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Effect of harvesting and storage conditions on the post harvest quality of tomato (*Lycopersicon esculentum* Mill) cv. Roma VF

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Abstract

The study was conducted to undertake the effect of harvesting stage and storage conditions on the post harvest quality of tomato cv. Roma VF (*Lycopersicon esculentum Mill*) during the process of ripening in storage. Fruit of three maturity stages such as mature green (mature but green in color), half ripen (breaker stage when fruit turns to yellow) and full ripen (yellow and soft, edible stage) were kept under three different conditions; open condition (control), covering with white polythene and finally treatment by CaC_2^+ polythene. High and significant variation was observed in quality characteristics under different harvesting stages, storage conditions and their combinations. The highest value for rotting and total sugar content was distinguished in full ripens tomato. The highest weight loss and shelf life was measured in mature green. The half ripen tomato showed the highest value of vitamin C and titrable acidity. The percentage of decay (rotting) and weight loss, pH, titrable acidity and total sugar were increased with gradual increasing of storage time, irrespective to maturity stages while the percentage of vitamin C was decreased with progressing time of storage. The highest value of weight loss, shelf life and titrable acidity was recorded in control treatment. The high decay (rotting percent) and total sugar content was recorded under CaC_2^+ polythene covering treatment while the highest vitamin C content and pH was measured in simple polythene covering treatment at the final observation day (15^{th} day). The values of all parameters except for vitamin C were increased gradually with the exceeding of storage time irrespective to storage condition. Tomato plants placed under CaC_2^+ treatment, covered with polythene have shown the highest decay, titrable acidity and total sugar content at the final observation day.

Keywords: Maturity stage; storage condition; quality character; tomato.

Introduction

Tomato (*Lycopersicon esculentum*) in Solanaceae family is a herbaceous plant native to central, South and Southern North America from Mexico to Argentina (Rick & Butler, 1956). The tomato is now grown worldwide for its edible fruits. Proper harvesting determines the nutrient contents as well as storage durability of any fruit. Tomato is normally harvested at different maturity stages, such as green mature stage, half ripen stage and red ripen stage. Fruits treated with CaC_2^+ have shown higher values for fresh firmness during storage whereas they have quicker development of red color, greater weight loss,

Table 1. Main effect of storage conditions on the percent of decay or rotting and weight loss of tomato.

Treatment	Decay or rotting (%)						Weight loss of tomato (%)					
	0DS	3DS	6DS	9DS	12DS	15DS	0DS	3DS	6DS	9DS	12DS	15DS
Uncovered	00	4.92	14.34	20.36	34.21	51.48	00	5.96	9.39	11.51	12.7	15.35
S. covering	00	4.88	14.18	21.48	38.67	55.62	00	5.94	9.29	11.45	12.5	15.25
$CaC2^{+}$poly	00	4.89	16.37	23.14	42.87	57.38	00	5.89	9.23	11.33	12.5	15.21
LSD (0.05)	00	00	0.263	0.263	5.042	0.806	00	0.03	0.00	0.063	0.07	0.055
LSD (0.01)	00	00	0.362	0.362	6.942	1.110	00	0.04	0.07	0.075	0.1	0.075

and higher soluble solids content rather than non-treated fruits during the shelf life (Garcia *et al.,* 1995). Goojing *et al.,* (1999) reported that 78.2% and 47.5% of rotting can be found in red ripen and mature harvested fruits, after three weeks of storage at 15-20°C, respectively. Mallik *et al.,* (1996) reported that fruit of tomato (cv.Roma VF) showed the lowest physiological weight loss about 7.7-9.7% after 6 days of storage under ambient condition. They also stated that CaC_2^+ treatment accelerated ripening and resulted in higher percentage of weight loss during storage. Shelf life is the most important aspect in loss reduction biotechnology of fruit and vegetables. Anju-Kumari *et al.,* (1993) reported that the shelf life of all tomato cultivars were longest when harvested at green mature stage. The fruit acid content is lower in immature fruit and highest when the color starts to appear, with a rapid decrease when the fruit ripens. Concentration of acid linearly reduced when temperature increased and then went up again when fruit stored at 15°C (Islam, *et al.,* 1996). pH is an importing factor in fruit processing industry. Cultivars with high pH are not suitable for processing. Saimbhi *et al*., (1987) reported a wide range of variation of pH content from 3.6 to 4.6 in different tomato varieties. Botrel *et al.,* (1993) observed that ripen pineapple fruits held at 5°C had higher pH than 25°C.

