

FLAVONOID CONTENT AND ANTIOXIDANT ACTIVITY OF CARAWAY ROOTS (*CARUM CARVI* L.)

Agnieszka NAJDA¹, Jan DYDUCH^{1,2}, Norbert BRZOZOWSKI²

¹ University of Life Sciences

Kr. Leszczyńskiego 58, 20-068 Lublin, Poland

² Studium Generale Sandomiriense

Krakowska 26, 27-600 Sandomierz, Poland

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Summary

Flavonoid content in the roots of caraway plants cv. Kończewicki and the antioxidant activity of extracts from those roots were determined in the first year of cultivation. The experiment revealed a significant relationship between the concentration of flavonoid compounds and the age of caraway roots. During the vegetative season the concentration of flavonoids in caraway roots gradually increased and ranged from an average level of 0.153 mg·g⁻¹ of air-dry matter (a.d.w.) in June to 0.512 mg·g⁻¹ a.d.w. in October. The largest amounts of these compounds were contained in the roots of the plants grown in 2006 (an average of 0.312 mg·g⁻¹ a.d.w.).

The ability to scavenge the DPPH radical by the extracts from caraway roots increased in direct proportion to the length of the vegetative period, flavonoid content and extract concentration.

key words: flavonoid content, antioxidant activity, DPPH, caraway, length of vegetative period

INTRODUCTION

Flavonoids are an important group of biologically active compounds that can be found in fruit and vegetables (Bravo 1998, Wolski & Dyduch 2000, Horbowicz 2000, 2003, Sembratowicz & Czech 2005, Mysiak & Tendaj 2006). They exhibit multidirectional pharmacological action and the effects they produce in humans and animals are to a considerable degree dependent on their solubility in body fluids (Shahidi & Naczek 1995, Bravo 1998, Małolepsza & Urbanek 2000). Flavonoid compounds seal and strengthen the walls of capillary vessels, improve blood circulation in the heart muscle, have a spasmolytic, diuretic, anti-aggregation effect on blood platelets, and also have anti-inflammatory, anti-ulcerative, anti-allergic and anti-hepatotoxic action. They have also been found to possess antifungal and antiviral properties, and have an

Corresponding author:

e-mail: katedra.warzywnictwa@up.lublin.pl

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inhibiting effect on the action of some enzymes. Moreover, the importance of flavonoids as so-called detoxifiers should be emphasized, as they easily form complex connections (chelates) with heavy metals (Robak & Gryglewski 1996, Blackburn 1997, Kohlmünzer 2000, Sembratowicz & Czech 2005).

The effectiveness and availability of antioxidants of plant origin arouse widespread interest. Flavonoids, apart from other natural antioxidants such as phenolic acids, tannin and tanning agents, are an important group of secondary metabolites capable of both preventing and eliminating the effects of reactive oxygen species (ROS). They exhibit a high antioxidant potential and are classed as natural non-nutrients (Smith & Yang 1994, Bravo 1998, Williamson 1999, Troszyńska *et al.* 2002, Gow-Chin *et al.* 2002). Polyphenolic compounds, especially flavonoids, flavonones and isoflavones, enhance the action of other antioxidants, e.g. vitamins soluble in fats and low-molecular substances soluble in water. This indicates that the presence of these compounds in the diet is very important (Politycka & Wójcik-Wojtkowiak 2001, Troszyńska *et al.* 2002, Podśędek & Anders 2002).

The fruit of the caraway plant (*Carum fructus*) are commonly used as seasoning in cooking, prepared foods, food industry, perfume and cosmetics industry, etc. They are also a herbal raw material that contains mainly ethereal (essential) oil, fatty oil, protein compounds, waxes, tanning agents, resins, flavonoids, organic acids, coumarin compounds, and mineral and other salts (Rumińska 1973, Węglarz 1982, 1983, Ożarowski & Jaroniewski 1989). The caraway plant can also be grown as a vegetable. Use is then made of the whole plants in the first year of cultivation – the leaves (soups, sauces, salads) and the roots, in which there are also many biologically active compounds (Weiss 2002, Dyduch *et al.* 2006).

