Evaluation of antioxidant content in introductions of cherry tomato (*Solanum* spp.)

Evaluación del contenido de antioxidantes en introducciones de tomate tipo cereza (*Solanum* spp.)

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Abstract

The greatest genetic diversity of tomato (*Solanum lycopersicum* L.) is found in wild species, with variability in fruit quality characteristics such as flavor, aroma, color, and content of lycopene and β-carotene. The aim of this study was to determine the content of antioxidants (lycopene, β-carotene and vitamin C) in cherry tomato fruits of 30 wild introductions from the Germplasm Bank of the National University of Colombia in Palmira. The field study was conducted at Montelindo farm, property of the University of Caldas, with an average temperature of 22.8 °C, at 1010 masl, 2200 mm of annual precipitation and relative humidity of 76%. The experimental design used was a rectangular lattice, with 30 treatments (introductions) and a commercial control (Sweet million) in four replicates per treatment and five plants in each one as experimental unit. The evaluated variables were lycopene, β-carotene, vitamin C and acidity of the fruit, which were determined by spectrophotometry and titration by color change and pH. Additionally, fruit production of the introductions was assessed. Data were analyzed using ANOVA and Duncan mean test by using SAS software (SAS Institute, Cary NC). Finally, we applied a weighted selection index based on the variables lycopene, β-carotene and vitamin C, applying a selection pressure of 17%. Significant differences (P <0.05) for the evaluated variables were found. The highest content of lycopene was found in the introduction LA1455 with 0.32 μg/ml, that of β-carotene in the introduction LA2076 (0.095 μg/ml), and vitamin C in commercial control (Sweet Million) (85 mg/100 g). The selection index showed as promising introductions: IAC 445, LA2076, LA2710, LA2845, and LA1546, indicating that phenotypic diversity exists among the introductions assessed for variables lycopene, β-carotene and vitamin C.

Key words: β-carotene, lycopene, plant genetic resources, vitamin C.

Resumen

La mayor diversidad genética de tomate (*Solanum lycopersicum* L.) se encuentra en especies silvestres, con variabilidad en características de calidad del fruto como sabor, aroma, coloración, y contenidos de licopeno y b-caroteno. El objetivo del presente trabajo fue determinar el contenido de antioxidantes (licopeno, b-caroteno y vitamina C) en frutos de tomate tipo cereza de 30 introducciones silvestres existentes en el Banco de Germoplasma de la Universidad Nacional de Colombia sede Palmira. El estudio de campo se realizó en la granja Montelindo de la Universidad de Caldas; temperatura promedio de 22.8 °C; a 1010 m.s.n.m.; 2200 mm de precipitación pluvial anual y una humedad relativa de 76%. El diseo experimental fue látice rectangular, con 30 tratamientos (introducciones) y un testigo comercial (Sweet million), con cuatro repeticiones por tratamiento y cinco plantas en cada una de ellas como unidad experimental. Las variables evaluadas fueron licopeno, b-caroteno, vitamina C y acidez del fruto, determinadas por espectrofotometría y titulación por cambio de color y pH. Adicionalmente se evaluó la producción de frutos. Los datos fueron analizados utilizando pruebas de varianza y prueba de medias por Duncan, con el programa SAS (SAS Institute Cary N.C). Finalmente se aplicó un índice de selección ponderado con base en las variables licopeno, β-caroteno y vitamina C, con aplicación de una presión de selección de 17%. Se encontraron diferencias significativas ($P < 0.05$) para las variables evaluadas. El mayor contenido de licopeno se halló en la introducción LA1455 con 0.32 μg/ml, el de b-caroteno en la introducción LA2076 (0.095 μg/ml), y el de vitamina C en el testigo comercial (Sweet million) (85 mg/100 g). El índice de selección mostró como introducciones promisorias: IAC 445, LA2076, LA2710, LA2845, y LA1546, lo cual indica que existe diversidad fenotípica entre las introducciones evaluadas para las variables licopeno, β-caroteno y vitamina C.

Palabras claves: β-caroteno, licopeno, recursos fitogenéticos, vitamina C.

Introduction

Tomato (*Solanum lycopersicum* L.) is the most important vegetable of Colombia and the world. It comprises 30% of the world vegetable production with 4.4 millions of cultivated hectares and 145,751,507 t of harvested fruits in 2010. In Colombia, tomato production for the same year was 546,322 t with a cultivated area of 16,227 ha and a yield of 33.66 t/ha (Faostat, 2010).

