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Evaluation of tomato genotypes for fruit yield and quality traits under Chhattisgarh plain conditions

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Abstract
Vegetables are important component of balanced human diet. Advanced production technologies are being followed to measure productivity and quality of produce. In this experiment 22 genotypes were studied for higher yield along with better nutritional qualityunder which Arka Vikas showed, highest average fresh fruit weight and dry weight which depicts that Arka Vikas had minimum moisture percentage (%), whereas genotype 2014/TODVAR-6 showed maximum moisture percentage (%). The lowest average fresh fruit weightwas observed in the genotype 2015/TOINDVAR-1. The highest fruit length (cm), diameter (cm) was observed in the genotypes 2013/TODVAR-1 and 2015/TOINDVAR-5,respectively. Genotype 2015/TOCVAR-1 and 2015/TOCVAR-6 showed maximum shelf life (days) and Arka Vikas gave higher yield (q/h) among all genotypes. Significant differences were observed for various biochemicals among the genotypes. Genotype 2014/TODVAR-3 showed highest β-carotene (mg/100 ml) and lycopene content (mg/100 ml). Genotype 2015/TOINDVAR-5 showed highest total carotenoid (mg/100 g). Highest Ascorbic acid (mg/100 g) and titrable acidity (%) was observed in the genotype 2014/TODVAR-5 and 2015/TOCVAR-5, respectively. Genotype 2014/TODVAR-3 is the best among all genotypes in terms of yield and nutritional qualities followed by 2015/TOINDVAR-5 and H-86.

Keywords: Tomato, yield traits, β-carotene, total carotenoid, ascorbic acid, titrable acidity

Introduction
Tomato is considered as healthy food because of itsnutritional awareness among people. Tomatoes find numerous uses in both fresh and processed forms that include ketchup, sauces, pastes and juice. In recent years, researchers are interested and focused on the identification of bioactive components in food that affects the health, and may also reduce the risk of some diseases. Naika *et al.* Awas *et al.*, indicated that, the high nutritional value and potential health benefits of tomato have drawn an increased interest towards tomato-based products among consumers. Hence major emphasis is being given to improve the quality of produce along with higher production. Due to carotenoids, lycopene and β-carotene, tomato has high nutritional value. Lycopene is the main carotenoid of tomato and is accumulated and highly concentrated in mature red fruits. Tomato decreases the risk from some types of cancer and heart diseases (Rao *et al.*, 2000) [34]. β-carotene is provitamin of vitamin A and its deficiency can cause xerophthalmia, blindness and premature death (Mayne, 1996) [23]. It is believed that ascorbic acid is vital in preventing cardiovascular diseases, some cancers, cataracts, and also prevents mutations of DNA caused by oxidative stress (Byers and Guerrero, 1995; Lutsenko *et al.*, 2002; Marchioli *et al.*, 2001) [7, 18, 21]. The nutritional importance of tomato indicates that it is necessary to formulate breeding programme and to develop cultivars rich in antioxidant compounds, processing traits with high quality of fruit as well as yield (Dar and Sharma, 2011) [8].

Materials and Methods
The experiment was conducted in an open field in a Randomized Block Design with three replications. The investigations included 22 tomato genotypes from different sources. During its growing season all standard growing measures have been applied to researched tomato genotypes. For the purposes of this research, fruits were harvested at full maturity stage. After harvesting, the samples were analysed morphologically and for different biochemical compositions.

Morphological observations
Randomly selected fruits of each genotype in each replication were taken for the study of all morphological characters of tomato i.e., fruit length (cm), fruit diameter (cm), pericarp

thickness (cm), fruit fresh weight (g), dry weight (g) moisture content (%) and fruit yield (q/ha). Shelf life (days) was recorded at room temperature. The number of days were counted till the fruits degraded upto 40%. For all observations the mean was calculated and averaged over replication.

