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Evaluation and selection of superior tomato genotypes for high antioxidant composition

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Abstract
A field experiment was conducted at the Department of Vegetable Crops, TNAU, Coimbatore to evaluate the performance of tomato genotypes for high antioxidant composition. The genotypes were raised in open field condition and high antioxidant composition was inferred through high lycopene, carotene, ascorbic acid and total phenol content. Among the 97 genotypes evaluated, LE 355 and LE 525 recorded the highest lycopene and β carotene content (8.79 and 8.50 mg/ 100g respectively). Among the genotypes, highest ascorbic acid content was recorded in LE 525 and LE 27. Total phenol content was also found to highest in the genotype *viz.,* LE355 (40.11 mg/ 100g). Hence, among 97 different tomato genotypes evaluated, LE 355 and LE 525 were identified for high antioxidant composition. These genotypes may be used in future breeding programme for the development of hybrids, rich in antioxidant composition.

Keywords: Tomato, antioxidant, genotypes, lycopene

Introduction
Tomato (*Solanum lycopersicum* L.) is one of the most important members of the botanical family Solanaceae with its origin in Peru-Ecuador region of South America. Owing to its acclimatization to a wide array of environment, as well as its high nutritive value, tomato remains in focus of the horticulture industry. Fresh tomatoes and tomato products are rich source of bioactive compounds, including carotenes (lycopene, β- carotene), ascorbic acid, tocopherol and phenolic compounds. Among the antioxidant compounds, lycopene is a strong antioxidant and exhibits higher (2 -10 times) singlet oxygen quenching ability compared with β -carotene and α tocopherol (Dimascio *et al.*, 1989) [5]. Further, lycopene prevents carcinogenesis or atherogenesis by interfering with oxidative damage to DNA and lipoproteins (Clinton, 1998) [3]. Numerous epidemiological and intervention studies have demonstrated that, dietary intake of lycopene rich foods results in decreased incidence of certain cancers, including prostate, lung, mouth and colon cancers, coronary heart diseases and macular degeneration (Dillingham & Rao, 2009) [4]. The objectives of this study therefore, are to evaluate different tomato genotype to select superior genotype for antioxidant activity.

Materials and Methods
The present investigation was undertaken during August – November, 2015 (Season I) and January – March, 2016 (Season II) at Department of Vegetable crops, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore with 97 genotypes of tomato. The experiment was laid out in randomized block design with two replications. All the recommended agronomic package of practices was followed to grow a healthy crop. In each replication, randomly 5 plants in each genotype were marked for observation.

Lycopene estimation
The lycopene content was determined by the spectrophotometric method described by Ranganna (1979) [13]. Ten grams of sample was extracted with acetone. The acetone extract was transferred to a separating funnel containing 15 ml of petroleum ether and mixed gently. The lower acetone phase was diluted with water containing five per cent sodium sulphate and then transferred to another funnel. The extraction was repeated with petroleum ether until it was colourless. Anhydrous sodium sulphate was added to the pooled petroleum ether extracts and the volume was made up to 100 ml with petroleum ether. An aliquot of 5 ml was diluted to 50 ml and the colour was read at 503 nm in a spectrophotometer against petroleum ether as blank. The lycopene content of the sample was expressed as mg/100g and calculated by the formula.

$$\text{Lycopene content} = \frac{[3.1206 \times \text{O.D.value of sample} \times \text{Volume .made up} \times \text{Dilution}]}{1.0 \times \text{weightof sample} \times 1000} \times 100$$

Carotene estimation
Total carotenoid content of the fruits was estimated by using the procedure suggested by Jensen (1978) [6]. Fresh fruits were cut and known amount (100mg) was ground in a mortar with 20ml of distilled acetone and a pinch of clean, fine sand. The extract was centrifuged at 2500 rpm for 10 minutes and the clear supernatant was made up to 10ml with 80% acetone. The absorbance of the extract was read at 480nm and 510nm.

