

CHARACTERISATION OF FIVE POTATO CULTIVARS ACCORDING TO THEIR NUTRITIONAL AND PRO-HEALTH COMPONENTS

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Introduction. Potatoes are very popular vegetables in Poland, 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, so 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, which guarantee proper antioxidant activity of this vegetable. The study was performed in order to analyse 5 Polish potato cultivars, according to nutritional components, i.e.: proteins, fat, starch, carbohydrates, ash and biologically active compounds: such as polyphenols, flavonoids, as well as dietary fibre. At the same time antioxidant activity of the cultivars was determined by means of two independent methods.

Material and methods. The material for the study consisted of five varieties of potatoes: Saturna, Hermes, Raja, Rosalind, Courage, which were analysed for the content of nutrients i.e. protein, fat, starch, carbohydrate, ash and biologically active compounds: polyphenols, flavonoids, and fiber. Antioxidant activity of the examined potato varieties was determined by two independent methods.

Results. It was shown, taking into account the nutrients, that the potato variety Raja was characterised by the lowest content of carbohydrate and ash, and high amounts of protein and fat. The highest content of insoluble dietary fibre was determined for Raja, and its soluble fraction for Saturna. The amounts of insoluble fibre were three times as much as the content of soluble fibre in the analysed potato cultivars. The highest total polyphenol content was measured for Saturna, and the lowest for Rosalind. Other cultivars revealed similar amounts of these components (3 mg catechin/g d.m.). The contents of flavonoids and flavonoids was not proportional to total polyphenol content in the analysed potato cultivars. Antioxidant activity determined by two independent methods was proportional to total polyphenol content in the analysed plant material.

Conclusions. It was shown that the content of pro-health ingredients such as: dietary fiber, total polyphenols and antioxidant activity was preferable for two of the five examined varieties of potatoes: Saturna and Raja.

Key words: antioxidant activity, dietary fibre, polyphenols, potatoes

INTRODUCTION

Potato is one of the basic crops, which significantly impact nutritive status of the world population. Its production places it fourth, after wheat, rye and corn [Zgórska 2008]. Among 130 countries, where this plant is cultivated, Poland is one of the major producers. The unique position of this vegetable in Poland is not only due to the area of its cultivation but also because of the culinary traditions of Polish people [Leszczyński 2000]. Nutritive value of potato is relatively high, because of protein content and composition (high percentage of essential amino acids: lysine, leucine, phenylalanine, threonine and valine) [Woolfe 1996, Kunachowicz et al. 2000, Lisińska 2006]. 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].

Potato is an excellent source of vitamin C and other biologically active substances, such as polyphenols and flavonoids, which are commonly described as antioxidants [Leszczyński 2000, Wroniak 2006]. These substances have beneficial influence on human organism, as they protect against cardiovascular disease, and cancer, as well as reduce blood cholesterol level [Baublis et al. 2000, Kaur and Kapoor 2001, Astley 2003]. Another nutritionally important component of tuber is dietary fibre (approx. 2.5% fresh mass), which is made of cellulose, hemicelluloses, pectins and lignin (constituting so called raw fibre), as well as other substances resistant to digestive enzymes [Mazurczyk 2005]. Although dietary fibre is not regarded as a bio-active component it is essential for proper human nutrition. It facilitates digestion by stimulating peristalsis, forms a growth medium for intestinal microflora, and exerts hypoglycaemic and hypocholesterolaemic effect [Wroniak 2006]. Therefore it is important to maintain the current, high status of potatoes in our daily diet.

The study was performed in order to analyse 5 Polish potato cultivars, according to nutritional components, i.e.: proteins, fat, starch, carbohydrates, ash and biologically active compounds: such as polyphenols, flavonoids, as well as dietary fibre. At the same time antioxidant activity of the cultivars was determined by means of two independent methods.

