EFFECT OF LOCATION, VARIETY, COLOUR OF FLESH AND WAY OF CULTIVATION ON THE CONTENT OF ASCORBIC ACID IN POTATO TUBERS*

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The results of three field trials in the Czech Republic from 2004 to 2009, which reflected the trend (nonsignificant difference) to higher content of ascorbic acid (AA) on the location Přerov nad Labem with the lowest altitude and the warmest climate (the average content of 185.69 mg/kg FM) against higher locations with higher altitudes (decrease of AA content of 4.1 to 8.3%), are reported. Content of AA in tubers was demonstrably affected by the genotype of the variety; the difference in content AA between the varieties Marabel (247.59 mg/kg FM) with the highest level and Saturna (142.20 mg/kg FM) with the lowest content was 42.6%. Varieties with purple and red pulp (169.8 to 232.8 mg/kg FM) reached in 2009 comparatively the order of the same content AA as the yellow-fleshed variety Agria (233.0 mg/kg FM). In the ecological cultivation of potatoes it was found out a tendency toward lower content AA when compared with conventional way of cultivation.

ascorbic acid; potatoes; location; variety; flesh colour; ecological way of cultivation

INTRODUCTION

Ascorbic acid (vitamin C) is the most important vitamin in potatoes. It has important physiological effectivity, e.g., as an antiscorbutic factor and one of the important natural antioxidants (Hamouz et al., 2007). Usual interval of ascorbic acid content in tubers presents Brown (2005) from 10 to 25 mg/kg of netto weight. According to literary data ascorbic acid content can be influenced by environmental conditions and by growing technology. Weber and Putz (1999) proved significant influence of genotype on ascorbic acid content. Zgórska and Frydecka-Mazurczyk (2000) found significant influence of a year. Pawelzik et al. (1999) monitored influence of site on ascorbic acid content, but their results were not definite. Nowacki et al. (2000) found in twelve years' experiments (on average of one hundred cultivars) higher content of ascorbic acid in potatoes tubers during dry years in comparison with the years with higher precipitations. The aim of this work was to verify influence of the above-mentioned factors on ascorbic acid content, i.e. in potato cultivars with coloured flesh, which are newly introduced in some countries including the CR.

MATERIAL AND METHODS

In precise field experiments during 2004–2008 there were grown in four repetitions the cultivars Impala, Karin, Ditta, Saturna and on the location Lípa and also the cultivars Agria, Asterix, Magda Marabel and Valfi on the four locations in the CR with different altitudes (Přerov nad Labem 178 m, Praha-Suchdol 286 m, Lípa 505 m, Stachy 860 m). In Přerov nad Labem in 2009 this experiment was followed up with another experiment, whose purpose has been to verify larger collection of cultivars with coloured flesh. In this experiment four cultivars of purple colour of flesh (Blaue Elise, Blaue St Galler, Blue Congo, Valfi), four cultivars of red flesh (Herbie 26, Highland Burgundy Red, Rosalinde, Rote Emma) and one control variant – yellow flesh cultivar Agria were included in the trial. After harvest in physiological maturity of stands the tuber samples of all variants were analyzed in the laboratory of the Department of Chemistry at CULS in Prague. An effect of ecological way of cultivation (without the use of mineral fertilizers and chemical protection) compared with the conventional method of cultivation was investigated in 2009 in another exact field trial in Prague-Uhříněves, with three yellow-flesh varieties (Katka, Monika, Finka) and one purple-fleshed variety (Salad Blue). Ascorbic acid content was determined by HPLC. The results were statistically evaluated by variance analysis with more detailed evaluation by the Tukey test with software SAS (version 8.02) at significance level of $P = 0.05$.

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RESULTS AND DISCUSSION

Influence of site

Of all four experimental sites, we found out in average of five years the highest ascorbic acid content at the site in Přerov nad Labem, while this result was definite and confirmative in the first two years (2004, 2005) of our experiments, and again in 2008 (Table 1).

In 2006 the differences in ascorbic acid content among locations were not confirmative and in 2007 in contrast with other years it was proved that the highest content of ascorbic acid was at the coldest and the most humid location Stachy. This influenced five years' average of the results and ascorbic acid increase in Přerov nad Labem in comparison with other locations exceeded confirmative difference HSD only in comparison with the location Suchdol. Even though there is a distinct trend to the highest ascorbic acid content in Přerov nad Labem, which is probably a result of the warmest climatic conditions in this lowland location of all sites. Our results are in accordance with the knowledge of Jabłońska-Ceglarek and Wadas (2005), in whose experiments the high temperatures during vegetation period stimulated vitamin C accumulation in tubers of early potato cultivars. Together with climatic conditions it could also be influence of loamy sands in Přerov nad Labem (confirmative difference in five years' average was found at the locality Suchdol with similar climatic conditions, but on loamy soil); the same conclusion was also reported by Mondy et al. (1979).

