

Nitrogenous substances in potato (*Solanum tuberosum* L.) tubers produced under organic and conventional crop management

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Key words: potatoes, proteins, nitrates, organic crop management

Abstract

The contribution presents data on crude protein and protein, free amino acid and nitrate contents in potato tubers produced under different crop management – conventional and organic. Field trials were carried out with five potato cultivars on two sites of different altitude in 2005. Mean content of crude protein was significantly higher in tubers from organic crop management than in tubers from conventional system (10.92 and 9.76 % in dry matter, respectively). Similar result was observed in protein content (5.44 and 5.09 % in dry matter, respectively). Cultivar was the factor having the highest direct effect on crude protein as well as protein contents. Tubers from conventional crop management showed an increased tendency to accumulate nitrates.

Introduction

The crude protein (N x 6.25) represents in tubers approximately 2 % on fresh weight basis and creates approximately 10 % of tubers dry matter. However, content of crude protein may range widely in dependence on genotype and growing conditions (Debre and Brindza 1996). Crude protein comprises a number of nitrogen fractions; the most important for human nutrition are protein fraction, amides and free amino acids (Eppendorfer et al. 1979). Protein fraction (pure protein) constitutes in average about 50 % of nitrogen compounds of potato tubers, with wide ranges between 34 % and 70 % (Shewry 2003) Nitrates rank among basic plant nutrients and their presence in plant organs is thus natural. They are harmful regarding human nutrition and health.

Nitrogen has a direct effect on tubers yield and quality. In average, 50 kg of N is needed for 10 t of tubers production (Jasińska and Kotecki 1999). Nitrogen requirement is filled in conventional potato management by the external nitrogen input in form of nitrogen fertilisers. In organic crop management, the crop requirement is resolved by nitrogen balance within crop rotation and nitrogen recovery from soil organic matter (Kölsch and Stöppler 1990, Vokál et al. 2004).

The aim of this contribution was to evaluate the content of nitrogenous substances in potato tubers from different crop management - organic versus conventional.

Materials and methods

The field trials with different crop management – conventional (CCM) and organic (OCM) one - were carried out on two sites with different altitude – Volyně (460 m; 49°

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Archived at <http://orgprints.org/10073/>

10°N 13° 54'E) and Pacov (620 m; 49° 34'N, 14° 58'E), Czech Republic, in 2005. The trials included five potato cultivars – Rosara (very early), Marabel (early), Karin (early), Satina (semi-early) and Bionta (late). The experiments were carried out in individual small plots (plot area 6.75 m²) which were arranged in a randomized complete block design replicated four times. Mineral fertilisers (at level 100 kg N, 35 kg P and 60 kg K per hectare), manure application (40 t ha⁻¹) and chemical control of Colorado beetle and late blight were applied in CCM, while OCM system included only manure application (40 t.ha⁻¹). The sums of rainfall and mean temperature during the vegetative period (April-September 2005) were: 556 mm and 14.8°C for the site Volyně and 507 mm and 13.8°C for the site Pacov.

Tubers were three months stored (under 4°C) after hand harvest and then following parameters were analysed:

- crude protein content by modified Dumas method using analyzer Flash EA 1112, USA/Italy,
- protein content by BCA Protein Assay Kit, Pierce, USA,
- free amino acids content by RP-HPLC,
- nitrate content by ion-selective electrode.

Contents of the determined components were expressed on tuber dry matter (DM). The obtained data were analysed by software STATISTICA, two-way ANOVA (relative variance components) and Tukey HSD test.

Results and discussion

The results of evaluated parameters – crude protein, protein, free amino acids and nitrate contents - are given in Tables 1 – 4. Expected higher contents of crude protein and protein in dry matter of potato tubers produced under conventional crop management were not observed. Significantly higher content of crude protein was found in 6 variants of potato tubers originated from organic crop management and in only one variant of conventional crop management (Table 1).

