Available online: www.notulaebotanicae.ro
Print ISSN 0255-965X; Electronic 1842-4309
Not Bot Horti Agrobo, 2016, 44(2):477-483. DOI:10.15835/nbha44210332

Notulae Botanicae Horti Agrobotanici Cluj-Napoca

Original Article

Assessment of Ascorbic Acid, Polyphenols, Flavonoids, Anthocyanins and Carotenoids Content in Tomato Fruits

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Abstract

The increased interest in organic tomatoes production demands breeders to develop new cultivars, which besides suitability in low-input production system and marketable quality, have to exhibit high nutritional value, including health-promoting compounds. In this respect, this paper aimed to assess and compare the nutritional value of four Romanian tomato cultivars, two with determinate growth ('Argeș 11' and 'Argeș 123') and two with indeterminate growth ('Costate 21' and 'Ștefănești 22'), created and recommended for organic production in open field and protected cultivation. The tomato cultivars were laid out in a high plastic tunnel crop and the tomato fruits were evaluated as chemical composition, being determined the following parameters: moisture, ash, soluble solids, pH, acidity and content in some antioxidant compounds, such as vitamin C, polyphenols, flavonoids, anthocyanins, lycopene and β-carotene. Considering some chemical parameters important in revealing tomato flavor, such as soluble solids, pH and acidity, 'Ștefănești 22' cultivar showed the best ratio among them. The differences in antioxidant composition among cultivars were not statistically significant ($P>0.05$) for most of the analyzed parameters, with the exception of lycopene content which showed significant variation. Thus, 'Costate 21' showed the highest amount of lycopene within indeterminate cultivars (17.49 mg 100 g^{-1} FW), while 'Argeș 11' showed the highest amount of lycopene within determinate cultivars (13.92 mg 100 g^{-1} FW). According to the nutritional value of cultivars assessed in this study, 'Costate 21' is the best recommendation for greenhouse cultivation while 'Argeș 11' is the best recommendation for open field cultivation.

Keywords: anthocyanins, β-carotene, flavonoids, lycopene, organic farming, tomatoes, vitamin C

Introduction

Vegetables are complex source of organic compounds, minerals, vitamins, phytoncides and antimicrobial substances important to the human body. Their high nutritional value but low energy contribution and the variety of biological phytonutrients recommends them as important part of a balanced diet (Butnariu and Butu, 2015; Duma, 2015).

Vegetables quality is a complex issue but the standards of quality, established globally by the Codex Alimentarius of the Food and Agriculture Organization (FAO) and the World Health Organization (WHO), refers only to features concerning market value of vegetables. Although maximum limit concentrations for nitrates and pesticides are included, important internal quality traits of vegetable products such as texture, flavor and health-related compounds are not considered (Rouphael *et al.*, 2012). However, in the last years consumers demand determined breeders to breed and farmers to select cultivars which besides high productivity and market requested quality (i.e. size, shape, colour, freshness, absence of defects etc.) have to fulfill requirements for a good taste, high minerals content and bioactive compounds (i.e. vitamins, health-promoting compounds), thus cultivars with a high nutritional value.

Received: 21 Mar 2016. Received in revised form: 15 Oct 2016. Accepted: 08 Dec 2016. Published online: 14 Dec 2016.

Tomato (*Lycopersicon esculentum* L.) is the most widely cultivated and the second worldwide consumed vegetable (FAOSTAT, 2013). It is consumed fresh, cooked or after processing in a wide range of products (canned tomato, tomato juice, ketchup, pasta, sauces and soups). Tomato has a high content of water (94.52%) and a low caloric value (18 kcal 100 g^{-1}) but it is a good source of vitamins (A, C, K, E and B complex) and minerals (K, P, Mg, Ca, Fe, Na and Zn) (USDA National Nutrient Database for Standard Reference, 2016). More specifically, tomato is the third source of vitamin C in our diet and the fourth for vitamin A (due to its content in β-carotene and to the large amount consumed) while potassium, phosphorus, magnesium and iron, among the minerals, are implied in the normal activity of muscles and nerves (Bhowmik *et al.*, 2012).

