

INFLUENCE OF A NON-WOVEN TEXTILE COVERING ON THE CONTENT OF NUTRIENT COMPOUNDS OF LETTUCE*

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Two cultivars of leaf and one cultivar of head lettuce were evaluated in a three-year experiment carried out in Lednice (Czech Republic), in spring of the years 1998–2000. The lettuces were grown with and without non-woven textile. After harvest, the following parameters were measured: vitamin C, minerals (K, Na, Ca, Mg), fibre, dry matter and nitrates, the weights of leaf rosettes or heads. The use of a non-woven textile covering reduced significantly the levels of vitamin C (from 202 to 132 mg/kg), potassium (from 3,628 to 3,081 mg/kg) and dry matter (from 80.3 to 67.4 g/kg). The levels of sodium, magnesium, calcium and the weights of leaf rosettes and heads were by using of non woven textile increased (but not significantly). There were significantly higher contents of magnesium and calcium in leaf lettuce cultivars (leaf lettuce: Mg 154 and Ca 275 mg/kg; head lettuce: Mg 107 and Ca 181 mg/kg). The head of Lednický cultivar was significantly heavier than leaf rosette of Lollo Rossa (Lednický 260 g; Lollo Rossa 208 g). There were significant variations from year to year in all the observed parameters, with the exception of vitamin C.

leaf and head lettuce; vitamin C; minerals; fibre; dry matter; nitrates

INTRODUCTION

The use of non-woven textile is standard practice in field vegetable production today. The higher temperature and humidity under the non-woven fabric increase yields and shorten the time to harvest, and can influence the nutritional content too. The aim of this article is a study the influence of a non-woven textile, cultivar and year on the nutritional value and leaf rosette and head of lettuce.

Nutrient content depends on growing conditions – temperature (e.g. Karmas, Harris, 1988), plant nutrition (Premuzic et al., 2004; Ducsay, Varga, 2003), irrigation (Panchal et al., 2001; Radovich et al., 2005), growing technique (Worthington, 2001) and cultivar (Ghebramalak et al., 2004; Petříková, Pokluda, 2003).

MATERIAL AND METHODS

Characterization of cultivars

Bergamo – type of lettuce similar to Lollo Bionda with bright green leaves which are strongly crimped and a globular leaf rosette.

Lollo Rossa – an attractive red-brown lettuce of the Lollo Rossa type. Strongly crimped forming a compact rosette. For spring, summer and autumn growing.

Lednický – an early cultivar of head lettuce, for spring and autumn outdoor cultivation.

Cultivation details

Sowing: mid February, planted out at the end of March. Harvest: early May.

Field experiments were carried out in the period 1998–2000. The lettuces were cultivated in outdoors in Lednice (MUAf in Brno), which is situated 164 m above sea level with haplic chernozem (pH from 7.4 to 7.7 during 1998–2000). Lednice lies in the south-eastern part of the Czech Republic with a warm and dry climate. Its average annual precipitation is 524 mm, and the precipitation during the growing period is 323 mm and average annual temperature is 9 °C.

The seedlings were planted out in two variants (with using and without using non-woven textile) in randomized blocks with three replicates with spacing of 0.20 x 0.25 m. The lettuce was cultivated in accordance with techniques recommended by Malý et al. (1996). Standard fertilizer applications (following soil sample tests), irrigation (by decline of efficient water capacity at 60%) and weed control practices (manual weeding) were used. Harvest dates were chosen in compliance with the Czech standards for lettuce (ČSN 46 3132), which sets a minimal weight for the leaf rosette and head of 150 g. The lettuces grown under a covering were harvested earlier because of better moisture conditions.

The analyses for nutrient contents were performed in laboratory of Horticultural Faculty in Lednice (Mendel University of Agriculture and Forestry Brno) after harvest. A mixed sample for analysis was prepared from the three plants taken from each replicate.

