Nutritional composition and yield of endive cultivars – *Cichorium endivia* L.

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ABSTRACT: Two year trials at the Horticultural Faculty in Lednice (part of the Mendel University of Agriculture and Forestry Brno) evaluated six cultivars of endive (*Cichorium endivia* L.): 3 cultivars of *C. endivia* L. var. *crispum* (Markant, Midori, Protos), and 3 cultivars of *C. endivia* L. var. *latifolium* (Malan, Maral, Nuance). At harvest time, the nutritional composition was evaluated: levels of vitamin C, minerals (K, Na, Ca, Mg), chlorophyll, dietary fibre, dry matter and nitrates. In addition, a single plant weight and yield were measured. It was observed that the cultivars of *C. endivia* var. *crispum* contained significantly higher quantities of dietary fibre and dry matter than those of *C. endivia* L. var. *latifolium*. Nitrate levels were significantly higher in the leaves of *C. endivia* L. var. *latifolium* cultivars. Except for vitamin C and dietary fibre, it was observed that all the investigated parameters varied significantly from one year to the next. Out of the six cultivars of endive, the Maral cultivar showed the highest average yield per 100 m^2 (662 kg).

Keywords: endive (*Cichorium endivia* L.); nutritional content; yield; weight

This less known vegetable offers an opportunity to widen the presently rather limited choice of vegetables available in shops and to increase the diversity of vegetables consumed. Endive is not a well-known vegetable in the Czech Republic; nevertheless, it is very valuable nutritionally, with a high content of dietary fibre, potassium and vitamin C (Kopec 1998). The bitter elements promote digestion and due to its inulin content, endive is suitable also for diabetics. In many European countries, e.g. Italy, Germany and Switzerland, this vegetable is very popular; in our country, it began to be grown for inclusion in mixed, pre-packed salads.

The aim of this work was to screen the different endive cultivars for selected chemical compounds and to measure their yields.

MATERIALS AND METHODS

Cultivars chosen

Nuance – a very fast growing cultivar of *C. endivia* var. *latifolium*, with full middle leaf rosette, resistant to magnesium deficiency. Similar cultivars, Malan and Maral, were also included.

Markant – a curled-leaf cultivar of *C. endivia* var. *crispum*, with long, erect leaves, and a good firm middle. Similar cultivars, Protos and Midori, were also included.

Cultivation details

Sowing: beginning of July. Planting outside: middle of August (spacing 0.3 × 0.3 m). Harvest: beginning of November.

Field trials were conducted in Lednice (altitude 164 m), in the fields of the Mendel University of Agriculture and Forestry Brno, in 1998 and 1999. There were three replications for each cultivar. Endive was grown using the techniques recommended by Malý et al. (1996). Plants were harvested at the stage prescribed by the Czech quality standards (ČSN 46 3132). Chemical analyses were carried out immediately after the harvest. Mixed samples were prepared from 3 plants taken from each replication of each cultivar.

Analytical methods

Vitamin C (ascorbic acid) – Tillman's titration method. *Chlorophyll* – colorimetric method. *Min-*

erals (K, Na, Ca, Mg) – capillary isotachophoresis method (equipment IONOSEP 900.1.). *Dietary fibre* – Henneberg-Stohmann method. *Dry matter* – drying oven (temperature of 103 ± 2°C). *Nitrates* – ion-selective electrode (ISE).

The investigated chemical compounds and single plant weights were statistically evaluated using ANOVA methods (at the level of $P = 0.05$). Unistat software was used for statistical analysis.

RESULTS AND DISCUSSION

Differences between years, varieties and cultivars in selected chemical compounds and weights of single plants presented in Tables 1 and 2 were as follows:

Vitamin C

Vitamin C levels ranged from 145 to 282 mg/kg. The highest levels were observed in the cultivars of *Cichorium endivia* L. var. *crispum:* Markant (282 mg/kg) in 1998, and Protos (248 mg/kg) in 1999. Pacík and Malý (2003) also observed higher levels of vitamin C in lettuce cultivars with curled leaves in comparison to oak-leaved cultivars, though this was not statistically proven. They did not observe significant differences between years, varieties or cultivars in vitamin C content. The highest levels of vitamin C were higher than those observed by Staugaitis and Viskelis (2001), who classified endive as a vegetable with low level of vitamin C (from 20 to 200 mg/kg).

Chlorophyll

Chlorophyll levels ranged from 391 to 1,056 mg/kg. The highest level of chlorophyll was observed in Malan in both years, being 533 mg/kg and 1,056 mg/kg, respectively. There were significantly higher levels of chlorophyll in 1999 than in 1998, but significant differences between varieties and cultivars were not found. There are no references in the literature to the chlorophyll content of endive.

