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Research Article

EFFECT OF PRE-COOLING TREATMENTS ON SHELF LIFE OF TOMATO IN AMBIENT CONDITION

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ABSTRACT
Tomato is one of the most widely used food crops in world vegetable economy. In order to reduce post-harvest losses and to meet market requirements of tomatoes, its preservation in the fresh state is of commercial importance. Tomato can be stored at ambient temperature for a period of up to 7 days (Zinidarcic *et al.,* 2006). The present investigation was carried out to enhance the shelf life of tomato *var. Avatar* in ambient condition and to study the effect of treatment on storage characteristics of tomato. Tomatoes were treated with hydro-cooling with raw water (HRW), hydro-cooling with ice water (HIW), hydro-cooling with ice water +$CaCl_2$ (HIWC) and forced air cooling treatments. All treated samples were stored for 13 days and sample were observed for weight, volume, density, titratable acidity, appearance, colour and ascorbic acid at 0^{th}, 3^{rd}, 5^{th}, 7^{th}, 9^{th}, 12^{th} and13^{th} day to determine the shelf life of tomatoes. Three tomatoes were taken in a sample and data were observed in triplicate. All treated samples along with control were observed for weight, volume, density, titratable acidity, appearance, colour and ascorbic acid during storage period. HIW and HIWC samples had the shelf life of 13 days while control had 9 days. Weight loss of HIW and HIWC samples was minimum and varied from 11-12 % during storage period. Volume of HIW and HIWC samples increased by 0.01 % and 3 % respectively while density decreased by 4.5 % and 15 % respectively during storage. Ascorbic acid and tiratable acidity for HIW and HIWC sample increased by 41 %, 32 % and 0.13 g/l, 0.1 g/l respectively during storage period of 13 days. Appearance of HIWC tomatoes was slightly better than HIW samples on 13^{th} day of storage.
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Key Words: *Tomato, Shelf Life, HIW, HIWC, Volume, Weight Loss, Ascorbic Acid and Appearance*

INTRODUCTION
Tomato (*Solanum lycopersicum*) is a herbaceous, usually sprawling plant in the nightshade family widely cultivated for its edible fruit. About 130 million tons of tomatoes were produced in the world in 2008. China, the largest producer, accounted for about one quarter of the global output, followed by United States, Turkey and India with a production of 10.26 million MT (FAO, 2008).

Tomato is one of the most widely used food crops in world vegetable economy (Chapagain and Wiesman, 2004). Consumer preferences for fresh tomatoes are influenced by appearance, texture, the fruit sensory quality, nutritional considerations and safety, mostly freedom from disease. In order to reduce post-harvest losses and to meet market requirements of tomatoes, its preservation in the fresh state is of commercial importance. Fast pre-cooling of tomatoes after harvest, reduces the rate of quality loss and extends the shelf life (Jeong *et al.,* 1996).

Pre-cooling for removing field heat from freshly harvested fruits reduces microbial- activity, metabolic activity, respiration rates and ethylene production. This also decreases the ripening rate, diminishes water loss and decay, and thus, helps preserving quality and prolongs shelf life of the fruits (Ferreira *et al.,* 1994 and Reina *et al.,* 1995). Pre-cooling methods are natural air-cooling, forced air cooling, hydro-cooling, ice cooling and vacuum cooling, and these are different in heat removal efficiency and processing cost. The rate of pre-cooling of the fruits and vegetables immediately after harvest is a determining factor for their quality and durability in storage (Tonini *et al.,* 1979).

(Hardenburg *et al.*, 1986) mentioned that storage under low temperature has been considered the most efficient method to maintain the quality of most fruits and vegetables due to its effects on reducing respiration rate, transpiration, ethylene production, ripening, senescence and rot development. Temperature plays an important role in maintaining post harvest quality of tomato fruits too (Ball, 1997). Tomato can be stored at ambient temperature for a period of up to 7 days (Zinidarcic *et al.*, 2006). It is generally agreed that for longer period, ripe tomato can be stored at a temperature of 10-15°C and 85-95 % relative humidity (Shewfelt *et al.*, 1987 and Castro *et al.*, 2005). At these temperatures chilling injury and ripening are minimal. Refrigerating a tomato reduces its flavor by approximately 30% (Ressureccion and Shewfelt, 1985). Flavor quality of tomatoes is largely determined by the sugar (estimated by soluble solid contents) and acid composition of the fruit (Moretti *et al.*, 1998). The cold temperature converts the sugar into starch and causes its firm texture to turn into pulpy (Adegoroye *et al.*, 1989).
Keeping in view all the above facts, the present investigation has been taken up with the following objectives: 1) to study the effect of pre-treatment on storage characteristics of tomato and 2) to optimize the shelf life of tomato.

