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Antioxidant properties of infusions from leaves of sweet potato (*Ipomoea batatas* L. Lam) depending on temperature and brewing time

Właściwości antyoksydacyjne naparów z liści słodkiego ziemniaka zależnie od temperatury i czasu parzenia

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ABSTRACT

Antioxidant activity of water infusions made from leaves of five sweet potato cultivars (Carmen Rubin, Georgia Jet, Beauguard, White Triumph and Satsumo Imo), originating from a field cultivation on brown and acidic soil (49°49'N 21°50'E) was determined by means of DPPH method. The field experiment was carried out using the randomized block method in triplicate. Leaves collected in the BBCH 68 phase, after drying, were brewed with water at a temperature of 80 and 100 °C, for 2, 5 and 10 minutes. The antioxidant activity of infusions from sweet potato leaves was determined applying spectrophotometric method with the DPPH radical. Individual varieties differed in antioxidant activity: the highest was White Triumph (52-57%) and the lowest - Beauguard (45-53%). The infusions prepared at 100 °C were characterized by higher antioxidant activity (52-58%) compared to those prepared with the use of water at 80 °C (41-47%). The time of brewing preparation had a significant effect on antioxidant activity. Its highest value was recorded after 5 minutes, and the lowest after 2 minutes of brewing the dried sweet potato leaves. Genetic characteristics of sweet potato significantly modified the value of antioxidant potential of infusions obtained from the leaves of this species. The highest antioxidant activity characterized infusions made from leaves of varieties White Triumph and Satsumo Imo, the lowest - Beauguard.

Keywords: antioxidants, DPPH, infusions, sweet potatoes

STRESZCZENIE

Określono aktywność antyoksydacyjną, metodą DPPH, wodnych naparów z liści pięciu odmian batata (Carmen Rubin, Georgia Jet, Beauguard, White Triumph i Satsumo Imo), pochodzących z uprawy polowej, na glebie brunatnej, kwaśnej (49°49′ N 21°50′ E). Doświadczenie polowe przeprowadzono metodą bloków zrandomizowanych, w trzech powtórzeniach. Liście, pobrane w fazie 68 BBCH, po wysuszeniu zaparzano wodą o temperaturze 80 i 100 °C, w czasie 2, 5 i 10 minut. Oznaczono aktywność przeciwutleniającą naparów z liści batata metodą spektrofotometryczną, z rodnikiem DPPH. Poszczególne odmiany różniły się aktywnością antyoksydacyjną. Najwyższą uzyskała odmiana White Triumph (52-57%) zaś najniższą – Beauguard (45-53%). Napary przygotowane w temperaturze 100 °C charakteryzowały się wyższą aktywnością antyoksydacyjną (52-58%), w porównaniu do przygotowanych z użyciem wody o temperaturze 80 °C (41-47%). Czas przygotowania naparu miał istotny wpływ na aktywność antyoksydacyjną. Najwyższą jej wartość zanotowano po 5 minutach, zaś najniższą po 2 minutach parzenia suszu z liści batata. Cechy genetyczne słodkiego ziemniaka istotnie zmodyfikowały wartość potencjału antyoksydacyjnego naparów uzyskanych z liści tego gatunku. Najwyższa aktywność przeciwutleniająca charakteryzowała napary z liści odmian White Triumph i Satsumo Imo, najniższa – Beauguard.

Słowa kluczowe: antyoksydanty, batat, DPPH, napary

INTRODUCTION

In recent years, the interest of consumers, as well as the food and pharmaceutical industries in the nutrients of vegetable origin with antioxidant properties has increased. From research by Fik and Zawiślak (2004), Kapusta et al. (2013), it follows that these substances play an important role in the fight against free radicals, which react with protein molecules, lipids and saccharides causing their oxidation and, in consequence, destroying the cellular and tissue structures and contributing to development of many diseases. The best-known, low-molecular substances with high antioxidant and antiradical activity are vitamins: E and C, carotenoids and polyphenol compounds of plant origin. Epidemiological studies have shown that consuming foods with high antioxidant potential can significantly reduce the risk of cardiovascular disease and some cancers (Kurata et al., 2007). The species characterized by a high antioxidant potential include sweet potato. It is a long-term species native for the warm and hot climate zone, whereas the one-year-old spring - for the temperate zone. Sweet potato belongs to plants with large adaptation abilities. The first reports on the effects of growing this species in Poland are provided by Sawicka et al. (2000, 2004), and later by Krochmal-Marczak et al. (2007, 2010, 2014). In the opinion of An (2004) and Sun et al. (2014), sweet potato leaves are a very good source of many vitamins, such as: A, C, B (riboflavin), and according to Ishiguro and Yoshimoto (2006), they are a great source of lutein. Their leaves contain about 90% dry matter, including: 12.6% protein, 3.3% fat, 19.1% fiber, 45.5% BZW, 10.2% mineral compounds (An, 2004; Krochmal-Marczak and Betlej, 2014). Infusions of sweet potato leaves are used, among others, in the treatment of type 2 diabetes (Aderonke, 2011).

