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Determination of fruit quality parameters of ten tomato (*Solanum lycopersicum*) genotypes and their Hybrids

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Abstract
Ten edible tomato genotypes and their hybrids were investigated with one check variety in 2018–2019. Fruit quality parameters like vitamin C, total soluble solids, lycopene and titrable acidity were evaluated. Among parents, Arka Meghali was recorded highest mean value for vitamin C (20 mg/100g). PKM 1 was recorded high mean value for TSS (5.83 ^{0}Brix). Akshaya was recorded high mean value for Lycopene (20.18 mg/100g). Lowest mean value for titratable acidity was recorded by Anagha (0.17%). Among the hybrids, L1T1, L1T2, L1T3, L2T3, L4T1, L4T3, L6T2, L7T1, L7T2 and L7T3 were recorded high mean value for Vitamin C (16 mg/100g). L5T2 and L7T2 were recorded high mean value for Total soluble solids (5.50 ^{0} Brix). Highest mean value for Lycopene was recorded by L7T2 (23.92 mg/100g). L1T3 was recorded lowest mean value for titratable acidity (0.17%). Therefore, choosing these genotypes and hybrids will enhance the flexibility of farmers and traders to when and where to market their fresh tomatoes in order to make maximum profit.

Keywords: Tomato, quality parameters, vitamin C, TSS, lycopene, titratable acidity, ANOVA

Introduction
Tomato (*Solanum lycopersicum* L.) belonging to Solanaceae is one of the most popular vegetables that is widely used worldwide and ranks second after potato in terms of global production and first in terms of yield (FAOSTAT, 2018) [7]. Tomato fruit for human health is reflected by its high consumption per capita, and the identification of tomato varieties that accumulate higher levels of primary and secondary metabolites in their fruit is a priority objective (Hou *et al*., 2020) [8]. This vegetable is a major source of vitamins such as B and C and also minerals such as P.

Moreover, tomatoes provide important nutritional components such as carotenoids, vitamin C (ascorbic acid), phenols, and flavonoids. Ascorbic acid, total soluble solids (TSS), lycopene and titratable acidity contents are commonly considered as fruit quality determining properties in tomato (Aboutalebi *et al*., 2012) [2]. Most variation in flavour can be related to differences in the sugars and acids contents of the fruits. Ascorbic acid (vitamin C) is an important antioxidant, therefore is as a protective against many of diseases produced by reactive oxygen such as superoxide (Aoun *et al*., 2013) [3]. Soluble solids include mainly the sugars such as glucose, fructose and sucrose. Lycopene is the most beneficial tomato compound with important health effects, having a higher level of antioxidant activity (Singh, 2008; Ilahi, 2011; Basuny, 2012; Abete, 2016; Stice, 2018; Chen, 2019; Yin, 2019; Zeng, 2019) [14, 9, 5, 1, 15, 6, 17, 18]. The acidity of the fruit is also important as a contributor to the flavour of the tomato products.

The amount of lycopene and total carotenoids content can vary with the variety, degree of ripeness, climatic conditions and agricultural practices. In tomato, quality parameters are the most important external characteristics to assess post-harvest life. This study evaluates the quality parameters, vitamin C, total soluble solids, lycopene and titratable acidity content of ten tomato genotypes, hybrids and one check variety.

Materials and Methods
The present investigation was carried out in the Department of plant breeding and Genetics, College of Agriculture, Vellayani, during 2017-2020. The experiment site is located at 8.5^o North latitude and 76.9^0 East longitude, at an altitude of 29.00 m above mean sea level. Predominant soil type of the experimental site is red loam to Vellayani series, texturally classified as sandy clay loam. The area enjoys a warm humid tropical climate.

The experimental material comprised of 10 genotypes collected from different sources (Table 1) and their hybrids and one check variety. The seedlings were raised in greenhouse in portrays

and 30 days old seedlings of thirty-two tomato genotypes were transplanted in field. The field was prepared to fine tilth by ploughing, harrowing, clod crushing and levelling. Plants were transplanted in main field at a spacing of 60 cm x 60 cm. The crop was managed as per the package of practices recommendation of Kerala Agricultural University (KAU, 2011). The experiment was laid out in Randomized Block Design (RBD) with three replications. A total of 32 genotypes were raised in a plot with a spacing of 60 x 60 cm. Recommended agronomic practices and need-based plant protection measures were taken. Five plants were randomly selected in each treatment in each replication tagged and observations with respect to quantitative traits were recorded.

