

EFFECT OF PLANTING DATE AND METHOD ON THE CHEMICAL COMPOSITION OF RADICCHIO HEADS

Anna Francke, Joanna Majkowska-Gadomska

**Chair of Horticulture
University of Warmia and Mazury in Olsztyn**

Abstract

The aim of the experiment, conducted from 2005 to 2006, was to determine the effect of planting date (spring, summer/fall) and method (seedlings, direct sowing) on the content of dry matter, selected organic components and nitrates in the heads of Italian chicory radicchio, cv. Palla Rossa 3. Statistical analysis revealed that both experimental factors had a significant effect on the content of dry matter and simple sugars in the edible parts of radicchio. Dry matter content was significantly affected by planting method, while the concentration of total sugars – by planting date. Chemical analysis of the harvested plant material indicated that radicchio grown in the spring contained more dry matter, L-ascorbic acid, simple sugars and total sugars. Plants obtained from seedlings accumulated more L-ascorbic acid and simple sugars, whereas those grown from directly sown seeds contained more dry matter and total sugars. The nitrate content of radicchio heads was found to be significantly dependent on both experimental factors. A significantly higher (by over 33%) concentration of nitrates was recorded in the edible parts of radicchio grown in the summer/fall. The impact of planting method on nitrate content was less noticeable, but radicchio plants grown from directly sown seeds accumulated more nitrates (by almost 11% on average) than those obtained from seedlings. The interaction between the analyzed factors had a significant effect on the bioaccumulation of dry matter, L-ascorbic acid, simple sugars, total sugars and nitrates.

Key words: radicchio, planting date, planting method, nutritive value, nitrates.

ZAWARTOŚĆ WYBRANYCH SKŁADNIKÓW CHEMICZNYCH W GŁÓWKACH CYKORII RADICCHIO W ZALEŻNOŚCI OD TERMINU I SPOSOBU UPRAWY

Abstrakt

W latach 2005–2006 oceniano zawartość suchej masy, wybranych składników organicznych i azotanów w główkach cykorii radicchio odmiany Palla Rossa 3 w zależności od terminu i metody uprawy. Cykorię uprawiano dwiema metodami – z rozsady przygotowanej uprzednio w szklarni oraz z siewu bezpośredniego w pole – w dwóch terminach – wiosennym i letnio-jesiennym. Analiza statystyczna wykazała istotny wpływ obydwu analizowanych czynników doświadczenia na zawartość witaminy C i cukrów prostych w częściach jadalnych cykorii. Na ilość zgromadzonej suchej masy istotnie wpłynęła metoda, natomiast cukrów ogółem – termin uprawy. Przeprowadzone po zbiorze badania chemiczne materiału roślinnego wykazały, iż zawartość suchej masy, kwasu L-askorbinowego, cukrów prostych i ogółem była większa w główkach cykorii z wiosennego terminu uprawy. Rośliny uprawiane z rozsady zgromadziły więcej kwasu L-askorbinowego i cukrów prostych, natomiast uprawiane z siewu bezpośredniego – więcej suchej masy i cukrów ogółem. Na gromadzenie azotanów w główkach cykorii istotny wpływ wywarły obydwa analizowane czynniki. Istotnie więcej azotanów (o ponad 33%) oznaczono w częściach jadalnych cykorii radicchio uprawianej w terminie letnio-jesiennym. Wpływ sposobu uprawy na badany czynnik nie był tak wyraźny – rośliny z siewu bezpośredniego zgromadziły średnio prawie o 11% azotanów więcej niż uprawiane z rozsady. Współdziałanie badanych czynników na bioakumulację suchej masy, kwasu L-askorbinowego, cukrów prostych i ogółem oraz azotanów było istotne.

Słowa kluczowe: cykoria radicchio, termin, metoda uprawy, wartość odżywcza, azotany.