The aim of this study is to assess the antioxidant activity of infusions from the leaves of five sweet potato varieties at varying time and temperature of brewing.

MATERIALS AND METHODS

Plant material

The plant material for research consisted of leaves of sweet potato five varieties: Carmen Rubin, Georgia Jet, Beauguard, White Triumph and Satsumo Imo, derived from the field experiment, established using the randomized block method, in triplicate, and carried out in 2017 in Żyznów (49°49'N and 21°50'E). Plants from all varieties were grown under the same soil conditions, on brown, slightly acidic soil (pH_{KCl}=5.6-6.1). Fertilization was carried out at a constant level, and care treatments according to good agricultural practice. The leaves were collected in phase 68 according to the BBCH scale. After harvest, the leaves were dried to constant weight in a forced-air laboratory dryer at 40 °C.

Preparation of infusions

Aliquots of 2 g dried leaves were weighed and put into the 250 ml flasks and then poured with 100 ml boiled drinking water at 80 °C and 100 °C. For both temperatures, three variants of brewing duration were used: 2, 5 and 10 minutes. After a certain time of brewing, the infusions were filtered and the resulting extracts were cooled to a temperature of about 25 °C. For each combination, 4 replicates were prepared.

Determination of antioxidant activity of infusions by means of spectrophotometric method with DPPH radical

The vial was successively filled with 2.9 ml of 96% ethanol, 1 ml of 0.3 M ethanolic DPPH solution and 0.1 ml of infusions. After mixing, the solution was incubated for 30 minutes in a dark place. At that time, the so-called A_0 solution was prepared by mixing 3 ml of 96% ethanol with 1 ml of 0.3 M DPPH solution. Prior to the measurement of the test samples, the spectrophotometer was calibrated by measuring the absorption at a wavelength λ = 517 nm with a reference solution of 96% ethanol, and then measured against the

test solution A0. Before measurement, the contents of the vial were thoroughly mixed, poured into cuvettes and the absorbance spectra were measured immediately. All assays were done in triplicate, using a Jenway 6850 UV/VIS spectrophotometer.

Calculation of results

Antioxidant activity of infusions was expressed as a percentage reduction of the DPPH radical after 30 minutes of infusion incubation with reference to the control sample. For this purpose, the arithmetic mean was determined from the measurements obtained from the spectrophotometric analysis and then the values were assigned to the formula:

$$A\ [\%] = (AC - AS) / AC \times 100$$

where:

A – percent inhibition of free radicals;

AC – absorbance of the control;

AS – average absorbance value of the test infusion solution (Zych and Krzepiłko, 2010).

Statistical analysis

A descriptive analysis of the test results was carried out using the Statistica 10 software (means, standard deviation). Significance of differences between means were calculated by Tukey's test at significance level p0.05. Achieved data was also subjected to multifactorial analysis of variance and main effects were determined (for physical properties: C - influence of the variety, M - influence of brewing time, T - influence of brewing temperature) and interaction effect of factors (CxM, CxT, MxT and CxMxT, respectively). A multidimensional analysis was used for the tested sweet potato varieties, as a result of which a dendrogram was prepared grouping individual varieties according to the degree of similarity (Stanisz, 2007).

RESULTS AND DISCUSSION

The antioxidant activity of sweet potato leaves water infusions, determined using the DPPH radical, ranged from 32.6% to 58.04%. Its value was influenced both by the genetic characteristics of the plants, from which the raw material was obtained, as well as the temperature and time of brewing preparation (Tables 1-3).

Temperature of water used to prepare infusions significantly influenced the antioxidant potential of obtained infusions. After pouring the leaves with water at 100 °C, infusions with significantly higher antioxidant activity were obtained, compared to those obtained with the use of water at 80 °C (Figure 1). According to Różańska et al. (2014), changes in the antioxidant potential during thermal treatment are influenced by the loss of antioxidant vitamins, especially vitamin C, that is very sensitive to high temperatures. Similar results were also obtained by Dewanto et al. (2002), who due to increasing the temperature of the infusion, found a reduction in the content of antioxidant compounds.