Winser *et al.,* (1962) found that the maximum acidity can be recorded at the pink stage of tomato fruits. Singa (1986) reported that sugar content increased during maturation from the green mature to the red ripen stage. Sugar content varied depends on harvesting stage. Dalal *et al.,* (1995) found that the reduction of sugar content ranged about 2.4% to 3.65 from large green to red ripen fresh fruits. At all temperatures, fruits concentration of soluble sugars increased with the storage long. The total soluble solid increased from mature green to red ripe stage (Winsor *et al.,* 1962). Sing (1980) reported 4.80 to 8.80% of total soluble solids in tomato juice. It was found that fruit soluble solids somewhat are increased during storage. The total soluble solids and sugar content are supposed to get more increased through the development of fruit (Boe *at al.,* 1967).

Estimation in the developing countries says that nearly 30-40% of harvested tomato can potentially be lost through spoilage (Akamine, 1970). Apart from physical quality, serious losses also occur in the essential nutrients, vitamins and minerals. Improper harvesting time (maturity), ripening conditions and lack of suitable storage facilities cause a glut during the peak harvesting period and a large portion of yield is sold very cheap. Therefore reduction of post harvest losses is so important to recover part of grower's costs. Suitable harvesting stage of fruit (maturity) and optimum ripening conditions to have the best quality and longer storage of tomato has not completely been recognized for developing countries. This study was conducted to find the optimum stages of maturity and ripening conditions that ensure better quality for fresh consumption and long distance marketing.

Materials and Methods

Experiment site

This experimental was carried out in the functional food laboratory, Departments of Biotechnology, University of Malay, Kuala Lumpur-50603, Malaysia

Plant material

Freshly harvested tomato fruit from variety Roma VF were collected from the field in Pealing Jaya. Roma VF variety is the most popularly grown tomato outdoor or in green house in Malaysia and is resistant to *Fusarium* wilt and *Verticillium* diseases.

Physical condition of the storage room

The average maximum and minimum temperature of the storage room was 28±1°C. Relative humidity was 75%.

Table 2. Combined effect of maturity stages and storage conditions on decay or rotting percentage and weight loss of tomato.

Treatment combination	Decay or Rotting (%)						Weight loss (%)					
	0DS	3DS	6DS	9DS	12DS	15DS	0DS	3DS	6DS	9DS	12DS	15DS
M_1T_1	0	0.000	0.000	0.000	9.130	28.430	0	6.320	10.300	11.750	13.62	15.48
M_1T_2	0	0.000	0.000	5.670	8.800	26.500	0	6.280	10.200	11.680	13.50	15.43
M_1T_3	0	0.000	6.830	8.670	8.900	27.000	0	6.230	10.150	11.650	13.42	15.43
M_2T_1	0	6.470	15.830	26.070	46.730	60.000	0	5.800	9.270	11.500	12.47	15.35
M_2T_2	0	6.520	15.330	25.370	45.350	62.370	0	5.830	9.180	11.450	12.10	15.25
M_2T_3	0	6.500	15.200	25.570	53.170	65.100	0	5.750	9.080	11.300	12.40	15.15
M_3T_1	0	8.300	27.200	35.000	46.700	66.000	0	5.780	8.600	11.280	12.15	15.22
M_3T_2	0	8.130	27.200	33.400	61.870	78.000	0	5.700	8.500	11.200	11.90	15.08
M_3T_3	0	8.130	27.070	35.200	66.530	80.030	0	5.680	8.450	11.050	11.83	15.05
LSD (0.05)	0	0.263	0.455	3.716	8.733	1.395	0	0.055	0.095	0.110	0.134	0.095
LSD (0.01)	0	0.362	0.626	5.120	12.030	1.923	0	0.075	0.131	0.151	0.185	0.131
CV (%)	0	3.080	1.750	9.910	13.080	1.470	0	0.480	0.600	0.530	0.590	0.380

