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ANNA GOLCZ, ELŻBIETA KOZIK

EFFECT OF SEVERAL AGROTECHNICAL FACTORS ON VITAMIN C CONTENT IN PEPPER (*CAPSICUM ANNUUM* L.) AND LETTUCE (*LACTUCA SATIVA* L.)

From Department of Horticultural Plants Nutrition
August Cieszkowski Agricultural University in Poznań

ABSTRACT. Vitamin C was determined in sweet pepper and hot pepper and in lettuce. It was shown that the diversified vitamin C content in vegetables depends on the species, place of growing, nitrogen and potassium fertilization (dose and fertilizer form), phase of harvest, atmospheric conditions preceding the harvest.

Key words: vitamin C, sweet and hot pepper, lettuce, agricultural factors

Introduction

Vitamin C is a necessary exogenous food component for man (**Wartanowicz** and **Ziemlański** 1992). It performs in the organism many functions such as participation in the biosynthesis of collagen and in the absorption of non ferroheme and in the increasing of organism resistance. Next to β-carotene and vitamin E, it is an antioxidant, which is believed to prevent and inhibit early developmental stages of neoplasms (**Moszczyński** and **Pyć** 1998). It has been observed that chronic shortage of vitamin C favours the development of sclerosis.

The actually recommended daily demand for vitamin C by adult person is 30-85 mg (**Ziemlański** and **Wartanowicz** 1995). The demand for vitamin C increases even by 50% in smokers, in person with arterial hypertension, in alcoholics, diabetics and in stress conditions, as well as in persons abiding in polluted environment (**Markowski** 1995). Insufficient saturation with vitamin C can occur particularly in winter and spring.

In Poland due to significant consumption, potatoes and cabbages are important sources of vitamin C. Besides, yellow, green and red vegetables contain particularly great amounts of this vitamin (**Borawska** et **al.** 1994).

The content of vitamin C in vegetable products oscillates in a rather wide range depending on a number of factors, among others on the species, cultivar, place and method

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of growing, climatic conditions of the given region, agrotechnical treatments, maturity degree of the fruits, method of storage, transportation and processing technology (**Kmiecik** and **Lisiewska** 1994, **Moszczyński** and **Pyć** 1998).

In the light of our many years' studies, we have analysed the content of vitamin C in pepper and lettuce in relation to several agrotechnical factors (species, cultivar, type of substrate, kind and dose of fertilizer, atmospheric conditions during growing, phase of harvest) which modify this quality parameter.

Material and methods

The plant material consisted of fruits of sweet pepper and hot pepper (*Capsicum annuum* L.) and lettuce (*Lactuca sativa* L.) from many years' experiments carried our in greenhouse and in foil tunnel on the area of Marcelin farm of Agricultural University in Poznań.

Subject of investigation was the effect on vitamin C content in sweet pepper, 'Bell Boy' cv. exerted by four types of nitrogen fertilizers: NH_4NO_3, $(NH_4)_2SO_4$, $Ca(NO_3)_2$, $CO(NH_2)_2$ and by the harvest phase and definite atmospheric conditions preceding the harvest.

Successive determinations of vitamin C content were carried out by analysing there cultivars of sweet pepper ('Delphin', 'Redgold', 'Luteus') in the aspect of potassium fertilization in the form of K_2SO_4 applied at two levels (300 and 500 mg K · dm^{-3} substrate) and using different term of fruit harvest.

The content of vitamin C was also compared in three Polish cultivars: 'Cyklon', 'Orkan', 'Wulkan', two American cultivars: 'Chillina' and 'Devilla', and two Korean cultivars: 'Capital' and 'Perfecto', of hot pepper grown in the same conditions.

Vitamin C content in lettuce, 'Marta' cv. was determined after its growing in different types of substrates consisting of: mineral soil, raised peat and mixtures (v:v = 1:1): mineral soil with raised peat, mineral soil with stored pine bark, mineral soil with raw pine bark, raised peat with raw pine bark and mineral soil with sawdust. The applied fertilization differed by three levels of nitrogen (120, 180, 240 mg N · dm^{-3} substrate) with the consideration of the initial content of this component.

In the successive studies, vitamin C content was analysed in five lettuce cultivars ('Agora', 'Bona', 'Ewelina', 'Marta', 'Action'). Here, the nitrogen fertilization differed by two levels (60 and 180 mg N · dm^{-3} substrate) using ammonium sulphate.