INTRODUCTION

The pattern of vegetable consumption per household in Poland indicates a clear dominance of a few species only. The intake of leaf vegetables, known for their high nutritive value and health-promoting properties, is well below the recommended levels. The optimistic news is that the area under vegetables – including less popular species – continues to increase steadily. This is of paramount importance, since too low food variety and dietary diversity contributes to a higher incidence of civilization-related diseases (NALBORCZYK 1999, ADAMCZYK 2002, DYDUCH, NAJDA 2005). Of particular note is Italian chicory – radicchio, widely appreciated for its specific, slightly bitter taste and very attractive appearance. The red and white leaves of radicchio make an excellent base for salads.

The aim of the study was to determine the effect of planting date and method on the content of dry matter, selected organic components and nitrates in the heads of Italian chicory (radicchio).

MATERIALS AND METHODS

The study was conducted during the years 2005–2006, at the Experimental Garden of the University of Warmia and Mazury in Olsztyn. Italian chicory (radicchio) cv. Palla Rossa 3 was grown in the spring or in the summer/fall, by two methods: from seedlings produced in a greenhouse over four weeks, and from seeds sown directly in the field. The experiment was performed in a randomized complete block design, in three replications. Plot area was 1.8 m². Twenty seedlings were planted per plot, at the 30 x 30 cm spacing. Both in the spring and summer, seeds were sown and seedling April and 31 July 2006. Radicchio heads were harvested from particular treatments once only, in a period from 4 to 27 July and from 20 to 27 October respectively.

Fresh plant material was collected from all treatments to determine the content of: dry matter – by the gravimetric method (according to the Polish Standard PN-90/A-75101/03), L-ascorbic acid – by the Tillmans method modified by Pijanowski (PN-90/A-75101/11), total sugars – by the Luff-Schoorl method (PN-90/A-75101/07). After harvest samples of the edible parts of vegetables were dried at 65°C in a KBC G 65/250 drier and ground in an electric mill. Nitrate concentration was determined by the colorimetric method, with the use of salicylic acid (KRAUZE, DOMSKA 1991). The percentage content of N – NO₃ was calculated according to the following formula:

$$X = a \cdot 100 \cdot b^{-1},$$

where:

- a – deviation from the standard curve, mg N-NO₃;
- b – sample weight;
- 100 – expressed as percentage.

The results were verified statistically. The significance of differences between mean values was estimated by Tukey's test at a significance level of $\alpha = 0.05$.

RESULTS AND DISCUSSION

Chemical analysis of the harvested plant materials indicated that plants grown from directly sown seeds contained significantly more (almost 1.5-fold) dry matter than plants obtained from seedlings. The differences were more noticeable in the summer/fall. A higher dry matter content was determined in the leaves of plants grown in the spring compared to those harvested in the fall (8.15% vs. 7.87% on average), but the effect of planting date on dry matter content was not confirmed by the statistical analysis.

L-ascorbic acid concentration in radicchio heads ranged from 46.4 to 144.5 mg·100 g⁻¹. Similar results were reported by ROŻEK (2002). L-ascorbic acid content was almost twofold higher in plants grown in the spring. Radicchio grown in the spring accumulated also more simple and total sugars – on average by 55.9% and 39.4% respectively. Other authors also reported higher concentrations of vitamin C and sugars in spring-grown leaf vegetables, such as lettuce (MAJKOWSKA-GADOMSKA, WIERZBICKA 2005b), Chinese cabbage (KRĘŻEL, KOŁOTA 2003), leaf mustard (CAPECKA 2006) and lamb's lettuce (ADAMCZEWSKA-SOWIŃSKA, KOŁOTA 2000). Plants obtained from seedlings accumulated more L-ascorbic acid and simple sugars, whereas those grown from directly sown seeds contained more dry matter and total sugars (Table 1).