Maturity stages **Storage condition**
M_1: Mature green T_1: Uncovered condition
M_2: Half ripe T_2: Covering with polythene
M_3: Full ripe T_3: Treated with CaC_2+ polythene covering
DS: days of storage

Treatment setting

The experiment consisted of two main factors, Factor-A (maturity stages) and Factor-B (storage conditions). The different levels of factor A were: (M_1) Matured green tomato (M_2) Half ripen tomatoes (M_3) Full ripen tomato. The levels of factor B were (1) Control: Uncovered condition (T1:28±1ºC) (2) Covering with polythene (T2:30±1ºC) (3) Placing CaC_2^+ below tomato and then covered with polythene (T3:31±1ºC) in a (3×3) combination of treatments.

Design of experiment

The experimental designed in a Randomized completely block design (RCBD) with three replications. One kg of uniform size tomato fruits were kept in each replication.

Decay or rotting (%)

Decay or rotting was determined by the visual observation. Development of spots on the fruit's skin and softening and rotting of fruits were also recorded.

Weight loss (%)

The weight loss of tomato fruit sample was calculated by differences between initial weight and final weight divided by initial weight.

Shelf life

The shelf life was calculated by counting the days required to attain the last stage of ripening, but up to the stage when fruit remained still acceptable for marketing.

Ascorbic acid content of pulp

Ascorbic acid in tomato pulp was estimated by 2, 6-Dichlorophenol-induphenol visual titration method as described by Rangana (1979).

pH of tomato juice

The pH of the sample was determined by the method described by Rangana (1979).

Total titrable acidity content of pulp

Total titrable acidity was determined using the following steps. At first sample blended, Filtered, transfer to volumetric flax and volume up to 100 ml mark, then titrated with 0.1N NaOH. %TA=

$$\frac{T \times N \times T \times V_{1\times 100}}{W \times V_2}$$

Table3. Main effect of maturity stages on the Vitamin C, pH and titrable acidity content of tomato at different days of storage

Treatment	Vitamin C (mg/100g)					pH					Titrable acidity (%)				
	DS 0	3	6	9	12	0	3	6	9	12	0	3	6	9	12
Mature green	8.58	7.67	6.82	5.19	4.86	20.05	17.51	16.51	15.14	4.16	13.54	11.36	10.29	9.35	7.86
Half ripen	0.045	0.071	0.032	0.032	0.055	0.062	0.097	0.044	0.044	0.075	4.23	4.27	4.38	4.35	4.63
Full ripen	4.16	4.20	4.25	4.27	4.37	4.17	4.23	4.25	4.17	4.27	0.03	000	0.001	0.07	0.045
LSD (0.05%)	0.044	000	0.014	0.107	0.062	0.40	0.45	0.44	0.45	0.44	0.41	0.44	0.46	0.48	0.46
LSD (0.01)	0.42	0.45	0.45	0.46	0.45	0.001	0.001	0.001	0.001	0.001	0.014	0.014	0.014	0.014	0.014

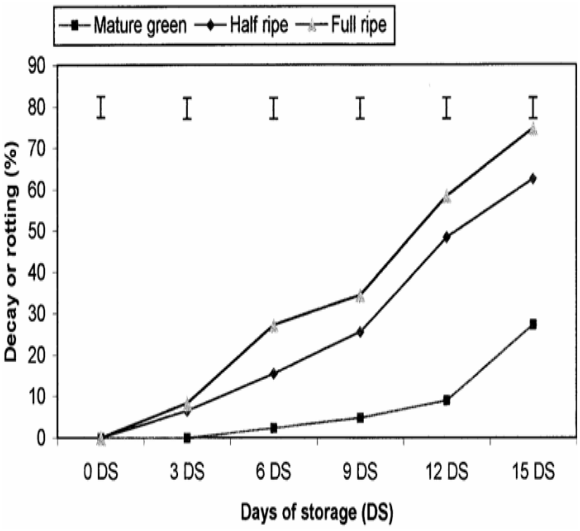

Fig 1. Decay or rotting (%) of tomato at different days of storage shown by different stages of matured fruits. Vertical bars indicate LSD value at 5% level of significance.

