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Post-harvest treatments to improve the shelf-life of tomato fruits at ambient conditions

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ABSTRACT

The present study was conducted to investigate the effect of various post-harvest treatments on physico-chemical parameters of tomato fruits. Different treatments *viz.,* control, polyethylene- 25µ and 50µ; waxes-semperfresh, stayfresh and stafresh; bavistin 0.05% and combination of bavistin with these treatments were tried. Out of these treatments, the combination of bavistin 0.05% + stayfresh was found to be most effective in improving the shelf-life (17.50 days as against 10 days in the control). The same treatment also recorded least physiological loss in weight. Retention of TSS, acidity and ascorbic acid content were also highest in the same treatment. This treatment also recorded the highest values for lycopene content (4.51 mg/100 g). Thus, the post harvest treatment of tomatoes with 0.05% bavistin + stayfresh was found to be best for extension of shelf-life and maintaining the fruit quality.

Key words: Polyethylene, waxes, bavistin, shelf-life.

INTRODUCTION

Tomato (*Solanum lycopersicon* Mill.) belongs to the family Solanaceae. It is one of the most popular and widely grown vegetables and cultivated throughout the world for its fruits which are used either as vegetable salad and, or for processed products. As a rich source of vitamins, minerals and organic acids, tomato fruit provides 3-4 per cent total sugars, 4-7 per cent total solids,15-30 mg/100 g ascorbic acid,7.5-10 mg/100 ml titratable acidity and 20-50 mg/ 100g fruit weight of lycopene (Chadha, 4). But the poor keeping quality of tomato fruit is a major problem during post-harvest handling, transportation and marketing leading to huge post-harvest losses. With the increasing production and demand over the years, it becomes imperative to preserve freshness and minimize the losses of the fruit. moreover, the shelf-life of the fruit is short at ambient conditions and so there is a need to develop a suitable method for extending the shelf-life. The aforesaid objectives can be achieved by the use of simple post-harvest treatments like wax emulsion coating, treatment with fungicide, storage in perforated polyethylene, *etc.* There are several reports of extension of shelf-life of tomato by waxing, polyethylene packaging, fungicidal dip, *etc.* But no integrated approach was adopted to see the effect of different treatments in India.

Therefore, the present study was carried out with the objective to retain quality and extend shelf-life of tomato fruit using various post-harvest treatments.

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MATERIALS AND METHODS

The present study was carried out in the Quality Control and Post-harvest Laboratory of the Department of Horticulture, AAU, Jorhat, Assam, during 2003-2004. Unblemished tomato fruits (cv. Arka Alok) of uniform size at four maturity stages, *i.e.,* mature green (MG), turning red (TR), pink (PK) and ripe (RP), were harvested from the field. The fruits were cleaned and their peduncles were removed. Altogether 50 fruits were taken for each treatment and then subjected to various treatments *viz.,* T_0 (control), T_1 (Polyethylene 25µ with 4 No. of ¼th inch hole), T_2 (polyethylene 50µ with 4 numbers of ¼th inch hole), T_3 (Semperfresh 1:10 with water), T_4 (Stayfresh 1:2 with water), T_5 (Stafresh 1:2 with water), T_6 (bavistin 0.05%), T_7 (T_6 + T_1), T_8 (T_6+ T_2), T_9 (T_6 +T_3), T_{10} (T_6 + T_4) and T_{11} (T_6 + T_5).

Semperfresh, stayfresh and stafresh commercial wax formulations were used in the present investigation. For the bavistin treated fruits, the fruits were dipped in bavistin for five minutes and then the treatments were subjected. The fruits after treatment application were stored at room temperature (21-24.5°C and 68.5-73 RH) till the fruits were of marketable condition. The above treatments were replicated three times. The periodical observations on various physico-chemical parameters like PLW, TSS, pH, ascorbic acid and lycopene content were made and data were analyzed statistically to test the level of significance by adopting a factorial completely randomized design (Panse and Sukhatme, 13).

Shelf-life of fruits were assessed on the basis of shrinkage and rotting of the fruits. More than 50 per cent decay of fruits was considered as the critical limit for shelf-life termination. Physiological loss in weight (PLW) was determined by periodical weighing of fruits and the differential weight loss, and expressed in per cent with respect to storage time and post-harvest treatments. TSS was determined by Abbe's hand refractometer and results were expressed in °Brix. Juice pH of the fruits were determined using a pH meter. Ascorbic acid content was determined using 2,6-dicholorophenol indophenol dye method of Freed (5). Lycopene content was determined following the method described by Rangana (14).