Tomato is an important source of antioxidants such as polyphenols, ascorbic acid, tocopherols, β-carotene and lycopene which are not compulsory in diet but, when present in sufficient level, prevent chronic diseases through the inhibition of the harmful effects of free radicals (Mostapha *et al.*, 2014). Tomato can provide an important proportion (85%) of antioxidants in the human diet through carotenoids and phenolic compounds (Aoun *et al.*, 2013; Liu, 2013). The most important natural antioxidant present in tomato is lycopene (Brandt *et al.*, 2006) which represents 90% of the total carotenoids and which is responsible for the deep red colour of ripe tomatoes and their derived products (Ibitoye *et al.*, 2009; Ilahy *et al.*, 2015). The dietary intake of lycopen has been reported to be associated with decreased risk of cancer and cardiovascular diseases (Soares *et al.*, 2014). The lycopene from tomato is a highly available source since, in contrast with other phytonutrients, does not decrease by tomatoes processing, but rather significantly increases. Moreover, there are studies which report that the bioavailability of lycopene in heat-processed tomato products is higher than in fresh tomatoes (Abushita *et al.*, 2000; Bhowmik *et al.*, 2012).

The world total land area cultivated with tomato in 2013 (FAOSTAT) reached 4.7 million ha. Considering the total land area cultivated with tomatoes in 2015 in Europe (De Cicco, 2016), Romania, with 24,300 ha, occupies the third place after Italy (107,200 ha) and Spain (58,200 ha), even if followed them at high distance, but it is situated before Portugal (18,700 ha), Greece (17,200 ha) and Poland (13,800). Unfortunately the situation is not the same when referring to the production quantity, where the leading countries are Italy (6.410 Mt) and Spain (4.839 Mt) followed by Portugal (1.407 Mt) and Greece (1.086 Mt).

Romania with 464,500 tons was surpassed even by Netherlands, which harvest 890,000 tons from only 1,800 ha. This is due, on the one hand, to the small average area assigned for growing vegetables in Romania (0.3 ha), which is under the EU average (1.7 ha) and means vegetable farms with less than 1 ha. On the other hand, the outdated technologies and production methods besides the lack of highly yielding cultivars well adapted to cultivation in our country should be considered. A good solution for small vegetable farms in Romania could be the organic production since it does not imply high technological investments (Saracin, 2016). Moreover, organic vegetables production under protected cultivation (greenhouse, high tunnels) has potential for out-of season market supply (Tuzel *et al.*, 2001).

More than 95% of cultivars used in organic vegetable production are bred for the conventional high-input system, thus lacking important traits required under organic low-input sector (Murphy *et al.*, 2007; Lammerts *et al.*, 2011). Considering the scarce availability of Romanian vegetable cultivars, including tomato, researchers plan to increase in the next five years the vegetable assortment by regeneration of local varieties, creation of new hybrids recommended for protected cultivation and creating varieties for traditional culture and organic production (Scurtu *et al.*, 2016)). In this respect at I.N.C.D.B.H. Stefănești, Argeș, four tomato cultivars ('Argeș 11', 'Argeș 123', 'Costate 21' and 'Ștefănești 22') recommended for organic farming were obtained and grown in a high plastic tunnel, in 2014, in order to be evaluated as yielding potential, diseases tolerance and behaviour at low fertilization inputs. Considering that nutritive value represents a useful approach in selection of cultivars with better health-promoting properties, this work aimed to evaluate the chemical composition of the tomato fruits from these cultivars, being determined the following parameters: moisture, ash, soluble solids, pH, acidity and content in some antioxidant compounds, such as vitamin C, polyphenols, flavonoids, anthocyanins, lycopene and β-carotene."