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Methods for determining nutritional content

Vitamin C (L-ascorbic acid) – determined by titration using Tillmans method (according to the J a v o r s k ý et al. 1987); **Minerals (K, Na, Ca, Mg)** – by means of capillary isotachophoresis on a IONOSEP 900.1 (according to K v a s n í č k a, 2008); **Fibre** – the method according to Henneberg-Stohmann (according to J a v o r s k ý et al., 1987); **Dry matter** – direct sample drying at 103 ± 2 °C under prescribed conditions, gravimetrically (according to J a v o r s k ý et al., 1987); **Nitrates** – using an ion selective electrode of Šenkýř – ISE (according to J a v o r s k ý et al., 1987).

The data on the contents of nutrient compounds and weight of the leaf rosettes and heads of lettuces were statistically evaluated by analysis of variance with significance levels $P = 0.05$ and $P = 0.01$ using Unistat (version 5.1) software.

RESULTS AND DISCUSSION

Differences in nutrient levels and weights of leaf rosette and head lettuce in relation to year, cultivar and covering by non-woven fabric

Vitamin C

The highest levels of vitamin C were found in the cultivar Bergamo cultivated without non-woven fabric in 1998, 242 mg/kg (Table 1). The lowest levels of vitamin C were seen in 2000 (Table 3) in the year with the highest temperatures (Table 7). The effect of higher temperatures on reducing vitamin C levels has been mentioned by K a r m a s and H a r r i s (1988).

The levels of vitamin C were significantly higher, usually 18–50% higher, in lettuces grown without a non-woven

textile cover (Table 6). A reduction in vitamin C levels of 12–39% caused by a non-woven textile covering has been documented by H a v e t t o v á (2002).

No significant differences in vitamin C levels were observed between the cultivars (Table 4), nor there was not any significant variation observed between the three years of this trial (Table 5). However, significant differences in vitamin C levels among lettuce cultivars have been found in other trials by P e t ř í k o v á and P o k l u d a (2003) and also among Chinese cabbage cultivars by M a l ý (2006).

Minerals (K, Na, Ca, Mg)

The mineral levels in leaf and head lettuces were as follows. Textile covered: potassium (1,860–3,567 mg/kg), sodium (45–84 mg/kg), calcium (136–331 mg/kg), magnesium (79–193 mg/kg); uncovered variation: potassium (2,431–4,633 mg/kg), sodium (53–84 mg/kg), calcium (138–363 mg/kg), magnesium (95–338 mg/kg) (Tables 1–3).

Potassium

The highest level of potassium was found in the Lednický cultivar (uncovered) cultivated in 2000, with 4,633 mg/kg (Table 3), but usually the levels of potassium were significantly higher in the Lollo Rossa cultivar compared to the Lednický cultivar.

The levels of potassium were significantly higher in the uncovered treatments and a significant difference between years was observed (Tables 5 and 6).

The levels of potassium in both the leaf and head lettuces in this study were usually higher than the 2,640 mg/kg observed by R u b a t z k y and Y a m a g u c h i (1997) and cited by R y d e r (1999).

Table 1. Nutrient levels in fresh matter and weights of leaf rosette and head lettuce (1998)

Cultivar	Vitamin C	Potassium	Sodium	Calcium	Magnesium	Fibre	Dry matter	Nitrates	Weight of leaf rosette/head
	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(g/kg)	(g/kg)	(mg/kg)	(g)
Lollo Rossa	–	3,746	70	363	146	6.74	70	3,817	198
Standard deviation	–	327	19	96	32	0.52	2	725	38
Bergamo	242	2,971	56	293	119	6.63	71	3,250	288
Standard deviation	22	109	11	39	22	1.18	4	973	128
Lednický	166	2,431	55	214	100	5.85	64	2,867	342
Standard deviation	13	238	29	16	52	0.52	1	404	155
Lollo Rossa*	–	3,267	53	331	91	5.09	56	3,750	192
Standard deviation	–	562	11	65	18	0.46	3	278	41
Bergamo*	145	2,850	79	248	97	5.61	56	2,667	260
Standard deviation	13	112	33	33	7	0.22	8	681	73
Lednický*	133	1,860	45	189	79	4.01	39	2,250	248
Standard deviation	45	357	9	23	19	0.30	5	377	46

– not set; *covered by non-woven textile

Lollo Rossa, Bergamo = (*Lactuca sativa* L. var. *crispa*), Lednický = (*Lactuca sativa* L. var. *capitata*)