Vitamin C content of tomato fruits was estimated using 2, 6-dichlorophenol indophenole dye method and reported as mg/100g of tomato fruit (Sadasivam and Manickam, 1996) [13]. Value was expressed in mg per 100g.

Total soluble solids of tomato fruits were recorded using a hand refractrometer (0-32 ^{0} Brix). A drop of tomato juice was used to determine the TSS content with the help of refractrometer and the value was expressed in per cent at room temperature.

Lycopene is responsible for red color of tomato, its content varies depending on the potential of the accession to accumulate the same, and hence the lycopene content was estimated using the protocol proposed by Ranganna (1976) [11]. Lycopene has absorption maxima at 473 nm and 503 nm. One mole of lycopene when dissolved in one litter petroleum (40-60 ^{o}C) and measured in a spectrophotometer at 503 nm in one cm light path gives an absorbance of 17.2 X 104. Therefore, a concentration of 3.1206 µg lycopene/ml gives unit absorbance. Value was expressed in mg per 100g.

For determination of the titratable acidity (TA) the samples were homogenised with distilled water and titrated with 0.1 N NaOH until reaching of 8.1 PH. The results been calculated using the following formula and expressed as percentages of citric acid content (Saad *et al*., 2014) [12]: Percent of titratable acidity = (V x N x 100 x 0.0064)/m, where N is the normality of NaOH, 0.0064 is the conversion factor for citric acid, V is the volume of NaOH used (mL) and m is the mass of tomato sample used (g).

Results and Discussions

Analysis of variance

The analysis of variance was carried out for all four characters studied. All the genotypes differed significantly among themselves for all the characters studied (Table 2). The treatment mean sum of square due to genotypes was found to be highly significant for all the characters studied which would ultimately indicate the diverse nature of selected genotypes. Therefore, there is an ample scope for selection of promising genotypes from the present gene pool for quality parameters.

Table 1: Details of the Tomato genotypes

Sl. No	Genotypes	Source of Collection
L1	Vellayani Vijay	KAU
L2	Anagha	KAU
L3	Akshaya	KAU
L4	PKM1	TNAU
L5	Arka Meghali	IIHR, Bengaluru
L6	Arka Alok	IIHR, Bengaluru
L7	Pusa Ruby	IARI, New Delhi
T1	Palakkadu Local	KAU
T2	Kuttichal Local	KAU
T3	Kottayam Local	KAU
Check	Arka Vikas	IIHR, Bengaluru

Table 2: Analysis of variance of RBD for different characters in Tomato

Source of Variation	Mean sum of square				
	d.f.	Vitamin C	TSS	Lycopene	Titrable acidity
Replication	2	4.16	0.39	0.98	0.02
Genotype	31	13.5**	1.68**	55.43**	0.09**
Error	62	0.72	0.04	0.15	0.0
S.E. (d)		0.69	0.18	0.31	0.11
C.D. /lsd		1.85	0.48	1.84	1.15

** Significant at 1% level of significance

Table 3: Mean performance of Tomato genotypes

S. No.	Name of genotypes	Vitamin C (mg/100g)	Total soluble solids (^{0} Brix)	Lycopene (mg/100g)	Titrable Acidity
1	L1	16.00*	4.17	12.27	0.38*
2	L2	16.00*	4.67*	14.46*	0.17*
3	L3	16.00*	4.00	20.18*	0.34*
4	L4	16.00*	5.83*	14.56*	0.64
5	L5	12.00	4.00	9.05	0.47
6	L6	20.00*	3.67	10.40	0.34*
7	L7	16.00*	3.50	6.55	0.47
8	T1	12.00	3.67	6.87	0.38*
9	T2	12.00	4.83*	12.69*	0.34*
10	T3	12.00	5.17*	18.10*	0.43
	Mean	14.80	4.35	12.51	0.40
11	L1T1	16.00*	5.17*	9.15	0.30*
12	L1T2	16.00*	3.00	11.65	0.21*
13	L1T3	16.00*	4.17	13.63	0.17*
14	L2T1	12.00	4.17	6.66	0.30*
15	L2T2	14.67*	4.67*	14.04	0.68
16	L2T3	16.00*	4.83*	16.02*	0.60
17	L3T1	12.00	4.00	16.75*	0.60
18	L3T2	14.67*	3.67	19.35*	0.34*

