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CHANGES IN ANTIOXIDANT AND PHYTOCHEMICAL PROPERTIES OF TOMATO (*LYCOPERSICON ESCULENTUM* MILL.) UNDER AMBIENT CONDITION

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Abstract

Duration of storage increased TSS and pH of tomato juice, while ascorbic acid content decreased gradually during storage. Carotenoids content increased approximately 3.5 times during storage in tomato because of advancement of ripening stage. During ripening chlorophyll gradually degrades and the carotenoid synthesis is enhanced. Increased levels of lycopene in tomato during storage might also be due to ripening of tomato fruits. The spoilage in fruits gradually increased in all cultivars with the advancement of storage period. Spoilage of fruits started on 6th day of storage in all cultivars except Avinash-2. The average shelf life of tomato fruits ranged from 6-12 days among cultivars based on 40% spoilage. The lowest shelf life of 6 days was noted in H-86 and highest of 12 days in Avinash-2. It was concluded that the tomato harvested at breaker stage may be utilized for almost one week along with increased contents of carotenoids and lycopene compensated for the decreased levels of acidity and ascorbic acid contents.

Introduction

Consumption of fruits and vegetables has been associated with the maintenance of health and prevention of numerous chronic diseases including cancer, cardio- and cerebro-vascular, ocular and neurological diseases (Rao & Agarwal, 1999; Giovannucci, 1999; Barber & Barber, 2002). Tomatoes (*Lycopersicon esculentum* Mill. syn. *Solanum lycopersicum* L.) are major contributors of antioxidants such as carotenoids (especially, lycopene and β-carotene), phenolics, ascorbic acid (vitamin C) and small amounts of vitamin E in daily diets. Ascorbic acid as an antioxidant directly eliminates superoxide and also hydroxyl radicals and singlet oxygen radicals and reduces hydrogen peroxide (Khan *et al.,* 2006). Several important changes occur in ultra structure of tomato during ripening, such as synthesis of pigments (e.g., lycopene), production of flavour and aromatic compounds and increase in the ratio of citric to malic acid (Grierson & Kader, 1986 and Saeed *et al.,* 2009). Giovanelli *et al*., (1999) and Abushita *et al*., (1997) reported an increase in ascorbic acid content of tomato during ripening. In addition to vitamin C, Toor & Savage (2006) reported increased total soluble solid (TSS), lycopene content and antioxidant activity of tomato during storage. Red colour of tomato fruits is the result of chlorophyll degradation (conversion of chloroplasts to chromoplasts) as well as synthesis of lycopene and other carotenoids (Fraser *et al*., 1994). Tomatoes are classified under the climacteric fruits and the metabolism in tomato fruits continues even after their detachment from the plant. Usually tomatoes are harvested at light red or breaker stage for distant transportation. Several studies have been conducted on storage behaviour and shelf life of tomatoes at varied temperature/conditions, however, the information on the overall nutritional implications of storage at ambient temperature on the tomato cultivars is scanty. This study was thus, conducted to determine the changes in the antioxidant components as well as nutritional values of tomato stored at ambient temperature.

Materials and Methods

Four cultivars of tomato including two open pollinated (OP) viz. H-86 (Kashi Vishesh) and DVRT-1 (Kashi Amrit), and two F_1 hybrids, viz. Avinash-2 and BSS-422 were selected from the trials conducted at experimental farm of Indian Institute of Vegetable Research, Varanasi, during the 2006-07. Fruits of uniform size, free from pest and disease injuries, bruises and blemishes were selected and harvested at breaker stage. Fruits were washed with water and dried with soft cloth and placed at a single layer in a paper carton. The tomato fruits were stored at ambient temperature and inspected regularly. The average minimum and maximum temperature during experimentation ranged from 15 ± 2^{o}C and 20 ± 4^{o}C and relative humidity between 55 and 65%. Shelf life and spoilage percentage were measured based on visual analysis (Behboudion & Tode, 1995) of texture, firmness, surface moulds, water soaking and presence of necrosis, development of undesirable patch (i.e., lesion and any obvious signs of deterioration) appear on the harvested fruits (Lange & Cameron, 1994).

