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PRODUCTION AND BIO-ACTIVE POTENTIAL OF OLD TOMATO CULTIVARS ORIGINATING FROM FORMER YUGOSLAVIA

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Abstract

Two old tomato cultivars (*Sarajevski jabucar* and *Novosadski jabucar*) have been studied for the production and bio-active potential. Investigation was performed in Burmir, Sarajevo, BH. The research included fruit weight and the yield of the fresh fruits per hectare. Lycopene was found in fresh fruits both in physiological and technological maturity. Fruit weight was significantly higher for *Sarajevski jabucar* than for *Novosadski jabucar*. Lycopene level in *Sarajevski jabucar* in physiological maturity was from 6.20 to 9.95, and in technological from 8.35 to 13.60 mg per 100 grams of fruit. Old varieties that have become domestic in the Balkan belong to genotypes rich in lycopene. The production potential was at the satisfactory level in some growing areas.

Keywords: tomato, old varieties, yield, level of bioactive matters

Introduction

Physiologically ripe tomato fruit, its refreshing, sweet-sour taste and the biological value contributed to the widespread use in diet. In European countries, 5-10% of the total consumption of vegetables is the tomato. This vegetable has an important place in the diet because of its culinary and nutritional properties. Tomatoes are especially valuable due to the contents of lycopene, which affects the colour of the fruit (Ilić et al., 2012) and acts as an antioxidant. Numerous epidemiological studies have confirmed the role of lycopene as a micronutrient with favourable effects on health (Marković, 2006).

The main function of lycopene is to protect the cell and its structure from the destructive effects of free radicals, which is extremely important in the prevention of many diseases. Lycopene is the most powerful antioxidant from the carotenoid group. It is a powerful deactivator of reactive oxygen forms. Activity of lycopene in slowing the progression of the cell cycle partly explains the slowdown in the spread of certain types of cancer. It can prevent malignant transformation - cellular process that represents the transformation of normal cells into cancer cells. It restores communication channels between cells and helps eliminate carcinogenic substances and toxins from the body. When combined with other natural antioxidants, it slows the oxidation of LDL cholesterol, which is a key factor in the development of atherosclerosis and coronary heart disease. More than 85% of lycopene comes from tomatoes and tomato products. The use of tomato products is recommended to ensure the intake of 40 mg of lycopene, which is sufficient to reduce LDL cholesterol and the development of arteriosclerosis and heart disease. (Rao and Agarwal, 1999). The main task of antioxidants is to protect the body from oxidative stress and condition in which there is an

imbalance between free radicals and antioxidants that fight against them. Antioxidant functions of the lycopene are associated with decrease of DNA damage, malignant transformation and biological reduction of biological oxidative damage of proteins, lipids and other cell parts (Shi and Le Maguer, 2000).
The content of lycopene in fresh tomato fruit ranges from 85 to 181 mg/kg. During three growing seasons, lycopene content was different for the same varieties and ranged from 88, 101 to 106 mg/kg (Garcia and Barrett, 2006). Results of the previous researches proved that the concentration of lycopene depends on the vegetation season, location, variety and degree of ripeness. Besides genetic factors, the content varies depending on crop management, especially depending on the input of nutrients into the soil (nitrogen, phosphorus, potassium and calcium) and temperature variations (Dumas et al., 2003; Adeniyi and Ademoyegun, 2012). The content of lycopene is genetically determined, but is strongly influenced by environmental conditions. Lycopene content can be changed by reducing or increasing the amount of potassium (Zdravkovic et al., 2001; Zdravkovic et al., 2007). Agronomic aspects of irrigation i.e., reduced irrigation treatments and acceptable yield, greatly alter or increase the dry matter content of the fruit, and thus increases the lycopene content (Savic et al., 2004). The level of lycopene is also different depending on the place of growing: an open field or protected area (Jarquín-Enríquez et al., 2013; David et al., 2013). Growing season can affect different lycopene content in fruits (Assimakopoulos, 2010). Recently, differences and variations in the lycopene content in tomato grown in organic systems versus the conventional way of farming was studied (Riahi et al., 2009; Barrios-Masias et al., 2011; Riahi and Hdider, 2013).
The aim of this study was to determine the lycopene content as an antioxidant and yield of two tomato varieties originating from the former Yugoslavia (Novosadski and *Sarajevski jabucar*), which is now cultivated in large areas. High quality and lycopene content of these varieties involves them in the selection of varieties that are intended for organic production at the Balkan Peninsula, where these old varieties are traditionally being grown.