19	L3T3	12.00	5.33*	18.31*	0.51
20	L4T1	16.00*	3.00	13.63	0.85
21	L4T2	12.00	5.33*	13.83	0.73
22	L4T3	16.00*	4.00	14.67	0.43*
23	L5T1	12.00	4.67*	8.32	0.38*
24	L5T2	14.67*	5.50*	13.73	0.38*
25	L5T3	12.00	5.17*	20.49*	0.21*
26	L6T1	12.00	5.00*	17.68*	0.26*
27	L6T2	16.00*	4.00	12.79	0.85
28	L6T3	14.67*	5.17*	15.60*	0.47
29	L7T1	16.00*	5.17*	17.27*	0.34*
30	L7T2	16.00*	5.50*	23.92*	0.55
31	L7T3	16.00*	4.00	17.27*	0.21*
	Mean	14.41	4.55	14.99	0.45
Check	Arka Vikas	16.00	4.33	18.20	0.47

* Significant at 5% level

Mean performance

Vitamin C recorded the mean value of 14.80 mg/100g for parents. Among the 10 parents, six genotypes had shown significantly higher values for Vitamin C based on mean value Vitamin C was the highest for Arka Alok (20 mg/100g). Low amount of Vitamin C was observed for Arka Meghali, Palakkadu local, Kuttichal local and Kottayam local (12 mg/100g). Among the thirty two hybrids, fourteen hybrids had shown significantly higher values for Vitamin C based on mean value. More amount of Vitamin C was found in L1T1, L1T2, L1T3, L2T3, L3T3, L4T3, L6T2, L7T1, L7T2 and L7T3 (16 mg/100g). L2T1, L3T1, L3T3, L4T2, L5T1, L5T3 and L6T1 had shown low amount of Vitamin C (12 mg/100g). High vitamin C content in tomato not only improves the nutrition, it also aids in better retention of natural colour and flavor of the products. Araujo *et al*., (2014) [4] also reported differences in plant height among cultivars/hybrids of tomato put under evaluation and screening trials.

The mean performance of the trait total soluble solids was 4.35 ^{0} Brix and range varied from 3.50 ^{0} Brix (Pusa Ruby) to 5.83 ^{0} Brix (PKM 1). Out of ten parents, four genotypes revealed significant for the trait total soluble solids based on the mean value. Among the thirty-two hybrids, mean performance of the trait total soluble solids was 4.55 ^{0} Brix and range varied from 3 ^{0} Brix (L1T2) to 5.50 ^{0} Brix (L5T2 and L7T2). Twelve genotypes revealed significant for the trait total soluble solids based on the mean value and these values are more than the value of Arka Vikas. It was found that full ripen tomato contained the highest quantity of TSS while it was the lowest in mature green tomatoes at harvest These results are in close conformity with the findings of Tigist *et al*., (2011) [16] who reported significant variation among the cultivars of tomato for the quality parameters.

Lycopene was recorded the mean of 12.51 mg/100g with the range of 6.55 mg/100g (Pusa Ruby) to 20.18 mg/100g (Akshaya) for the parents. Five genotypes had shown significantly high value for the trait. Among hybrids, mean of lycopene was 14.99 mg/100g with the range of 6.66 mg/100g (L2T1) to 23.92 mg/100g (L7T2) was recorded. Three hybrids had shown significantly high value for the trait when compare with the mean value (18.20 mg/100g) of check variety. We can say that lycopene content depending upon variety (Lahoz *et al*., 2016) [10].

The mean obtained from the parents for the trait titratable acidity was 0.40% with the range varied between 0.17% (Anagha) and 0.64% (PKM 1). Among one ten parental genotypes, six genotypes had shown significantly low value for the trait titratable acidity. Mean obtained from the hybrids for the trait titratable acidity was 0.45 with the range varied between 0.17 (L1T3) and 0.85 (L4T1 and L6T2). Twelve hybrids had shown significantly low value for the trait titratable acidity.

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