The aim of the experiment described in this paper was to determine the amounts of flavonoid compounds in the roots of caraway plants and to assess the antioxidant activity of extracts from those roots in relation to their age at harvest in the first year of cultivation.

MATERIALS AND METHODS

The experimental material consisted of the roots of caraway plants *cv.* 'Kończewicki', which had been obtained in the first year of cultivation in our own agrotechnical experiments with caraway conducted on the Felin Experimental Farm of the University of Life Sciences in Lublin. Fruits of the studied variety of caraway were sown between the 24th and 26th of April 2005 and 2006, on a flat plot, in rows 40 cm apart and 40 m long, with a seed barrow at 8 kg·ha⁻¹. After germination, the plants were thinned, leaving in each row 20 plants per running meter, which is around 50 plants per square meter. Maintenance and cultivation treatments were applied in accordance with the recommendations for growing carrot. In the two years of the experiment, plants were harvested on five different dates in the last ten days of each month from June through October. After harvesting, the roots of the caraway plants were separated from the above-ground parts, cleaned and dried at 30°C.

In air-dry and pulverized material, the concentration of flavonoid compounds ($\text{mg}\cdot\text{g}^{-1}$) was determined using the spectrophotometric method according to Christ & Muller (FP VI, 2002). In addition, antioxidant activity (%) measured by the ability to scavenge the DPPH radical was determined with the spectrophotometric method according to Chen & Ho (1997). For that purpose, aqueous extracts from caraway roots were prepared. The extracts were evaporated until dry and then lyophilized. The analyses were carried out on extracts at three concentrations: $20\ \mu\text{g}\cdot\text{mL}^{-1}$, $40\ \mu\text{g}\cdot\text{mL}^{-1}$, $80\ \mu\text{g}\cdot\text{mL}^{-1}$. Absorbance measurements were carried out at a wavelength of $\lambda=517\ \text{nm}$ in a Canberra Packard UVIKON 932 spectrophotometer.

The results of the laboratory tests were evaluated statistically using variance analysis and T-Tukey's confidence intervals at the 0.05 level of significance.

RESULTS AND DISCUSSION

The obtained results showed that the concentration of flavonoid compounds in the roots of caraway plants varied during their vegetative growth in the field in each year of the experiment (Table 1). The flavonoid content in the roots was at a level of 0.140 to $0.536\ \text{mg}\cdot\text{g}^{-1}$ of air-dry weight (a.d.w.), with decidedly larger amounts of those compounds found in the roots of plants harvested in October (an average of $0.512\ \text{mg}\cdot\text{g}^{-1}$ a.d.w.) than in June (an average of $0.153\ \text{mg}\cdot\text{g}^{-1}$ a.d.w.). Irrespective of the harvest date, the largest amounts of flavonoids were found in caraway roots in the year 2006 – an average of $0.312\ \text{mg}\cdot\text{g}^{-1}$ a.d.w. While analyzing the roots of two horseradish varieties, Horbowicz & Rogowska (2006) had revealed a different relationship. During the growing season, the level of kempherol in the analyzed roots was seen to decrease irrespective of the horseradish variety.

Table 1. Flavonoid content ($\text{mg}\cdot\text{g}^{-1}$ a.d.w.) in the roots of caraway plants

Month of harvest	Years of experiment		
	2005	2006	Average for years 2005-2006
June	0.140 a *	0.166 a	0.153 a
July	0.152 ab	0.186 ab	0.169 ab
August	0.208 b	0.238 b	0.223 b
September	0.439 c	0.493 c	0.466 c
October	0.488 c	0.536 c	0.512 c
Average	0.273	0.312	–