Biochemical analysis- Determination of Pigments (mg/100 ml)

β-carotene and lycopene were determined according to the method of Nagata and Yamshita (1992) [29]. It is a simple method for simultaneous determination of pigments in tomato. Contents were calculated according to the following equations:

Lycopene (mg/100 ml) = - 0.0458 *A*663 + 0.204 *A*645 + 0.372 *A*505 –0.0806-*A*453

β-carotene (mg/100 ml) = 0.216 *A*663 -1.22 *A*645 – 0.304 *A*505 + 0.452 *A*453

Determination of Total carotenoids (mg/100 g)

Total carotenoids was determined according to the method of Harborne (1973). After analysis content was calculated according to the following equations:

$$\text{Amount of carotenoids in 100 mg plant tissue} = \frac{4\times \text{OD} \times \text{Total volume of sample (i.e. we have made 10 ml supernatant}}{\text{weight of fresh plant tissue (} i.e. \text{ we have taken 100 mg plant tissue to grind)}}$$

Determination of Ascorbic acids (mg/100 gm)

The ascorbic acid in fresh fruits was measured by titration against 2.6 dichlorophenolindophenol dye according to Albrecht (1993) [2]. In this experiment 10 ml of tomato juice was taken and made up to 100 ml with 3% HPO3 and filtered. 10 ml of filtrate was taken with the help of pipette into a conical flask and titrate with the standard dye solution to a pink colour end-point persisting for at least 15 second titre was determined. It should be taken care that titre should not exceed 3 to 5 ml. Three parallel titrations were performed for each sample. For the calculation of L- ascorbic acid content in the tomato, the average values of the volumes of three titrations were taken.

Determination of Titrable acidity (%)

Acid content of the extracted juice of five fruits from each plot was determined by titrating 10 ml of tomato juice against 0.1 N NaOH using phenolphthalein as an indicator. The end point appeared as light pink colour. Acidity was expressed in terms of percentage by using following formula:

$$\text{Acidity (\%)} = \frac{\text{Titre} \times \text{Normality of alkali} \times \text{Equivalent weight of acid} \times \text{Volume made up} \times 100}{\text{Volume of sample taken} \times \text{Wt. of volume of for estimation sample taken} \times 1000}$$

Result and Discussion

A significant variations were observed among different genotypes for morphological traits (Table 1). Average fruit (single fruit) weight ranged from 5.18 g to 137.88 g. Results found are similar with the studies of Biswas *et al.* (2015) [4] who found individual fruit weight as 115.9 g. Rana *et al.*, (2014) [33] also reported similar results. Dry weight of fruit ranged from 0.59 g to 33.31 g. The range of moisture percentage was 75.79 per cent to 94.66 per cent, similar results were reported by Gupta *et al.*, (2011) [11] who studied two genotypes and found 94.45 and 92.24 per cent moisture. Average fruit length ranged from 1.77cm to 5.01 cm and diameter varied from 1.73 cm to 5.71 cm similar results were reported by Saimbhi *et al.*, (1995) [35] and Naidu (2001) [26]. The shelf life of various genotypes (Table 1) varied between 2 to 18 days with overall mean of 11 days. Rai *et al*., (2012) [32] reported that average shelf life of tomato fruits ranged from 6-12days among cultivars based on 40% spoilage. Average fruit yield per hectare ranged from 75.66 q to 366.07 q (Table 2). The highest fruit yield per hectare was noted in Arka Vikas (366.07 q) whereas, the lowest fruit yield per hectare was noted in 2014/TODVAR-2 (75.66 q). Rana *et al*., (2014) [33] reported that tomato plants grown in polyhouse climate produced about 50% higher fruit yield (90 t ha^{-1}) than the tomato plants grown in open field conditions (54 t ha^{-1}).

Lycopene is a pigment, responsible for the red colour of the mature tomato and its products (Shi *et al*., 2000) [36]. The present data on lycopene content showed significant variations among various genotypes (Table 2), it varied between 0.028mg/100ml to 0.483 mg/100ml.The findings are in accordance with values obtained by Mladenovic *et al.* (2014) [24] 0.031mg /100g-4.330mg/100g. Kumar *et al.*(2014) [17, 33] and Kaur and Chemma (2005) [15] also found lycopene content ranged from0.042 and 0.016 mg/100gm, and 0.29 to 3.31 mg /100 g fresh fruit respectively. Hammed *et al.* (2012) [13] and Burns *et al*., (2003) [6] also reported similar results. β-carotene ranges from 0.032mg/100ml – 0.268mg/100ml (Table 2). Results were similar as reported by Hallmann *et al*., (2008) [12] that tomato fruits contained 0.26mg/100g fw of β-carotene, while in 2009 it was 0.21mg/100g fw. Kotikova *et al*., (2009) [16] also reported similar results. Abushita *et al.*, (2000) [1] found that the β-carotene content was between 2.9mg/kg- 6.2mg/kg. It is believed that the differences among the contents depend upon the growing methods and climate conditions (Raffo *et al*., 2002) [31], but on the traits of the researched tomato genotypes, too.

