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Variation in Physical and Biochemical Properties of Cherry Tomato cv. Nagmoti Grown under Different Growing Conditions

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ABSTRACT

Background: The intended research was carried out with an aim to evaluate the differences in health promoting bioactive compounds in cherry tomato cv. Nagmoti among the different growing conditions.

Methods: Cherry tomato cv. Nagmoti were grown under different conditions as per standard agronomic practices and harvested fruits were were analyzed for physical, biochemical and postharvest quality parameters.

Result: About 1.63-fold variation in total carotenoid and 1.39-fold variation in lycopene content was recorded among the different growing structures. Highest titratable acidity (0.118%) and total phenolic content (µg GAE/100g FW) was found in the shade net structures. The highest antioxidant activity was recorded in insect-proof net house (15.45 µmol trolox equiv. g^{-1}) while the least was found in open field (12.04 µmol trolox equiv. g^{-1}) condition. Walking tunnel followed by shade net and insect-proof net house was found best for the better accumulation of functional parameters.

Key words: Functional quality, lycopene content, Titratable acidity, Total antioxidant activity, Total carotenoids, Total phenolics.

INTRODUCTION

In the recent years, popularity of cherry tomatoes (*Solanum lycopersicum* var. *cerasiforme*) has been increased due to high total soluble sugar, health-promoting bioactive (antioxidants, phenolic compounds, mineral contents) compounds as compared to conventional tomatoes. Cherry tomato cv. Nagmoti is an indeterminate early maturing cherry tomato hybrid, its fruits are small round in shape, reddish in colour and individual fruit weight varies from 10 to 12 g having good taste, flavour and aroma. It is suitable for protected as well as for open conditions. For increasing the production and productivity of crops under protected cultivation technologies *viz*., polyhouse, shade net, micro tunnel, *etc*., are capable of producing resource-efficient, exportable quality of vegetable crops (Harisha *et al*., 2019). Cherry tomatoes are mainly grown in polyhouses and open field conditions, besides these conditions it is also grown under shade net, walking tunnel and insect-proof net houses with superior or almost equal quality of the produce. High solar radiation, heat stress, drought, desiccating winds and hail storms are some of the major environmental limitations to optimal productivity and nutritional quality of field-grown vegetables. Low-cost plastic tunnels are commonly used for tomato cultivation in India. Overheating could be a serious problem in these tunnels considering high summer temperatures therefore the use of shade nets becomes very popular due to the very high (35-40°C) temperatures in the summer season. Photo-selective shade-nets provide physical protection against hail, wind, bird and insect-transmitted virus diseases. Transmitted solar radiation under shading reduces the canopy and air temperatures as well as the transpiration rate in the greenhouses. This consequently reduces water consumption by about 50% and at the same time, it increases the water use efficiency and enhances crop productivity by up to 40% (Ahemd *et al*., 2016). The present work aimed to evaluate the variation in physical biochemical and health-promoting bioactive compounds in cv. Nagmoti grown under different growing conditions in north Indian conditions.

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MATERIALS AND METHODS

Present study was conducted at research field at CPCT, Indian Agricultural Research Institute (IARI), New Delhi, India during 2016-17. Fruits were harvested from different

structures *viz*., open field, shade net, insect-proof net house and walking tunnel immediately after harvesting at red ripen commercial maturity stage; fruits were taken to laboratory to evaluate its functional and biochemical parameters. Healthy fruits of uniform size, shape, colour and free from disease, pest or physical injuries were selected for the study. A total of thirty fruits were taken from each growing condition with three replications, having ten fruits per replication. Analytical work was performed in food quality analysis laboratory at the Division of Food Science and Postharvest Technology, Indian Agricultural Research Institute, New Delhi, India. All the analytical grade chemicals and reagents used for the study were procured from Merck India Ltd.

Respiration rate were measured by using auto gas analyzer (Model: Checkmate 9900 O_2/CO_2, PBI Dansensor, Denmark) and expressed as ml CO_2 $kg^{-1}h^{-1}$. The total soluble solids of samples were estimated using FISHER Hand Refractometer having a score of 0-50 °brix and expressed in percent. Titratable acidity (%) was estimated by standard titration method with 0.1 N NaOH using phenolphthalein indicator.