Ascorbic acid estimation
The ascorbic acid content was estimated using the procedure of A.O.A.C. (1975) [1] and expressed as mg 100 g $^{-1}$of fresh sample. Five grams of fruit were mixed with 50 ml of four per cent oxalic acid and filtered. The filtrate was made upto 50 ml using four per cent oxalic acid and then titrated against 2, 6-dichloro phenol indo phenol dye solution. The end point was the appearance of light pink color.
The phenolics content of the fruits was estimated by using the procedure proposed by Malik and Singh (1980) [7]. The data on various parameters studied during the course of investigation were statistically analysed, applying the technique of analysis of variance suggested by Panse and Sukhatme (1978) [11].

Result and Discussion
Analysis of results showed that tomato genotypes differed significantly for the level of lycopene, β-carotene and L-ascorbic acid (Table 1). Lycopene is a pigment, responsible for red colour of the mature tomato and its products (Shi and Maguer 2000) [16]. The highest lycopene content was recorded in LE 355 with mean value of 8.47 and 9.12 mg/100g respectively season I and II. This was followed by genotype LE 525 (8.23and 8.78 mg/100g respectively season I and II). The lowest lycopene content was recorded in LE 20 (0.66and 0.51 mg/100g respectively season I and II). Similar results was reported by Rukshar and Sharma (2011) [14], Nour *et al*. (2013) [10], Vinod *et al*. (2012) [18] and Al-Said *et al*. (2007) [2].
There was a significant difference between genotypes on β-carotene content in season I and season II. The highest β-carotene content was recorded in LE 355 with mean value of 10.24 and 9.65 mg/100g respectively in season I and season II. This was followed by genotype LE 525 (10.01and 9.46 mg/100g respectively in season I and season II). The lowest lycopene content was recorded in LE 2004-5 (1.25and 1.2 mg/100g). Similar results was reported by Rukshar and Sharma (2011) [14] and Salvador (2010) [15].
The highest ascorbic acid content was recorded in LE 27 with mean value of 45.19 and 48.93mg/100g respectively in season I and season II. This was followed by genotype LE 525 (47.03 and 45.45mg/100g respectively in season I and season II).The lowest lycopene content was recorded in LE 10 (19.98and 15.83mg/100g respectively in season I and season II). Similar results was reported by Vinod Kumar *et al*. (2012) [18], Rukshar and Sharma, (2011) [14] and Nour *et al*. (2013) [10]. This might be due to the genotypic character of germplasm. This is found to be in accordance with Miladenovic *et al*. (2014) [8], who stated that environmental growing conditions and cultivar genotype having major effects on ascorbic acid composition.
The major phenolics in tomato (chlorogenic acid, caffeic acid and rutin) also exhibit a wide range of physiological properties, such as anti-inflammatory, antimicrobial, cardio protective, hepatoprotective, hypoglycemic and antiviral effects (Navarro-González *et al*., 2011) [9]. The pooled analysis revealed that the genotype LE 355 was recorded highest phenolic content with pooled mean of 40.11mg/100g and lowest was recorded in LE 114 (4.83mg/100g).
The level of acidity in tomato fruits is an important parameter associated with sensory attributes like flavor and astringency and also acid constitutes an important factor for processing tomato. Among 97 genotypes, the highest titrable acidity was recorded in genotype H 24 with mean value of 0.47 and 0.55% respectively in season I and season II, which is followed by LE 1223(0.41 and 0.40% respectively in season I and season II).The lowest mean titrable acidity was recorded in genotype Utkal Kumari (0.01 and 0.02% respectively in season I and season II).Similar results was reported by Miladenovic *et al*. (2014) [8] and Puttaraju *et al.* (2011) [12].
For processing purpose, high TSS is an important quality parameter which decides the utility of the variety. One percent increase in TSS content of fruits result in 20 percent increase in recovery of processed product (Shivanand, 2008) [17]. In the present study, it was observed that genotype LE 2373 recorded highest total soluble solids. The difference among the varieties in TSS content of fruits might be due to the genetic constitution of the varieties. These results are in agreement with the finding of Puttaraju *et al.* (2011) [12].

