

Research Article

# Effect of Preharvest Application of Alginate Oligosaccharides on Postharvest Quality and Shelf Life of Tomato

Prianka Howlader , Santosh Kumar Bose\* 

Department of Horticulture, Patuakhali Science and Technology University (PSTU), Patuakhali, Bangladesh

## Abstract

Alginate oligosaccharide (AOS) is a water-soluble non-toxic compound and act as plant biostimulator. In order to know the preharvest spraying effect of AOS on postharvest quality and shelf life of tomato, an experiment was conducted. Two varieties of tomato namely Roma VF and BARI tomato 14, and different preharvest treatments viz., control, AOS 25 mg/L, AOS 50 mg/L, AOS 100 mg/L and AOS 250 mg/L were used for this study. The field experiment was carried out in a Randomized Complete Block Design (RCBD) and Lab experiment will be conducted in a Completely Randomized Design (CRD) with three replications. Results displayed that most of the studied parameters were significantly influenced by the varieties and preharvest application of AOS. The maximum number of fruits per plant (67.0), fruit weight per plot (1.67 kg) and yield (75.55 t/ha) were obtained from BARI tomato 14 when treated with AOS 100 mg/L. AOS 100 mg/L treated BARI tomato 14 fruits showed minimum weight loss (9.02%) during storage, while untreated Roma VF tomato fruits exhibited maximum weight loss (10.42%). The maximum firmness (4.407) and titratable acidity (0.048%) was recorded from BARI tomato 14 when treated with AOS 100 mg/L whereas the highest total sugar (4.89), vitamin C content (17.90 mg 100 g<sup>-1</sup>) and shelf life (9.40 days) were recorded from the combined effect of 'Roma VF' variety treated by AOS 100 mg/L. The lowest percentage of disease incidence (9.11%) and disease severity (66.51%) were also found in Roma VF tomato' treated by AOS 100 mg/L. The findings of this study suggests that pre-harvest application of AOS is very useful for increasing yield, enhancing quality and shelf life of tomato.

## Keywords

Alginate Oligosaccharide, Tomato, Postharvest Quality, Shelf Life

## 1. Introduction

Tomato (*Solanum lycopersicum* L.) is the second most important horticultural product and globally one of the most widely consumed vegetables. Its vibrant color, unique flavor and versatility in culinary uses make an important part of diets in many countries and cultures [1]. The nutritional importance

of tomatoes is largely described by their numerous health-promoting substances, including vitamins, carotenoids, and phenolic substances [2]. Tomatoes are an excellent source of vitamins, minerals, and bioactive compounds which contribute to human health. They are particularly rich in vitamin

\*Corresponding author: [santosh@pstu.ac.bd](mailto:santosh@pstu.ac.bd) (Santosh Kumar Bose)

Received: 22 March 2025; Accepted: 31 March 2025; Published: 27 April 2025



Copyright: © The Author(s), 2025. Published by Science Publishing Group. This is an **Open Access** article, distributed under the terms of the Creative Commons Attribution 4.0 License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution and reproduction in any medium, provided the original work is properly cited.

C, with an average of 18-22 Mg per 100 grams, which supports immune function and collagen synthesis. Recent findings revealed that tomatoes as a remarkable source of lycopene, *b*-carotene, and lutein which are responsible for tomatoes' color and associated with declining the risk of certain cancers, cardiovascular and eye diseases [3, 4]. Economically, tomatoes are a significant cash crop for many countries, providing livelihood opportunities for millions of farmers and contributing to national economies. The adaptability of tomatoes to various climatic conditions, from temperate to tropical regions, has made them a global crop [5]. Technological advancements in tomato breeding have led to the development of high-yielding and disease-resistant varieties, further enhancing their economic and nutritional importance [6]. The demand for organic and sustainably grown tomatoes has also increased due to growing consumer awareness of health and environmental concerns [7]. Research efforts have been made to enhance the tomato production to some extent but till to date no such technologies developed to reduce postharvest loss as a result gaining of maximum profit are far beyond from expectation. The purpose of obtaining maximum benefit will be served only if the increased production is supplemented with similar efforts to reduce the post-harvest losses and prolong the shelf life. The changes of physico-chemical quality of fruits during storage can be affected by both preharvest and postharvest management practices. Due to the consumers concerns about the detrimental effects of synthetic fungicides on environment and human health, it is prime need to search new alternatives. To enhance the shelf life and maintain the quality of agro products, preharvest spraying of agro-chemical substances such as chitosan, salicylic acid and related substances can be considered [8]. Inadequate postharvest infrastructure, particularly in developing regions, exacerbates these problems. The lack of proper cold chain systems, inefficient packaging, and poor handling practices leads to significant quality deterioration and post-harvest losses [9]. The adoption of low-cost preservation technologies, such as natural coatings using chitosan, has shown great potential in minimizing these losses and maintaining postharvest quality [10]. Addressing postharvest challenges with technological innovations and improved storage practices is crucial for improving the economic and nutritional value of tomatoes. Tomato fruit exhibits very short storage life mainly because of their proneness to various pathogens and mechanical injuries which can quickly reduce the quality during storage [11]. Lack of proper postharvest management causes huge economic loss, increase poverty, hunger and malnutrition. To reduce postharvest losses, globally different postharvest technologies and synthetic chemical treatments are extensively used, but most of them are claimed to enhance the risk for human health and environment. Globally, consumers preference are more natural, eco-friendly processed products with minimum changes in their fresh characteristics with high nutritional quality and longer shelf life. Recently, oligosaccharides have attracted much consid-

eration because of their various health benefits, and conceivable applications in agriculture [12]. Alginate oligosaccharides (AOS), a low molecular weight fragments obtained through hydrolysis of alginate extracted from brown sea algae. AOS is an eco-friendly water-soluble non-toxic plant biostimulator which can accelerate plant development and work against plant diseases and had potential preservative effects during storage of fruits [13]. Therefore, above discussion indicate that, as a nontoxic, biocompatible, biodegradable and water-soluble product from natural sources, AOS might be a promising alternative to synthetic chemicals for increasing production as well as preserving fruit quality and enhance shelf life of tomato.

## 2. Materials and Methods

### 2.1. Study Location and Treatment Selection

The experiment was conducted at the research field and Postharvest laboratory, Department of Horticulture, Patuakhali Science and Technology University, Bangladesh during July 2022 to June 2023. Two-factor experiment with ten treatment combinations consisted of two varieties of tomato viz., Roma VF and BARI Tomato 14; and four different levels of AOS (T<sub>1</sub>: 25ppm, T<sub>2</sub>: 50ppm, T<sub>3</sub>: 100ppm, T<sub>4</sub>: 250ppm) with control (T<sub>0</sub>) were used. The field experiment was carried out in a Randomized Complete Block Design (RCBD) and Lab experiment was conducted in a Completely Randomized Design (CRD) with three replications. The total experimental plot was divided into 3 blocks each containing 10-unit plots. In total, there were 30-unit plots. To prepare 25ppm AOS, 25mg AOS powder was dissolved into 1000 ml water. Same procedures were followed in case of 50, 100 and 250ppm AOS preparation. The selected treatments were randomly assigned to each unit plot two times; first spray was done when tomato fruits become marble size and 2<sup>nd</sup> spray was done when fruit become fully mature and turn into yellowish color.

### 2.2. Observation

When fruits turn yellow to red color were collected from plant and immediately transfer to the postharvest lab of the department of horticulture. During the storage period, the fruits used for experiment were keenly observed and data was recorded on physico-chemical changes at 2, 4, 6, and 8 days after storage.

### 2.3. Parameters Studied

#### 2.3.1. Number of Fruits and Weight of Fruits per Plant

Total number of mature fruits were calculated by counting at 60, 90 and 110 DAT and the mean value was expressed as

number for data analysis. During each fruit harvesting, the weight of individual fruit was measured up to final harvesting and total weight was calculated to get fruit weight per plant.

### 2.3.2. Fruit Yield per Hectare

Total yield of each plot was measured and then it was converted into ton per hectare.

### 2.3.3. Determination of Fruit Firmness and Total Weight Loss (%)

Tomato fruit firmness was measured by using a penetrometer with a cylindrical probe of 5 mm which was penetrated from three points of equatorial region of fruit. Firmness of each fruit was calculated as means of three measurements and the force required for penetration in fruit was noted in Newtons (N).

Weight loss of tomato fruit was determined by using following formula.

$$\text{Titrateable acidity (\%)} = \frac{\text{Titre} \times \text{Normality of NaOH} \times \text{Volume made up} \times \text{Equivalent weight of acid}}{\text{Volume of sample taken} \times \text{Weight of sample taken} \times 1000} \times 100$$

### 2.3.5. Total Sugar

Sugar content of fruit was estimated by the following procedures described by [14].

#### (i). Standardization of Fehling's Solution

Ten milliliter of previously mixed Fehling's solution A and Fehling's solution B was taken in a 250 ml conical flask and 25 ml distilled water was added to it. Thereafter mixed solution containing conical flask was heated on a hot plate. When the solution started to boil, three drops of methylene blue indicator solution was added to it without removing the flask from the hot plate. Subsequently mixed solution was titrated by standard sugar solution. The end point was indicated by decolorization of the indicator. Fehling's factor was calculated by using the following formula:

$$\text{Fehling's Factor (g of invert sugar)} = \frac{\text{Titre} \times 2.5}{1000}$$

#### (ii). Preparation of Sample

Tomato fruit juice (50 ml) was taken and mixed with 100 ml of distilled water and 5 ml of neutral lead acetate solution. The mixed solution was then kept for 10 minute and was homogenized. Then homogenized material was taken in a 250 ml volumetric flask and the volume was made up to the mark with distilled water. The solution was then filtered.