Tab. 1: Crude protein content in potato tubers (% DM)

Cultivar	Site Volyně			Site Pacov		
	CCM	OCM	LS	CCM	OCM	LS
Rosara	12.25	12.89	*	12.75	11.61	***
Marabel	9.61	14.05	***	10.70	10.92	n.s.
Karin	10.00	12.08	***	9.38	10.07	*
Satina	8.78	11.79	***	7.52	7.72	n.s.
Bionta	9.37	8.87	n.s.	7.28	9.19	***

* significant for $P < 0.05$; ** significant for $P < 0.01$; *** significant for $P < 0.001$; n.s. not significant (Tukey HSD test)

DM - dry matter; LS - level of significance; CCM - conventional crop management; OCM - organic crop management

Tab. 2: Protein content in potato tubers (% DM)

Cultivar	Site Volyně			Site Pacov		
	CCM	OCM	LS	CCM	OCM	LS
Rosara	4.33	4.42	n.s.	5.04	5.09	n.s.
Marabel	6.14	7.90	***	6.66	4.58	***
Karin	5.38	5.50	n.s.	4.60	5.51	***
Satina	5.35	7.22	***	5.25	4.95	n.s.
Bionta	3.92	4.82	**	4.09	4.46	n.s.

For abbreviations and symbols see Table 1

Tab. 3: Free amino acids content in potato tubers (% DM)

Cultivar	Site Volyně			Site Pacov		
	CCM	OCM	LS	CCM	OCM	LS
Rosara	3.48	3.70	n.s.	3.32	3.08	n.s.
Marabel	2.00	2.67	***	2.23	1.53	***
Karin	2.92	3.95	***	2.91	2.70	n.s.
Satina	2.17	3.09	***	1.65	1.50	n.s.
Bionta	1.81	2.10	n.s.	1.87	2.09	n.s.

For abbreviations and symbols see Table 1

Tab. 4: Nitrate content in potato tubers (mg kg⁻¹ fresh matter)

Cultivar	Site Volyně			Site Pacov		
	CCM	OCM	LS	CCM	OCM	LS
Rosara	327	148	***	200	153	***
Marabel	178	131	***	137	73	***
Karin	147	71	***	104	97	n.s.
Satina	139	120	*	107	108	n.s.
Bionta	243	136	***	169	167	n.s.

For abbreviations and symbols see Table 1

Mean content of crude protein was significantly higher in tubers from organic crop management (10.92 % DM) than in tubers from conventional crop management (9.76 % DM). Similar findings were observed in true protein content and free amino acids content (Tables 2 and 3). Organic crop management produced tubers with significantly higher protein content (mean 5.44 % DM) as compared with tubers from conventional system with mean 5.09 % of true protein in DM. From three tested factors (cultivar, crop management and site), cultivar had the highest direct effect on crude protein as well as protein contents (46 and 37%, respectively). The effect of crop management showed itself particularly in interactions with other tested factors. Nitrate content was affected primarily by cultivar (351 %), but direct effect of different crop management was also important (20.9 %). In seven from ten tested variants (Table 4), tubers produced under conventional system had significantly higher nitrate content than tubers from organic crop management. The highest nitrate content was determined in

the very early cultivar Rosara. The obtained results confirmed lower nitrate accumulation in tubers produced under organic crop management (Kölsch and Stöppler 1990). The Czech statutory limit of 300 mg kg⁻¹ of nitrate on tuber fresh basis was not exceeded and there seems to be an extensive reserve. In spite of evaluation data from the only one experimental year, the results indicate that production of potato tubers in organic crop management has a better chance to obtain tubers with higher protein content and with lower accumulation of nitrates than tubers from conventional crop management. Moreover, conventional potato management is dependent on nitrogen supply from mineral fertilisers. Validity of this trend is necessary to verify in multi-annual experiments.

Conclusions

The mean content of crude protein was significantly higher in tubers produced under organic crop management (10.92 % DM) than in tubers cultivated under conventional crop management (9.76 % DM). Similar findings were observed for protein and free amino acids contents. Tubers from organic system showed mean content of protein 5.44 % in dry matter, while tubers from conventional crop management contained 5.09 % in dry matter. Tubers from conventional system had also higher nitrate content than tubers from organic crop management. The results indicate that production of potato tubers in organic crop management has better chance for production of tubers with higher protein content and with lower accumulation of nitrates.

Acknowledgments

This work was supported by research project of the Ministry of Education, Youth and Sports of the Czech Republic MSM 6007665806.

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