**International Journal of Food Science and Nutrition**
**ISSN: 2455-4898; Impact Factor: RJIF 5.14**
**Received: 08-06-2020; Accepted: 22-06-2020; Published: 09-07-2020**
**www.foodsciencejournal.com**
**Volume 5; Issue 4; 2020; Page No. 36-42**

# Effect of maturity and ripening chemical treatment in post-harvest physiology of tomato

**Ashfak Ahmed Sabuz[1*], Md Hafizul Haque Khan[2], Mohammad Mainuddin Molla[3], Rahmatuzzaman Rana[4], Raju Ahmmed[5]**

[1] Scientific Officer, Postharvest Technology Division, Bangladesh Agricultural Research Institute, Gazipur, Bangladesh
[2] Chief Scientific Officer, Postharvest Technology Division, Bangladesh Agricultural Research Institute, Gazipur, Bangladesh
[3] Senior Scientific Officer, Postharvest Technology Division, Bangladesh Agricultural Research Institute, Gazipur, Bangladesh
[4] Assistant Professor, Food Engg. & Tea Technology, Shahjalal University of Science & Technology, Sylhet, Bangladesh
[5] Assistant Professor, Chemical & Food Engg., Dhaka University of Engg. & Technology, Gazipur, Bangladesh

**Abstract**
A study was carried out to compare the effect of maturity stage and ripening chemical treatment on physico-chemical changes during post-harvest ripening and processing of tomatoes. For this purpose chemically treated and untreated tomato fruits were harvested at different maturity stage (Mature green, Breaker, Pink) and changes in different physico-chemical properties (i.e. weight loss, TSS, pH, sugar content, vitamin C content, titratable acidity) were studied at 0, 3, 6, 9 days of storage under ambient conditions. Study revealed that highest cumulative weight loss (10.25%), moisture content (94.81%), pH (4.41), and TSS/titratable acidity(16.66) were obtained from the fruits of mature green stage, while the fruits of pink stage had the highest dry matter content (13.18%), TSS(6.05 $^0$B), titratable acidity (0.445%), reducing sugar (3.97%), non-reducing sugar(1.25%), total sugar (5.21%), and vitamin C content (25.60 mg/100gm). Increase in dry matter content (from 5.22% to 11.64%), TSS (from 5.16 to 5.60), titratable acidity (from 0.308% to 0.418%), reducing sugar (from 2.28% to 3.48%) were observed during storage. A decreasing trend in moisture content (from 94.80% to 88.50%), pH (from 4.58 to 4.25), TSS/titratable acidity (from 15.54 to 13.56) and vitamin C content (from 17.94mg/100g to 13.68 mg/100 g) was observed during storage. Untreated tomato (5.33) had higher TSS than treated (5.23) one. Reducing sugar was higher in untreated tomato (2.49%) than that of treated tomato (2.36%). Non-reducing sugar content was higher in untreated (0.901%) than treated tomato (0.886%). Vitamin C content was higher in untreated (17.94 mg/100g) tomato than the treated tomatoes (17.73mg/100g). Moisture content was higher in untreated tomatoes (94.09%) than that of treated tomatoes (93.96%) and dry matter content of untreated tomatoes (6.01%) was higher than that of treated tomatoes (5.84%).The study suggested that tomato fruits harvested at breaker stage may be suitable for fresh consumption and for long distance transportation.

**Keywords:** tomato, ripening, chemical, physico-chemical

## 1. Introduction
Tomato is one of the most popular and universally known nutritious vegetables of the world. In Bangladesh, 388725 metric tons of tomato grows in 68366 acres of land (BBS, 2017).

Tomato fruits are popular because of its high nutritive value and diversified use (Bose and Som, 1985) [3]. Its food value is very rich because of higher contents of vitamins A, B and C and calcium (Bose and Som, 1990) [3]. The food value of tomato is greatly dependent on its chemical composition, such as, dry matter, titratable acidity, total sugar, total soluble solid and ascorbic acid, which facilitates development of post-harvest quality, intrinsic quality such as flavor and taste, transportability and processing. Studies in United States indicated that flavor and taste of tomato is related to free sugars, organic acids and sugar acid ratio (Kader *et al.*, 1978) [7].

In Bangladesh, tomato is planted during October-November, and the crop becomes ready for harvest and marketing by January-March. Tomato fruits are consumed fresh or cooked. It adds variety of color and flavor to food. It is most popular as salad in the raw state and is made into soups, juice, ketchup, pickles, sauces, puree, paste, powder and other products (Bose and Som, 1985) [3].

At fresh condition the fruit possess short shelf life and deteriorate rapidly due to high perishable nature.

The post-harvest life of any fruit consists of ripening and chains of some physiological and chemical changes. The ripening and subsequent senescence is some total of a number of post-harvest physical and chemical changes. The prolonging of storage life of a fruit consists of slowing down the process leading to ripening, and if possible stopping the degradation and fermentation changes that causes senescence after ripening.