The infusion preparation time clearly differentiated the antioxidant activity of the infusions obtained. The most favorable in this respect was the infusion brewed for 5 minutes, for each of the tested varieties, both using water at 80 °C and 100 °C. Achieved values of this feature were in the range of 52-58% at 100 °C and 41-47% at 80 °C. Similar results were reported by Yen et al. (1997), who found the most antioxidant compounds in 5-minute infusions. Dmowski et al. (2014) reported that prolonging the brewing time from 3 to 15 minutes resulted in an increase in antioxidant activity, but only for some types of black teas. Wang et al. (2000) found that excessively long brewing time significantly reduces the antioxidant properties. This is also confirmed by the conducted research. Extending the brewing time to 10 minutes resulted in the infusion characterized by slightly lower antioxidant activity, both at 100 °C (46.3-5.2%) and 80 °C (38.1-46.6%). The lowest value of this feature was recorded for infusions obtained after 2 minutes of brewing (respectively 36.3-44.6% and 29-35.3%). Very high eta-squared (η^2) showed that all factors influenced the antioxidant activity of the infusions under investigation (Table 3).

Table 1. Antioxidant activity of infusions from sweet potato leaves brewed in water at 100 °C

Cultivars	Time of brewing (min)		
	2	5	10
'Carmen Rubin'	^{a}37.19±0.27^{x}	^{a}52.08±0.1^{y}	^{a}46.33±0.47^{z}
'Georgia Jet'	^{b}44.11±0.87^{x}	^{b}57.01±0.65^{y}	^{bd}51.59±0.46^{z}
'Beauguard'	^{a}36.27±0.45^{x}	^{a}52.08±0.85^{y}	^{c}48.64±0.41^{z}
'White Triumph'	^{b}44.65±0.51^{x}	^{b}58.04±0.8^{y}	^{d}53.19±1.07^{z}
'Satsumo Imo'	^{c}41.75±0.35^{x}	^{b}57.5±0.54^{y}	^{d}53.21±0.88^{z}
Mean	40.79^{C}	55.34^{A}	50.59^{B}

$^{x, y, z, A, B, C}$ Values in the rows marked with different letters differ significantly (P>0.05). ^{a,b,c} Values in the columns marked with different letters differ significantly (P>0.05).

Table 2. Antioxidant properties of infusions from sweet potato leaves brewing in water at 80 °C

Cultivars	Time of brewing (min)		
	2	5	10
'Carmen Rubin'	^{a}34.59±0,16^{x}	^{a}40.88±0.97^{y}	^{a}38.11±0.83^{z}
'Georgia Jet'	^{b}32.66±0,64^{x}	^{b}43.97±1.01^{y}	^{b}42.1±0.7^{z}
'Beauguard'	^{c}29±0,53^{x}	^{c}45.85±0.7^{y}	^{c}45.35±0.95^{y}
'White Triumph'	^{a}35.25±0,54^{x}	^{d}47.45±0.17^{x}	^{c}46.55±0.66^{z}
'Satsumo Imo'	^{b}32.59±1,51^{x}	^{cd}46.52±0.42^{y}	^{c}45.79±0.85^{y}
Mean	32.8^{C}	44.93^{A}	43.58^{B}

$^{x, y, z, A, B, C}$ Values in the rows marked with different letters differ significantly (P>0.05). ^{a,b,c} Values in the columns marked with different letters differ significantly (P>0.05).

Table 3. Influence of water temperature and infusion time on antioxidant activity of infusions from sweet potato leaves

Statistical effect	Antioxidant activity	Eta-squared (η^2)
Cultivars (C)	*	0.947
Brewing time (M)	*	0.992
Brewing temperature (T)	*	0.944
The interaction effect of factors		
C x M	*	0.871
C x T	*	0.728
M x T	*	0.72
C x M x T	*	0.78

* Values in the rows differ significantly (P>0.05).

