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Effect of Ethephon Treatment on Vitamin and Mineral Contents of Fresh Tomatoes

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Ethephon처리가 토마토의 비타민 및 무기질함량에 미치는 영향

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Abstract

Vitamin and mineral composition of ethephon treated tomatoes were studied, and the results are summarized as follow:

1. Ascorbic acid, carotene (total and beta-carotene), thiamin and riboflavin contents in tomato fruits were not adversely affected by ethephon treatment 1 week before harvest, and these results were consistent for two consecutive years. Riboflavin content of tomatoes in 1979 was significantly higher than that in 1978, and this difference could be due to enviornmental factors.

2. Mineral content in tomato fruits were not significantly affected by ethephon treatment 1 week before harvest. Calcium and manganese contents in treated tomatoes significantly varied from year to year.

Introduction

The noticeable food value of fresh tomatoes in the diet is due to high vitamin content, especially ascorbic acid and carotenes. Also, the importance of mineral content in tomatoes is recognized. The reported results indicated that many factors, including varieties, cultural practices, harvesting at right maturity, and post harvest handling, cause a wide variation of nutrient composition in tomatoes.

Ethephon (2-chloroethyl phosphonic acid), which slowly produce ethylene upon field treatment, has been used for uniform ripening of tomatoes for once-over mechanical harvesting or for early ripening of fresh market tomatoes. The effect of ripening methods on the ascorbic acid content of tomatoes has been studied by numerous investigators, but there is a lack of general agreement. Craft and Teinze[1], Murneek *et al.*[2] and Hamner *et al.*[3] reported that vitamin C content of artifically ripened tomatoes was similar to that of vine ripe tomatoes, while Scott and Kramer[4], Pantos and Markakis[5] and Bakulina[6] found vine ripe tomatoes contained more ascorbic acid than artificially ripened tomatoes. Jones and Nelson[7] reported that ethylene treatment of green tomatoes produced no significant changes in their vitamin C potency in all samples of the green fruits tested, but ethylene-ripened tomatoes and air-ripened tomatoes were richer in vitamin C than the green fruits.[8]

Many researchers[9-12] reported that the carotence content of tomatoes increased during ripening. Ellis and Hamner[13] and Sadina and Ahmad[12] indicated that vine-ripened fruits are more potent sources than fruits detached while partially green and ripened in air or ethylene, and that ripe fruits are richer than green fruits regardless of ripening methods.

There were concerns over whether ethylene treatment to green tomatoes adversely affect nutrient content of tomato fruits. The objective of this study was to investigate the effect of ethephon treatment upon vitamin and mineral content of ripe tomatoes.

Material and Methods

Tomato variety

Campbell 1327, a variety suitable for processing and fresh fruits, was used to study the effect of ethephon treatment upon nutrient composition of tomato fruits for two consecutive years.

Ethephon treatment

Ethephon was treated to tomato plants at three rates; no treatment (control), 0.375 pounds per acre and 0.70 pounds per acre. Each treatment, consisting of 50 tomato plants, was replicated three times.

Sample handling

Ripe fruits with red color were harvested, washed and divided into two groups. Tomatoes for ascorbic acid and carotene analysis were stored at 10° and 90% RH for less than two days before analysis. Those for thiamin and riboflavin analysis were cut into quarters and frozen at -20°C in a air blast freezer after packing in polyethylene bags.

