OPEN ACCESS Potravinarstvo® Scientific Journal for Food Industry

Potravinarstvo, vol. 10, 2016, no. 1, p. 72-77
doi:10.5219/539
Received: 4 October 2015. Accepted: 4 January 2016.
Available online: 24 January 2016 at www.potravinarstvo.com

ISSN 1337-0960 (online)

THE CONTENT OF TOTAL POLYPHENOLS IN DIFFERENT VARIETIES OF *SOLANUM TUBEROSUM* GROW IN SPIŠ AREA

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ABSTRACT
Potatoes can be classified into groups of foods that are consumed regularly and in relatively large quantities, they are an essential source of polyphenol compounds. Phenolic compounds are the predominant antioxidants in nutrition and their study is currently being paid much attention. These antioxidants act synergistically; polyphenol compounds protect vitamin C and β-carotene, which in turn helps to increase the effect of vitamin E. Potatoes are very popular vegetables in Slovakia, not only in terms that they are easy to prepare, but also by the fact that they combine the wholesomeness of cereals and delicacy and characteristic chemical composition of vegetables. It is important that they find their place in our diet. Nutritional value of potatoes is determined by the content of nutrients such as protein, starch, fat, minerals, and absence of toxins, as well as by a significant content of bioactive components from the group of polyphenols. The study was performed in order to analyse 7 Slovak potato varieties from Spiš area, according to biologically active compounds: such as polyphenols. The content of total polyphenols was determined by the method of Lachman et al., (2003). The lowest determined content of total polyphenol (mg.kg^{-1} dry matter) in locality Spišský Štvrtok was measured in a variety Victoria (795.05 mg.kg^{-1} dry matter) and the highest content of total polyphenols in locality Spišský Štvrtok was measured in variety Laura (1238.42 mg.kg^{-1} dry matter). In the locality Odorín was determine the lowest content of total polyphenols in variety Red Anna (974.09 mg.kg^{-1} dry matter) and the highest content of total polyphenols was determined in variety Laura (978.95 mg.kg^{-1} dry matter). Between all varieties in locality Spišský Štvrtok was confirmed the statistically significant difference in the influence of the variety in the contents of total polyphenols (mg.kg^{-1} DM). This varietal dependence was not appear in samples taken in the locality Odorín. The total polyphenols content of the potatoes can be influenced by other factors, for example locality. In this case, there were statistically significant differences in the content of total polyphenols in variety Laura obtained from two different localities.

Keywords: potato; variety; total polyphenol; compound; Spiš area

INTRODUCTION

Eatable potatoes have an important role in the production of agricultural crops and also of produced food raw materials. The potatoes are frequently consumed in Europe but sometimes overlooked nutritional quality of this staple crop. *Solanum tuberosum* follows only rice and wheat in world importance as a food crop for human consumption. Cultivated potatoes have spread from the Andes of South America where they originated to 160 countries around the world. Consumption of fresh potatoes has declined while processed products have increased in popularity.

According to **Frančáková, et al., (2001)**, potato tuber is growing for its rhizone tubers, which is known as potatoes. Potatoes filled in human nutrition mainly for volume function, than eating function and protective function. Potatoes are an important food, industrial raw materials, feed and a major agricultural crops with high yield potentially useful biomass. As the potato becomes a staple in the diets of an increasing number of humans, small differences in potato nutritional composition will have major impacts on population health (**Camire et al., 2009)**.

According to **Lisińska (2006)** the nutritive value of potato is relatively high, because of protein content and composition (high percentage of essential amino acids: lysine, leucine, phenyloalanine, threonine and valine). Potato is also characterised by high amounts of starch, and lower content of sugars, minerals (K, Mg, Fe, Cu, J, P) and vitamins of group B, folic acid, fat-soluble vitamins E, K, and carotenoids, which may be converted into vitamin A **(Wroniak, 2006)**. The content of vitamins in tubers is not high, however 200 g of potatoes covers much of the daily requirement for these compounds, especially vitamin B6 (20 – 26%), vitamin B1 (12 – 20%), niacin (10 – 20%), folic acid (4 – 12%), and pantothenic acid (10%) **(Lisińska and Leszczyński, 1989)**. According to **Astley (2003)** *Solanum tuberosum* is an excellent source of vitamin C and other biologically active substances, such as polyphenols and flavonoids, which are commonly described as antioxidants. These substances have beneficial influence on human organism, as they protect against cardiovascular disease, and cancer, as well as reduce blood cholesterol level. The potato is a carbohydrate-rich, energy-providing food with little fat. Potato protein content is fairly low but has an excellent biological value of 90 – 100. Potatoes are particularly high in vitamin C and are a good source of several B vitamins and potassium. The skins provide

Table 1 Characterictics of soil and nutrient content.

