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Effect of tomato fruit maturity on pH, titerable acidity and hue value

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Abstract

The physiochemical parameters of tomato fruits were affected by developmental stages of fruit. Since the knowledge of pH, titerable acidity and hue value of tomato fruits at various developmental stages will be a useful piece of information for food industry and pharmaceutical industry. In the present study, cherry red, arka rakshak, heemsona and hisar lalit tomato fruits at distinct maturity stages i.e. green, breaker and red were screened for these physiochemical parameter. The findings reflect that as the fruit advanced through these development stages, the pH was slightly increases till early breaker stage after that pH value decreases with maturity and minimum pH value observed at fully ripened stage. Titratable acidity decreased gradually with advance in maturation but after breaker stage it increases till maturity. The decrease in hue value was observed with ripening stages reflected the darkening of the fruits with carotenoid synthesis, degradation of chlorophylls and, consequently, the disappearance of greenness of fruits

Key words: Tomato fruit, pH value, titerable acidity and hue value .

Introduction

Tomato (*Lycopersicon esculentum* Mill.) is a member of the Solanaceae (nightshade) family. It is an important vegetable crop grown in many countries across the world for fresh market and in multiple processed forms. Tomato is the second most widely grown vegetable crop in the world other than potato (Panno et.al., 2021). Tomato is considered as an important cash generating crop for smallholders and medium-scale commercial farmers providing employment opportunity in the production and processing industries (Wosene et.al., 2022). Tomatoes find numerous uses in both fresh and processed forms that include ketchup, sauces, pastes and juice. Tomatoes, commonly consumed in daily diets, are a major source of antioxidants 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 (Salehi et.al., 2019). All these constituents make tomato a good candidate as antioxidant food and nutraceutical. Being rich in vitamin C, lycopene, and polyphenols, it is important for pharmaceutical industry also. The tomato crop besides size, colour and yield, loss due to diseases, pest and limited shelf life are the factors affecting its economical statistics. Agricultural institutes are regularly working to develop new varieties with traits of disease resistance, pest resistance, prolonged shelf life and high yield to improve net outcome of the crop for farmers. A physico-chemical and biochemical scan of the fruits of these improved popular cultivars at different stages of maturity is required to explore their nutraceutical and pharmaceutical applications along with improved agricultural practices. In Haryana along with Cherry red, the wild variety, 30 varieties of tomato are being grown by open and protected cultivation to cater the requirements in market. Among these Arka rakshak, Heemsona and Hisar lalit are the varieties improved to reduce the losses due to pests and low shelf life. Heemsona is developed to improve shelf life of fruits. It is preferred for high yield potential and long fruiting duration of 4-6 months, whereas hisar lalit is a nematode resistance variety developed by CCSHAU, Hisar. It is derived from the cross HS101 x Resistant Bangalore (Bodanapu et.al., 2019). Plants of this variety are determinate and early maturing. Fruits are round and medium to large in size. It is suitable for cultivation in nematode infested areas. Arka Rakshak is high yielding F1 hybrid with triple disease resistance (ToLCV, BW and early blight) (Sadashiva et.al., 2022). The fruits are square round, large (90-100g), deep red colored, firm, suitable for fresh market and processing. Tomato fruits of Heemsona, NT-8 (Hisar lalit), Arka Rakshak and Cherry red are harvested at different ripening stages from green to a red ripe colour but these varieties