Total soluble solid (TSS): The total soluble solid were analyzed by hand refractometer and results were reported as ^{0}Brix at 20^{o}C.

pH: The pH of tomato juice was measured using a bench top pH meter (Orion-420 A).

Titrable acidity: The titrable acidity was estimated by method suggested by Ranganna (1976). The pulp material was added to boiling water, cooled, filtered and transferred in volumetric flask. The volume was made up and aliquot was titrated with 0.1 N NaOH using 1% phenolphthalein solutions as an indicator.

Ascorbic acid content: The ascorbic acid contents were estimated titrimatically, using 2, 6-dichlorophenol indophenol dye (DCPI) (Anon., 1980). Ten gram sample was blended with 4% w/v oxalic acid, made up to 100 ml and filtered. An aliquot was titrated against standard dye solution (2, 6-DCPI) to a light pink end point. The procedure was repeated with a blank solution omitting the sample and ascorbic acid content was calculated as mg of vitamin C per 100 g edible sample.

Total carotenoids content: The total carotenoids were extracted and partitioned in acetone and petroleum ether, respectively, as described by Thimmaih (1999). Absorbance was measured at 452 nm and total carotenoids content (mg/100g sample) was calculated using a calibration curve prepared against a high purity standard β-carotene.

Lycopene content: Lycopene was extracted and analyzed according to Thimmaih (1999). Briefly, tomato juice (from 5-10 g pulp) was extracted with acetone until the residue is colourless. The acetone extracts were transferred to a separate funnel containing 20 ml petroleum ether and mixed gently. Subsequently, 20 ml of 5% sodium sulphate solvent was added. The two phases formed were separated and the lower aqueous phase was re-extracted with additional petroleum ether, until the aqueous phase was colourless. Petroleum ether extracts were pooled in a brown bottle containing 10 gm anhydrous sodium sulphate. After standing it for ten minutes the petroleum ether extract was decanted in 100 ml volumetric flask through a funnel containing cotton wool. The volume was made up and the absorbance measured using a UV-visible double beam spectrophotometer (Shimadzu-UV-160) at 503 nm using petroleum ether as blank. The lycopene content (mg/100g) was calculated using molar extinction coefficient $\sum = 17.2 \times 10^{-4}\ M^{-1}cm^{-1}$.

Results and Discussion

Analysis of variance (ANOVA) revealed significant differences in the physicochemical characteristics and antioxidant components of tomatoes. It was observed that TSS increased with period of storage and maximum TSS content was recorded in DVRT-1 (4.53%), followed by BSS-422 (4.3%), at 12 days of storage (Table 1). The increasing rate of TSS content in DVRT-1 cultivars was found maximum as compared to other cultivars. Comparative study of cultivars on the basis of mean value, maximum TSS content were recorded in DVRT-1 (3.75) and minimum was noted i.e. 3.61 in H-86 and Avinash-2. The finding is agreement with Singh *et al*., (2003). Increase in TSS during storage might be associated with the transformation of the pectic substances, starch, hemi cellulose or other polysaccharides in soluble sugar and also with dehydration of fruits (Bhullar *et al*., 1981; Hoda *et al.*, 2000).

Table 1. Changes in biochemical properties of stored tomato.

Storage period	H-86	DVRT-1	Avinash-2	BSS-422	Mean
TSS					
0DAS	3.30	3.00	3.26	3.26	3.21
4DAS	3.33	3.26	3.46	3.36	3.35
8DAS	3.60	4.20	3.66	3.80	3.82
12DAS	4.20	4.53	4.06	4.23	4.26
Mean	3.61	3.75	3.61	3.66	3.66
pH					
0DAS	3.43	3.60	3.90	3.90	3.71
4DAS	3.43	3.60	4.03	4.00	3.77
8DAS	4.20	4.06	4.40	4.30	4.24
12DAS	4.06	4.23	4.63	4.55	4.37
Mean	3.78	3.87	4.24	4.19	4.02
Acidity					
0DAS	0.72	0.70	0.54	0.52	0.63
4DAS	0.64	0.67	0.47	0.48	0.57
8DAS	0.53	0.65	0.37	0.40	0.49
12DAS	0.40	0.54	0.25	0.23	0.36
Mean	0.58	0.65	0.41	0.41	0.51
Spoilage					
0DAS	0	0	0	0	0.00
4DAS	20	15	0	10	11.25
8DAS	50	40	10	35	33.75
12DAS	100	85	25	75	71.25
Mean	42.50	35.00	8.75	30.00	29.06