MATERIAL AND METHODS

Material consisted of five potato cultivars: Saturna (PS), Hermes (PH), Raja (PRa), Rosalind (PRo), Courage (PC). The tubers were checked for the levels of protein, fat, carbohydrates and ash [AOAC... 1995]. Starch content was determined according to ICC method [ICC... 1995]. Total polyphenol content (TPC) was assessed according to the method of Singleton et al. [1999], while flavonols and flavonoids were measured

following Oomah et al. [2005]. Two independent methods were used for determination of antioxidant activity of potatoes. FRAP method was based on the method of Benzie and Strain [1996], modified by Bartoń et al. [2005], while ABTS method was used as described by Re et al. [1999]. Extracts used for determination of TPC and antioxidant activity (FRAP and ABTS) were obtained with mixture of methanol and acetone (v/v 1:1). Flavonols and flavonoids were determined in ethanol extracts of the potato tubers.

Statistical analysis. The obtained results were compared by one-way analysis of variance, performed with the help of Statistica 8.0 (Statsoft). The significance of differences between samples was evaluated by Duncan's test, at the significance level $\alpha = 0.05$. The results of statistical analysis are shown in the tables.

RESULTS AND DISCUSSION

According to many authors [Leszczyński 2000, Wroniak 2006] potato is the major vegetable throughout the world. In Poland it provides the basis of most meals, although its widespread utilisation is not parallel to the knowledge of nutritional value. On the contrary there is a common belief, that potatoes cause obesity, and have no valuable components. This is the reason, why their consumption has gradually decreased in recent years. To change this negative trend, it is important to point out the nutritionally important components of potato tubers and bioactive compounds, such as polyphenols.

Tables 1 and 2 demonstrate the nutritional characteristics of five Polish potato cultivars: Saturna (PS), Hermes (PH), Raja (PRa), Rosalind (PRo), Courage (PC). The lowest content of protein was found in Hermes, while the highest in Raja, Rosalind and Courage. The difference between the extreme levels of this component ranged 16%. Saturna cultivar contained 12% less protein than Raja, Rosalind and Courage (Table 1). The lowest content of fat was assessed for Saturna, Rosalind and Courage in comparison to other cultivars. Raja and Hermes contained 60 and 44% more fat, respectively in comparison to other cultivars. The lowest amounts of ash were found for Raja and Saturna, while the highest for Courage (Table 1). The amounts of minerals in Hermes and Rosalind were comparable. Basic nutritive components in 100 g of fresh mass of potato tubers were as follows: protein 1.7-2.17 g; fat 0.21-0.62 g; ash 0.78-1.07 g, which is consistent with the results of other authors [Leszczyński 2000, Wroniak 2006, Zgórska 2008].

Table 1. Content of protein, fat and ash in five potatoes cultivars

| Kind of sample | Dry matter g·100 g ⁻¹ | Content of, g·100 g ⁻¹ d.m. | | |
|----------------|-------------------------------------|--|---------|---------|
| | | protein | fat | ash |
| PS | 24.23 | 8.27 b | 1.11 ab | 3.98 a |
| PH | 22.67 | 7.82 a | 2.03 bc | 4.21 b |
| PRa | 19.84 | 9.37 c | 3.12 d | 3.95 a |
| PRo | 23.4 | 9.29 c | 1.19 ab | 4.58 bc |
| PC | 21.47 | 9.45 c | 0.98 a | 4.71 c |

Different letters denote mean values that statistically differ from one another (Duncan's test, at $p = 0.05$).

Table 2. Content of carbohydrates in five potatoes cultivars

| Kind of sample | Contents of, g·100 g ⁻¹ f.m. | |
|----------------|---|----------|
| | sugar | starch |
| PS | 1.10 de | 12.51 cd |
| PH | 0.76 cd | 12.33 c |
| PRa | 0.28 ab | 8.87 a |
| PRo | 1.48 f | 10.62 b |
| PC | 0.53 bc | 10.35 ab |

Different letters denote mean values that statistically differ from one another (Duncan's test, at $p = 0.05$).