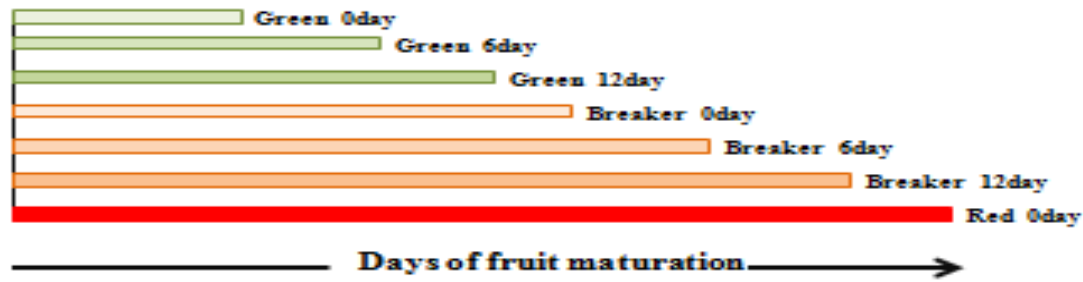
are not analysed for their physico-chemical characteristics at different stages. Therefore, the analysis of physiochemical parameter, as well as their variation during ripening, is of great relevance both to human health and commercial purposes. The present study is purposed to analyze the physiochemical parameters of tomato fruits of the four most popular cultivars Cherry red (taken as a wild variety), Arka rakshak, Heemsona and Hisar lalit at different stages of ripening.

Materials and method

3.1. Plant material and Growing Technique

Seeds of Hisar lalit, Heemsona and Cherry red varieties obtained from Medicinal aromatic and Potential Crop Section, Department of Genetic and Plant Breeding College Agriculture, CCS Haryana Agricultural University, Hisar. Seeds of Arka rakshak procured from ICAR-IIHR, Bangalore. Seeds were germinated in seedling tray filled with mixture of soil, coco peat and water was sprinkled. After 28 days, the plant saplings with three to four leaves were transplanted to the ground soil of polyhouse. Plants of all the four varieties of tomatoes namely Heemsona, NT-8 (Hisar lalit), Arka rakshak (AR) and Cherry red (CR) were grown in the polyhouse of the Department of Vegetable Science, CCS Haryana Agricultural University, Hisar, located at 29.09°N 75.43°E in western Haryana. The irrigation of the plants was done by dripping, with two cycles of irrigation daily that depending upon to crop evapotranspiration of the plants. Flowering became evident within 43 days (Cherry red), 70days (Arka rakshak), 60 days (Heemsona) and 65 days (Hisar lalit) in four tomato cultivars. At this stage, the flowers were tagged. Fruit were observed after about 33 days in Cherry red, 38days in Arka rakshak, 40 days in Heemsona and 45 days in Hisar lalit cultivars. The tagged fruits were collected on 0, 6 and 12 days as samples of green stage. 4 days thereafter green fruits turned to light pink that was considered the 0 day breaker stage and the fruits were collected after 6 and 12 days as samples of breaker stage. 3 days thereafter, fruits attained fully ripened stage which were collected, fruits collected at all stages (7 in total) were analyzed for physico- chemical parameters, antioxidant profile, antioxidant potential and impact on redox status of cultured skeletal muscle cells.

Sampling scheme



Sample preparation

Tomato homogenates were prepared by pooling 1cm slice from equatorial region of tomato fruit (n=3). After that the tomatoes slice were weighed and homogenized by using motor pestle. A part of the homogenate was centrifuged for 10min at 4700rpm at 4°C to separate supernatant.

pH value

Tomato fruits were sliced to obtain 1cm slice from equatorial region (n=3). Tomato slices of each cultivar were weighed and homogenized by using mortar and pestle. The homogenate was centrifuged for 10min at 4700rpm at 4°C to separate supernatant. The pH value of the supernatant was measured by using pH meter (Systronic μ pH System 361) after standardization at pH 4.0 and pH 7.0 (Tolesa et. al., 2017).

Titrateable acidity

The titrateable acidity was measured by titrating 10ml supernatant to an end point of $\text{pH } 8.0 \pm 0.02$ with 0.1 N NaOH, using a pH meter (Systronic μ pH System 361) as described by Tolesa et. al., 2017. The titrateable acidity was calculated, using the following equation:

$$\% \text{ Titrateable acidity} = \frac{\text{ml of NaOH used} \times 0.1 (\text{Normality of NaOH}) \times 100}{\text{Volume of supernatant used}}$$

Hue value

The L, a, b values were measured for the surface of each tomato using a Konica Minolta Chromameter CR-410. The value L*(lightness) indicates the ratio of white and black color, value a* is the ratio of red and green colors, value b* is the ratio of yellow and blue colors. Chroma/Chromaticity (C*) is the saturation or vividness of color. As chromaticity increases, as the color becomes more intense; and decreases, as the color becomes more dull. The hue value was calculated by computing the $\tan^{-1}(b/a)$ (Fava et.al., 2017; Tilahun et.al., 2018).

