

Nutritional compositions and yield of sweet fennel cultivars – *Foeniculum vulgare* Mill. ssp. *vulgare* var. *azoricum* (Mill.) Thell

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ABSTRACT: In two-year trials taking place at the Faculty of Horticulture in Lednice (Mendel University of Agriculture and Forestry in Brno), three cultivars of sweet fennel (*Foeniculum vulgare* Mill. ssp. *vulgare* var. *azoricum* [Mill.] Thell) – Precoce di Bologna, Rudy F1 and Zefa Fino have been evaluated. The trials were conducted in two terms in each of the trial years (summer and autumn term). In the harvest time, nutritional value was evaluated: content of vitamin C, minerals (K, Na, Ca, Mg), dietary fibre, dry matter and nitrates. Besides, the weights of pseudobulbs and its yield have been evaluated. The content of the monitored substances ranged in the following intervals: vitamin C 87–347 mg/kg, K 4,241–5,851 mg/kg, Na 77–512 mg/kg, Ca 56–363 mg/kg, Mg 82–389 mg/kg, dietary fibre 5.75–7.59 g/kg, dry matter 61–75.8 g/kg, nitrates 650 to 3,767 mg/kg, weight of pseudobulb 199–383 g. A significant influence of cultivar on K content has been observed; furthermore, growing term markedly influenced the content of vitamin C, K, Na, Ca, Mg, dietary fibre, nitrates and on weight of pseudobulb. A significant influence of year on the content of vitamin C, Ca, Mg, dietary fibre, dry matter, nitrates and weight of pseudobulb has been recorded as well. From the three tested cultivars, Zefa Fino showed significantly higher average yield (331 kg/100 m²) in summer terms and Rudy F1 (267 kg/100 m²) in autumn terms.

Keywords: sweet fennel (*Foeniculum vulgare* Mill. ssp. *vulgare* var. *azoricum* [Mill.] Thell); Precoce di Bologna; Rudy F1; Zefa Fino; vitamin C (ascorbic acid); minerals (K, Na, Ca, Mg); dietary fibre; dry matter; nitrates; weight of pseudobulb

Using less known kinds of vegetables is one of the possibilities to improve unsatisfactorily low vegetable consumption, which is 80 kg/person per year in the Czech Republic, as well as assortment diversity of the consumed vegetables. The latter is also vital because of high content of nutritional components that those less known vegetables contain (KOPEČ 1998).

In the Czech Republic, sweet fennel is still rather an uncommon kind of vegetable. Its blanched fleshy basal part (pseudobulb) is used for consumption.

The aim of this work was to screen the values of selected chemical components in different cultivars of sweet fennel and to investigate their yield parameters.

MATERIAL AND METHODS

Selected cultivars

Precoce di Bologna (Sativa – Soc. Coop. a r.l.) – cultivar recorded in the Czech Republic since 1997. Not suitable for early sowing at the beginning of May; from June sowing, it gives high yield of pseudobulbs, which are suitable for storage (ANONYMOUS 2007).

Rudy F1 (Bejo Zaden) – uniform, balanced, high yield cultivar, suitable for spring, summer and autumn production. It gives round, shiny, white pseudobulbs, resistant to blooming (ANONYMOUS 2000).

Zefa Fino (Nickerson-Zwaan) – very early cultivar; it has soft, medium-size leaves, pseudobulbs are flat spheric, white coloured, relatively resistant against blooming (ANONYMOUS 1994).

Terms of sweet fennel growing

Summer term – sowing: middle of April, outplanting: end of May (growing space 0.5 × 0.2 m), harvest: beginning of August.

Autumn term – sowing: beginning of July, outplanting: middle of August (growing space 0.5 × 0.2 m), harvest: beginning of November.

Field trials were conducted in Lednice (altitude 164 m) on a field of the Mendel University of Agriculture and Forestry in Brno in 1998 and 1999. There were three repetitions for each cultivar. Sweet fennel was grown according to the recommended technology (MALÝ et al. 1998). Plants were harvested in the stage pursuant to the quality standard (ČSN 46 3173). Chemical analyses were done at harvest by taking three plants from each lot. Mixed samples were prepared from the 3 plants.

Analytical methods

Vitamin C (ascorbic acid) – determination by Tillmans titration method; minerals (K, Na, Ca, Mg) – capillary isotachopheresis method (equipment IONOSEP 900.1.); dietary fibre – Heneberg-Stohmann method; dry matter – drying (temperature of 103 ± 2°C); nitrates – ion selective electrode (ISE).