Values followed by the same letter are not significantly different at $P=5\%$

Studies conducted by Shahidi & Naczk (1995) revealed that rich sources of flavonoids include vegetables, fruit, seeds of various plants, some cereals, as well as red wines, tea (especially green tea), coffee, fruit juices and many seasonings. Particularly high concentrations of polyphenolic compounds can be

found in vegetable plants of the family *Brassicaceae* (*Cruciferae*) such as white cabbage, red cabbage, brussels sprouts, cauliflower, kale and broccoli ($0.7\text{--}3.2\text{ mg}\cdot\text{g}^{-1}$ f.w.), and also other vegetables such as tomato ($0.9\text{--}2.4\text{ mg}\cdot\text{g}^{-1}$ f.w.) and capsicum ($0.6\text{ mg}\cdot\text{g}^{-1}$ f.w.). Large amounts of these compounds are also contained in the seeds of oil plants such as soya-bean, rape and flax ($1.5\text{--}18.4\text{ mg}\cdot\text{g}^{-1}$ d.w.), and leguminous plants such as pea, bean and lentil ($1.1\text{--}6.3\text{ mg}\cdot\text{g}^{-1}$ d.w.).

On the other hand, Mysiak & Tendaj (2006) showed that plants of the various species of alliums grown for bunch harvest can be a valuable source of flavonoid compounds in early spring. The authors found out that among the three studied species – onion, shallot, and bunching onion – irrespective of the conditions for growing in the field or forcing in a greenhouse, the largest amounts of flavonoids were present in shallot plants (an average of $0.754\text{ mg}\cdot\text{g}^{-1}$ f.w. in field-cultivated plants and $0.611\text{ mg}\cdot\text{g}^{-1}$ f.w. in greenhouse-forced plants). In our experiment, the total concentration of flavonoid compounds in the roots of caraway plants was at a level of between 0.140 and $0.512\text{ mg}\cdot\text{g}^{-1}$ a.d.w., regardless of the harvest date.

The aqueous extracts from the roots of caraway plants showed the ability to reduce the DPPH radical to diphenylpicrylhydrazine, whose amount increased with the increase in the concentration of the tested extracts (Table 2). After 30 minutes, at the extract concentration of $80\text{ }\mu\text{g}\cdot\text{mL}^{-1}$, the highest ability to scavenge the DPPH radical was shown by the extracts from the roots harvested in October - 47.32%. The effect of scavenging the DPPH radical by the extracts from the roots that had been harvested in the months June through September was considerably smaller and was at an average level of between 17.38% and 23.21% at the extract concentration of $80\text{ }\mu\text{g}\cdot\text{mL}^{-1}$.

Table 2. Antioxidant activity (%) of aqueous extracts from the roots of caraway plants expressed in terms of their ability to scavenge the DPPH radical

Month of harvest	Extract concentration ($\mu\text{g}\cdot\text{mL}^{-1}$)								
	2005			2006			Average for years 2005-2006		
	20	40	80	20	40	80	20	40	80
June	3.98 a	9.17 a	14.93a	4.24 a	10.11 a	19.83 a	4.11 a	9.64 a	17.38 a
July	4.11 a	10.02 ab	15.02 a	4.41 a	10.64 a	20.16 a	4.26 a	10.33 a	17.59 a
August	9.44 b	15.37 bc	15.94 ab	10.12b	15.99 bc	24.56 ab	9.78 b	15.68 b	20.25 ab
September	15.79 c	18.36 c	20.71 b	16.49 c	18.86 c	25.71 b	16.14 c	18.61 bc	23.21 b
October	18.03 c	18.97 c	43.31 c	18.67 c	19.57 c	51.33 c	18.35 c	19.27 c	47.32 c

Values followed by the same letter are not significantly different at $P=5\%$

The ability of the extracts to neutralize the DPPH free radical at the concentrations of 20 and $40\text{ }\mu\text{g}\cdot\text{mL}^{-1}$ was below 20% in both years of the experiment and irrespective of the age of the roots. A considerably lower ability to reduce the DPPH radical was shown by the extracts from the roots of the caraway plants produced in 2005.