Ascorbic acid content in cherry tomato was quantified by 2, 6-dichlorophenol indophenols dye method and results were expressed as mg/100g FW. Total phenolic content of the fruit extracts was determined as method described by Kannaujia *et al.* (2021) and results were expressed as µg of Gallic acid equivalents (GAE)/100g. Total antioxidant activity was determined according to Apak *et al*. (2008) and results were expressed as µmol trolox equiv. g^{-1}. Total carotenoids and lycopene content were determined by following the methods of Kannaujia *et al*. (2019) and results were expressed as mg 100/g FW.

The experiment was conducted in a completely randomized design with three replicates. The results were statistically analyzed using Analysis of variance (ANOVA) and the mean values were compared by Duncan's multiple range test (DMRT) at a significance level of *P*=0.05. Further, a significant difference amongst the means was determined by Tukey's HSD test. Principal component analysis (PCA) was carried out to find the linear relationship among the different variables to identify the trait that causes the maximum proportion of variability in the different growing conditions.

RESULTS AND DISCUSSION

Respiration rate

Difference in respiration rate was not much varied but still difference was shown in different growing conditions. Data presented in Table 1 showed that Nagmoti cultivar grown in open field condition had a higher respiration rate (6.88 ml CO_2 kg^{-1} h^{-1}) followed by insect-proof net house (6.22 ml CO_2 kg^{-1} h^{-1}) while shade net grown recorded the least (5.82 ml CO_2 kg^{-1} h^{-1}).

Respiration rate, ethylene evolution, PLW and fruit firmness are interlinked characters. Deviation in any above individual character proportionally affects to other physiological activities. Reduction in respiration rate in cherry tomato grown inside shade net could also be because of higher firmness in fresh fruits due to a minimal activity of cell wall degrading enzymes like pectin methylesterase and polygalacturonase (Yaman and Bayoindirli, 2002). Available Moisture content in the fruit also affects the respiration rate.

Total soluble solids

Irrespective of growing structures walking tunnel grown cultivar recorded highest TSS (6.20°Brix) followed by insect-proof net house (5.90°Brix) while least TSS content was obtained in shade net (4.50°Brix). Fruits obtained from walking tunnel recorded 1.38 times higher TSS in comparison to shade net structure.

The solubility, synthesis and concentration of total soluble solid substances influenced with growing environment and storage temperature along with genotype. The decrease in moisture content in the fruits is usually accompanied by an increased percentage of TSS because TSS is a major constituent of dry matter (Malundo *et al*., 1995). Pronounced variation has not been observed for TSS content under polyhouse and open condition were reported by Jha and Kumari (2015).

Titratable acidity

Results presented in Table 1 showed that highest titratable acidity was found in shade net (0.114%) followed by walking tunnel (0.118%), while the least (0.102%) titratable acidity was found in insect-proof net house. The presented results confirm that variation in Nagmoti cultivar among the different growing structures is pronounced, however difference was not much significantly observed.

Shading can reduce the solar radiation and temperature during the day time, thus heat stress to the plant is reduced. Light shading led to an increase in productivity and quality of tomato, pear, apple, strawberry, grape and chili pepper (Rajapakse and Shahak, 2007; Shahak *et al*., 2008).

Ascorbic acid

Results presented in Table 1 indicated that walking tunnel grown cultivar had the highest content of ascorbic acid (20.88 mg/100g FW) followed by a shade net (19.88 mg/100g FW) while least was found in the open field (17.92 mg/100g FW) condition. In our study, variation in ascorbic acid content varied from 17.92-20.88 mg 100g FW among the different structures.

Variation in ascorbic acid content may be due to the variety, growing area, size and shape of individual crops (Lee *et al*., 1976). The vitamin C content was affected by cultural practices (Topuz and Ozdemir, 2007) and abiotic factors (light and temperature) (Lopez-Marin *et al*., 2011). Fruits produced under the pearl shade nets contain more ascorbic acid at harvest and retain more after postharvest storage, perhaps through delayed ripening (Mashabela *et al*., 2015).

Antioxidant activity

The main antioxidant compounds in cherry tomato are carotenoids, lycopene, lutein and ascorbic acid etc. In this study, antioxidant activity among the different conditions ranged from 12.04 (open field condition) to 15.45 µmol trolox

equiv. g^{-1} FW in insect-proof net house under CUPRAC assays. Results presented in this study showed that the significant variations were observed among the different growing structures.