RESULTS AND DISCUSSION

The results indicated that the shelf-life of the fruits decreased with the advancement of maturity stages (Table 1). Fruits harvested in the mature green stage recorded longest shelf-life (19.75 days) than the fruits harvested at other stages of maturity. Among all treatments, the highest shelf-life (17.50 days) was recorded in the treatment T_{10} (bavistin 0.05% + stafresh) whereas fruits under control have the shortest shelf-life (10 days). The bavistin + stafresh treated fruits delayed ripening which resulted in longer shelf-life. Similar results were reported by Agnihotri and Ram (1) in tomatoes.

Table 1. Effect of post-harvest treatments on shelf-life (days) of tomato fruits during storage.

Treatment	Stage				
	MG	TR	PK	RP	Mean
T_0 (Control)	15.0	11.0	8.0	6.0	10.00
T_1 (Polyethylene 25 μ)	17.0	11.0	9.0	6.0	10.75
T_2 (Polyethylene 50 μ)	19.0	13.0	9.0	6.0	11.75
T_3 (Semperfresh)	17.0	13.0	8.0	7.0	11.25
T_4 (Stayfresh)	24.0	20.0	12.0	9.0	16.25
T_5 (Stafresh)	22.0	19.0	12.0	9.0	15.50
T_6 (Bavistin 0.05%)	16.0	11.0	8.0	6.0	10.25
T_7 (T_6 + T_1)	20.0	14.0	9.0	6.0	12.25
T_8 (T_6 + T_2)	20.0	16.0	11.0	6.0	13.25
T_9 (T_6 + T_3)	18.0	15.0	9.0	6.0	12.00
T_{10} (T_6 + T_4)	26.0	20.0	14.0	10.0	17.50
T_{11} (T_6 + T_5)	23.0	17.0	10.0	8.0	14.50
Mean	19.75	15.0	9.92	7.08	12.94

$CD_{0.05}$ Treatment (T) = 0.77
Stage (S) = 0.44
T × S = 1.54

The physiological loss in weight (PLW) of the fruits increased with increasing period of storage in all the maturity stages (Table 2). The loss was reduced with the advancement of maturity at harvest, the mature

Table 2. Effect of post-harvest treatments on per cent physiological loss in weight (%) of tomato fruits during storage.

Treatment	At ripening stages					At shelf-life termination (SLT) stage stages				
	MG	TR	PK	RP*	Mean	MG	TR	PK	RP	Mean
T_0 (Control)	4.38	4.02	4.00	2.35	3.69	15.07	11.46	10.35	4.08	10.24
T_1 (Polyethylene 25 μ)	1.55	1.53	1.56	1.19	1.46	6.38	5.09	5.10	2.92	4.87
T_2 (Polyethylene 50 μ)	1.29	1.38	1.44	1.10	1.30	5.58	5.10	5.01	2.95	4.66
T_3 (Semperfresh)	2.34	2.15	2.09	1.30	1.97	5.95	5.02	4.98	2.92	4.46
T_4 (Stayfresh)	1.35	1.33	1.38	0.77	1.21	5.54	4.80	4.77	2.31	4.36
T_5 (Stafresh)	1.86	1.65	1.62	0.74	1.47	5.73	5.70	5.34	2.35	4.78
T_6 (Bavistin 0.05%)	4.27	4.05	3.98	2.08	3.60	10.36	8.36	8.45	4.01	7.80
T_7 (T_6 + T_1)	1.81	1.65	1.71	0.87	1.51	5.33	5.30	5.22	2.57	4.61
T_8 (T_6 + T_2)	1.50	1.43	1.37	0.74	1.26	5.14	4.22	4.31	2.43	4.03
T_9 (T_6 + T_3)	1.90	2.10	2.05	1.23	1.82	5.79	5.04	4.95	2.79	4.64
T_{10} (T_6 + T_4)	1.33	1.31	1.41	0.53	1.15	5.08	4.75	4.67	2.16	4.17
T_{11} (T_6 + T_5)	1.54	1.60	1.53	0.75	1.36	5.15	4.82	4.80	2.19	4.24
Mean	2.09	2.02	2.01	1.14	1.82	6.76	5.81	5.66	2.81	5.24