This species is grown in all the continents and represents one of the main sources of important vitamins, minerals and fiber (Esquinas-Alcázar and Nuez, 1995), for health and human nutrition (Razdan and Matoo, 2007). It contains different nutrients and molecules like ascorbic acid, vitamin E, flavonoids, phenolic acids and carotenoids (Kuti and Konuru, 2005); it is the main source of lycopene for humans and is consumed in fresh or processed (Candelas-Cadillo *et al.*, 2005).

Carotenoids are one of the several families of plant metabolites derived from isoprenoids and share a five carbon precursor, isopentyl pyrophosphate (IPP), with close to 20,000 plant metabolites. Four IPP units are bound to form a subunit with twenty carbons: geranyl geranyl pyrophosphate (GG PP). The first step for carotenoids biosynthesis is the bonding of two GGPP molecules to form phytoene of forty carbons. Four steps are required from the precursor phytoene to get a series of 11 conjugated double bonds found in lycophene.

The first two desaturations are catalyzed by the phytoene desaturase (PDS) producing phytofluene followed by ζ-carotene (Adalid, 2011). Conversion of ζ-carotene to neurosporene and later to lycophene is done by the ζ-caroten-desaturase (ZDS), which has a high activity since the ripe tomato fruit has small amounts of ζ-caroten or neurosporene (Fraser and Bramley, 2004). Lycophene is the main carotenoid accumulated in ripe tomato, and it is the starting point in the biosynthetic pathway of other carotenoids, like formation of β-carotene (Adalid, 2011).

Vitamin C biosynthesis starts from two plant compounds, D-galacturonic acid and D-galacturonic acid methyl ester, which produce ascorbic acid by the Wheeler-Smirnoff reaction (Wheeler *et al.*, 1998). According to Miller and Tanksley (1990) most of the tomato diversity is found in its wild relatives, with genetic diversity for traits such as flavor, aroma, color and texture, with high nutrient content of vitamin C, higher than 57 mg/100g in fresh weight and, high lycopene content, higher than 10 mg/100 g. Recent tendencies on genetic breeding for new commercial cultivars are oriented to incorporate quality traits such color, hardness, taste and high carotenoids content. All these are found in higher proportion in traditional cultivars than in the commercial ones which have been selected by productivity and agronomical characteristics of interest before that fruit quality (Valcárcel, 2009).

Fruit and vegetable consumption with high antioxidant levels is considered as a way to prevent cardiovascular diseases and cancer, which is associated with higher demands during the last years. Tomato consumption has been stable in time, stimulating its genetic breeding to obtain new cultivars high on lycophene, β-carotene and vitamin C contents (Adalid *et al.*, 2007). Raffo *et al.* (2003) studied sources of vitamin C, E and specific carotenoids and determine that tomato is the first source of lycophene (71.6%), second in vitamin C (12%) and β–carotene (17.2%) and third as vitamin E source (6%). Nutritionists estimate the daily requirement of lycophene is between 3 and 7 mg, meaning a weekly consumption of seven portions of tomato rich products (Rodríguez, 1999). Abushita *et al.* (1997) estimate a daily requirement of 60 to 100 mg of vitamin C to reduce the risk of chronic diseases and to be in good health.

According to Abadie and Berretta (2001), the value of the germplasm banks reside on its use. Collections must provide breeders with different genetic, genes or genotypes, which allow them to respond to new challenges established by the productive systems; for that purpose is indispensable to know the characteristics of the conserved germoplasm. Cherry tomato adaptation provides high possibilities for inclusion in breeding programs, using their valuable characteristics on genetic diversity for selecting parentals, together with their large geographical diversity (Medina and Lobo, 2001). Some cherry tomato species are considered promising for the market due to their high content of antioxidants like lycophene and β-carotene (Nuez, 1999). These characters of wide genetic variability and the genes that they bring, warrant the inclusion of wild species in breeding programs for cultivated tomato, in order to evaluate heterozygous combinations of traits of agronomical interest (Pratta *et al.*, 2003).

Nowadays, the internal quality (nutritive and organoleptic) is one of the main goals of tomato breeding for fresh market (Roselló *et al.*, 2000). Additionally, is important to identify sources for stress resistances, biotic and abiotic, and for high nutritional quality that contributes to a sustainable agriculture management.

