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Quality and nutritional composition in tomato fruit at different stages of maturity

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Abstract

A total of six released tomato hybrids *viz.*, Swarna Baibhav, Swarna Sampada, Swarna Samridhi, Swarna Vijaya, Swarna Deepti, Swarna Anmol and two open pollinated tomato varieties *viz*., Swarna Lalima and Swarna Naveen of ICAR-RCER, RC Ranchi were analyzed for their quality and nutritional composition at different stages of maturity. Swarna Samridhi recorded highest antioxidant activity (26.17%) and highest TSS (7.6%) at fully ripe stage. Ascorbic acid was highest at Swarna Naveen (21.75 mg/100 g) at fully ripe stage. All genotype showed marked increase in antioxidant activity and ascorbic acid content from green to breaker stage. TSS was recorded highest at fully ripe stage due to breakdown of starch and polysaccharides. Hence, fully ripe tomato is best for consumption in terms of nutritional quality.

Keywords: Tomato, antioxidant activity, ascorbic acid, TSS, nutritional quality

Introduction

Tomato (*Solanum lycopersicum*) is one of the most important Solanaceous vegetable crops of Peru-Ecuador origin (Rick 1969), grown throughout the world, eaten either as a salad or cooked or in processed form. It is the second most consumed vegetable after potato. India is the second tomato producing country in the world after China with a productivity of 21.2 t/ha. During the year 2013-14, 426536.00 Mt of tomato was exported from India with a value of Rs. 86091.00 lakh. Tomato is termed as "functional food" due to rich in antioxidants such as carotenoids, vitamin C, phenolics and tocopherols (Ranieri et al. 2004). Consumption of fresh tomatoes and tomato products restrict the development of different types of cancer (Giovannucci 1999) and plasma lipid peroxidation (Balestrieri 2004). Antioxidants play a potential role in scavenging free radicals and prevent many degenerative and chronic diseases, such as cancer, cardiovascular diseases, cataract, digestive tract tumors, hypertension, diabetes, obesity and immunity system dysfunctions (Canene-Adams et al. 2005). Lycopene is the principle carotenoid (> 80% of the total carotenoid) present in fully red-ripe tomato fruits and is responsible for the characteristic red colour (Shi and Le-Maguer 2000). Lycopene has the highest antioxidant activity among all dietary antioxidants (George et al. 2004) and it is fairly stable to storage and cooking. In addition, heat processing such as cooking increases the bioavailability of lycopene in the human body (Bohm and Bitsch 1999). Other carotenoids present in ripe tomato fruits include â-carotene and small amounts of phytoene, phytofluene, zeta-carotene, gamma-carotene,, neurosporene, and lutein (Khachik et al. 2002). Total soluble solids which contain 50-55% carbohydrates (Helyes et al. 2006) is the most important indicator of the taste of tomato and the fruits containing soluble solids above 4.5 °Brix are the most desirable (Clement et al. 2008). Vitamin C, water-soluble dietary antioxidant compound, significantly decreases the adverse effects of the reactive oxygen and nitrogen which cause oxidative damage to lipids, DNA and proteins (Padayatty et al. 2003). Vitamin C also cooperates with the lipid-soluble vitamin E to regenerate membrane-bound oxidized 5ØüÞ-tocopherol. The percentage of vitamin-C and non-reducing sugar were found to decrease gradually with advancement of storage time (Moneruzzaman et al. 2008). During ripening process various physiological, biochemical, and structural changes occur including degradation of chlorophylls, synthesis of carotenoids (mainly lycopene and 5ØýÞ-carotene) (Ilahy et al. 2011) resulting in change of quality of tomato fruit. Hence the fruits are to be harvested at proper stage where the nutritional composition is optimum. Keeping this in view the objective of the present study was to examine the quality of tomato fruit at different stages of maturity.