$CD_{0.05}$ - Treatment (T) = 0.013 0.015
Stage (S) = 0.008 0.009
T × S = 0.03 0.031

*For ripe stage, the values are at three days of storage.

green stage recording higher PLWs than the other stages of maturity. The fruits treated with polyethylene and waxes recorded lower PLWs (1.38 and 1.55 respectively) over the other treatments (bavistin 3.60) which was due to these treatments forming a barrier for loss of moisture on the fruit surface. The loss was least in the bavistin + stafresh treated fruits. Gaur and Bajpai (6) reported that in litchi wax coating provided protection against moisture loss by blocking stomata and lenticels and maintained the quality as near the fresh condition as possible for longer period.

The TSS of the fruits increased slightly during ripening but decreased at shelf-life termination stage irrespective of the stages of maturity and treatment (Table 3). TSS content, in general, was more in the ripe stage. Hydrolysis of starch or conversion of acids or other salts to sugars could be the reason for increased TSS with the increase in storage period. A sudden decline could be attributed to the utilization of sugars as a substrate for increased rate of respiration during storage. Retention of TSS was more in the wax treated fruits. This might be due to the fact that wax forms a layer of thin coating on the fruit surface and blocks lenticels partially thereby reducing rates of respiration and ethylene production which, in turn, was responsible for highest retention of TSS. Similar results were also reported by Jagadeesh *et al.* (8) in guava fruits.

The different post-harvest treatments had significant influence on the pH of the fruits (Table 4). pH showed an increasing trend with increasing storage period irrespective of post-harvest treatments and maturity stages. This increase in pH might be due to a reduction of free and combined acids in fruits. In general, pH was more in the ripe stage. Lambeth *et al.* (10), and Lower and Thompson (11) reported that field ripened fruits had higher pH than room-ripened fruits and this might be the reason for higher pH in the ripe stage. The changes in pH were low in fruits treated with waxes as the pH is related to the moisture content of the fruits (Bartholomew and Sinclair, 2).

The ascorbic acid content showed an increasing trend at the beginning of storage period, while a decline was observed at the end of shelf-life in all the treatments and maturity stages (Table 5). Kitagawa *et al.* (9) and Malewski and Markakis (12) had observed that ascorbic acid in tomatoes increased to a maximum level and then decreased with the advancement of ripening. This decrease in vitaminC might be due to the oxidative destruction of vitamin C in the presence of molecular oxygen by ascorbic acid oxidase. Bavistin + stafresh treated fruits retain appreciably higher amounts of ascorbic acid than other treatments. This might be due to partial sealing of pores on fruit surface by waxing which protected oxygen sensitive ascorbic acid from being

Table 3. Effect of post-harvest treatments on TSS (°Brix) of tomato fruits during storage.

Treatment	At ripening stages					At SLT (shelf-life termination) stages				
	MG	TR	PK	RP*	Mean	MG	TR	PK	RP	Mean
T_0 (Control)	5.80	5.80	5.90	6.00	5.88	4.50	4.75	4.70	4.80	4.69
T_1 (Polyethylene 25 μ)	5.83	5.85	5.90	6.05	5.91	4.90	4.70	4.60	4.80	4.75
T_2 (Polyethylene 50 μ)	5.78	5.80	5.85	6.00	5.86	4.55	4.75	4.70	5.00	4.75
T_3 (Semperfresh)	5.82	5.80	5.90	5.95	5.87	4.35	4.70	4.80	4.70	4.64
T_4 (Stayfresh)	5.80	5.82	5.85	5.89	5.84	4.55	4.80	5.00	4.75	4.78
T_5 (Stafresh)	5.82	5.85	5.85	5.90	5.86	4.70	4.75	4.70	4.70	4.71
T_6 (Bavistin 0.05%)	5.80	5.85	5.95	6.10	5.93	4.40	4.70	4.80	4.80	4.68
T_7 (T_6 + T_1)	5.85	5.90	5.89	6.05	5.92	4.40	4.80	4.70	4.75	4.66
T_8 (T_6 + T_2)	5.83	5.85	5.85	6.00	5.88	4.55	4.80	4.80	4.80	4.74
T_9 (T_6 + T_3)	5.82	5.89	5.90	5.95	5.89	4.55	4.78	5.00	4.70	4.76
T_{10} (T_6 + T_4)	5.80	5.83	5.85	5.90	5.85	4.60	4.95	4.92	4.90	4.84
T_{11} (T_6 + T_5)	5.85	5.85	5.85	5.95	5.88	4.60	4.87	4.80	4.70	4.74
Mean	5.82	5.84	5.88	5.98	5.88	4.55	4.78	4.78	4.78	4.73

$CD_{0.05}$ -	Treatment (T)	=	NS	0.09
	Stage (S)	=	0.08	0.05
	T × S	=	NS	0.18

*For ripe stage, the values are at three days of storage.

