Indian Journal of Agricultural Sciences **86** (9): 1225–7, September 2016/Short communication
https://doi.org/10.56093/ijas.v86i9.61528

Lycopene estimates in terms of chromaticity value in tomato (*Solanum lycopersicum*)

V K SINGH[1], KAMINI SINGH[2] and POOJA SAXENA[3]

ICAR–Central Institute for Subtropical Horticulture, Rehmankhera, Lucknow, Uttar Pradesh 226 101

Received: 19 September 2015; Accepted: 9 May 2016

Key words: Color index, Chromaticity value, Green house, Lycopene, Tomato

Tomato (*Solanum lycopersicum* Mill.), an important horticultural crop in India, is currently the second largest vegetable in terms of production. It is consumed in diverse ways including raw, as an ingredient in many dishes, sauces, salads, drinks etc. and widely known for its outstanding source of bioactive compounds along with high concentration of lycopene (Kaur *et al*. 2013). It is well established fact that there is an important association between lycopene and its antioxidant properties as it quenches singlet oxygen and decreases the lipid peroxidation and hydroxyl radical formation (Shi *et al*. 2002). Epidemiological studies also have indicated positive health benefits by consumption of diets high in lycopene (Jian *et al*. 2007, Matos *et al*. 2000).

In tomato, fruit colour is the most important quality parameter for consumers as it imparts attractive red colour due to predominant constituent pigment, lycopene. There are several important factors that affect the fruit quality and lycopene content in tomato, viz. light and temperature, besides other cultural practices.

Optimal mean daily temperature for tomato lie between 21 and 24°C, depending on the developmental stage, however, synthesis of lycopene in various tomato cultivars was completely inhibited above 32°C (Dumas *et al.* 2003). Exposing the fruit to intense sunlight cause localized increase in the fruit temperature which partially suppresses the lycopene synthesis.

Lycopene content was recorded to be higher in the shaded fruits than in the non-shaded fruits. This difference was due to increased temperature on fruit surface exposed to direct light as lycopene is the major membrane bound antioxidant (inside the chromoplast) in tomato. Some of the varieties of tomato were recently reported to be good in maintaining lycopene level at elevated temperature (Shivashankara *et al*. (2015). Since lycopene has value as a phytonutrient, the main objective of the breeders is to maximize lycopene content in the breeding programme and utilize production method to increase lycopene content. Thus, simple and inexpensive assay to quantify lycopene over a broad spectrum of tomato varieties/green plants is desirable prerequisite to develop a tomato cultivar with higher content of this phytonutrient.

Lycopene concentration in tomatoes can be determined accurately in the laboratory by spectorphotometric measurements of tissue extract (Mencarelli and Saltveit 1988). However, this is time-consuming and destructive procedure. Nondestructive, external measurement of fruit color provides a less tedious method for assessing ripening than the chemical analysis. Measurement of color is closely related to visual perception in tomatoes (Shewfelt *et al*. 1988). Goodenough *et al.* (1982) used 'a' values to monitor colour development during storage of tomatoes. Several workers (Yang *et al*. 1990) measured tomato colour using colorimeter and expressed values as colour difference but they have not tested the chromaticity value in relation to lycopene content. Effect of variable climatic conditions on fruit quality and lycopene content under year round cultivation in greenhouse has little been worked out.

The objective of present study is to evaluate the changes in lycopene content in tomato cv. Naveen grown under greenhouse condition in comparison to open conditions and to establish its relationship with chromaticity value by a non-destructive method.

Tomato cv. Naveen plants were transplanted in greenhouses located at Central Institute for Subtropical Horticulture, Rehmankhera, Lucknow located at 26.54°N Latitude, 80.45°E Longitude and 127 m above mean sea level. Seeds were treated with fungicide (Thiram 1g/kg) for 5 min and rinsed with distilled water thoroughly and sown in protrays filled with cocopeat and farm yard manure (FYM) in the ratio of 1:1 during the end of September 2011 and 2012. Grown up seedlings (up to 25-30 days) were transplanted on October 2nd week in twin rows, 0.60 m and 0.45 m spacing between plant to plant and row to row,

[1]Principal Scientist (e mail: singhvk_cish@rediffmail.com), Division of Crop Production. [2]Senior Research Fellow (e mail: kamini_cish@yahoo.com), [3]Senior Research Fellow (e mail: psbiochem@gmail.com), Precision Farming Development Centre, Lucknow.

respectively, (2.5 plants/m) in green house and similarly in open condition for comparison. Black polyethylene mulch (200 µ thick UV stabilized) and drip irrigation was used during experimental period in both condition. The experimental design was a complete randomized block with five replications. Air temperature (°C) and light intensity (µE/s/m) in both the conditions were measured daily with a HT-3001 C digital humidity/ temperature meter and TES 1332 digital Lux Meter, respectively. The first mature healthy tomato fruits having comparable size and weight in a range of 150-240 g were harvested manually at required ripening stage (breaking, turning, pinkish, red and red ripe respectively). Harvested fruits were properly washed under running tap water and then air dried for further experimental use. The fruits in five replications, each represented by 10 tomatoes from greenhouse and open condition at different maturity stages were used.