Statistical analysis

The SPSS software (SPSS 16.0 version) was used for statistical analysis. Data was reported as mean $\pm$ SD. One-way analysis of variance (ANOVA) test and Tukey's test ($P < 0.05$) were used to analyze the values of all evaluated parameters.

Result and discussion

pH values

pH is an indicator of concentration of organic acids in fruits. The pH values of four tomato cultivars namely Cherry red, Arka rakshak, Heemsona and Hisar lalit were analysed on different days of maturity stages (green, breaker and red) of tomato fruits. The pH values of these cultivars were quite similar and did not significantly ($p > 0.05$) differ at green stage and ripening, ranging from 4.21 in Cherry red to 4.29 in Arka rakshak (**Table 1**). pH of tomato fruits does not change till the breaker stage in all varieties. However with maturity to breaker stage, variations in pH are observed among different cultivars. A slight increase and their after decrease is observed in all varieties (**Figure 1**). Our observations are supported by previous studies that shown pH values of 'Cherry', 'Monika' and 'Isabella' varieties were not changed significantly ($p > 0.05$), ranging from 3.5 to 4.2 during fruit maturation. This finding is consistent with the literature, which reports that certain organic acids, such as malic acid and oxalic acid, did not change markedly during the ripening of tomato, but were affected by cultivar. The concentration of citric acid, malic acid, oxalic acid and ascorbic acid increased with the maturity of some tomato fruit cultivars, reaching maximum concentrations at the pink stage of ripening (Priyankara et.al., 2017).

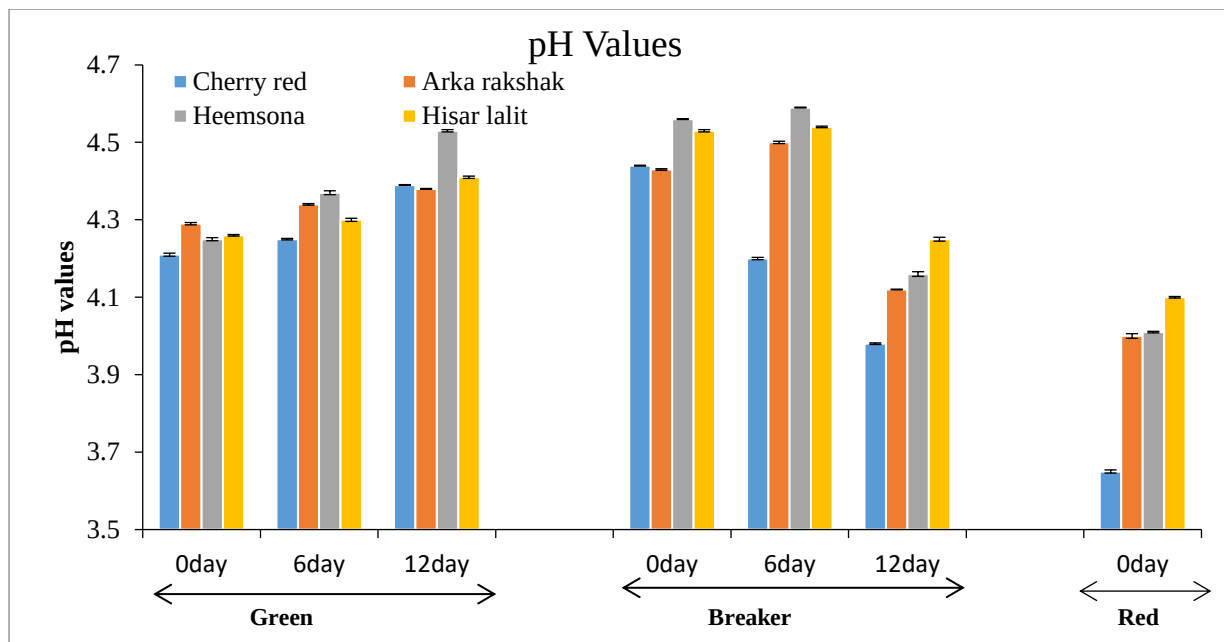


Figure 1: pH values of tomato cultivars (Cherry red, Arka rakshak Heemsona and Hisar lalit) on different days of maturity stages green, breaker and red.