Point of delivery	pH (KCl)	C_{ox}	mold	P	K	Ca	Mg
		%		(mg.kg^{-1})			
Matejovce	5.75	1.56	2.69	36.27	191.03	2780	193.50
Spišský Štvrtok	5.22	2.74	3.21	30.23	178.38	1710	180.0
Odorín	5.19	2.22	2.83	82.71	179.75	1590	161.0

substantial dietary fiber. Many compounds in potatoes contribute to antioxidant activity and interest in cultivars with pigmented flesh is growing. Potato tubers present in human nutrition an important source of antioxidants. According to **Musilová et al., (2010)** in the potatoes are the greatest extent represented polyphenols (1226 – 4405 mg.kg^{-1}) and ascorbic acid (170 to 990 mg.kg^{-1}), carotenoids (4 – 4.5 mg.kg^{-1}), α-tocopherol (0.5 to 2.8 mg.kg^{-1}), in small amounts of selenium (0.1 mg.kg^{-1}) and α-lipoic acid. Polyphenols are important sources in potatoes. They are divided into two main groups: phenolic acids and flavonoids, which create from 1/3 to 2/3 of all antioxidants **(Tapiero et al., 2002**; **Musilová et al., 2013)**.

Polyphenols are a group of plant secondary metabolites that are markedly represents in the diet of humans and animals. The main factor responsible for the delayed research on polyphenols is the variety and the complexity of their chemical structure **(D'Archivio et al., 2007**; **Hegedűsová et al., 2015)**.

Lachman et al., (2013) present that phenolic compounds are the most commonly used group of antioxidants, most of which is represented by the chlorogenic acid isomers, and caffeic acid. Polyphenolic substances contained in foods of plant origin are at present pursued plant components. According to **Suli et al., (2014)** polyphenols are found in normal foods of plant origin in varying amounts. The content of phenolic compounds in natural materials is quite variable, depending on each type of crop, but also of their varieties. According to **Mareček et al., (2013)** in the varietal composition, we have to take more account of varietal differences, especially in the carbohydrates content and in the options of processing to different products. Polyphenol content is conditioned by genetically influenced and agronomic soil and weather or environmental conditions. **André et al., (2009)** classed the polyphenols into a group of natural antioxidants. About the effect of polyphenolic substances on human health is constantly debated in professional and general level, with views on the action of these agents are not completely uniform **(Lachman et al., 2013**; **Volnová et al., 2015)**. Content of total polyphenolic compounds and anthocyanins is dissimilar at different stages of tuber maturity; it is affected by different environmental conditions, e.g. longer days and lower temperatures **(Reyes et al., 2004)** or ecological way of cultivation **(Hamouz et al., 2005)**.

The aim of this research was to evaluate a set of seven potato varieties and watched the content of total polyphenols in different varieties of *Solanum tuberosum* grow in Spiš area.

MATERIAL AND METHODOLOGY

Material: For analyses we used seven potato varieties from Spiš area: Victoria, Laura (Spišský Štvrtok), Belana, Laura (Odorín), Red Anna, Marabel, Malvína (Matejovce), which were analysed for the content of biologically active compounds: total polyphenols and potato varieties were collected from Spiš area. Each variety was removed from four places of our area of interest.

Methods: analysis of potatoes: Total polyphenols were determined by the method of **Lachman et al., (2003)** and expressed in mg eq. gallic acid per kg dry matter. Gallic acid is usually used as a standard unit for phenolics content determination because a wide spectrum of phenolic compounds. The total polyphenol content was estimated using Folin-Ciocalteau reagent. The Folin-Ciocalteau phenol reagent was added to a volumetric flask containing an aliquot of extract. The content was mixed and a sodium carbonate solution (20%) was added after 3 min. The volume was adjusted to 50 mL by adding of distilled water. After 2 hours, the samples were centrifuged for 10 min. and the absorbance was measured at 765 nm of wave length against blank. The concentration of polyphenols was calculated from a standard curve plotted with known concentration of gallic acid.