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

### 2.3.4. Total Soluble Solids (TSS) and Titratable Acidity (%)

Total soluble solids were measured by using Digital Hand Refractometer (BOE-32195, Germany). A drop of tomato juice was placed on the prism of the refractometer and direct reading was recorded as total soluble solids.

For titratable acidity determination, 50 g of tomato pulp was taken and blended with distilled water by using a Blender machine. The blended material was filtered and clear supernatant was taken in a 250 ml volumetric flask and the volume was made up with distilled water. Five milliliter of filtered supernatant was taken in a conical flask and titrated with 0.1 N NaOH just below the end point, using phenolphthalein as indicator. The titration was done for three times.

#### (iii). Titration of Reducing Sugar

Mixed Fehling's solution (10 ml) was taken in a 250 ml conical flask and made up to mark with distilled water. Purified juice solution (filtrate) was taken in a burette. Conical flask containing mixed Fehling's solution was heated on a hot plate. Three to five drops of methylene blue indicator were added to the flask when boiling started and titrated with solution taken in burette. The end point was indicated by decolorization of indicator. Percent reducing sugar was calculated according to the following formula:

$$\text{Reducing sugar (\%)} = \frac{\text{Fehling's solution} \times \text{Dilution} \times 100}{\text{Titre} \times \text{Weight of sample} \times 1000}$$

#### (iv). Titration of Total Invert Sugar

Purified solution (50 ml) was taken in a 250 ml conical flask and 5 g citric acid and 50 ml distilled water was added to it. Then conical was boiled for inversion of sucrose and finally cooled. After that the solution was taken to a 250 ml volumetric flask and neutralized by 1N NaOH using Phenolphthalein indicator. The volume was made up to the mark with distilled water. Then the mixed Fehling's solution was titrated using similar procedure followed as in case of invert sugar (reducing sugar) mentioned earlier. The percentage of total invert sugar was calculated by using the formula used in case of reducing sugar.

#### (v). Estimation of Non-Reducing Sugar

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

$$\text{Non reducing sugar (\%)} = \% \text{ Total invert sugar} - \% \text{ Reducing sugar}$$

## (vi). Estimation of Total Sugar

$$\text{Total sugar (\%)} = \text{\%Reducing sugar} + \text{\%Non reducing sugar}$$

### 2.3.6. Vitamin C Content

For estimation of vitamin C, the following steps were followed:

#### (i). Standardization of Dye Solution

Standard ascorbic acid solution (5 ml) and metaphosphoric acid (5 ml) were taken in a conical flask. A micro-burette was filled with dye solution and the mixed solution was titrated with Dye using phenolphthalein as indicator. Dye factor was calculated using the following formula:

$$\text{Dye factor} = \frac{0.5}{\text{Titre}}$$

$$\text{Vitamin C (mg per 100 g FW)} = \frac{\text{Titre} \times \text{Dye factor} \times \text{Volume made up}}{\text{Volume of extract taken for estimation} \times \text{Weight of sample taken for estimation}} \times 100$$

### 2.3.7. Shelf Life

Shelf life of tomato fruits as influenced by different concentration of AOS preharvest application and variety was calculated by counting the days required to ripe fully as to retaining optimum marketing and eating qualities.

### 2.3.8. Disease Incidence (%) and Severity (%)

The fruits were critically examined every day for the appearance of rot. The incidence of fruit rot was recorded at 2 days interval.

In case of disease severity, the percentage of fruit skin diseased was recorded. All the infected fruits were selected to determine percent fruit area infected. The percent fruit area diseased was measured based on eye estimation.

### 2.3.9. Statistical Analyses

The collected data was statistically analyzed by using Statistix 10 computer package program. The means for all the treatments was calculated and analysis of variance (ANOVA) for all the parameters were performed by F-test. The significance of difference between the pair of means was compared by Tukey's test at the 1 and 5% significant level of probability [15].

## 3. Results and Discussion

### 3.1. Number of Fruits and Weight of Fruits Per Plant

Number of fruits per plant between the tomato varieties

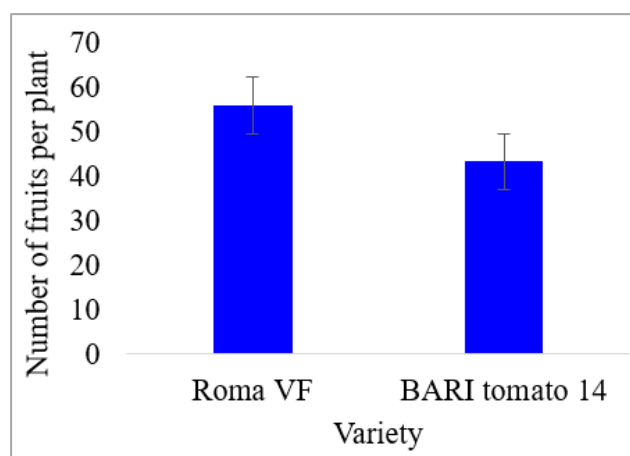
#### (ii). Preparation of Sample

Twenty-gram tomato fruit pulp was taken in a Blender machine and blended with 3% metaphosphoric acid. The blended materials were filtered and taken in a 250 ml volumetric flask and the volume was made up to the mark with metaphosphoric acid.

#### (iii). Titration

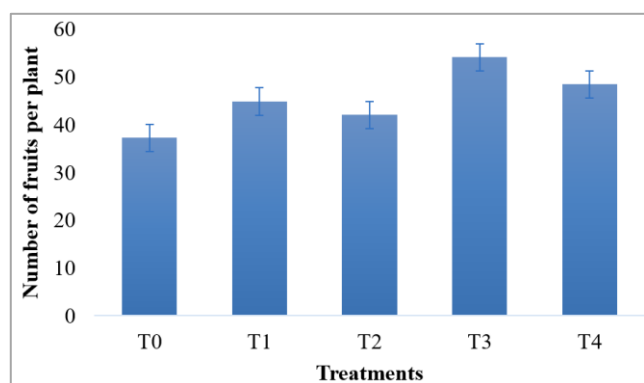
Five ml of metaphosphoric acid extracted sample was taken as an aliquot and titrated with standard dye solution, using phenolphthalein indicator. Vitamin C content was calculated by using the following formula:

were statistically significant (Figure 1). The result indicated that the variety Roma VF exhibited higher number (55.92) fruits compared to BARI tomato 14 (43.20).



**Figure 1.** Effect of variety on the number of fruits per plant, Vertical bars represent standard error.

Significant variation was noted among the different concentration of AOS as foliar application in respect of number of tomato fruits per plant (Figure 2). The highest number of fruits per plant was found from 100 mg/L AOS (54.12) treatment which was followed by 250 mg/L AOS (48.46) whereas the minimum number of fruits per plant was recorded from control treatment (37.28) (Figure 2).

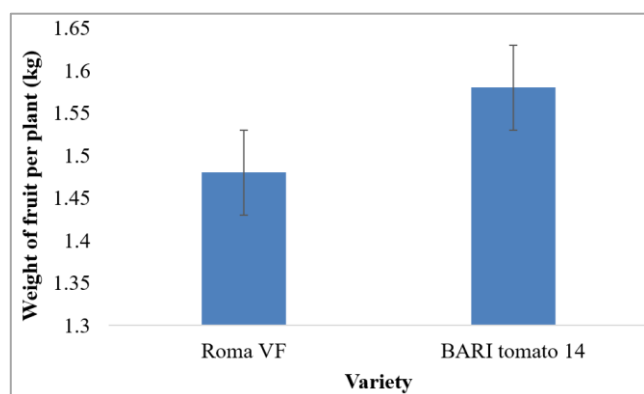


**Figure 2.** Effect of different AOS treatment on the number of fruits per plant.

Here, T<sub>0</sub>= Control; T<sub>1</sub>= 25 mg/l AOS; T<sub>2</sub>=50 mg/l AOS; T<sub>3</sub>=100 mg/l AOS; T<sub>4</sub>=250 mg/l AOS. Vertical bars represent standard error.

Combined effect of varieties and AOS treatment on the number of fruits per plant was noted significant. It was observed that the highest number of fruits was noted from the treatment combination of V<sub>1</sub>T<sub>3</sub> (67.00) followed by V<sub>1</sub>T<sub>1</sub> (61.12) and V<sub>2</sub>T<sub>3</sub> (55.23). On the other hand, the lowest number of fruits per plant was recorded from V<sub>1</sub>T<sub>0</sub> (43.10) (Table 1).

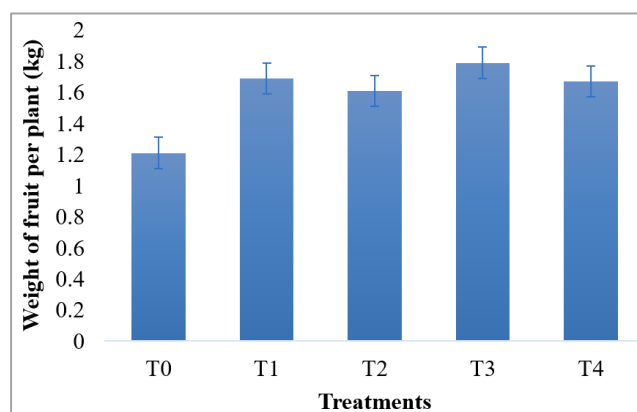
Statistically significant difference was observed between two varieties of tomato in case of fruit weight per plant (Figure 3). The result showed that the variety BARI tomato 14 exhibited higher fruit weight (1.58 kg) compared to Roma VF tomato (1.48 kg).