Minerals

Measurement of the mineral content produced the following range of values: potassium 2,483 to 6,155 mg/kg, sodium 162 to 617 mg/kg, calcium 332 to 851 mg/kg and magnesium 126 to 417 mg/kg (Table 1).

Potassium

Markant had the highest level of potassium in both years; 3,682 mg/kg and 6,155 mg/kg. There were significantly higher levels of potassium in 1999 than in 1998 (Table 2), but differences between varieties and cultivars were not found.

Sodium

Maral had the highest level of sodium in both years, 258 mg/kg and 617 mg/kg. There were significantly higher levels of sodium in 1999 than in 1998, but differences between varieties and cultivars were not found.

Table 1. Chemical components of endive (in fresh matter, in 1998 and 1999)

	Vitamin C (mg/kg)	Chlorophyll (mg/kg)	Potassium (mg/kg)	Sodium (mg/kg)	Calcium (mg/kg)	Magnesium (mg/kg)	Dietary fibre (g/kg)	Dry matter (g/kg)	Nitrates (mg/kg)
1998									
Maral	218	430	3,117	258	392	148	6.74	75	952
Malan	205	533	3,302	237	449	158	6.66	72	1,030
Nuance	213	456	3,037	199	342	126	6.23	65	982
Markant	282	496	3,682	256	640	139	9.80	112	797
Protos	145	391	2,711	213	332	147	7.88	79	265
Midori	255	505	2,483	162	378	133	10.55	108	190
1999									
Maral	215	906	5,018	617	535	340	8.71	116	913
Malan	215	1,056	5,640	441	657	316	9.05	114	903
Nuance	226	830	5,462	319	602	325	8.27	104	920
Markant	236	926	6,155	461	632	267	8.96	116	893
Protos	248	816	5,211	381	851	417	9.56	111	793
Midori	218	857	5,305	374	699	322	9.68	121	730

Table 2. Significance of differences in chemical compounds in endive cultivars

	Malan					Maral					Nuance					Markant					Midori				
	vitamin C	chlorophyll	dietary fibre	dry matter	nitrates	vitamin C	chlorophyll	dietary fibre	dry matter	nitrates	vitamin C	chlorophyll	dietary fibre	dry matter	nitrates	vitamin C	chlorophyll	dietary fibre	dry matter	nitrates	vitamin C	chlorophyll	dietary fibre	dry matter	nitrates
Protos					++					++					++										
Midori					++					++				+	++					++					
Markant														+											
Nuance																									
Maral																									

+ significant difference at $P = 0.05$, ++ significant difference at $P = 0.01$

Calcium

The values for calcium content were highest for Markant (640 mg/kg) in 1998, and for Protos (851 mg/kg) in 1999. There were significantly higher levels of calcium in 1999 than in 1998, but differences between varieties and cultivars were not found.

Magnesium

Malan had the highest levels in 1998 (158 mg/kg), and Protos in 1999 (471 mg/kg). There were significantly higher levels of magnesium in 1999 than in 1998, but differences between varieties and cultivars were not found.

The potassium, sodium, magnesium and calcium levels reported here are similar to those published by Kopec (1998). Although the mineral content of lettuce varies between cultivars (Pokluda, Petříková 2004; Drevs et al. 1996), this is not the case of endive. However, the mineral levels did vary significantly from one year to the next.

Dietary fibre

The dietary fibre levels ranged from 6.23 to 10.55 g/kg. Midori had the highest levels in both years, being 10.55 g/kg and 9.68 g/kg, respectively; in general, dietary fibre was significantly higher in the *Cichorium endivia* L. var. *crispum* cultivars. Midori had higher levels than Nuance, Maral and Malan, and Markant had significantly higher levels than Nuance and Maral. Significant differences between years were not observed. Observed values are lower than the 20 g/kg figure published by Kopec (1998), but they are similar to the 9 g/kg quoted by Rubatzky and Yamagucchi (1997) in Ryder (1999).

Dry matter

Dry matter ranged from 65 to 121 g/kg. Markant had the highest levels (112 g/kg) in 1998 and Midori (121 g/kg) in 1999. There were significantly higher levels in 1999 than in 1998, and levels were significantly higher in the *Cichorium endivia* L. var. *crispum* cultivar. Midori and Markant both had higher levels than Nuance. Santamaria et al. (2005) reported dry matter values ranging from 60 to 66 g/kg in endive grown hydroponically, which is only half of the values observed in this study; it reflects the influence of the growing system on dry matter content.

