IMPACT: International Journal of Research in Humanities, Arts and Literature (IMPACT: IJRHAL)
ISSN (P): 2347–4564; ISSN (E): 2321–8878
Vol. 7, Issue 6, Jun 2019, 485–496

EFFECTS OF POSTHARVEST APPLICATION OF HEXANAL ON PHYSICO-CHEMICAL CHARACTERISTICS OF TOMATOES (CV. *VAISHALI*) DURING STORAGE

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Received: 06 Jun 2019 **Accepted:** 10 Jun 2019 **Published:** 14 Jun 2019

ABSTRACT

The tomato fruits (Cv. Vaishali) harvested at breaker stage of their maturity were washed with clean water and subsequently treated with 500 ppm solution of fungicide benomyl. After treatment with fungicide, the hexanal treatment at variable concentrations such as 300, 600, 900 and 1200 µL-1 given to tomato fruits in four different lots at 20 oC for 24 hrs and these treated fruits were stored for investigation of different characteristics at 20 oC. Various physico-chemical parameters were recorded during storage period at subsequent time intervals of 4 days, and the findings obtained showed decreased physiological loss in weight (10%), the hue angle and hence the surface color increased from -3.24 to 3.59, TSS found increased from 1.5 to 3.1 obrix, firmness showed drastic decline from 361 to 112 gf, percent titrable acidity also changed 0.40 to 0.15 %, however AA content showed very gradual and steady decrease from 72.58 to 21.64 mg/100 g, total phenolic content showed very significant retention and only reduced from 3.80 to 3.21 mg GAE/g and lycopene content which is one of the key parameter of tomato also showed significant retention and showed up trend from 6.98 to 12.08 mg/100g respectively.

KEYWORDS: *Tomato. Hexanal, Post-harvest, Parameters, Shelf Life, Quality*

INTRODUCTION

Tomato fruits (Lycopersicumesculentum Mill) are an important part of diet worldwide. Population studies have established a link between dietary intake of tomatoes having carotenoid and lycopene compounds that can reduce risk of various maladies, like cancer and cardiovascular diseases. Tomatoes are a rich source of fibre, vitamins A, C, and lycopene and epidemiological studies indicate that increased consumption of tomato lycopenes is co-incident with a lower occurrence of cardiovascular disease (1-2).

The tomato fruits have deep red color owing to carotenoid pigment that is synthesized during fruit ripening (3). It is most widely cultivated vegetable worldwide. India ranking second in production and contributes 14 percent to the world tomato production. Presently area under tomato cultivation is 7.99 lakh ha with production of 1.95 MMT (4).

It is one of the most important vegetable crops cultivated all over the world for its fleshy fruits. Tomatoes are mainly used as fresh commodity or in various processed form. Salad tomatoes must have a flavour, colour and texture that satisfy the consumer’s preference. Canned and sun-dried tomatoes, ketchup, pastes, juices, purees, soups, sauces, and salads are important processed tomato products (5).

Since ethylene regulates the ripening behavior of most of the fruits, several technologies have been successfully used for targeting ethylene biosynthesis and ethylene action based on functional modification in recent times, number of chemicals which have their role in inhibition of ethylene have been explored both in India and abroad but, with erratic and inconsistent results particularly in a fruit like a mango and tomato. Ethylene synthesis and action in fruits can be affected by low temperature storage, controlled or modified atmosphere and application of ethylene antagonists such as silver thiosulfate, 2,5-norbornadiene, diazocyclopentadine or 1 methylcyclopropene (6). Many compounds have shown the ability to block the ethylene binding site, causing either the suppression or the inhibition of ethylene effects (7). Diazocyclopentadiene and 2,5 norbonadiene have shown the ability to control both ripening and softening of apples (8). However, none of these compounds is commercially acceptable due to toxicity and manufacturing concerns (9).

