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Tomato Ripeness Influence on Fruit Quality

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***Abstract*—**Tomato nutrition value, color, flavor of their fruits and products depends mainly on lycopene, β-carotene, ascorbic acid, sugars and their ratio. The two most important carotenoids in fruits of tomato are lycopene, which determined fruits red color, and β-carotene, which accounts for approximately 7% of the tomato carotenoids. Therefore, tomato products and their quality can be well characterized by the content of these elements.Maturity at harvest is very important to composition and quality of tomatoes. This is especially a problem with tomatoes picked green since it is difficult to differentiate between mature and immature-green fruits. Typical and advanced mature-green tomatoes will usually attain a much better flavor than those picked at the immature or partially mature stages.To better understand the synthesis of biochemical compounds, their concentration should be compared not only at the last stage of maturity, but also during all fruit ripening period in different varieties.

***Keywords*—**quality, ripeness, tomato, variety

I. Introduction

TOMATO nutrition value, color, flavor of their fruits and products depends mainly on lycopene, β-carotene, ascorbic acid, sugars and their ratio.The two most important carotenoids in fruits of tomato are lycopene, which determined fruits red color, and β-carotene, which accounts for approximately 7% of the tomato carotenoids. Therefore, tomato products and their quality can be well characterized by the content of these elements [1].

Most of the research worksdescribetomato biochemical composition in the fully ripen fruits (in red tomato)at technical fruit maturity stage. To better understand the synthesis of carotenoids and other biochemical compounds, their concentration should be compared not only in red fruits, at the last stage of maturity, but also during all fruit ripening period (from green tomato fruit ripening stage to the technical fruit maturity) in different varieties. During tomato fruit ripening, carotenoids concentrations are changing constantly. It is related with chlorophyll degradation and carotenoids synthesis processes, when chloroplasts are synthesized in to the chromoplasts [2], [3].

Maturity at harvest is very important to composition and quality of tomatoes. This is especially a problem with tomatoes picked green since it is difficult to differentiate between mature and immature-green fruits. Typical and advanced mature-green tomatoes will usually attain a much better flavor at the table-ripe stage then those picked at the immature or partially mature stages. The latter are also much more susceptible to physical injuries and water loss because of their thin cuticle.

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Ripeness stage at harvest affects fruit composition and quality. Tomatoes accumulate acids, sugars and ascorbic acid during ripening on the vine [4], [5].In addition to chemical composition, texture is also very important quality attribute of tomato fruits. Fruit firmness is related to the susceptibility of tomato fruit to physical damage during harvest and storage. Also, it can be the most important consumer preference characteristic which may be tested by fingers [6].

II. Materials and Methods

Investigation was carried out at the Lithuanian Research Centre for Agriculture and Forestry in 2007–2008. Tomatoes were grown under integrated tomato growing technology adopted by Institute of Horticulture in no heated greenhouses in the soil.Evaluating fruit ripening impact on the tomato quality, tomatoes were picked at different ripening stages: I – degree of ripeness (100 % green tomato fruits), II – degree of ripeness, early stage of ripeness (10-30 % colored tomato fruits), III – degree of ripeness – tomato fruits gained color specific to the breed (60-90 % colored tomato fruits), IV – degree of ripeness, fully ripen (over 90 % colored tomato fruits).The research objective was 5tomato (*Lycopersiconesculentum* Mill.)varieties: 'Aušriai', 'Skariai', 'Milžinai', 'Vilina' and 'Vėža'.