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Materials and Methods

Tomato fruits of six released hybrids *viz*., Swarna Baibhav, Swarna Sampada, Swarna Samridhi, Swarna Vijaya, Swarna Deepti, Swarna Anmol and two open pollinated varieties *viz*., Swarna Lalima and Swarna Naveen of ICAR-RCER, RC Ranchi were taken for the study based on their fruit weight and yield parameters. The trials were conducted during main season of 2014-16 at Experimental Farm of ICAR RCER Research Centre, Ranchi (23.35^0 N and 85.33^0 E at 629 m altitude). Total annual rainfall was 1430mm with 1100 mm during June to September and the average maximum and minimum temperatures 37^0C and 40^0C, respectively. The net plot size was 2.25m x 2.4m with 60 x 45 cm inter and intra spacing respectively. All the recommended agronomic practices were followed to raise the normal crop. Fruit samples of the individual cultivars selected from each plot at three different ripening stages *viz*., green, breaker and fully ripe stage were evaluated for three quality parameters viz., antioxidant activity, ascorbic acid and total soluble solids (TSS) content.

Antioxidant activity: Antioxidant activity of fresh vegetable samples was measured in the form of 2, 2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging ability (Kang and Saltveit 2002).

Extraction for antioxidant activity - Sample extraction for DPPH assay was carried out using 80% methanol. One g of fresh leaf sample was homogenized with 20 ml of methanol (80%) in a pestle and mortar and centrifuged at 4000 rpm. Supernatant was collected to be used for measuring the antioxidant activity. The pellet was again homogenized with 10 ml of methanol (80%). This extraction was repeated 2-3 times and the supernatants were pooled making up the volume to 50 ml.

DPPH Free Radical Scavenging Activity assay- The assay is based on the reduction of DPPH radicals in methanol by the antioxidants which cause a reduction of absorbance at 517nm. The decrease in absorbance with sample addition was used for calculation of antioxidant activity. A standard curve using different concentrations of ascorbic acid (20-100 µg/ml) was also developed and the results were expressed as mg ascorbic acid equivalent antioxidant capacity (AEAC)/ 100g.

Ascorbic acid content: The ascorbic acid was determined by the procedure detailed in A.O.A.C. (1990). Ascorbic acid was extracted by macerating a given amount of the pulp with 3% metaphosphoric acid. The extract was filtered and appropriate volume was made. A suitable aliquot was titrated against 2, 6-dichlorophenol-indophenol dye till the light pink colour appeared. Results were expressed in mg of ascorbic acid per 100g of fresh pulp weight.

Total soluble solids (TSS): The pulp of the fruits was crushed in a mortar with pestle and the juice was squeezed by hand through muslin cloth. The juice was immediately utilized for determination of TSS by hand refractometer of 0-32.0% range. Pulp from three fruits was crushed at a time and there were three replications per treatment. The values were expressed as per cent total soluble solids.

The statistical analysis of the mean data was performed using the software, OPSTAT.

Results and Discussion

Antioxidant activity (%): Antioxidant activity is an

Table 1: Physical characteristics of tomato hybrids and varieties

Hybrids/ Varieties	Fruit characteristics	Fruit weight (g)	Average fruit yield (t/ha)	Special features
Swarna Baibhav (F_1)	Determinate, round, deep red colour, firm, contain high pulp	140-150	90-100	-
Swarna Sampada (F_1)	Determinate, round, red colour, firm, contain high pulp, TSS 4.5-5° brix, acidity 0.35-0.40%	70-80	100-105	Resistant to bacterial wilt and early blight
Swarna Samridhi (F_1)	Indeterminate, cluster bearing (8-10), round, red, firm, contain high pulp, TSS 5-6° brix	40-50	100-105	Resistant to bacterial wilt and early blight
Swarna Vijaya (F_1)	Determinate, round, cluster bearing (6-8), red colour, firm, contain high pulp, TSS 4-5° brix, acidity 0.35-0.40%	80-90	100-105	Resistant to bacterial wilt and early blight
Swarna Deepti (F_1)	Determinate, round, cluster bearing (4-5), deep red colour, firm, contain high pulp, TSS 4-5° brix, acidity 0.35-0.40%	120-130	100-105	Resistant to bacterial wilt and early blight
Swarna Anmol (F_1)	Round fruited, cluster bearing (5-6), red colour with light green shoulder, TSS 4.5-5° brix, acidity 0.30-0.35%, ascorbic acid content 40-42 mg/100g	60-70	160-180	Resistant to bacterial wilt and suitable for protected cultivation
Swarna Lalima	Deep red, round, TSS 4° brix	120-125	60-70	-
Swarna Naveen	Oblong, deep red, TSS 5° brix	45-50	60-70	-