Table 1: Variations of the measured compounds content in tomato as a function of genotype

Genotypes	Lycopene (mg/100g)	Carotene (mg/100g)	Ascorbic acid (mg/100g)	Total phenols (mg/100g)	Titratable acidity (%)	TSS (^{0} brix)
LE 1	1.73	2.62	27.99	23.29	0.06	6.55
LE 2	1.02	1.46	26.98	14.21	0.33	4.69
LE 3	1.40	1.73	34.48	24.11	0.37	5.14
LE 4	2.60	3.11	30.26	17.69	0.18	6.10
LE 5	1.17	1.27	32.87	12.37	0.19	5.46
LE 6	1.05	1.66	29.31	12.18	0.14	5.58
LE 7	1.19	1.63	29.10	33.53	0.38	4.86
LE 10	1.16	1.91	17.91	33.34	0.32	4.85
LE 11	1.35	2.16	32.09	17.53	0.26	4.16
LE 12	1.45	1.69	29.06	22.02	0.20	6.16
LE 13	1.56	2.47	36.06	17.05	0.12	6.12
LE 14	1.09	1.51	23.79	16.39	0.40	3.84
LE 15	1.30	2.16	39.37	22.12	0.13	6.64
LE 18	1.40	1.89	32.84	15.13	0.25	4.44
LE 20	0.59	1.26	24.17	13.68	0.28	4.89
LE 21	0.84	1.29	35.58	11.54	0.18	5.54
LE 22	0.97	1.47	38.11	23.85	0.12	5.32
LE 23	0.99	2.29	33.85	20.26	0.18	6.15