Total carotenoid ranged from 0.101 mg/100g to 0.531 mg/100g (Table 2). It shows that maximum total carotenoid was recorded in the genotype 2015/TOINDVAR-5 (0.531 mg), whereas the minimum total carotenoid content was recorded in the genotype2014/TODVAR-6 (0.101 mg). Similar results were reported by Kotikova *et al.* (2009) [16] who evaluated 11 varieties and reported an average content of carotenoids as 665 µg/g dry mass. Large differences in L-ascorbic acid content among genotypes (Table 2) were found. The highest level was found in genotype 2014/TODVAR-5 (26.50 mg)and the lowest in the genotype 2014/TODVAR-6 (2.50 mg). Similar results were found by Gupta *et al.* (2011) [11] who studied two genotypes and reported the amount of ascorbic acid as 31.33 and 27.82 mg. Moneruzzaman *et al.*,(2008) [25], Rai *et al.*,(2012) [32], Abushita *et al.*,(2000) [1] and Nagar *et al.*,(2015) [28] also reported similar results. Gould (1992) [10], in his recommendations for breeding varieties for processing, suggested the need for developing varieties which have ascorbic acid in excess of 20 mg/100 g. In light of this, cherry varieties, 818 cherry, T-56 and BR-124, having high ascorbic acid may be recommended as potential varieties for processing and for improvement of nutritional value in breeding programmes. Consumption of these varieties as fresh salad may also serve as a good source of dietary antioxidant.

The level of acidity in tomato fruits is an important parameter associated with sensory attributes like flavor and astringency. Titrable acidity varied significantly between 0.35 to 0.83 per cent (Table 2). The results are in accordance with Manna and Paul (2012) who reported acidity ranging from 0.30 to 0.73 percent. Nour *et al.* (2013) [30], Rai *et al.* (2012) [32] and George *et al.* (2004) [9] also reported similar results.

According to Mahakun *et al.* (1979) [19], the genetic factor is the major acid content determinant in tomato plant fruits, with great variation occurring between genotypes.

High yield with better nutritional quality

Table 2 shows data regarding high yielding genotypes with better nutritional quality. It was observed that 2014/TODVAR-3 is the best genotype among all genotypes in terms of yield and nutritional qualities. It is a high yielding genotype (248.51 q) with high beta carotene (0.268 mg/100ml), lycopene (0.483 mg/100ml), total carotenoids (0.371 mg/100ml) but comparatively low ascorbic acid (6.17mg/100g) followed by 2015/TOINDVAR-5 and H-86.Genotype 2015/TOINDVAR-5 yields 326.07 q fruit with 0.207mg/100ml beta carotene, 0.232mg/100ml lycopene, 0.531 mg/100ml total carotenoids and 4.33 mg/100g ascorbic acid. Whereas, H-86 yields 145.69 q fruit with 0.170mg/100ml beta carotene, 0.142 mg/100ml lycopene, 0.210 mg/100ml total carotenoids and 6.83 mg/100g ascorbic acid.

The chemical composition of the fruit depends on genetics, environmental factors (temperature, light, water and nutrient availability, air composition), agricultural techniques (varieties, plant growth regulators, ripening stage at harvest, training and irrigation system), and on post-harvest storage conditions (Borguini and Da Silva Torres, 2009; Maršić *et al.*, 2011; Vinkovic Vrcek *et al*., 2011) [5, 22, 37]. The nutritional importance of tomato indicates that it is necessary to formulate breeding programme and to develop cultivars rich in antioxidant compounds, processing traits with high quality of fruit as well as yield (Dar and Sharma, 2011) [8].