Table 2. Nutrient levels in fresh matter and weights of leaf rosette and head lettuce (1999)

Cultivar	Vitamin C	Potassium	Sodium	Calcium	Magnesium	Fibre	Dry matter	Nitrates	Weight of leaf rosette/head
	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(g/kg)	(g/kg)	(mg/kg)	(g)
Lollo Rossa	–	3,725	84	250	176	10.94	118	607	234
Standard deviation	–	537	16	88	41	2.47	29	81	38
Bergamo	222	3,554	53	274	114	7.62	89	867	213
Standard deviation	18	239	7	62	19	0.72	9	108	22
Lednický	238	3,416	64	138	126	6.98	85	1,600	247
Standard deviation	18	94	11	29	73	0.60	3	87	136
Lollo Rossa*	–	3,567	81	250	161	7.33	70	1,170	157
Standard deviation	–	403	22	21	30	0.57	4	62	16
Bergamo*	112	3,471	84	325	126	7.59	76	1,240	208
Standard deviation	20	141	19	42	22	1.45	15	72	24
Lednický*	147	3,077	64	182	127	9.65	109	657	183
Standard deviation	40	272	6	36	11	2.04	27	51	25

– not set; *covered by non-woven textile

Lollo Rossa, Bergamo = (*Lactuca sativa* L. var. *crispa*), Lednický = (*Lactuca sativa* L. var. *capitata*)

Table 3. Nutrient levels in fresh matter and weights of leaf rosette and head lettuce (2000)

Cultivar	Vitamin C	Potassium	Sodium	Calcium	Magnesium	Fibre	Dry matter	Nitrates	Weight of leaf rosette/head
	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(g/kg)	(g/kg)	(mg/kg)	(g)
Lollo Rossa	–	4,207	70	215	130	6.16	80	867	199
Standard deviation	–	631	3	31	7	0.90	7	42	30
Bergamo	199	3,965	73	253	338	5.51	76	843	232
Standard deviation	70	372	7	43	60	0.71	2	60	33
Lednický	146	4,633	66	224	95	4.40	70	553	248
Standard deviation	80	1,255	9	57	32	0.52	5	61	44
Lollo Rossa*	–	3,246	50	215	151	5.18	73	747	269
Standard deviation	–	314	4	31	16	0.57	8	67	33
Bergamo*	164	3,403	62	280	193	5.00	71	583	311
Standard deviation	70	116	7	40	18	0.17	4	67	64
Lednický*	91	2,985	56	136	112	4.14	57	500	292
Standard deviation	42	85	18	56	44	0.60	8	111	36

– not set; *covered by non-woven textile

Lollo Rossa, Bergamo = (*Lactuca sativa* L. var. *crispa*), Lednický = (*Lactuca sativa* L. var. *capitata*)

Sodium

Over all of the three years the highest sodium levels (84 mg/kg) were observed in 1999, in both the Lollo Rossa cultivar (uncovered) and Bergamo (covered) (Table 2).

The amount of sodium in leaf and head lettuces varied significantly between the years (Table 5), but not between cultivars (Table 4), and the use of the non-woven textile covering (Table 6). The observed sodium levels were usually lower than the 90 mg/kg given by Rubatzky and Yamaguchi (1997) for leaf lettuce and cited by Ryder (1999).

Calcium

The highest values of calcium were seen in the Lollo Rossa cultivar (363 mg/kg) in 1998 (Table 1).

Calcium levels were significantly higher in the leaf lettuce cultivars Bergamo and Lollo Rossa than in the Lednický cultivar of head lettuce (Table 4). Significant differences were observed between years in the calcium levels (Table 5), but not in the effect of a covering (Table 6). Calcium levels were usually lower than the value of 680 mg/kg given by Rubatzky and Yamaguchi (1997) and cited by Ryder (1999).