Sugar content of pulp

Sugar content was estimated by determining the volume of unknown sugar solution of tomato pulp required for complete reduction of standard Fehling's solution (Fehlings H, 1849).

$$\text{Percentage of sugar} = \frac{F \quad D \quad \times \quad 1 \quad 0}{T \quad W \quad \times \quad 1 \quad 0 \quad 0 \quad 0}$$

Results

The total rotting percent of full ripen fruit was 8.19 at the third day of storage, and then raised to 74.68 % on 15th day of storage (Fig 1). On the other hand, rotting percent in mature green fruit was 0% at the third day and increased to 27.31 % at 15th day of storage. However, at day 15 of storage the mature green fruits treated by CaC_2^+ polythene have shown 57.38% of rotting. (Table1). The rotting percent of tomato under covering with polythene and control treatment were 55.62 and 51.48 percent, respectively. The full ripen fruits under CaC_2^+ polythene covering treatment showed maximum rotting percentage of 80.03 %, followed by 62.37 % in half ripen with polythene covering. The mature green fruits under uncovered condition have shown lowest rotting percentage of 28.43 % (Table 2).

Total weight loss in mature green fruits was always higher during the entire period of storage. At the third day of storage, it was 6.28 % then was raised to 13.31 % at 12th day (Fig 2). In full ripen fruits; weight loss was the lowest value of 5.72 % at the third day and 11.96 % at day twelve of storage. Total weight loss in mature green fruits was always higher during the entire period of storage. The mature green fruits also have shown maximum shelf life (13 days), followed by half ripen (12 days) and full ripen (10.33 days) (Fig 3). Fruits under control treatment was recorded to give the longest life (12.67 days), followed by simple polythene covering (12 days). The lowest shelf life was recorded by CaC_2^+ polythene covering treatment (11.33 days)(Fig 4). The highest shelf life (14.50 days) was observed in mature green fruits under the control condition, followed by treatment of half ripen and control (12.50 days), while it was lowest (9.5 days) in full ripen under CaC_2^+ polythene covering treatment (Fig 5). Ascorbic acid content of fruit pulps was significantly different depends on maturity stages (Table3). The half ripen tomato contained the highest quantity of ascorbic acid (20.05 mg/100g fruit pulp) while the mature green contained the lowest quantity of ascorbic acid just about 8.58mg. The ascorbic acid contents were 12.21 mg/ 100g pulp and 4.86 mg/100g in half ripen and mature green stage respectively, at day twelve of storage. The maximum ascorbic acid content (12.23mg/100g pulp) at day twelve of storage were recorded in half

Table 4. Main effect of storage conditions on the vitamin C, pH and titrable acidity content of tomato at different days of storage

Treatment	Vitamin C (mg/100g)					pH					Titrable acidity				
DS	0	3	6	9	12	0	3	6	9	12	0	3	6	9	12
Uncovered	14.06	12.18	11.29	9.89	8.29	4.12	4.22	4.27	4.30	4.44	4.12	4.22	4.27	4.30	4.44
Covering (poly)	14.04	12.20	11.20	9.90	8.33	4.14	4.21	4.29	4.25	4.45	4.14	4.21	4.29	4.25	4.45
CaC_2+P.covering	14.08	12.1`7	11.21	9.89	8.32	4.21	4.28	4.31	4.24	4.39	4.21	4.28	4.31	4.24	4.39
LSD (0.05%)--	--	--	--	--		0.044	--	0.001	--	0.045	0.032	--	0.001	--	0.045
LSD (0.01%)--	--	--	--	--		0.044	--	0.014	--	--	0.044	--	0.014	--	--

