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Studies on Biochemical Composition of Various Tomato (*Solanum lycopersicum* L.) Genotypes

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A B S T R A C T

An experiment was carried out to study biochemical composition of different genotypes of tomato. A total of 22 genotypes were studied in which significant differences were observed for various biochemical traits among the genotypes. Genotype 2014/TODVAR-3 showed highest β-carotene (mg/100 ml) and lycopene content (mg/100 ml), whereas genotype 2015/TOCVAR-3, showed highest chlorophyll a (mg/100 ml) and b. Genotype 2015/TOINDVAR-5 showed highest total carotenoid (mg/100 g). Highest Ascorbic acid (mg/100 g), titrable acidity (%) and pH was observed in the genotype 2014/TODVAR-5, 2015/TOCVAR-5 and 2015/TOCVAR-3, respectively. The highest TSS percent (%) was recorded in genotype 2015/TOCVAR-5 on the other hand genotype2015/TOINDVAR-5 gave highest total sugar (%) and reducing sugar (%), and 2015/TOINDVAR-4 gave highest non-reducing sugar (%).

Introduction

Vegetables are important component of balanced human diet. Advanced production technologies are being followed to measure productivity and quality of produce. Tomato occupies a prime position in list of protective vegetable fruits since it is a rich source of minerals, vitamins and organic acids. Tomato fruit contains high moisture and dry matter (DM) of 5-7.5% (Davies and Hobson, 1981). The composition of dry matter in tomato consists of sugars, mainly glucose and fructose, organic acids (citric and malic acid); minerals, (N, P and K), vitamins and anti-oxidant pigments such as lycopene; they have beneficial effects on human health. Franceschi *et al.,* (1994) and Frusciante *et al.,* (2000) reported that the consumption of the tomato and its products (i.e., ketchup, paste) is negatively correlated with the development of tumours in the digestive tract and prostate cancer. β-carotene is known for its provitamin A activity and lutein for reduced risk of lung cancer (Sies, 1991). Vitamin C plays an important role in human health and its main

functions are in the prevention of scurvy and maintenance of skin and blood vessels (Lee and Kader, 2000). Besides its importance for consumption, fruit acidity and total soluble solid content are vital factors in the processing industry. The acidity is related to pH and low pH of the pulp prevents the growth of microorganisms that are harmful (Carvalho, 1980), which in turn decreases the period of heating needed for sterilisation during processing (Stevens, 1972). However, the total soluble solids content (TSS) is important especially when the objective is dehydration, concentrated pulp preparation, or both (Stevens, 1972).

The antioxidant content of tomato mostly depends on both genetic and environmental factors and the ripening stage (Hart and Scott, 1995; George *et al.*, 2004; Hallmann, 2012; Nour *et al.*, 2013). Gupta *et al.*, (2011) reported that tomatoes contribute to a well-balanced healthy diet with the right proportion of vital nutrients such as minerals, vitamins, essential amino acids, sugars, lycopene and other carotenoids and dietary fibres. Tomato being acceptable to people as a food could be a source of nutrients as well as a nutraceutic in the sub-continent. Therefore present experiment was carried out to study biochemical composition of different genotypes of tomato.

Materials and Methods

The present investigation was carried out in an open field in a Randomized Block Design with three replications.

For the purpose of this research, fruits were harvested at full maturity stage. 22 genotypes of tomato were evaluated for different biochemicals i.e. lycopene, β-carotene, chlorophyll a, chlorophyll b, total carotenoid, ascorbic acid, titrable acidity, total soluble solids pH and sugars.

Determination of pigments (mg/100ml)

β-carotene, lycopene, chlorophyll a and b were determined according to the method of Nagata and Yamshita (2015). It is a simple method for simultaneous determination of pigments in tomato. One gm sample of tomato was taken in a tube and 20 ml of acetone-hexane (4:6) solution was added and then vortexing and centrifugation (3000 rpm) was done for 10 and 15 minutes respectively.