The vitamin C content in the studied species of vegetables was determined by Tillmans' method (**Charłampowicz** et **al.** 1966).

Results and discussion

It was shown that the content of vitamin C in the edible parts of vegetables depends primarily on the species (Table 1) and cultivar (Tables 4, 5, 6).

The content of vitamin C in the fruits of sweet pepper was influenced by the type of the applied nitrogen fertilizer, harvest term (developmental phase) and fruit colour

(Table 2). When $(NH_4)_2SO_4$ was used as the source of nitrogen, the smallest amounts of vitamin C were determined in green fruits (VII) and the greatest amounts in red fruits (VIII) harvested in the phase of full fructification. In red fruits, independent of the harvest term, the least amount of vitamin C content was found in fruits fertilized with NH_4NO_3. Independent of the applied type of nitrogen fertilizer, the fruits harvested in the phase of full fruiting contained by 30% more vitamin C in comparison to the fruits harvested in the phase of physiological maturity.

Table 1

Average content of vitamin C (mg %) in selected vegetable species
Średnie zawartości witaminy C (mg %) w wybranych gatunkach warzyw

Species Gatunek	Own study Badania własne	Other authors' studies Badania innych autorów
Sweet pepper – Papryka słodka		
green – zielona	156 – 192	107 **Piekarska** et **al.** 1989 91 **Kunachowicz** et **al.** 1999
red – czerwona	244 – 316	144 **Kunachowicz** et **al.** 1999
yellow – żółta	240	
Hot pepper – Papryka ostra	358 – 457	215 **Orłowski** et **al.** 2003 270 **Buczkowska** and **Najda** 2002
Lettuce – Sałata	15 – 58	13 **Kunachowicz** et **al.** 1999 4.5 **Piekarska** and **Łoś-Kuczera** 1983

Table 2

The effect of nitrogen form of the content of vitamin C in green and red fruits of sweet pepper
Wpływ formy azotu na zawartość witaminy C w zielonych i czerwonych owocach papryki słodkiej

Type of fertilizer Rodzaj nawozu	Vitamin C – Witamina C mg %		
	I harvest – I zbiór	II harvest – II zbiór	III harvest – III zbiór
$(NH_4)_2\ SO_4$	82	210	131
$Ca(NO_3)_2$	–	194	153
NH_4NO_3	106	180	121
$CO(NH_2)_2$	117	188	130
Mean – Średnia	102	193	134

I harvest – green fruits (VII).
II harvest – red fruits – full of fructification (VIII).
III harvest – dark red fruits – physiological maturity phase (IX).
I zbiór – owoce zielone (VII).
II zbiór – owoce czerwone – faza pełni owocowania (VIII).
III zbiór – owoce ciemnoczerwone – faza dojrzałości fizjologicznej owoców (IX).

In green fruits, the contents of vitamin C were smaller (mean 102 mg %) than in the red coloured fruits (mean 164 mg %) independent of the nitrogen fertilizer form used for pepper growing.

As illustrated by the data contained in Table 3 in all cultivars sweet pepper, the green fruits contained less vitamin C than the red or yellow fruits. The fruits of sweet pepper with an increased potassium level in the substrate (500 mg K · dm^{-3}) accumulated more vitamin C independent of the harvest phase.

An exception were the green fruits of 'Redgold' cultivar (Table 3).

Table 3

Effect of potassium fertilization level, cultivar and fruit maturity phase on the content of vitamin C in sweet pepper fruits
Wpływ poziomów nawożenia potasem, odmiany i fazy dojrzałości owoców na zawartość witaminy C w owocach papryki słodkiej

Cultivar Odmiana	Vitamin C – Witamina C (mg %)			
	green fruits owoce zielone		red (1) and yellow (2) fruits owoce czerwone (1) i żółte (2)	
	potassium fertilization level (mg K · dm^{-3} substrate) poziom nawożenia potasem (mg K · dm^{-3} podłoża)			
	300	500	300	500
Delphin(1)	156.7	178.5	244.0	258.0
Redgold(1)	192.4	188.4	309.0	316.0
Luteus(2)	169.1	188.7	243.9	235.0
Mean – Średnia	172.7	185.1	265.6	269.6

The cultivars of hot pepper (Table 4) in comparison to the cultivars of sweet pepper (Table 2 and 3) in the phase of physiological maturity contained definitely more vitamin C. This dependence found a confirmation in the studies by **Buczkowska** and **Najda** (2002).