Decrease in pH as the fruits mature is much sharper in Cherry red (4.44 to 3.65) as compared to other varieties which have pH in range of 4.00 to 4.10 at fully ripen stage. Indicating wild variety is rich in organic acids and the organic acid content is compromised in other developed varieties.

Table 1 : pH of various tomato cultivars on days of maturity stages green, breaker and red

Varieties	Stages and days of fruit maturity						
	Green			Breaker			Red
	0	6	12	0	6	12	0
Cherry red	4.21 ±0.004	4.25 ±0.002	4.39 ±0.001	4.44 ±0.001	4.20 ±0.003	3.98 ±0.002	3.65 ±0.004
Arka rakshak	4.29 ±0.003	4.34 ±0.002	4.38 ±0.001	4.43 ±0.002	4.50 ±0.003	4.12 ±0.001	4.00 ±0.006
Heemsona	4.25 ±0.004	4.37 ±0.005	4.53 ±0.003	4.56 ±0.001	4.59 ±0.001	4.16 ±0.006	4.01 ±0.002
Hisar lalit	4.26 ±0.002	4.30 ±0.004	4.41 ±0.003	4.53 ±0.003	4.54 ±0.002	4.25 ±0.005	4.10 ±0.002

Each value in the table is represented as mean $\pm$ SD. Values are significantly different ($P < 0.05$).

Titrateable acidity

The titrateable acidity of four tomato cultivars namely Cherry red, Arka rakshak, Heemsona and Hisar lalit were analysed on different days of maturity stages (green, breaker and red) of tomato fruits. The titrateable acidity of these cultivars were quite similar and did not significantly ($p > 0.05$) change with fruit maturation and ripening, ranging from 0.459 to 0.589 (**Table 2**). Titrateable acidity decreased significantly ($p < 0.05$) with the development of fruits from mature green to full ripe. Maximum acidity (0.598) was found in Cherry red tomato at fully ripen stage. Titrateable acidity decreased gradually with advance in maturation after breaker stage it was increases with maturity (**Figure 2**). This is largely due to changes in ascorbic acid content of tomato fruits with maturity stages. The titrateable acidity of tomatoes was reported to be directly proportional to the ripening of tomatoes (Priyankara et.al., 2017).