Indiscriminate use of pesticides and ripening chemical for producing agricultural commodities has been major concern now-a-days. Firstly, overdosing of this chemical creating tremendous health hazards. Secondly, huge amount of products are being demolished without proper investigation of the fact that to what extent it is harmful for human consumption.

In Bangladesh, effect of maturity and packaging technique on postharvest diseases and quality has been conducted by Molla *et al.* (2017) [13] but best of our knowledge, no study has been conducted to search the effect of maturity and ripening chemical treatment on post-harvest physiology of tomato Hence, it is necessary to understand the post-harvest changes of tomato in order to develop and apply adequate post-harvest technologies. Considering these facts the study was carried out in order to find out to assess the optimum maturity stage of tomato, to determine the physico-chemical changes in tomato associated with the maturity stage of

tomato during post-harvest ripening and storage and to compare the shelf-life of treated and untreated tomato.

## 2. Materials and methods

**2.1 Material:** Tomato (Local variety from farmer's field)

**2.2 Experimental Information:** The experiment was carried out in the laboratory of the Department of Food Technology and Rural Industries, Bangladesh Agricultural University, Mymensingh, during the period of October 2010 to March 2011.

The average temperature and relative humidity of the month of February'11 was 21. 55° C and 72.68% and that of March'11 were 24.50° C and 73.61%, respectively.

### 2.3 Treatments

**Factor A**

Mature green ($M_1$): The fruit is fully grown, the light green color at the blossom end has changed to yellow cast, the seeds are surrounded by locular jelly and the flesh is hard.

Breaker ($M_2$): One-fourth of the surface at the blossom end shows some pink color.

Pink ($M_3$): Half of the fruit surface is pink and the flesh is firm.

**Factor B**

Not treated with ripening chemical ($T_1$)

Treated with ripening chemical ($T_2$)

The experiment was set in Completely Randomized Design.

### 2.4 Methods of studying different parameters

#### 2.4.1 Change of color

Change in color of fruit over the storage period was determined with eye estimation**.**

#### 2.4.2 Cumulative weight loss

Tomato samples of each 500g weight stored in the laboratory in normal temperature and humidity. Weight loss of fruits on the 3rd, 6th, and 9th day was calculated by using the following formula:

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

Then cumulative weight loss in 6th and 9th day was calculated using the following formula:

Cumulative weight loss in 6th day = Weight loss in 3rd day + Weight loss in 6th day

Cumulative weight loss in 9th day = Weight loss in 3rd day + Weight loss in 6th day + Weight loss in 9th day

#### 2.4.3 Percentage Moisture content

The samples were taken in porcelain crucibles in triplicate and placed in an oven at 80°C for 12 hours until constant weight attained. Percent Moisture content was calculated according to the formula;

$$\% \text{ Moisture} = \{(W_1 - W_2)/W_1\} * 100$$

Where,

$W_1$= Initial weight of sample, $W_2$= Final weight of sample.

#### 2.4.4 Percentage Dry matter content

Percent dry matter content was calculated estimation using the formula: Percent dry matter = 100 -Percent moisture content.

#### 2.4.5. pH

The pH of the fruit was recorded by busing an electronic pH meter. The pH meter was standardized with a buffer solution as described by Ranganna (1994) [15].

#### 2.4.6 Total soluble solids (TSS)

Total soluble solid was estimated by using Abbes' Refractometer. A drop of sample of the tomato juice was placed on the prism of the Refractometer and percent total soluble solids were obtained from direct reading. Temperature correction was made by using the methods described by Ranganna (1994) [15].

#### 2.4.7 Titratable acidity

It was calculated using the methods described by Ranganna (1994) [15].

#### 2.4.8 Solid/acid ratio of fruit pulp

The TSS/ titratable acidity ratio of fruit pulp was calculated using the following formula:

$$\text{TSS/titratable acidity ratio of fruit pulp} = \frac{\text{Total soluble solid}}{\text{Titratable acidity}}$$

#### 2.4.9 Sugars

Sugar content of fruit was estimated by the following procedures and steps described by Lane and Eynon (1923) [10].

Non-reducing sugar was estimated by using the following formula;

% Non-reducing sugar = % Total invert sugar - % Reducing sugar

- Estimation of total sugar

% Total Sugar = % Reducing sugar + % Non- reducing sugar

#### 2.4.10 Vitamin C content

It was calculated using the methods described by Ranganna (1994) [15].

#### 2.4.11 Statistical analysis

The collected data were statistically analyzed by F- variance test. The pair comparisons were made by LSD test at 5% and 1% level of significance.