The range of pH varied from 3.43-3.90 at fresh harvested tomato fruits (Table 1). Days of storage induced increased pH of tomato juice. Maximum pH content in tomato fruits juice was recorded in Avinash-2 (4.63) at 12 days of storage. Davis & Hobson (1981) studied 200 genotypes of tomato accessions and found that the pH varied from 4.26-4.82. The titrable acidity gradually decreased with increasing days of storage as minimum acidity (0.236%) was recorded in BSS-422 at 12 days of storage, while H-86 (0.544%) expressed maximum acidity. The reduction in acidity during storage might be associated with the conversion of organic acid into sugar and their derivatives or their utilization in respiration (Bhullar *et al.,* 1981). Kumar (1998) and Kumar & Dhawan (1995) also recorded the similar results in mango.

The titrimatric analysis of ascorbic acid showed significant variation in fresh tomato. Vitamin C concentration ranged from 23.79-29.32 mg per 100 g. Maximum vitamin C content was recorded in DVRT-1 (29.32 mg/100g) followed by H-86 (27.48 mg/100g). Sharma *et al*., (1996) reported ascorbic acid content ranged from 11.21-53.29 mg/100g in tomato genotypes. During storage, the ascorbic acid content of tomato decreased gradually during storage (Fig. 1). Maximum ascorbic acid content (21.78 mg/100 g) was retained by Avinash-2 on the last day of storage whereas least in BSS-422 (19.08 mg/100g). Singh *et al*., (2003) reported similar decreasing trends in goose berry.

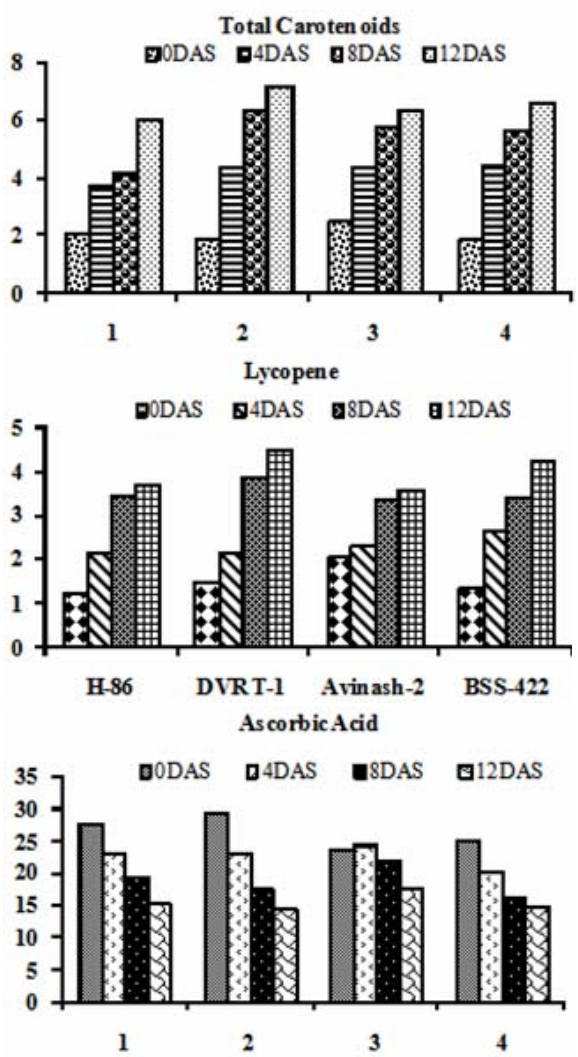

Fig. 1. Biochemical traits of tomato cultivars affected by duration of storage.
(Numbers at X-axis: 1- H-86, 2- DVRT-1, 3-Avinash-2 and 4-BSS-422)