Table 4. Effect of cultivar on statistical differences in nutrient levels and weight of leaf rosette and head lettuce

	Bergamo									Lollo Rossa								
	Vitamin C	Potassium	Sodium	Calcium	Magnesium	Fibre	Dry matter	Nitrates	Weight leaf rosette/head	Vitamin C	Potassium	Sodium	Calcium	Magnesium	Fibre	Dry matter	Nitrates	Weight of leaf rosette/head
Lednický				++	++						+		++					+
Lollo Rossa																		

+ significant difference $P = 0.05$; ++ significant difference $P = 0.01$

Table 5. Statistical differences in nutrient levels between the trial years 1998, 1999 and 2000

	1998									1999								
	Vitamin C	Potassium	Sodium	Calcium	Magnesium	Fibre	Dry matter	Nitrates	Weight leaf rosette/head	Vitamin C	Potassium	Sodium	Calcium	Magnesium	Fibre	Dry matter	Nitrates	Weight of leaf rosette/head
2000		+		+	+										+	+	+	+
1999		+	+			+	+	+	+									

+ significant difference $P = 0.05$; ++ significant difference $P = 0.01$

Magnesium

The cultivar Bergamo (uncovered) had the highest observed level of magnesium (338 mg/kg) in the year 2000 (Table 3), and had significantly higher levels of magnesium than the cultivar Lednický (Table 4). Magnesium levels varied from year to year (Table 5), but no differences were seen as a result of using the covering of non-woven textile (Table 6).

Magnesium levels were similar to those presented by K o p e c (1998) in head lettuce.

Fibre

In all three years the highest fibre content was in the Lollo Rossa cultivar (uncovered), in 1999 (10.94 g/kg, Table 2).

Significant differences in fibre content were seen between years (Table 5), but not between cultivars (Table 4) and as a result of the textile covering (Table 6). Values varied widely, but generally were in accordance with values of 7 g/kg as given by R u b a t z k y and Y a m a g u c h i (1997) and cited by R y d e r (1999).

The nutritional composition of vegetables belongs to one of the most important quality characteristics. Z a v a d i l o v á (1996) showed that leaf lettuce has more fibre in comparison to head lettuce, which makes this type

Table 6. Statistical differences in nutrient levels between covered and non-covered plants

	Covered								
	Vitamin C	Potassium	Sodium	Calcium	Magnesium	Fibre	Dry matter	Nitrates	Weight of leaf rosette/head
Non covered	+	+					+		

+ significant difference $P = 0.05$; ++ significant difference $P = 0.01$

of lettuce more valuable from a nutritional point of view. The values we observed for fibre content were also usually higher in leaf lettuce than in head lettuce, even if not significant.

Dry matter

The highest values of dry matter were found in Lollo Rossa (uncovered) in 1999 (118 g/kg, Table 2). Statistically significant differences in dry matter content were found in lettuces grown without a non-woven textile covering (Table 6), and significant differences were seen between years (Table 5) but not cultivars (Table 4).

Table 7. Meteorological characteristics of Lednice in 1998–2000

Month		III.	IV.	V.	Average (III.–V.)
Air temperature (°C)	1998	4.7	12.3	15.7	10.9
	1999	4.7	9.5	14.8	9.7
	2000	5.7	14.1	17.6	12.5
Month		III.	IV.	V.	Sum (III.–V.)
Precipitation (mm)	1998	15.9	39.2	25.8	27.0
	1999	27.1	32.7	37.7	32.5
	2000	64.3	8.9	4.6	25.9
Hours of sunshine (h)	1998	146.0	170.0	248.0	188.0
	1999	135.0	192.0	224.0	183.7
	2000	94.0	227.0	274.0	198.3

The amount of light energy is listed by Reinink (1993) as a significant factor influencing the dry matter content in lettuce. In periods with higher intensity of light there is a tendency to accumulate a greater amount of dry matter. This was the situation with the uncovered plants, which received more light energy in comparison to those which were covered.

According to Reinink (1993), the dry matter content in lettuce is also influenced by the reaction of lettuce plants to environmental change – in this trial, the different conditions prevailing under the non-woven textile and in the open air.

Nitrates

The nitrate levels ranged in the covered plants from 500 to 3,750 mg/kg and in the uncovered plants from 553 to 3,817 mg/kg (Tables 1–3). There were significant differences between years (Table 5). The highest value was observed in the Lollo Rossa cultivar (uncovered) 3,817 mg/kg in 1998 (Table 1). Differences between cultivars were not significant (Table 4).