## 3. Results and discussion

### 3.1 Changes in physical characteristics of fruits

#### 3.1.1 Change in color

Changes in fruit color were observed both due to storage and harvesting stages. Mature green stage had green color, which changed to light yellow in color on 9 days of storage in both the sample. The breaker stage had the light-yellow color, which changed to deep red in both the sample (Table-1) after 9 days of storage. The deep red color was attractive. The pink stage had red fruits which changed to reddish black in both sample (Table-1) over the storage period. The reddish black color of full ripe tomato was not attractive. As the fruits were kept in room temperature their color rapidly changed. Room temperature might have a great role in changing the fruit color. Whitaker (1993) [17] found similar result with tomatoes stored in room temperature. Rahman

(2002) [3] reported that change of color were rather slow for tomatoes stored at refrigerated temperature compared to those at room temperature. Change in color in both samples followed same way.

### 3.1.2 Cumulative Weight loss

Treatment and stage of maturity of fruits and their combinations were found to have significant effect on cumulative weight loss of fruit. At the 3rd day of storage cumulative weight loss was 5.04% which increased to 10.25% on the 9th day of storage. The total cumulative weight loss was lowest in full ripe stage, being 3.12% at 3rd day of storage and 6.75 % at 9th day (Table-2). The cumulative weight loss in green fruit was higher probably because of higher rate of dehydration through a particular mechanism. Similar result was also reported by Kaynas and Surmeli (1994) [8]. Room temperature might have an important role on cumulative weight loss. Kaynas and Surmeli (1995) [9] reported increased weight loss with increasing temperature. Treatment also had significant effect on cumulative weight loss of fruits during storage. The highest cumulative weight loss was found in the treated tomato which was 9.75% on the 9th day of storage, in case of untreated tomato which was found to be 6.77% on the 9th day of storage (Table-3). Treated tomato had higher cumulative weight loss than untreated tomato.

There was significant variation among the combination of stage of maturity and treatment in cumulative weight loss of fruits. The highest cumulative weight loss was 14.21 % in treated and mature green stage on the 9th day of storage and the lowest cumulative weight loss was 6.02 % for untreated pink sample at 9th days of storage (Figure-1).

### 3.1.3 Moisture Content

Stage of maturity had significant effect on moisture content. Mature green stage had the highest moisture content (94.81%), while the fruits of pink stage had the lowest moisture content at the 9th day of storage (86.80) (Table-2). Pink stage lost higher moisture content than green and breaker stage.

### 3.1.4 Dry matter content (%)

Stage of maturity had significant effect on dry matter content (Table-2). Fruits of pink stage had the highest dry matter content (13.18%) on the 9th day of storage, where green stage had lowest moisture content (11.64%) on 9th days of storage. Dry matter content increased with increasing maturity and days of storage (Table-2).

Ripening chemical treatment had pretty small effect on dry matter content. Untreated tomato had relatively higher dry matter content than other one (Table-3).

The combination of stage of maturity and treatment had significant effect on dry matter content only on 6th and 9th days of storage (Figure-2).

## 3.2 Changes in chemical characteristics

### 3.2.1 pH

The stage of maturity had highly significant effect on change of pH of fruit. pH value was always higher in green stage than breaker and pink stage (Table-2). The highest pH value (4.58) was observed in green stage, followed by breaker (4.36) and pink stages (4.22) at 0th days of storage. The pH value decreased with time of storage and stage of maturity (Table-2). Similar result was also reported by Rahman (2002).

Chemical treatment had no significant effect on change of pH of tomato (Table-3).

The combined effect of stage of maturity and treatment had significant effect on the change of pH in tomato. The lowest value was observed in untreated tomato at mature green stage (Figure-2).

### 3.2.2 Total Soluble Solids (TSS)

Stage of maturity had significant effect on TSS of tomato fruit. Pink stage had higher TSS than breaker and green stage (Table-4). Similar result was also reported by kaynas and Surmeli (1994) [8]. The highest TSS (6.05) was observed in pink fruits on 9th day of storage and lowest TSS (5.60) was recorded in green fruits on same day. TSS content increased with days of storage and stage of maturity (Table-4). Rahman (2002) found similar results in both room and refrigerated condition.

Treatment had significant effect on TSS content up to 6th days of storage. Higher value (5.81) was obtained in untreated tomato on 9th day of storage and it was 5.75 for untreated sample. TSS increased with days of storage in both samples (Table-5).

The combined effect of treatment and stage of maturity had significant effect on TSS. The highest value was obtained (6.05) from untreated pink stage on 9th day of storage. The lowest TSS content (5.48) was obtained from treated breaker stage on that day (Figure-3).

### 3.2.3 Titratable acidity

Stage of maturity had significant effect on the titratable acidity (TA) content of tomato fruits. Pink stage had higher TA content than the other two stages. The highest TA content (0.445%) was obtained in pink stage on 9th day of the storage. The lowest TA content (0.308%) was obtained in the mature green stage (0.418) on that day. TA increased with increasing days of storage and with the maturity of tomato fruit (Table-4). Rahman (2002) also reported similar trend in both room and refrigerated condition.