Reducing sugars are typical components of potatoes, while they are formed mainly by the hydrolysis of starch – the major constituent of tubers. The levels of these compounds is shown in Table 2. Starch content in all examined tubers ranged from 9 to 12.5% fresh mass (f.m.), which allows to classify them as low-starch. The lowest amounts of reducing sugars were observed in potatoes Raja, which also contained the smallest amounts of starch. On the other hand cultivar Rosalind with only slightly higher level of starch, was richest in reducing sugars among all the examined samples. The contents of reducing sugars in Rosalind and Saturna was twice as much as typically in these vegetables. This effect is probably caused by the starch degradation during storage. Reducing sugars have a negative impact on potato quality, because at high temperature they participate in Maillard reaction, forming substances potentially dangerous for human health [Friedman 1991].

According to Leszczyński [2000] the amounts of reducing sugars in fresh potatoes should not exceed 0.5% (and starch content should be about 15%). It is important to notice, that chemical composition depends on potato cultivar, soil, weather and agro-technical factors [Leszczyński 1994, Zimnoch-Guzowska and Flis 2006], which is consistent with our results.

The amounts of dietary fibre in the analysed samples (Table 3) was in the range 9.35-10.3 g/100 g dry mass (d.m.), which corresponds to 2.17-2.3 g/100 g fresh mass (f.m.). These data are comparable to the results of other authors [Leszczyński 2000, Wroniak 2006], which were close to 2.5% g/100 g f.m. Total content of dietary fibre in Raja was about 10% higher than in Courage and on average 5% higher in comparison to other potato cultivars (Table 3).

Amounts of insoluble and soluble fractions of dietary fibre were also evaluated, and approached 1.7% f.m. (6.5% d.m.), and 0.5% f.m. (2.5% d.m.), respectively (Table 3).

Both these fractions have a beneficial influence on human organism, insoluble dietary fibre functions as a filler, while soluble has hypoglycaemic and hypocholesterolaemic activity. The measured values are relatively high for potatoes, and the largest amounts of insoluble fraction are detected in Raja cultivar, which corresponds to the total content of dietary fibre. On the other hand Saturna was characterised by the highest level of soluble fibre.

The fraction soluble constitutes only 1/4 of total dietary fibre, which is normal for typical plant material, such as vegetables and cereals.

Table 3. Content of dietary fibre in five potatoes cultivars

| Kind of sample | Insoluble fraction of dietary fibre | Soluble fraction of dietary fibre | Total dietary fibre |
|----------------|-------------------------------------|-----------------------------------|---------------------|
| | g · 100 g ⁻¹ d.m. | | |
| PS | 7.34 bc | 2.60 bc | 9.94 bc |
| PH | 7.21 b | 2.30 a | 9.51 ab |
| PRa | 7.84 c | 2.46 ab | 10.30 c |
| PRo | 7.21 b | 2.52 b | 9.73 b |
| PC | 6.88 a | 2.47 ab | 9.35 a |

Different letters denote mean values that statistically differ from one another (Duncan's test, at $p = 0.05$).

It was observed, that the analysed cultivars of potatoes variability in the level of soluble fibre was significantly lower in comparison to the differences in insoluble fraction (Table 3).

Polyphenols are one of the most important functional components of plants, so they were analysed in detail. Pro-health properties of phenolic compounds are demonstrated by their anticarcinogenic and antimutagenic activity, as well as cardiovascular protective effect, connected mainly with decreased cholesterol concentration in plasma and prevention of arteriosclerosis [Friedman 1997, Kozłowska and Troszyńska 1999, Hanczakowski 2002].