There are genetic sources of cherry tomato in Colombia that have not been evaluated for quality traits as lycophene, β-carotene and vitamin C, thus its potential use in breeding programs is unknown. This resource use is subjected to previous identification and selection of promising materials. In this study thirty wild introductions of cherry tomato (*Solanum* spp.) from the Germplasm bank of the National University of Colombia-Palmira were evaluated to select genotypes based on their antioxidants (lycophene, β-carotene and vitamin C) content in order to breed commercial tomatoes and cherry tomato.

Materials and methods

The experiment was performed in the Montelindo farm from the Universidad de Caldas, located in Palestina (Caldas), Colombia, with mean temperature of 22.8 °C, at 1100 masl, with 2200 mm of annual precipitation and relative humidity of 76%, in sandy loam soil derived from volcanic ashes. Thirty introductions of cherry tomato without characterization reports were used in order to include them in cultivated tomato breeding programs. The commercial control used was Sweet million (Table 1).

Plantlets were grown in trays of 72 spots with peat as substrate and were transplanted when they had four true leaves; sowing was done in the second semester of 2010. Experimental design used was a rectangular lattice 5 x 6 (30 introductions) with two replicates per main block and the experimental unit was composed of 5 plants per introduction sowed at 1.5 m x 0.8 m. Agronomical practices were the conventional ones for a commercial tomato crop and the plant architecture was defined in three axes/plant. For weed control it was used padding with black-white plastic 0.8 m wide, 1.2 caliber. Fruits were harvested when totally ripe according to the behavior of each introduction.

Variables measured

Fruit acidity and vitamin C content.

For these measurements were taken 10 ml samples of juice from 10 fruits of the second cluster of each introduction and replicate, harvested at ripening stage. Each sample was diluted in 100 ml of distilled water and titrated with NaOH 0.1 N till pH 8.2 to express the result as citric acid (%) for fruit acidity. For vitamin C the solution was titrated with iodine 0.1 N till changes in color, expressing the result in milligrams/100 g of fresh weight (mg/100 g) (IPGRI, 1996).

Table 1. Cherry tomato introductions evaluated by antioxidants content.

Introduction (no.)	Tomato type	Introduction (no.)	Tomato type
IAC391[a]	Red Cherry	LA1546	Cherry
IAC420	Cereja	LA1705	Cherry
IAC421	Cereja Alemão Vermelho	LA2076	Cherry
IAC424	Cereja	LA1334	Cherry
IAC426	Cereja Juliet	LA2131	Cherry
IAC445	Cereja Jundiai	LA168	Cherry
IAC1621	Cereja alemán 12	LA2640	Cherry
IAC1624	Cereja	LA2692	Cherry
IAC1685	Cereja 11B	LA2710	Cherry
IAC1688	Lili cereja	LA2845	Cherry
IAC1622	Cherry	LA3139	Cherry
IAC1686	Cherry	LA3652	Cherry
IAC412	Cherry	LA1455	Cherry
IAC416	Cherry	LA1428	*S. pimpinelifollium*
LA 1480	Cherry	LA3158	*S. pimpinelifollium*
Testigo	Sweet million		

[a]**IAC:** Introductions from the Agronomical Institute of Campinas, Campinas, Brasil.
[b]**LA:** Introductions from the Tomato Genetics Resources Center (TGRC). University of California, Davis.

Lycopene and β–carotene contents.

For these measurements 0.6 g of tomato pulp were weighted for each introduction and replicate, harvested at ripening time. Next, 5 ml of acetone-n-hexane mix on 4:6 ratio were added. It was centrifuged at 5000 rpm, for 5 min at 4 °C; supernatant was extracted and read on a spectrophotometer of visible light at wavelengths of 453 nm, 505 nm, 645 nm and 663 nm using the acetone-n-hexane mix as blank according to Rosales' methodology (2008) standardized for tomato fruits. Lycophene and β–carotene contents were quantified using the following equations proposed by Nagata and Yamashita (1992) for tomato antioxidants.

$$Lycophene\ (\mu g/ml) = 0.0458\ A_{663} + 0.204\ A_{645} + 0.372\ A_{505} - 0.0806\ A_{453}$$

$$\beta\text{-}carotene\ (\mu g/ml) = 0.216\ A_{663} - 1.220\ A_{645} - 0.304\ A_{505} + 0.452\ A_{453}$$

Tomato yield per introduction and replication was expressed in grams per plant (g/plant) and in tons per hectare (t/ha).