At harvest TSS (°Brix) for MG = 4.66, TR = 4.75, PK = 5.27 and RP stage = 5.49.

Table 4. Effect of post-harvest treatments on pH of tomato fruits during storage.

Treatment	At ripening stages					At S LT (shelf-life termination) stages				
	MG	TR	PK	RP*	Mean	MG	TR	PK	RP	Mean
T_0 (Control)	4.05	4.22	4.25	4.40	4.23	4.11	4.42	4.45	4.52	4.38
T_1 (Polyethylene 25 µ)	4.18	4.20	4.28	4.35	4.25	4.21	4.41	4.38	4.54	4.39
T_2 (Polyethylene 50 µ)	4.10	4.28	4.30	4.50	4.30	4.23	4.37	4.42	5.20	4.56
T_3 (Semperfresh)	4.17	4.25	4.12	4.52	4.27	4.28	4.38	4.20	4.50	4.34
T_4 (Stayfresh)	4.15	4.17	4.25	4.30	4.22	3.99	4.31	4.41	4.48	4.30
T_5 (Stafresh)	4.10	4.16	4.32	4.34	4.23	4.21	4.33	4.43	4.45	4.36
T_6 (Bavistin 0.05%)	4.20	4.20	4.39	4.42	4.30	4.26	4.38	4.56	4.57	4.44
T_7 (T_6 + T_1)	4.00	4.25	4.36	4.35	4.24	4.02	4.28	4.52	4.66	4.37
T_8 (T_6 + T_2)	4.10	4.33	4.34	4.29	4.27	4.21	4.52	4.38	4.31	4.36
T_9 (T_6 + T_3)	4.00	4.11	4.38	4.40	4.22	4.07	4.26	4.57	4.60	4.38
T_{10} (T_6 + T_4)	4.00	4.15	4.26	4.32	4.18	4.04	4.28	4.38	4.50	4.30
T_{11} (T_6 + T_5)	3.99	4.19	4.28	4.52	4.25	4.03	4.28	4.41	4.77	4.37
Mean	4.09	4.21	4.29	4.39	4.25	4.14	4.35	4.43	4.59	4.38

$CD_{0.05}$ -	Treatment (T)	=	0.02	0.07
	Stage (S)	=	0.011	0.04
	T × S	=	0.04	0.14

*For ripe stage, the values are at three days of storage.

At harvest pH for MG = 3.92, TR = 4.00, PK = 4.09 and RP stage = 4.13.

Table 5. Effect of post-harvest treatments on ascorbic acid (mg/100 g) content of tomato fruits during storage.

Treatment	At ripening stages					At SLT (shelf-life termination) stages				
	MG	TR	PK	RP*	Mean	MG	TR	PK	RP	Mean
T_0 (Control)	15.05	16.12	17.11	20.45	17.18	14.54	15.60	15.79	17.95	15.97
T_1 (Polyethylene 25 µ)	14.93	16.32	17.02	19.98	17.06	14.72	15.68	15.95	18.60	16.24
T_2 (Polyethylene 50 µ)	14.75	16.50	15.04	20.52	16.70	14.58	15.58	13.79	18.44	15.60
T_3 (Semperfresh)	14.90	15.34	15.32	22.25	16.95	14.58	15.70	14.90	18.85	16.01
T_4 (Stayfresh)	13.38	15.42	15.32	21.05	16.69	14.55	15.63	14.90	19.94	16.26
T_5 (Stafresh)	14.45	13.98	15.85	22.89	16.53	14.70	13.86	15.91	17.50	15.49
T_6 (Bavistin 0.05%)	13.98	15.12	16.32	20.55	16.61	14.39	15.06	15.82	17.09	15.59
T_7 (T_6 + T_1)	14.94	16.12	17.10	20.50	16.93	13.88	15.70	14.17	18.58	15.58
T_8 (T_6 + T_2)	14.35	16.23	17.05	20.55	17.19	14.65	15.72	15.89	18.95	16.30
T_9 (T_6 + T_3)	14.86	14.48	16.33	21.10	16.57	14.25	13.82	15.90	18.08	15.51
T_{10} (T_6 + T_4)	14.28	14.86	16.93	20.25	16.98	14.74	15.74	15.80	19.04	16.33
T_{11} (T_6 + T_5)	14.57	15.82	16.55	20.94	16.90	13.99	15.77	15.95	18.96	16.17
Mean	14.57	15.61	16.33	20.92	16.86	14.46	15.32	15.40	18.50	15.92