Investigated chemical components and single plant weight were statistically evaluated using ANOVA method (at the level of $\alpha = 0.5$ and $\alpha = 0.01$). PC programme Unistat (Version 4.53) was used for statistical evaluation.

RESULTS AND DISCUSSION

Differences between years, terms and cultivars in selected chemical compounds and pseudobulbs weights

Vitamin C

Recorded values of vitamin C content ranged from 87 to 347 mg/kg in the fennel (Tables 1 and 2). The cultivar Precoce di Bologna reached the highest values in all terms (summer and autumn of both years); the differences of vitamin C content among cultivars were however not significant (Table 3). Contrary to this, significant differences in vitamin C content among lettuce cultivars were found out by PETŘÍKOVÁ and POKLUDA (2003), among Chinese cabbage by MALÝ (2003). Growing period and year nevertheless significantly influenced vitamin C content (higher values were in autumn terms) (Tables 4 and 5). Values of vitamin C content recorded in this work are similar to those presented by DOBROMILSKA (1996); she reported vitamin C content values in inkrassate bottom part of stems at the level of 140–200 mg/kg.

Minerals (K, Na, Ca, Mg)

Mineral content in fennel ranged in the following intervals: K (4,241–5,851 mg/kg), Na (77–512 mg/kg), Ca (56–363 mg/kg), Mg (82–389 mg/kg) (Tables 1 and 2).

Potassium

The highest values of K (5,851 mg/kg) were found in the Precoce di Bologna cultivar in the autumn growing term of 1998, and in the Rudy F1 cultivar (5,568 mg/kg) in the autumn term of 1999. Values of K content were significantly higher: – in the autumn term of 1998 than in the summer term of that year (Table 4),

Table 1. Chemical components of sweet fennel (in fresh matter)

Cultivar	Vitamin C	K	Na	Ca	Mg	Dietary fibre	Dry matter	Nitrates
						(g/kg)	(g/kg)	(mg/kg)
Summer 1998								
Precoce di Bologna	102	4,610	79	61	92	6.62	67	1,537
Rudy F1	87	4,322	77	58	85	6.51	65	1,177
Zefa Fino	89	4,393	84	56	82	5.96	63	1,717
Autumn 1998								
Precoce di Bologna	347	5,851	239	224	199	6.65	67	3,767
Rudy F1	124	5,187	356	280	174	5.75	61	3,250
Zefa Fino	278	4,899	293	209	141	6.55	65	3,100

Table 2. Chemical components of sweet fennel (in fresh matter)

Cultivar	Vitamin C	K	Na	Ca	Mg	Dietary fibre	Dry matter	Nitrates
	(mg/kg)					(g/kg)		(mg/kg)
Summer 1999								
Precoce di Bologna	120	4,241	218	140	152	7.14	68	713
Rudy F1	112	4,948	196	156	166	7.30	70	783
Zefa Fino	91	4,807	195	160	212	6.82	68	650
Autumn 1999								
Precoce di Bologna	151	4,272	512	322	339	6.37	68	2,167
Rudy F1	129	5,568	281	167	389	6.52	68	3,173
Zefa Fino	148	5,266	495	363	359	7.59	76	3,023

– in the Rudy F1 cultivar than in the Precoce di Bologna cultivar in 1999.

No significant influence of year or cultivar on K content was found in both (1998, 1999) summer and autumn growing terms (Tables 3 and 5). Significantly higher content of K in autumn cultivation term of head lettuce was reported by PETŘÍKOVÁ et al. (2004).

Sodium

The Rudy F1 cultivar reached the highest values of Na content in the autumn term of 1998 (356 mg/kg) as well as the Precoce di Bologna cultivar in the autumn term of 1999 (512 mg/kg).

There were statistically significantly higher values of Na content in autumn terms when compared to summer terms of each year (1998 and 1999). No statistically significant influence of year and cultivar was observed on Na content of summer or autumn terms (Tables 1 to 5).

Calcium

The highest Ca content was recorded in the Rudy F1 cultivar in the autumn term of 1998 (280 mg/kg)

and in the Zefa Fino cultivar in the autumn term of 1999 (363 mg/kg).

Significantly higher values of Ca content were found in autumn than in summer growing terms in both years. Similarly, PETŘÍKOVÁ et al. (2004) mentioned significantly higher content of Ca in head lettuce in the autumn growing term in comparison to summer growing term.

The influence of year was significant in summer growing terms (Tables 1, 2, 4 and 5). The influence of cultivar on Ca content was not confirmed in either of the terms (1998 and 1999).