The TA content (0.428%) was observed in untreated on the 6th day of storage and in case of treated sample it was 0.427% (Table5). Saimbhi *et al.* (1987) [16] also reported changes in TA content due to variation of treatment.

The combination of treatment and stage of maturity had significant effect on TA. The highest TA (0.446%) was found in treated at pink stage on the 9th day of storage. The lowest TA content (0.417%) was observed in treated tomato at mature green stage on the same day (Figure-3).

### 3.2.4 Reducing Sugar (%)

Stage of maturity had significant effect on reducing sugar content of tomato (Table-4). The highest reducing sugar content (3.97%) was observed in pink stage, whereas the lowest reducing sugar (3.48%) was observed in mature green stage at 9th days of storage. Reducing sugar content increased with increased days of storage and stage of maturity (Fig-19). Similar trend was also reported by Kaynas and Surmeli (1994) [9]; Islam *et. al.* (1995) [6]; Rahman (2002).

Chemical treatment had significant effect on reducing sugar content. Higher reducing sugar (3.65) was observed in the untreated tomato at the 9th day of storage (Table-5).

The combination of treatment and stage of maturity had significant effect on reducing sugar content (Figure-4).

Highest reducing sugar content (4.02%) was observed in untreated at pink on the 9th day of storage. Lowest RS content (3.41%) was observed in treated tomato of breaker stage on 9th days of storage.

### 3.2.5 Non- Reducing Sugar (%)

Stage of maturity had significant effect on non-reducing sugar content of tomato. The highest non-reducing sugar (1.26%) was observed in pink stage whereas the lowest non-reducing sugar (1.07%) was observed in mature green stage at 9th days of storage. Non-reducing sugar content increased with increasing days of storage and stage of maturity (Table-4). Similar trend was also reported by Rahman (2002).

Treatment had significant effect on non-reducing sugar content (Table-5). The highest non-reducing sugar (1.20%) was observed in untreated tomato at the 9th day of storage (Table-5).

The combination of treatment and stage of maturity had significant effect on non-reducing sugar content (Figure-4). The highest non-reducing sugar content (1.28%) was observed in untreated at pink stage on the 9th day of storage and that was only 1.01% in case of treated mature green tomato (Figure-4).

### 3.2.6 Solid/ acid ratio

Maturity stages had significant effect on TSS/titratable acidity. The highest TSS/ titratable acidity (16.66) was obtained in mature green stage whereas the lowest TSS/ titratable acidity (13.22) was obtained in pink stage (Table-6). The TSS/titratable acidity decreased with days of storage and decreased with maturity (Table-6).

Chemical treatment had significant effect on TSS/titratable acidity. Untreated tomato had higher TSS/ titratable acidity (15.54) than treated one (15.31) (Table-7).

The combination of treatment and stage of maturity had significant effect on TSS/ titratable acidity (Figure-5). The highest TSS/ titratable acidity (16.88) was observed in green stage of untreated tomato, and the lowest TSS/ titratable acidity (13.19) was observed in the pink stage of untreated tomato.

### 3.2.7 Vitamin C

Stage of maturity had significant effect on vitamin C content. Pink stage had the highest vitamin C content (25.60 mg/100g), while green stage had the lowest vitamin C content (8.62 mg/100g) (Table-6) initially. Vitamin C content decreased with increasing days of storage but increased with stage of maturity. Mallik and Biswajit (1996) [11]; Islam *et. al.*, (1996) [5] also observed similar results in different maturity stages of tomatoes.

Treatment had significant effect on vitamin C content. Untreated tomato had higher vitamin C content treated (Table-7). Matthews *et al.*, (1973) [12] and Dod and Kale (1997) [4] also reported difference in vitamin C content due to variation.

The combination of treatment and stage of maturity had significant effect on vitamin C content. Untreated tomato at pink stage had the highest vitamin C content (20.72 mg/100g), and the lowest vitamin C was found in treated at mature green stage (5.18mg/100g) at 9th days of storage (Figure-5).

## 4. Tables and Figures

**Table 1:** Color change of treated and untreated tomato harvested at different maturity & stored in ambient conditions

| Days of storage | Maturity stage | Color Development | |
|---|---|---|---|
| | | Treated | Untreated |
| 0 | Mature green | Green | Dark Green |
| | Breaker | Light Yellow | Light Yellow |
| | Pink | Red | Red |
| 3 | Mature green | Green | Green |
| | Breaker | Light Red | Light Red |
| | Pink | Red | Red |
| 6 | Mature green | Light Green | Light Green |
| | Breaker | Red | Red |
| | Pink | Deep Red | Deep Red |
| 9 | Mature green | Light Yellow | Light yellow |
| | Breaker | Deep Red | Deep Red |
| | Pink | Reddish Black | Reddish Black |