Table 1

The content of dry matter and some chemical components in radicchio heads
(mean for years 2005-2006)

Planting date	Method	Dry matter (%)	L-ascorbic acid (mg·100 g ⁻¹)	Simple sugars (g·100 g ⁻¹)	Total sugars (g·100 g ⁻¹)
Spring	seedling	6.960	144.5	2.210	2.447
	direct sowing	9.340	93.7	1.747	2.270
Mean		8.150	119.1	1.978	2.358
Summer - -autumn	seedling	5.800	68.7	1.320	1.500
	direct sowing	9.930	46.4	1.220	1.883
Mean		7.865	57.5	1.270	1.692
Mean	seedling	6.380	106.6	1.765	1.973
	direct sowing	9.635	70.0	1.483	2.077
LSD _{0.05}					
I term of cultivation		n.s.	2.08	0.072	0.111
II method		0.552	2.08	0.072	n.s.
I × II		0.780	2.94	0.101	0.157

Statistical analysis revealed that both experimental factors had a significant effect on nitrate accumulation in radicchio heads. A substantially higher concentration of nitrates was determined in the edible parts of radicchio plants grown in the summer/fall compared to those grown in the spring (1534.7 mg·kg⁻¹ fresh weight vs. 1130.2 mg·kg⁻¹ fresh weight on average). These results are consistent with the findings of JAWORSKA and KMIECIK (1999). The cited authors demonstrated that spinach grown in the fall contained nearly 16-fold more nitrates in comparison with spinach grown in the spring. Their observations were confirmed by KRĘŻEL and KOŁOTA (2003) for Chinese cabbage, by WIERZBICKA et al. (2002) and MAJKOWSKA-GADOMSKA, WIERZBICKA (2005a) for lettuce and by FRANCKE (2005) for *Eruca sativa*. The above is a consequence of, among others, much lower light intensity in the fall. According to SADE et al. (1995), insufficient

daylight always leads to excessive nitrate accumulation in crops. A significantly higher concentration of nitrates was recorded in the edible parts of radicchio plants grown from directly sown seeds. The interaction between planting date and method was statistically significant. However, the average nitrate content of radicchio heads did not exceed the maximum permissible limits set for green vegetables (Journal of Laws No. 2 of 2005, item 9) – Table 2.

Table 2

Nitrate content in heads of cichory radicchio cv. Palla Rosa 3 as dependent on cultivation time and methods (mg N-NO₃ · kg⁻¹ f.m.)

Method		2005	2006	Mean
		spring		
Seedling		1013.7	1221.7	1117.7
Direct sowing		1312.0	968.2	1142.6
Mean		1162.9	1095.0	1130.2
Summer – Autumn				
Seedling		1509.7	1310.4	1410.3
Direct sowing		1893.6	1417.7	1660.0
Mean		1701.7	1364.1	1534.7
Mean	seedling	1261.7	1266.1	1264.0
	direct sowing	1602.8	1193.0	1400.9
LSD _{0.05}				
I term of cultivation		13.6	20.0	10.0
II method		13.6	20.0	10.0
I × II		19.2	28.3	14.1

CONCLUSIONS

1. Chemical analysis of the harvested plant materials indicated that radicchio grown in the spring contained more dry matter, L-ascorbic acid, simple sugars and total sugars.

2. Plants obtained from seedlings accumulated more L-ascorbic acid and simple sugars, whereas those grown from directly sown seeds contained more dry matter and total sugars.

3. A significantly higher (by over 33%) concentration of nitrates was recorded in the edible parts of radicchio plants harvested in the fall. Radicchio plants grown from directly sown seeds accumulated more nitrates (by almost 11% on average) than those obtained from seedlings. The average nitrate content of radicchio heads did not exceed the maximum permissible limits set for green vegetables.