Materials and Methods

Plant material

Four tomato cultivars, two with determinate growth ('Argeș 11' and 'Argeș 123') and two with indetermined growth ('Costate 21' and 'Ștefănești 22'), were grown in 2014 under organic and low-input production conditions in a high plastic tunnel at I.N.C.D.B.H. Ștefănești, Argeș. One kg of healthy fruits, free of defects, uniform in size and harvested at red ripe stage for each cultivar, randomly selected, were collected for analysis.

Tomato fruits were washed and wiped with a paper towel, then cut into slices and transformed into a homogeneous mash with a vertical mixer. The samples were stored at -4 °C until to perform all analyses.

Chemical substances

Polyphenols (gallic acid), flavonoids (catechins) and Folin-Ciocalteu standards were purchased from Redox Bucharest - Sigma Aldrich, Dako, Epp. Romania. Methanol, ethanol, acetone, hexane, sodium hydroxide, sodium carbonate, sodium nitrite, hydrochloric acid, potassium iodide, starch, potassium iodate and aluminum chloride were purchased from Merck Romania SRL.

Chemical analysis and equipment

The moisture (water content) was determined gravimetrically by drying 1 g tomato in an oven at 105-110 °C for 2 hours (AOAC, 1999) and expressed as g 100 g^{-1} FW. The ash content was determined by calcination of residue (resulted after extraction of water content) for 4 hours at 550 °C (AOAC, 1999) and expressed as g 100 g^{-1} DW. Soluble solids were determined using a Kruss DR201-95 refractometer and the results were reported as °Brix at 20 °C (AOAC, 1999). pH was measured by the squeezing of tomatoes, using a multimeter C-561, after calibration of the apparatus with solutions of pH 7 and 4, respectively (AOAC, 1999).

The acidity was determined by titration of the tomato samples with a solution of NaOH 0.1 M (AOAC, 1999), using the bromothymol blue (as indicator) and the results were expressed in g L^{-1} citric acid.

Vitamin C was determined by iodometric method (AOAC, 1999). In a volumetric flask, over 5 g of tomato puree was added solution of hydrochloric acid 2% up to a final volume of 100 mL. After 15 minutes of extraction, the mixture was filtered and 5 mL filtrate was put in an Erlenmeyer flask of 100 mL, followed by adding 5 mL of distilled water, 3 mL solution of potassium iodide 1% and 2 mL of starch 1%. The obtained sample was titrated with a solution of potassium iodate 0.0017 M, freshly prepared. The content of vitamin C, expressed in mg 100 g^{-1} FW, was determined based on the volume of potassium iodate used for the titration, according to the mass of tomato from each sample. The blank sample was prepared under the same conditions as tomato samples.

Quantitative determination of polyphenols was performed by spectrophotometric method using a UV-Vis spectrophotometer PerkinElmer Lambda25. The methodology proposed by Singleton and Rossi (1965) was respected. The principle of method is based on forming a blue colored compound between phosphotungstic acid and polyphenols, in an alkaline medium. For analysis, a methanolic extract of tomato with concentration 1 mg/mL was used. The concentration of polyphenols was calculated using the calibration curve, performed under the same conditions as the sample, using the absorbance values at the maximum absorption, located at 750 nm. To obtain the calibration curve, a stock solution of gallic acid with concentration of 100 mg/L was used. 0.5 mL of the methanol extract of tomato was added to a 10 mL flask containing 5 mL of distilled water and 0.5 mL of Folin-Ciocalteu reagent. After 5 minutes of rest, 2 mL solution of sodium carbonate 10% was added, then diluted with distilled water up to the final volume of 10 mL. After 2 hours of rest, absorbance of the samples was measured and the concentration of polyphenols was estimated. The content of polyphenols was expressed as mg gallic acid equivalent (GAE) 100 g^{-1} FW.