MATERIALS AND METHODS

The tomatoes (Cv. *Avatar*) were harvested from the poly house located at the Department of Irrigation and Drainage Engineering, G.B. Pant University of Agriculture and Technology, Pantnagar. Fresh harvested tomatoes were treated with five different treatments i.e. hydro-cooling with raw water (HRW, T_1), hydro-cooling with ice water (HIW, T_2), hydro-cooling with ice water + $Cacl_2$ (HIWC, T_3), forced air cooling (T_4) and control (T_5). All treated samples were stored for 15 days and sample were observed for weight, volume, density, titratable acidity, appearance, colour and ascorbic acid at 0th day, 3rd day, 5th day, 7th day, 9th day, 12th day and 15th day to determine the shelf life of tomatoes. Data were observed in triplicate.
Weight, volume and density were measured by the method given by Mohesnin (1992). Titratable acidity and ascorbic acid were determined using the method given by Sharma (2009). Appearance was calculated by rating tomato on a scale of 1-10 with naked eyes based on its colour and firmness. For measurement of colour, images of fruit sample was analysed by Abode Photoshop 7.0 to obtain RGB colour parameters of the image (Papadakis *et al.*, 2000).

RESULT AND DISCUSSION

Weight, Volume and Density

Effect of storage period and pre-treatments on weight, volume and density of tomatoes were determined. ANOVA indicated that weight and volume of the tomatoes were not significantly ($P > 0.05$) dependent on days, but the density was significantly ($P < 0.05$) dependent on the days. Weight, volume and density were significantly ($P < 0.05$) dependent on treatment. No significant ($P > 0.05$) interaction between different treatments and days was observed.
Figure 1a depicts that the weight loss in tomatoes showed similar trend for different treatments though the rate of weight loss varied for different treatments as the days passed. The samples of treatment T_4 and T_5 were deteriorated on day 9 and that of T_1 deteriorated on day 10. The best results were given by the HIW samples as their weight loss was 11% followed by HIWC samples in which the weight loss was around 12%.
Figure 1b depicts that the volume of all samples of tomatoes decreased at different rates till days 5, but after day 5 and increase in volume is visible till day 7 and after day 7 it again started decreasing. Maximum increase in volume of about 32% was observed in the controlled samples and the best results were shown by HIW samples with a negligible increase of 0.01% followed by HIWC samples with a 3% increase in volume. The samples of treatment T_4 and T_5 were deteriorated on day 9 and that of T_1 deteriorated on day 10.