**Table 2:** Effect of stage of maturity on % cumulative weight loss, % moisture content, dry matter and pH of tomato fruits during storage

| Stage of maturity | % Cumulative weight loss | | | | % Moisture content | | | | % Dry matter content | | | | pH | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Days of storage | | | | | | | | | | | | | | | |
| | 0 | 3 | 6 | 9 | 0 | 3 | 6 | 9 | 0 | 3 | 6 | 9 | 0 | 3 | 6 | 9 |
| M1 | - | 5.04 | 7.96 | 10.25 | 94.81 | 93.66 | 92.06 | 88.36 | 5.22 | 6.34 | 7.94 | 11.64 | 4.58 | 4.32 | 4.29 | 4.25 |
| M2 | - | 3.60 | 5.32 | 7.23 | 94.06 | 92.69 | 90.74 | 87.78 | 5.94 | 7.31 | 9.27 | 12.22 | 4.36 | 4.27 | 4.21 | 4.13 |
| M3 | - | 3.12 | 4.93 | 6.75 | 93.24 | 91.63 | 89.16 | 86.80 | 6.76 | 8.37 | 10.84 | 13.18 | 4.22 | 4.18 | 4.17 | 4.13 |
| LSD (0.05) | - | 0.749 | 1.052 | 1.279 | - | 1.261 | 1.749 | 0.704 | - | 1.261 | 1.749 | 0.704 | 0.047 | 0.047 | 0.033 | 0.033 |
| LSD (0.01) | - | 1.027 | 1.455 | 1.768 | - | - | 2.396 | 0.964 | - | - | 2.396 | 0.964 | 0.064 | 0.064 | 0.046 | 0.046 |
| CV (%) | - | 18.29 | 16.28 | 14.55 | 1.77 | 1.30 | 1.84 | 0.76 | 27.89 | 16.37 | 17.81 | 5.42 | 0.90 | 0.91 | 0.58 | 0.88 |

M1= Mature green, M2= Breaker, M3= Pink

**Table 3:** Effect of treatment on the changes in cumulative weight loss and % moisture content, % dry matter content and pH of tomato fruits during storage

| Treatment | % Cumulative weight loss | | | | % Moisture content | | | | % Dry matter content | | | | pH | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Days of storage | | | | | | | | | | | | | | | |
| | 0 | 3 | 6 | 9 | 0 | 3 | 6 | 9 | 0 | 3 | 6 | 9 | 0 | 3 | 6 | 9 |
| $T_1$ | - | 3.12 | 4.95 | 6.77 | 94.09 | 92.81 | 90.73 | 87.78 | 6.01 | 7.49 | 9.47 | 12.48 | 4.41 | 4.25 | 4.26 | 4.17 |
| $T_2$ | | 4.66 | 7.19 | 9.75 | 93.96 | 92.51 | 90.57 | 87.52 | 5.84 | 7.19 | 9.23 | 12.22 | 4.37 | 4.26 | 4.21 | 4.17 |
| LSD | | 0.838 | 0.405 | 0.499 | - | - | - | - | - | - | - | - | - | - | - | - |
| CV (%) | | 18.29 | 16.28 | 14.55 | 1.77 | 1.30 | 1.84 | 0.76 | 27.89 | 16.37 | 17.81 | 5.42 | 0.90 | 0.91 | 0.58 | 0.88 |

$T_1$= Untreated, $T_2$= Treated.

**Table 4:** Effect of stage of maturity on change of TSS, titratable acidity, % Reducing sugar and % Non-reducing sugar content of tomato fruits during storage

| Stage of maturity | TSS | | | | % Titratable acidity | | | | % Reducing sugar | | | | % Non-reducing sugar | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Days of storage | | | | | | | | | | | | | | | |
| | 0 | 3 | 6 | 9 | 0 | 3 | 6 | 9 | 0 | 3 | 6 | 9 | 0 | 3 | 6 | 9 |
| $M_1$ | 5.16 | 5.30 | 5.44 | 5.60 | 0.308 | 0.348 | 0.401 | 0.418 | 2.28 | 2.74 | 3.07 | 3.48 | 0.850 | 0.926 | 0.98 | 1.07 |
| $M_2$ | 5.25 | 5.44 | 5.59 | 5.71 | 0.320 | 0.381 | 0.405 | 0.420 | 2.48 | 3.00 | 3.31 | 3.42 | 0.905 | 0.974 | 1.03 | 1.15 |
| $M_3$ | 5.45 | 5.64 | 5.87 | 6.05 | 0.412 | 0.422 | 0.421 | 0.445 | 2.51 | 2.81 | 3.22 | 3.97 | 0.915 | 0.947 | 0.98 | 1.26 |
| LSD (0.05) | 0.074 | 0.081 | 0.081 | 0.074 | 0.011 | 0.011 | - | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 | 0.011 |
| LSD (0.01) | 0.102 | 0.112 | 0.112 | 0.102 | 0.014 | 0.014 | - | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 | 0.014 |
| CV (%) | 1.39 | 1.37 | 1.33 | 1.24 | 0.28 | 0.25 | 5.01 | 0.27 | 0.44 | 0.45 | 0.40 | 0.31 | 1.10 | 0.93 | 0.76 | 0.84 |

$M_1$= Mature green, $M_2$= Breaker, $M_3$= Pink.

