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Appreciation of ethrel on ripening dynamic and on the content of ingredients in processing tomato *(Lycopersicon lycopersicum* (L.) *Karsten)* varieties

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Summary: Tomato (*Lycopersicon lycopersicum (L) Karsten*) is an important crop cultivated in Hungary. Ethrel has been used to advance maturity and promote uniform ripening of processing tomato since 25–30 years in Hungary. The aims of the present study were 1) to evaluate the effects of two different ethrel concentrations on ripening rate, 2) to investigate lycopene content of different maturity stages, 3) to test the effect of ethrel on lycopene content. It is important to note that the experimental year (in July and August) was very rainy and cool.
Ethrel was applied at two rates: 1500 and 3000 ppm. The results clearly indicate that Ethrel can be a useful and effective tool of maturity-enhancement, under present circumstances. Ripening concentration increased significantly by Ethrel. In spite of this, Ethrel treatments did not affect lycopene content of examined varieties significantly. The quality of tomato products are characterised by their lycopene content. Colour is highly important quality factor of food products. The range in lycopene contents from all samples evaluated was 48.7 to 113.0 mg kg^{-1} fresh weight. Also correlations between lycopene content and colour (a*/b*, and chroma) were investigated also.

Key words: Ethrel, lycopene, variety, harvesting time, *Lycopersicon lycopersicum*

Introduction

Ethephon has been used to advance maturity and promote uniform ripening of processing tomato since the 1970s. Ethephon [(2-chloroethyl) phosphonic acid] has been registered as a fruit maturity enhancer for processing tomatoes since 1973. It was first introduced by Amchem Products, Inc., under the trade name Ethrel®. The mode of action and important parameters of ethephon on processing tomatoes have been described by *Robinson* et al. (1968). Long-term exposure to ethephon applied as a root drench at concentrations of 1000 µl liter-1 increase transpiration rates, stomatal conductance and, occasionally, throughout the 14 daylong observation period. Photosynthesis showed a biphasic response to ethephon, wherein elevations of 13.2% then 16.7% were observed over control plants for two of the measurement days for the 50 and 5µl ethephon/liter concentrations, respectively. Stomatal conductance showed a large increase at 50µl ethephon/liter on day 2, while 5µl $liter^{-1}$ did not show this difference (*Briede* et al., 1992). Ethrel is an effective and efficient crop management tool and it helps to ripen fruit quickly and uniformity. The colour (lycopene content) and pH of processing tomato at harvest are an important criterion of quality. According to *Renquis*t et al. (2001), ethephon did not alter these temperature/pH relationships. Results of ethephon experiments have often been influenced by weather and those other factors, which vary with the season (*Battilani,* 1994). Product rates and environmental interactions are important factors to be considerred because of ethephon's chemical instability during periods of sustained air temperatures exceeding 35 °C. The optimal concentration of Ethrel is 1000–1500 ppm, but the temperature up to 35 °C decreases its effectiveness (*Murray,* 2001).

It is a well-known fact among the scientists that lycopene gives the red colour of tomato berries. Lycopene is accumulated mainly in deep red stage and colour is an indicator of lycopene level. The higher the ratio of a*/b* the higher the lycopene concentration (*Brandt* et al., 2006). According to *Helyes* et al. (2003), the lycopene content of sixteen different tomato varieties in Hungary ranged between 39.3 and 171.0 mg kg^{-1}. Lycopene is one of the main carotenoids of human tissues and blood (*Sies & Stahl,* 1999). Fruit colour is a guide to quality, but not alone a reliable index of maturity (*Young* et al., 1993).

Materials and methods

Tomato fruits were used from the test sites of Szent István University Gödöllő. The following varieties were investigated: Elegi F1 and Brigade F1. Seeds were sown at 7th April 2005 and planted out at 13th May 2005. Seedlings were arranged in double (twin) rows with a distance of 1.2 and 0.4 m between the rows and of 0.3 m between the plants. Each variety was cultivated in four replications. Test sites were harvested by hand. Two times during the growing season (24. 08. and 31. 08.) the tomato fruits were randomly selected from the middle section of the plants. The tomato plant stands were treated with

ethrel in 1500 and 3000 ppm concentrations, respectively two weeks preceding the harvest.

Four samples from the picked fruits of each variety were taken for investigation. At least 8–10 fruits from each repetition were washed, cut and mixed and the juice samples were refrigerated at -18 °C until analysis. Lycopene from homogenised tomato was extracted with n-hexane-methanol-acetone (2:1:1) mixture containing 0.05% BHT. Water-free Na_2SO_4 was used to remove water traces of the upper part. Optical density of the hexane extract was measured spectrophotometrically at 500 nm against hexane blank (Sadler et al., 1990) by UV-VIS Spectrophotometer Lambda 3B (Perkin Elmer). Concentration of lycopene was calculated using specific extinction coefficient (*E*1cm1% 3150) (Merck Index, 1989). The $Brix^0$ of the 1st and 2nd harvesting time was examined with refractometer. *Figure 1* show environmental parameters (precipitation, temperature) in August, during harvesting times.