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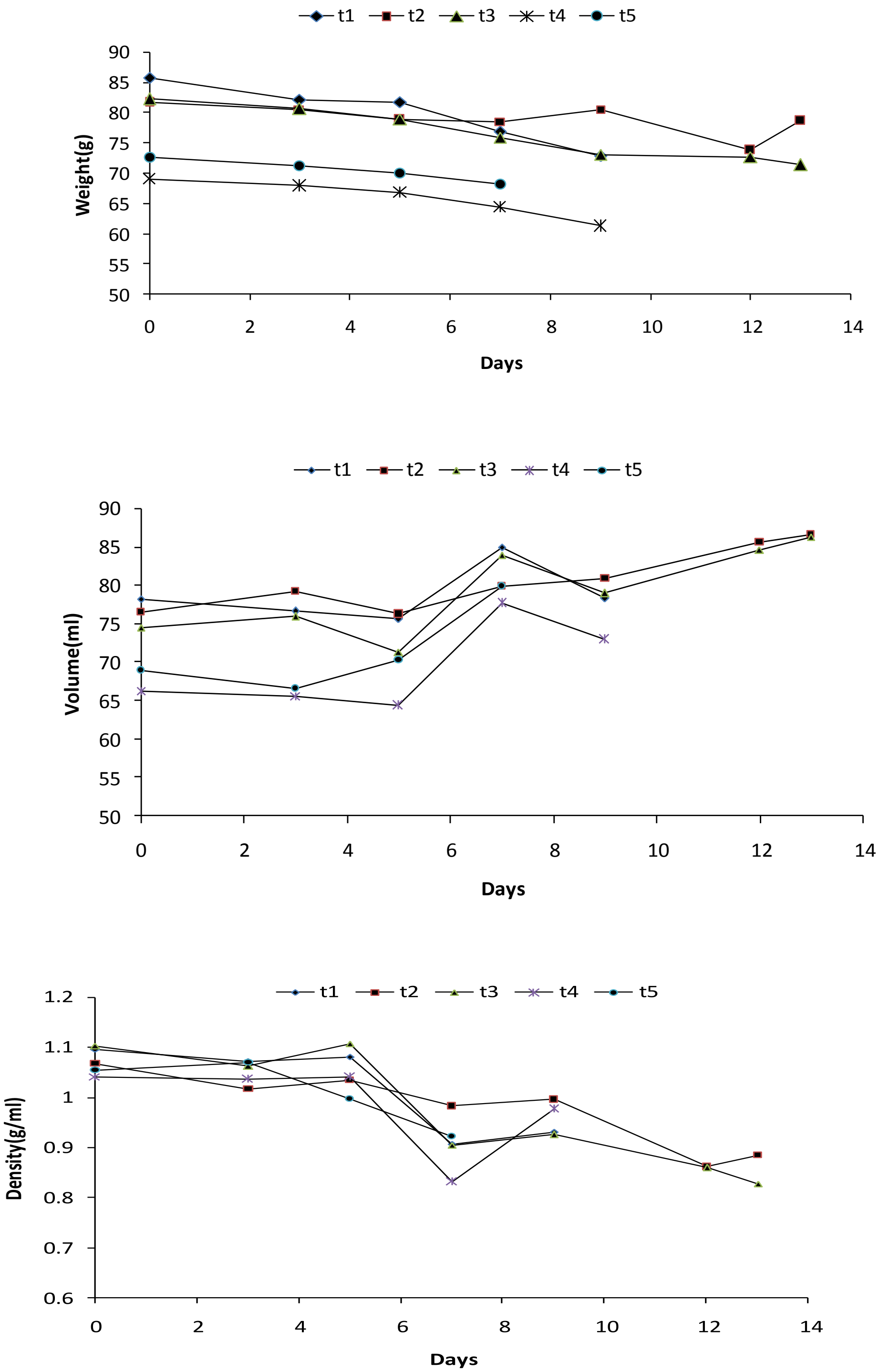

(a)

(b)

(c)

Figure 1: Variation of a) Weight b) Volume and c) Density of Tomato for Different Treatments

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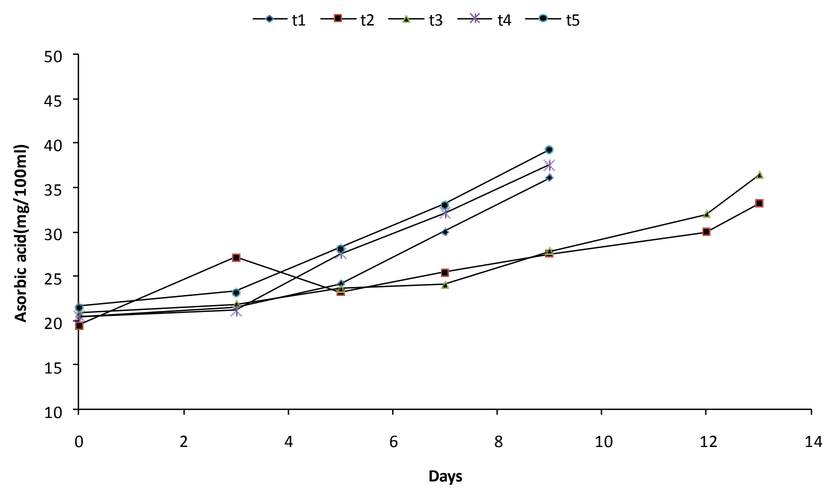
Figure 1c shows that the variation in density was more effected with number of days rather than the treatments. For all the treatment except T_1, density of tomato remained almost constant till day 5 and thereafter decreased relatively. Among all treatments HIW samples gave best results with a 4.5% decrease in density followed by HIWC samples with a 15% decrease in density on day13.The samples of treatment T_4 and T_5 were deteriorated on day 9 and that of T_1 deteriorated on day 10.