LE 27	2.98	3.13	47.06	7.18	0.17	5.31
LE 57	1.60	1.99	35.89	13.85	0.10	8.04
LE 85	0.98	1.49	36.27	12.89	0.28	5.74
LE 87	1.29	2.18	36.44	11.93	0.17	6.39
LE 88	1.14	1.36	27.73	12.89	0.04	5.84
LE 89	0.89	1.57	22.16	14.05	0.19	6.35
LE 100	1.27	2.37	32.05	9.75	0.14	7.33
LE 102	0.95	1.68	34.45	27.98	0.11	6.20
LE 104	0.89	1.28	38.83	10.10	0.23	5.58
LE 114	0.81	1.28	33.81	4.83	0.29	5.78
LE 115	0.87	2.26	27.55	8.81	0.12	5.27
LE 116	7.95	8.22	38.70	16.59	0.13	5.52
LE 118	6.56	9.26	40.44	13.94	0.17	5.08
LE 125	1.58	2.16	33.30	14.72	0.18	5.74
LE 150	6.75	9.62	38.33	22.68	0.11	6.35
LE 184	7.96	9.47	34.03	21.60	0.09	6.16
LE 210	1.21	2.48	32.09	22.44	0.09	6.74
LE 215	1.38	2.22	36.10	34.58	0.12	5.24
LE 228	1.23	1.63	31.10	36.67	0.13	6.78
LE 231	1.49	2.02	22.51	10.77	0.11	6.35
LE 315	1.32	1.37	35.40	33.34	0.05	5.59
LE 338	1.36	1.41	35.17	7.18	0.12	5.16
LE 339	1.42	2.12	33.73	17.13	0.14	5.52
LE 355	8.79	9.95	30.15	40.11	0.12	5.43
LE 411	8.10	9.07	39.52	20.56	0.16	5.21
LE 470	1.79	2.09	30.14	14.11	0.19	5.09
LE 471	1.51	2.01	40.25	36.80	0.17	5.68
LE 523	1.77	2.13	25.13	37.77	0.15	7.64
LE 525	8.50	9.74	46.24	16.16	0.19	4.84
LE 591	1.12	1.58	39.13	23.73	0.11	5.49
LE 598	7.14	9.15	45.24	18.98	0.22	5.32
LE 812	1.18	2.04	29.89	15.90	0.23	5.29
LE 828	1.23	1.57	40.41	7.07	0.17	6.13
LE 887	1.48	2.59	26.42	36.27	0.15	5.91
LE 933	1.33	2.24	38.45	7.73	0.15	6.42
LE 966	1.03	2.56	34.11	8.10	0.09	6.09
LE 971	0.71	2.35	21.35	11.14	0.12	5.17
LE 980	0.75	1.29	35.22	17.62	0.14	6.09
LE 1020	1.95	2.21	24.67	17.97	0.13	6.29
LE 1029	0.78	1.32	33.05	10.00	0.19	4.31
LE 1164	1.33	2.37	34.30	9.11	0.15	6.00
LE 1165	1.42	1.43	24.03	7.32	0.12	5.91
LE 1204	1.74	2.23	32.51	11.94	0.19	5.59
LE 1211	1.25	2.12	34.49	10.46	0.09	6.30
LE 1223	0.93	1.30	26.15	13.03	0.41	5.07
LE 1817	0.83	1.26	23.35	18.46	0.31	5.47
LE 2311	0.89	1.25	25.70	11.54	0.30	5.14
LE 2373	1.29	1.81	29.24	21.29	0.14	8.87
LE 2004-5	0.76	1.22	34.44	18.28	0.26	4.49
LE 2004-52	1.21	1.61	34.53	11.54	0.21	4.69
LE 2004-82	0.79	1.87	23.03	15.39	0.09	6.71
LE2004-513	1.40	2.72	34.54	22.73	0.25	4.98
LE 900	1.31	1.42	30.14	17.62	0.12	5.83
LE 910	5.96	4.29	39.37	24.35	0.13	6.63
LE 975	2.08	2.29	34.02	12.62	0.09	6.24
CO 3	1.32	2.23	32.91	12.38	0.09	7.52
PKM 1	1.04	1.26	24.13	29.02	0.28	5.52
LE 990	2.08	2.25	39.03	13.46	0.20	4.53
DVRT 2	1.37	1.87	22.79	11.95	0.08	7.15
H 24	2.47	3.13	39.32	14.05	0.51	3.92
LE 995	1.97	2.28	34.01	12.68	0.13	6.36
LE 996	0.86	2.07	36.38	17.61	0.16	5.29
HN 2	2.75	2.48	33.61	8.72	0.23	4.94
LE 997	1.75	2.38	38.19	13.33	0.16	6.27
LE 998	3.23	3.70	33.76	12.57	0.12	5.17
EC455010	1.62	2.26	39.35	10.77	0.13	6.12
LE 999	0.80	1.24	34.42	22.57	0.29	5.10
Suvarna	4.28	3.91	36.66	13.96	0.15	4.61
Utkalkumari	1.35	2.29	25.24	11.43	0.02	8.72

LE 1000	1.26	1.33	34.78	10.66	0.07	7.06
LE 1001	1.32	2.70	31.86	11.54	0.19	6.02
LE 1002	1.02	1.13	35.34	18.16	0.06	6.87
LE 1003	1.13	1.70	32.71	12.37	0.28	5.25
LE 1004	1.03	1.24	29.59	19.17	0.04	8.31
LE 1005	1.34	1.49	37.53	16.43	0.08	8.39
LE 1006	1.29	1.92	33.38	11.67	0.31	5.40
LE 1007	0.80	2.27	28.29	33.91	0.11	6.44
LE 1008	0.88	1.22	34.68	10.10	0.20	5.02
LE 1009	0.93	1.27	26.16	11.17	0.09	7.55
SEd	0.25	0.24	2.15	1.36	0.02	0.63
C.D (0.05)	0.50	0.47	4.81	2.67	0.05	1.24

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