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Tomato Fruit Quality of Different Cultivars Growth in Lithuania

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***Abstract*—**Two cultivars ('Rutuliai', 'Saint Perrie') and five hybrids ('Tolstoi', 'Brooklyn', 'Tocayo', 'Benito', 'Tourist') of edible tomato (*Lycopersicon esculentum* Mill.) were investigated at the LRCAF Institute of Horticulture. The following fruit quality parameters were evaluated: the amount of lycopene, β-carotene, ascorbic acid, total and inverted sugar, sucrose, dry matter soluble solids in fresh tomato matter, also were determined fruit skin and flesh firmness, color indexes (CIE L*a*b*) and calculated hue angle (h°) with chroma (C).

***Keywords*—**Carotenoids, cultivar, nutrition, tomato.

I. Introduction

TOMATOES are one of the most valuable vegetable, particularly popular in Lithuania. Quality factors such as size, firmness, color, taste, and nutritional content are important criteria for marketing of tomato fruit. Tomato can be represented by several hundred cultivars and hybrids in response to the fresh consumption tomato market, demanding fruits which have very different characteristics. Therefore, tomato cultivars for fresh consumption show great differences in fruit characteristics in terms of fruit size, shape, color, and nutrition quality [1].

Tomatoes are widely consumed either fresh or processed, they are known as health stimulating fruit because of the antioxidant properties of their main compounds. Antioxidants are important in disease prevention in plants as well as in animals and humans. Their activity is based on inhibiting or delaying the oxidation of biomolecules by preventing the initiation or propagation of oxidizing chain reactions. The most important antioxidants in tomatoes are carotenoids. Among the carotenoids, lycopene dominates, and its content varies significantly depending on ripening, environment and cultivar [2], [3].The second most important carotenoid is β-carotene, which represents about 7% of the total carotenoid content. The amount of carotenes as well as their antioxidant activity is significantly influenced by tomato cultivar [4].

Higher amount of fruit total and soluble solids is a major economic value for the processing tomato industry, since even a small increase can significantly enhance yield and decrease the cost of dehydration of puree into sauce and paste. Soluble solids are also of prime concern in fresh market tomato production due to the important contribution that sugars and acids make to the overall flavor of the fruit [5]-[7].

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The selection of cultivars or hybrids with good yield and fruit quality potential has great importance in greenhouse tomatoes culture in order to improve the economic efficiency of this crop. Consumer interest in the quality of vegetable products also increased in the last years. So, it is important to evaluate fruits quality of different tomato cultivars and hybrids.

II. Materials and Methods

Two cultivars ('Rutuliai', 'Saint Perrie') and five hybrids ('Tolstoi', 'Brooklyn', 'Tocayo', 'Benito', 'Tourist') of edible tomato (*Lycopersicon esculentum* Mill.) were investigated at the LRCAF Institute of Horticulture. Plants were grown under the same conditions in the natural soil in not heated greenhouse covered with polymeric film.

The following fruit quality parameters were evaluated: the amount of lycopene, β-carotene, ascorbic acid, total and inverted sugar, sucrose, dry matter soluble solids in fresh tomato matter, also were determined fruit skin and flesh firmness, color indexes (CIE L*a*b*) and calculated hue angle (h°) with chroma (C). For every replication, 10 fully ripen tomatoes were harvested at random. The tomatoes were cut in small pieces immediately after harvesting, homogenized and filtered. The quality of tomato fruit at harvesting was evaluated at the Laboratory of Biochemistry and Technology applying chemical and physical methods of investigations.

Ascorbic acid was determined by titration using 2,6–dichlorphenolindophenol sodium natrium solution [8], sugar the AOAC method [9]. In order to establish carotenoids– β-carotene and lycopene content, 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 [10], using a spectrophotometer "Cintra 202". Dry matter and soluble solids were established using NIR (Near Infrared) method, by transmittance principle using the near infrared spectrophotometer ("NIR Case NCS001A", SacmiImola, S. C. Imola, Italy). Measurement range was 600–1000 nm. Tomato texture measured with texture analyzer ("TA.XTPlus", Stable Micro Systems, Godalming, England). The analysis was conducted in three replications and data processing by "Texture Exponent" program. Color indexes in the space of even contrast colors were measured with spectrophotometer MiniScan XE Plus (Hunter Associates Laboratory, Inc., Reston, Virginia, USA). In the regime of light reflection there were measured parameters L*, a* and b* (correspondingly lightness, indexes of redness and yellowness according to scale CIE L*a*b*) and calculated chroma (C = (a*2+b*2)1/2)

and hue angle (h° = arctan (b*/a*)). The volumes L*, C, a* and b* are measured in NBS units, hue angle ho – in degrees from 0 to 360°. NBS unit is a unit of USA national Standard Bureau and corresponds to one threshold of color distinction power, i.e. the least distinction in color, which the trained human eye can notice [11]. Before each series of measurements spectrophotometer was calibrated with light catcher and standard of white color, the color coordinates XYZ of which in color space are X = 81.3; Y = 86,2; Z = 92.7.