Significant variation ($p<0.05$) was recorded in total carotenoids content in the tomato cultivars. The values for carotenoids ranged from 1.79-2.55 mg/100g harvested at breaker stage (fresh). After 12 days of storage carotenoids content increased in tomato approximately 3.5 fold. Maximum carotenoids content were recorded in Avinash-2 (2.55 mg/100g) at fresh harvest and in DVRT-1 (7.20 mg/100g) after 12 days of storage, respectively. Raffo *et al*., (2002) reported that carotenoids content of tomato were very low at the breaker stage (1.08 mg/100g) which increased 10-fold during ripening and reached 12.705 mg/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 (Pretel *et al.,* 1995).Similarly significant variation in lycopene content (red pigment of tomato fruits) was observed and the recorded were 1.26-3.67mg/100g (H-86), 1.45-4.51 mg/100g (DVRT-1), 2.07-3.58 mg/100g (Avinash-2) and 1.34 - 4.26 mg/100g (BSS-422) (Fig. 1). Lycopene increased gradually with duration of storage (Toor *et al*., 2006). Increased levels of lycopene in tomato during storage might be due to ripening advancements of tomato fruits and conversion of chloroplasts to chromoplasts. The increasing in redness of tomatoes during ripening is due to lycopene accumulation, in association with the internal membrane system (Grierson & Kader, 1986). This effect has been reported earlier by Ajlouni *et al*., (2001) where the values increased from 3.6-9.0mg/100g in green house grown tomato during storage at 22°C for a period of 14 days. The spoilage in fruits gradually increased in all cultivars with the advancement of storage period. Spoilage of fruits started on 6th day of storage in all cultivars except Avinash-2 (Table 1 and Fig. 2). Avinash-2 was most efficient in retaining the spoilage of fruits in all the days of observations and showed only 25% spoilage on 12th day of storage, followed by BSS-422 and DVRT-1. Cultivar H-86 recorded 100 per cent spoilage on 12 days after storage.

The average shelf life of tomato fruits ranged from 6-12 days among cultivars based on 40% spoilage. The lowest shelf life of 6 days was recorded in OP cultivar, H-86 and highest of 12 days in F_1 hybrid cultivar, Avinash-2. De *et al*., (2002) have also found greater shelf life for hybrid tomatoes.

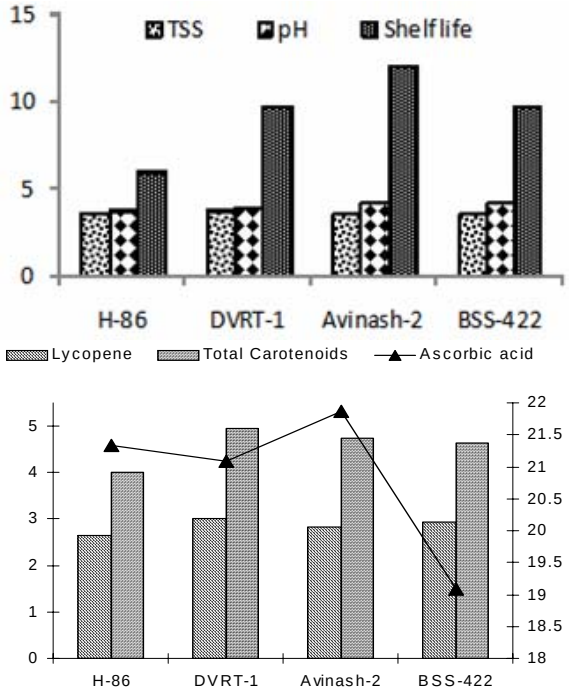

Fig. 2. Comparative performance of physico-chemical properties of tomato cultivars.

Conclusion

The experimental results revealed that the total soluble solids and pH of tomato fruits increased with the period of storage under ambient condition. Similarly, amount of carotenoids and lycopene also increased during storage. Moreover, spoilage due to storage for longer duration also gradually increased with time in all cultivars

except, Avinash-2 which could sustain the damage during storage due to its thick pericarp. However, as anticipated, decreased trend of ascorbic acid content and acidity was observed in all the cultivars. Based on 40 per cent spoilage data, the average shelf life of tomato under ambient condition was 6-12 days after harvesting at breaker stage. Thus, tomato harvested at breaker stage may be successfully utilized for consumption for almost one week without much deterioration in its qualities, however, fruits having thicker pericarp may be stored for longer period of time. The decrease in acidity and ascorbic acid may be compensated with increase level of carotenoids and lycopene in tomato fruits.

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