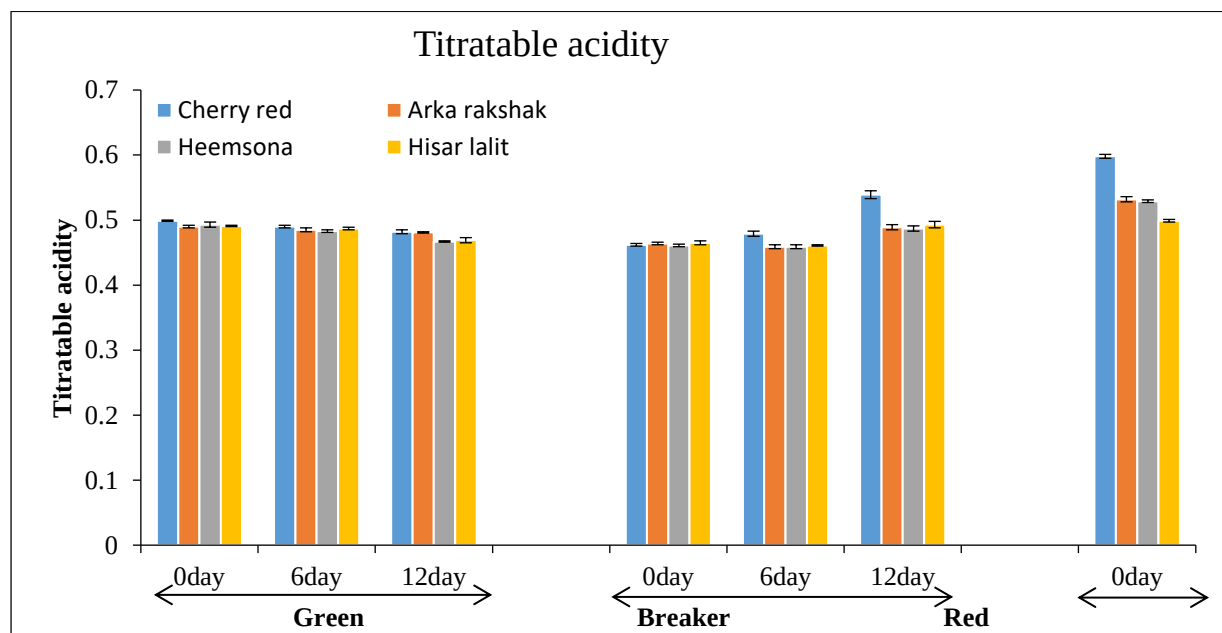


Figure 2: Titrateable acidity of tomato cultivars (Cherry red, Arka rakshak Heemsona and Hisar lalit) on different days of maturity stages green, breaker and red.

Although pH of Arka rakshak, Heemsona and Hisar lalit are comparable at maturity, titrateable acidity varies from 0.499 ± 0.002 of Hisar lalit to 0.532 ± 0.004 in Arka rakshak, although it is much lower than 0.598 ± 0.003 in Cherry red.

Table 2 : Titratable acidity of various tomato cultivars on days of maturity stages green, breaker and red

Varieties	Stages and days of fruit maturity						
	Green			Breaker			Red
	0	6	12	0	6	12	0
Cherry red	0.499 ±0.001	0.490 ±0.002	0.482 ±0.003	0.462 ±0.002	0.479 ±0.004	0.539 ±0.006	0.598 ±0.003
Arka rakshak	0.490 ±0.002	0.485 ±0.003	0.481 ±0.001	0.464 ±0.002	0.459 ±0.003	0.489 ±0.004	0.532 ±0.004
Heemsona	0.493 ±0.004	0.483 ±0.002	0.467 ±0.001	0.461 ±0.002	0.459 ±0.003	0.487 ±0.004	0.529 ±0.002
Hisar lalit	0.491 ±0.001	0.487 ±0.002	0.469 ±0.004	0.465 ±0.003	0.461 ±0.001	0.493 ±0.005	0.499 ±0.002

Each value in the table is represented as mean $\pm$ SD. Values are significantly different ($P < 0.05$).

Hue value

The hue value is a neumerical representation of color, calculated using the formula $\tan^{-1}(b/a)$. The L, a and b values were measured for the surface of tomato fruits of four cultivars: Cherry red, Arka rakshak, Heemsona and Hisar lalit at different developmental stages of tomato fruits. The lowest hue value was calculated for Cherry red tomato fruit at fully ripen stage, while the highest hue value was observed at 0 day of green stage of cherry red tomato fruit (**Table 3, Figure 3**). The gradual decline in hue value with maturity stages of tomato fruit was also observed by Ayuso-Yuste et.al., 2022. The decrease of hue value with ripening reflected the darkening of the fruits with carotenoid synthesis, the degradation of chlorophylls and, consequently, the disappearance of greenness of fruits.