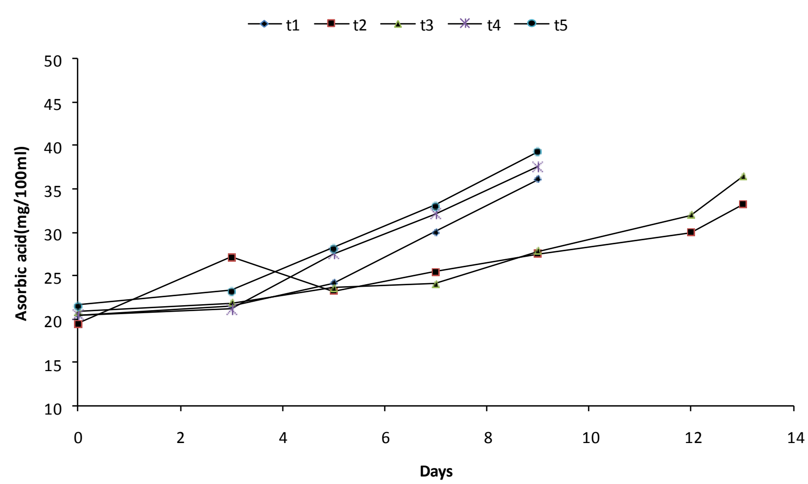
Titrable Acidity and Ascorbic Acid

ANOVA indicated that titrable acidity of tomatoes was not significantly ($P > 0.05$) dependent on the days and treatment, while ascorbic acid was significantly ($P < 0.05$) dependent on days and treatment.

Changes in titratable acidity during storage were relatively small (Figure 2a). The quantity of titratable acidity contents of fruit at the time of storage varied similarly for all samples except the one which were not given any treatment i.e. controlled sample. During storage the acidity increasing slightly in the first five days in case of air cooling, HRW, HIW and HIWC, but in the case of controlled sample the increase



(a)



(b)

Figure 2: Variation of a) Titrable Acidity and b) Ascorbic Acid of Tomato for Different Treatments

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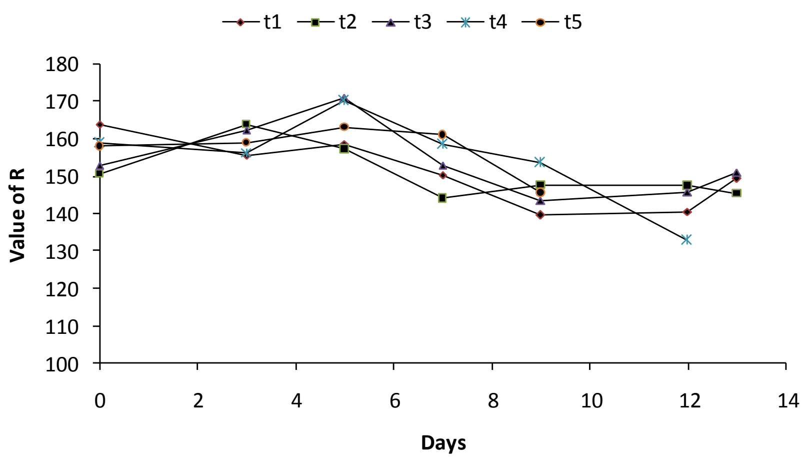
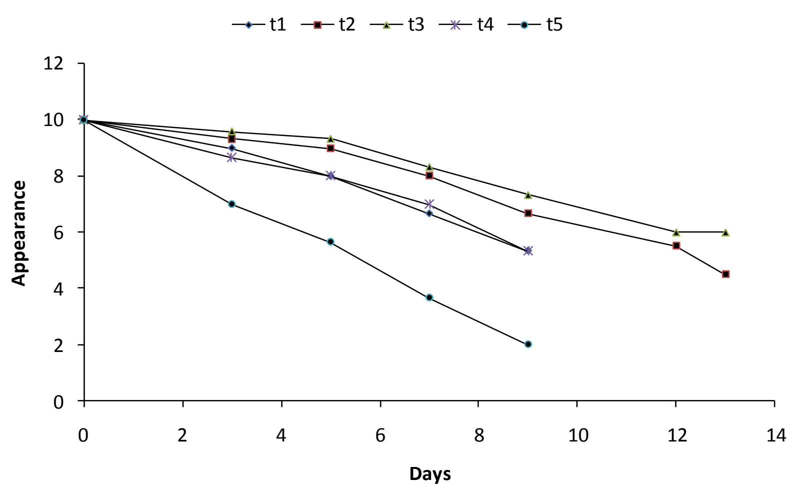
was rapid after the third day. During this period, the content of titratable acidity was increased by 0.99 g/l (in HRW), 0.13 g/l (in HIW), 0.1(in HIWC), 0.12 g/l (in air cooling) and 0.81 g/l (in controlled sample) on average per day. Afterward the content of titratable acidity started to decrease in all samples. The decrease in titratable acidity after 5 days was almost linear in all cases although the rate of decrease was slightly higher in the controlled samples at the end of the storage period there was no significant differences among acidity at different treatments. The controlled sample was found to be most acidic and the samples of HRW treatment were least acidic till 9 day. These results agreed with those from (Castro *et al.*, 2005) presenting an acidity decrease with maturity. (Will *et al.*, 1981) showed, that amount of organic acid usually decrease during maturity, because they substrate of respiration. Figure 2b depicts that the ascorbic content of tomatoes increased with days at a steady rate till day 3 the rate of increase was similar in all samples but after day 3 the rate of increase of ascorbic acid was more in T_1, T_4 and T_5 compared to