Chromaticity of each fruit was recorded using a Konica Minolta CM 2002 Spectrophotometer which uses a pulsed xenon light bulb that illuminates a round aperture 0.8 cm in diameter where the whole fruit was placed. The reflected light was focused on a silicon photodiode and the reûected light between 400 and 700 nm was measured. The chromacity value in terms of L, a, b (lightness, red/green, yellow, a/b coordinate) values were measured using the observer at 10° and D65 illuminant. Five measurements were made in each fruit (one on the peduncle zone, two on the equatorial zone and two on the distal zone). The a and b values were used to estimate the tomato color index (a/b) as recommended earlier (Arias *et al.* 2000, Brandt *et al.* 2006).

Lycopene extractions of the fruits were conducted immediately after colour measurement following the method as described by Hunter *et al*. (1987). Pulp (2g fresh weight) along with pericarp corresponding to the locations of chromaticity measurements was removed and then homogenized. Lycopene content of the homogenized fruits was extracted in 10 ml of pure acetone in darkness at 4°C to prevent its oxidation. Extraction was done in separating funnel with 10-15 ml petroleum ether by shaking for 15 min. The extract was centrifuged at 1 000 g for 10 min, and absorbance of the supernatant was measured at 473 nm using a Double beam UV-VIS Spectrophotometer. The concentration of lycopene was calculated using the specific extinction coefficient 17.2×10^4 mole/cm and expressed as mg/g fresh weight (Beerh and Siddappa 1959). The data was analyzed using two way analysis of variance (ANOVA) and the mean values were separated according to the student's test (P = 0.05). Correlation analysis were used to determine the relationship between L, a and b, a/b chromacity value and lycopene content of fruit. Some varieties of tomato were earlier reported to contain a good quality of lycopene with high phenol and flavonoid under greenhouse (Kavitha *et al*. 2013).

Perusal of data clearly showed that the colour index changed and lycopene content increased gradually during the course of ripening in tomato grown both in green house and in open condition (Table 1). As expected the colour index was minimum at breaker stage and maximum during red ripe stage in both the conditions at different magnitude. Similarly lycopene varied at different stage of ripening and increased gradually from breaker stage to red ripe stage. Interestingly, the lycopene content in fruits produce in the green house was higher (0.061-0.779 mg/g FW) than the fruits harvested from open condition (0.007-0.099 mg/g FW) at different stages of ripening. In both the conditions there was no significant difference in the following ripening stage being highest lycopene content at red ripe stage in greenhouse (0.779 mg/g FW) as compared to other stages (0.061 - 0.189 mg/g FW) as well as corresponding stages in open condition (0.007- 0.099 mg/g FW). These data clearly showed that the green house condition had a significant positive influence on lycopene content of the fruit.

Table 1 Color index (a/b) and lycopene concentration (mg/g FW) in tomato cv. Naveen fruit in different maturity stages

Stages	Polyhouse condition		Open condition	
	Lycopene (mg/g fw)	a/b	Lycopene (mg/g fw)	a/b
Breaking stage	0.061±0.001	-0.022	0.007±0.001	-0.033
Turning stage	0.075±0.001	0.080	0.022±0.001	0.060
Orangish stage	0.131±0.002	0.232	0.085±0.002	0.185
Red	0.189±0.002	0.405	0.095±0.002	0.308
Red ripe	0.779±0.008	0.908	0.099±0.006	0.612

The light intensity inside the polyhouse was in the range of 312.65 - 444.00 µ mol/m/s while the light intensity outside was in the range of 456.95-1 665.00 µ mol/m/s. The results suggest that moderate light intensity and consistent temperature (22.0 to 31.5°C) inside the greenhouse as compared to the open condition, positively affect the lycopene biosynthesis. Present study also indicated that lycopene content decreases, especially in situations where the fruit has been directly exposed to intense sunlight. Thus, under more direct sunshine in open condition, the fruit are exposed to higher surface temperature, leading to lower fruit lycopene content.

The elevated lycopene content of greenhouse grown tomato than those grown in the open field suggests that the differences in its content may be due to temperature induced differences in lycopene synthesis rather than lycopene degradation. Temperature influence on total carotenoids and lycopene content in other variety of tomato were also reported (Kaur 2013). The yield (140.00 tonnes /ha) and span (120 days) of harvesting period in tomato grown in green house was also increased as compared to open condition, i.e. 48.00 tonnes/hectare and 90 days, respectively.

Best fit linear regression model was used to relate chromacity values to lycopene concentrations. L*, which represents degree of lightness, provided a reasonably good fit (R^2=0.855) and negatively correlated to lycopene content. The 'a' value (a measure of redness) was a fairly good predictor and is positively related with lycopene, however,

the 'b' value (a measure of yellowness) was poorly related (R^2=0.0710). Using the ratio of ('a' and 'b') increased predictability of lycopene because it was consistently well related to lycopene concentrations and provided a reasonably good fit (R^2=0.8571). The equation do not predict lycopene concentration accurately enough to substitute entirely for chemical extraction, however, it is useful for screening or estimating lycopene concentrations, especially *in-situ* studies because the colorimetric method is destructive. Thus, besides the yield, the quality of tomato in terms of lycopene can be maximized by growing under greenhouse condition and its level can be predicted non-destructively by measuring fruit chromacity value.

