

## Effect of Stages of Maturity and Ripening Conditions on the Physical Characteristics of Tomato

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**Abstract:** The study was carried out to undertake the effect of different stages of maturity and ripening conditions on the physical characteristics of tomato fruit during the process of ripening. Fruit of three maturity stages viz., mature green, half ripen and full ripen were kept under three ripening conditions viz., floor without covering(control), covering with straw and CaC<sub>2</sub>+straw covering. Data were taken on color development of fruit, firmness of tissue, decay or rotting percentage, weight loss percentage and Shelf life of tomato. Different maturity stages, ripening conditions and their combination showed highly significant variation in different physical characteristics of tomato were studied. The highest value of decay or rotting was shown by full ripen tomatoes. However, the highest weight loss and shelf life were found by mature green tomatoes. The percentage of decay or rotting and weight loss was increased with gradual advancement of time. The highest value of weight loss and shelf life were recorded in tomatoes of uncovered treatment and decay or rotting was recorded by CaC<sub>2</sub> + straw covering treatment. The values of all the parameter were increased gradually with the advancement of ripening process irrespective of different keeping conditions. The tomato was placed over CaC<sub>2</sub> and covered with straw has shown highest decay or rotting.

**Key words:** Maturity stage, ripening condition, physical character, tomato

### INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill) is one of the most universally known, widely consumable nutritious and widely grown vegetables in the world. It is native to the Peruvian and Mexican regions<sup>[12]</sup> and was introduced in the sub-continent during the British period. The crop is one of the most important and popular vegetables in Bangladesh with a considerable total production of 100 thousand tons produce in an area of 13000 hectares<sup>[3]</sup>.

Proper harvesting determines the nutrient contents as well as storage durability of any fruit. In all over the world, tomatoes are harvested at different maturity stages, such as green mature stage, half ripen stage and red ripen stage. In the process of ripening, chlorophyll is degraded and yellow orange carotenoid and red lycopene are synthesized. The synthesis of this pigment was light and temperature depended<sup>[10]</sup>. The fruit which are harvested green or half ripen stage were replaced by the growers under different ripening conditions for rapid color development and ripening. Due to highly perishable in nature, tomato fruits at this stage undergo serious losses, at this stage.

A predicted estimation that total losses in the developing countries could be nearly 30-40% of crop harvested and the losses occur through spoilage<sup>[1]</sup>. Apart from physical losses in quality, serious losses also occur in the essential nutrients, vitamins and mineral.

Color is an extremely important for tomato quality characteristic. For the consumer color is an important indicator of the eating quality. The color of tomato fruit depends on their lycopene content and B-carotene. Tomes<sup>[13]</sup> reported that carotenoid biosynthesis was very sensitive to temperature. He also stated that the development of lycopene during was inhibited at temperature greater than 30°C. Boe *et al.*<sup>[4]</sup> found that B-carotene and lycopene concentration increased as the fruit developed from mature grown to ripening stages. Firmness of tissue is one of the most important aspects of tomato fruit quality. It depends on the stages in fruit maturity. The number of locules per fruit depends on variety of tomato, manurial treatment and environmental factors. Garcia *et al.*<sup>[6]</sup> observed that CaC<sub>2</sub> treated fruit showed higher value of fresh firmness during storage but they also found that quicker development of red color, greater weight loss and

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higher soluble solids content in treated than in non treated fruit during shelf life. Tomato fruit firmness decrease during storage. Goojing *et al.*<sup>[7]</sup> reported that after 3 weeks of storage at 15-20°C the red ripen stage tomato fruit were found 78.2% rotting but only 47.5% fruit rotting was found in fruits harvested at the mature stage. Mallik *et al.*<sup>[11]</sup> reported that fruit of tomato (cv. roma VF) showed the lowest physiological weight loss 7.7-9.7% after 6 days of storage under ambient condition. They also stated that CaC<sub>2</sub> 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. There is a natural tendency for the perishable fruits and vegetables to degrade to the simpler inorganic compounds (CO<sub>2</sub>, H<sub>2</sub>O and NH<sub>3</sub>) through spontaneous biochemical reaction. This type of reaction loss of free energy and reduces the shelf life as well as other qualities of fruits and vegetable. Anju-Kumari *et al.*<sup>[2]</sup> reported that the shelf life for all tomato cultivars were longest with harvesting at the mature green stage (10.9-13.5). Dennis *et al.*<sup>[5]</sup> stated that it was possible to store green mature fruits cultivars (Sonata and Soatine) for up to 6 to 10 weeks at in control atmosphere storage (3% O<sub>2</sub>, 5% CO<sub>2</sub>, 92% N<sub>2</sub>) at 13°C and 93-95% RH. At room temperature tomato fruits could be stored up to 12 days. Improper stage of maturity, ripening conditions and lack of proper storage facilities cause a glut during the peak period of harvest and a large portion of fruits is sold at thrown away prices. The need to reduce post harvest losses is, therefore a paramount important. Suitable stages of fruit maturity and optimum ripening conditions for quality and longer storage of tomato has not yet been developed for developing countries like Bangladesh. No literatures are found regarding present research such as suitable stages of maturity and ripening conditions for quality assessment. Keeping all above facts in mind, the following objectives have been included in the research project such as, (1) to find the suitable stage of maturity, (2) to find the optimum ripening condition, (3) to assess the quality of fruit at different stages of maturity and at different ripening condition.