Over the past few years, a widely occurring natural aldehyde hexanalthat is generally synthesized as a result of cell destruction through lipoxyginase pathway has repeatedly proved to be improving the storage life and post-harvest quality of some temperate fruits, such as strawberries, peaches, nectarines, and cherries. Although hexanal's mode of action is not clear, a previous study has suggested that it works by inhibiting the action of the enzyme phospholipase-D which catalyzes hydrolysis of membrane phospholipids and initiates membrane deterioration and thus, fruit softening (10). Hexanal treatment results in cell membranes remaining intact and stable, causing fruits to remain firmer and fresher-looking for a longer period.

Thus hexanal, a plant hormone plays an important role in induction of plant defense against a variety of biotic and abiotic stresses through morphological, physiological and biochemical mechanisms. Function of exogenous hexanal at non-toxic concentrations has been exposed to decrease the ripening and softening of banana (11) and it has also been used for different crops to prolong their shelf life. Many physiological, biochemical and structural changes occur during fruit repining which induce starch degradation or other polysaccharides to produce sugars. Therefore, the aim of this study is to utilize the metabolic roles of hexanal to delay the ripening of tomato to extend the shelf-life and hence the present investigation was undertaken to provide a better understanding of the role of hexanal in the control of tomato fruit specifically of cv. *Vaishali* variety ripening and its effect on various physicochemical parameters during storage (11).

MATERIALS AND METHODS

The present study was carried out in the Food Technology Laboratory, University Department of Chemical Technology of Dr. Babasaheb Ambedkar Marathwada University, Aurangabad. Materials used and methods adopted for the present investigations are presented under suitable headings.

Materials, Instruments and Equipments

Tomato fruits (cv. *Vaishali*) were harvested at breaker stage of physiological maturity. The good quality analytical grade chemicals were obtained from the reputed manufacturers. The hexanal powder procured from Himedia Laboratory Chemicals Limited, Mumbai, however, Benomyl fungicide was obtained from local agro service center of Aurangabad city.

The sophisticated analytical instruments available in the Food technology laboratories were effectively and efficiently used in the present research work. The instruments like Cool Chamber (Nanolab India), Minolta Colorimeter (Model-CR-10, Konica, Japan), Handheld Digital Refractometer (PAL-3, Atago, Japan), UV Spectrophotometer, etc.

Selection of Tomato Fruits

The regional *Vaishali* variety of the tomato fruits harvested at proper green and breaker stage of their physiological maturity from the well-managed commercial farm. The fruits were washed thoroughly with clean water and then prepared for treatments.

Treatment of Hexanal

The fruits harvested at proper stage of maturity were selected, washed and graded on the basis of their specific gravity and given the fungicidal treatment of 500 ppm followed byhexanal treatment at various

Table 1: Treatment Details of Hexanal on Tomato Fruit

	Treatment Details
T_0	Control Fruit (Tomato) + 20 ^oC Storage temperature
T_1	Hexanal - 300 µL/L + 20 ^oC Storage temperature
T_2	Hexanal - 600 µL/L + 20 ^oC Storage temperature
T_3	Hexanal - 900 µL/L + 20 ^oC Storage temperature
T_4	Hexanal - 1200 µL/L + 20 ^oC Storage temperature

concentrations viz. 300, 600, 900 and 1200 µL/L concentrations for 24 hrs respectively along with absolute control sample and then stored at 20 ºC for further investigation with respect to overall quality parameters. The hexanal treatment details on tomato fruits are shown in Table 1.

Physicochemical Analysis of Tomato Fruits

Various physicochemical analyses of the control and treated fruits were carried out in order to determine the effect of treatments of hexanal on quality and shelf life extension of tomato fruit. The observations were recorded at frequent intervals of time during storage periodfor various parameters.

Physical Properties

Evaluations of the control and treated fruit were carried out in order to determine the effect of treatments of hexanal on physical quality and shelf life of tomato fruit.

Percent Physiological Loss in Weight of Fruit (%PLW)

The tomato fruits of each lot were weighed after regular interval from first day of storage till their spoilage. The weighing of tomatoes was carried out on digital weighing balance (Vibra, Essae Teraoka, Bengaluru, India) in order to record the percent physiological loss in weight (% PLW) of the fruits during successive storage days (12).

