases the nutritional quality of the proteins because it is an essential nutrient for animals (KATAGIRI and NAKAMURA, 2002). In this trial, the average content in the studied genotypes varied from 0,01 to 0,12% of tuber fresh weight (Tab.1.).

Table 1. Mean and range values of the analyzed plants for N, K, Na and sugar content in the tubers of Helianthus tuberosus

	Valid N	Mean ± SE	SD	Minimum	Maximum
Total nitrogen (N) % m/m dry weight	114	1,25±0,03	0,28	0,70	2,18
Crude protein % dry weight	114	7,84±0,17	1,77	4,34	13,62
α-amino-N % m/m fresh weight	114	0,07±0,002	0,02	0,01	0,12
K % m/m fresh weight	114	0,40±0,004	0,04	0,23	0,45
Na % m/m fresh weight	114	0,007±0,0003	0,003	0,0003	0,0143
K/Na ratio	114	85,31±17,73	189,26	14,66	1148,00
Total sugars % m/m fresh weight	114	19,15±0,17	1,84	13,69	22,94

Potassium is an essential mineral micronutrient in human nutrition; it is the major cation (positive ion) inside animal cells, and it is thus important in maintaining fluid and electrolyte balance in the body. Average potassium concentration (fresh weight basis) of all genotypes was 0,4% at full maturity. Population TUB CG 14 had the lowest (0,23%) and TUB CG 10 the highest content (0,45%) (Tab.1.). Most genotypes exhibited K content between 0,4 and 0,45 while the largest variability was recorded among the genotypes that originate from Montenegro (TUB CG). Previously reported values range from 0,42 to 0,65% (KAYS and NOTTINGHAM, 2007). Tubers of *H.tuberosus* contain potassium four times that of raw apple (0,11%) and about the same as raw peeled potato (0,42%) (WATT and MERRILL,1963).

Sodium concentration was on average 0,007% (fresh weight basis). The highest content was found in a population collected in the US (TUB 2046 0, 0143%) and the lowest in TUB CG 13 (0,0003%) (Tab.1.). Previously reported values range from 0,002 to 0,004% (KAYS and NOTTINGHAM, 2007). Sodium content seems to be higher than some vegetables like raw peeled potato (0,003%) and rutabaga (0,005%) (WATT and MERRILL, 1963).

The K/Na ratio was high in tubers of *H.tuberosus* and the content of K was on average 85 times that of Na. If the extreme values are excluded than most of the genotypes (98 out of 114) had the K/Na ratio between 16 and 51 (Tab.1.). That kind

of ratio can only benefit nutritional value of *H.tuberosus* tubers. The increased content of potassium in food can positively affect the reduction of Na/K ratio and lower systolic blood pressure by a significant amount in adults with mild hypertension (SIANI *et al*., 1991).

The total content of sugars was on average 19,15%, with a range of values from 13,7 to 23% (Tab.1.). More than 80% of the sugars in the tubers is inulin which as a dietary fiber and a fructose polymer positively influences digestion and sugar blood levels (SAENGTHONGPINIT and SAJJAANANTAKUL, 2005).

If breeding is considered for some, or all the mentioned traits, than it is necessary to determine possible correlations between them. Correlations for most of the traits were either positive or non significant (Tab.2.). The K/Na ratio is strongly negatively correlated with the Na content for obvious reasons and it is also in negative correlation with the α-amino-N content. If the extreme values of K/Na ratio are excluded than the correlation is not so high (-0, 17) and with the available variability it should not pose a problem for any possible selection goal.

Table 2. Correlation coefficients (r) for total N, α-amino N, K, Na, K/Na and sugar content in the tubers of Helianthus tuberosus

	Total N % m/m dry weight	α-amino-N % m/m fresh weight	K % m/m fresh weight	Na % m/m fresh weight	K/Na ratio	Total sugars % m/m fresh weight
Total N % m/m dry weight	1,00					
α-amino –N % m/m fresh weight	0,59**	1,000				
K % m/m fresh weight	0,43**	0,49**	1,00			
Na % m/m fresh weight	0,05	0,42**	0,12*	1,00		
K/Na Ratio	0,08	-0,29**	0,07	-0,93**	1,00	
Total sugars % m/m fresh weight	0,31**	0,18**	0,20**	-0,04	0,11*	1,00

The obtained results suggest that selection of populations with appropriate nutritive values is possible. Further research is needed to estimate the share of genetic in total variability and to determine whether the selection for new cultivars is justified. Further analysis for the content of other micro and macro minerals in leaves and tubers is planned.

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VARIJABILNOST SADRŽAJA AZOTA I ŠEĆERA U KRTOLAMA TOPINAMBURA (*HELIANTHUS TUBEROSUS*)

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I z v o d

Tokom 2006. godine obavljeno je ispitivanje nekih prehrambenih vrednosti krtola 114 populacija topinambura (*Helianthus tuberosus*). Korišćen materijal je deo kolekcije divljih vrsta suncokreta Instituta za ratarstvo i povrtarstvo, koja se nalazi na lokalitetu Rimski Šančevi u blizini Novog Sada. Uzorci su analizirani u svežem stanju na ”Venema” automatskoj laboratoriji za sadržaj alfa amino azota, natrijuma i kalijuma. Ukupni sadržaj šećera je određen refraktometrijski kao Brix vrednost. Ukupni azot je određen na sušenim uzorcima Kjeldahl metodom.

Pokazalo se da postoji značajna varijabilnost za sve ispitivane osobine. Sadržaj ukupnog azota je varirao od 0,695 do 2,179% suve mase (prosečna vrednost 1,23%), alfa amino azota 0,012-0,118% sveže mase (p.v. 0,07%), kalijuma 0,231-0,452% sveže mase (p.v. 0,403%) i natrijuma 0,0003- 0,0143% sveže mase (p.v. 0,007%). Ukupni sadržaj šećera je varirao od 13,69 do 22,94% sveže mase (p.v. 19,14 %).

Alfa amino azot je obavezan u ishrani životinja pa je i njegova zastupljenost u krtolama topinambura kao hrane pozitivna. Sadržaj proteina je približan krompiru i kao takav zadovoljavajući za ishranu. Odnos Na i K je povoljan jer povećani sadržaj K u hrani može pozitivno da utiče na smanjenje relativnog odnosa Na i K i da dovede do značajnog smanjenja krvnog pritiska kod osoba sa blagom hipertenzijom. Inulin čini do 80% od ukupnog sadržaja šećera u krtolama topinambura, a kao dijetalno vlakno i polimer fruktoze može pozitivno da utiče na varenje i nivo šećera u krvi.

Ustanovljena varijabilnost topinambura za analizirane osobine ukazuje da postoji mogućnost za odabir populacija sa odgovarajućim prehrambenim kvalitetima. Potrebna su dalja ispitivanja da bi se odredio udeo genetičke varijabilnosti u ukupnoj varijabilnosti i da bi se utvrdila opravdanost eventualnog pristupa selekciji radi dobijanja novih sorti.

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