Experiments were conducted as a random complete block with two factors (ethrel treatment and harvesting time). The data were analysed by two-factor analysis of variance (ANOVA) with repetitions and the means were separated using the Student's test.

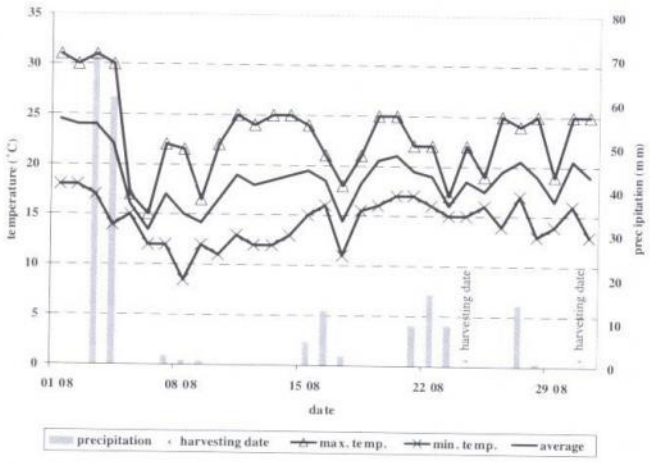

Fig. 1. Daily temperature and precipitation during fruit ripening period in 2005

Result and discussion

It should be taken into account that the abundant precipitation, more than 100 mm, during August before harvest was unusual in Hungary. The 14 rainy days of August lowered the temperature substantially, the maximum ranged between 15 and 20 °C. In spite of that the experiment results indicate that ethephon was effective and enhanced the maturity of fruits. Ethrel was effective in both varieties, concentrations and harvesting times except one case rainy and cool season maturity-enhancement tool. Effect of Ethrel treatments are ripening concentration increasing remarkably except all but one (in case of Brigade F1, at 1500 ppm in the first harvest).

In case of Elegi F1, there were significant ($P<0.001$) differences in ripening concentration caused by ethepon treatments, for example ripening concentration increased from 55 % (no ethrel) to 80 % and 84 % at the first harvest

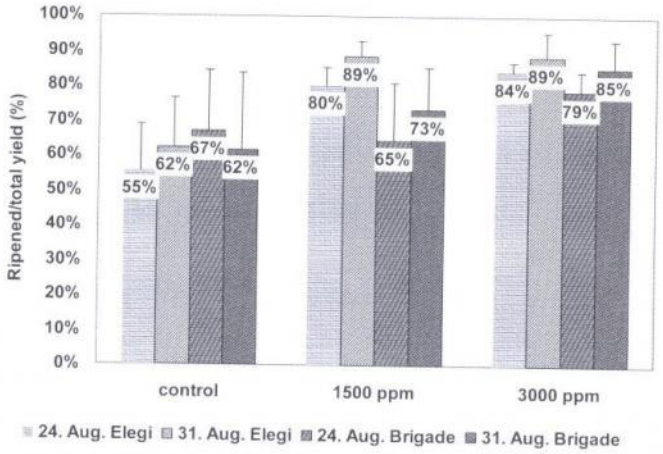

Fig. 2. Effect of ethrel and harvest date on ripeness of tomato fruits (mean±SE; n=4)

and from 62% to 89% at the second harvest, so average increment 25–27 %. (*Figure 2* and *Table 1*).

Practically, the fruit doesn't contain any lycopene in mature green stage; its value hardly reached the level of detection. In the following maturity stages the quantity of accumulated lycopene is continuously increasing in the fruits. However, it is remarkable that almost the half of the lycopene content, accumulating as determined by the genetic potential of the variety and the environmental circumstances (mainly temperature and light), is synthesized and accumulated in the 6th maturity stage *(Figure 3)*. *Figure 4* shows average lycopene content of berries in both harvesting times and Ethrel treatments. The average lycopene content ranged from 4.9 to 9.3 mg $100g^{-1}$. There were no significant differences in lycopene content among Ethrel treatments. Comparing the harvesting times there was significant difference ($P<0.001$) in lycopene content in case of Brigade F1 *(Table 1)*. The average lycopene content was significantly lower for the second harvest date. We measured 65% average lycopene content only compared with the previous harvest of Brigade F1.

Conclusions

The following conclusions were drawn from this study: This experiment confirmed that all of the ethephon rates exceeding 3000 ppm caused enhanced fruit maturity,

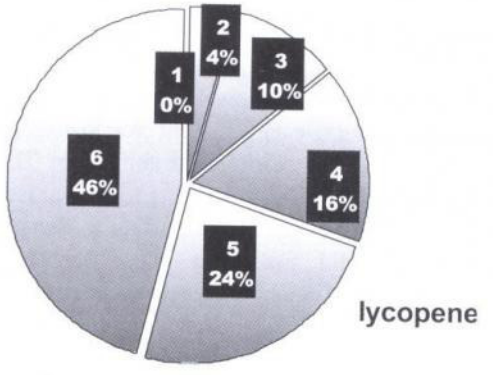

Fig. 3. Proportion of lycopene content depending on maturity stages

Table 1. The effect of ethrel and harvesting date on yield and quality of processing tomatoes (mean±standard deviation), with significant differences at P=0.05.