**Figure 3.** Effect of variety on the weight of fruits per plant, Vertical bars represent standard error.

Different concentration of AOS as foliar application showed significant variation in respect of weight of fruits per plant of tomato (Figure 4). The maximum weight of fruits per plant was counted from 100 mg/L AOS (1.79 kg) treatment which was followed by 25 mg/L AOS (1.69 kg) whereas, the lowest weight of fruits per plant was observed from control treatment (1.21 kg) (Figure 4). Our results are in agreement with [16], they reported that AOS foliar application increased the bulb weight of onion. This could be attributed to auxin

supplied by the oligosaccharides which enhanced cell division and elongation in addition to enhance uptake of higher proteins and nucleic acid reserves, eventually ensuring higher fruit size and weight.



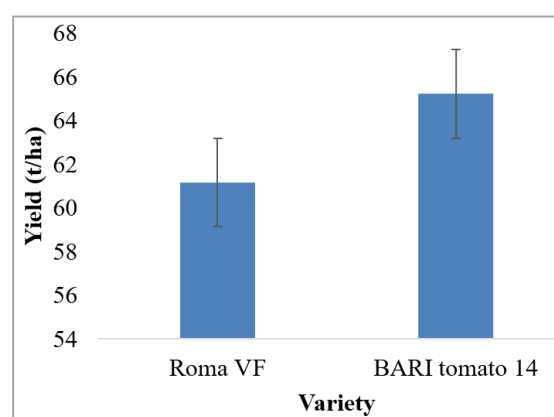
**Figure 4.** Effect of different AOS treatment on the weight of fruits per plant.

Here, T<sub>0</sub>= Control; T<sub>1</sub>= 25 mg/l AOS; T<sub>2</sub>=50 mg/l AOS; T<sub>3</sub>=100 mg/l AOS; T<sub>4</sub>=250 mg/l AOS. Vertical bars represent standard error.

Combined effect of varieties and AOS treatment on the weight of fruits per plant was found significant. It was observed that the highest weight of fruits was noted from the treatment combination of V<sub>2</sub>T<sub>3</sub> (1.67 kg) followed by V<sub>1</sub>T<sub>3</sub> (1.51 kg) and V<sub>2</sub>T<sub>2</sub> (1.24 kg). On the contrary, the minimum fruit weight per plant was recorded from V<sub>1</sub>T<sub>0</sub> (0.92 kg) (Table 1).

### 3.2. Yield

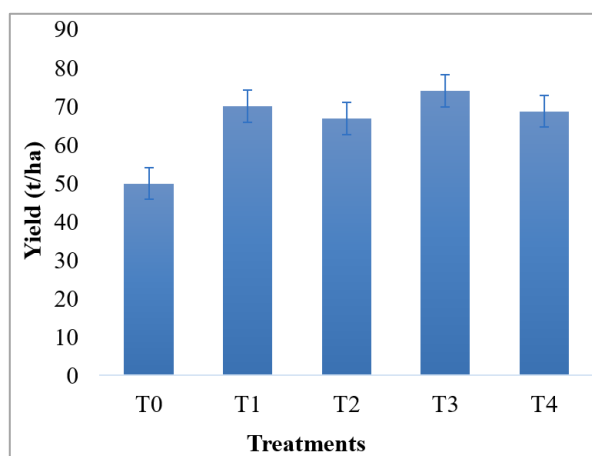
A significant variation was found on yield of tomato is respect of variety in consideration of varietal performance. Results indicated that variety BARI tomato showed the maximum yield (65.22 t/ha) compared to variety Roma VF (61.17 t/h) (Figure 5).



Vertical bars represent standard error.

**Figure 5.** Effect of variety on the weight of fruits per plant.





**Figure 6.** Effect of different AOS treatment on the yield of tomato.

Here, T<sub>0</sub>= Control; T<sub>1</sub>= 25 mg/l AOS; T<sub>2</sub>=50 mg/l AOS; T<sub>3</sub>=100 mg/l AOS; T<sub>4</sub>=250 mg/l AOS. Vertical bars represent standard error.

Different concentration of AOS as foliar application exhibited significant difference in case of yield of tomato (Figure 6). It was observed that the maximum yield (74.06 t/ha)

was noted from 100 mg/L AOS treatment and the minimum yield (49.93 t/ha) was recorded from control treatment (Figure 6). Similar findings were reported by [16], they revealed that preharvest foliar application of AOS increased the yield of onion which supports our results.

Yield of tomato was also significantly affected by the combined effect of variety and AOS treatments. In the experiment it was observed that the highest yield was noted from V<sub>2</sub>T<sub>3</sub> (75.55 t/ha) followed by V<sub>2</sub>T<sub>4</sub> (73.56 t/ha) whereas the lowest yield was recorded from V<sub>1</sub>T<sub>0</sub> (45.10 t/ha) (Table 1). AOS application may increase the yield of tomato by increasing the photosynthetic rate and assimilate product accumulation and accelerating transfer of assimilate product from leaves to fruit. Similar results were reported in case of Citrus fruits and noted that AOS foliar application improved quality and sugar accumulation by increasing the photosynthetic rate and assimilate product [17]. In another study, [18] reported that wheat yield was increased by increasing the number of spikes, the number of grains per spike and 1000 grain weight.

**Table 1.** Combined effect of variety and alginate oligosaccharides on number of fruit per plant, fruit weight per plant and yield of tomato.

Varieties × Treatments	Number of fruits per plant	Fruit weight per plant (kg)	Yield (t/ha)
V <sub>1</sub> T <sub>0</sub>	43.10	0.92	45.10
V <sub>1</sub> T <sub>1</sub>	61.12	1.12	65.88
V <sub>1</sub> T <sub>2</sub>	52.51	1.26	62.65
V <sub>1</sub> T <sub>3</sub>	67.00	1.51	71.03
V <sub>1</sub> T <sub>4</sub>	53.52	1.35	64.19
V <sub>2</sub> T <sub>0</sub>	45.00	0.97	49.11
V <sub>2</sub> T <sub>1</sub>	47.52	1.15	67.45
V <sub>2</sub> T <sub>2</sub>	54.12	1.24	71.15
V <sub>2</sub> T <sub>3</sub>	55.23	1.67	75.55
V <sub>2</sub> T <sub>4</sub>	48.67	1.46	73.56
Level of significance	*	*	*
CV%	4.59	4.15	5.95

V<sub>1</sub>= Roma VF, V<sub>2</sub>= BARI Tomato 14; T<sub>0</sub>= Control, T<sub>1</sub>= 25 mg/L AOS, T<sub>2</sub>= 50 mg/L AOS, T<sub>3</sub>=100 mg/L AOS and T<sub>4</sub>= 250 mg/L AOS; \* = Significant at 5% level of probability; CV= Co-efficient of Variation.

### 3.3. Fruit Firmness and Total Weight Loss

Firmness of tissue makes sure the quality of fruits at storage condition. During storage, fruits of studied varieties lost firmness. Changes of fruit firmness between the storage tomato varieties were significant at different days after storage

(Table 2). The changes of fruit firmness had maximum in 'Roma VF' (4.82, 4.26, 3.59 and 2.89 N) at 2, 4, 6 and 8 DAS, respectively than that of the variety 'BARI tomato 14' (4.52, 4.07, 3.44 and 2.23 N, respectively). These results revealed that the fruit firmness gradually decreased with the advancement of storage period. The above observation was also agreed by the findings of [19] who reported that the fruit

firmness was varied significantly between two varieties of mango. The difference between two varieties in respect of firmness during storage period may be due to their genetic variation.

Firmness changes showed significant in case of preharvest application of AOS treatments at postharvest condition (Table 2). It was exhibited that fruit firmness changes occurred at faster rate in without AOS application, whereas the rates were slower in those fruits treated with AOS. At 2, 4, 6 and 8 DAS, the maximum firmness was measured in 100 mg/l AOS (5.40, 4.94, 4.49 and 3.48 N) treatment and the minimum firmness was recorded from control treatment (4.14, 3.91, 2.81 and 1.90 N), respectively (Table 2). Present results are in agreement with previous findings, it was reported that preharvest application of chitosan oligosaccharides and AOS increased strawberry [20] and kiwi fruit [21] firmness compared to

untreated fruits. Fruit firmness gradually decreases with prolonged storage period but decreasing rate was slower in treated fruits compared to untreated fruits [22, 23].

Combined effect of varieties and different concentration of AOS preharvest treatments showed significant variation in respect of fruit firmness (Table 3). At 2, 4, 6 and 8 DAS, the highest firmness was recorded from V<sub>2</sub>T<sub>3</sub> (5.987, 5.380, 4.783 and 4.407 N) treatment whereas the lowest firmness was noted from V<sub>1</sub>T<sub>0</sub> (4.110, 3.740, 2.570 and 1.470 N), respectively. Fruit firmness is the most important quality indices of fruit and it is gradually decrease with the advancement of ripening. Previous studied results demonstrated that postharvest application of AOS delayed the loss of firmness by suppressing the activity of N-glycan processing enzymes (a-Man and b-Hex) along with their encoding gene expression. [24].