Supernatant was collected and filtered through Whatman No.4 filter paper. The absorbance of the filterate was measured at 663nm, 645nm, 505nm and 453nm by spectrophotometer at the same time. Contents of β-carotene, lycopene, chlorophyll a and b were calculated according to the following equations:

Chlorophyll a (mg/100ml) = 0.999 *A*663 - 0.0989 *A*645

Chlorophyll b (mg/100ml) = - 0.328 *A*663 + 1.77 *A*645

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

*A*453 β-carotene (mg/100ml) = 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). 100 mg of fresh crushed plant tissue was taken in a tube and 10 ml of 80% acetone was added and centrifuged at 3000 rpm for 10 minutes. Supernatant was taken in a separate tube and volume make up was done upto a known volume of 10 ml with 80% acetone. The optical density of supernatant was measured at 480 nm in UV spectrophotometer. Total Carotenoid was calculated according to the following equations:

Calculation

Amount of total carotenoid =

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

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). 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 of at least 15 second titre was determined. It should be taken care that titre should not exceed 3 to 5ml.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.

Determination of total soluble solids (%), ph and sugars (%)

The fruits were cut into small pieces and squeezed to obtain the juice and with the help of the ERMA hand refractometer, TSS (%) of fruit was determined. The average was calculated and was expressed as per cent total soluble solids in juice. The pH of the fruit juice extracted from five randomly selected fruits from each plots was recorded with the help of pH meter. Sugars were determined by the method of Lane and Eynon as described by Ranganna (1997).

Results and Discussion

Significant differences were detected among tomato genotypes in all studied biochemical parameters grown under the same agricultural, geographical and climatic conditions. lycopene is a pigment, responsible for the red colour of the mature tomato and its products (Shi *et al.,* 2000). The present data on lycopene content showed significant variations among various genotypes (Table 1), it varied between 0.028mg/100ml to 0.483 mg/100ml. The findings are in accordance with values obtained by Mladenovic *et al.,* (2014) 0.031mg/100g to 4.330mg/100g. Kumar *et al.,* (2014) and Kaur and Chemma (2005) also found lycopene content ranged from 0.042 and 0.016 mg/100gm,0.29 to 3.31 mg /100 g fresh fruit respectively. Hammed *et al.,* (2012) and Burns *et al.,* (2003) also reported similar results. Lycopene is the major carotenoid found in tomatoes and in the second place in the carotenoids ranking is beta-carotene.

The content of lycopene in tomato fruits depends on many factors, including the level of nitrogen in soil. The increase in lycopene content along with more intense nitrogen fertilization is justified by Lacatus *et al.,* (1995)as follows: nitrogen is the main element that forms Acetyl-CoA enzyme which plays a central role in the synthesis of carotenoid pigments and converts beta-carotene into lycopene. Dadomo *et al.,* (1994) found that with the increased dose of nitrogen the yield of red and uniformly stained fruits as well as the number of fruits per unit of cultivation area were higher.

β-carotene ranged from 0.032mg/100ml – 0.268mg/100ml (Table 1). Results were similar as reported by Hallmann *et al.,* (2008)that tomato fruits contained 0.26mg/100g fw of β-carotene, while in 2009 it was 0.21mg/100g fw. Kotikova *et al.,* (2009) also reported similar results. Abushita *et al.,* (2000) 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), but on the traits of the researched tomato genotypes, too.

Chlorophyll a and Chlorophyll b ranges between 0.003mg/100ml - 0.068 and 0.004 mg/100ml - 0.255mg/100ml, respectively (Table 1). Watada *et al.,* (1976) reported that the average chlorophyll content decreased from 13.45µg/g fw in immature green fruit to 0.3µg/g fw in partially ripe fruit. In present investigation the range of total carotenoid was 0.101mg/g-0.531mg/g. Raffo *et al.,* (2006) reported that carotenoids content of tomato were very low at the breaker stage (1.08mg/100g) which increased 10-fold during ripening and reached 12.705mg/100g at full ripening stage. The carotenoids content increased during storage in tomato because of advancement of ripening stage, chlorophyll degradation and increase in the carotenoids synthesis Prete *et al.,* (1995). Carotenoid concentrations in fruits and vegetables were shown to vary with plant variety, degree of ripeness, time of harvest and growing and storage conditions Lessin *et al.,* (1997). Apart from that, environmental factors such as temperature, plant nutrition, and light can also considerably affect the biosynthesis of carotenoids. There were significant differences in the amount of ascorbic acid in the different genotypes of tomatoes studied, it ranges between 2.50 mg/100g to 26.50 mg/100g (Table 1). Similar results were found by Gupta *et al.,* (2011) who studied two genotypes and reported the amount of ascorbic acid as 31.33 and 27.82 mg. Moneruzzaman *et al.,* (2008), Rai *et al.,* (2012), Abushita *et al.,* (2000) and Nagar *et al.,* (2015) also reported similar results. Gould (1992), 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. Titratable acidity varied significantly between 0.35 to 0.83 per cent (Table 1). The results are in accordance with Manna and Paul (2012) who reported acidity ranging from 0.30 to 0.73 percent. Similar results were also reported by Nour *et al.,* (2013), Rana *et al.,* (2014), Rai *et al.,* (2012) and George *et al.,* (2004). According to Mahakun *et al.,* (1979), the genetic factor is the major acid content determinant in tomato plant fruits, with great variation occurring between genotypes. (Stevens and Rick, 1986) these authors reported variation in fruit acidity (% citric acid) for different accessions of *Lycopersicon esculentum,* from 0.40% to 0.91%; Stevens *et al.,* (1979) and Mitchell *et al.,* (1991) found lower citric acid percentage values, down to 0.25%. Loures (2001), evaluating the hybrid 'Carmem', found fruit titratable acidity (% citric acid) of 0.46% and 0.49% under greenhouse and field conditions, respectively.