SUMMARY

Lycopene content as well as colour are the most important factors in the visual and nutraceutical quality of tomatoes (*Solanum lycopersicum* L.) and these factors are affected by temperature and light in different condition. In the present study color development in terms of chromaticity value (L, a, b and a/b) and lycopene accumulation in tomato fruits cv. Naveen known for virus resistant with prolific bearing, was assessed independently at different maturity stages, viz. breaking, turning, pinkish, red and red ripe, grown in greenhouse and compared with the fruits grown in open condition. The data on light and temperature were recorded periodically throughout the experimental period. The lycopene content (0.779±0.008 mg/FW) and chromacity value (a/b 0.908) were maximum in red ripe tomato fruits harvested from greenhouse as compared to open condition (0.099±0.006 mg/FW and 0.612 , respectively) . The direct relationships between chromaticity value and lycopene concentration at different stages was obtained. Thus the assessment of chromaticity value can be used as a nondestructive method to envisage the lycopene content in tomato fruits.

ACKNOWLEDGEMENTS

The authors thank Director, ICAR-Central Institute for Subtropical Horticulture, Lucknow, for providing laboratory facilities and encouragement and NCPAH, MoA & FW, GoI, New Delhi for providing necessary financial support during the study.

REFERENCES

Arias R, Lee T, Logendra L and Janes H. 2000. Correlation of lycopene measured by HPLC with the L*, a*, b* color readings of a hydroponic tomato and the relationship of maturity with color and lycopene content. *Journal of Agricultural and Food Chemistry* **48**: 1 697–702.

Beerh O P and Siddappa G S. 1959. A rapid spectrophotometric method for the detection and estimation of adulterants in tomato ketchup. *Food Technology*, **13**: 414–8.

Brandt S, Pék Z, Barna E, Lugasi A and Lajos H. 2006. Lycopene content and color of ripening tomatoes as affected by environmental conditions. *Journal of the Science of Food and Agriculture* **86**: 568–72.

Dumas Y, Dadomo M, Di Lucca G, and Grolier P. 2003. Effects of environmental factors and agricultural techniques on antioxidant content of tomatoes. *Journal of the Science of Food and Agriculture* **83**: 369–82.

Goodenough P W, Turker G A, Griersen D and Thomas T. 1982. Changes in color, polygalacturonase mononsaccharide and organic acids during storage of tomatoes. *Phytochemistry* **21**: 281–4.

Hunter R S and Harold R W. 1987. The Measurement of Appearance, 2nd ed. Wiley, New York.

Jian L, Lee A H and Binns C W. 2007. Tea and lycopene protect against prostate cancer. *Asia Pac J Clin Nutr.Asia Pacific Journal of Clinical Nutrition,* 16 Suppl **1**: 453–7.

Kaur C, Walia S, Nagal S, Walia S, Singh J, Singh B B, Saha S, Singh B, Kalia P, Jaggi S and Sarika. 2013. Functional quality and antioxidant composition of selected tomato (*Solanum lycopersicum* L) cultivars grown in Northern India. *Food Science and Technology* **50**: 139–45.

Kavitha P, Shivashankara K S, Rao V K, Sadashiva A T, Ravishankar K V and Sathish G J. 2013. Genotypic variability for antioxidant and quality parameters among tomato cultivars, hybrids, cherry tomatoes and wild species. *Journal of the Science of Food and Agriculture* **94**: 993–9.

Matos H R, Di Mascio P and Medeiros M H. 2000. Protective effect of lycopene on lipid peroxidation and oxidative DNA damage in cell culture. *Archives of Biochemistry and Biophysics* **383(1):** 56–9.

Mencarelli F and Saltveit M E Jr. 1988. Ripening of mature-green tomato fruit slices. *Journal of the American Society for Horticultural Science* **113**: 742–5.

Shewfelt R L, Thai C M, and Davis J W. 1988. Prediction of changes in color of tomatoes during ripening at different constant temperatures. *Journal of Food Science*, **53**: 1433-7.

Shivashankara K S, Pavithra K C, Laxman R H, Sadashiva A T, Roy T K and Geetha G A. 2015. Changes in fruit quality and carotenoid profile in tomato (*Solanum lycopersicon* L.) genotypes under elevated temperature. *Journal of Horticultural Science* **10**: 38–43.

Shi J, Maguer Le M and Bryan M. 2002. Lycopene from tomatoes. (In) Shi J, Ghazza Le Maguer, *Funtional Foods. Biochemical and Processing Aspects*, Vol 2, pp 135–66. M (Eds), CRC Press, Ottawa, Canada.

Yang R F, Cheng T S and Shewfelt R L. 1990. The effect high temperature and ethelene treatment on the ripening of Tomatoes. *Journal of Plant Physiology* **136**: 368–72.