With decreasing porosity of the shade net, the radiation transmittance may tend to decrease in antioxidant activity in shade net grown cherry tomatoes (Castellano *et al*., 2006). Solar radiation and temperature seems to affect tomato fruit quality such as texture, firmness, appearance (Dorais *et al*., 2001) and both oxidant and antioxidant compounds (Alba *et al*., 2000). On the other hand, greenhouse-grown tomatoes contains lower levels of vitamin C and flavonoids than open-air grown tomatoes due to lower light intensity inside greenhouse (Lopez-Andreu *et al*., 1986).

Total phenolics

The total phenolic content among the different conditions varied from 558.13 μg GAE/100g FW (walking tunnel) to 689.00 μg GAE/100g FW (shade net structure) depicting 1.24-fold variation (Table 1). The concentration of total phenolic content amongst the different growing structures in descending order was: Shade net ≥ open field ≈ insect-proof net house ≥ walking tunnel. Our study results confirm that nutritional content can significantly influence the same variety grown under different conditions/structures.

Total carotenoids and lycopene

Results showed that highest total carotenoids (13.21 mg/100g) were found in the Nagmoti cultivars grown under walking tunnel while the least content (8.13 mg/100g) were found in open field condition. While in case of lycopene content again, walking tunnel showed the highest content (9.37 mg/100g) followed by a shade net (8.83 mg/100g) while least (6.75 mg /100g) was found in cherry tomato grown under open field condition.

Tomatoes grown under net house had lower lycopene content than field-grown tomatoes as reported by Gomez *et al*. (2001) could be attributed due to temperature and light quality. The highest content of carotenoids in the leaves of pepper plants cultivated under plastic tunnels was observed in the fields integrated with black nets. Carotenoids protect chlorophyll from too much light or the harmful wavelengths and act as a selective filter. Carotenoids may also scavenge any singlet oxygen that forms during photosynthesis (Bergquist, 2006). A strong positive linear relation was observed between the chlorophyll content of leaves and yield (Ombódi *et al*., 2016).

Coefficient correlation between bioactive compounds and antioxidant activity

A significant positive correlation (r=0.41) was recorded between total antioxidant activity (CUPRAC) and total carotenoid content (Table 2). Similarly, total carotenoids were found positively correlated with lycopene content (r=0.96); and total carotenoids with ascorbic acid (r=0.92). For lycopene content and titratable acidity, a significant positive correlation (r= 0.78) was observed. However, in our study,

Table 1: Biochemical and technological parameters of cherry tomato cv. nagmoti under different growing conditions.

Growing structure	Respiration rate (ml CO_2 kg^{-1} h^{-1})	TSS (°Brix)	Titratable acidity (%)	Ascorbic acid (mg/100g)	Total antioxidants (μmol trolox equiv. g^{-1})	Total phenolics (μg GAE/100g)	Total carotenoids (mg/100g)	Lycopene content (mg/100g)
Open field	6.88±0.056a	5.00±0.052c	0.103±0.0013b	17.92±0.224c	12.04±0.12c	632.50±7.14b	8.13±0.13c	6.75±0.096d
Shade net	5.82±0.056c	4.50.052d	0.118±0.0013a	19.88±0.224ab	12.50±0.12c	689.00±7.14a	12.08±0.13b	8.83±0.096b
Insect proof net house	6.22±0.056b	5.90±0.052b	0.102±0.0013b	18.96±0.224b	15.45±0.12a	616.00±7014b	11.83±0.13b	8.03±0.096c
Walking tunnel	6.18±0.056b	6.20±0.052a	0.114±0.0013a	20.88±0.224a	13.11±0.12b	558.13±7.14c	13.21±0.13a	9.37±0.096a

Values followed by same alphabet in a column do not differ significantly (p≤0.05).

Table 2: Correlation coefficient matrix of cherry tomato cv. nagmoti under different growing conditions.