Source: Technical Bulletin No. R-42/Ranchi-15

important and desirable property of a food product to prove its health benefits. Antioxidant activity represents the ability to inhibit the process of oxidation which plays a crucial role in the pathogenesis of several human diseases as well as aging. Tomatoes exhibit high antioxidant properties due to the presence of several natural antioxidants such as lycopene, phenolic compounds, ascorbic acid, and flavonoids (Meléndez-Martínez et al. 2010). In the present experiment, the antioxidant content ranged from 13.19-26.17% in hybrids and ranged between 15.97-18.24% in OP varieties (Table 2). There was a continuous increase in antioxidant content throughout ripening until the fully ripe stage. The hybrid Swarna Samridhi showed highest amount of antioxidant content at fully ripe stage (26.17%) followed by Swarna Baibhav (24.36%) and OP variety Swarna Lalima possess the highest amount of antioxidant content at fully ripe stage (18.24%) (Fig. 1). Previous researchers also reported that tomatoes harvested at fully ripe stage exhibited the highest level of carotenoids (primarily lycopene) and antioxidant activity (Kamis et al. 2004). Similarly, Bhandari and Lee (2016) also studied ripening-dependent changes in seven commercial cultivars (two general and five cherry) of tomatoes and found that antioxidant activities significantly differed at different ripening stages, where in most cases, antioxidant activities increased from the breaker stage to the red stage. The highest antioxidant activity in red ripe tomato could be as the result of lycopene accumulation in the fruit (Nour et al. 2014).

Ascorbic acid (mg/100g): The ascorbic acid content of the hybrids varied between 11.50-21.75 mg/100g and OP varieties ranged between 9.4-19.32 mg/100g. It increased as the maturity advances from green to fully ripe stage. The hybrid Swarna Naveen showed highest amount of ascorbic acid content at fully ripe stage (21.75 mg/100g) followed by Swarna Vijaya (15.28 mg/100g) and OP variety Swarna Lalima possess the highest amount of ascorbic acid content at fully ripe stage (19.32 mg/100g) (Fig. 2). Bhandari and Lee (2016) reported that ascorbic acid showed continuously increasing patterns throughout ripening until the red stage.

Total soluble solids (TSS %): TSS is one of the most important quality factors for most of fruit. The TSS content of the tomato hybrids at fully ripe stage ranged between 4.4-7.6% and OP varieties ranged from 3.8-7.0% and suddenly increased as the fruit reaches to fully ripe stage. The TSS content of hybrids and varieties showed least differences in green and breaker stages. The hybrid Swarna Samridhi showed highest amount

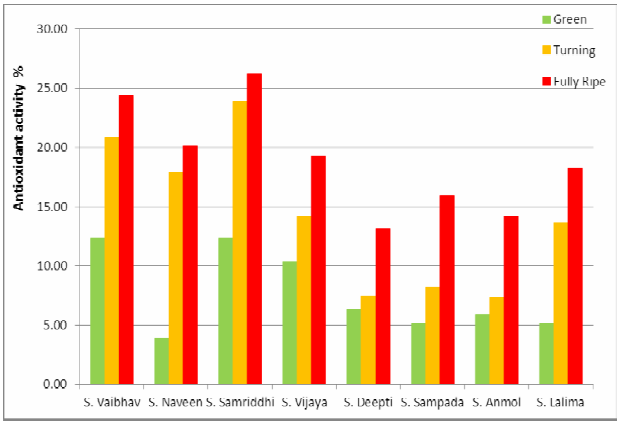

Fig.1: Changes in antioxidant activity % of tomato fruits with ripening

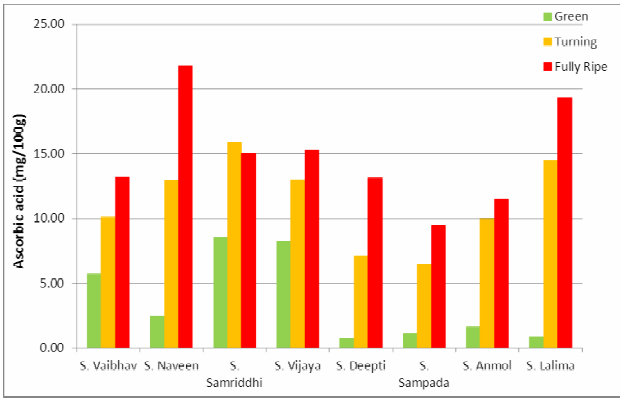

Fig. 2: Changes in ascorbic acid (mg/100g) content of tomato fruits with ripening