Nitrates

Nitrate levels were very variable and ranged from 190 to 1,030 mg/kg. Malan had the highest levels in 1998 (1,030 mg/kg), and Nuance in 1999 (920 mg/kg). *Cichorium endivia* L. var. *latifolium* cultivars had

Table 3. Significance of differences between years

	1998									
	Vitamin C	Chlorophyll	Potassium	Sodium	Calcium	Magnesium	Dietary fibre	Dry matter	Nitrates	Weight of one plant
1999		++	++	++	++	++		++		++

++ Significant difference at $P = 0.01$

Table 4. Average plant weights and yields of endive (kg/100 m^2)

Cultivar	Single plant weight (g)			Yield (kg/100 m^2)
	1998	1999	(total average)	
Maral*	773	420	597	662
Malan*	633	363	498	553
Nuance*	728	372	550	610
Markant	619	413	516	573
Protos	654	328	491	545
Midori	564	387	476	528

*Cultivars of *Cichorium endivia* L. var. *latifolium,* no asterisk – cultivars of *Cichorium endivia* L. var. *crispum*

higher levels than those of *Cichorium endivia* L. var. *crispum*, which is related to their different morphological structures. The leaves of *C. endivia* L. var. *crispum* create a more open leaf-rosette that captures more light, and this is an important factor influencing the accumulation of nitrates.

Malan, Nuance and Maral had higher levels of nitrates than Midori and Protos, while Markant had higher levels of nitrates than Protos. Differences between years were not observed. Staugaitis and Viskelis (2001) classified endive as a vegetable with low nitrate levels (from 601 to 1,200 mg/kg), which this study confirms. The observed values were generally lower, with only minor exceptions, than the maximum limit prescribed by 53/2002 Sb.

Single plant weights and yields (kg/100 m^2)

The weight of individual plants of endive ranged from 328 to 773 g (Table 4). Maral had the heaviest plants in both years, with 773 g and 420 g. Single plant weights were higher in 1998 than in 1999. No differences between varieties or cultivars were found. Weights in the first growing year were similar to those published by Sarrazyn et al. (2000) for cultivars of *C. endivia* L. var. *latifolium* (maximum about 850 g).

Maral had the highest average yield (662 kg per 100 m^2) and Midori the lowest (528 kg/100 m^2). The Maral cultivar of *C. endivia* var. *latifolium* had the highest average plant weight and average yield in both years.

CONCLUSION

Levels of vitamin C, chlorophyll, potassium, sodium, calcium, magnesium, dietary fibre, dry matter and nitrates were measured in 3 cultivars of *Cichorium endivia* L. var. *latifolium*, and 3 cultivars of *Cichorium endivia* L. var. *crispum*. In general, the observed values varied significantly from one year to the next, but not between the two varieties or the individual cultivars. However, the cultivars of *Cichorium endivia* L. var. *crispum* had higher levels of dietary fibre and dry matter.

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Nutriční hodnota a výnos odrůd endivie *Cichorium endivia* L.

ABSTRAKT: V dvouletých pokusech založených na Zahradnické fakultě Mendelovy zemědělské a lesnické univerzity Brno v Lednici bylo hodnoceno šest odrůd štěrbáku zahradního – z toho tři odrůdy eskariolu (*C. endivia* var. *latifolium*) Malan, Maral a Nuance a tři odrůdy endivie kadeřavé (*C. endivia* var. *crispum*) Markant, Midori a Protos. V době sklizně byla hodnocena nutriční hodnota: obsah vitaminu C, minerálních látek (K, Na, Ca, Mg), chlorofylu, vlákniny, sušiny a obsah dusičnanů. Dále byla hodnocena hmotnost jedné rostliny a výnos. Bylo zjištěno, že u odrůd endivie kadeřavé byl průkazně vyšší obsah vlákniny a sušiny než u eskariolu. Obsah dusičnanů byl naopak výrazně vyšší u eskariolu. Průkazný vliv odrůdy byl zaznamenán v obsahu vlákniny, sušiny a dusičnanů. Vliv roku se průkazně projevil na obsahu všech zjišťovaných látek s výjimkou vitaminu C a vlákniny. Ze šesti odrůd štěrbáku zahradního vykazovala největší průměrný výnos na 100 m^2 odrůda Maral (662 kg).

Klíčová slova: štěrbák zahradní (*Cichorium endivia* L.); obsahové látky; výnos; hmotnost

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