A significant influence of the cultivar on the content of vitamin C was shown in hot peppers (Table 4). Particularly the American cultivars contained more vitamin C (mean 440 mg %) than the Korean ones (mean 382 mg %) and the Polish cultivars (mean 371 mg %). **Buczkowska** and **Najda** (2002) also showed the effect of the cultivar on the amount of vitamin C in the fruits of Polish hot pepper cultivars. Definitely the greatest amount of vitamin C, similarly as in our studies, was found by the mentioned authoresses in 'Orkan' cultivar. In turn, **Orłowski** et **al.** (2003) did not confirm the effect of cultivar on the content of vitamin C. In field experiments, the authors identified decidedly lower contents of this vitamin. The mean value from three analysed cultivars of hot pepper ('Cyklon', 'Tajfun', 'Beros') was 237.6 mg %. On the other hand, the conclusion referring to the dependence of vitamin C content on the phase of fruit harvesting is convergent with our results. Similarly as in our work, both in sweet pepper and in hot pepper, a significantly smaller content of vitamin C was found in green fruits in comparison with physiologically mature fruits (Table 3).

Table 4

Average content of vitamin C in some hot pepper cultivars grown in greenhouse
Średnie zawartości witaminy C u kilku odmian papryki ostrej uprawianej w szklarni

Cultivar Odmiana	Seed origin Pochodzenie materiału siewnego	Vitamin C Witamina C mg %
Cyklon	Poland	360
Orkan		395
Wulkan		358
Mean – Średnia		371
Chillina	USA	457
Devilla		423
Mean – Średnia		440
Capital	Korea	375
Perfecto		388
Mean – Średnia		382
Total mean – Średnia ogółem		389.5

Studies illustrated in Table 5 indicate that temperature and the number of insolation hours during 8 days preceding the pepper fruit harvest had a positive effect on the level of vitamin C. The best quality fruits were obtained in the II term of harvest when the temperature and insolation were the highest. The same positive effect of insolation during several days preceding harvest on the content of vitamin C in tomato fruits ripening on the plants was described by **Pudelski** (1998).

Table 5

Effect of temperature and insolation on the content of vitamin C in the green and red fruits of sweet pepper
Wpływ temperatury i usłonecznienia na zawartość witaminy C w zielonych i czerwonych owocach papryki słodkiej

Term of fruit harvest Termin zbioru owoców	Fruit colour Barwa owocu	Mean air temperature Średnia temperatura powietrza	Number of insolation hours Liczba godzin usłonecznienia	Vitamin C Witamina C mg %
		during 8 days before harvest przez 8 dni poprzedzających zbiór		
I – July I – Lipiec	green – zielony	16.1	47.8	82-117
II – August II – Sierpień	red – czerwony	18.8	63.2	180-210
III – September III – Wrzesień	dark red ciemnoczerwony	13.6	56.9	121-153

The content of vitamin C in lettuce, 'Marta' cv. was diversified depending on the type of the applied substrate and on the level of nitrogen fertilization (Table 6). The smallest mean content of this component was found in plants grown in raised peat with stored pine bark (v:v = 1:1), and the highest content of this component characterized the plants which were grown in mineral soil with stored pine bark. Similarly, **Kowalska** (1995) showed differences in the content of ascorbic acid in the fruits of tomato and in lettuce leaves grown in garden soil and in peat substrate.

Table 6

Content of vitamin C in lettuce grown in different substrates with increasing nitrogen fertilization
Zawartość witaminy C w sałacie uprawianej w różnych podłożach przy wzrastającym nawożeniu azotem

Substrate Podłoże	Level of nitrogen fertilization mg N · dm^{-3} substrate Poziom nawożenia azotem mg N · dm^{-3} podłoża			
	120	**180**	**240**	Mean – Średnia
Mineral soil Gleba mineralna	29.1	31.0	28.9	29.7
Raised peat Torf wysoki	23.8	30.8	31.8	28.8
Soil + peat Gleba + torf	30.4	26.7	19.2	25.4
Soil+ bark (1) Gleba + kora (1)	31.0	31.1	32.6	31.6
Peat + bark (1) Torf + kora (1)	16.0	17.5	19.4	17.6
Soil + bark (2) Gleba + kora (2)	21.8	18.0	24.3	21.4
Peat + bark (2) Torf + kora (2)	33.3	23.6	29.1	28.7
Soil + sawdust Gleba + trociny	28.5	28.4	25.1	27.3
Mean – Średnia	26.7	25.9	26.3	

(1) Pine bark, stored.
(2) Pine bark, fresh, ground.
(1) Kora sosnowa składowana.
(2) Kora sosnowa surowa, mielona.