Analysis of ascorbic Acid

Ascorbic acid was determined using a modification of the method reported by Loeffler and Ponting.[14] Fifty grams of freshly sliced tomatoes from 4-5 fruits was blended for 3 min. in a Waring blender with 450*ml* of 0.5% oxalic acid solution. After blending, the slurry was filtered through Whatman No. 5 filter paper to clarify. One ml portions of the extract were pipetted into 3 matched colorimeter tubes. Nine *ml* of water added to one tube which was used to adjust the colorimeter (Bausch and Lomb Spectronic 70) to read 100% T. To each of the tubes, 9*ml* of working dye solution was added. The reading on each tube was taken within 10 seconds from the beginning of the dye solution. Ascorbic acid content in tomatoes was calculated using the following formula;

$$\text{Ascorbic acid (mg/100g)} = 10.0(L_1-L_2)\frac{ml\ \text{acid} + g\ \text{sample}}{g\ \text{sample}}$$

where L_2 is the average absorbance of sample tubes and L_1 is that of dye blanks. The factor 10.0 was determined as the slope of a standard curve using solutions of ascorbic acid.

Analysis of carotenes

Tomato slices from several fruits were blended and 10g of slurry was weighed into 250*ml* beaker. To each beaker was added 140*ml* of ethanol-hexane solution (2:1 v/v), and then stirred on a magnetic stirrer for 5 min. The sample was filtered through a coarse glass filter under suction. The residue on the filter was washed with two 25*ml* of 95% ethanol followed by one 25*ml* of hexane.

The liquid was transferred to a 500*ml* separatory funnel. The filter flask was rinsed with 50*ml* of 1% sodium sulfate solution which was added to the contents of the separatory funnel. The content of the separatory funnel was shaken and the layers allowed to separate. The lower water layer was drawn off into a second separatory funnel. This fraction was then washed with three 25*ml* of hexane to extract any remaining pigments. Each hexane wash was added to the hexane fraction in the first separatory funel. The water layer was then discarded.

The hexane fraction was washed with five 100*ml* of water followed by one 50*ml* of water. The water wash was discarded. The hexane extract was then filtered through anhydrous sodium sulfate into a 250*ml* volumetric flask, using Whatman No.2 filter paper. The flask was made to volume with hexane. This extract represented the total carotene fraction and an aliquot of the extract was transferred to a colorimeter tube for measurement of total carotenes at 436nm. A 100*ml* of total carotene extract was evaporated by air to 10*ml* in preparation for column chromatography. Column chromatography was accomplished using 1 + 2 mixture of activated MgO and diatomaceus earth, according to the method described in Methods of Vitamin Assay (Association of Vitamin Chemists, Inc., 1966). The elute obtained from column chromatography was made up to 100*ml* with hexane. The absorbance of beta-carotene was measured at 436nm.

Extraction of thiamin and riboflavin

75g of tomato slurry was weighed into a 400*ml* beaker and 75*ml* of 2.5N-HCl was added. After mixing, the beaker was covered with aluminum foil and held in a boiling water for 30 min. with occational swirling. After

digestion, sample was cooled and adjusted to pH 4.5 with 10N-NaOH and 2.5N-soidum acetate.

The digest was transferred to a 200*ml* flask which contained several *mg* of fungal pectinase. The flask was swirled and allowed to incubate at room temperature for 3-4 hours. The flask was made to volume with water and filtered through Whatman No. 5 filter paper into a brown glass bottle. The extract was stored in a refrigerator and subsequently used for analysis of thiamin and riboflavin.

All these steps were carried out under reduced light as both thiamin and riboflavin were destroyed by visible light.

Analysis of thiamin

25*ml* of vitamin extract was added to 50*ml* of isobutanol in a 125*ml* separatory funnel. The mixture was shaken for 2 min. and allowed to separate for at least 30min. The lower aquous layer was used for thiamin analysis.

An automated method[15] was used for the thiamin analysis. Thiamin was oxidized to thiochrome with alkaline potassium ferricyanide, and then thiochrome extracted into isobutional. The fluorescence of this extract was measured ast 436 *nm* using a Technicon Autoanalyzer (Technicon Instrument Corp.).

Analysis of riboflavin

10*ml* of the extract was placed into a test tube. A drop of conc. HCl and 0.5*ml* of 3% $KMnO_4$ were added to it. The content was mixed, and allowed to stand exactly 2 min. Then, 0.5*ml* of H_2O_2 was added and mixed. The red color disappeared within 10 seconds.