Surface Color

In present investigation, Konisca Minolta Tristimulus Colorimeter was used to assess color differences between two samples that records the readings in terms of L, a, b values. These surface color values of tomatoes were recorded using this colorimeter having CIE standard illuminant D-65and the hue angle calculated by using following formula (13).

$$\text{Hue angle } (^{\circ}h) = \text{Tan}^{-1}.(B/A).$$

Texture/ Firmness

Tomato fruits were evaluated for their firmness by using TL-Pro system software V1.18-305 of TMS-Pro Texture analyzer (Food Technology Corporation, USA). The tomato fruit was placed on sample stand below the 5 mm diameter test probe followed by 1 mm/s movement speed of the probe which travelled 10 mm inside the fruit with the help of 0.5 N trigger force. The force generated during the travelling of the test probe as a result of resistance offered by the fruit during travelling of the probe was expressed in terms of either Newton (N) or gram force (gf).

Chemical Properties

Chemical properties of the control and treated fruits were carried out in order to determine the effect of external application of hexanalphytochemical on storage quality characteristics of the cv. *Vaishali* of the tomato fruits.

Total Soluble Solids (TSS)

Portable Atago digital Refractometer (PAL-3)was used for recording the obseravtions of soluble solids percentage in tomatoes for regular interval during their storage (14). For precision and accuracy of the TSS values, the prism of refractometer was washed with distilled water and wiped dry before every reading.

Titrable Acidity (%)

Tomato juice was extracted each time for determining the total titrable acidity of hexanal treated tomato fruits (15). The juice extracted from the tomatoes titrated against the 0.1 N solution of sodium hydroxide by adding phenolphthalein as an indicator and the obtained values were expressed in terms of percentage.

Ascorbic Acid Content (mg/100g)

The ascorbic acid content of tomato fruit was estimated by using 2, 6 dichlorophenol indophenols dye titration method (16) and expressed as mg 100 g-1 of fruit.

Total Phenolic Content

Estimation of the total phenolic contents of the fruitswas carried out by using methanol and determined by reading absorbance on UV-VIS Spectrophotometer (LABINDIA-3000+plus, India) at 765 nm using Folin–Ciocalteu reagent by making slight modification in the analytical method suggested by (17). The results were expressed as gallic acid as a standard in mg gallic acid equivalents per gram (mg GAE/g) of tomato fruits.

Lycopene Content

Tomato fruits were analyzed for lycopene content by using the method suggested by (18) and modified by [19]. The estimation of lycopene was carried out by using solvents such as BHT, acetone and ethanol with the help of deionized water and therefore allowing the solvent mixture for phase separation followed by dilution of the uppermost layer of the solvent with the addition of hexanal in 1:10 proportion. Thereafter, the absorbance of the sample was measured at 503 nm by using UV-VIS Spectrophotometer (LABINDIA-3000+plus, India).

$$\text{Lycopene } (\mu g/g) = \frac{\text{Absorbance} \times 31.2 \times \text{Dilution}}{\text{gram of sample}}$$

Statistical Analysis

The present research work was carried out by following completely randomized design (CRD) with factorial arrangements for the each lot of tomato fruits of cv. *Vaishali* and analysis was also carried out accordingly. The obtained research data with respect to the all physic-chemical parameters was then processed for one-way analysis of variance (ANOVA) at 5% level of least significance by using statistical analytical software SPSS-14.0 (LEAD Tools, Lead Technologies®, USA).The means were compared by the Least Significant Difference (LSD) test ($p \leq 0.05$). Storage duration (days) and treatments were considered as two factors as an independent variables.

RESULTS AND DISCUSSION

The results obtained with respect to various physico-chemical, sensorial characteristics and shelf life of tomato fruits during storage period is presented and discussed under suitable headings and subheadings in this chapter.