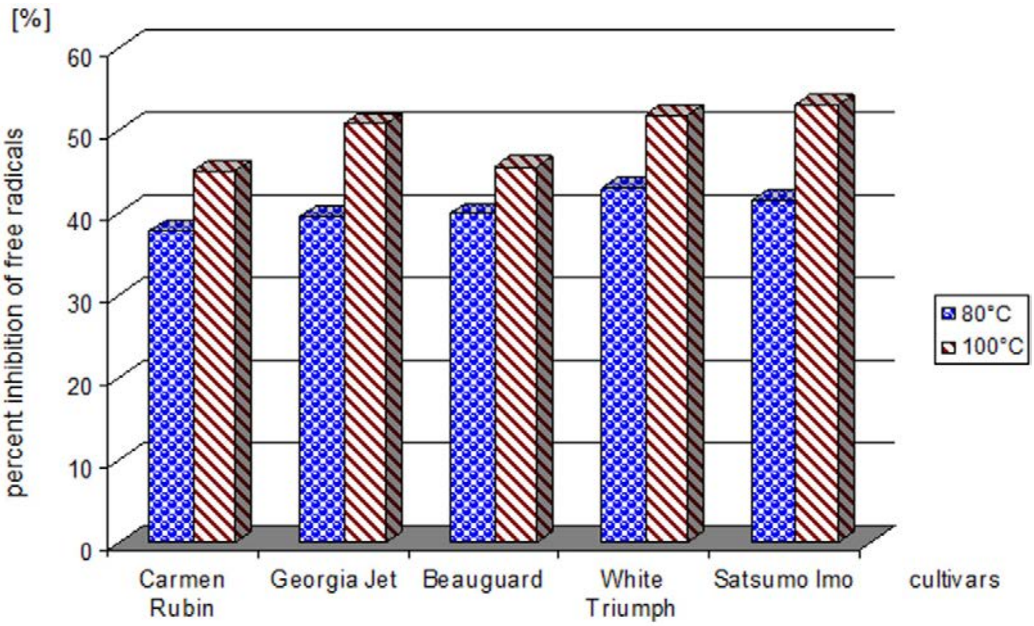

Figure 1. Influence of water temperature on antioxidant activity of infusions from 5 varieties of sweet potato leaves

Considering the varietal diversity of leaves used for making infusions, it was observed that the highest antioxidant activity was demonstrated by infusions prepared from the leaves of the varieties White Triumph and Satsumo Imo. Under the most favorable conditions for brewing, i.e. 5 minutes of brewing with water at 100 °C, the percentage of scavenged free radicals was 58.04% and 57.5% for the varieties studied, respectively. Similar differences in the antioxidant activity of other sweet potato varieties are reported by Rumbaoa et al. (2009) and Hue et al. (2012). Multidimensional statistical analyses allowed to identify two subgroups characterized by similar antioxidant potential, regardless of the conditions for the infusion preparation. The dominant sweet potato variety, in terms of antioxidant activity, was Georgia Jet (Figure 2).

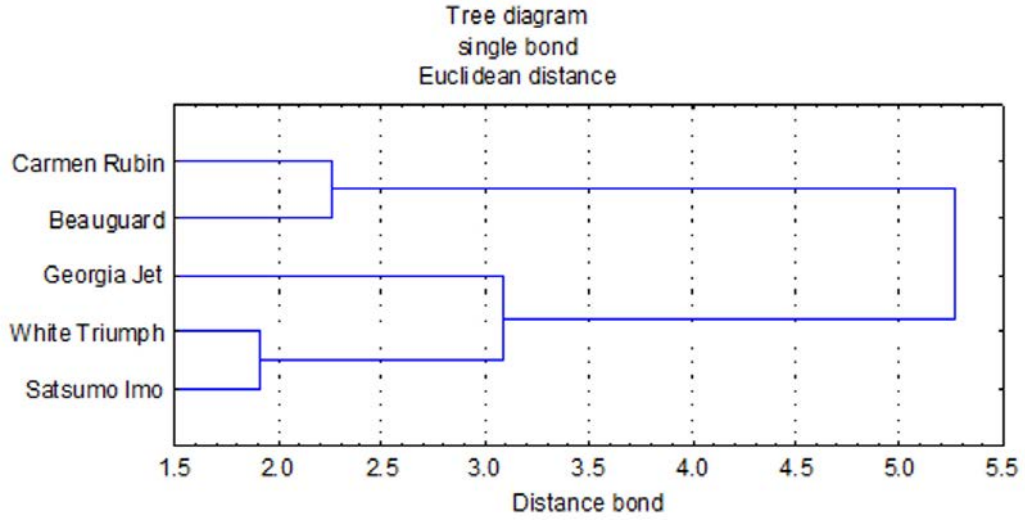

Figure 2. Dendrogram of five sweet potato cultivars based on antioxidant activity of their infusions.

CONCLUSIONS

1. Antioxidant activity of tested infusions obtained from sweet potato leaves ranged from 32.6% to 58%, depending on the variety and 32.8-44.93%, depending on the time of infusion preparation.
2. Infusions prepared at 100 °C were characterized by higher antioxidant activity, compared to those prepared with the use of water at 80 °C.
3. Time of infusion preparation had significant effect on antioxidant activity. Its highest value was noted after 5 minutes, and the lowest - after 2 minutes of dried leaves brewing.
4. Genetic characteristics of sweet potato significantly modified the value of antioxidant potential of infusions obtained from the leaves of this species. The highest antioxidant activity characterized infusions made from leaves of varieties White Triumph and Satsumo Imo, the lowest - Beauguard.

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