Technicon Autoanalyzer system was used for the riboflavin analysis and the automated procedure reported by Kirk[15] was followed. The prepared sample was pumped into the machine and dialyzed against dilute NaCl before the fluorescence of the sample was measured. The sample was excited with 436 *nm* light and the fluorescence was measured at 510 *nm*. Sample blanks were measured by quenching flourescene with $Na_2S_2O_4$.

Analysis of potassium

Samples for potassium analysis were weighed into a glass jar followed by 50*ml* of water. The jar was capped and agitated at every 30 min. for 2hrs. Samples were then filtered through Whatman No. 1 filter paper and the extract was used for potassium analysis at 755*nm* using a Beckman Model B Flame Photometer.

Analysis of other minerals

P, Na, Ca, Mg, Mn, Fe, Cu, and Zn were determined using an Applied Research Laboratory Quantograph. One-half gram of ground freeze dried samples was ashed at 500°F for 10 hrs. The ash was dissolved in a nitric acid solution and analyzed. Levels of elements in samples were determined by comparison to the standard curve.

Statistical analysis.

Significance of each factor in various observations of samples was determined by analysis of variance. Mean separation was made by Duncan's Multiple Range test, wherever significant differences at 5% level were found by analysis of variance. Analsysis of variance and Duncan's Multiple Range test were accomplished using a CDC 6500 computer.

Results and Discussion

Ascorbic acid content

The effect of ethephon treatment on the ascorbic acid content of tomatoes in 1978 and 1979 seasons is given in Table 1.

Table 1. Effect of ethephon treatment on ascorbic acid content in tomatoes (mg/100g of fresh weight).

Ethephon treatment	Year	
	1978	1979
Control	13.0 a[1]	14.4 b
0.375 1b/acre	15.5 a	14.7b
0.70 1b/acre	171. a	13.3 b

1. Values within colmns followed by the same letter are not significantly different at 0.05 level.

In 1978, the ethephon treated tomatoes were slightly higher in ascorbic acid content than the control. However, no significant effect was detected by analysis of variance. There was no significant yearly variation in ascorbic acid content of ethephon treated tomatoes.

Jones and Nelson[7] studied the effect of ethylene treatment of the green tomatoes on the ascorbic acid content of ethylene ripened tomatoes. They found no significant changes in the ascorbic acid potency in all green fruits tested.

Carotene content

Tomato fruits, treated with ethephon one week

Table 2. Effect of ethephon treatment on total carotene content in tomatoes (mg/100g of fresh weight)

Ethephon treatment	Year	
	1978	1979
Control	5.0 a[1]	7.8 c
0.375 lb/acre	6.0 b	7.6 c
0.70 lb/acre	6.3 b	7.4 c

1. Means within columns followed by the same letter are not significantly different at the 0.05 level.

Table 3. Effect of ethephon treatment on beta-carotene content in tomatoes (mg/100g of fresh weight).

Ethephon treatment	Year	
	1978	1979
Control	0.9 a[1]	1.1 b
0.375 lb/acre	1.0 a	1.2b
0.70 lb/acre	1.0 a	1.0 b

1. Means within columns followed by the same letter are not significantly different at the 0.05 level.

before harvesting, were subjected to carotene analysis, and the results are contained in Tables 2 and 3.

Control had a significantly lower total carotenes content than treated tomatoes in the 1978 season, while no considerable difference were observed in total carotenes content between control and ethephon treated tomatoes in the 1979 season (Table 2). It was found that there was no significant effect of ethephon treatment on beta-carotene content in either year.

Morgan and Smith[10] reported that ethylene ripened tomatoes were equivalent to vine ripened fruits in vitamin A potency. The results of Salunkhe *et al.*[16] indicated no significant differences in color between control frutis and those treated with 1000 ppm ethephon. Based on the experimental results, it appears that ethephon treatment a week before harvest does not adversely affect carotene content of treated tomatoes.