TSS is a key determinant of shelf life and quality of the crop, whether it is for the fresh produce or for processing. Furthermore, TSS levels also contribute strongly to the tomato flavor and consistency (Stevens *et al.,* 1997).

Table.1 Beta carotene, lycopene, chlo.a, chlo.b, total carotenoid, ascorbic acid and titrable acidity as affected by different genotypes of tomato

Genotypes	β-Carotene (mg/100ml)	Lycopene (mg/100ml)	Total Carotenoids (mg/g)	Chlo.a (mg/100ml)	Chlo.b (mg/100ml)	Ascorbic Acid (mg/100g)	Titrable Acidity (%)
2013/TODVAR-1	0.056	0.055	0.131	0.010	0.007	7.83	0.54
2013/TODVAR-2	0.087	0.032	0.355	0.011	0.016	5.00	0.43
2013/TODVAR-3	0.086	0.267	0.255	0.007	0.021	9.67	0.35
2014/TODVAR-1	0.032	0.051	0.108	0.004	0.004	11.17	0.51
2014/TODVAR-2	0.072	0.159	0.122	0.007	0.007	9.00	0.38
2014/TODVAR-3	0.268	0.483	0.371	0.014	0.109	6.17	0.59
2014/TODVAR-4	0.082	0.132	0.251	0.003	0.005	3.83	0.57
2014/TODVAR-5	0.073	0.121	0.168	0.011	0.167	26.50	0.47
2014/TODVAR-6	0.112	0.118	0.101	0.048	0.080	2.50	0.53
2015/TOCVAR-1	0.078	0.033	0.162	0.007	0.164	19.67	0.72
2015/TOCVAR-2	0.103	0.094	0.238	0.007	0.009	7.00	0.70
2015/TOCVAR-3	0.083	0.120	0.190	0.068	0.255	16.83	0.51
2015/TOCVAR-5	0.104	0.052	0.223	0.022	0.032	7.83	0.83
2015/TOCVAR-6	0.151	0.071	0.207	0.035	0.025	21.17	0.40
2015/TOINDVAR-1	0.088	0.042	0.228	0.007	0.015	11.33	0.54
2015/TOINDVAR-2	0.049	0.028	0.168	0.031	0.105	9.17	0.51
2015/TOINDVAR-3	0.040	0.041	0.160	0.007	0.015	4.83	0.53
2015/TOINDVAR-4	0.064	0.089	0.159	0.012	0.008	4.50	0.42
2015/TOINDVAR-5	0.207	0.232	0.531	0.008	0.011	4.33	0.65
H-86	0.170	0.142	0.210	0.035	0.108	6.83	0.51
ARKA VIKAS	0.128	0.071	0.114	0.016	0.013	3.50	0.38
SWARNA RATAN	0.063	0.050	0.319	0.006	0.019	11.17	0.48
CD at 5%	**0.01**	**0.02**	**0.04**	**0.004**	**0.01**	**1.33**	**0.08**
CV (%)	**9.88**	**15.94**	**12.29**	**15.47**	**13.61**	**8.46**	**10.26**

Table.2 pH, TSS, total sugar, reducing sugar, non reducing sugar, as affected by different genotypes of tomato