Magnesium

The highest Mg content was found in the Precoce di Bologna in the autumn term of 1998 (199 mg/kg) and in the Rudy F1 cultivar in the autumn term of 1999 (389 mg/kg).

Values of Mg content were significantly higher in autumn than in summer growing terms in both years (Tables 1, 2, 4 and 5). Significant influence of year on Mg content in both growing terms was found, whereas no significant influence of cultivar on Mg content was observed (Table 3).

Table 3. Significance of differences in chemical composition and pseudobulb weight in sweet fennel cultivars

	Precoce di Bologna								Rudy F1										
	Vitamin C	Dietary fibre	Dry matter	Nitrates	K	Na	Mg	Ca	Weight of single pseudobulb	Vitamin C	Dietary fibre	Dry matter	Nitrates	K	Na	Mg	Ca	Weight of single pseudobulb	
Zefa Fino																			
Rudy F1					+														

+ significant difference at $P = 0.05$

Table 4. Significance of differences between terms

	Summer								
	Vitamin C	K	Na	Ca	Mg	Dietary fibre	Dry matter	Nitrates	Weight of single pseudobulb
Autumn	++	++	++	++	++	+		++	++

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

SHUMAILA et al. (2005) presented the following values of minerals in dry matter of sweet fennel pseudobulb: K 133.33 mg/g, Na 80 mg/g, Ca 0.62 mg/g, Mg 19.81 mg/g. In the case of K, Na and Mg, their values exceed values from our trials several times (after recomputation to dry matter). On the contrary, Ca content mentioned by SHUMAILA et al. (2005) showed several times lower values.

KOPEC (1998) mentioned the following values of mineral contents in fennel: K 4,940 mg/kg, Na 860 mg/kg, Ca 1,090 mg/kg, and Mg 80 mg/kg. The values mentioned by KOPEC (1998), except for Na and Ca, are similar to the results reported in this work. K content was significantly influenced by growing term and cultivar; Na content was significantly influenced by growing term, and Ca and Mg content by growing term and year.

Dietary fibre

The highest content of dietary fibre was found in the Precoce di Bologna in the autumn term of 1998 (6.65 g/kg) and in the Zefa Fino cultivar in the autumn term of 1999 (7.59 g/kg).

Values of dietary fibre content were significantly higher in the summer than in the autumn term of 1999. In summer terms, statistically significant influence of year on dietary fibre content was found

Table 5. Significance of differences between years

	1998								
	Vitamin C	K	Na	Ca	Mg	Dietary fibre	Dry matter	Nitrates	Weight of single pseudobulb
1999	+			++	++	+	+	++	++

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

(Tables 1, 2, 4 and 5). It could have been caused by a lower level of rainfalls in summer terms, resulting in higher formation of dietary fibre in summer growing terms, particularly in 1999.

Results of dietary fibre content in this work ranged from 5.75 g/kg to 7.59 g/kg; they are several times lower than the values (approximately 33 g/kg) mentioned by KOPEC (1998). The results of dietary fibre content were significantly influenced by growing term and year.

Dry matter

The highest content of dry matter was shown by the Precoce di Bologna cultivar in 1998 (67 g/kg) and the Zefa Fino cultivar in the autumn term of 1999 (76 g/kg).

A significant influence of growing term and cultivar on dry matter content in sweet fennel was not confirmed, while a significant influence of year was found (Tables 1 to 5).

Nitrates

The highest content of nitrates was found in the Precoce di Bologna in the autumn growing term of 1998 (3,767 mg/kg) and in the Rudy F1 cultivar in the autumn growing term of 1999 (3,173 mg/kg).

Table 6. Pseudobulb weight (g)

Cultivar	Summer			Autumn		
	1998	1999	average	1998	1999	average
Precoce di Bologna	353	300	327	218	240	229
Rudy F1	337	199	268	283	251	267
Zefa Fino	383	278	331	219	222	221

Spacing 0.5×0.2 m for sweet fennel (10 pieces/m²)

Significantly higher values of nitrate contents were found in autumn when compared with summer growing terms 1998 and 1999. There was a significant influence of year on nitrate content in autumn and summer growing terms (Tables 1, 2, 4 and 5).

The observed values ranging from 650 mg/kg to 3,767 mg/kg were higher in both growing terms of 1998 and in the autumn growing term of 1999 than the maximum limit stipulated by the National Decree 53/2002 Coll. (1,000 mg/kg for leafy vegetable). Lower values were reached only in summer 1999.