Quantification of flavonoids was performed by spectrophotometric method using a UV-Vis spectrophotometer PerkinElmer Lambda25. The methodology proposed by Zhishen *et al.* (1999) was respected. The principle of method is based on the formation of a yellow-orange-colored compound by the reaction of flavonoids and aluminum chloride. For analysis, a methanolic extract of tomato with concentration of 1 mg/mL was used. The concentration of the flavonoid has been calculated using the calibration curve, performed under the same conditions as the sample solutions, using the absorbance values of the maximum absorption, located at 510 nm. To obtain the calibration curve, a stock solution of catechin with concentration of 100 mg/L was made. 1 mL of methanolic extract of tomato was added to a 10 mL volumetric flask containing 4 mL of distilled water and 0.3 mL of sodium nitrite 5%. After 5 minutes of rest, in the volumetric flask was added 0.3 mL of aluminum chloride 10%. After 5 minutes, 2 mL solution of sodium hydroxide 1M was added and was diluted with distilled water up to the final volume of 10 mL. The solution absorbance was measured at 510 nm. Flavonoid concentration was estimated using the calibration curve of catechins and, finally, the content of flavonoids was expressed as mg catechin equivalent (CE) 100 g^{-1} FW.

Quantitative determination of anthocyanins was performed by spectrophotometric method using a UV-Vis spectrophotometer PerkinElmer Lambda25. The methodology proposed by Distefano and Cravero (1989) was used. Anthocyanins extraction was performed with dilute hydrochloric acid 1%, at 70 □. The clear supernatant was cooled and passed to a 1000 mL volumetric flask. Other 3-5 extractions were made up to the complete decolorizing of the tomato fragments and the supernatant was collected each time in the volumetric flask. Quantitative determination of anthocyanins was accomplished by measuring the optical density of the supernatant sample at 520 nm and the result was expressed as cyanidin-3-O-glucoside equivalent mg 100g^{-1} FW.

Quantitative determination of carotenoids (lycopene and β-carotene) was performed with a UV-Vis spectrophotometer PerkinElmer Lambda25, based on the methodology proposed by Zechmeister and Polgar (1943).

For extraction of the two compounds, 1 g of tomato puree was used, which was added over 25 mL mixture of solvents (hexane: ethanol: acetone in 2:1:1 volume ratio). The mixture was stirred for 30 minutes at 1500 rpm and then was added 10 mL of distilled water and stirring was continued for another 10 minutes. After 15 minutes of rest, the phases were separated. The concentration of carotenoids, expressed as mg 100 g^{-1} FW, was calculated using molar extinction coefficients of 184900 $M^{-1}cm^{-1}$ at 470 nm and 172000 $M^{-1}cm^{-1}$ at 503 nm for lycopene (Rubio-Diaz *et al.*, 2011; DeRitter and Purcell, 1981), while 108427 $M^{-1}cm^{-1}$ at 470 nm and 24686 $M^{-1}cm^{-1}$ at 503 nm for β-carotene in hexane, respectively (Zechmeister and Polgar, 1943).

Statistical analyses

The reported results represent means of triplicates for all chemical parameters. The data were processed by analysis of variance (ANOVA) and the mean values for all determined parameters were separated with Duncan's multiple range tests at 5% level of probability.

Results and Discussion

Some chemical parameters of the analyzed cultivars, such as moisture, ash, soluble solids, pH and acidity are presented in Table 1.

The water content of ripe tomato fruits is high (around 94%) offering them freshness and crisp texture at harvest time, having important hydration effect on human body. The water content of the four cultivars assessed in this study ranged from 93.22% for 'Ștefănești 22' to 95.14% for 'Costate 21', results which are in agreement with those reported by Hernandez Suarez *et al.* (2008) and Gupta *et al.* (2011). However, no significant differences among cultivars were observed ($P>0.05$).