## MATERIALS AND METHODS

**Site:** The experimental site was in the field laboratory, Departments of Horticulture and of Biochemistry, Bangladesh Agricultural University, Mymensingh, Bangladesh.

**Plant material:** Freshly harvested tomato fruit of the variety Roma VF were collected from one contact

grower's field in the village Bagua under gaffargaon upazila in Mymensingh district. Fruit were transferred carefully to the BAU campus immediately after harvest.

**Physical condition of the storage room:** The average maximum and minimum temperature of the storage room was 30.70°C and 18.88°C. Relative humidity was 75%.

**Treatment setting:** The experiment comprised of two factors. Factor-stages of maturity of tomato fruits. Factor B-Ripening condition. The levels of factor A were-1) Matured green tomato (M<sub>1</sub>) 2) Half ripen tomatoes (M<sub>2</sub>), 3) Full ripen tomato (M<sub>3</sub>)

**The level of factor B were:-1) Control:** Uncovered condition (T1:30±3°C) 2). Covering with straw (T2:31±3°C) 3). Placing CaC<sub>2</sub> below tomato and then covered with straw (T3:31±3°C). Thus there were (3×3) treatment combinations.

**Design of experiment:** The experimental design was randomized Complete Block Design (RCBD) with three replications. One kg of uniform size tomato fruits were kept in each replication. The data were analyzed was performed by F-test and the significance of difference between pairs of treatment mean was evaluated by the Least Significant Difference (LSD) test, at 1% and 5% level of probability<sup>[15]</sup>

**Color development of fruit, Firmness of tissue, Decay or rotting (%), Weight loss (%) and shelf-life of tomato:**

**Color development of fruit:** The peel color of fruit was recorded by using a Minolta Chromometer Model CR 200<sup>[8]</sup>. Development of various spots on the peel of fruit; softening and rotting of fruit were also recorded.

**Firmness of tissue:** Firmness of tissue of tomato pulp was determined by finger pressure at 3 days interval. Firmness classes were identified as hard, slightly hard, medium hard, slightly soft, medium soft and soft.

**Decay or rotting (%):** Decay or rotting was determined by the visual observation. Development of various spots on the peel of fruits and softening and rotting of fruits were also recorded.

**Weight loss (%):** The Weight loss of tomato fruit sample was calculated by using the following formula:

$$\% \text{ Total weight loss of fruits} = \frac{\text{Initial weight} - \text{Final weight} \times 100}{\text{Initial weight}}$$

The weight losses of the same sample were recorded periodically during the storage period.

**Shelf life of tomato:** 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.

### RESULTS

**Color development of fruit:** Changes in color and development of spots on peel of tomato occurred during process of ripening of different types of matured fruit have been shown in Table 1.

It was found that matured green tomato under control condition required 15 days to become completely yellow (Fig. 7). Red color was not attained at all. But the half ripe tomato and full ripen tomato become red at 12 and 9 days respectively (Fig. 5 and Fig. 6). The tomatoes kept under straw covering received more temperature and there by obtaining ripening color so quickly. In this category, yellow color was developed in mature green tomatoes within 12 days while half ripen tomatoes showed red color by 9 and 6 days respectively (Fig. 4). On the other hand, mature green, half ripen and full ripen tomatoes provide with CaC<sub>2</sub>+straw covering showed the sign of ripening respectively by 12, 6 and 3 days, whenever it is compared with 1<sup>st</sup> day (Fig. 2 and Fig. 3). Over ripened fruits of either type was symptom zed by black spot showing the sign of spoilage (Fig. 7). The spoilage symptoms were more dominant in fruit of CaC<sub>2</sub>+straw covering possibly because of creation of high temperature inside covering and more ethylene production.