$CD_{0.05}$	Treatment (T)	=	NS	0.03
	Stage (S)	=	0.62	0.018
	T × S	=	NS	0.06

*For ripe stage, the values are at three days of storage.

At harvest ascorbic acid content (mg/100 g) for MG = 10.07, TR = 10.46, PK = 11.23 and RP stage = 13.03.

Table 6. Effect of post-harvest treatments on lycopene content (mg/100 g) of tomato fruits during storage.

Treatment	At ripening stages					At SLT (Shelf-life termination) stages				
	MG	TR	PK	RP	Mean	MG	TR	PK	RP	Mean
T_0 (Control)	3.80	4.02	4.00	4.12	3.99	4.35	4.41	4.48	4.56	4.45
T_1 (Polyethylene 25 μ)	3.82	3.95	4.01	4.15	3.98	4.42	4.45	4.52	4.48	4.47
T_2 (Polyethylene 50 μ)	3.75	3.97	3.95	4.05	3.93	4.40	4.23	4.45	4.62	4.43
T_3 (Semperfresh)	3.85	4.00	3.98	4.05	3.97	4.36	4.35	4.48	4.60	4.45
T_4 (Stayfresh)	3.60	3.96	3.99	4.00	3.89	4.30	4.41	4.39	4.45	4.39
T_5 (Stafresh)	3.84	3.95	4.00	4.00	3.95	4.45	4.50	4.45	4.54	4.49
T_6 (Bavistin 0.05%)	3.82	4.00	3.95	4.01	3.95	4.23	4.45	4.34	4.48	4.38
T_7 (T_6 + T_1)	3.85	4.10	4.02	4.10	4.02	4.32	4.48	4.48	4.48	4.44
T_8 (T_6 + T_2)	3.80	4.00	3.98	4.10	3.97	4.40	4.33	4.45	4.59	4.44
T_9 (T_6 + T_3)	3.81	3.94	4.11	4.00	3.97	4.43	4.42	4.37	4.54	4.44
T_{10} (T_6 + T_4)	3.81	3.97	3.98	4.04	3.95	4.42	4.44	4.56	4.60	4.51
T_{11} (T_6 + T_5)	3.79	3.95	3.98	4.00	3.93	4.38	4.39	4.45	4.58	4.45
Mean	3.80	3.98	4.00	4.05	3.96	4.37	4.79	4.45	4.54	4.54

$CD_{0.05}$	Treatment (T)	=	0.02	0.04
	Stage (S)	=	0.01	0.02
	T × S	=	0.03	0.07

*For ripe stage, the values are at three days of storage.

At harvest lycopene content (mg/100g) for MG = 0.02, TR = 0.25, PK = 1.77 and RP stage = 3.26.

degraded. Jagadeesh *et al*. (8) reported similar results of retention of ascorbic acid in guava fruits by waxing.

Lycopene content of tomato fruits showed and increasing trend with increasing storage period irrespective of post-harvest treatments and maturity stages. This increase in lycopene might be due to the conversion of chlorophyll to lycopene at the time of ripening. Lycopene content, in general, was more in the ripe stage. This finding is in conformity with the findings of Hubert and Bhowmik (7), Sashikala *et al*. (15), Singh *et al*. (16) and Thiagu *et al.* (13) in tomato. Among the treatments, the highest lycopene content (4.51 mg/100 g) was recorded in the treatments T_{10} (bavistin 0.05% + stafresh) and the lowest (4.38 mg/100g) in the T_6 treatment (bavistin 0.05%) at shelf-life termination stage.

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