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Effect of growing conditions at greenhouse on vitamin E content in sweet pepper (*Capsicum annuum* L.) fruits

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Abstract

The studies on effect of growing conditions on vitamin E content in fruits of two cultivars of sweet pepper (Bendigo F_1 and Lamuyo F_1) were carried out. The influence of growing substrate type (sphagnum peat or rockwool, Flormin, Poland), season of fruits harvesting (Summer or Autumn) and dosages of mineral liquid nutrition were investigated. It was found that fruits of sweet pepper grown in rockwool contained more vitamin E than those from sphagnum peat substrate (ring culture), during Summer harvesting. In Autumn differences appeared too, but most of them were not statistically proved. The sweet pepper fruits harvested at Summer contained more vitamin E than fruits from Autumn. There were not significant differences among vitamin E level in fruits of the plants cultivated in rockwool at different dosages of fertilizers.

INTRODUCTION AND LITERATURE REVIEW

Fat soluble vitamins and vitamin C are very important components of food. Vegetable tissues are particularly rich in vitamin C and provitamin A (β-carotene), as well as in vitamin E. Among vegetable crops leaves and roots of parsley, watercress and physiologically matured sweet pepper fruits contain a large quantity of the vitamin E (H o r b o w i c z, 1989 a).

The vitamin E activity has four chemical compounds – so called tocopherols and four another called tocotrienols. Tocopherols and tocotrienols have in their names a Greek letter prefixes: α, β, γ and δ. The molecules of tocopherols have various number of methyl groups. Tocotrienols have additionally three double C-C bonds in 16-carbon side chain. The most important among all compounds having vitamin E activity is α-tocopherol, because it has three times higher activity than β-tocopherol,

five times than γ-, and hundred times than δ-tocopherol (Ziemlańska, 1985). There is accumulated mainly α-tocopherol, small quantities of β- and γ-tocopherols, and no δ-tocopherol or tocotrienols in human body.

From the nutritional point of view the sweet pepper is very valuable vegetable. The fruits of it contain large amounts of vitamin C, and rather high levels of provitamin A and vitamin E. The vitamins are joined together by synergism of their action in human organism. The vitamin E has strong antioxidative activity. First of all it protects the vitamin A in intenstines and counteracts an oxidation polyunsaturated fatty acids (Wysokińska, 1969; Ziemlańska, 1985). Because of strong antioxidative activity the vitamin E reduces level of peroxides produced by oxidation of unsaturated lipids, and free radicals having high carcinogenic activity. Vitamin E is also an inhibitor of nitrosamine biosynthesis (Lathia and Blum, 1989). The vitamin E is quickly oxidised to nonactive chinons, but the presence of high amounts of ascorbic acid can convert those chinons back to active reduced form (Kunert and Ederer, 1985). The process of convertion needs high proportion of ascorbic acid to vitamin E – at least 15 : 1. Such proportion occurs in sweet pepper tissue (Kanner et al., 1979)

The vitamin E content of plants depends on growing factors, such as: the weather conditons or place of cultivation (Kivimae and Carpena, 1973), and light intensity (Janiszowska et al., 1978; Lichtenthaler, 1979). Leaves exposed to sunshine contain much more α-tocopherol than shaded ones. Short waves light is the best for tocopherols biosynthesis (Lichtenthaler and Grumbach, 1974). The great influence of temperature on rate of tocopherols biosynthesis was observed too (Janiszowska and Rygier, 1982). Authors showed that increase of growing temperature from 20 to 29°C increased the tocopherols level at leaves of *Calendula officinalis* ten times.

There are several references to vitamin C and provitamin A content in sweet pepper fruits (Michna, 1966; Buczak et al., 1967-68; Michalik et al., 1975; Korzeń and Perucka, 1978; Biacs et al., 1992). Data on vitamin E level at sweet pepper are usually presented in table charts together with other vegetables or foods (Wysokińska, 1975; McLaughlin and Weichrauch, 1977; Ziemlański, 1985; Piironen et al., 1986). There are no references to the effects of method of greenhouse cultivation, growing methods and harvest season or rate of used mineral nutrition.

The aims of the studies were to establish the effect of growing substrate: sphagnum peat and rockwool, level of used mineral nutrition, and influence of harvesting season (Summer and Autumn) on vitamin E (α-tocopherol) content in sweet pepper fruits.