**Table 2.** Main effect of variety and alginate oligosaccharides on firmness and weight loss of tomato during storage.

Varieties	Fruit firmness at different DAS				Weight loss (%) at different DAS			
	2	4	6	8	2	4	6	8
V <sub>1</sub>	4.523	4.066	3.442	2.232	3.468	5.249	7.359	9.647
V <sub>2</sub>	4.827	4.256	3.594	2.894	3.166	4.912	6.841	9.145
Level of significance	**	**	**	**	**	**	**	**
CV (%)	1.37	0.97	1.00	0.77	0.90	0.94	0.53	0.51
Treatments								
T <sub>0</sub>	4.14	3.91	2.81	1.90	3.72	5.61	7.71	10.18
T <sub>1</sub>	4.60	4.11	3.82	3.10	3.20	5.28	7.51	9.80
T <sub>2</sub>	5.28	4.77	4.37	3.25	3.10	4.99	6.71	9.36
T <sub>3</sub>	5.40	4.94	4.49	3.48	2.82	4.31	6.28	8.32
T <sub>4</sub>	5.13	4.70	3.94	3.22	3.20	5.08	7.28	9.51
Level of significance	*	*	*	*	*	*	*	*
CV (%)	1.37	0.97	1.00	0.77	0.90	0.94	0.53	0.51

V<sub>1</sub>= Roma VF, V<sub>2</sub>= BARI Tomato 14; T<sub>0</sub>= Control, T<sub>1</sub>= 25 mg/L AOS, T<sub>2</sub>= 50 mg/L AOS, T<sub>3</sub>=100 mg/L AOS and T<sub>4</sub>= 250 mg/L AOS; \*\*&\* = Significant at 1% and 5% level of probability; CV= Co-efficient of Variation

**Table 3.** Combined effect of variety and alginate oligosaccharides on firmness and weight loss of tomato during storage.

Varieties × Treatments	Fruit firmness at different DAS				Weight loss (%) at different DAS			
	2	4	6	8	2	4	6	8
V <sub>1</sub> T <sub>0</sub>	4.110	3.740	2.570	1.470	3.80	5.74	7.85	10.42
V <sub>1</sub> T <sub>1</sub>	4.177	3.977	2.917	1.917	3.650	5.49	7.58	9.95
V <sub>1</sub> T <sub>2</sub>	4.810	4.500	4.200	2.090	3.54	4.74	7.19	9.43

Varieties × Treatments	Fruit firmness at different DAS				Weight loss (%) at different DAS			
	2	4	6	8	2	4	6	8
V <sub>1</sub> T <sub>3</sub>	5.163	4.763	3.803	3.203	3.47	5.37	7.42	9.76
V <sub>1</sub> T <sub>4</sub>	4.713	4.453	4.113	1.983	3.48	5.38	7.32	9.43
V <sub>2</sub> T <sub>0</sub>	4.110	3.740	2.660	1.493	3.66	5.43	7.38	9.83
V <sub>2</sub> T <sub>1</sub>	4.107	3.847	2.697	1.887	3.05	4.98	6.58	9.02
V <sub>2</sub> T <sub>2</sub>	5.840	5.090	4.630	4.220	3.46	4.61	6.98	9.32
V <sub>2</sub> T <sub>3</sub>	5.987	5.380	4.783	4.407	3.02	4.58	6.77	8.97
V <sub>2</sub> T <sub>4</sub>	5.100	4.640	3.820	3.230	3.12	5.20	6.66	9.28
Level of significance	*	*	*	*	*	*	*	*
CV (%)	1.37	0.97	1.00	0.77	0.90	0.94	0.53	0.51

V<sub>1</sub>= Roma VF, V<sub>2</sub>= BARI Tomato 14; T<sub>0</sub>= Control, T<sub>1</sub>= 25 mg/L AOS, T<sub>2</sub>= 50 mg/L AOS, T<sub>3</sub>=100 mg/L AOS and T<sub>4</sub>= 250 mg/L AOS; \*\*&\*= Significant at 1% and 5% level of probability; CV= Co-efficient of Variation

In case of total weight loss, significant variation was noted between two tomato varieties at different DAS (Table 2). From the Table 2, it was found that the variety 'BARI tomato 14' showed the minimum loss in weight of tomatoes (3.166, 4.912, 6.841 and 9.145%) compare to 'Roma VF' (3.468, 5.249, 7.359 and 9.647%) at 2, 4, 6 and 8 days after storage, respectively. The weight loss is one of the most substantial indicators for maintaining the quality of any fruits during postharvest storage. The weight loss reduction is unsurprising to the physiological loss in weight due to water respiration and transpiration through peel tissue, and other organic changes taking place in the fruit [25].

Significant variation was obtained by the effect of preharvest application of AOS treatments regarding to weight loss percentage during storage (Table 2). The weight loss was lower (2.83, 4.32, 6.28 and 8.32%) in those fruits which were treated with 100 mg/l AOS at 2, 4, 6 and 8 days after storage, respectively while it was statistically differed from other treatments. In contrast, the highest weight loss had (3.72, 5.62, 7.72 and 10.19%) was recorded in control or untreated fruits at 2, 4, 6 and 8 DAS, respectively. These results appeared that all the treatments showed significant variation among them where AOS 100 mg/l recorded the greater performance. During storage fruit weight loss gradually increased but postharvest treatments delayed the loss of weight [19, 26]. AOS postharvest treatment delayed the weight loss compared to untreated fruit which may possibly due to lowering respiration and transpiration activity of fruits [12].

A significant variation was noted by the combined effect of studied tomato varieties and different AOS treatments at different DAS (Table 3). Among the treatment combinations, the minimum weight loss in (3.02, 4.58, 6.77 and 8.97%) was found from the 'BARI tomato 14' fruits treated with 100 mg/l AOS at 2, 4, 6 and 8 DAS, respectively and the maximum

weight loss (3.80, 5.74, 7.85 and 10.42%) was obtained from the Roma VF fruits which was not subjected to any treatments. From previous study, it was noted that AOS pre-harvest treatment effectively reduce weight loss of kiwi fruit during postharvest storage [27].

### 3.4. Total Soluble Solid Content and Titratable Acidity

Analysis of variance data on the effect of varieties showed significant variation regarding to total soluble solids (% Brix) at different days after storage (Table 4). Between the varieties, 'Roma VF' gave the maximum TSS (4.44, 5.31, 5.62 and 5.99 °Brix) than 'BARI tomato 14' (4.18, 5.27, 5.58 and 5.92% °Brix) at 2, 4, 6 and 8 DAS, respectively (Table 4). These results revealed that the TSS content significantly increased with prolong storage period. Similar views were expressed by [20] who observed that preharvest application of COS increased the TSS content of strawberry and postharvest treatment of COS significantly delayed the loss of TSS [28].

Preharvest application of different concentration of AOS exhibited highly significant variation in respect of TSS content at different days after storage (Table 4). The fruits treated with 100 mg/l AOS showed the highest TSS (4.99, 5.53, 5.83 and 6.3 °Brix) at 2, 4, 6 and 8 DAS, respectively. On the other hand, the lowest TSS (4.32, 5.17, 5.44 and 5.76) was recorded from control treatment at 2, 4, 6 and 8 DAS, respectively (Table 4). Similar results were also obtained by [29], they reported that foliar application of alginate derived oligosaccharides enhance the TSS content of tomato.

Combined effect of the tomato varieties and different concentration of AOS preharvest treatment showed significant in respect of TSS content (°Brix) during postharvest storage (Table 5). The highest total soluble solid contents



were observed in V<sub>1</sub>T<sub>3</sub> treatment (5.67 and 5.98 °Brix) at 6 and 8 DAS while initially the TSS content was 4.79 °Brix and it was statistically varied from other treatment combinations at every data recording period. On the other hand, the lowest TSS (5.49 and 5.88 °Brix) was recorded from control treatment at 6 and 8 DAS, respectively (Table 5). These results indicate that the TSS content enhanced significantly during storage period while the TSS was the maximum in those fruits

of ‘Roma VF’ treated with 100 mg/l AOS. However, this increase in TSS content during storage and ripening is because of the transformation of complex carbohydrates into simple sugars and it is also correlated with hydrolytic changes in starch and change of starch to sugar being an important index of ripening process in climacteric fruits including tomato.

**Table 4.** Main effect of variety and alginate oligosaccharides on total soluble solid and titratable acidity content of tomato during storage.

Varieties	TSS (% Brix) at different DAS				Titratable acidity at different DAS			
	2	4	6	8	2	4	6	8
V <sub>1</sub>	4.44	5.31	5.62	5.99	0.29	0.34	0.39	0.42
V <sub>2</sub>	4.18	5.27	5.58	5.92	0.27	0.33	0.37	0.41
Level of significance	*	*	*	*	*	*	*	*
CV (%)	0.90	0.62	0.55	0.67	0.96	0.73	1.71	2.73
Treatments								
T <sub>0</sub>	4.32	5.17	5.44	5.76	0.27	0.32	0.36	0.39
T <sub>1</sub>	4.57	5.28	5.49	5.97	0.28	0.33	0.38	0.41
T <sub>2</sub>	4.83	5.35	5.68	5.89	0.31	0.35	0.39	0.42
T <sub>3</sub>	4.99	5.53	5.83	6.39	0.33	0.37	0.41	0.44
T <sub>4</sub>	4.59	5.32	5.54	5.94	0.32	0.34	0.37	0.41
Level of significance	*	*	*	*	*	*	*	*
CV (%)	0.90	0.62	0.55	0.67	0.96	0.73	1.71	2.73

V<sub>1</sub>= Roma VF, V<sub>2</sub>= BARI Tomato 14; T<sub>0</sub>= Control, T<sub>1</sub>= 25 mg/L AOS, T<sub>2</sub>= 50 mg/L AOS, T<sub>3</sub>=100 mg/L AOS and T<sub>4</sub>= 250 mg/L AOS; \*\*&\*= Significant at 1% and 5% level of probability; CV= Co-efficient of Variation

**Table 5.** Combined effect of variety and alginate oligosaccharides on total soluble solid and titratable acidity content of tomato during storage.