The ability to reduce the DPPH radical by the extracts from the roots of caraway plants was several times greater in relation to the results presented by Gawlik-Dziki & Świeca (2007), which had been obtained for extracts from dried greens of dill (8-12%), parsley (3-6%) and the fruits of black pepper (6-16%) and *Nigella sativa* (5-7%).

On the basis of the obtained results it can be stated that the analyzed roots of caraway plants contain chemical compounds which are secondary metabolites exhibiting antioxidant properties that make the caraway plant a vegetable of a high biological value.

CONCLUSIONS

1. Flavonoid content in caraway roots was determined. There was a significant relationship between the concentration of flavonoid compounds and the age of caraway plants.
2. Considerably greater amounts of flavonoids were found in the roots of caraway plants harvested in October ($0.512 \text{ mg}\cdot\text{g}^{-1}$ a.d.w., on average) in comparison with the roots of the plants harvested in June ($0.153 \text{ mg}\cdot\text{g}^{-1}$ a.d.w., on average).
3. The ability to reduce the DPPH radical to diphenylpicrylhydrazine increased with the increase in the concentration of the tested extracts.
4. The greatest ability to scavenge the DPPH radical was shown by the aqueous extracts from the roots harvested in October (47.32%, on average) at the extract concentration of $80 \text{ }\mu\text{g}\cdot\text{mL}^{-1}$.
5. The lowest ability to reduce the DPPH radical was shown by the extracts from the roots harvested in June (4.11%, on average) at the extract concentration of $20 \text{ }\mu\text{g}\cdot\text{mL}^{-1}$.

REFERENCES

- Blackburn G.L. 1997. Functional foods in the prevention and treatment of disease: significance of the Dietary Approaches to Stop Hypertension Study. *Am. J. Clinical Nutrition* 66 (5): 1067-1071.
- Bravo L. 1998. Polyphenols: chemistry, dietary sources, metabolism and nutritional significance. *Nutr. Rev.* 56: 317-333.
- Chen J.H., Ho C.T. 1997. Antioxidant activities of caffeic acid and its related hydroxycinnamic acid compounds. *J. Agric. Food Chem.* 45: 2374-2378.
- Dyduch J., Najda A., Brzozowski N. 2006. [Growth and chemical content of caraway (*Carum carvi* L.) in the first year of cultivation]. *Folia Hort.* sup. 2006/1: 108-112. [in Polish with English summary]
- Farmakopea Polska VI. 2000. Wyd. PTFarm Warszawa. [in Polish]
- Gawlik-Dziki U., Świeca M. 2007. Influence of simulated digestion in various pH conditions on antioxidant activity and composition of extracts from selected spices. *Herba Pol.* 3: 278-285.
- Gow-Chin Y., Pin-Der D., Hui-Ling T. 2002. Antioxidant and pro-oxidant properties of ascorbic acid and gallic acid. *Food Chem.* 79: 307-313.