Analysis of soil: In each locality we determined exchange soil reaction (pH/KCl) – was determined oxidimetry %, with using translation method of Ťurin, Cox carbon content (%) and mold (%) – were determined oxidimetry %, with using translation method of Ťurin, and content of macroelements (mg.kg^{-1}) – we set by Mehlich II method, analytical method for the determination of output was atomic absorption spectrophotometer (AAS Varian AA Spectr DUO 240FS/240Z/UltrAA). We evaluated the indicators based on the Code of Good Agricultural Practice **(Bielek, 1996, Decree no. 338/2005 Coll.)** Results were statistically evaluated by the Analysis of Variance (ANOVA – Multiple Range Tests, Method: 95.0 percent LSD) using statistical software STATGRAPHICS (Centurion XVI.I, USA) and the regression and correlation analysis (Microsoft Excel) was used.

RESULTS AND DISCUSSION

The results of the analysis of different locations are referred to Table 1. Soil from Matejovce area have been weakly alkaline, with middle content of mold, very low content of phosphorus, middle content of potassium and good content of magnesium (193.50 mg.kg^{-1}). The soil from locality Odorín is alkaline, with middle content of mold, high content of P, middle content of K and good content of Mg and soil from Spišský Štvrtok area is alkaline too, with middle content of mold, with good content of phosphorus, middle content of K and good content of magnesium. Nowadays, the great emphasis is placed on research of polyphenols from plant extracts, as well as their biological activity **(Arnal et al., 2012; Duchnowicz et al., 2012**; **Stojadinovic et al., 2013**; **Zhang et al., 2013)**. The polyphenols are the most abundant antioxidants in the

Table 2 Multiple Range Tests for the locality effect on the total polyphenols content (mg.kg^{-1} DM) in potato tubers (Spišský Štvrtok locality).

Variety	Count	Mean	Homogenous groups
Victoria	16	795.05 ±108.92	X
Belana	16	956.75 ±129.54	X
Laura	16	1238.42 ±23.31	X

Method: 95,0 percent LSD.

Table 3 ANOVA Table for total polyphenol content by variety.

Source	Sum of Squares	Df	Mean Square	F-Ratio	*P*-Value
Between groups	1.61096E6	2	805480.0	82.79	0.0000
Within groups	437810.0	45	9729.1		
Total (Corr.)	2.04877E6	47			

human diet **(Bystrická et al., 2010)**. They are known to exhibit stronger antioxidant activity than monophenols **(Troszynska et al., 2002)**. In our work, we watched the locality effect on the total polyphenols content in different varieties of potatoes. The results of analyzes of individual samples have statistically processed (Table 2 – 7)

As we can see in Table 2, determined values of total polyphenol content in three different varieties were in range from 795.05 mg.kg^{-1} DM (locality Spišský Štvrtok, Victoria variety) to 1238.42 mg.kg^{-1} DM (Spišský Štvrtok area, Laura variety). Minimal measured values in variety Victoria was 614.72 mg.kg^{-1} DM, in variety Belana was 722.72 mg.kg^{-1} DM and in variety Laura was 1202.72 mg.kg^{-1} DM. Maximal measured value in variety Victoria was 993.28 mg.kg^{-1} DM, in variety Belana was 1112.12 mg.kg^{-1} DM and in variety Laura was 1268.88 mg.kg^{-1} DM. Statistically significant differences in total polyphenols content between individual variety is confirmed. The differences were between varieties Victoria – Belana and Laura, between varieties Belana – Victoria and Laura and between variety Laura – Belana and Victoria.

Between the content of total polyphenols in varieties of locality Odorín were only minimal differences, while the lowest and highest TPC we have established in variety Laura (minimum: 883.12 mg.kg^{-1} DM and maximum 1037.76 mg.kg^{-1} DM, which is almost 18% difference). The difference between the lowest and highest average value of TPC is only 0.5%. These contents of total polyphenols in testing varieties were determined only with minimal difference. There were not statistically significant differences between different varieties. The content of total polyphenols was not different in average

Based on the results of the statistical evaluation it can be stated that there are significant differences in potatoes of the same variety Laura from different areas (Odorín and Spišský Štvrtok). The TPC in variety Laura from locality Spišský Štrvtok was nearly about 27% higher as from Odorín area. Minimal measured value was in variety Laura 883.12 mg.kg^{-1} DM from locality Odorín, and maximum was in variety Laura 1268.88 mg.kg^{-1} DM from locality Spišský Štvrtok.