Total polyphenol content (TPC) was determined by spectrophotometric method, with the use of Folin-Ciocalteu reagent, according to Singleton et al. [1999], and the content of flavonols and flavonoids by the method of Oomah et al. [2005]. The highest total polyphenol content (TPC) was observed for Saturna cultivar, and the lowest for Rosalind (Table 4). Other cultivars were characterised by total polyphenol content close to 3 mg catechin/g d.m. (Table 4). Opposite trend was observed for flavonols, which were most abundant in Rosalind cultivar and relatively deficient in Saturna. The contents of flavonols in Hermes and Raja were comparable, while significantly lower levels were detected for Courage, where their content was half as high as in Rosalind cultivar (Table 4). Comparing all the analysed potato cultivars, the amounts of flavonoids were decreasing in the following order: Saturna, Raja and Hermes, Rosalind and Courage (Table 4). It could be stated, that the amounts of flavonols and flavonoids are not proportional to total polyphenol content in analysed samples. Each potato cultivar contained different levels of these biologically active compounds, which is in general agreement with observations of other authors, because the content of phenolic compounds depends on potato cultivar, weather, soil and agrotechnical conditions [Hamouz et al. 1999]. Content of phenolic compounds in potato tubers is in the same range as in other reports [Leszczyński 2000, Teow et al. 2007].

Antioxidant activity of potato tubers was measured by two independent methods. Antioxidant activity by FRAP was determined according to Benzie and Strain [1996] with the modification of Bartoń et al. [2005], while ABTS method was based on the work of Re et al. [1999].

The results of antioxidant activity measured by both methods are collected in Table 5.

Table 4. Content of polyphenolic compounds and flavonol and flavonoids in five potatoes cultivars

| Kind of sample | TPC mg catechin·g ⁻¹ d.m. | Contents of flavonols mg quercetin·g ⁻¹ d.m. | Contents of flavonoids mg rutin·g ⁻¹ d.m. |
|----------------|---|--|---|
| PS | 3.37 c | 0.01 a | 1.00 b |
| PH | 2.91 b | 0.05 b | 0.80 ab |
| PRa | 3.09 bc | 0.06 b | 0.82 ab |
| PRo | 2.12 a | 0.27 d | 0.73 a |
| PC | 2.96 b | 0.13 c | 0.71 a |

Different letters denote mean values that statistically differ from one another (Duncan's test, at $p = 0.05$).

Table 5. Antioxidant activity of 5 potatoes cultivars measured by using FRAP and ABTS

| Kind of sample | TEAC mM Tx·kg ⁻¹ d.m. | FRAP mM Fe ²⁺ ·kg ⁻¹ d.m. |
|----------------|-------------------------------------|--|
| PS | 26.7 d | 14.35 cd |
| PH | 20.98 b | 12.1 bc |
| PRa | 21.4 bc | 13.3 c |
| PRo | 18.37 a | 6.2 a |
| PC | 25.47 c | 11.3 b |

Different letters denote mean values that statistically differ from one another (Duncan's test, at $p = 0.05$).

It may be concluded that antioxidant activity evaluated with ABTS is proportional to total polyphenol content (TPC) in plant material. The highest antioxidant activity was evaluated in Saturna cultivar, which was also the richest source of polyphenols and the lowest in Rosalind which was relatively deficient in these compounds. Two other cultivars: Hermes and Raja revealed antioxidant activity proportional to total polyphenol content, and no such relation was observed only in case of cultivar Courage (Tables 4 and 5).

Similar pattern could be observed also when FRAP method was applied. Saturna revealed the highest antioxidant activity (the highest amount of total polyphenol content and flavonoids), and Rosalind the lowest (the lowest amount of total polyphenol content and flavonoids). The difference in antioxidant activity between these potato cultivars was considerable (approx. 47%), while the other analysed samples exhibited values, which were on average 17% lower than those measured for Saturna (Table 5). Basing on the results obtained by FRAP, it could be observed that antioxidative activity decreases in the following order: Saturna, Raja, Hermes~Courage and Rosalid, proportionally to total content of polyphenols in plant material (Tables 4 and 5).

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 uni-

versal, 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.

CONCLUSIONS

1. Potato cultivars: Raja, Rosalind and Courage contained the highest amounts of protein, while Rosalind, Courage and Saturna the lowest levels of fat.

2. The content of ash was the lowest in case of Saturna and Raja, and the highest for Courage.

3. Starch content in all analysed cultivars ranged from 9 to 12.5% f.m., which indicates that examined cultivars could be regarded as low-starch. High content of reducing sugars in Rosalind and Saturna is probably caused by starch degradation during storage.