The ash content in tomato fruits ranged from 6.5% for 'Ștefănești 22' to 9.5% for 'Costate 21'. Higher ash contents were revealed in 'Costate 21' from indeterminate cultivars and in 'Argeș 123' from determinate cultivars, both with significant differences ($P<0.05$) as compared with the other two studied cultivars. These results are close to those reported by Gupta *et al.* (2011) in two tomato cultivars grown in North-Western India (7.21% and 7.24%, respectively) and by Pinela *et al.* (2012) in four tomato cultivars grown in North-Eastern Portugal (values between 5.4% and 7.4%).

Soluble solids (SS) is one of the most important quality factor for most fruits and represents a great part (75%) of the total solids (TS) content in tomatoes, being an indicator of sweetness, since reducing sugars (glucose and fructose) are the main soluble components of tomatoes (Malundo *et al.*, 1995). Organic acids, lipids, minerals and pigments are the remaining soluble solids besides a very small quantity of sucrose. The total solids of tomatoes consist also of insoluble solids (ISS) (25%) which include proteins, cellulose, hemicellulose, pectins and polysaccharides, which determine fruit juice (Aoun *et al.*, 2013). Salunkhe *et al.* (1974) and Moneruzzaman *et al.* (2008) reported the increase of soluble solids content with the tomatoes ripening and maturation, because of the polysaccharide biosynthesis or degradation. The amount of soluble solids of the four studied cultivars ranged from 3.4 °Brix for 'Argeş 11' to 4.8 °Brix for 'Ştefăneşti 22', being comparable with the results obtained by Aoun *et al.* (2013) and Duma (2015), who reported in different tomato cultivars values between 2.02 and 4.57 °Brix and between 4.6 and 6.3 °Brix, respectively. When comparing the soluble solids content among the assessed cultivars, only small variation can be observed, the highest and statistical significant difference being obtained in 'Ştefăneşti 22'.

pH and acidity are important parameters for assessing tomatoes' quality. The pH for the analyzed cultivars ranged from 3.88 to 4.16, the obtained values being very close and included in the optimum pH range (3.7-4.5), reported by Sulieman *et al.* (2011). The same author specifies that the optimum pH range is considered to be a limiting factor for the preservation and storage of tomatoes in the form of tomato pasta, while Foolad (2007) states also that lower pH (<4) reduces the risk of pathogen growth in tomato products. The evolution of pH during storage of fruits for two weeks under ambient conditions was also considered in this study, and the results are showed in Fig. 1. One week after harvest, pH values for all cultivars were included in the optimum pH range but two weeks after harvest, pH values exceeded the upper limit. The increased pH values are due probably to tomatoes' altering at two weeks after harvest. These results show that tomatoes should be consumed fresh, within two weeks from harvest. Statistical significant differences in pH only for 'Argeş 123' and in acidity only for 'Stefăneşti 22', as compared with all the other tested cultivars, were recorded.

The acidity level in tomatoes is associated with the sensory attributes, such as flavor and astringency. Citric acid is the most abundant acid from tomatoes and contributes most to acidity (Aoun *et al.*, 2013). Acidity values for the four tomato cultivars ranged from 4.73 g L^{-1} for 'Argeş 123' to 5.87 g L^{-1} for 'Stefăneşti 22'. These results are in agreement with those of Aoun *et al.* (2013) who reported values of titratable acidity ranging between 2.9 and 7.9 g L^{-1} in an experiment with traditional varieties of tomato grown in Tunisia. If considered that titratable acidity has no significant effect on tomato flavor unless pH is low, as stated by the same author, it seems that 'Stefăneşti 22' is the most flavored cultivar because it has the highest content of SS, the lowest pH and the highest acidity.

Tomatoes have antioxidant features due to the presence of some bioactive compounds, such as vitamin C, polyphenols, flavonoids, anthocyanins and carotenoids (Cernîşev and Şleagun, 2007), which are considered indicators of health, thus operating as biomarkers of food quality. Since the level of bioactive compounds can vary with genotype (Slimestad and Verheul, 2009) it was considered necessary to study the antioxidant compounds content in the tomato fruits of the tested cultivars in order to determine their health benefit attributes.