Varieties × Treatments	TSS (% Brix) at different DAS				Titratable acidity (%) at different DAS			
	2	4	6	8	2	4	6	8
V <sub>1</sub> T <sub>0</sub>	4.47	5.17	5.49	5.96	0.28	0.33	0.38	0.42
V <sub>1</sub> T <sub>1</sub>	4.65	5.32	5.53	5.92	0.29	0.35	0.39	0.41
V <sub>1</sub> T <sub>2</sub>	4.54	5.21	5.43	5.78	0.31	0.33	0.41	0.43
V <sub>1</sub> T <sub>3</sub>	4.79	5.34	5.67	5.98	0.36	0.38	0.43	0.45
V <sub>1</sub> T <sub>4</sub>	4.48	5.21	5.62	5.87	0.32	0.34	0.38	0.43
V <sub>2</sub> T <sub>0</sub>	4.67	5.17	5.49	5.88	0.29	0.34	0.39	0.42
V <sub>2</sub> T <sub>1</sub>	4.02	5.34	5.68	5.95	0.30	0.35	0.40	0.43
V <sub>2</sub> T <sub>2</sub>	4.46	5.15	5.44	5.74	0.32	0.37	0.40	0.44
V <sub>2</sub> T <sub>3</sub>	4.05	5.22	5.54	5.92	0.34	0.39	0.45	0.48

Varieties × Treatments	TSS (% Brix) at different DAS				Titratable acidity (%) at different DAS			
	2	4	6	8	2	4	6	8
V <sub>2</sub> T <sub>4</sub>	4.12	5.35	5.63	5.89	0.32	0.35	0.39	0.43
Level of significance	*	*	*	*	*	*	*	*
CV (%)	0.90	0.94	0.53	0.51	0.90	0.73	1.71	2.73

V<sub>1</sub>= Roma VF, V<sub>2</sub>= BARI Tomato 14; T<sub>0</sub>= Control, T<sub>1</sub>= 25 mg/L AOS, T<sub>2</sub>= 50 mg/L AOS, T<sub>3</sub>=100 mg/L AOS and T<sub>4</sub>= 250 mg/L AOS; \*\*&\*= Significant at 1% and 5% level of probability; CV= Co-efficient of Variation

Significant differences were observed in respect of titratable acidity content between two varieties of tomato at different days after storage (Table 4). Between the varieties, 'Roma VF' showed the maximum titratable acidity (0.39 and 0.42%) compare to 'BARI tomato 14' (0.37 and 0.41%) at 6 and 8 DAS, respectively while initially the titratable acidity was 0.29 and 0.27% in 'Roma VF' and 'BARI tomato 14', respectively.

Different AOS preharvest treatment effect had highly significant on titratable acidity content at different days after storage (Table 4). From the table 4, it was noted that AOS 100 mg/l treated fruits had higher (0.41 and 0.44%) at 6 and 8 DAS, respectively which was closely followed by AOS 100 mg/l treated fruits of tomato (0.39 and 0.42%, respectively) at 6 and 8 DAS, respectively. However, the minimum TA content (0.36 and 39%) was recorded from control treatment at 6 and 8 DAS, respectively. The TA content increased with increasing days after storage and with the maturity of tomato fruit. Similar report was explored by [20], they noted that preharvest application of COS increased the TA content of strawberry during postharvest storage.

A highly significant differences was obtained among the combined effect of varieties and various AOS preharvest treatments in respect of TA content at different days after storage (Table 5). The highest TA content (0.45 and 0.48%) was marked in those fruits of 'BARI tomato 14' treated with 100 mg/l AOS at 6 and 8 DAS, respectively which was statistically unlike from other treatment combinations. The smallest amount of TA content (0.38 and 42%) was estimated from the untreated fruits of the variety 'Roma VF' at 6 and 8 DAS, respectively. These results declared that the TA content enhanced gently with the prolong storage time among the all-treatment combinations.

### 3.5. Total Sugar Content

Total sugar content between two studied tomato varieties

were statistically significant at different DAS (Table 6). Between two tomato varieties, the variety 'Roma VF' had higher to produces the total sugar content (4.15%) than 'BARI tomato 14' (3.94%) at 6 DAS. At 8 DAS, both varieties were statistically similar in respect of total sugar content due to its non-significant variation. The variety 'Roma VF' had higher (5.091%) total sugar content than 'BARI tomato' (5.056%) at 8 DAS.

Various AOS preharvest treatments were significantly influenced the total sugar content of tomatoes during the storage period (Table 6). Among the AOS treatments, AOS 100 mg/l treated fruits recorded the higher total sugar content (3.33, 3.60 4.41 and 5.73%) at 2, 4, 6 and 8 DAS, respectively whereas it was statistically dissimilar from other treatments. On the contrary, the lowest total sugar content (3.08, 3.18, 3.86 and 4.86%) were recorded at 2, 4, 6 and 8 DAS, respectively. Above results revealed that the total sugar content gently increased with the advancement of storage period whereas AOS 100 mg/l was more efficient than other treatments. Similar findings were also found by [20] who reported that COS preharvest treatment increased total sugar content of strawberry fruit during storage.

Combined effect of the studied tomato varieties and different preharvest treatments were significantly influenced by total sugar content during storage (Table 7). From the Table 7, it was recorded that the AOS 100 mg/l treated fruits of 'Roma VF' exhibited the higher total sugar content (3.35, 3.45, 4.29 and 4.89%) at 2, 4, 6 and 8 DAS, respectively which was statistically different from other treatment combinations. Similarly, the lowest total sugar content (3.17, 3.27, 3.68 and 4.54%) was found in those fruits of 'BARI tomato 14' which was not subjected to any treatments. These results indicated that the total sugar content significantly increase with the increasing period of storage regarding to both varieties and also the whole postharvest treatments.

**Table 6.** Main effect of variety and alginate oligosaccharides on total sugar and vitamin C content of tomato during storage.

Varieties	Total sugar (%) at different DAS				Vitamin C (mg/100 g FW) at different DAS			
	2	4	6	8	2	4	6	8
V <sub>1</sub>	3.09	3.313	4.149	5.091	29.09	25.23	21.79	17.72
V <sub>2</sub>	3.07	3.187	3.941	5.056	26.07	22.89	20.20	17.02
Level of significance	*	*	*	NS	*	*	*	*
CV (%)	0.96	1.90	1.59	1.73	2.90	2.40	2.24	2.71
Treatments								
T <sub>0</sub>	3.08	3.18	3.86	4.85	28.08	24.73	20.80	16.84
T <sub>1</sub>	3.18	3.24	4.06	5.05	28.48	25.02	20.90	17.27
T <sub>2</sub>	3.21	3.38	4.17	5.10	28.65	25.14	20.98	17.55
T <sub>3</sub>	3.33	3.60	4.41	5.73	28.93	25.29	21.81	18.38
T <sub>4</sub>	3.12	3.22	4.00	4.94	28.32	25.01	20.90	17.24
Level of significance	*	*	*	*	*	*	NS	*
CV (%)	0.96	1.90	1.59	1.73	2.90	2.40	2.24	2.71

V<sub>1</sub>= Roma VF, V<sub>2</sub>= BARI Tomato 14; T<sub>0</sub>= Control, T<sub>1</sub>= 25 mg/L AOS, T<sub>2</sub>= 50 mg/L AOS, T<sub>3</sub>=100 mg/L AOS and T<sub>4</sub>= 250 mg/L AOS; \*\*&\*= Significant at 1% and 5% level of probability; CV= Co-efficient of Variation

**Table 7.** Combined effect of variety and alginate oligosaccharides on total sugar and vitamin C content of tomato during storage.