Thiamin and riboflavin contents

Although ethephon has been used for uniform ripening of tomatoes, the effect of ethephon treatment on thiamin and riborflavin contents has not been studied.

The results in Tables 4 and 5 showed that thiamin and riboflavin contents in tomatoes were not significantly affected by ethephon treatment, and these results were observed in two consecutive years. However, the riboflavin content in all tomato samples of 1979 was significantly higher than that of 1978.

Table 4. Effect of ethephon treatment on thiamin content (mg/100g of fresh weight)

Ethephon treatment	Year	
	1978	1979
Control	0.07 a[1]	0.06 b
0.375 lb/acre	0.09 a	0.07b
0.70 lb/acre	0.09 a	0.07 b

Table 5. Effect of ethephon treatment on riboflavin content in tomatoes (mg/100g of fresh weight).

Ethephon treatment	Year	
	1978	1979
Control	0.03 a	0.06 b
0.375 lb/acre	0.04 a	0.05b
0.70 lb/acre	0.03 a	0.05 b

Secomska[17] reported that fresh tomatoes contained 42μg of thiamin/100g. Lefebure and Leclerc[18] found that thiamin content of tomatoes increased between May and June from 40 to 80 μg/100 of fresh weight. A study by Hodson[19] using the fluorometric method showed that riboflavin content of tomatoes was 52μg/100g, whereas Lanford *et al.*[20] found a value of 37.7 μg/100g of fresh tomatoes, using rat assay.

Minerals

The mineral content in ethephon treated tomatoes is summarized in Table 6. The results indicated that ethephon treatment 1 week before harvest did not significantly affect the mineral content in tomato fruits in either year. Manganese content in tomatoes was noticeablely higher in 1979 than in 1978, whereas calcium content in tomatoes was higher in 1978 than in 1979. These yearly variation might be due to environmental factors.

Table 6. Effect of ethephon treatment on mineral content in tomatoes.

Minerals	1978			1978		
	Control	rate 1*	rate 2**	Control	rate 1	rate 2
Na(%)***	0.21	0.19	0.18	0.19	0.18	0.17
K (%)	3.5	3.8	3.1	3.3	3.2	3.5
P (%)	0.41	0.43	0.37	0.38	0.33	0.36
Ca (%)	0.03	0.04	0.05	0.02	0.02	0.02
Mg (%)	0.18	0.19	0.18	0.18	0.17	0.17
Mn (mg/100g)	1.9	1.6	1.5	2.7	2.8	3.0
Fe (mg/100g)	9.2	9.0	10.9	10.6	8.9	9.1
Cu (mg/100g)	1.4	1.2	1.5	0.9	0.7	1.0
Zu (mg/100g)	1.6	1.2	1.3	1.6	1.8	1.1

* Rate 1 = 0.375 lb/acre

* Rate 2 = 0.70 lb/acre

*** All values expressed on a dry weight basis.

요 약

과실의 균일한 숙성을 위하여 ethephon을 흔히 사용하는데, 수확전의 토마토에 ethephon을 처리했을때 토마토의 비타민과 무기질 함량에 어떤 영향을 주는지에 관하여 연구한 결과를 요약하면 다음과 같다.

1. 수확 1주일 전의 토마토에 ethephon 처리는 아스콜빈산, 캐로틴(총 캐로틴 및 베타-캐로틴), 지아민, 리보후라빈의 함량에 영향을 주지 않았으며, 이런 결과는 2년간 계속적으로 확인되었다. 토마토의 리보후라빈 함량이 1979년에 1978년 보다 높았던 것은 아마도 생육환경의 영향에 의한 것으로 여겨진다.

2. 토마토의 무기질 함량은 수확 1주일전의 ethephon 살포에 의하여 영향을 받지 않았다. 그러나 ethephon 살포와는 관계없이 칼슘과 망간함량은 해에 따라 변하였다.

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