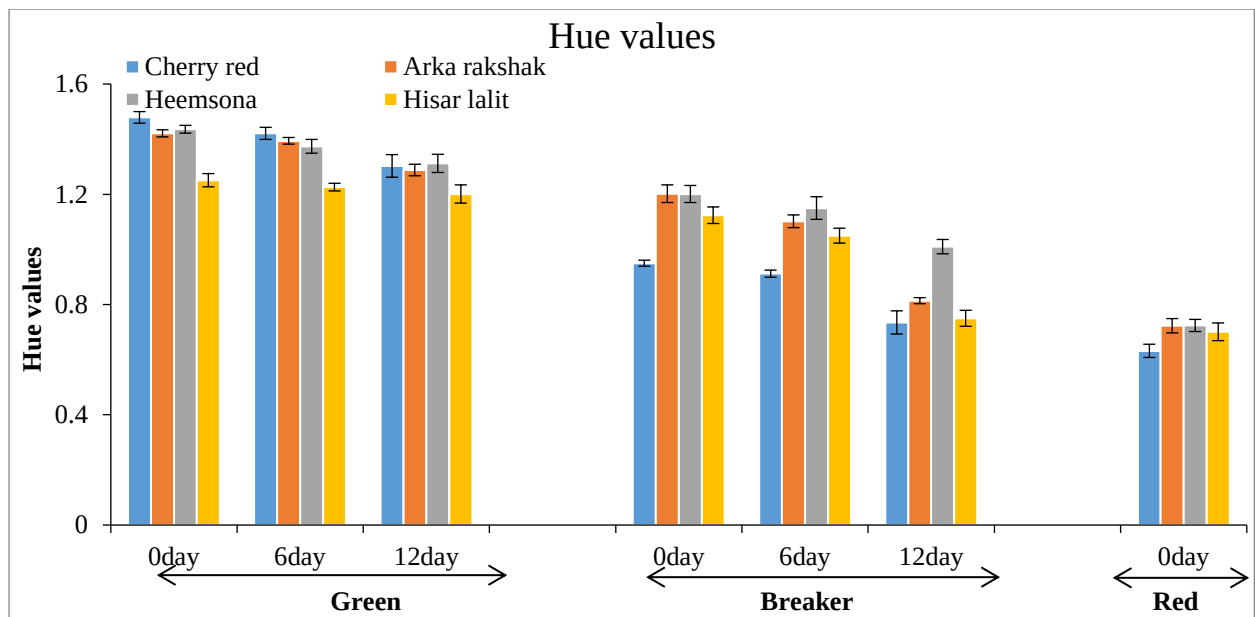


Figure 3: Hue values of tomato cultivars (Cherry red, Arka rakshak Heemsona and Hisar lalit) on different days of maturity stages green, breaker and red.

The data indicates sharp decline in chlorophyll content at maturity stages in cherry red while the fruits of other varieties have high hue value which may be due to lower content of carotenoids.

Table 3: Hue value of various tomato cultivars on days of maturity stages green, breaker and red

Varieties	Stages and days of fruit maturity						
	Green			Breaker			Red
	0	6	12	0	6	12	0
Cherry red	1.479 ±0.041	1.421 ±0.022	1.303 ±0.041	0.950 ±0.011	0.912 ±0.013	0.735 ±0.042	0.632 ±0.024
Arka rakshak	1.421 ±0.013	1.394 ±0.012	1.288 ±0.021	1.202 ±0.032	1.102 ±0.023	0.814 ±0.011	0.723 ±0.026
Heemsona	1.436 ±0.014	1.374 ±0.025	1.312 ±0.033	1.201 ±0.031	1.150 ±0.041	1.01 ±0.026	0.724 ±0.022
Hisar lalit	1.251 ±0.024	1.226 ±0.014	1.201 ±0.033	1.124 ±0.030	1.05 ±0.027	0.750 ±0.029	0.701 ±0.032

Each value in the table is represented as mean $\pm$ SD. Values are significantly different ($P < 0.05$).

Conclusion

This study indicates that the pH increased somewhat as the fruit progressed through these developmental phases, reaching the early breaker stage. After that, the pH value decreased as the fruit matured, reaching its lowest value at the fully ripened stage. pH of Cherry red fruits is much lower than other varieties. Titratable acidity steadily reduced as maturation progressed, although it increased beyond the breaker stage, Cherry red fruits have high titerable acidity indicating higher amount of organic acid in these fruits than other varieties. The ripening stages were associated with a drop in hue value, which was indicative of the fruits' darkening due to carotenoid synthesis, the breakdown of chlorophylls, and, ultimately, the cessation of their greenness. Wild variety, Cherry red overtake other varieties in this parameter also.

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Acceptance with rules of ethics

Contradictory interests Researchers have declared no contradictory interests

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