Varieties × Treatments	Total sugar (%) at different DAS				Vitamin C (mg/100 g FW) at different DAS			
	2	4	6	8	2	4	6	8
V <sub>1</sub> T <sub>0</sub>	3.18	3.29	4.03	4.70	26.45	25.21	21.92	17.05
V <sub>1</sub> T <sub>1</sub>	3.20	3.26	4.08	4.81	26.85	25.29	21.38	17.14
V <sub>1</sub> T <sub>2</sub>	3.25	3.36	4.10	4.83	27.25	25.37	22.49	17.24
V <sub>1</sub> T <sub>3</sub>	3.35	3.45	4.29	4.89	27.75	25.61	22.82	17.90
V <sub>1</sub> T <sub>4</sub>	3.20	3.33	4.09	4.83	27.15	25.26	22.05	17.20
V <sub>2</sub> T <sub>0</sub>	3.17	3.27	3.68	4.54	26.45	22.25	19.68	16.17
V <sub>2</sub> T <sub>1</sub>	3.18	3.25	3.80	4.73	26.15	22.99	20.08	17.08
V <sub>2</sub> T <sub>2</sub>	3.22	3.34	3.83	4.78	26.45	23.02	20.35	17.25
V <sub>2</sub> T <sub>3</sub>	3.32	3.36	4.04	4.81	26.95	23.90	20.98	17.70
V <sub>2</sub> T <sub>4</sub>	3.21	3.31	4.01	4.74	26.35	22.99	20.10	16.74
Level of significance	*	*	*	*	*	*	*	*
CV (%)	1.93	1.90	1.59	1.73	2.90	2.40	2.24	2.71

V<sub>1</sub>= Roma VF, V<sub>2</sub>= BARI Tomato 14; T<sub>0</sub>= Control, T<sub>1</sub>= 25 mg/L AOS, T<sub>2</sub>= 50 mg/L AOS, T<sub>3</sub>=100 mg/L AOS and T<sub>4</sub>= 250 mg/L AOS; \*= Significant at 5% level of probability; CV= Co-efficient of Variation

### 3.6. Vitamin C Content

The data regarding vitamin C content was significantly influenced by the tomato varieties during storage (Table 6). Between two varieties, the variety 'Roma VF' had higher vitamin C content (21.79 and 17.72 mg 100 g<sup>-1</sup> FW) at 6 and 8 DAS, respectively while initial vitamin C content was 29.09 mg 100 g<sup>-1</sup> FW. In contrast, 'BARI tomato 14' showed the lower vitamin C content (20.20 and 17.02 mg 100 g<sup>-1</sup> FW) at 6 and 8 DAS, respectively while the initial vitamin C content was 26.07 mg 100 g<sup>-1</sup> FW. Present results suggested that the vitamin C content gradually declined with the advancement of storage period.

The data on vitamin C content was significantly influenced during postharvest conditions by the effect of preharvest application of AOS treatments (Table 6). From the table 6, it was observed that the maximum vitamin C content (28.93, 25.29, 21.81 and 18.38 mg 100 g<sup>-1</sup> FW) was recorded from the tomato fruits stored in ambient temperature while it was treated with 100 mg/l AOS at 2, 4, 6 and 8 DAS. In contrast, the lowest vitamin C content (28.08, 24.73, 20.80 and 16.84 mg 100 g<sup>-1</sup> FW) was noted from the untreated tomato fruits which were statistically differed from other treatments at 2, 4, 6 and 8 DAS, respectively. These results uncovered that AOS preharvest treatment increased the vitamin C content compared to untreated fruits and vitamin C content gradually declined with the prolong storage period because of the transformation of acid to sugar with the activity of ascorbic dehydrogenase which results was fully agreed by Caron et al. [30].

Analysis of variance data regarding to vitamin C content had significantly affected by the combined effect of the tomato varieties and various AOS preharvest treatments during storage (Table 7). From the Table 7, it was appeared that the maximum vitamin C content (17.90 mg 100 g<sup>-1</sup> FW) was obtained by the variety 'Roma VF' while it was treated with AOS @ 100 mg/l at 8 DAS whereas the lowest vitamin C content (16.17 mg 100 g<sup>-1</sup> FW) was measured in untreated fruits of 'BARI tomato 14' which was statistically dissimilar from other treatments.

### 3.7. Disease Incidence and Severity

Disease incidence is an important factor for the storage fruits

in case of the shelf life. The shelf life of storage fruits fully depends on the incidence percentage of disease. Varietal effect showed significant variation in respect of disease incidence at different DAS (Table 8). Between two varieties, the storage fruits of 'BARI tomato 14' were highly infected by insect as well as the higher disease incidence (2.85, 4.14, 6.75 and 11.04%) were occurs under this variety. Similarly, 'Roma VF' was less affected by insect during storage than 'BARI tomato 14' as well as the lowest disease incidence (2.69, 3.99, 6.53 and 10.87%) was recorded at 2, 4, 6, and 8 DAS, respectively.

The data on disease incidence varied significantly by the effect of various preharvest AOS treatments during postharvest conditions (Table 8). The disease incidence of the storage fruits was observed at 2, 4, 6 and 8 DAS whereas 100 mg/L AOS treated fruits recorded the lowest incidence (2.31, 3.29, 3.49 and 6.63%) than that of other treatments. On the contrary, the untreated storage fruits showed the higher incidence of disease (5.15, 8.41, 10.88 and 16.04%) at 2, 4, 6 and 8 DAS, respectively which was statistically inconsistent from other treatments. These results discovered that the incidence of disease was significantly influenced in increasing storage period. Control treatment recorded the maximum disease incidence due to the lower un-controlling agent were effective during storage than that of other treatments [26, 31]. AOS treated fruit exhibited lower disease incidence, may be due to the antimicrobial effect of AOS. Similar findings were reported previously and they demonstrated that AOS postharvest treatment reduce the disease percentage of Kiwi fruit during storage [21].

Combined effect of studied tomato varieties and the application of different AOS treatments were significantly influenced on disease incidence during storage (Table 9). Among the treatment combinations, the maximum disease incidence (5.25, 8.51, 10.98 and 15.98%) was recorded in those fruits of 'BARI tomato 14' which was not treated by any treatments at 2, 4, 6 and 8 DAS, respectively. However, the lowest disease incidence (1.95, 2.82, 4.95 and 8.89%) was noted from the 25 mg/L AOS treated fruits of 'Roma VF' at 2, 4, 6 and 8 DAS, respectively. These results disclosed that the diseases incidence was significantly enhanced with the advancement of storage time regarding to whole treatment combinations whereas AOS 25 mg/L treatment recorded the lower incidence of disease than that of other treatment combinations.

**Table 8.** Main effect of variety and alginate oligosaccharides on disease incidence and severity of tomato during storage.

Varieties	Disease incidence (%) at different DAS				Disease severity (%) at different DAS			
	2	4	6	8	2	4	6	8
V <sub>1</sub>	2.690	3.986	6.525	10.87	33.78	44.40	53.96	64.44
V <sub>2</sub>	2.849	4.144	6.745	11.04	34.32	44.79	54.32	64.79
Level of significance	*	*	*	*	**	*	**	**

Varieties	Disease incidence (%) at different DAS				Disease severity (%) at different DAS			
	2	4	6	8	2	4	6	8
CV (%)	1.97	2.47	0.45	1.39	2.80	3.31	2.50	2.59
T <sub>0</sub>	5.15	8.41	10.88	16.04	33.23	53.26	73.21	93.18
T <sub>1</sub>	3.45	5.19	6.20	10.46	30.22	53.21	66.60	73.23
T <sub>2</sub>	3.20	4.11	5.31	9.58	29.88	33.24	46.58	59.91
T <sub>3</sub>	2.31	3.29	3.49	6.63	26.77	30.20	33.25	39.92
T <sub>4</sub>	3.34	3.40	5.25	9.45	30.06	39.92	53.25	69.91
Level of significance	*	*	*	*	*	*	*	*
CV (%)	1.97	2.47	0.45	1.39	2.80	3.31	2.50	2.59

V1= Roma VF, V2= BARI Tomato 14; T<sub>0</sub>= Control, T<sub>1</sub>= 25 mg/L AOS, T<sub>2</sub>= 50 mg/L AOS, T<sub>3</sub>=100 mg/L AOS and T<sub>4</sub>= 250 mg/L AOS; \*= Significant at 5% level of probability; CV= Co-efficient of Variation.

**Table 9.** Combined effect of variety and alginate oligosaccharides on disease incidence and severity of tomato during storage.

Varieties × Treatments	Disease incidence (%) at different DAS				Disease severity (%) at different DAS			
	2	4	6	8	2	4	6	8
V <sub>1</sub> T <sub>0</sub>	5.04	8.30	10.77	16.10	33.10	53.10	73.07	93.77
V <sub>1</sub> T <sub>1</sub>	1.95	2.82	4.95	8.89	30.83	53.12	59.83	73.13
V <sub>1</sub> T <sub>2</sub>	2.01	3.01	5.14	9.34	29.81	33.14	59.81	72.81
V <sub>1</sub> T <sub>3</sub>	3.34	5.08	10.14	15.41	26.81	30.14	39.81	66.51
V <sub>1</sub> T <sub>4</sub>	3.09	3.29	6.09	10.35	30.15	39.49	58.12	72.82
V <sub>2</sub> T <sub>0</sub>	5.25	8.51	10.98	15.98	34.31	53.31	73.28	93.98
V <sub>2</sub> T <sub>1</sub>	2.17	3.04	5.17	9.11	31.05	54.05	60.05	73.35
V <sub>2</sub> T <sub>2</sub>	2.23	3.23	5.36	9.56	30.03	54.36	60.03	73.03
V <sub>2</sub> T <sub>3</sub>	3.56	5.30	10.36	15.63	27.03	30.36	40.03	66.73
V <sub>2</sub> T <sub>4</sub>	3.31	3.51	6.31	10.57	31.37	40.71	63.34	72.84
Level of significance	**	**	*	*	**	*	*	*
CV (%)	1.97	2.47	0.45	1.39	2.80	3.31	2.50	2.59

V1= Roma VF, V2= BARI Tomato 14; T<sub>0</sub>= Control, T<sub>1</sub>= 25 mg/L AOS, T<sub>2</sub>= 50 mg/L AOS, T<sub>3</sub>=100 mg/L AOS and T<sub>4</sub>= 250 mg/L AOS; \*\*= Significant at 5% level of probability; CV= Co-efficient of Variation

Percentage of disease severity also affected significantly due to the effect of studied tomato varieties during storage (Table 8). Between two studied storage tomato varieties, 'Roma VF' recorded the lowest disease severity (33.78, 44.40, 53.96, and 64.44%) than that of 'BARI tomato 14' (34.32, 44.79, 54.32 and 64.79%) at 2, 4, 6 and 8 DAS, respectively.