**Table 5:** Effect of treatment on changes in TSS, titratable acidity, % Reducing sugar and % Non-reducing sugar content of tomato fruits during storage

| Treatment | TSS | | | | % Titratable acidity | | | | % Reducing sugar | | | | % Non-reducing sugar | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Days of storage | | | | | | | | | | | | | | | |
| | 0 | 3 | 6 | 9 | 0 | 3 | 6 | 9 | 0 | 3 | 6 | 9 | 0 | 3 | 6 | 9 |
| $T_1$ | 5.33 | 5.50 | 5.65 | 5.81 | 0.348 | 0.384 | 0.405 | 0.428 | 2.49 | 2.90 | 3.26 | 3.65 | 0.901 | 0.958 | 1.001 | 1.20 |
| $T_2$ | 5.23 | 5.42 | 5.55 | 5.75 | 0.346 | 0.383 | 0.413 | 0.427 | 2.36 | 2.79 | 3.15 | 3.60 | 0.886 | 0.940 | 0.99 | 1.11 |
| LSD | 0.083 | - | 0.091 | - | 0.012 | 0.012 | - | 0.012 | 0.12 | 0.01 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 | 0.012 |
| CV (%) | 1.39 | 1.37 | 1.33 | 1.24 | 0.28 | 0.25 | 5.01 | 0.27 | 0.44 | 0.45 | 0.40 | 0.31 | 1.10 | 0.93 | 0.76 | 0.84 |

$T_1$= Untreated, $T_2$= Treated.

**Table 6:** Effect of stage of maturity on change of TSS/titratable acidity and vitamin C content of tomato fruits during storage

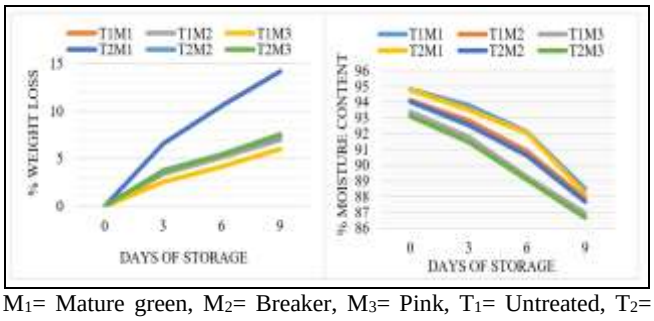
| Stage of maturity | TSS/Titratable acidity | | | | Vitamin C content (mg/100g) | | | |
|---|---|---|---|---|---|---|---|---|
| | Days of storage | | | | | | | |
| | 0 | 3 | 6 | 9 | 0 | 3 | 6 | 9 |
| $M_1$ | 16.66 | 15.22 | 13.56 | 13.39 | 8.62 | 7.72 | 6.78 | 5.19 |
| $M_2$ | 16.41 | 14.28 | 13.78 | 13.60 | 19.29 | 17.17 | 16.41 | 15.06 |
| $M_3$ | 13.22 | 13.36 | 13.83 | 13.56 | 25.60 | 24.22 | 22.39 | 20.67 |
| LSD (0.05) | 0.213 | 0.210 | - | 0.166 | 0.011 | 0.011 | 0.011 | 0.424 |
| LSD (0.01) | 0.291 | 0.288 | - | - | 0.014 | 0.014 | 0.014 | 0.581 |
| CV (%) | 1.31 | 1.40 | 6.02 | 1.16 | 0.07 | 0.10 | 0.12 | 2.96 |

$M_1$= Mature green, $M_2$= Breaker, $M_3$= Pink.

**Table 7:** Effect of treatment on changes of TSS/titratable acidity and vitamin C content of tomato fruits during storage.

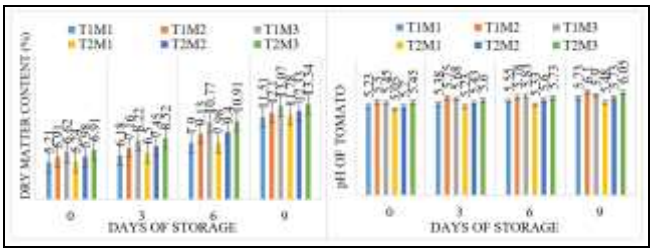
| Treatment | TSS/titratable acidity | | | | Vitamin C content (mg/100g) | | | |
|---|---|---|---|---|---|---|---|---|
| | Days of storage | | | | | | | |
| | 0 | 3 | 6 | 9 | 0 | 3 | 6 | 9 |
| $T_1$ | 15.54 | 14.37 | 14.0 | 13.56 | 17.94 | 16.51 | 15.33 | 13.68 |
| $T_2$ | 15.31 | 14.20 | 13.45 | 13.47 | 17.73 | 16.23 | 15.06 | 13.60 |
| LSD (0.05) | 0.174 | 0.172 | - | - | - | - | - | - |
| LSD (0.01) | - | - | - | - | 0.012 | 0.012 | 0.012 | - |
| CV (%) | 1.31 | 1.40 | 6.02 | 1.16 | 0.07 | 0.10 | 0.12 | 2.96 |

$T_1$= Untreated and $T_2$= Treated.