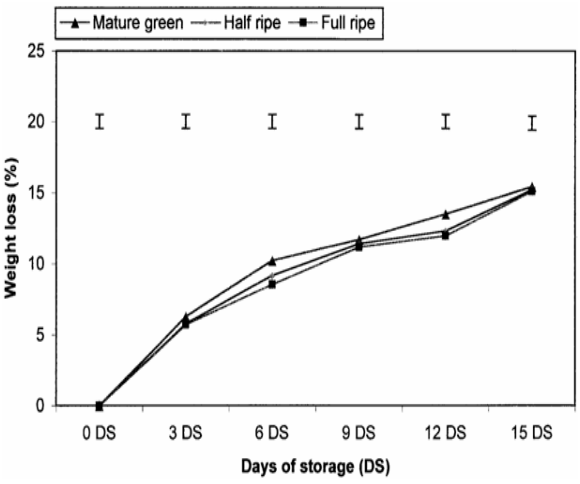

Fig 2. Weight loss (%) of tomato at different days of storage shown by different stages of matured fruits. Vertical bars indicate LSD value at 5% level of significance.

ripen covered with polythene while it was minimum (4.77mg/100g pulp) in mature green fruits (Table 5) at the zero, third and twelfth day of storage.

It was found that fruit's pH increased with the advancement of ripening (Table 3). The highest pH value (4.63) was observed in mature green followed by half ripen (4.37) and full ripen fruit (4.27) respectively at twelfth days of storage (Table 4). The highest pH value (4.71) was recorded in mature green tomatoes under covering with polythene; while it was lowest (4.26) in full ripen under the control treatment at twelfth day of storage (Table 5). The half ripens tomato pulp contained highest quantity of total titrable acidity (0.48 percent) followed by full ripe (0.47%) and mature green (0.44 percent) at 9^{th} day of storage. The highest acidity value (0.469 percent) was recorded in simple polythene covered while minimum of 0.46 percent measured in control condition at 9^{th} storage day (Sinaga, 1986). The total titrable acidity content was significantly influenced by the combined effect of stages of maturity and storage conditions (Table 5). The maximum content of total titrable acidity (0.48 percent) was recorded in half ripen fruits with CaC_2^+ polythene covered treatment at 9^{th} storage day, while it was minimum (0.45 percent) in mature green stage under the control treatment.

We estimated that the reduction rate of sugar content was increased with the advancement of fruit ripening. Though full ripen tomato contained the highest quantity of sugar reduction whereas the mature green tomato contained the lowest quantity at all time of observations (Table 6) Dalal *et al.,* (1965) also observed the similar results. The highest increase in reducing sugar content was recorded under CaC_2^+ polythene covering condition, while the control was found to show less value in this regard (Table 7). The combined effect of stages of maturity and storage conditions significantly affects the reducing sugar content in fruits (Table 8). The highest quantity of reducing sugar content (4.44 percent) was recorded in full ripen fruits under CaC_2^+ use with polythene covering treatment while it was minimum (3.83 percent) in mature green under control treatment at day twelfth of storage.

Total sugar content of tomato pulp varied significantly in fruits of different maturity. It was found that total sugar content was increased with the advancement of ripening of fruits irrespective of maturity condition. The highest quantity of total sugar (4.03 percent) was recorded in full ripen tomatoes while it was lowest quantity (3.30 percent) in mature green tomatoes at twelfth day of storage. Ripening conditions was found to be affected significantly on total sugar content of tomato at different storage durations (Table 7). The highest quantity of total

Table 5. Combined effects of maturity stages and storage conditions on the Vitamin C, pH and titrable acidity of tomato at different storage days.