**Firmness of tissue:** Firmness is one of the most important aspects of tomato fruit quality. Firmness depends on the stages of tomato fruit maturity, the number of locules per tomato fruit, variety of tomato, manorial and environmental factors.

It was found that matured green tomato under normal condition required 15days to become soft. But the half ripen and full ripen tomato becomes soft at 12 and 9 days respectively. Tomatoes kept under straw covering mature green, half ripen and full ripen become soft 15, 12 and 6 days respectively. Half ripe and full ripe tomatoes provided with CaC<sub>2</sub>+straw covering showed the sign of soggy respectively by 12 and 9 days. Firmness decrease with advancement of time. Similar result was found by<sup>[9]</sup>.

**Decay or rotting (%):** Stages of maturity, ripening conditions and their combinations were found to have significant effect on decay or rotting (%) of tomatoes. Rotting in ripe tomatoes was found always higher during the entire period of storage. At the 3rd day of storage total rotting % was 8.19% that rose to 74.68% on 15th day of storage. On the other hand rotting% in mature green tomatoes being (0%) at 3rd day and 27.31% at 15 day of storage (Fig. 1). The decay or rotting (%) is higher in ripe tomato because of higher rate of respiration, more skin permeability for water loss and high susceptibility to decay organism of this type of fruit.

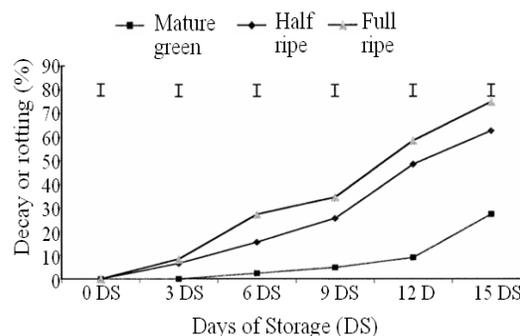


Fig. 1: Decay or rotting (%) of tomato at different days of storage shown by different stages of matured fruits. Vertical bars indicate LSD value at 5% level of significance

Table 1: Effect of maturity stages of fruits and ripening conditions on the changes in color development of tomato fruits during storage

Ripening conditions	Maturity stages	Day after storage					
		0	3	6	9	12	15
Uncovered	M. green	Green	Green	L. green	L. green	L. yellow	Yellow
	Half ripe	L. yellow	yellow	L. yellow	L. red	Red	Deep red
	Full ripe	Y. red	Y. red	L. red	Red	Red	Pale red
Straw covering	M. green	Green	Green	L. green	L. green	Yellow	Yellow
	Half ripe	L. yellow	Yellow	Yellow	Red	Red	Deep red
	Full ripe	Y. red	Y. red	Light red	Red	Deep red	Pale red
CaC <sub>2</sub> +sraw covering	M. green	Green	Green	L. green	L. gree	Yellow	Y. red
	Half ripe	L. yellow	Yellow	Red	Red	Red	Deep red
	Full ripe	Y. red	Y. red	Red	Red	Deep red	Pale red

M: Mature; L: Light; Y: Yellowish

Table2: Effects of maturity stages of fruit and ripening conditions on the changes in firmness of tissue of tomato fruits during storage

Ripening conditions	Maturity stages	Day after storage					
		0	3	6	9	12	15
Uncovered	M. green	Hard	m. hard	m. hard	m. hard	m. soft	Soft
	Half ripe	m. hard	s. soft	m. soft	m. soft	Soft	S. soggy
	Full ripe	s. soft	m. soft	m. soft	Soft	S. soggy	S. soggy
Straw covering	M. green	Hard	m. hard	m. hard	m. hard	M. soft	Soft
	Half ripe	m. hard	s. soft	s. soft	m. soft	Soft	S soggy
	Full ripe	s. soft	m. soft	Soft	Soft	s. soggy	S. soggy
CaC <sub>2</sub> +strw covering	M. green	Hard	m. hard	m. hard	m. hard	m. soft	Soft
	Half ripe	M. hard	S. soft	m. soft	M. soft	Soft	S. soggy
	Full ripe	S. soft	m. soft	Soft	Soft	S. soggy	S. soggy

M: Mature; m: Medium; s: Slightly; S: Soft



Fig. 2: Photograph showing color of tomato fruit of different stages of maturity on the 1st day of storage



Fig. 5: Photograph showing color of tomato fruit of different stages of maturity on the 9th day of storage



Fig. 3: Photograph showing color of tomato fruit of different stages of maturity on the 3rd day of storage



Fig. 6: Photograph showing color of tomato fruit of different stages of maturity on the 12th day of storage



Fig. 4: Photograph showing color of tomato fruit of different stages of maturity on the 6th day of storage



Fig. 7: Photograph showing color of tomato fruit of different stages of maturity on the 15th day of storage

The highest rotting of 57.38% was recorded in treatment of CaC<sub>2</sub>+straw covering at 15th day of storage. The rotting (%) of tomato under covering with straw and control treatment were 55.62 and 51.48%.