The higher levels of nitrates in lettuce cultivated under a non-woven textile covering as a result of the lower intensity of light, as reported by Krezel and Kolota (2003), was not confirmed.

Weight of leaf rosette and head lettuces

The heaviest leaf rosette recorded was for the cultivar Bergamo (covered) in 2000 (311 g), and the cultivar Lednický (*Lactuca sativa* L. var. *capitata*) had the highest head weight in uncovered way of growing in 1998 (342 g) (Table 1).

The weights were statistically higher in the cultivar Lednický than in Lollo Rossa (Table 4). The weights varied significantly between years (Table 5), but not as a result of using a covering (Table 6). However, it must be pointed out that the lettuces grown under a covering were harvested on average 8 days earlier because of better temperature and moisture conditions.

CONCLUSIONS

1. The content of selected nutrients in lettuce and the weights of leaf rosettes and heads in the covered treatments had the following ranges: vitamin C (91 to 164 mg/kg), potassium (1,860 to 3,567 mg/kg), sodium (45 to 84 mg/kg), calcium (136 to 331 mg/kg), magnesium (79 to 193 mg/kg), fibre (4.01 to 9.65 g/kg), dry matter (39.1 to 109 g/kg), nitrates (500 to 3,750 mg/kg), weights of leaf rosettes (157 to 311 g) and heads (183 to 292 g).
2. The content of selected nutrients in lettuce and the weights of leaf rosettes and heads in the uncovered treatments had the following ranges: vitamin C (146 to 242 mg/kg), potassium (2,431 to 4,633 mg/kg), sodium (53 to 84 mg/kg), calcium (138 to 363 mg/kg), magnesium (95 to 338 mg/kg), fibre (4.40 to 10.94 g/kg), dry matter (64 to 118 g/kg), nitrates (607 to 3,817 mg/kg) and weight of leaf rosettes (198 to 288 g) and heads (247 to 342 g).
3. There were found significant differences between the cultivars of leaf and head lettuce regarding potassium, magnesium, calcium and weights of their leaf rosettes or heads.
4. The covering using a non-woven textile significantly decreased the content of vitamin C, potassium and dry matter.
5. There were significant differences between years for all the observed parameters except vitamin C.
6. Covering the lettuce with a non-woven textile enabled the harvest to be 8 days earlier because of better temperature and moisture conditions.

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Vliv nakrývání netkanou textilií na obsah nutričních látek u salátu.

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V tříletých polních pokusech (1998–2000) založených v Lednici (Zahradnická fakulta MZLU v Brně) byly hodnoceny dvě odrůdy listového salátu (Bergamo a Lollo Rossa) a jedna odrůda hlávkového salátu (Lednický). Saláty byly pěstovány v jarním termínu ve dvou variantách – s použitím a bez použití netkané textilie. Po sklizni byly stanoveny tyto parametry: vitamin C, minerální látky (K, Na, Ca, Mg), vláknina, sušina a dusičnany. Také byla stanovena hmotnost listové růžice a hlávky salátu. Použití netkané textilie průkazně snížilo obsah vitamínu C (z 202 na 132 mg/kg), draslíku (z 3,628 na 3,081 mg/kg) a sušiny (z 80,3 na 67,4 g/kg). U varianty zakryté netkanou textilií došlo ke zvýšení obsahu sodíku, hořčíku, vápníku a hmotnosti listové růžice a hlávky, tyto rozdíly však nebyly průkazné. Průkazný vliv odrůdy byl zaznamenán u těchto parametrů: vyšší obsah hořčíku a vápníku v odrůdách listového salátu (listový salát: Mg 154 a Ca 275 mg/kg; hlávkový salát: Mg 107 a Ca 181 mg/kg); průkazně těžší hlávky odrůdy hlávkového salátu Lednický (260 g) v porovnání s hmotností listové růžice odrůdy listového salátu Lollo Rossa (208 g). Průkazné rozdíly byly zaznamenány mezi jednotlivými roky ve všech sledovaných parametrech s výjimkou vitamínu C, přičemž vliv roku lze označit jako faktor, který měl silnější vliv než předešlé dva hodnocené faktory (odrůda a použití netkané textilie).

listový a hlávkový salát; vitamin C; minerální látky; vláknina; sušina; dusičnany

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