Treatment Combinations	Vitamin C (mg/100g)					pH					Titrable acidity				
DS	0	3	6	9	12	0	3	6	9	12	0	3	6	9	12
M_1T_1	8.55	7.68	6.84	5.19	4.77	4.27	4.28	4.32	4.36	4.67	0.401	0.434	0.436	0.453	0.443
M_1T_2	8.58	7.69	6.80	5.20	4.89	4.12	4.27	4.40	4.33	4.71	0.401	0.457	0.440	0.454	0.443
M_1T_3	8.62	7.66	6.81	5.19	4.92	4.30	4.26	4.42	4.35	4 .52	0.402	0.458	0.448	0.454	0.443
M_2T1	20.03	17.54	16.54	15.14	12.22	4.20	4.17	4.25	4.29	4.38	0.402	0.440	0.470	0.479	0.443
M_2T_2	20.05	17.47	16.49	15.14	12.23	4.15	4.16	4.24	4.29	4.37	0.417	0.444	0.461	0.482	0.462
M_2T_3	20.07	17.52	16.50	15.14	12.18	4.134	4.27	4.25	4.24	4.37	0.418	0.442	0.467	0.483	0.464
M_3T_1	13.59	11.33	10.29	9.35	7.86	4.17	4.20	4.24	4.25	4.26	0.438	0.457	0.457	0.466	0.459
M_3T_2	13.48	11.43	10.29	9.35	7.86	4.16	4.20	4.25	4.13	4.28	o.431	0.452	0.460	0.470	0.455
M_3T_3	13.54	11.33	10.30	9.35	7.87	4.19	4.30	4.25	4.12	4.27	0.417	0.457	0.455	0.462	0.457
LSD (0.05)	0.077	0.122	0.077	0.077	0.095	0.055	0.110	0.017	0.134	0.077	0.017	0.017	0.017	0.017	0.017
LSD (0.01)	0.107	0.169	0.107	0.107	0.107	0.107	-	0.024	0.185	0.107	0.023	0.024	0.024	0.024	---
CV (%)	0.31	0.59	0.24	0.28	0.60	0.71	1.56	0.36	1.77	1.06	3.02	0.39	0.53	0.53	0.34

DS- Days of storage

Table 6. Main effect of maturity stages on the percentage of sugar reduction, non-reducing sugar and total sugar content of tomato at different storage days.

Treatments	Reducing sugar(%)					Non-reducing sugar (%)					Total sugar (%)				
DS	0	3	6	9	12	0	3	6	9	12	0	3	6	9	12
Mature green	2.39	2.99	3.45	3.64	3.86	0.91	1.21	1.41	1.24	0.878	3.3	4.21	4.86	4.87	4.73
Half ripen	2.66	3.21	3.51	3.66	3.99	0.96	1.25	1.46	1.27	0.877	3.62	4.46	5.00	4.93	4.87
Full ripen	2.99	3.25	3.57	3.70	4.34	1.03	1.33	1.64	1.28	0.586	4.03	4.58	5.21	4.98	4.92
LSD (0.05)	0.001	0.032	0.032	0.001	0.045	0.001	0.032	0.032	--	0.001	0.032	0.045	0.045	0.045	0.032
LSD (0.01)	0.014	0.044	0.044	0.014	0.062	0.014	0.044	0.044	--	0.014	0.044	0.062	0.062	0.062	0.044

Table 7. Effect of storage conditions on the percentage of reducing, non-reducing and total sugar content of tomato at different storage days.

Treatments	Reducing sugar (%)					Non-reducing sugar (%)					Total sugar (%)				
DS	0	3	6	9	12	0	3	6	9	12	0	3	6	9	12
Uncovered	2.65	3.11	3.48	3.61	4.01	0.95	1.25	1.50	1.27	0.787	3.60	4.36	4.99	4.89	4.79
Covering(poly)	2.68	3.16	3.52	3.66	4.06	0.97	1.25	1.52	1.25	0.763	3.65	4.41	5.04	4.92	4.82
CaC2+Poly Covering	2.72	3.18	3.53	3.72	4.12	0.98	1.29	1.51	1.26	0.790	3.70	4.48	5.04	4.98	4.91
LSD (0.05)	0.001	0.032	--	0.001	0.045	0.001	--	--	--	0.001	0.032	0.045	--	0.045	0.032
LSD (0.01)	0.014	0.044	--	0.014	0.062	--	--	--	--	0.014	0.044	0.062	--	0.062	0.044

Table 8. Combined effects of stages of maturity and storage conditions on the percentage of reducing, non-reducing and total sugar content of tomato at different days of storage.