The full ripe tomatoes under CaC<sub>2</sub>+straw covering showed maximum rotting percentage of 80.03%, followed by half ripe tomatoes with straw covering 62.37% and the lowest of 28.43% mature green tomatoes placed under uncovered condition (Table 4).

Table 3: Main effect of ripening 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
CaC <sub>2</sub> +straw	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	0.00	0.263	0.263	5.042	0.806	00	0.03	0.00	0.063	0.07	0.055
LSD (0.01)	00	0.00	0.362	0.362	6.942	1.110	00	0.04	0.07	0.075	0.10	0.075

Table 4: Combined effect of stages of maturity and ripening conditions on the percent decay or rotting 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 <sub>1</sub> T <sub>1</sub>	0	0.000	0.000	0.000	9.130	28.430	0	6.320	10.300	11.750	13.62	15.48
M <sub>1</sub> T <sub>2</sub>	0	0.000	0.000	5.670	8.800	26.500	0	6.280	10.200	11.680	13.50	15.43
M <sub>1</sub> T <sub>3</sub>	0	0.000	6.830	8.670	8.900	27.000	0	6.230	10.150	11.650	13.42	15.43
M <sub>2</sub> T <sub>1</sub>	0	6.470	15.830	26.070	46.730	60.000	0	5.800	9.270	11.500	12.47	15.35
M <sub>2</sub> T <sub>2</sub>	0	6.520	15.330	25.370	45.350	62.370	0	5.830	9.180	11.450	12.10	15.25
M <sub>2</sub> T <sub>3</sub>	0	6.500	15.200	25.570	53.170	65.100	0	5.750	9.080	11.300	12.40	15.15
M <sub>3</sub> T <sub>1</sub>	0	8.300	27.200	35.000	46.700	66.000	0	5.780	8.600	11.280	12.15	15.22
M <sub>3</sub> T <sub>2</sub>	0	8.130	27.200	33.400	61.870	78.000	0	5.700	8.500	11.200	11.90	15.08
M <sub>3</sub> T <sub>3</sub>	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: M<sub>1</sub>: Mature green; M<sub>2</sub>: Half ripe; M<sub>3</sub>: Full ripe; DS: days of storage

Ripening condition: T<sub>1</sub>: Uncovered condition; T<sub>2</sub>: Covering with straw; T<sub>3</sub>: Treated with CaC<sub>2</sub>+ straw covering

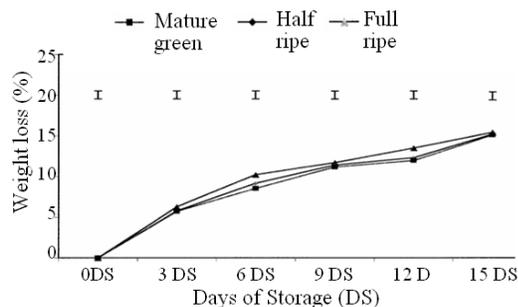


Fig. 8: Weight loss (%) of tomato at different days of storage shown by different stages of matured fruits. Vertical bars indicate LSD value at 5% level of significance

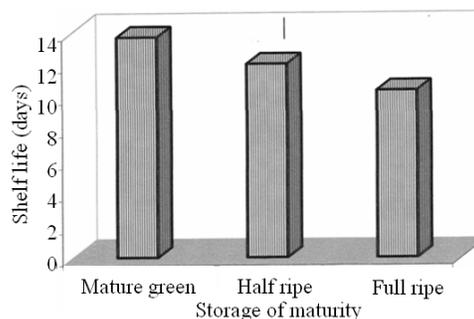


Fig. 9: Shelf life of tomato as influenced by fruit of different stages of maturity. Vertical bar indicates LSD value at 5% level of significance

The interaction effect of maturity stages and ripening conditions was found significant on decay or rotting % of tomato fruits.

**Weight loss (%):** Maturity Stages, ripening conditions and their combination effect were found to have significant effect on total loss in weight of fruit. Total weight loss in mature green tomatoes was always higher during the entire period of storage. At the 3rd day of storage, it was 6.28% that rose to 13.31% at 12th day. In full ripen tomatoes; weight loss was lowest, being 5.72% at 3rd day and 11.96% at 12th day of storage (Fig. 8). Weight loss in mature green tomatoes was higher because of higher rate of dehydration that generally happened in tender tissue.