Value L* indicates the ratio of white and black color, value a* –the ratio of red and green color, value b*– the ratio of yellow and blue color.

The data are presented as the averages of three measurements. Color indexes are processed by program Universal Software V.4–10. For the evaluation of data significance statistical programs SAS and ANOVA were used.

III. Results and Discussion

Tomato fruit taste mainly depends on its content of sugar and acids. The higher amount of sugars gives sweeter and more pleasant taste of tomato fruits [12]. One of the main compounds in sugar is sucrose, which can be formed by plants and cyanobacteria but not by other organisms. Sucrose is found naturally in many food plants along with the monosaccharide fructose. In human organism, sucrose is broken down into its constituent monosaccharides, glucose and fructose then molecules of glucose and fructose can be absorbed into the bloodstream [13]. Amount of water soluble portion of the fruit dry matter, about half is in the form of the reducing sugars fructose (25%) and glucose (22%). A further quarter of the dry matter consists of citric (9%), malic (4%) and dicarboxylic amino acids (2%), lipids (2%), and minerals (8%) [6], [14].

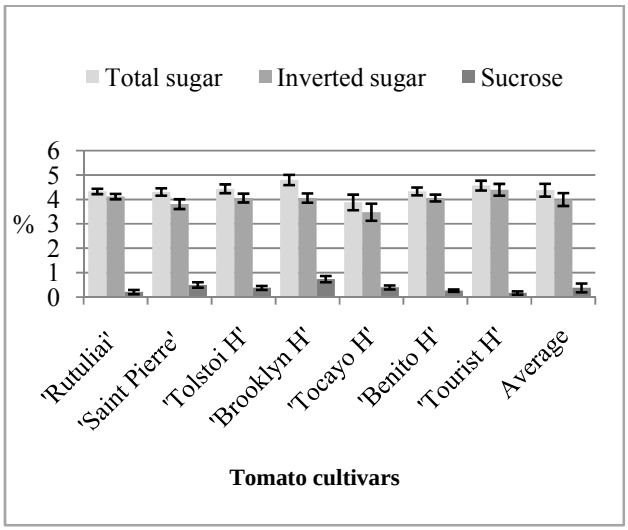

Fig. 1 Sugar content in different tomato cultivars

Consumers and processors value tomatoes with high fruit sugar content; however, most breeding and cultural practices negatively impact this trait. Wild tomato species can accumulate two- to three-fold more fruit sugar than cultivars and are proving to be valuable both as a source of high-sugar *loci* to broaden the genetic base of currently produced cultivars, and as research material to understand this trait [14]. According to our data, it was established that amount of total sugar (Fig. 1) varied from 3.88 ('Tocayo H') till 4.80% ('Brooklyn H'), amount of inverted sugar – from 3.48 ('Tocayo H') till 4.40% ('Tourist H') andamountofsucrose – from 0.17 ('Tourist H') till 0.74% ('Brooklyn H') in fresh tomato fruits.

Tomatoes are a good dietary source of ascorbic acid (Vitamin C); however the ascorbic acid content varies greatly. Many factors contribute to this variation, but environmental growing conditions and cultivar have been reported as having major effects on the ascorbic acid composition. Most researchers have found less than 100% variation in ascorbic acid content between different cultivars for a single season and growing location [15]. The same trends were identified in our experiment where average amount of ascorbic acid of analyzed tomatoes reached 13.31mg $100g^{-1}$. The highest significant amount of ascorbic acid (Fig. 2) was detected in cv. 'Tolstoi H' (16.20mg $100g^{-1}$), cv. 'Tocayo H' (15.80mg $100g^{-1}$) and cv. 'Rutuliai' (14.80mg $100g^{-1}$) in compare with other investigated cultivars. The lowest amount of ascorbic acid (8.20mg $100g^{-1}$) was determined in cv. 'Saint Perrie' fruits.