Treatments Combinations	Reducing sugar (%)					Non-reducing sugar (%)					Total sugar (%)				
	DS	0	3	6	9	12	0	3	6	9	12	0	3	6	9	12
M_1T_1	2.39	2.96	3.42	3.61	3.83	0.90	1.20	1.42	1.23	0.900	3.29	4.16	4.84	4.84	4.73	
M_1T_2	2.39	2.99	3.44	3.63	3.85	0.92	1.20	1.40	1.23	0.833	3.31	4.19	4.84	4.86	4.69	
M_1T_3	2.38	3.03	3.48	3.67	3.88	0.91	1.24	1.40	1.25	0.900	3.29	4.27	4.88	4.92	4.78	
M_2T1	2.61	3.17	3.48	3.60	3.94	0.95	1.25	1.45	1.31	0.877	3.58	4.42	4.93	4.91	4.81	
M_2T_2	2.68	3.22	3.53	3.66	4.01	0.95	1.23	1.49	1.27	0.853	3.63	4.44	5.02	4.93	4.87	
M_2T_3	2.68	3.25	3.52	3.73	4.04	0.98	1.26	1.53	1.23	0.900	3.66	4.52	5.06	4.96	4.94	
M_3T_1	2.92	3.20	3.55	3.63	4.25	1.00	1.30	1.64	1.28	0.583	3.92	4.50	5.18	4.91	4.83	
M_3T_2	2.97	3.28	3.58	3.70	4.31	1.05	1.33	1.68	1.26	0.603	4.02	4.61	5.25	4.96	4.92	
M_3T_3	3.10	3.28	3.59	3.76	4.44	1.04	1.36	1.60	1.20	0.570	4.14	4.64	5.19	5.05	5.01	
LSD (0.05)	0.017	0.055	0.05	0.017	0.017	0.017	0.055	0.055	0.077	0.017	0.055	0.077	0.077	0.077	0.005	
LSD (0.01)	0.024	0.075	0.07	0.024	0.107	0.024	0.075	0.075	0.107	0.024	0.075	0.107	0.107	0.075	0.075	
CV (%)	0.81	0.80	1.09	0.46	0.96	2.23	3.00	1.57	3.52	1.56	0.95	1.05	0.97	0.87	0.76	

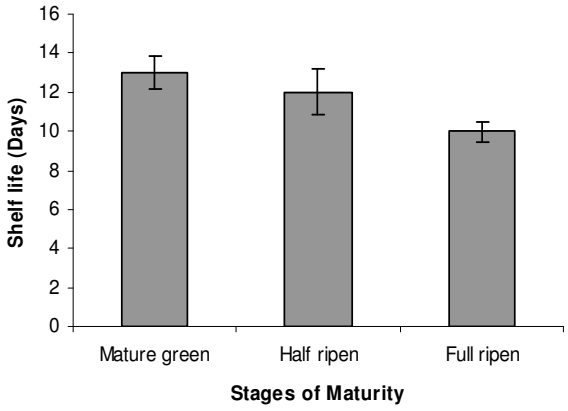

Fig 3. Shelf life of tomato influenced by different stages of fruit maturity.

sugar content (4.91 percent) was recorded in tomatoes under CaC_2^+ polythene covering treatment at twelfth day of storage followed by the covering with simple straw treatment (4.82 percent) and it was lowest in mature green tomato (4.72 percent) under control condition. The combined effect of stages of maturity and ripening conditions significantly affected the total sugar content of tomato during storage (Table 6). At twelfth day of storage the highest quantity of total sugar content (5.01 percent) was recorded in full ripen tomatoes under CaC_2^+ polythene covering treatment and lowest quantity of total sugar (4.69 percent) was recorded in mature green tomatoes under simple polythene covering treatment.