Treat-ment[z]	1500 ppm		3000 ppm		control		SD[y]	
Variety: Elegi F_1	**24. Aug.**	**31. Aug.**	**24. Aug.**	**31. Aug.**	**24. Aug.**	**31. Aug.**	Harv. date	Treat-ment
Ripened /total yield (%)	**0.80±0.05^A**	**0.89±0.04^A**	**0.84±0.03^A**	**0.89±0.07^A**	**0.55±0.14^B**	**0.62±0.14^B**	**NS**	**0.11*****
Brix°	4.35±0.10	4.40±0.22	4.45±0.19	4.58±0.22	4.63±0.28	4.60±0.14	NS	NS
Organic acid (g kg^{-1})	3.66±0.14	3.66±0.09	3.92±0.15	3.67±0.32	3.96±0.44	3.78±0.41	NS	NS
Sugar (g $100g^{-1}$)	2.15±0.26	2.23±0.17	2.13±0.05	2.23±0.17	2.10±0.24	2.35±0.10	NS	NS
Lycopene (mg$100g^{-1}$)	**5.82±2.55**	**8.22±0.45**	**7.58±2.87**	**7.86±1.39**	**9.03±1.38**	**7.15±1.31**	**NS**	**NS**
HMF (µmol l^{-1})	50.5±7.0^A	61.0±4.30^A	56.8±5.30^A	54.6±11.2^A	74.4±23.0^B	79.7±28.9^B	NS	14.0*
a*/b*	1.40±0.11	1.30±0.07	1.43±0.05	1.40±0.15	1.43±0.11	1.45±0.08	NS	NS
(a*2+b*2)0.5	40.9±0.62^A	41.8±1.73^A	38.9±1.61^B	40.2±1.7^B	40.7±1.3^A	37.1±1.43^C	NS	1.24**
Variety: Brigade F_1								
Ripened/total yield (%)	**0.65±0.16**	**0.73±0.12**	**0.79±0.06**	**0.85±0.08**	**0.67±0.17**	**0.62±0.22**	**NS**	**NS**
Brix°	4.60±0.37	4.50±0.08	4.48±0.30	4.50±0.08	4.83±0.33	4.83±0.30	NS	NS
Organic acid (g kg^{-1})	3.82±0.54	3.72±0.42	4.17±0.08	3.72±0.42	3.69±0.28	3.60±0.26	NS	NS
Sugar (g $100g^{-1}$)	2.13±0.15^a	2.43±0.26^b	2.08±0.10^a	2.43±0.26^b	2.33±0.32^a	2.70±0.39^b	0.28**	NS
Lycopene (mg$100g^{-1}$)	**9.25±1.45^a**	**4.94±1.07^b**	**8.83±1.04^a**	**4.94±1.07^b**	**7.4±1.38^a**	**5.81±0.87^b**	**1.22*****	**NS**
HMF (µmol l^{-1})	72.7±10.9	53.8±13.7	68.4±10.6	53.8±13.7	91.3±34.1	74.7±42.2	NS	NS
a*/b*	1.34±0.10	1.38±0.22	1.22±0.13^a	1.54±0.09^b	1.47±0.08	1.48±0.11	0.19*	NS
(a*2+b*2)0.5	42.3±3.01	40.6±2.56	43.8±1.18^a	39.1±0.9^b	41.1±2.44^a	38.3±1.44^b	2.18**	NS

SD Significant difference

[z]Data in the same row bearing the same superscript of a lower case letter (between harvesting dates) and capital (between treatments) are not significantly different at the 5% level (tested by Student's test).

[y](*** P<0.001; ** P<0.01; * P<0.05)

NS Not significant

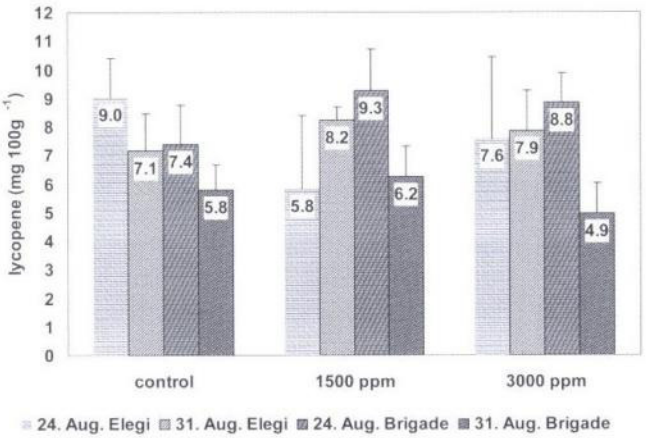

Fig. 4. Effect of ethrel and harvest date on lycopene of tomato fruits (mean±SE; n=4)

compared with the untreated controls. There were no significant differences in fruit quality (Brix°, organic acid, sugar and lycopene content) observed resulting from ethephon effects.

Acknowledgement

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