Materials and Methods

The study was carried out on the site: Butmir (Sarajevo) (cca 500 m, M.S.L), in years 2010 and 2011, on brown valley soil. Features: fruit weight, yield of fresh fruit per acre of the old varieties: *Novosadski jabucar* and *Sarajevski jabucar* were tested. Chemical properties were investigated on fresh fruits, while lycopene was detected in fresh fruits and in tomatoes juice. The tests were performed according to methodology of testing new and foreign tomato varieties issued by the Federal Ministry of Agriculture, Water Management and Forestry (2006.) in random block system with 5 replications.
The number of plants in the experiment was 100%. Irrigation was performed by drip system. Studied plants reached the stage of five flowers. After this stage the plant top was cut off. Measurements were taken in six harvests. During the study, tomato fruit samples were taken for determination of the bioactive properties of variety Vračar (2001):
Dry matter (%) – by drying at 102-105^{0}C
The degree of acidity (%) – titermetrically
Total sugars – according to Luff-Schoorl gravimetrically
Lycopene – spectrophotometrically (Beerh and Siddappa, 1959)
Results were analyzed by applying analysis of variance method. Differences among the varieties were expressed by the least significant difference (LSD test).

Agro-ecological conditions of cultivation

Table 1. Chemical traits of soil (location: Butmir, B&H)

Year	pH H_2O	KCl	Total N %	Humus %	P_2O_5 mg / 100g	K_2O_2 mg / 100g
2010	6,02	-	0,08	1,80	8,45	14,20
2011	6,28	5,45	0,230	1,75	11,50	8,50

Soil in 2010 and 2011 was poorly supplied with nitrogen and potassium. The land had a higher content of phosphorus in 2009 than in 2010.

Table 2. Average monthly air temperature (ºC) for 2010 and 2011 (location Butmir, B&H)

Year	I	II	III	IV	V	VI	VII	VIII	IX
2010	0,4	1,8	5,2	10,4	14,4	18,1	20,8	20,9	15,0
2011	0,2	0,6	5,2	11,0	14,0	18,9	20,5	21,7	19,1
Annual average (1996-2005)	0,07	1,02	5,27	9,58	15,16	18,7	20	14,4	11,1

Table 3. Maximal monthly air temperature (ºC) in 2010 and 2011 (Location: Butmir, B&H)

Year	I	II	III	IV	V	VI	VII	VIII	IX
2010	15,4	14,2	22,4	25,2	28,0	34,4	34,9	20,9	15,0
2011	13,9	14,4	22,5	24,9	29,8	33,2	37,9	37,5	34,5
Annual average (1996-2005)	16,7	19,6	26,6	29,8	32	34,2	38,2	37,4	30,8

Table 4. Minimal monthly air temperature (ºC) 2010 and 2011

Year	I	II	III	IV	V	VI	VII	VIII	IX
2010	-11,4	-13,5	-9,5	1,4	5,6	5,7	9,4	20,9	15,0
2011	-9,9	-10,2	-10,3	0,1	0,8	7,6	9,1	8,9	6,7
Annual average (1996-2005)	-21	-16,4	-16,8	-6,2	0,5	2,5	5,4	5,5	2,8

Table 5. Monthly precipitation (l/m^2) in 2010 and 2011

Year	I	II	III	IV	V	VI	VII	VIII	IX
2010	161,3	95,9	63,1	59,1	93,2	181,5	19,2	20,9	15,0
2011	37,9	35,9	40,7	32,7	103,6	76,3	134,4	4,8	38,9
Annual average (1996-2005)	70	71,4	50,8	85,1	70,6	71,8	74,5	65,3	124

Temperatures during this study (2010 and 2011) were in the range of annual average.