Vitamin C is a major natural antioxidant in tomatoes, which react with oxygen, thus removing it in a closed system. In the analyzed cultivars, the vitamin C content ranged from 22.61 mg 100 g^{-1} FW in 'Argeş 11' to 32.21 mg 100 g^{-1} FW in 'Costate 21' (Table 2). The result is in line with that reported by Ilahy *et al.* (2016) who revealed a vitamin C content ranging from 22.18 to 27.16 mg 100 g^{-1} FW. No significant variation in vitamin C content among cultivars was revealed, with the exception of 'Costate 21' which for the result is comparable with open field grown tomatoes, even if the tested cultivars were grown in high plastic tunnel. The evolution of vitamin C content in tomato fruits during two weeks of storage under ambient conditions is presented in Fig. 2. Higher decrease in vitamin C was revealed by 'Argeş 11', 'Argeş 123' and 'Ştefăneşti 22' with 50% at 7 days after harvesting and 75% at 14 days after harvesting, while lower decrease was recorded in 'Costate 21' with 35% at 7 days after harvesting and 65% at 14 days after harvesting, respectively. The observed decrease of vitamin C content during storage is a result of ascorbic acid degradation due to oxidation under the presence of oxidizing enzymes. These results are in agreement with findings of Christakou *et al.* (2005) who reported a decrease of vitamin C content in melon during storage period. In an experiment with fresh market tomatoes harvested at mature green stage, Tigist *et al.* (2013) reported an initially increase of vitamin C content during storage under ambient conditions (approximately for three weeks) followed by a subsequent decrease.

Tomato fruits are rich in polyphenols and flavonoids, compounds of high interest in the food industry and the

Table 1. Some chemical parameters in tomato fruits of the four assessed cultivars

Variety	Moisture (g 100 g^{-1} FW)	Ash (g 100 g^{-1} DW)	Soluble solids (°Brix)	pH at 20 °C	Acidity (g citric acid L^{-1})
'Costate 21'	95.14 a	9.5 a	3.7 b	3.88 b	5.01 b
'Argeş 11'	94.92 a	7.1 b	3.4 b	3.88 b	5.01 b
'Stefăneşti 22'	93.22 a	6.5 b	4.8 a	3.87 b	5.87 a
'Argeş 123'	95.12 a	8.9 a	4.1 ab	4.16 a	4.73 b

Note: values followed by the same letters not significantly different at P≤0.05, according to Duncan's test

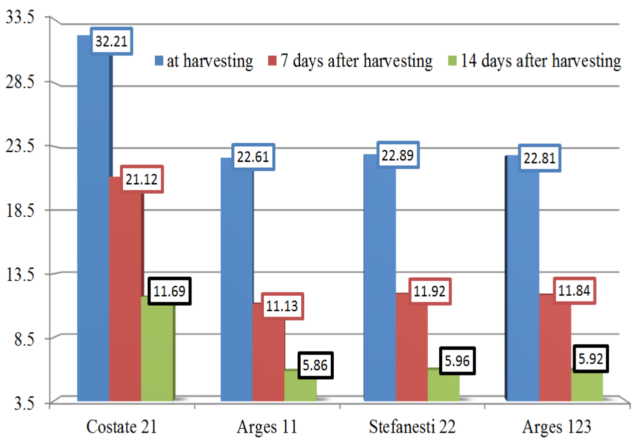

Fig. 1. The evolution of pH during storage of tomato fruits for two weeks under ambient conditions

Table 2. Some antioxidant compounds in tomato fruits (mg 100 g^{-1} FW) of the four assessed cultivars