The average TPC of all samples middle early varieties was in the variety Victoria 795.05 mg.kg^{-1} DM and standard deviation was 108.92, in variety Belana was average value of TPC 956.75 mg.kg^{-1} DM and standard deviation was about 129.54 and in the last variety Laura from Spišský Štvrtok was average value TPC 1238.42 mg.kg^{-1} DM and standard deviation was 23.31. Based on these results it can be assumed correlation between the location and the total polyphenol content in potatoes, which is confirmed by the results of many authors who deal with the issue **Reddivari et al., (2007)**; **Hamouz et al., (2007)**. **Burgos et al., (2013)** as one of the key factors indicate variety and the conditions in their processing, too. **Lachman et al., (2008)** also confirm the significant effect of locality, which have a high content of TPC and higher

Table 4 Multiple Range Tests for the effect of variety on the total polyphenols content (mg.kg^{-1} DM) in potato tubers (locality Odorín).

Variety	Count	Mean	Homogenous groups
Red Anna	16	974.09 ±42.44	X
Marabel	12	977.79 ±31.77	X
Laura	16	978.95 ±54.16	X

Method: 95,0 percent LSD

Table 5 ANOVA Table for total polyphenol content by variety.

Source	Sum of Squares	Df	Mean Square	F-Ratio	*P*-Value
Between groups	203.218	2	101.609	0.05	0.9506
Within groups	82124.7	41	2003.04		
Total (Corr.)	82327.9	43			

Table 6 Multiple Range Tests for the effect of variety Laura on the total polyphenols content (mg.kg^{-1} DM) in potato tubers (Odorín and Spišský Štvrtok localities).

C.locality	Count	Mean	Homogenous groups
Odorín	16	978.95	X
Sp. Štvrtok	16	1238.42	X

Method: 95,0 percent LSD

Table 7 ANOVA Table for total polyphenols content by variety Laura.

Source	Sum of Squares	Df	Mean Square	F-Ratio	*P*-Value
Between groups	538597.0	1	538597.0	309.82	0.0000
Within groups	52152.3	30	1738.41		
Total (Corr.)	590750.0	31			

yields of potatoes in the area, which had the lowest average annual temperature and minimum daily temperatures. Further the author notes, that the content of total polyphenols can be influenced by variety. This fact is confirmed by many other authors. According to **Navarre et al., (2011)** a difference in the content of total polyphenols may be caused, for example, genotype or varietal affiliation. The influence of variety as an important factor influence the polyphenol content in potato tubers is confirmed by our results.

Pawelzik et al., (1999) and **Friedman (1997)** determined a significant effect of variety on TP content, which has already been confirmed by our results.

CONCLUSION

Polyphenols are secondary metabolites of plants with antioxidant properties.

The potato is one of the richest sources of antioxidants in the human diet. The main antioxidants are polyphenols (123 – 441 mg 100 g^{-1}), ascorbic acid (8 – 54 mg 100 g^{-1}), carotenoids (up to 0.4 mg 100 g^{-1}) and tocopherols (up to 0.3 mg 100 g^{-1}). L-Tyrosine, caffeic acid, chlorogenic acid and ferulic acid are amongst the main polyphenols, which have about twice the level in the skin compared with the flesh of the potato. In terms of chemical structure, it is a diverse group of chemically related substances, which are divided into several classes and subclasses. Technological processes used in the food production, storage and the meals treatment lead to changes in polyphenol content in foods. These factors together effect the representation of polyphenols in foods and also their utility.

Content of polyphenols is especially affected by variety, year of cultivation, stress factors (mechanical damage of tubers, attack of pathogens or action of light on tubers) and by cooking treatment. In a lesser extent the effect of locality, potassium fertilization, storage temperature, γ-irradiation and other factors could be involved, but there is only a little demonstrable empirical evidence in the literature references.

Polyphenolic exceed biological activity in the human body, among others they can take active part in the removal of free radicals, metal ion chelatation as well as affect enzyme activity and protein availability. Although their health beneficial properties, polyphenolic compounds are prevalent, between others, coronary heart disease, cancer, inflammatory diseases.

Nutritional value of potatoes is influenced by the content of nutrients, absence of toxic substances and presence of biologically active polyphenols, which are responsible for antioxidant activity of this vegetable. Potato is easy to prepare, widespread and versa, as it combines energy value of cereals and chemical composition typical for vegetables. It is therefore very important to include it in our everyday diet.

In our work we deal with the research of changes to the total polyphenols content in different varieties of potatoes. In conclusion we can say that the lowest content of total polyphenols we found in a variety Victoria of locality Spišský Štvrtok and the highest content of total polyphenols we have established in a Laura variety of locality Spišský Štvrtok. Total polyphenols content was statistically significant in the area Spišský Štvrtok and statistically not significant in the area Odorín. So the effect of locality on the content of total polyphenols in potato tubers in variety Laura was statistically significant.

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Acknowledgments:

Article was developed with the financial support by grant VEGA 1/0456/12.

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