(a)



(b)

Figure 3: Variation of a) Color and b) Appearance of Tomato for Different Treatments

Colour and Appearance

T_2 and T_3. The controlled sample recorded the maximum value of ascorbic acid at the end of day 9 of 39.36 mg/100 ml. The samples of treatment T_4 and T_5 were deteriorated on day 9 and that of T_1

deteriorated on day 10. Whereas the best results were shown by T_2 and T_3 samples with HIWC samples recording an increase of 32 % followed by HIW samples recording an increase of 41% in the value of ascorbic acid during 13 days of storage. The effect of the treatment and days on colour was seen on each component i.e. R, G, and B of RGB colour separately. ANOVA indicated that R, G, B values of the colour of tomatoes was significantly ($P < 0.05$) dependent on days and only G value was also significantly ($P < 0.05$) dependent on treatment.
Carotenes and xanthophyll's contained in tomato, especially lycopene oxidize during the storage, gradually changed colour from bright red to dark brown. Figure 3a depicts that after 5 days the fruits reached their maximum red colour and the maximum value of RGB components were observed in T_3 on day 5. Also the best results were given by T_3 as the final value 151.1 of RGB components on day 13 were highest in HIWC sample among all other samples followed by HIW samples with a value of 145.5. The samples of treatment T_4 and T_5 were deteriorated on day 9 and that of T_1 deteriorated on day 10. Our data is in accordance with (Iwahashi *et al.,* 1999).
The appearance of the tomato deteriorated very rapidly in the case of controlled samples of tomatoes followed by the samples which were air cooled. After 9 days both the controlled and air cooled sample showed rupture of skin and got fungus on the surface or it can be said that they had the minimum shelf life of 9 days among all samples. The shelf life of the sample of HRW treatment came to be 10 days. Whereas the best results were given by the tomatoes given HIWC treatment followed by HIW treatment with their shelf life exceeding 13 days but the value of appearance in HIWC samples was slightly higher than that of HIW samples. The samples of treatment T_4 and T_5 were deteriorated on day 9 and that of T_1 deteriorated on day 10 (Figure 3b).

Conclusion

In the present study different post-harvest treatments were given to tomato which included air cooling for 24 hours, hydro cooling with raw water for 45 min, hydro cooling with ice water for 30 min and hydro cooling with ice water and $CaCl_2$ for 30 min. The different storage characteristics of tomato namely weight, volume, density, appearance, ascorbic acid, titratable acid and colour were calculated for different treatment up to 15 days to find out the treatment which gave the maximum shelf life of tomato.
The minimum weight loss was for HIW samples of 11% followed by HIWC samples with 12% weight loss during the 13 days of storage. The minimum increase of 0.01% in volume was observed in HIW samples followed by HIWC samples with a 3% increase in volume during the 13 days of storage. HIW samples gave best results for density with a 4.5% decrease followed by HIWC samples with a 15% decrease during the 13 days of storage. HIWC samples recorded an increase of 32 % followed by HIW samples with 41% increase in the value of ascorbic acid during the 13 days of storage. In HIW the rate of increase of titratable acidity was minimum at 0.13 gm/lt followed by 0.1gn/lt in HIWC on average per day during the 13 days of storage. Final R value of 151.1 in HIWC samples on day 13 was highest among all samples followed by HIW samples with a value of 145.5. Appearance of HIWC tomatoes was slightly better than HIW samples during the 13 days of storage. HIWC gave the best storage characteristics of tomatoes resulting increase in shelf life up to 13 days.

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