- Horbowicz M. 2000. [Occurrence, biosynthesis and biological properties of the flavonols.] Post. Nauk Roln. 2: 3-18. [in Polish with English summary]
- Horbowicz M. 2003. The occurrence, role and contents of glucosinolates in *Brassica* vegetables. Veget. Crops Res. Bull. 50: 81-91.
- Horbowicz M., Rogowska M. 2006. Content of isothiocyanates and flavonols in roots during vegetation of two types, horseradish. Veget. Crops Res. Bull. 65: 95-104.
- Kohlmünzer S. 2000. Farmakognozja. Podręcznik dla studentów farmacji. PZWL Warszawa. [in Polish]
- Małolepsza U., Urbanek H. 2000. Flawonoidy roślinne jako związki biochemicznie czynne. Wiad. Bot. 44: 27-37. [in Polish]
- Mysiak B., Tendaj M. 2006. Content of flavonoids in some *Allium* species grown for green bunching. Veget. Crops Res. Bull. 65: 105-111.
- Ożarowski A., Jaroniewski W. 1989. Rośliny lecznicze i ich praktyczne zastosowanie. Inst. Wyd. Zw. Zaw. Warszawa: 191-193. [in Polish]
- Podśedek A., Anders B. 2002. Polifenole warzyw jako naturalne antyoksydanty. IV konferencja „Flawonoidy i ich zastosowanie” Rzeszów 2002: 123-142. [in Polish]
- Politycka B., Wójcik-Wojtkowiak D. 2001. Mechanizmy oddziaływań allelopatycznych. pp: 13-24. In: Biochemiczne oddziaływania środowiskowe. (Oleszek W., Głowniak K., Leszczyński B. eds.) AM Lublin [in Polish]
- Robak J., Gryglewski R. 1996. Bioactivity of flavonoids. Polish J. Pharmacol. 48: 555-564.
- Rumińska A. 1973. Rośliny lecznicze. PWN Warszawa: 127-138. [in Polish]
- Sembratowicz I., Czech A. 2005. [Natural antioxidants in the food]. Post. Nauk Roln. 1: 75-88. [in Polish with English summary]
- Shahidi F., Naczk M. 1995. Food phenolics, sources, chemistry, effects applications. Technomic Publishing Company, Inc.
- Smith T.J., Yang Ch.S. 1994. Food phytochemicals for cancer prevention. In: Fruits and Vegetables. (M.T. Huang, T. Osawa, Ch.T. Ho, R.T. Rosen, eds.). American Chemical Society, Washington, DC: 18.
- Troszyńska A., Honke J., Kozłowska H. 2002. [Natural non-nutrients of plant origin as the components of functional food]. Postępy Fitoterapii. 2: 17-22. [in Polish with English summary]
- Węglarz Z. 1982. [Effect of agricultural agents on the transition of *Carum carvi* L. from vegetative to generative phase. Part I. Effect of seeding rootstocks size on the value of caraway seedlings]. Herba Pol. 3-4: 171-179. [in Polish with English summary]
- Węglarz Z. 1983. [Effect of agricultural agents on the transition of *Carum carvi* L. from vegetative to generative phase. II. Effect of fertilization and soil moisture on the development and cropping of *Carum carvi* L.]. Herba Pol. 1:21-26. [in Polish with English summary]
- Weiss E.A. 2002. Spice Crops. CABI Publishing, Australia: 232-243.
- Williamson G. 1999. Functional Foods-A new challenge for the food chemists. Proceedings of Euro Food Chem. X, Budapest 1: 192.
- Wolski T., Dyduch J. 2000. [Importance of vegetables and fruit in civilisation-related therapy]. Ann. Univ. Mariae Curie-Skłodowska, sec. EEE. Supl. VIII: 19-37. [in Polish with English summary]

ZAWARTOŚĆ FLAWONOIDÓW I AKTYWNOŚĆ ANTYOKSYDACYJNA KORZENI KMINKU ZWYCZAJNEGO (*CARUM CARVI* L.)

Streszczenie

Oznaczono zawartość flawonoidów oraz określono aktywność antyoksydacyjną ekstraktów z korzeni kminku zwyczajnego odmiany 'Kończewicki' w pierwszym roku uprawy. Na podstawie przeprowadzonych badań wykazano istotną zależność pomiędzy zawartością związków flawonoidowych a wiekiem korzeni kminku. Podczas sezonu wegetacyjnego poziom flawonoidów w badanych korzeniach stopniowo wzrastał i kształtował się na poziomie średnio od 0,153 mg·g⁻¹ p.s.m. w czerwcu do 0,512 mg·g⁻¹ p.s.m. w październiku. Najwięcej tych związków zawierały korzenie roślin uprawianych w roku 2006 (średnio 0,312 mg·g⁻¹ p.s.m.).

Zdolność znoszenia rodnika DPPH przez ekstrakty z korzeni kminku zwyczajnego wzrastała wprost proporcjonalnie do długości okresu wegetacji, zawartości flawonoidów i stężenia ekstraktów.