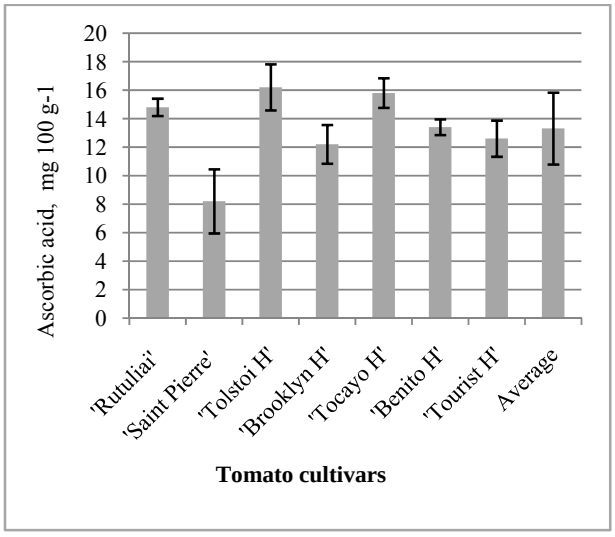

Fig. 2 Ascorbic acid content in different tomato cultivars

Scientist found that relationship between fruit weight and its composition could be mainly related to sink strength through cell division whose intensity modulated by fruit load. An antagonism between fruit fresh weight and dry matter content only detected at the inter-genotypic level, in conditions of competition for assimilates [16]. Soluble-solids content, mainly constituted by sugars, is high in wild tomato species such as *Solanum pimpinellifolium* or *Solanum chmielewskii* with more than 6% and 10% of the fruit fresh weight, respectively, whereas most of the fresh-market tomatoes contain less than 4% soluble solids. A negative relationship between fresh weight and soluble-solids content in the fruit was detected. Amount of fruit total and soluble solids is a major economic parameter for the tomato nutrition value [17].

Our study showed (Fig. 3) that average amount of dry matter was 6.50% and amount of soluble solids – 4.69 % in tomato fruits. Cv. 'Rutuliai', 'Benito H' and 'Tourist H' had distinguished with high amount (respectively 6.72; 6.73 and 6.93%) of dry matter; also cv. 'Tolstoi H' and cv. 'Tourist H' were unrivaled according to the content of soluble solids (4.90 %).

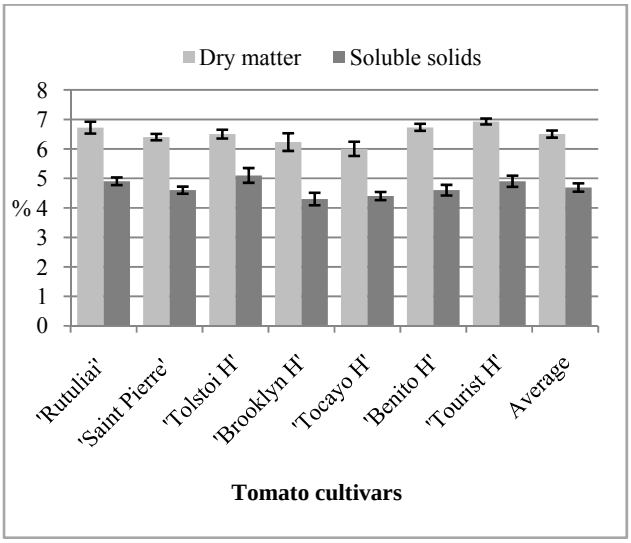

Fig. 3 Dry matter and soluble solids content in different tomato cultivars

In higher plants, carotenoids fulfill an additional important purpose as colorants of flowers and fruits. In these tissues they accumulated in chromoplasts and render bright yellow, orange or red colors to attract animals which facilitate pollination and seed dispersion. Content of carotenoids in tomato fruits can vary several times. Plant genotype and growing conditions are the main factors determining amount of lycopene and β-carotene in tomato [18]-[20]. Scientist reported that concentrations of lycopene and the various phenolic compounds as well as the antioxidant activity were significantly influenced by the tomato cultivar. Content of lycopene found in cv. 'Ramillete', cv. 'Pera' and cv. 'Durina' were >5 mg 100 g^{-1} fresh weight, while the concentration in the other investigated varieties was between 5 and 3mg 100 g^{-1}, with the exception of cv. 'Liso' (less than 2mg 100 g^{-1}) [21]. According to our data (Fig. 4), it was found that average content of lycopene reached 3.42 and β-carotene – 0.41mg 100 g^{-1} in fresh tomato fruits. The highest amount of lycopene (4.95mg 100g^{-1}) was detected in cv. 'Saint Perrie' fruits and the highest content of distinguished with (mg 100 g^{-1}) – in cv. 'Tocayo H'. Tomato hybrid 'Benito H' has distinguished with lowest content of lycopene (2.02 100g^{-1}) and β-carotene (0.20 100 g^{-1}).