4. The highest content of insoluble dietary fibre was determined for Raja, and its soluble fraction for Saturna. The amounts of insoluble fibre were three times as much as the content of soluble fibre in the analysed potato cultivars.

5. The highest total polyphenol content was measured for Saturna, and the lowest for Rosalind. Other cultivars revealed similar amounts of these components (3 mg catechin/g d.m.). The contents of flavonols and flavonoids was not proportional to total polyphenol content in analysed potato cultivars.

6. Antioxidant activity determined by two independent methods was proportional to total polyphenol content in analysed plant material.

7. It could be stated that among all the analysed samples, the highest total polyphenol content (TPC) and antioxidant activity is found for Saturna, and the lowest for Rosalind.

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CHARAKTERYSTYKA PIĘCIU ODMIAN ZIEMNIAKÓW POD WZGLĘDEM SKŁADNIKÓW ODŻYWCZYCH I PROZDROWOTNYCH

Wstęp. Ziemniaki są bardzo popularne w Polsce, łącząc łatwość przygotowania, pożywność roślin zbożowych oraz delikatność i skład chemiczny charakterystyczny dla warzyw. Dlatego tak ważne jest, aby znalazły miejsce w naszej diecie. Wartość żywieniowa ziemniaków jest determinowana zawartością składników odżywczych, tj. białka, skrobi, tłuszczu, składników mineralnych, nieobecnością toksyn oraz wieloma składnikami biologicznie aktywnymi z grupy polifenoli, które gwarantują odpowiednią aktywność antyutleniającą tego warzywa. Celem pracy jest charakterystyka pięciu odmian polskich ziemniaków pod względem składników odżywczych, tj. białka, tłuszczu, skrobi, węglowodanów, po-

popiołu oraz związków biologicznie aktywnych, czyli polifenoli, flawonoidów i błonnika. Ponadto celem pracy było określenie dwoma niezależnymi metodami aktywności antyutleniającej pięciu odmian ziemniaków.

Materiał i metody. Materiałem do badań było pięć odmian ziemniaków: Saturna, Hermes, Raja, Rosalind, Courage, w których oznaczono zawartość składników odżywczych: białka, tłuszczu, skrobi, węglowodanów, popiołu oraz związków biologicznie aktywnych, czyli: polifenoli, flawonoidów i błonnika. Określono również dwoma niezależnymi metodami aktywność antyutleniającą analizowanych odmian ziemniaków.

Wyniki. Wykazano, biorąc pod uwagę składniki odżywcze, że odmiana Raja charakteryzowała się najmniejszą zawartością węglowodanów i popiołu, a dużą ilością białka i tłuszczu. Stwierdzono, że największą zawartością frakcji nierozpuszczalnej charakteryzowała się Raja, a frakcji rozpuszczalnej – odmiana Saturna. Ilość frakcji nierozpuszczalnej błonnika była trzy razy większa od ilości frakcji rozpuszczalnej w analizowanych odmianach ziemniaków. Największą zawartością polifenoli ogółem charakteryzowała się Saturna, a najmniejszą Rosalind. Pozostałe odmiany ziemniaków wykazały podobną zawartość wspomnianych związków (3 mg katechiny/g s.m.). Natomiast ilość flawonoidów i flawonoli nie była proporcjonalna do zawartości polifenoli ogółem w analizowanym materiale roślinnym. Aktywność antyoksydacyjna, wyznaczona dwoma niezależnymi metodami, była proporcjonalna do zawartości polifenoli ogółem w analizowanych próbkach.

Wnioski. Wykazano, że spośród pięciu analizowanych odmian ziemniaków Saturna i Raja wypadły korzystnie pod względem zawartości składników prozdrowotnych tj.: błonnika pokarmowego, polifenoli ogółem oraz aktywności antyutleniającej.

Słowa kluczowe: aktywność antyutleniająca, błonnik, polifenole, ziemniaki

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