Influence of cultivar and flesh colour

Ascorbic acid content in average of five experimental years ranged between 248–142 mg/kg FM and was confirmatively influenced by a cultivar (Table 2). The highest ascorbic acid content was obtained in the cultivar Marabel, which confirmatively exceeded all other cultivars by 13.4–74.1%. Above average values reached also the cultivars Karin, Ditta, Asterix, average content had the cultivar Agria. In the cultivar Valfi with purple flesh we found ascorbic acid content slightly under the average of all cultivars.

In group of eight cultivars with purple or red flesh grown in 2009 on the location Přerov nad Labem we found in average of all cultivars ascorbic acid content of 191.78 mg/kg FM (Table 3), which is by 17.7% less in comparison with the control yellow flesh cultivar Agria (233.00 mg/kg FM) in the same year on the same location. On the other hand these cultivars have higher content of total polyphenols and higher antioxidative activity of tubers in comparison with yellow flesh cultivars, which was proved by Lachman et al. (2008). In the cultivars with coloured flesh the highest ascorbic acid content was found in the cultivar Highland Burgundy Red with red flesh (232.75 mg/kg FM), but the differences in ascorbic acid content in this cultivar were not confirmative in comparison with the cultivars Rosalinde (217.75 mg/kg FM – red flesh), Blaue Elise (202.00 mg/kg FM – purple flesh) and Valfi (189.75 mg/kg FM – purple flesh). Other cultivars with coloured flesh had confirmatively higher content of ascorbic acid

Table 1. Effect of location on ascorbic acid content (mg/kg FW); average of Impala, Karin, Ditta and Saturna varieties

Location	$\bar{x}$ [1]	$HSD_{(P \geq 0.05)}$	Signif.[2]
Přerov nad Labem	185.69		a
Suchdol	170.32		b
Lípa	178.15	11.475	ab
Stachy	177.02		ab

[1] average of four varieties in four repetitions; [2] differences between average values marked with the same letters are statistically nonsignificant

Table 2. Effect of variety on ascorbic acid content (mg/kg FW); Lípa; average of years 2004–2008

Variety	mg/kg FW [1]	$HSD_{(P \geq 0.05)}$	Signif.[2]
Agria	183.91		c
Asterix	187.28		c
Impala	161.58		cd
Karin	218.29		b
Ditta	190.54	29.047	bc
Magda	163.99		cd
Marabel	247.59		a
Saturna	142.20		d
Valfi	180.88		c

[1] average of four repetitions; [2] differences between average values marked with the same letters are statistically nonsignificant

Table 3. Effect of purple- and red-fleshed varieties on ascorbic acid content (mg/kg FW); Přerov nad Labem; 2009

Variety/flesh colour	mg/kg FW [1]	$HSD_{(P \geq 0.05)}$	Signif.[2]
Agria/yellow	233.00		a
Blaue Elise/purple	202.00		abc
Blaue St Galler/purple	176.25		bc
Blue Congo/purple	167.75		c
Valfi/purple	189.75	42.576	bc
Herbie 26/red	178.25		bc
Highland Burgundy Red/red	232.75		a
Rosalinde/red	217.75		ab
Rote Emma/red	169.75		c

[1] average of four repetitions; [2] differences between average values marked with the same letters are statistically nonsignificant

Table 4. Effect of flesh colour on ascorbic acid content (mg/kg FW); Přerov nad Labem; 2009

Flesh colour	mg/kg FW[1]	$HSD_{(P \geq 0.05}$	Signif.[2]
Purple	174.08	17.459	b
Red	199.63		a

[1] average of all varieties with mentioned colour of flesh (four repetitions); [2] differences between average values marked with the same letters are statistically nonsignificant