Analysis of variance of the data was performed by the GLM procedure of SAS SAS (1992) (SAS Institute Cary N.C; version 9.0) for mean comparison through the Duncan's mean test. From the best obtained results, a pressure of selection of 17% was applied to select the best introductions, using as criterion the weighted selection index. The selection index (ISi) was built considering the lycopene, β-carotene and vitamin C traits, using the same weight for each one of them (33.33%). For vitamin C the obtained results were expressed as grams per 100 g of fresh weight, thus, all the variables were express in decimals to keep the selection index unaltered. This index is defined as follows:

$$IS_i = = [P_j\ (\bar{X}_{ij} - \bar{X}_{.j})/S_j]$$

where,

Pj = correspond to the weighting.

$\bar{X}ij$ = mean of the genotype *i* for the character *j*.

$\bar{X}.j$ = mean of the population for the character *j*.

Sj = Standard deviation for the character *j*.

17% of the genotypes were selected with the best ISi values and above 0.

Results and discussion

Data analysis showed that all the evaluated variables were significantly different ($P < 0.05$).

Fruit production.

For production per plant, introductions with the highest yields were: IAC426 (2040 g/plant, equivalent to 17 t/ha) and IAC1624 (1937 g/plant and 16.1 t/ha); control produced 2055 g/plant and17.1 t/ha, however, this had the largest number of damaged fruits (1570 g and 13 t/ha) (n.p.); LA3158 introduction showed the lowest yield (277 g/ plant and 2.3 t/ha) (Table 2). Zaror (1996) found with cherry tomato under greenhouse that the largest yield was in the Sweet cherry (2739 g/plant) cultivar, value that is similar to the ones found in this study for IAC426 and IAC1624 and with the control (commercial cherry tomato F1 Sweet million) (2055 g/plant). Macua *et al.* (2006, 2008) observed in nine varieties of cherry tomato and average yield of 85.78 t/ha and 2 years later, working with eleven cherry tomato varieties they found yield between 66 and 103.68 t/ha. Uresti *et al.* (2007) in tomato grown hydroponically found yields of 30.1 t/ha in a population of 25,650 plants/ha.

In this study, the highest ripe tomato productions were obtained with the control Sweet million (17.1 t/ha) and with the introductions IAC426 (17 t/ha) and IAC1624 (16.1 t/ha) on a density of 8333 plants/ha (Table 2).

Lycopene and β-carotene contents.

LA1455 and LA2845 introductions had the highest lycopene contents with similar concentrations of 0.32 μg/ml, followed by the IAC426 introduction with 0.30 μg/ml; however β–carotene content in both of them can be considered low. The lowest lycopene contents were found in IAC412 (0.04 μg/ml) and LA2640 (0.02 μg/ml).

LA2076 introduction had the highest β-carotene content (0.096 μg/ml) followed by IAC412 with 0.094 μg/ml. In total 11 introductions representing 35% of the population did not show β-carotene content and had acceptable contents of lycopene (Table 2). It is estimated that between 87% and 90% of the carotenoids in tomato are carotenes (Fraser and Bramley, 2004). Lycopene is the most abundant carotenoid in red tomatoes and can represent 90% of the total carotenoids in this vegetable (Adalid, 2011), results that agree with the ones found in this study where the lycopene percentage was 86.1% for the total carotenoids. According to Adalid (2011) a typical red tomato fruit has lower levels of other pigments like β-carotene, δ-carotene, γ-carotene and neurosporene. In this study, 14 introductions with 80% of red fruits showed higher lycopene contents than the average (0.18 μg/ml) (n.p.), whereas the introduction with ripe fruits with colors between red and pink had higher β–carotene contents. Lycopene concentration in tomato fruits depends on the genetic composition and the interaction between genotype and environment. High light intensities favors carotenoids content, in special the one of lycopene (Dumas *et al.*, 2002), which agrees with the light conditions in the location of the study and the genetic variability of the evaluated germplasm, favoring higher lycopene contents instead of β–carotene in some introductions.

Zambrano *et al.* (1995) evaluated lycopene content in two tomato cultivars (Rio Grande and pear type varieties) and concluded that lycopene synthesis increases progressively during the ripening of the fruits; in Rio Grande from 0.233 μg/g in physiological maturity to 28.720 μg/g in ripe stage and, in the pear type from 0.21 μg/g to 29.720 μg/g in the previously named stages. In this research, fruits were harvested at full ripening and reached the maximum values of 0.318 μg/ml in LA1455 and minimum of 0.024 μg/ml for LA2640.