Effect of Hexanal on Physiological Loss in Weight (PLW) of Tomato Fruit (%)

Statistically significant ($P < 0.05$) difference was observed in percent PLW values. Percent physiological loss in weight (%PLW) is important physical quality parameters deciding wholesomeness and shelf life of any natural products. The stage change from development to senescence which comes about into deterioration of natural product is distinguished by these quality parameters. The loss of weight is one of the fore most imperative variables dependable for natural product quality weakening.

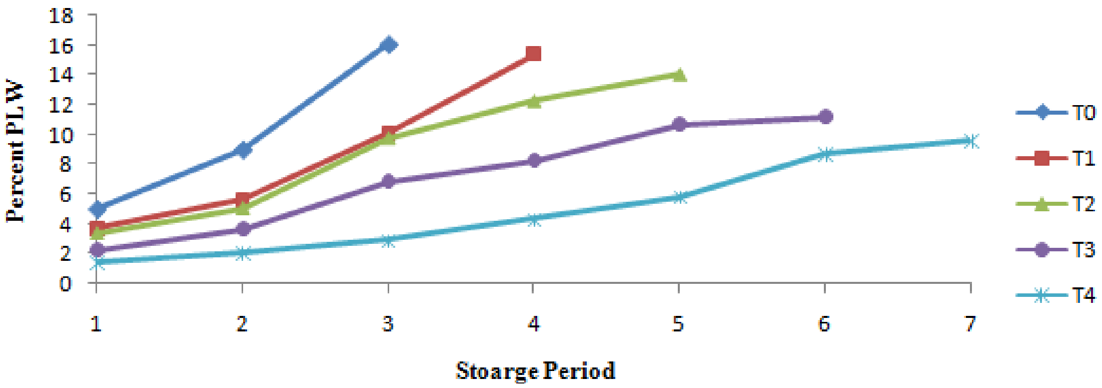


Figure 1: Effect of Hexanal on Physiological Loss in Weight (PLW) of Tomato Fruits (%).

The results presented in Figure 3for the effect of hexanal on physiological loss in weight (PLW) of tomato fruit indicated that PLW of tomato increased during the period of storage under study and exhibited statistically significant difference ($P < 0.05$). Results showed that, PLW of control sample increased from 4.0 to 13.1 within 12 days of storage. The tomatoes which were treated at 1200 μL/L hexanal concentration showed very gradual increase in PLW from 3.0 to 10.0 on 28 days of their shelf life with better retention of quality parameters than any other treatments. The increases in PLW of tomato might be due to the transpiration of tomato in the 20^{0}C storage condition and results were found in close proximity with (20, 12).

Effect of Hexanal Treatment on Surface Colour of Tomato Fruits

As shown in Table 2, hue angle measures the lightness (L) of fruit, which gave values in L, a and b which goes on changing. The L values decreased in the last days of storage period and hue angle goes on changing.

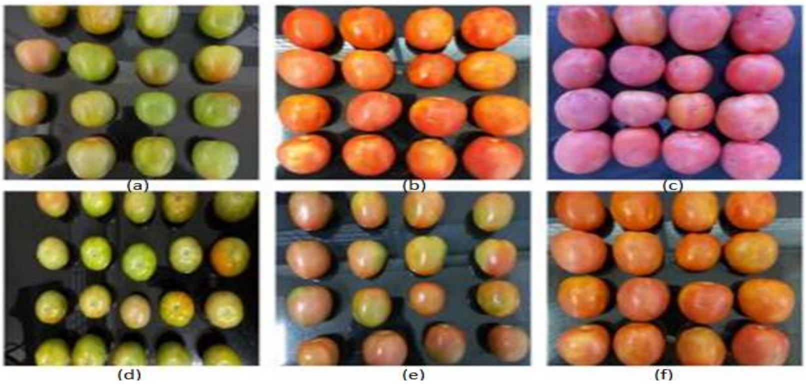
Table 2: Effect of Hexanal on Surface Color (Hue Angle) of Tomato Fruits