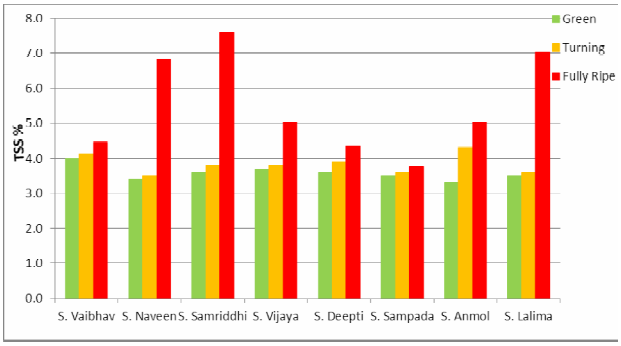

Fig. 3: Changes in TSS % of tomato fruits with ripening

Table 2: Quality parameters of tomato hybrids and varieties

Features	TSS			Ascorbic acid			Antioxidant activity (%)		
	Green	Turning	Fully Ripe	Green	Turning	Fully Ripe	Green	Turning	Fully Ripe
Mean	3.58	3.83	5.51	3.66	11.22	14.82	7.68	14.16	18.94
Range	3.30-4.00	3.50-4.30	3.80-7.60	0.77-8.53	6.40-15.87	9.40-21.75	3.89-12.39	7.35-23.88	13.19-26.17
SE (mean)	0.08	0.10	0.50	1.17	1.20	1.43	1.23	2.24	1.63
CV	5.93	7.09	25.61	90.74	30.37	27.27	45.16	44.68	24.30

of TSS at fully ripe stage (7.6%) followed by Swarna Baibhav (6.8%) and OP variety Swarna Lalima contained the highest amount of TSS at fully ripe stage (7.0%) (Fig. 3). Similar result was also reported by Getinet et al. (2008). According to Crouch (2003), the TSS content increased due to the conversion of starch into sugars or the hydrolysis of cell wall polysaccharides.

Conclusion

Almost all the hybrids and varieties show marked increase in antioxidant activity and ascorbic acid content of tomato fruits from green to fully ripe stage, whereas for TSS% the hybrids and varieties showed less difference between green and breaker stage. TSS was highest at fully ripe stage due to breakdown of starch into sugars or the hydrolysis of cell wall polysaccharides. Hence, it is recommended that fully ripe tomato is best for consumption in terms of nutritional quality.

सारांश

टमाटर के अवमुक्त कुल छः संकर किस्मों–स्वर्ण वैभव, स्वर्ण सम्पदा, स्वर्ण समृद्धि, स्वर्ण विजया, स्वर्ण दीप्ति, स्वर्ण अनमोल तथा दो मुक्त परागित किस्मों स्वर्ण लालिमा एवं स्वर्ण नवीन की गुणवत्ता एवं पोषक संघटन हेतु परिपक्वता की विभिन्न अवस्थाओं में विश्लेषण भा.कृ.अनु. प. का पूर्वी अनुसंधान परिसर, अनुसंधान केन्द्र, राँची में किया गया। स्वर्ण समृद्धि में पूर्णतः पकी अवस्था में एंटीऑक्सीडेन्ट की अधिकतम सक्रियता (26.17 प्रतिशत) एवं अधिकतम कुल विलेय ठोस (7.6 प्रतिशत) पायी गयी। अधिकतम एस्कॉर्बिक एसिड की मात्रा (21.75 मिग्रा./100 ग्रा.) स्वर्ण नवीन की पूर्णतः पकी अवस्था में पायी गयी। सभी जीनरूपों में हरी एवं पूर्ण पकने के बीच की अवस्था तक एंटीऑक्सीडेन्ट गतिविधि तथा एस्कॉर्बिक एसिड की मात्रा में स्पष्ट वृद्धि देखी गयी। पूर्णतः पकी अवस्था में स्टार्च एवं पॉलीसैकेराइड्स के रूपान्तरण के कारण कुल विलेय ठोस की मात्रा अधिकतम पायी गयी। अतः पोषण की गुणवत्ता की दृष्टि से पूर्णतः पके टमाटर उपभोग के लिए सर्वोत्तम होते हैं।

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