REFERENCES

- ADAMCZEWSKA-SOWIŃSKA K., KOŁOTA E. 2000. Ocena plonowania i wartości odżywczej kilku odmian roszonek w uprawie na zbiór wczesnowiosenny i jesienny. Roczn. AR Poznań CCCXXIII, Ogrodn., 31 (1): 205-209.
- ADAMCZYK G. 2002. Wybrane aspekty zachowań konsumpcyjnych i wzorców spożycia żywności w polskich gospodarstwach domowych w latach dziewięćdziesiątych. Roczn. AR Poznań CCCXLIII, Ekon., 1: 31-41.
- CAPECKA E. 2006. Liściowa forma gorczycy sarepskiej *Brassica juncea* (L.) Czern. w uprawie polowej. Fol. Hort. Supl., 1: 77-81.
- DYDUCH J., NAJDA A. 2005. Zmiany zawartości suchej masy i kwasu L-askorbinowego w liściach roślin dwu odmian selera naciowego (*Apium graveolens* L. var. *dulce* Mill./Pers.) w zależności od wieku zbieranych roślin i ściółkowania gleby. Zesz. Nauk AR Wrocław, Rol., 86 (515): 111-119.
- FRANCKE A. 2005. Wpływ terminu uprawy oraz rodzaju gleby na zawartość azotanów i metali ciężkich w liściach rakiety siewnej (*Eruca sativa* L.). Zesz. Probl. Post. Nauk Rol., 507: 135-141.
- JAWORSKA G., KMIECIK W. 1999. Content of selected mineral compounds, nitrates III and V, and oxalates in spinach (*Spinacia oleracea* L.) and New Zealand spinach (*Tetragonia expansa* Murr.) from spring and autumn growing seasons. Electronic J. Pol. Agric. Univ., Food Sc. Technol. (2): 2. www.ejpau.media.pl/volume2/issue2/food/art-03.html
- KRAUZE A., DOMSKA D. 1991. Ćwiczenia specjalistyczne z chemii rolnej. Wyd. ART Olsztyn.
- KRĘŻEL J., KOŁOTA E. 2003. Yield evaluation of some Chinese cabbage cultivars in spring and autumn cultivation. Fol. Hort., 15/1: 11-18.
- MAJKOWSKA-GADOMSKA J., WIERZBICKA B. 2005a. The effect of cultivation season and selected sorbents on the yield and nitrate content of butterhead lettuce (*Lactuca sativa* L. var. *capitata* L.). Pol. J. Natur. Sc., 18, 1Y: 15-21.
- MAJKOWSKA-GADOMSKA J., WIERZBICKA B. 2005b. Wpływ terminu uprawy i wybranych sorbentów na plon i zawartość wybranych składników pokarmowych w liściach sałaty. Zesz. Nauk AR Wrocław, Rol., 86 (515): 339-345.
- NALBORCZYK E., 1999. Rośliny alternatywne rolnictwa XXI wieku i perspektywy ich wykorzystania. Zesz. Probl. Post. Nauk Rol., 468: 17-30.
- Rozporządzenie ministra zdrowia z dnia 22 grudnia 2004 r., zmieniające rozporządzenie w sprawie maksymalnych poziomów zanieczyszczeń chemicznych i biologicznych, które mogą znajdować się w żywności, składnikach żywności, dozwolonych substancjach dodatkowych, substancjach pomagających w przetwarzaniu albo na powierzchni żywności. Dz.U. Nr 2, poz. 9. 2005.
- ROŻEK E. (2002): Ocena wielkości i jakości plonu kilku odmian cykorii sałatowej (*Cichorium intybus* L. var. *foliosum* Bisch.). W: Jakość warzyw i ziół na tle uwarunkowań uprawowych i pozbiornych, Warszawa, 27-28 czerwca, 78 ss.
- SADY W., ROŻEK S., MYCZKOWSKI J. 1995. Effect of different forms of nitrogen on the quality of lettuce yield. Acta Hort., 401: 409-416.
- WIERZBICKA B., MAJKOWSKA J., KUSKOWSKA M. 2002. Zawartość azotanów w sałacie uprawianej na podłożu z dodatkiem hydrożeli. Biul. Nauk., 14: 145-150.