Variety	Vitamin C	Polyphenols	Flavonoids	Anthocyanins	Lycopene	β-carotene
'Costate 21'	32.21 a	2061 b	347 a	13.66 b	17.49 a	0.45 c
'Argeş 11'	22.61 b	2178 a	222 b	22.77 a	13.92 b	1.45 b
'Ştefăneşti 22'	22.89 b	2028 ab	206 b	14.23 b	11.17 c	1.88 a
'Argeş 123'	22.81 b	1992 c	194 b	22.85 a	8.84 d	1.63 ab

Note: Polyphenols are expressed as mg gallic acid equivalent (GAE) 100 g^{-1} FW; flavonoids are expressed as mg catechin equivalent (CE) 100 g^{-1} FW; anthocyanins are expressed as mg cyanidin-3-O-glucoside equivalent 100 g^{-1} FW. Values followed by the same letters not significantly different at P≤0.05, according to Duncan's test

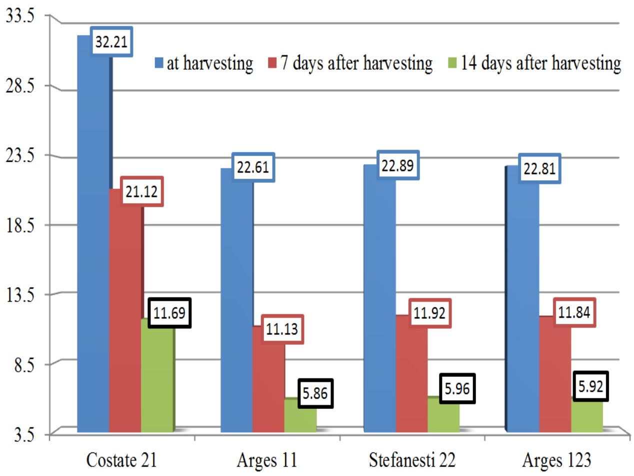

Fig. 2. The evolution of vitamin C (mg 100 g^{-1} FW) during storage of tomato fruits for two weeks under ambient conditions

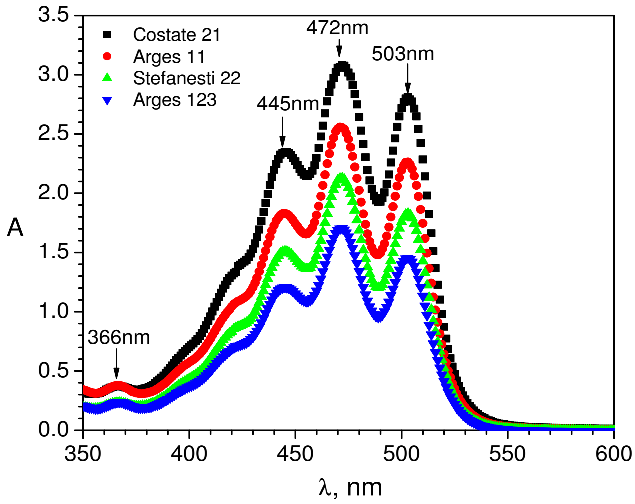

Fig. 3. UV-Vis spectra of tomatoes supernatant

medical field. Phenolic compounds are a class of antioxidants that prevent oxidative damage to lipids, thus increasing the nutritional value of the food. They possess a broad spectrum of biochemical activities such as antioxidant, antimutagenic and anticarcinogenic (Nakamura *et al.*, 2003). Flavonoids are a group of phenolic compounds that are low present in tomatoes compared with other vegetables (Lammerts *et al.*, 2011). Polyphenols content in analyzed tomatoes ranged from 1992 mg GAE 100 g^{-1} FW in 'Argeş 123' to 2178 mg GAE 100 g^{-1} FW in 'Argeş 11', while the content of flavonoids ranged from 194 mg CE 100 g^{-1} FW in 'Argeş 123' to 347 mg CE 100 g^{-1} FW in 'Costate 21' (Table 2). Martinez-Valverde *et al.* (2002) and Mechlouch *et al.* (2012) obtained similar results. High polyphenols content was submitted by 'Argeş 11' followed by 'Costate 21' and 'Ştefăneşti 22' but differences among these cultivars were not statistically significant. Flavonoids content was not significantly different among cultivars, with the exception of 'Costate 21'.