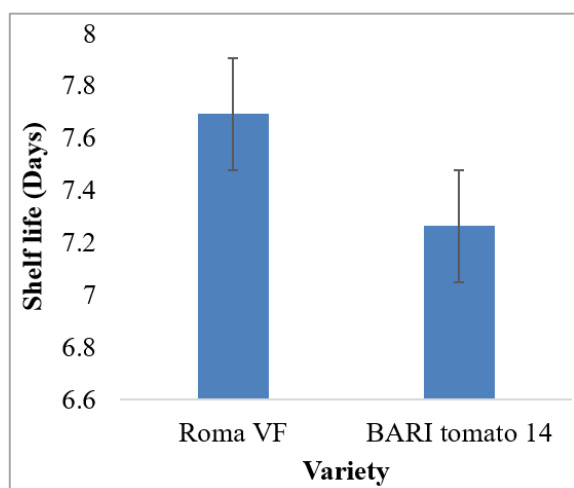
The data on disease severity varied significantly by the effect of various preharvest AOS treatments during post-harvest conditions (Table 8). The disease incidence of the storage fruits was observed at 2, 4, 6 and 8 DAS whereas 100 mg/l AOS treated fruits recorded the lowest severity (26.77, 30.20, 33.25 and 39.92%) than that of other treatments. Diversely, the untreated storage fruits showed the higher



severity of disease (33.23, 53.26, 73.21 and 93.18%) at 2, 4, 6 and 8 DAS, respectively which was statistically dissimilar from other treatments. These results disclosed that the severity of disease was significantly accelerated in increasing storage period.

Combined effect of varieties and different concentration of AOS preharvest treatments were significantly influenced in respect of disease severity at different days after storage (Table 9). The disease severity of the storage fruits was observed at 2 days interval from 2 DAS up to 8 DAS (four times) whereas AOS 100 mg/l treated Roma VF tomato fruits recorded the lowest severity than that of other treatments. The diseases severity was the lowest (26.81, 30.14, 39.81 and 66.51%) at 2, 4, 6 and 8 DAS, respectively in those storage Roma VF tomato fruits which were treated with 100 mg/l AOS and stored in room or ambient temperature (Figure 9) whereas it was statistically differed among other treatments. In contrast, untreated storage BARI tomato 14 fruits showed the higher severity (34.31, 53.31, 73.28 and 93.98%) at 2, 4, 6 and 8 DAS, respectively which was also statistically unlike from other treatments. These results revealed that the disease severity was gradually increased in increasing the storage time. Two experiments were carried out by [32] reported that the decay incidence was higher during storage. This result would be attributed to the suppression of fungal growth by AOS due to the antimicrobial properties.

### 3.8. Shelf Life



Vertical bars represent standard error.

Figure 7. Effect of variety on shelf life of tomato.

The data of shelf life of fruits affected significantly at 1% level of probability between the varieties (Figure 7). From the Figure 7, it was noted that the studied 'Roma VF' extent the more shelf life (7.693 days) compares to 'BARI tomato 14' (7.265 days).

Shelf life of tomato fruits was significantly affected at 1% level of provability due to the effect of various preharvest treatments of AOS (Figure 8). Shelf life extension of tomato has been one of the most important concerns of the researchers. These results discovered that the extended shelf life (11.62 days) of tomato fruits was noted from AOS 100 mg/l treated fruits followed by AOS 50 mg/l (9.30 days). The shortest shelf life of tomato (5.01 days) was observed from the untreated fruits (Figure 8). Mondal et al. [31] reported similar results and they suggested that different treatments increased shelf life of fruits compared to untreated fruits.

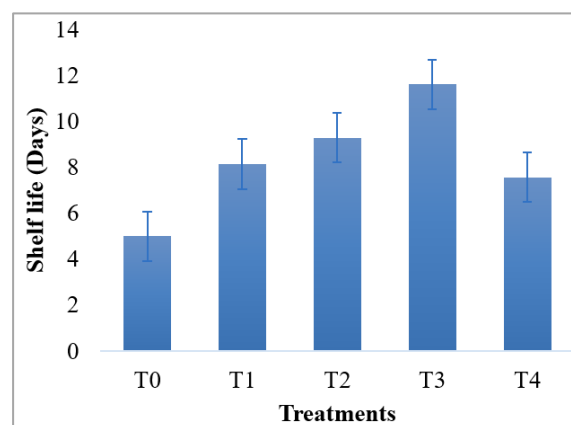
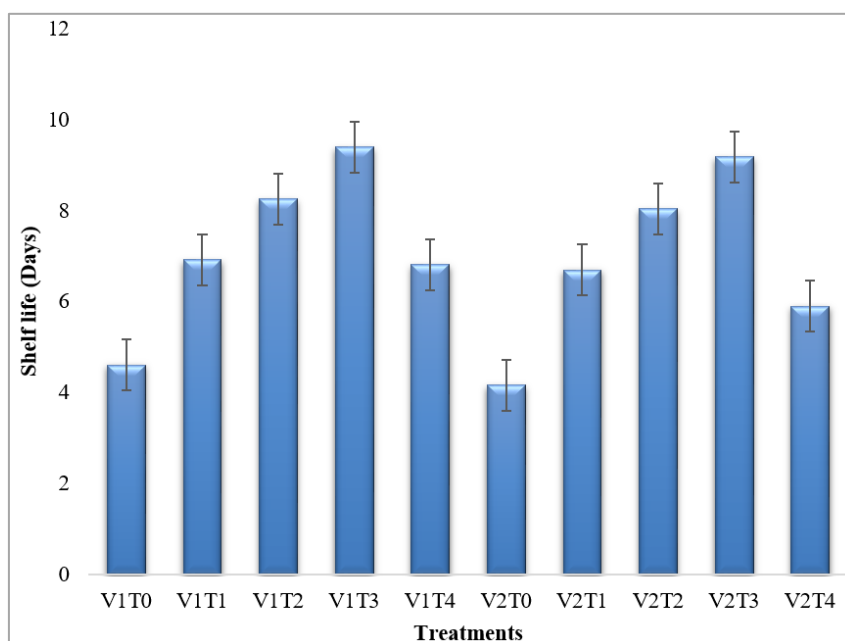


Figure 8. Effect of different AOS treatment on shelf life of tomato.

Here, To= Control; T1= 25 mg/l AOS; T2=50 mg/l AOS; T3=100 mg/l AOS; T4=250 mg/l AOS, Vertical bars represent standard error.

The combined effects of the studied tomato varieties and postharvest treatments had significant variation in respect of shelf life (Figure 9). The prolonged shelf life was counted in those fruits of 'Roma VF' treated with AOS 100mg/l (11.40 days) which was statistically dissimilar from other treatment combinations. On the contrary, the shortest shelf life (4.17 days) was recorded in those fruits of 'BARI tomato 14' which was not treated by any treatment (Figure 9). The extended shelf life of tomato was counted from the fruits of 'Roma VF' which was stored in room temperature treated with 100 mg/l AOS due to the lower weight loss, less disease incidence and severity.



**Figure 9.** Effect of variety and preharvest application of AOS on shelf life of tomato.

Here, V1= Roma VF, V2= BARI Tomato 14; To= Control, T1= 25 mg/L AOS, T2= 50 mg/L AOS, T3=100 mg/L AOS and T4= 250 mg/L AOS; Vertical bars represent standard error.

## 4. Conclusion

Considering the stated finding it may be concluded that significant variation was marked due to the effect of varieties of tomato and preharvest application of AOS and also their combined effect on most of the studied parameters. Between two tomato varieties, the variety 'Roma VF' exhibited superior performance than 'BARI tomato 14' among the whole studied characteristics while AOS 100 mg/L preharvest application showed best performance compared to other treatments. Their combined effect displayed also better performance as well as the extended shelf life was recorded. So, therefore, the variety 'Roma VF' and preharvest treatment of AOS 100 mg/L alone or their combination would be highly beneficial for increasing yield and maintaining postharvest quality and extend shelf life of tomato. Further studies with other variety in different region are needed before recommendation.

## Abbreviations

AOS	Alginate Oligosaccharide
DAS	Days After Storage
BARI	Bangladesh Agricultural Research Institute
RCBD	Randomized Complete Block Design
CRD	Completely Randomized Design

## Acknowledgments

I am grateful to the Patuakhali Science and Technology

University research system for financial support to conduct the research work. I am also grateful to Prof. Dr. Heng Yin, Natural Products and Glyco-biology Laboratory, Dalian Institute of Chemical Physics, University of Chinese Academy of Sciences for providing AOS.

## Author Contributions

**Santosh Kumar Bose:** Conceptualization, Methodology, Validation, Data curation, Supervision, Writing-review and editing

**Prianka Howlader:** Methodology, Investigation, Resources, Writing original draft, Funding acquisition

## Conflicts of Interest

The authors declare no conflicts of interest.