MATERIALS AND METHODS

Sweet pepper plants cv. Lamuyo F_1 and Bendigo F_1 were cultivated at greenhouse conditions in 1989, and Bendigo F_1 in 1991. Seeding was performed on

January 9th, 1989 and January 28th, 1991. Transplanting of pepper seedlings were done on March 10th and March 21st respectively, and begining of fruiting time was on May 4th and June 4th. Last fruits were harvested on November 15th, 1989 and November 25th, 1991.

Plants were cultivated by using two substrates: rockwool (Flormin, Poland) and sphagnum peat substrate (sphagnum peat and pine bark, 1:1, ring culture). During peat substrate cultivation nutrition was applied according to chemical analyses of nutrients available by plants. A mineral fertilizers solution together with drop irrigation was used.

1. In experiments on effect of harvest time on vitamin E content fruits were picked in July and October 1989, and in June and September 1991. The fruits were mature green, and one replicate contained 10 randomly taken fruits. The plants of both cultivars were cultivated in rockwool and in sphagnum peat substrate.
2. Samples of pepper fruits for experiments on effect of growing substrate on vitamin E level were taken to analyses in the same time.
3. In experiment on effect of mineral nutrition on sweet pepper cultivated in rockwool fruits of Bendigo F1 cultivar were taken to analyses. The samples were picked in June, August and September 1991.
   Following dosages of mineral liquid fertilizers were applicated (concentration of each fertilizer in mg l^{-1}):
   a. N – 150; P – 60; K – 220; Ca – 120; Mg – 40
   b. N – 225; P – 105; K – 500; Ca – 200; Mg – 60
   c. N – 300; P – 50; K – 400; Ca – 160; Mg – 50

All the chemical analyses were carried out in three replicates. The means were subjected to statistical analyses using the t-Student test, at probability coefficient $\alpha = 0.05$.

The vitamin E (α-tocopherol) content was analysed by HPLC method (H o r b o w i c z, 1989 b), and dry matter was measured by gravimetric method after drying in dryer equipped in fan.

RESULTS AND DISCUSSION

During two years of studies on two sweet pepper cultivars contents of vitamin E in fruits from rockwool cultivation were found higher than those from sphagnum peat substrate (Fig. 1). It was particularly clear and statistically proved in fruits from Summer harvesting (bars 1 and 2, Fig. 1). In fruits harvested in Autumn the differences appeared too, but were smaller and in most cases not statistically significant (bars 3 and 4, Fig. 1). The phenomena is difficult to explain. Possibly the is that because the fruits from rockwool cultivation reached green stage maturity faster than the fruits from sphagnum peat substrate (S t ę p o w s k a, 1994).