Anthocyanins, which belong to flavonoids class of compounds, are soluble pigments of large spectrum, responsible for the colour (red, orange, purple or blue) of flowers, fruits and vegetables. They are odorless substances, but helping taste with a moderate astringent sensation. At the investigated cultivars were found anthocyanins content between 13.66 mg cyanidin-3-O-glucoside equivalent 100 g^{-1} FW in 'Costate 21' and 22.85 mg cyanidin-3-O-glucoside equivalent 100 g^{-1} FW in 'Argeş 123' (Table 2). These results are comparable with those of Jones *et al.* (2003) and Mes *et al.* (2008), who reported anthocyanin content between 7.79 and 41.5 mg 100 g^{-1} FW in different tomato genotypes. Cultivars with determinate growth revealed almost double anthocyanins content than cultivars with indeterminate growth, the differences between the two types being significant (P<0.05).

Carotenoids are natural pigments present in red-orange vegetable products. Carotenoids act as antioxidants, fighting against free radicals, thus working against premature ageing and appearance of blemishes on the skin. Lycopene and β-carotene absorb light in the 350-550 nm region of the visible spectrum. The characteristics of the absorption spectra of the two carotenoids dissolved in hexane are showed in the literature (Zechmeister and Polgar, 1943; DeRitter and Purcell, 1981; Zang *et al.*, 1997; Takaichi, 2000). The UV-Vis spectra of the two carotenoids have three absorption peaks located at 443, 471 and 502 nm for lycopene and 425, 450 and 478 nm for β-carotene. It is known that the maximum absorption at 360 nm indicates the presence of lycopene *cis*-isomers. Fig. 3 indicates the UV-Vis absorption spectra of the tomatoes supernatant, obtained by extraction of carotenoids with mixture of hexane, ethanol and acetone.

Analyzing the UV-Vis absorption spectra of the tomatoes supernatant, the content of those two carotenoids was calculated. The lycopene content in the analyzed cultivars ranged from 8.84 mg 100 g^{-1} FW in 'Argeş 123' to 17.49 mg 100 g^{-1} FW in 'Costate 21', while the β-carotene content ranged from 0.45 mg 100 g^{-1} FW in 'Costate 21' to 1.88 mg 100 g^{-1} FW in 'Ştefăneşti 22' (Table 2). Similar results were obtained by Abushita *et al.* (2000), Martinez-Valverde *et al.* (2002) and Helyes *et al.* (2012). The lycopene content was significantly different among the studied tomato cultivars (P<0.05), higher contents being revealed in 'Costate 21' from indeterminate cultivars (17.49 mg 100 g^{-1} FW) and in 'Argeş 11' from determinate cultivars (13.92 mg 100 g^{-1} FW). The highest content in β-carotene was recorded in 'Ştefăneşti 22' (1.88 mg 100 g^{-1} FW) followed by 'Argeş 123' (1.63 mg 100 g^{-1} FW) and 'Argeş 11' (1.45 mg 100 g^{-1} FW), even if the differences among these cultivars were not significant.

Conclusions

Tomatoes are rich source of minerals, vitamins and antioxidants. Tomato cultivars assessed in this study revealed variation in chemical composition but statistical significant differences ($P<0.05$) were found only in lycopene content. Since cultivars were grown in the same environmental conditions and cultural practices it can be concluded that variability in chemical composition has depended on cultivar. 'Costate 21' with high content of antioxidant compounds, especially vitamin C, phenolic compounds and lycopene, represents a valuable cultivar for improving dietary antioxidants supply in our diet.

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