Table 1: Fresh weight, dry weight, moisture %, fruit length, fruit diameter, fruit shelf life as affected by different of genotypes Tomato

Genotypes	Fresh wt.(g)	Dry wt.(g)	Moisture %	Fruit length (cm)	Fruit Diameter (cm)	Fruit Shelf Life (Days)
2013/TODVAR-1	95.32	6.71	92.90	5.01	5.60	12.33
2013/TODVAR-2	72.73	6.32	91.26	4.57	4.17	12.33
2013/TODVAR-3	28.10	5.45	80.61	3.99	4.36	16.67
2014/TODVAR-1	71.31	6.28	93.14	4.25	4.61	18.33
2014/TODVAR-2	44.25	6.33	91.74	4.49	5.00	17.67
2014/TODVAR-3	69.66	6.38	92.70	4.39	5.12	15.33
2014/TODVAR-4	62.56	8.31	89.52	4.39	4.55	9.33
2014/TODVAR-5	59.09	6.12	92.24	4.55	4.12	14.33
2014/TODVAR-6	51.72	3.78	94.66	4.74	4.74	7.67
2015/TOCVAR-1	10.80	1.28	88.11	2.68	1.73	18.67
2015/TOCVAR-2	9.22	0.87	90.53	1.86	1.89	17.67
2015/TOCVAR-3	14.09	1.45	89.69	2.51	2.53	18.33
2015/TOCVAR-5	14.16	2.34	83.57	2.61	2.06	15.67
2015/TOCVAR-6	12.03	1.34	88.86	2.02	2.05	18.67
2015/TOINDVAR-1	5.18	0.59	88.63	1.83	1.94	2.00
2015/TOINDVAR-2	6.65	0.70	89.32	1.77	1.85	2.33
2015/TOINDVAR-3	60.83	5.41	90.66	3.46	3.61	3.67
2015/TOINDVAR-4	55.24	6.97	86.57	4.34	4.35	4.67
2015/TOINDVAR-5	68.80	4.53	93.28	4.82	5.71	3.67
H-86	108.70	20.09	86.37	4.77	5.13	6.33
ARKA VIKAS	137.88	33.31	75.79	3.70	4.46	7.33
SWARNA RATAN	10.33	1.34	87.03	2.18	2.26	17.33
CD at 5%	9.61	0.80	3.18	0.44	0.45	1.91
CV (%)	12.01	7.88	2.17	7.52	7.4	9.83

Table 2: High fruit yield with better nutritional quality

Genotypes	β-Carotene (mg/100ml)	Lycopene (mg/100ml)	Total Carotenoids (mg/100g)	Yield q/ha	Ascorbic Acid (mg/100g)	Titable Acidity (%)
2013/TODVAR-1	0.056	0.055	0.131	234.62	7.83	0.54
2013/TODVAR-2	0.087	0.032	0.355	150.20	5.00	0.43
2013/TODVAR-3	0.086	0.267	0.255	104.09	9.67	0.35
2014/TODVAR-1	0.032	0.051	0.108	90.74	11.17	0.51
2014/TODVAR-2	0.072	0.159	0.122	75.66	9.00	0.38
2014/TODVAR-3	0.268	0.483	0.371	248.51	6.17	0.59
2014/TODVAR-4	0.082	0.132	0.251	250.95	3.83	0.57
2014/TODVAR-5	0.073	0.121	0.168	127.29	26.50	0.47
2014/TODVAR-6	0.112	0.118	0.101	95.76	2.50	0.53
2015/TOCVAR-1	0.078	0.033	0.162	209.42	19.67	0.72
2015/TOCVAR-2	0.103	0.094	0.238	141.89	7.00	0.70
2015/TOCVAR-3	0.083	0.120	0.190	216.05	16.83	0.51
2015/TOCVAR-5	0.104	0.052	0.223	254.33	7.83	0.83
2015/TOCVAR-6	0.151	0.071	0.207	151.71	21.17	0.40
2015/TOINDVAR-1	0.088	0.042	0.228	125.00	11.33	0.54
2015/TOINDVAR-2	0.049	0.028	0.168	89.58	9.17	0.51
2015/TOINDVAR-3	0.040	0.041	0.160	201.94	4.83	0.53
2015/TOINDVAR-4	0.064	0.089	0.159	240.83	4.50	0.42
2015/TOINDVAR-5	0.207	0.232	0.531	326.07	4.33	0.65
H-86	0.170	0.142	0.210	145.69	6.83	0.51

ARKA VIKAS	0.128	0.071	0.114	366.07	3.50	0.38
SWARNA RATAN	0.063	0.050	0.319	263.94	11.17	0.48
CD at 5%	0.01	0.02	0.04	55.85	1.33	0.08
CV (%)	9.88	15.94	12.29	18.14	8.46	10.26

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