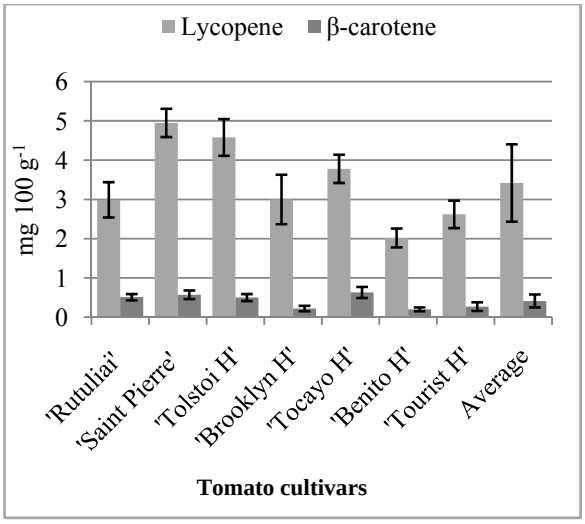

Fig. 4 Carotenoids content in different tomato cultivars

Tomato fruit hardness can be a crucial factor to the consumer choice. Transportability of fruit is very important factor, because the stronger fruits are less vulnerable to harvest, sorting, packaging and transportation of production. Quality of tomato texture is determined by tomato skin and flesh firmness and their relationship. Skin and flesh firmness of tomato fruits are mainly influenced by plant genotype [22].

Tomato skin firmness ranged from 605 N cm^{-2} (cv. 'Saint Perrie') till 1005 N cm^{-2} (cv. 'Benito H') in fully ripens fruits (Fig. 5). Flesh firmness ranged from 71 N cm^{-2} in fully ripens fruits of cv. 'Rutuliai' to 188 N cm^{-2} in fully ripen fruits of cv. 'Benito H'.

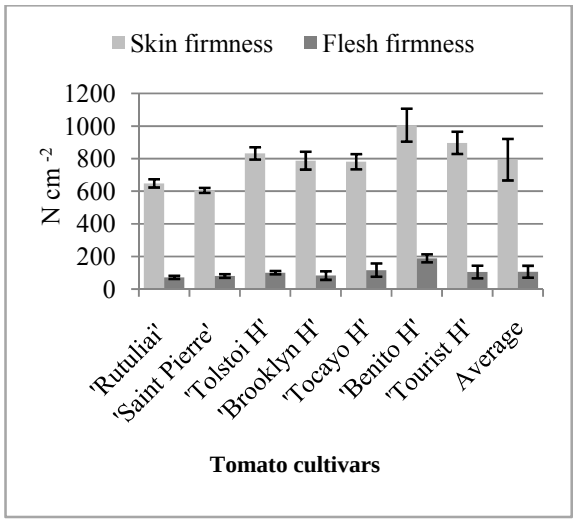

Fig. 5 Fruit skin and flesh firmness in different tomato cultivars

For fresh tomatoes, the two quality attributes that are most important to buyers and consumers are texture and skin color. Human identification of colors is quite complex where sensations like brightness, intensity, lightness and others modify the perception of the primary colors (red, blue, yellow) and their combinations (orange, green, purple, etc.) [23].

Thompson and colleagues [18] made comparison of the color readings taken from tomatoes at the equatorial region with those of the homogenate prepared from the same region showed that the hue of tomato homogenate was a better indicator of lycopene content than tomato surface hue. The previous colorimetric study showed that the ratio between the chromatic co-ordinates of the CIELAB system (a*/b*) separated the fruits of the different varieties as a function of their external color better than the tomato color index [24], [25].

TABLE I
COLOR INDEXES OF DIFFERENT TOMATO CULTIVARS

	L*	a*	b*	C*	h*
'Rutuliai'	44,6	20,8	28,8	35,6	54,2
'SaintPierre'	50,7	20,3	32,9	38,7	58,3
'Tolstoi H'	44,4	26,1	30,2	39,9	49,3
'Brooklyn H'	49,3	12,9	29,8	32,5	66,6
'Tocayo H'	42,3	28,6	30,2	41,6	46,6
'Benito H'	49,6	24,7	36,5	44,1	55,9
'Tourist H'	48,0	19,9	30,6	36,6	57,4
Average	47,0	21,9	31,3	38,4	55,5

According to Table I we can see that tomato fruit lightness (L*) range from 42.3 ('Tocayo H') till 50.7 ('Saint Pierre'), color index a* (redness) varied from 12.9 ('Brooklyn H') till 26.1 ('Tolstoi H'), color index b* (yellowness) – from 28.8 ('Rutuliai') till 36.5 ('Benito H'), chroma (C*) – from 32.5 ('Brooklyn H') till 44.1 ('Benito H') and hue angle (h*) – from 49.3 ('Tolstoi H') till 66.6 ('Brooklyn H').

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