Genotypes	pH	TSS (%)	Total Sugar (%)	Reducing sugar (%)	Non Reducing sugar (%)
2013/TODVAR-1	3.86	3.19	3.24	3.17	0.07
2013/TODVAR-2	4.00	4.80	3.63	3.26	0.37
2013/TODVAR-3	4.01	3.89	3.25	3.15	0.11
2014/TODVAR-1	3.97	3.73	3.48	3.32	0.16
2014/TODVAR-2	3.89	4.68	3.22	3.13	0.09
2014/TODVAR-3	4.00	3.80	3.18	3.03	0.15
2014/TODVAR-4	3.96	3.83	3.26	2.93	0.33
2014/TODVAR-5	3.95	4.28	3.33	3.06	0.27
2014/TODVAR-6	4.07	3.99	3.30	3.00	0.3
2015/TOCVAR-1	4.15	6.11	3.21	3.08	0.13
2015/TOCVAR-2	4.46	5.55	3.25	3.14	0.11
2015/TOCVAR-3	4.53	5.44	3.42	3.26	0.16
2015/TOCVAR-5	3.91	7.14	3.11	2.91	0.2
2015/TOCVAR-6	3.76	5.75	3.37	3.21	0.16
2015/TOINDVAR-1	4.00	6.65	3.31	3.09	0.22
2015/TOINDVAR-2	4.00	6.10	3.21	3.17	0.04
2015/TOINDVAR-3	3.62	3.50	3.32	3.21	0.11
2015/TOINDVAR-4	3.92	3.53	3.63	3.02	0.61
2015/TOINDVAR-5	4.05	3.79	3.89	3.64	0.25
H-86	4.17	3.72	3.37	3.22	0.15
ARKA VIKAS	3.99	3.95	2.84	2.70	0.14
SWARNA RATAN	3.85	5.43	3.30	3.15	0.15
CD at 5%	**0.14**	**0.66**	**0.11**	**0.13**	**0.04**
CV (%)	**2.24**	**8.69**	**2.06**	**2.66**	**15.28**

TSS ranged from 3.19 % to 7.14 % (Table 2). The findings are in agreement with Saimbhi *et al.,* (1995) who found total soluble solids ranged from 3.2 to 5.2 per cent; Kaur *et al.,* (2005), George *et al.,* (2004), and Hammed *et al.,* (2012) also reported similar results. Tomato TSS is mostly composed of reducing sugar (Ho and Hewitt, 1986). Thus, any factor that alters sucrose synthesis (photosynthetic activity) will affect glucose and fructose accumulation in the fruits, thus altering TSS.

The observations recorded for pH are presented in table 2. The pH ranged from 3.62 to 4.53 under different genotypes. Results are close to the findings of Saimbhi *et al.,* (1995) who reported range of pH from 3.7 to 4.9. Teka *et al.,* (2013), also reported similar results. The pH of tomatoes is determined primarily by the acid content of the fruit that determine the product safety. Anthon *et al.,* (2011) suggested that pH 4.4 is the maximum desirable for safety and the optimum target pH should be 4.25 to ensure food safety. Paulson *et al.,* (1974) reported that values of pH are crucial for processing tomatoes since values higher than 4.4 mean susceptibility of the pulp to thermophilic pathogens. Thus, pH values as low as possible (up to the point that it does not adversely affect taste) should be breed into tomato cultivars for industrial use (Georgelis *et al.,* 2002).

The data regarding total sugar, reducing sugar and non-reducing sugar percent are depicted in Table 2. It shows that the range of total sugar varied between 2.84 % to 3.89 % in different genotypes. Results are similar with Nagar *et al.,* (2015) and Rana *et al.,* (2014) who reported higher total sugar content as 4.5 % and 2.5 % respectively. Dorais *et al.,* (2001) also reported similar results. Maximum reducing sugar ranged from 2.70 % to 3.64 %, results are in accordance with Dalal *et al.,* (1965) and Teka *et al.,* (2013). Non reducing sugar varied between 0.06-0.61 percent. Tsuda *et al.,* (1999) reported that total sugar content will increase due to conversion of starch into sugars. The sugar content is the most important characteristics of tomatoes as high sugars determine sweetness and are required for best flavour Rodica *et al.,* (2008). Wills *et al.,* (1998) reported that, the increase in sugars renders the fruit much sweeter and more acceptable.

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). 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).

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