An intensive negative influence of low light intensity on nitrate accumulation was noted. This corresponds with KREZEL and KOOTA (2003) and other authors.

LIPSKA-SZPUNAR (1992) mentioned the nitrate level in sweet fennel from 4,261 to 4,300 mg/kg. These relatively high values are due to the conditions in high plastic tunnels where the higher content of nitrates is caused by lower light intensity when compared with field conditions.

Weight of single pseudobulb, yield of pseudobulbs (kg/100 m²)

The highest value of single pseudobulb weight was found in the Zefa Fino cultivar in the summer growing term of 1998 (383 g) and in the Precoce di Bologna cultivar in the summer growing term of 1999 (300 g).

Pseudobulbs weights ranged from 199 g to 383 g. Values of pseudobulbs weights were significantly higher in 1998 summer growing term in comparison with autumn. A significant influence of year on pseudobulb weight was observed in summer growing terms (Tables 4–6).

The Precoce di Bologna cultivar showed the highest average yield from all growing terms (278 kg for 100 m²). Differences among average yield were minimal.

The ascertained values of sweet fennel yield correspond with values 200–300 kg/100 m² listed by PETŘÍKOVÁ et al. (2006).

CONCLUSION

Levels of vitamin C, chlorophyll, K, Na, Ca, Mg, dietary fibre, dry matter and nitrates were measured in sweet fennel (*Foeniculum vulgare* Mill. ssp. *vulgare* var. *azoricum* [Mill.] Thell).

The following values of monitored parameters were recorded: vitamin C 87–347 mg/kg, K 4,241 to 5,851 mg/kg, Na 77–512 mg/kg, Ca 56–363 mg/kg, Mg 82–389 mg/kg, dietary fibre 5.75–7.59 g/kg, dry matter 61.0–75.8 g/kg, nitrates 650–3,767 mg/kg, pseudobulb weight 199–383 g.

Cultivar significantly influenced only the content of K. Factors that influenced the monitored parameters (nutritional compounds and pseudobulb weight) of sweet fennel more significantly were growing term (spring and summer) and year.

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Nutriční hodnota a výnos u fenyklu sladkého *Foeniculum vulgare* Mill. ssp. *vulgare* var. *azoricum* (Mill.) Thell

ABSTRAKT: Ve dvouletých pokusech, které probíhaly na Zahradnické fakultě v Lednici (Mendelova zemědělská a lesnická univerzita v Brně), byly hodnoceny tři odrůdy fenyklu sladkého – hlíznatého (*Foeniculum vulgare* Mill. ssp. *vulgare* var. *azoricum* [Mill.] Thell) – *Precoce di Bologna*, *Rudy F1* a *Zefa Fino*. Pokusy byly uskutečněny ve dvou termínech pro každý pokusný rok (letní a podzimní termín). V době sklizně byla hodnocena nutriční hodnota: obsah vitamínu C, minerálních látek (K, Na, Ca, Mg), vlákniny, sušiny a dusičnanů. Byla také hodnocena hmotnost nepravých cibulí a výnos. Obsah sledovaných látek se pohyboval v následujících intervalech: vitamín C 87 až 347 mg/kg, K 4 241–5 851 mg/kg, Na 77–512 mg/kg, Ca 56–363 mg/kg, Mg 82–389 mg/kg, vláknina 5,75 až 7,59 g/kg, sušina 61–75,8 g/kg, dusičnany 650–3 767 mg/kg, hmotnost nepravých cibulí 199–383 g. Byl zjištěn průkazný vliv odrůdy na obsah K. Termín pěstování významně ovlivnil obsah vitamínu C, K, Na, Ca, Mg, vlákniny, dusičnanů a hmotnost nepravé hlízy. Rovněž byl zaznamenán průkazný vliv roku na obsah vitamínu C, Ca, Mg, vlákniny, sušiny, dusičnanů a hmotnost nepravé hlízy. Ze tří testovaných odrůd vykazovala nejvyšší průměrný výnos v letních termínech odrůda *Zefa Fino* (331 kg/100 m²), zatímco v podzimních termínech pěstování vykazovala nejvyšší výnos odrůda *Rudy F1* (267 kg/100 m²).

Klíčová slova: fenykl sladký – hlíznatý (*Foeniculum vulgare* Mill. ssp. *vulgare* var. *azoricum* [Mill.] Thell); *Precoce di Bologna*; *Rudy F1*; *Zefa Fino*; vitamín C (kyselina askorbová); minerální látky (K, Na, Ca, Mg); vláknina; sušina; dusičnany; hmotnost nepravé cibule

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