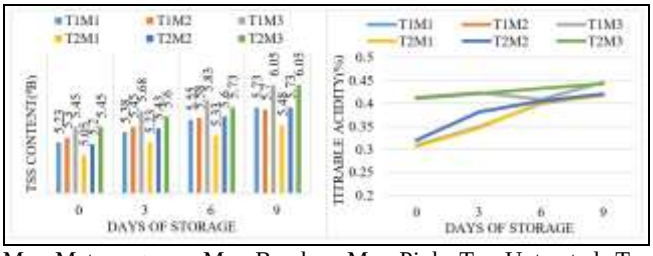

$M_1$= Mature green, $M_2$= Breaker, $M_3$= Pink, $T_1$= Untreated, $T_2$= Treated.

**Fig 1:** Combined effect of maturity stage and treatment on weight loss and moisture content



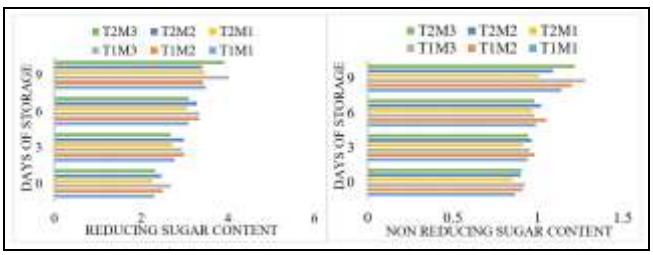

$M_1$= Mature green, $M_2$= Breaker, $M_3$= Pink, $T_1$= Untreated, $T_2$= Treated.

**Fig 2:** Combined effect of maturity stage and treatment on dry matter content and pH



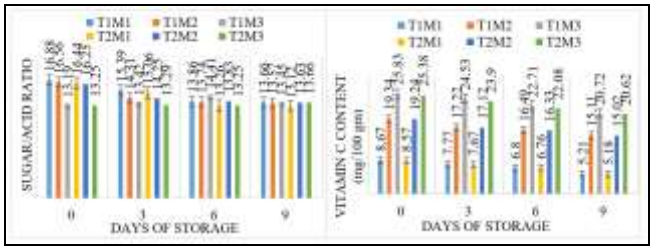

$M_1$= Mature green, $M_2$= Breaker, $M_3$= Pink, $T_1$= Untreated, $T_2$= Treated.

**Fig 3:** Combined effect of maturity stage and treatment on TSS and titratable acidity




$M_1$= Mature green, $M_2$= Breaker, $M_3$= Pink, $T_1$= Untreated, $T_2$= Treated.

**Fig 4:** Combined effect of maturity stage and treatment on reducing and non-reducing sugar content




$M_1$= Mature green, $M_2$= Breaker, $M_3$= Pink, $T_1$= Untreated, $T_2$= Treated.

**Fig 5:** Combined effect of maturity stage and treatment on solid/acid ratio and vitamin C content

## 5. Conclusion

Different maturity stages and treatment had significant effect on cumulative weight loss. The highest cumulative weight loss (14.21%) was observed in mature green stage of treated tomato on 9th day, followed by mature green stage (10.56 %) of treated tomato. Treated tomato had higher weight loss than untreated tomato under the same storage condition.

Maturity stages had significant effect on moisture content. Mature green stage had the highest moisture content (94.81%), while pink fruit had the minimum (86.80). The stage of maturity had significant effect on dry matter content. The highest dry matter content (13.18%) was observed in pink stage fruits. On the other hand, green fruits had the lowest dry matter content (5.22 %). Between the untreated higher dry matters content (12.48 %) was observed in treated tomato.

Stage of maturity had significant effect on pH. The highest pH value (4.58) was observed in green stage, while the pink stage had the lowest pH value (4.13). Pink stage had the highest TSS content (6.05), while the green stage had the lowest (5.14).

Stage of maturity and treatment had significant effect on titratable acidity (TA). The highest TA (0.445 %) was observed in pink stage, while the green stage had the lowest TA (0.308 %). Titratable acidity increased with maturity. Stage of maturity and treatment had significant effect on TSS/ titratable acidity. The highest TSS/TA (16.66) was observed in green stage, while the pink stage had the lowest TSS/ TA (13.22).