**Shelf life of tomato:** It was recorded that mature green tomato had a higher storability than the half ripens followed by ripen tomatoes irrespective of their keeping condition. Figure 9 presented that the maximum shelf life (13 days), followed by half ripe tomato (12 days) and minimum was (10.33 days) for full ripen tomatoes. Similar result was also reported by<sup>[14]</sup>. Ripening condition also had significant effect on shelf life of tomatoes (Fig. 10). Control was recorded to give the longest life (12.67 days), followed by simple straw covering (12 days) and the lowest life was (11.33 days) was recorded by CaC<sub>2</sub>+ straw covering treatment.

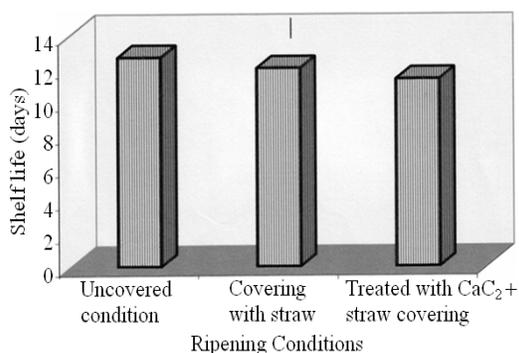


Fig. 10: Shelf life of tomato as influenced by different ripening conditions. Vertical bar indicates LSD value at 5% level of significance

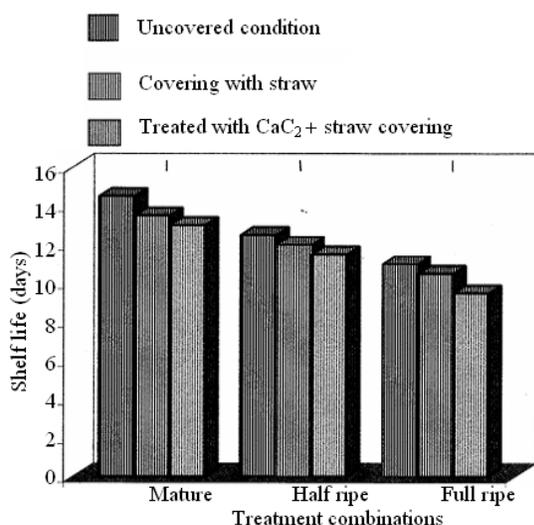


Fig. 11: Shelf life of tomato as influenced by combined effects of stages of fruit maturity and ripening conditions. Vertical bars indicate LSD value at 5% level of significance

The highest shelf life (14.50days) was observed in mature green tomatoes under the control condition, followed by treatment of half ripen tomatoes and control (12.50days), while it was found lowest (9.5days) in full ripen tomatoes under CaC<sub>2</sub>+straw covering treatment (Fig. 11).

### DISCUSSION

Different maturity stages, ripening conditions and their combination showed highly significant variation on different physical characteristics of tomatoes studied. The highest value of decay or rotting (74.68%)

were shown by full ripe tomatoes and highest weight loss (15.45%), shelf life (13.67days) by mature green tomatoes at final day observation (15 days of storage). On the contrary, the lowest values in weight loss (15.12%), shelf life were recorded in full ripe tomatoes and decay or rotting (27.31%) by mature green tomatoes. The percentages of decay or rotting and weight loss were found to increase with gradual advancement of time. The Ripening condition also showed significant influence on different parameters studied. The values of weight loss (15.35%) and shelf life (12.67) were recorded in tomatoes of uncovered treatment and decay or rotting (57.38%) were recorded by CaC<sub>2</sub>+straw covering treatment at final day of observation (15 or 12 days). On the contrary, the lowest value of decay or rotting (51.48%) were recorded by uncovered tomatoes and weight loss (15.21%) and shelf life (11.33days) were recorded by CaC<sub>2</sub>+straw covering. The values of all the above parameters were found to increase gradually with the advancement of ripening process irrespective of different keeping conditions. The combination effect of maturity and ripening conditions also influenced significantly different on physical character of tomato during ripening. The full ripen tomato placed over CaC<sub>2</sub> and covered with straw has shown highest decay or rotting (80.03%) and the mature green tomatoes kept in uncovered condition showed the lowest performances in decay or rotting (28.43%) at final day of observation.

### CONCLUSION

From the present study it may be concluded that maintaining physical quality of tomato during ripening and marketing, fruit should be harvested at mature green stage for long distance marketing and full ripen stage for fresh consumption and mature green tomatoes should be kept under CaC<sub>2</sub>+straw covering for early ripening and color development

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