No explicit effect of the amount of nitrogen in thy substrate on the mean content of vitamin C in the lettuce was found. The decrease of vitamin C content together with an increased amount of nitrogen in the substrate from 120 to 240 mg N · dm^{-3} was found in lettuce grown in mineral soil, in a mixture of mineral soil with peat or sawdust and in peat with fresh ground pine bark. In lettuce growing in the remaining substrates (i.e. in raised peat, mineral soil with raw pine bark, ground or stored pine bark and raised peat

with stored pine bark) at the level of 240 mg N · dm^{-3} substrate, the content of vitamin C was the highest.

The content of vitamin C in lettuce depended on the cultivar and on nitrogen level in the substrate (Table 7). Greater differences in vitamin C content in the studied cultivars were shown at the level of 60 mg N · dm^{-3} substrate than at the level of 180 mg N · dm^{-3}. The highest content of vitamin C, independent of the nitrogen level in the substrate was found in 'Agora' cv. Also **Sady** et **al.** (1995), **Rożek** et **al.** (1995) showed differences in the content of ascorbic acid in the studied lettuce cultivars. The increase of nitrogen content in the substrate caused a decrease of vitamin C in all cultivars, whereby that dependence was the greatest in Marta cultivar, and the smallest in 'Bona' cultivar.

Table 7

Effect of nitrogen fertilization level in the substrate and effect of cultivar on vitamin C content in lettuce

Wpływ poziomu nawożenia azotem w podłożu i odmiany na zawartość witaminy C w sałacie

Cultivar Odmiana	Vitamin C – Witamina C mg %		
	Level of nitrogen fertilization mg N · dm^{-3} substrate Poziom nawożenia azotem mg N · dm^{-3} podłoża		
	60	**180**	Mean – Średnia
Agora	58.5	29.1	43.8
Bona	38.5	27.7	33.1
Ewelina	49.2	28.8	39.0
Marta	50.5	15.3	32.9
Action	39.1	24.8	32.1
Mean – Średnia	47.2	25.1	

Conclusions

1. It was found that the content of vitamin C in pepper and lettuce depended on the studied agrotechnical factors.

2. The factors contributing in the highest degree to vitamin C content include the following ones (arranged in a progressive order): for pepper: sub – species, cultivar, type of nitrogen fertilizer, potassium level, atmospheric conditions during cultivation; for lettuce: cultivar, nitrogen dose, type of substrate used for growing.

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WPŁYW KILKU CZYNNIKÓW AGROTECHNICZNYCH NA ZAWARTOŚĆ WITAMINY C W PAPRYCE (*CAPSICUM ANNUUM* L.) I SAŁACIE (*LACTUCA SATIVA* L.)

S t r e s z c z e n i e

Przedstawiono zależność między zawartością witaminy C, oznaczoną metodą Tillmansa, w papryce słodkiej i ostrej oraz sałacie masłowej, a różnymi czynnikami agrotechnicznymi: gatunkiem, odmianą, rodzajem podłoża, rodzajem i dawką nawozu zastosowanego do uprawy, warunkami atmosferycznymi podczas uprawy, fazą zbioru roślin – modyfikującymi ten parametr jakości.

Wykazano duże różnice w zawartości badanej witaminy w zależności od gatunku i odmiany. Zawartość witaminy C wynosiła: w papryce słodkiej 156-316 mg %, w papryce ostrej 358-457 mg %, a w sałacie 15-58 mg %. Ponadto na zawartość witaminy C wpływały: u papryki – rodzaj nawozu azotowego, poziom potasu, warunki atmosferyczne – podczas uprawy, a u sałaty – dawki azotu i rodzaj podłoża zastosowanego do uprawy.