## References

- [1] FAO. 2024. The future of food and agriculture: Trends and challenges: 1-151.
- [2] Li, Y., Wang, H., Zhang, Y., & Martin, C. (2018). Can the world's favorite fruit, tomato, provide an effective biosynthetic chassis for high-value metabolites? *Plant Cell Reports*, 37, 1443-1450. <https://doi.org/10.1007/s00299-018-2283-8>
- [3] Bertin, N., & Génard, M. (2018). Tomato quality as influenced by preharvest factors. *Scientia horticulturae*, 233, 264-276. <https://doi.org/10.1016/j.scienta.2018.01.056>

- [4] Meng, F., Li, Y., Li, S., Chen, H., Shao, Z., Jian, Y., & Wang, Q. (2022). Carotenoid biofortification in tomato products along whole agro-food chain from field to fork. *Trends in Food Science & Technology*, 124, 296-308. <https://doi.org/10.1016/j.tifs.2022.04.023>
- [5] Bhandari, R., Neupane, N., & Adhikari, D. P. (2021). Climatic change and its impact on tomato (*Lycopersicon esculentum* L.) production in plain area of Nepal. *Environmental Challenges*, 4, 100129. <http://dx.doi.org/10.1016/j.envc.2021.100129>
- [6] Yuan, L., Gai, W., Xuan, X., Ahikpa, J. K., Li, F., Ge, P., & Zhang, Y. (2024). Advances in improving tomato fruit quality by gene editing. *Horticultural Plant Journal*. <https://doi.org/10.1016/j.hpj.2024.04.008>
- [7] Sattar, S., Iqbal, A., Parveen, A., Fatima, E., Samdani, A., Fatima, H., & Shahzad, M. (2024). Tomatoes Unveiled: A Comprehensive Exploration from Cultivation to Culinary and Nutritional Significance. *Qeios*. <https://doi.org/10.32388/CP4Z4W>
- [8] Zeraatgar, H., Davarynejad, G. H., Moradinezhad, F., & Abedi, B. (2018). Effect of salicylic acid and calcium nitrate spraying on qualitative properties and storability of fresh jujube fruit (*Ziziphus jujube* Mill.). *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*, 46(1), 138-147. <https://doi.org/10.15835/nbha46110743>
- [9] Mohan, A., Krishnan, R., Arshinder, K., Vandore, J., & Ramanathan, U. (2023). Management of postharvest losses and wastages in the Indian tomato supply chain—a temperature-controlled storage perspective. *Sustainability*, 15(2), 1331. <https://doi.org/10.3390/su15021331>
- [10] Hernández, V., Botella, M. Á., Hellín, P., Fenoll, J., & Flores, P. (2022). Dose-dependent potential of chitosan to increase yield or bioactive compound content in tomatoes. *Horticulturae*, 8(12), 1152. <https://doi.org/10.3390/horticulturae8121152>
- [11] Sinha, S. R., Singha, A., Faruquee, M., Jiku, M. A. S., Rahman, M. A., Alam, M. A., & Kader, M. A. (2019). Post-harvest assessment of fruit quality and shelf life of two elite tomato varieties cultivated in Bangladesh. *Bulletin of the National Research Centre*, 43, 1-12. <https://doi.org/10.1186/s42269-019-0232-5>
- [12] Bose, S. K., Howlader, P., Jia, X., Wang, W., & Yin, H. (2019). Alginate oligosaccharide postharvest treatment preserve fruit quality and increase storage life via Absciscic acid signaling in strawberry. *Food chemistry*, 283, 665-674. <https://doi.org/10.1016/j.foodchem.2019.01.060>
- [13] Bose, S. K., Howlader, P., Wang, W., & Yin, H. (2021). Oligosaccharide is a promising natural preservative for improving postharvest preservation of fruit: A review. *Food chemistry*, 341, 128178. <https://doi.org/10.1016/j.foodchem.2020.128178>
- [14] Lane, J. H. & Eynon, L. (1923). *Journal of Society of Chemical Industry* 42, 32T.
- [15] Gomez, K. A., & Gomez, A. A. (1984). Statistical procedure for agricultural research (2nd edition). John Wiley and sons, NewYork, 680p.
- [16] Islam, H., Mondal, D. R., Malek, M. A., Howlader, P., & Bose, S. K. (2023). Effects of Alginate Oligosaccharides on Growth and Yield of Onion. *International Journal of Innovative Research*, 8(2): 40-47, 2023.
- [17] Li, Z., Duan, S., Lu, B., Yang, C., Ding, H., & Shen, H. (2023). Spraying alginate oligosaccharide improves photosynthetic performance and sugar accumulation in citrus by regulating antioxidant system and related gene expression. *Frontiers in Plant Science*, 13, 1108848. <https://doi.org/10.3389/fpls.2022.1108848>
- [18] Zhao, X., Zhang, R., Wang, W., Hong, B., Zhang, S., & Yin, H. (2022). The effects of foliar application of alginate oligosaccharide at different stage on wheat yield components. <https://doi.org/10.21203/rs.3.rs-1603067/v1>
- [19] Nitu, N. J., Ullah, M. S., Howlader, P., Mehedi, M. N. H., Meem, H. Z., & Bose, S. K. (2025). Chitosan oligosaccharides maintained postharvest quality and increased shelf life of mango. *Journal of Horticulture and Postharvest Research*, 8(1), 43-66. <http://dx.doi.org/10.22077/jhpr.2024.7888.1395>
- [20] He, Y., Bose, S. K., Wang, W., Jia, X., Lu, H., & Yin, H. (2018). Pre-harvest treatment of chitosan oligosaccharides improved strawberry fruit quality. *International journal of molecular sciences*, 19(8), 2194. <https://doi.org/10.3390/ijms19082194>
- [21] Liu, J., Kennedy, J. F., Zhang, X., Heng, Y., Chen, W., Chen, Z., & Wu, X. (2020). Preparation of alginate oligosaccharide and its effects on decay control and quality maintenance of harvested kiwifruit. *Carbohydrate polymers*, 242, 116462. <https://doi.org/10.1016/j.carbpol.2020.116462>
- [22] Supa, S. A., Howlader, P., Ali, M., Rupa, R. A., & Bose, S. K. (2024). Edible coatings maintained postharvest quality and increased shelf life of guava fruits. *Journal of Horticulture and Postharvest Research*, 7(Special Issue-Postharvest Technologies), 15-34. <http://dx.doi.org/10.22077/jhpr.2023.6531.1324>
- [23] Ullah, S. K., Nitu, N. J., Howlader, P., Mehedi, N. H., & Bose, S. K. (2025). Natural Preservatives Maintained Postharvest Quality, Reduced Decay Percentage and Increased Shelf Life of Mango. *International Journal of Horticultural Science and Technology*, 1261-1280. <https://doi.org/10.22059/ijhst.2025.379925.890>
- [24] Bose, S. K., He, Y., Howlader, P., Wang, W., & Yin, H. (2021). The N-glycan processing enzymes  $\beta$ -DN-acetylhexosaminidase are involved in ripening-associated softening in strawberry fruit. *Journal of food science and technology*, 58, 621-631. <https://doi.org/10.1007/s13197-020-04576-2>
- [25] Atlaw, T. K. (2018). Preparation and utilization of natural Aloe vera to enhance quality of mango fruit. *Journal of Food and Nutrition Sciences*, 6(3), 76-81. <http://dx.doi.org/10.11648/j.jfns.20180603.12>
- [26] Mondal, D. R., Malek, M. A., Bose, S. K., & Rahman, M. M. (2023). Effect of Postharvest Treatments on Shelf Life and Physico-Chemical Properties of Mango cv. *Amrapali*. *International Journal of Innovative Research*, 8(1), 20-25.
- [27] Liu, T. M., Wang, W., Hu, J., & Yin, H. (2017). Effects of alginate oligosaccharide preharvest treatment on the storage quality of kiwifruit. *Liaoning Agricultural Sciences*, 6, 6-10.

- [28] He, Y., Bose, S. K., Wang, M., Liu, T., Wang, W., Lu, H., & Yin, H. (2019). Effects of chitosan oligosaccharides postharvest treatment on the quality and ripening related gene expression of cultivated strawberry fruits. *Journal of Berry Research*, 9(1), 11-25. <http://doi.org/10.3233/JBR-180307>
- [29] Van Cuong, T., Thoa, N. T., & Duwoon, K. (2018). Marine alginate oligosaccharides-A promising biomaterial: current use and future perspectives in food industry and pharmaceutical applications. *Vietnam Journal of Science and Technology*, 56(2), 133-147. <http://dx.doi.org/10.15625/2525-2518/56/2/10014>
- [30] Caron, V. C., Tessmer, M. A., Mello, S. C., & Jacomino, A. P. (2013). Quality of mini tomatoes harvested at two maturity stages and kept chilled in three packages. *Horticultura Brasileira*, 31, 279-286. <http://dx.doi.org/10.1590/S0102-05362013000200017>
- [31] Bose, S., & Mondal, M. (2007). Effects of different treatments on incidence and severity of post harvest diseases and shelf life of papaya. *Journal of the Bangladesh Society for Agricultural Science and Technology*, 4(3&4), 127-130.
- [32] El-Bab, T. S. F, Mohamed, G. A., Botros, H. W. & Mahmoud, G. A. 2009: Effect of hot water treatments on microbial load, chilling injury alleviation and keeping quality of tomato fruits. *Egyptian Journal of Biotechnology*, 33, 16-33. <http://dx.doi.org/10.5897/JSPPR2016.0221>