Results and discussion

Table 6. Fruit weight (g)

Characteristic	*Sarajevski jabucar*		*Novosadski jabucar*	
	2010.	2011.	2010.	2011.
Fruit weight (g)	184	254	93	88

Fruit number and fruit weight were varietal characteristics. Varieties with large fruits have a lower number of fruits per plant and in inflorescence, and vice versa (Takač, 2001).
Sarajevski jabucar had higher fruit weight comparing to *Novosadski jabucar*, during two years of research. The average fruit weight was from 88 to 93 grams for *Novosadski jabucar*, which was less than results obtained by (Krstić, 2006) in Vojvodina growing conditions. Fruit weight of *Sarajevski jabucar* was from 184 (2010) to 254g (2011), Table 6. Great variation of fruit weight within a genotype which is a variety bred from the population is in accordance with results obtained by Zdravković (1997). She researched old varieties that varied a lot within the genotype.

Table 7.Impact of factors of variety and year on the yield (t/ha)

Variety	Year				Average yield
	2010.		2011.		
	t/ha	Rel.	t/ha	Rel.	t/ha
Sarajevski jabucar	47,22**	157	30,84**	130	39,03*
Novosadski jabucar	29,92	100	23,68	100	26,80
LSDp=5%	*2,24*		*0,79*		*8,84*
LSDp=1%	*3,52*		*1,127*		*14,62*

Yield of *Sarajevski jabucar* were significantly higher in 2010 and 2011 comparing to *Novosadski jabucar*. In 2010 yield of *Sarajevski jabucar* was 57% higher, while in 2011 it was 30% higher comparing to *Novosadski jabucar*. Biological potential of some plant species and varieties for synthesis of organic matters is genetically controlled (Sarić, 1984).

Table 8. Chemical composition of tomato fruits per harvest

Physiological maturity of the fruit	Date of yield	*Sarajevski jabucar*	*Novosadski jabucar*
Dry matter (%)	9.8.2010.	4,98	5,73
	26.8.2011.	4,65	6,05
Total sugars (%)	9.8.2010.	3,85	4,80
	26.8.2011.	3,30	4,08
Acidity, expressed as acetic (g/100 ml of product)	9.8.2010.	0,45	0,27
	26.8.2011.	0,33	0,43
Lycopene (mg/100 g)	9.8.2010.	-	-
	26.8.2011.	9,81	9,50

Chemical-technological analysis of tomato samples gave: % of dry matter, % of total sugars and acidity expressed as acetic in 2010 and 2011, and lycopene in 2011. *Sarajevski jabucar* had lower percentage of dry matter and total sugars in 2010 than in 2011. *Novosadski jabucar* had higher % of dry matter in 2011, and higher % of total sugars in 2010. Acidity in fruits

expressed as acetic acid was lower in *Sarajevski jabucar* than in *Novosadski jabucar* in 2011, while it was vice versa in 2010.
The acid content greatly affects the technological value of tomatoes. The high acidity (low pH) determines the mode of conservation of various tomato products (pasteurization, not sterilisation like other vegetables). Acid content in tomatoes varies depending on the variety and maturity (KrstiC, 2006).