Stage of maturity and treatment had significant effect on reducing sugar content. Pink stage had the highest reducing sugar (3.97 %), while the green stage had lowest (2.28 %) reducing sugar content. Stage of maturity and treatment had significant effect on non-reducing sugar. Pink stage had the highest non-reducing sugar (1.25 %), while green stage had the lowest (0.860 %). Untreated tomato had higher amount of non-reducing sugar than treated tomato.

Stage of maturity and treatment had significant effect on total sugar content. The pink stage had the highest amount of total sugar (5.21 %), while the green stage had the lowest total sugar (3.14%). Stage of maturity and treatment had significant effect on vitamin C content. The pink stage had the highest vitamin C (24.22 mg/ 100g), while the green stage had the lowest vitamin C content (8.62 mg/100g).

It may be concluded that significant variation existed among the fruits of different maturity stages in respect of the quality parameters studied. Ripening chemical treatment also had significant variation in respect of some quality parameters. Fresh fruits at pink stage appeared to be the best for immediate consumption. Harvesting at breaker may be appropriate for storage and long-distance transport.

## 6. Acknowledgements

The authors wish to acknowledge “Technology dissemation for value addition to horticultural produces by poor farmers to improve their livelihood” project funded by DANIDA for their financial support. The authors wish to express their gratitude towards Supervisor, Professor Dr.M. Burhan Uddin, and Co-Supervisor, Professor Dr. Shams-Ud-Din, Department of FTRI, BAU, Mymensingh for their invaluable guidance and suggestions complete research work and writing up the thesis for the degree of Master of Science (MS) in Food Engineering.

## 7. Reference

1. BBS. Yearbook of Agricultural Statistics of Bangladesh. Bangladesh Bureau of Statistics, Statistics Division, Ministry of Planning, Govt. of the Peoples Republic Bangladesh, Dhaka, 2017.
2. Bose TK. Fruits of India Tropical and Subtropical. Naya Prokash.206, Bidhansarani, Calcutta 700000. India, 1985, p.75.
3. Bose TK, Som MG. Vegetables Crops in India. Naya Prokash, Calcutta, India, 1990, 249 p.
4. Dod VN, Kale PB. Performance of some tomato varieties under v1darbha conditions. PKV Res. J. 1997; 21(2):201-203.
5. Islam MS, Matsui T, Yoshida Y. Physical, chemical and physiological changes in storage tomatoes under various temperature. Technical Bulletin of the Faculty of Agriculture. Kagwa University. 1996; 48(1):7-16.
6. Islam MS, Matsui T, Yoshida Y. Effect of post-harvest carbon dioxide enrichment on the post-harvest quality of tomatoes. J Jap. Soc. Hort. Sci. 1995; 64(3):649-655.
7. Kader AA, Monis LL, Stevens LL, Albright M. Composition and flavor quality of fresh market tomatoes as influenced by some post-harvest handling procedures. J Amer. Soc. Hort. Ski. 1978; 103(1):6-13.
8. Kaynas K, Surmeli H. Characteristic changes at various ripening stage of tomato fruits stored at different temperatures. Turkish J Agril. Fores. 1995; 19(4):227-285.
9. Kaynas K, Surmeli H. Changes in chemical composition and respiration patterns of some tomato varieties at different ripening stages. Turkish J Agril. Fores. 1994; 18(1):71-79.
10. Lane JH, Eynon L. Methods for determination of reducing and non-reducing sugars. J Soc. Chem. Ind. 1923; 42(2):32-37.
11. Mallik SC, Biswajit B. Effect of storage at harvest on storage life and quality of tomato. Envir. Ecology. 1996; 14(2):301-303.
12. Matthews RAF, Crill P, Burgis DS. Ascorbic acid content of tomato varieties. Proc. Florida State Hort. Soc, 1973; 858:242-245.
13. Molla MM, Rahman E, Khatun A, Islam MF, Uddin MJ, Ullah MA, *et al*. Color retention and extension of shelf life of Litchi fruit in response to storage and packaging technique. American Journal of Food Technology, 2017; 12:322-331.
14. Rahman MA. Studies on the physico-chemical and storage qualities of tomato (Lycopersicon esculentum) and tomato ketchup. MS Thesis. Dept. Food Tech. and Rural Indus., BAU, Mymensingh, Bangladesh, 2002.

15. Ranganna S. Manual of anlysis of fruit and vegetable products. Tata McGraw-Hill Publishing Company Limited, New Delhi, 1994, 1112p.
16. Saimbhi MS, Mahaian R, Singh S, Gill BS. Physico-chemical constituents of some root-knot nematode resistant tomato lines and varieties for processing. J Res. Punjub Agril. Univ, 1987; 24:229-238.
17. Whitaker BD. A reassessment of heat stress as a mean of reducing chilling injury in tomato fruits. Acta Hort. 1993; 34(3):281-280.