	Total antioxidants	Total phenolics	Total carotenoids	Lycopene content	Ascorbic acid	Respiration rate	TSS	Titratable acidity
Total antioxidants	1.00	-0.28	0.41	0.14	0.04	-0.25	0.60	-0.43
Total phenolics		1.00	-0.29	-0.26	-0.37	-0.25	-0.93	0.20
Total carotenoids			1.00	0.96	0.92	-0.85	0.45	0.60
Lycopene content				1.00	0.98	-0.84	0.32	0.78
Ascorbic acid					1.00	-0.73	0.38	0.78
Respiration rate						1.00	0.06	-0.74
TSS							1.00	-0.28
Titratable acidity								1.00

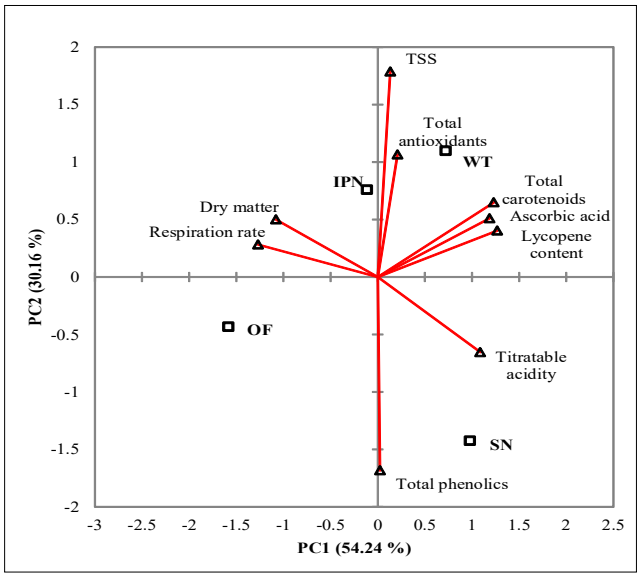

Fig 1: Biplot of first two principal components obtained for functional parameters of cherry tomato grown under open field (OF), shade net (SN), insect-proof net (IPN) and walking tunnel (WT).

we found a negative correlation among the total antioxidant activity and total phenolics as well as total phenolics and total carotenoids/ lycopene content. Oboulbiga *et al*. (2018) reported the strong positive correlation between lycopene and β–carotene contents, as the lycopene content is high, the β–carotene content is also high and *vice-versa*. Similarly, higher antioxidant activity owing to the presence of a higher amount of ascorbic acid and phenolic compounds has also been reported earlier in mango (Barman and Asrey, 2014).

Principal component analysis (PCA)

It is required to identify the trait that causes the maximum proportion of variability in the population and is used to evaluate their genetic diversity. In the present study, PCA was applied to functional parameters of cherry tomatoes produced under different conditions and summarized in Fig 1. The highest explained variance (PC1) was associated with total carotenoids, lycopene content, ascorbic acid and titrable acidity in one direction while respiration rate and dry matter on opposite direction. PC1 explained 54.24% variance whereas second factor (PC2) explained about 30.16% variance. PC2 was associated with total antioxidants and TSS in one direction and total phenolics on opposite direction. PC1 and PC2 jointly could account for 84.40 % of the total variance explained for functional parameters of cherry tomatoes produced under different conditions.

It is evident from Fig 1 that walking tunnel (WT) is loaded on the right side of PC1 and was closely associated with total antioxidants, total carotenoids, lycopene content and ascorbic acid. Higher values of these functional parameters can be related to a better quality of the cherry tomatoes. Thus, cherry tomatoes produced under walking tunnel were found with higher amount of functional parameters. Results also indicated that shade net house (SN) showed a close association with total phenolics and titrable acidity whereas as insect-proof net (IPN) was found to be associated with respiration rate and dry matter.

CONCLUSION

This study proves that diverse growing conditions can also significantly hamper the postharvest quality and nutrient accumulations in the same variety. A significant difference in terms of bioactive compounds and biochemical parameters was observed grown under different conditions. Nagmoti grown under walking tunnel has more accumulation and synthesis of lycopene content, total carotenoids, ascorbic acid and total soluble solids than other growing structures. However shade net was favorable for higher retention of total phenolics and titratable acidity inside the mature fruits. Walking tunnel followed by shade net and insect-proof net house was found best for a better accumulation of functional parameters. The findings of this study can guide growers as well as entrepreneurs to grow cherry tomato according to climate and season so the availability of more nutritious and bioactive rich fruits can be obtained and they can earn more profit according to higher nutrient availability.

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Conflict of interest: None.

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