Tomato fruit biochemical composition and texture analysis were carried out at the laboratory of biochemistry and technology. Ascorbic acid determined by titration using 2,6 – dichlorphenolindophenol sodium salt solution, sugar by the AOAC method [7]. To establish the amount of carotenoids(β-carotene and lycopene), tomato fruits were homogenized by "Bosch Easy Mixx" (type CNHR6, Robert Bosch GmbH, Stuttgart, Germany) blender. β-carotene and lycopene content has been determined spectrophotometrically [8], [9], using a spectrophotometer "Cintra 202", and color indexes of the spectrophotometer "MiniScan XE Plus" (Hunter Associates Laboratory, Inc., Reston, Virginia, USA). Tomato texture measured by texture analyzer "TA.XTPlus" (Stable Micro Systems, Godalming, England).Flat head stainless cylindrical probe of 2 mm diameter was used for penetration test. The start of penetration test was the contact of the probe and tomato surface, finish – when the probe penetrated the tissues to depth of 8 mm. the probe speed was 1 mm s^{-1}. For each test five tomato fruits of every variety were selected and each tomato was punctured three times around the equatorial area. The obtained data was processed by "Texture Exponent" program.

Tomato texture and biochemical composition data were evaluated statistically using statistical programs: "STATISTICA 9", and "ANOVA".

III. Results and Discussion

Tomato fruit color mainly depends on its content of lycopene and β-carotene and their concentration and

distribution. Plant growing conditions, genotype and fruit ripeness can have a significant impact on carotenoids content in their fruits [10], [11], [12]. According to scientific publications, amount of lycopene in fully ripen tomatoes can vary several times. Heinonen and colleagues found 3.1 mg 100 g^{-1} lycopene in tomatoes [13], Tonucci with colleagues reports that average amount of lycopene in tomato is 9.27 mg 100 g^{-1}[14]. Ngyuen and Schwartz found 3.1-7.7 mg 100 g^{-1} of lycopene in fresh tomato fruits [1].According to our data, it was established that the highest amount of accumulated lycopene was found in fully ripen fruits and ranged from 9.21 ('Milžinai') to 12.69 mg per 100 g^{-1} ('Vilina') (Fig. 1). The lowest lycopene levels were detected in the green tomato fruits, where lycopene content range from 0.25 ('Milžinai') to 0.72 mg 100 g^{-1} ('Vėža').

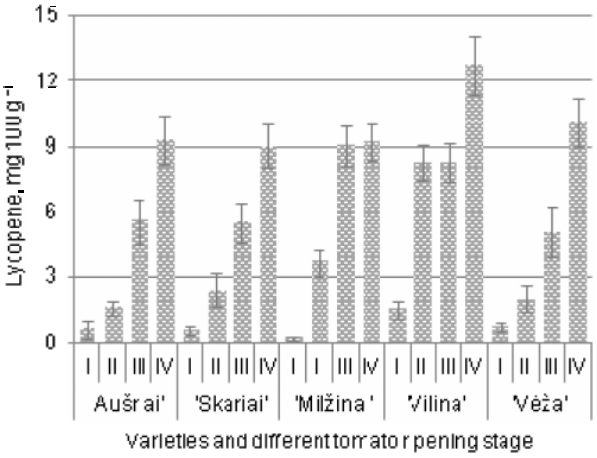

Fig. 1 Lycopene content in different tomato varieties at different ripening stage.

The same trends have been identified with β-carotene (Fig. 2), where the highest amount of β-carotene was found in fully ripen fruits and ranged from 1.40 ('Vėža') to 1.69 mg 100 g^{-1} ('Vilina'). The less amount of β-carotene was detected in the green tomato fruits and ranged from 0.20 ('Milžinai') to 0.47 mg 100 g^{-1} ('Vėža'). So, according to investigation data, lycopene and β-carotene levels increased consistently in red tomatoes fruit during ripening, only varieties 'Vilina' (between the second and third stages of ripeness) and 'Milžinai' (between the third and fourth stages of ripeness) were statistically insignificant increases of lycopene and β-carotene content.