Rodríguez-Amaya (1997) observed an increase in carotenoids content, especially lycopene, during ripening of tomato fruit. Seven days after the full ripening stage, lycopene levels were 44 μg/g, while for β-carotene was

Table 2. Mean test (Duncan) on the evaluation of antioxidant content in 30 cherry tomato introductions.

Introduction	Yield (g/plant)	LYC (µg/ml)	β-carotene (µg/ml)	Vitamin C (mg/100 g)	Acidity (%)	Yield (t/ha)
Control	2054 a*	0.181 efgh	0.032 c	85 a	1.392 fgh	17.1
IAC426	2039 a	0.301 ab	0 e	33 lm	1.208 hij	17.0
IAC1624	1937 a	0.269 bc	0 e	60 cd	1.569 ef	16.1
LA1480	1704 b	0.259 cd	0 e	44 fghijkl	1.144 ij	14.2
IAC391	1643 bc	0.173 ghij	0 e	38 jklm	1.352 fghi	13.7
IAC1688	1642 bc	0.135 jkl	0.042 c	51 cdefghi	1.904 cd	13.7
LA3652	1574 bcd	0.229 cde	0.023 cde	48 efghij	2.208 b	13.1
IAC1621	1432 cd	0.244 cde	0 e	41 hijkl	1.568 ef	11.9
IAC424	1421 cd	0.052 def	0 e	52 cdefghi	1.28 ghi	11.8
LA2692	1420 cd	0.119 lm	0.067 b	33 lm	1.944 cd	11.8
LA2131	1369 d	0.238 cde	0 e	41 hijkl	1.456 fg	11.4
IAC421	1348 d	0.152 ijkl	0.036 c	44 fghijkl	1.544 f	11.2
LA2076	1314 d	0.086 mn	0.096 a	59 cde	2.072 bc	11.0
LA2845	1032 e	0.316 a	0.009 de	56 cdef	1.552 f	8.6
LA1705	1013 e	0.077 no	0.005 e	49 defghij	1.2 hij	8.4
LA1428	979 ef	0.209 efg	0.03 cd	35 klm	2.048 bcd	8.2
IAC445	958 ef	0.163 hijk	0.084 ab	61 c	1.04 j	8.0
IAC420	887 efg	0.123 klm	0.087 ab	47 fghijk	1.872 cd	7.4
IAC1686	878 efgh	0.123 klm	0.033 c	41 hijkl	2.2 b	7.3
LA2640	817 efgh	0.024 p	0.002 e	35 klm	1.472 fg	6.8
LA168	814 efgh	0.228 cde	0 e	47 efghijk	1.472 fg	6.8
IAC412	739 fghi	0.038 op	0.094 a	43 ghijkl	2.44 a	6.2
IAC1685	629 ghij	0.179 efgh	0.007 e	34 lm	1.832 cd	5.2
LA2710	619 hij	0.204 efgh	0 e	73 b	2.008 bcd	5.2
LA3139	551 ij	0.146 ijkl	0.004 e	53 cdefgh	1.84 cd	4.6
IAC1622	517 ijk	0.178 efgh	0 e	54 cdefg	1.92 cd	4.3
LA1546	512 ijk	0.245 cde	0.038 c	55 cdefg	1.792 de	4.3
LA1455	475 ijk	0.318 a	0 e	52 cdefghi	1.888 cd	4.0
LA1334	418 jk	0.239 cde	0.032 c	40 ijklm	1.912 cd	3.5
IAC416	388 jk	0.055 nop	0.025 cde	29 m	1.552 f	3.2
LA3158	277 k	0.086 mn	0.033 c	45 fghijkl	1.896 cd	2.3

3.0 µg/g. After 21 days, lycopene reached 65 µg/g while β-carotene slightly decreased to 2.2 µg/g, indicating that at higher lycopene content β-carotene decreases, results that are similar to the ones found in this study.

Lenucci *et al.* (2006) found variations among tomato cultivars, β-carotene content changed between 0.5 and 20 mg/kg and lycopene between 8 and 250 mg/kg, and in tomato introductions var. cesariforme lycopene was between 0.2 and 17.4 mg/100 g; whereas the highest value was found in *S. pimpinellifolium* with values of 18 and 25 mg/100 g in dark red fruits. Lycopene content average for the evaluated introductions was 0.18 µg/ml, it was found that 55% of them, including the control Sweet million, had higher values than the average. Hernández *et al.* (2007) found lycopene values between 1.89 and 2.56 mg/100 g in the commercial cultivars Dunkan and Thomas.