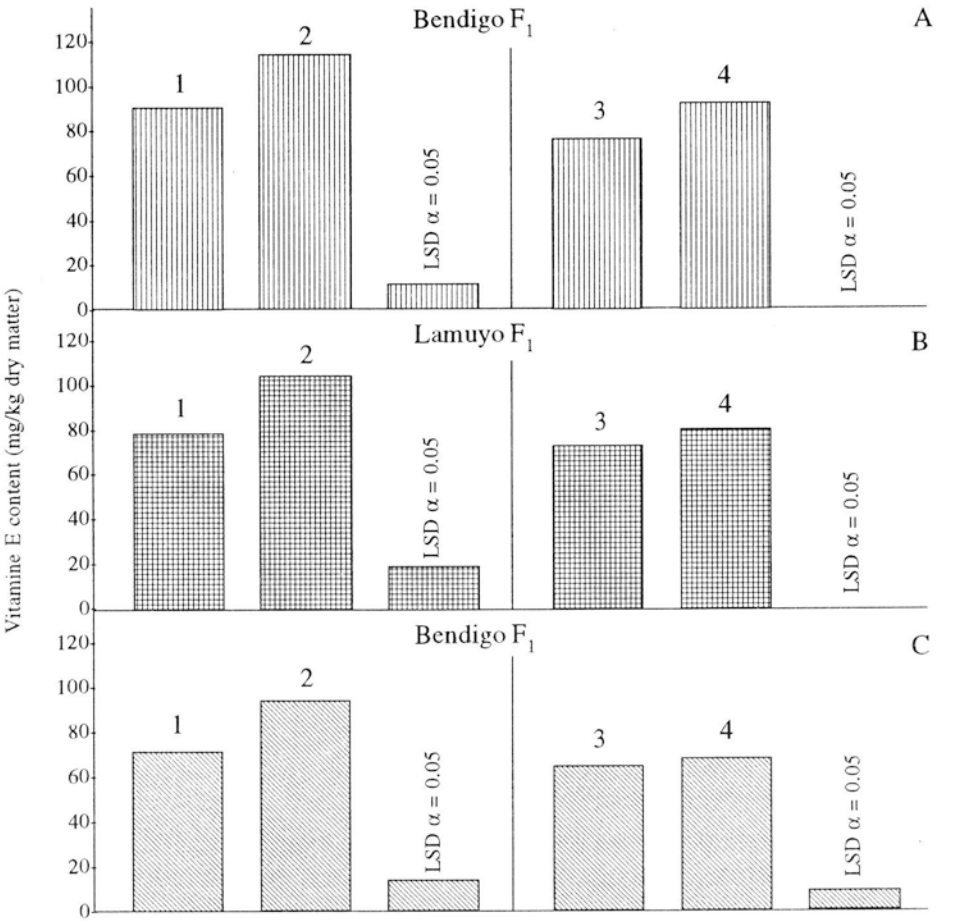

Fig.1. Effect of growing substrate on vitamin E content in fruits of two sweet pepper cultivars

Description of plots: Bars 1 and 3 – fruits from plants cultivated in sphagnum peat substrate; Bars 2 and 4 – fruits from plants cultivated in rockwool; Bars 1 and 2 – fruits harvested in Summer; Bars 3 and 4 – fruits harvested in Autumn; Plots A and B – experiments from 1989; Plot C – experiment from 1991

Sweet pepper fruits harvested in Summer contained more vitamin E than those from Autumn harvest (Fig. 2). The differences between fruits from plants cultivated in rockwool (bars 3 and 4, Fig. 2) are bigger in comparison with sphagnum peat substrate (bars 1 and 2, Fig. 2). The similar phenomena was found in both cultivars during two years studies. The main reason of it is probably caused by different light conditions occured in Summer and Autumn vegetation period. Mean sunshine periods for Skierniewice region are for June and July 250 and 240 hours, and for September and October 166 and 114 hours respectively. According to J a n i s z o w s k a et al. (1978) light intensity plays important role in tocopherols biosynthesis. Authors have studied young seedlings of *Calendula officinalis* and found that leaves from plants grown at light intensity 780 μmol m^{-2} s^{-1} contained much more α-tocopherol

in comparison with plants grown at light intensity 58 μmol m^{-2} s^{-1}. Similar results were obtained by L i c h t e n t h a l e r (1979). The author found in 5-days old *Raphanus sativus* seedlings grown under strong light (20000 lux, or 400 μmol m^{-2} s^{-1}) 2.5 times more of α-tocopherol than in seedlings from weak light growing (1000 lux, or 31 μmol m^{-2} s^{-1}).

Because of sunshine intensity and outside warm conditions the temperature during Summer vegetation at greenhouse is much higher than in Autumn. According to J a n i s z o w s k a and R y g i e r (1985) cultivation temperature has considerable influence on tocopherols biosynthesis. The authors have found ten times more tocopherol contents in leaves of *Calendula officinalis* grown at 29°C than in leaves of plants grown at 20°C.