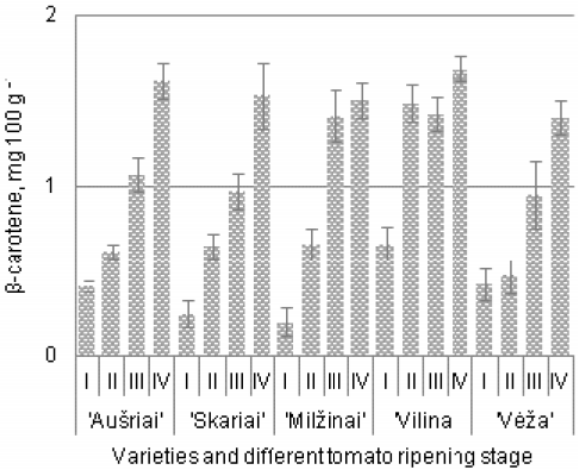

Fig. 2 β-carotene content in different tomato varieties at different ripening stage

Tomato fruit taste is determined by sugar and acid content and their ratio. The more sugar and less acid, the taste is more pleasant [15], [16].During tomato ripening period, fruit quality is changing. At the beginning of the tomatoes ripening, there are more organic acids and less ascorbic acid in the fruits, and at the end of fruit ripening there are the biggest amounts of dry matter and total sugar in tomatoes. However, about ascorbic acid and total sugar content in tomatoes during ripening we can find a different views, some authors say that tomatoes ascorbic acid levels are increasing rapidly through ripening [17], while others reports, that found no significant differences [18].

Study showed that during fruit ripening ascorbic acid (Fig.3)and total sugar (Fig. 4) content increased in some tomato varieties, but in others – ascorbic acid and total sugar had declined. The average vitamin C content of fully ripen tomato fruits varies from 10 to 20 mg 100 g^{-1}, although some authors point out that the average ascorbic acid content in tomatoes is 25 mg 100 g^{-1}[19]. It was established that the highest amount of ascorbic acid (20.4 mg 100 g^{-1}) was in fully ripen fruits of variety 'Vilina'. During fruit ripeningascorbic acid increased rapidly only in variety's 'Vilina' fruits. There were no any tendencies detected of ascorbic acid accumulation in other varieties during fruit ripening.Tomato variety 'Milžinai'accumulated less amount of ascorbic acid in all ripening stages, it varied from 3.8 to 4.2 mg 100 g^{-1}.It is possible to say, that amount of ascorbic acid mainly depends on tomato genotype and lees influence had fruit ripening stage. The amount of total sugar varied independently of the fruit maturity. Three of the five investigated varieties accumulated the highest total sugar amount in fully ripen fruits and it had varied from 4.71 to 5.14 %.

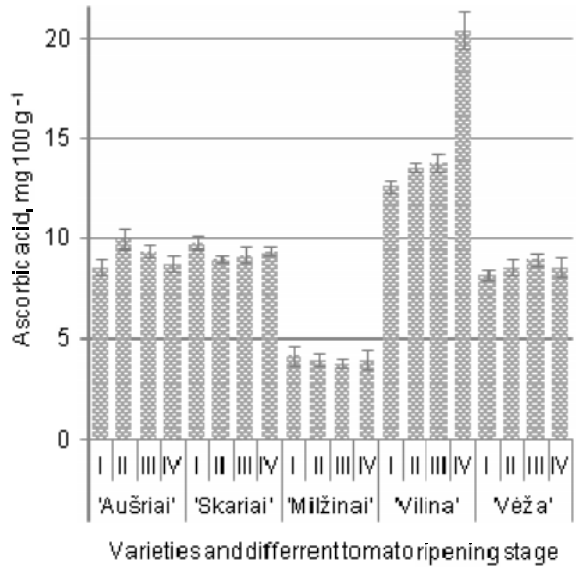

Fig. 3 Ascorbic acid content in different tomato varieties at different ripening stage