Discussion

In this study effect of maturity stages and storage conditions on the post harvest quality of tomato fruits was evaluated. Some factors, such as decay or rotting, sugar reduction percentage and total sugar, elevated with maturity. Similar improvements for decay or rotting, sugar reducition and total sugar, have been reported previously with maturity stage in Sapota Mamey fruit (Diaz-perez *et al.,* 2000). Maturity had the highest negative effects on the weight loss, shelf life and non-reducing sugar in green mature fruits resulting, the reduced quality parameter (Hossain *et al.,* 1996). The half ripen tomato has given the best result in the Vitamin C (12.21 mg/100g) and titrable acidity (0.463%) values. The vitamin C and titrable acidity content of tomato juice was increased with maturity stages and reached the peak and thereafter started to decreased (Sinaga 1986). It was found that pH value increased with the advancement of fruit ripening. The highest pH value was observed in mature green tomato followed by half ripe and full ripen tomato (Botrel *et al.,* 1993). The other factors such as total sugar and TSS were increased with the advancement of fruit ripening, irrespective to maturity condition (Tsuda *et al.,* 1999). Tsuda et al., (1999) stated that total sugar and TSS content of Mango fruits increased during the ripening period and storage. The increased in total sugar content might be due to conversion of starch into sugars.

The percentage of decay or rotting, weight loss, pH, titrable acidity, reducing sugar, and total sugar, were found to increase by the gradual advancement of

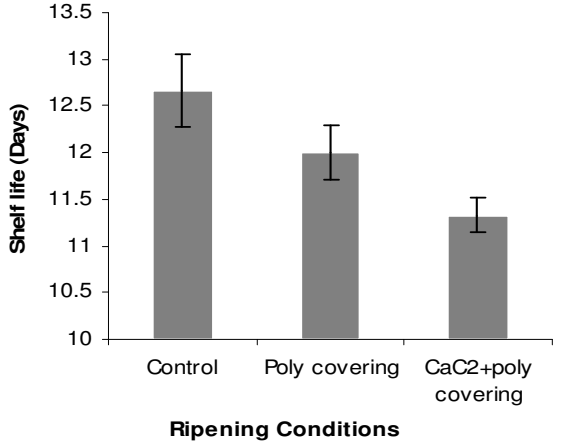

Fig 4. Shelf life of tomato as influenced by different storage conditions.

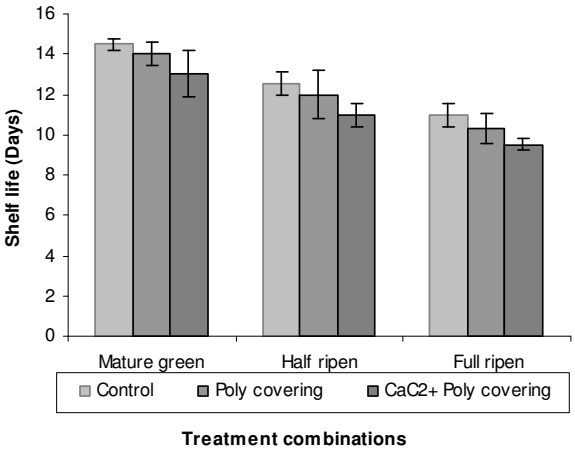

Fig 5. Shelf life of tomato as influenced by combined effects of stages of maturity and storage conditions.

time, irrespective to maturity stages while percentage of vitamin C and non reducing sugar to be decreased in the progressing time of storage (Mallic *et al.,*1996). The storage conditions also showed significant influence on different parameters studied.

The combined effect of maturity and storage conditions have also significantly influenced on physico-chemical characters of tomato during ripening. The full ripen tomato placed over CaC_2^+ and covered with polythene showed highest decay or rotting, titrable acidity, reducing sugar, non-reducing sugar and total sugar at the final day of observation (Winsor *et al.,* 1962). The mature green tomatoes kept in uncovered condition showed the lowest performances in respect to factors such as decay or rotting, vitamin C, titrable acidity, sugar reduction, non-reducing sugar and total sugar (Mallic *et al.,* 1996)

Conclusion

We suggest that tomato fruits can be harvested at mature green for long distance marketing and full ripen stage for fresh consumption. The mature green tomatoes should be kept under CaC_2^+ polythene covering for better early ripening and color development which maintains the best physico-chemical quality of fruit during storage to marketing.

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