Table 9.Percentage of dry matter, total sugars, acids and lycopene per harvest in Butmir - Sarajevo

Date of harvest	Old cultivar	Dry matter %	Total sugars %	Total acids %	Lycopene (mg/100g)	
					Physiological maturity	Technological maturity
26.08.2011.	*Sarajevski jabucar*	***4.65***	***3.30***	***0.33***	***9.81***	***10.95***
26.08.2011.	*Novosadski jabucar*	***6.05***	***4.08***	***0.43***	***9.50***	***10.63***
02.09.2011.	*Sarajevski jabucar*	***5.36***	***3.83***	***0.50***	***9.95***	***11.15***
02.09.2011.	*Novosadski jabucar*	***6.07***	***4.32***	***0.53***	***9.74***	***10.05***
09.09.2011.	*Sarajevski jabucar*	***5.01***	***3.06***	***0.24***	***8.50***	***9.95***
09.09.2011.	*Novosadski jabucar*	***6.67***	***4.70***	***0.28***	***6.76***	***8.23***
16.09.2011.	*Sarajevski jabucar*	***4.66***	***2.66***	***0.37***	***7.40***	***8.35***
16.09.2011.	*Novosadski jabucar*	***6.60***	***4.40***	***0.46***	***6.15***	***7.30***
21.09.2011	*Sarajevski jabucar*	***5.19***	***3.12***	***0.38***	***6.20***	***9.54***
21.09.2011.	*Novosadski jabucar*	***5.91***	***3.36***	***0.62***	***5.84***	***9.85***
27.09.2011-	*Sarajevski jabucar*	***6.04***	***3.84***	***0.30***	***7.56***	***13.60***
27.09.2011.	*Novosadski jabucar*	***5.97***	***3.80***	***0.33***	***6.80***	***9.20***

Novosadski jabucar had higher level of dry matter, total sugars and total acids.
Balacheva et al. (2011) determined by biochemical analyzes, no significant differences between the genotypes of yellow and red fruit in the content of dry matter and sugar. The moment of harvest, a stable survival of lycopene and other biochemical parameters in stages after picking are essential for selecting genotype (Brashlyyanova and Ganeva, 2009).
Lycopene content was higher in fruits of *Sarajevski jabucar*. Lycopene content was higher in technological than in physiological maturity. Changes in lycopene level increase or decrease antioxidative impact and it is desirable to find a tomato genotypes with high content of lycopene in fruit (Ilahy et al., 2011). Lycopene level in *Sarajevski jabucar* in physiological maturity ranged from 6.20 to 9.95, and in technological maturity from 8.35 to 13.60 mg/100

grams of fruit. In studies of ZdravkoviC et al. (2002) lycopene levels were are significantly lower than in our tests. The researched genotype *Novosadski jabucar* had the average value of 5.6 mg%, which is not in accordance with the results of our study. The level of lycopene in *Novosadski jabucar*, in physiological maturity ranged from 5.84 to 9.74, and in technological maturity from 7.30 to 10.63 mg/100grams of fruit. Lycopene level varied depending upon variety and yield. The degree of expression of lycopene depends on the time of maturity. These tests included the 6 harvests, so the level of lycopene was steady because the fruits were at the same stage of maturation (Riggi et al., 2008). With ripening, the level of lycopene is changing and growing, even in the post-harvest period. Tomato fruits with climacteric breathing are able to develop normal colouring after harvesting and the synthesis of the pigments continues during ripening (Ilić i sar., 2007).

Reduction of total acid and lycopene in heterozygous *rin/rin+* F1 tomato hybrids was not statistically significant. There were no statistically significant difference among hybrids and lines in chemical compound, accept for the level of lycopene. According to Makovic et al. (2010) mother components of hybrids (*rin/rin* genotype) have low level of lycopene (6,0-6,8 mg%) comparing to hybrids with significantly higher level of lycopene (13,2-22,4 mg%).

Results of the analysis of tomato juice on the content of lycopene obtained in Butmir 2011 were similar to results obtained by Markovic (2002). The content of lycopene ranges in varieties of pink and red fruits from 3.7 to 5.9 mg (Balacheva et al., 2011).

Conclusion

Old and domesticated tomato varieties grown in the Western Balkan belong to the tomatoes that are rich in flavour and aroma, with satisfactory yield and acceptable level of resistance to diseases. These genotypes represent good start selection material for breeding varieties and hybrids intended for this market, where the consumers are used to tomato of well defined taste and aroma and, on the other hand, well adapted to ecological conditions of Balkan.

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