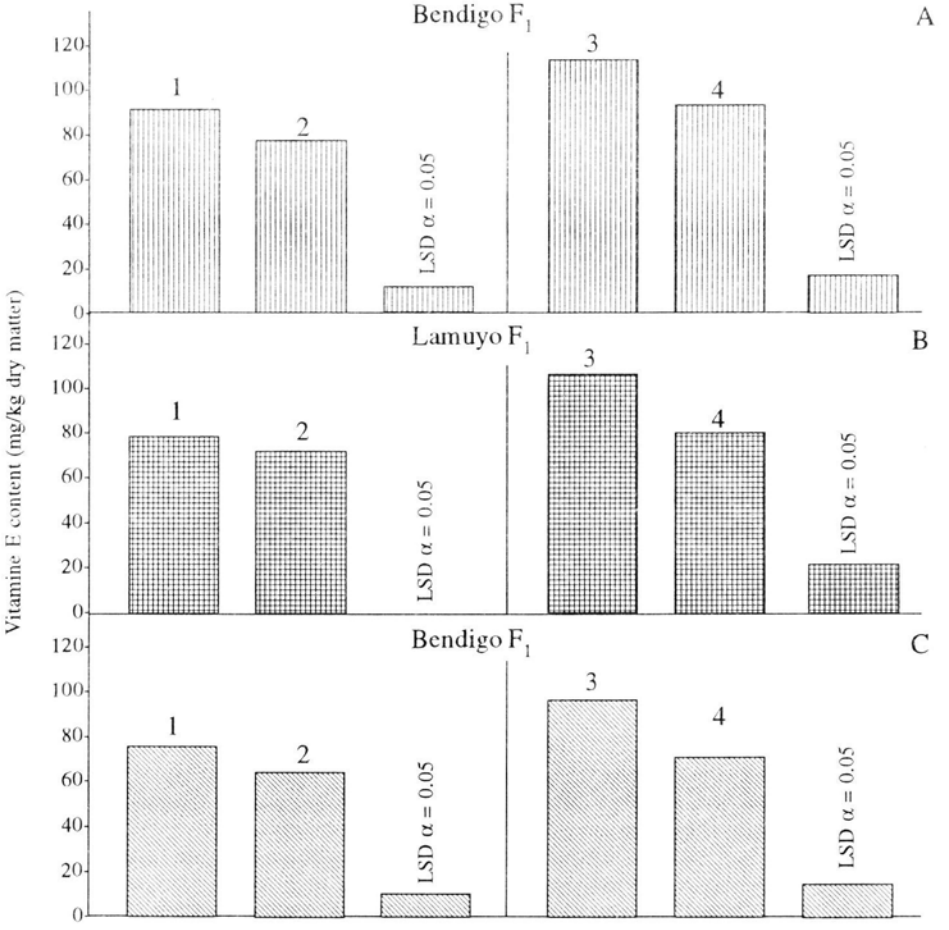

Fig.2. Effect of harvest season on vitamin E content in fruits of two sweet pepper cultivars

Description of plots: Bars 1 and 3 – fruits harvested in Summer; Bars 2 and 4 – fruits harvested in Autumn, Bars 1 and 2 – fruits from plants cultivated in sphagnum peat substrate; Bars 3 and 4 – fruits from plants cultivated in rockwool; Plots A and B – experiments from 1989, Plot C – experiment from 1991

Any significant effect of used mineral nutrition dosages on vitamin E level in fruits of sweet pepper grown in rockwool was not found (Tab. 1). Some decreases of the vitamin level appeared in case of the highest concentration of nitrogen in liquid fertilizer, but they were not statistically proved. There is no published data on effect of mineral fertilization on the vitamin E in plants in available literature. According to unpublished data mineral nutrition caused decrease of vitamins C, A and E in comparison with control without any fertilizers in 8-days and 16-days old watercress seedlings (H o r b o w i c z, unpublished data).

T a b l e 1

Effect of mineral nutrition dosages on vitamin E content in fruits of sweet pepper (cv. Bendigo F_1) cultivated in rockwool

Nutrition levels (mg l^{-1} nutrient solution)					Vitamin E (mg kg^{-1} of dry matter		
					Month of fruits harvest		
N	P	K	Ca	Mg	June	August	September
150	60	220	120	40	96	100	71
225	105	500	200	60	100	104	72
300	50	400	160	50	79	93	71
LSD $\alpha = 0.05$					ns	ns	ns

CONCLUSIONS

1. Vitamin E content in sweet pepper harvested in Summer was bigger in fruits from plants cultivated in rockwool than those from sphagnum peat substrate.

2. The vitamin E level at fruits of sweet pepper harvested in Summer was higher than in fruits from Autumn.

3. Dosages of mineral nutrition had no effect on vitamin E content in fruits of sweet pepper cultivated in rockwool.

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Wpływ warunków uprawy szklarniowej na zawartość witaminy E w owocach papryki słodkiej (*Capsicum annuum* L.)

Streszczenie

Przeprowadzono badania nad wpływem warunków uprawy na zawartość witaminy E w owocach dwóch odmian papryki słodkiej (Bendigo F_1 i Lamuyo F_1). Oceniano wpływ substratu do uprawy roślin (torf wysoki-kora, 1:1 i wełna mineralna – Flormin, Polska), sezonu zbierania owoców (lato lub jesień), oraz dawki nawozów w postaci płynnej pożywki stosowanej w uprawie na wełnie mineralnej. Stwierdzono, że owoce papryki uprawiane na wełnie mineralnej zbierane latem zawierały wiecej witaminy E niż owoce z roślin uprawianych w cylindrach z substratem torfowym. Podczas zbioru jesiennego rożnice też wystąpiły, ale na ogół nie zostały statystycznie udowodnione. Owoce zbierane latem charakteryzowały się wyższą zawartością witaminy E niż ze zbiorów jesiennych. Nie stwierdzono istotnego wpływu zastosowanych dawek nawozowych w uprawie papryki na wełnie mineralnej na poziom witaminy E w owocach.