In this study, LA2710 and IAC445 introductions showed fruit vitamin C contents of 73 mg/100 g and 61 mg/100 g, respectively, while the control had a concentration of 85 mg/100 g; in contrast, IAC426 and IAC416 had lower concentrations, 33 mg/100 g and 29 mg/100g, respectively (Table 2).

The introduction with the highest acidity in fruit was IAC412 with 2.44% followed by the LA3652 and IAC1686 introductions with 2.2%; while LA1480 (1.14%) and IAC445 (1.04%) showed the lowest acidity (Table 2). Raffo *et al*. (2003) found that ascorbic acid is highly variable in cherry tomato grown under greenhouse conditions, nonetheless the concentration is in the range of the recommended daily value for vitamin C (60 mg). LA2710, IAC445, IAC1624 and LA2076 together with the control showed equal or higher concentrations than this value, thus they are considered like promising as commercial cultivars.

All the evaluated introductions in this study revealed higher vitamin C contents than the ones found by Lenucci *et al*. (2006) who evaluated 20 tomato var. cerasiforme and *S. pimpinellifolium* introductions from the COM AV Germplasm Bank (Center for Agrobiodiversity Conservation and Breeding of the Polytechnic University of Valencia-Spain) among them: LA2933 (37 mg/100 g), LA2656 (25 mg/100 g) and BGV009560 (21 mg/100 g). Galiana-Balaguer *et al*. (2000) found that the vitamin C levels in tomato vary significantly according to the species, from 80mg/kg in cultivated varieties till 1.113 mg/kg of fresh weight in *S. pimpinellifolium* L. Rosales (2008) studied cherry tomatoes harvested three times along the production cycle and on a similar ripening stage and found 3.57 mg/g and 3.70 mg/g of citric acid. Urrestarazu (2004) found titrable acidity values for cherry tomato between 520 and 807 mg/ml of citric acid, whereas in common tomato values were between 370 and 550 mg/ml. Murray *et al*. (2004) evaluated cherry tomato fruits var. cerasiforme cv. Super sweet grown under greenhouse and harvested at different ripening stages and found titrable acidity (citric acid %) of 1.01% in pink tomatoes, 00.96% in red tomatoes and 0.81 in turning stage, values that are lower to the ones found in this study on similar ripening stages, which varied between 1.04 and 2.44% for citric acid.

The Selection Index established LA2076, LA2710, LA2845 and LA1546 from the Germplasm Bank at Davis, California, and IAC445 from the Germplasm Bank of the Agronomical Institute of Campinas, Brazil, as the best introductions (Table 3).

Table 3. Selection index of the lycopene, β-carotene and vitamin C parameters of the cherry tomato introductions.

Introduction	PDN (g/plant)	LYC (µg/ml)	β-CAR (µg/ml)	Vita C (mg/1OOg)	IS
IAC445	958.7	0.163	0.084	61	1.085
LA2076	1314.7	0.086	0.096	58.75	0.839
LA2710	619.3	0.204	0	72.5	0.736
LA2845	1032.3	0.316	0.009	55.75	0.726
LA1546	512.2	0.245	0.038	54.75	0.721
Testigo	2054.6	0.18	0.032	0.085	-0.327

PDN = Production per plant, LYC = Lycopene content, β-car= β-carotene, Vita C = Vitamine C, IS = Selection Index.

Conclusions

- Introductions with higher lycopene content (0.32 µg/ml) were LA1455 and LA2845; with the highest β-carotene content were LA2076 (0.096 µg/ml) and IAC412 (0.094 µg/ml). Fourteen introductions showed lycopene values higher than the average (0.18 µg/ml), 80% of them had red ripe fruits, indicating a direct relation between color and lycopene content.
- The Selection Index showed as best introductions LA2076, LA2710, LA2845 and LA1546 from the Germplasm bank of Davis, California and IAC445 from the Agronomical Institute of Campinas, Brazil; they showed higher values than the average for

lycopene, β-carotene and vitamin. Additionally, LA2076 and LA2845 reveal yields above 1000 g.

- There is phenotypic diversity among the evaluated introductions for the lycopene, β-carotene, vitamin C, fruit acidity (citric acid %) and production, being promising in genetic breeding programs of cherry tomato and of commercial tomato cultivars.

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