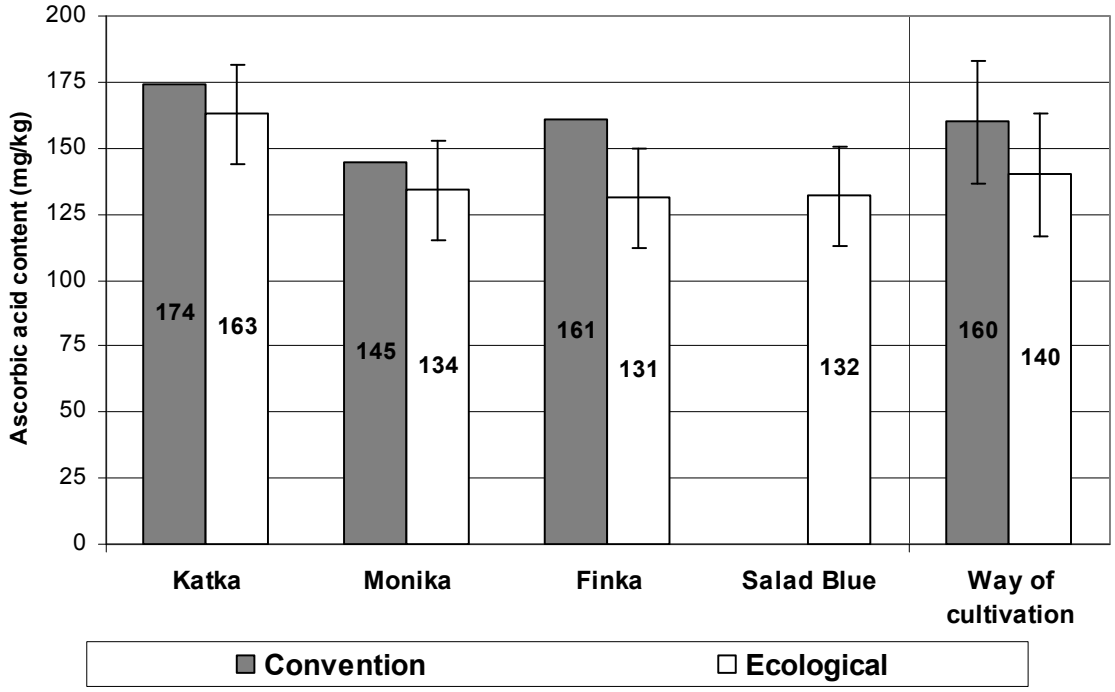

Fig. 1. Influence of ecological and conventional way of cultivation on the ascorbic acid content in the yellow-fleshed and purple-fleshed (mg/kg FW); Uhříněves; 2009; vertical lines represent $HSD_{(P \geq 0.05)}$; HSD(varieties) = 37.59, HSD(way of cultivation) = 44.79

(by 18.5–27.9%) in comparison with the cultivar Highland Burgundy Red. If we compare influence of purple or red colour of flesh on ascorbic acid content (Table 4), we find the trend of higher ascorbic acid content in the cultivars with red flesh (199.63 mg/kg of net weight) in comparison with the cultivars with purple flesh (174.08 mg/kg FM), but the difference among averages did not exceed the level of statistical significance. Ascorbic acid content in potatoes from our experiments is in accordance with the results of other authors (Brown, 2005; Zgórska, Frydecka-Mazurczyk, 2000). Our results also confirm confirmative influence of cultivars on ascorbic acid content, which was published by Weber, Putz (1999), Zgórska, Frydecka-Mazurczyk (2000) and Pawelzik et al. (1999).

Influence of ecological way of cultivation

When comparing conventional and ecological way of cultivation no significant differences in the content of AA were found, but a tendency toward higher content of AA in the conventional method of cultivation is distinctive (Fig. 1). Our results are thus consistent with the findings of Diviš, Vodička (1999) and Hajšlová et al. (1998), who also found inconclusive differences in AA content in tubers from conventional and ecological cultivation. However, in the case of the results of Hajšlová et al. (1998), unlike of our results, the tendency to higher AA content in ecological cultivation was reported. In the organically grown potatoes the highest content of AA for the variety Katka (163 mg/kg FM), was found, which is by 17.8–19.7% higher in comparison with other varieties, but this difference was not significant; the same result was obtained in the purple-flesh variety Salad Blue.

CONCLUSION

Ascorbic acid content in tubers with yellow, purple and red flesh is confirmatively influenced by a cultivar genotype with trend (non-confirmative difference) to lower content of ascorbic acid in cultivars with coloured flesh in comparison with yellow flesh cultivars.

In experiment from 2009 we found out higher content of ascorbic acid in cultivars with red flesh in comparison with purple flesh cultivars.

Regarding location conditions, in lowland area with warmer climate there is a significant trend to higher ascorbic acid content in tubers in comparison with colder conditions of highland areas.

In ecological way of cultivation no significant difference in AA content between yellow-fleshed varieties and purple-fleshed Salad Blue was found.

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Vliv stanoviště, odrůdy, barvy dužniny a způsobu pěstování na obsah kyseliny askorbové v hlízách brambor.

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Jsou prezentovány výsledky tří polních pokusů v České republice z let 2004 až 2009, v nichž se projevil trend (neprůkazný rozdíl) k vyšším obsahům kyseliny askorbové (KA) na lokalitě Přerov nad Labem s nejnižší nadmořskou výškou a s nejteplejším klimatem (průměrný obsah 185,69 mg/kg č. h.) proti vyšším polohám (pokles obsahu KA o 4,1 až 8,3 %). Obsah KA v hlízách byl prokazatelně ovlivněn genotypem odrůdy; rozdíl v obsahu KA mezi odrůdami Marabel (247,59 mg/kg č. h.) s nejvyšším obsahem a Saturna (142,20 mg/kg č. h.) s nejnižším obsahem činil 42,6 %. Odrůdy s fialovou a červenou dužninou (169,8 až 232,8 mg/kg č. h.) dosahovaly v roce 2009 řádově stejných obsahů KA jako žlutomasá odrůda Agria (233,0 mg/kg č. h.). U brambor z ekologického pěstování byl zjištěn trend k nižšímu obsahu KA proti konvenčnímu způsobu.

kyselina askorbová; brambory; lokalita; odrůda; barva dužniny; ekologické pěstování

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