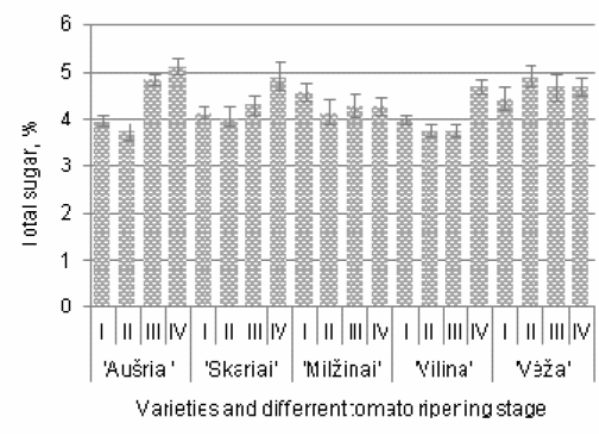

Fig. 4 Total sugar content in different tomato varieties at different ripening stage

Tomato fruitsmaturationcontinues after their harvest, so they may quicklyover-ripe, which affectsfruit quality andreducetheir realizationtime. Quality of tomatotextureis determined by tomatoskinandfleshfirmnessandtheir relationship. Tomatofruitfirmnessis strongly correlated withfruitqualityparameters(color,shape, appearance, etc.). Fruitfirmnessis usedas a parameterin determiningthe quality oftomatoes. Hardness ofthe fruitcanbea crucial factorto the consumerchoice. Transportabilityof fruit is veryimportant factor, because the strongerfruits are lessvulnerable toharvest,sorting, packaging andtransportation ofproduction [20], [21]. The assessment of data showedthattomatofruits skin (fig. 7)and flesh (Fig. 8)firmness decreased during fruit ripening.

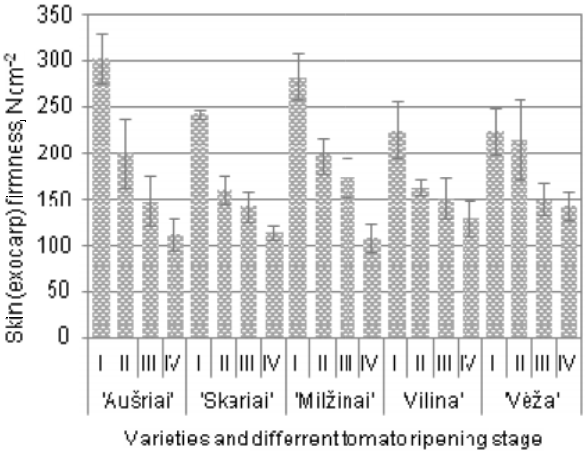

Fig. 5 Tomato skin firmness of different tomato varieties at different ripening stage.

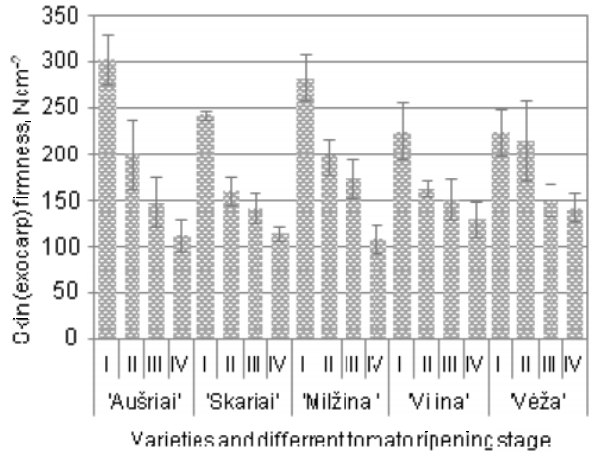

Fig. 6 Tomato flesh firmness of different tomato varieties at different ripening stage.

Tomato skin firmness ranged from 109Ncm^{-2} in fully ripen fruits of variety 'Milžinai'to 303 Ncm^{-2} in green fruits of variety 'Aušriai'.Flesh firmness ranged from 6.0Ncm^{-2} in fully ripen fruits of variety 'Vilina'to 68.0Ncm^{-2} in green fruits of variety 'Milžinai'. Comparision of fully ripen fruits revealedthat tomatoesvariety 'Vėža'hadthe strongestskinand fruits of variety 'Aušriai'had the strongest flesh. It was established significant increase of tomato flesh firmness between III and IV ripening stages in variety's'Skariai' fruits.

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