Treatments	Storage Period (Days)							
	0	4	8	12	16	20	24	28
T_0	-3.30±0.1	1.77±0.3	2.49±0.5	5.0±0.5	*	*	*	*
T_1	-3.38±0.3	1.37±0.2	1.79±0.3	2.47±0.6	4.67±0.8	*	*	*
T_2	-3.11±1.0	1.37±0.8	1.39±0.9	2.87±0.7	3.81±1.2	4.35±0.2	*	*
T_3	-3.26±0.4	2.57±0.5	2.74±0.7	3.14±0.5	3.38±0.7	3.57±0.4	4.24±0.2	*
T_4	-3.24±0.1	1.24±0.3	1.57±0.4	1.87±0.9	2.44±0.9	2.57±0.8	3.34±0.3	3.59±0.1

T0: Control T1:50 ppm T2: 100 ppm T3: 150ppm T4: 200ppm *Discarded due to spoilage

-Assessed by ANOVA and post hoc multiple pairwise LSD test at P<0.05

Control test showed statistically significant ($P \leq 0.05$) falling down from -3.30 to 5.0 within 12 days of storage period which was much drastic as compared with T_4tests which were treated with 1200 μL/L hexanal showed moderate changes in color values up to their maximum shelf life of 28 days.



*(a), (b) and (c) are the control samples at intervals of 1, 4 and 12 days respectively
*(d), (e) and (f) are hexanal treated samples at intervals of 1, 16 and 28 days respectively

Figure 2: Effect of Hexanal Treatment on Tomato Fruits (cv. Vaishali) during Storage.

The surface color of tomatoes in T_4 treatment appeared turning red from its faint yellow color in progressive way which is very critical and worthy as compared with other medicines [21, 13].

Effect of Hexanal Treatments on Firmness of Tomato Fruits

Statistically significant ($P \leq 0.05$) difference was observedas shown in Figure 4 values of firmness in terms of gram force or Newton.

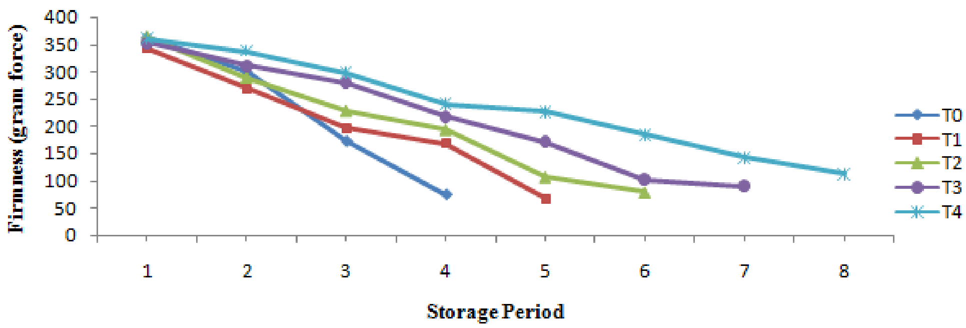


Figure 3: Effect of Hexanal on Firmness of Tomato Fruits (gf).

Higher values demonstrates firm or rigid surface of tomatoes which could be a great marker of the development stage of a fruit and subsequently valuable in deciding quality at a specific storage period.

Noteworthy retention of shelf life was observed in tomatoes treated with hexanal as compared with untreated control tomato fruits. The best results for the tomatoes with 1200 µL/L hexanal in which the conclusive28 days shelf life, having 112 gram force firmness found distant superior than the control and rest of the tomato fruits which endured for 12 days with 74 gram force firmness (22).

Effect of Hexanal Treatment on TSS of Tomato Fruits

Least significant difference (P > 0.05) was observed in terms of Total soluble solids content (TSS) is major quality parameters of the fruits and indicates the degree of ripening. The effect of hexanal concentrations, exposure time and storage temperatures on the TSS content of fruits were studied and the results obtained are presented in Table 3.

Table 3: Effect of Hexanal Treatment on TSS (Brix) of Tomato Fruits

Treatments	Storage Period (Days)							
	0	4	8	12	16	20	24	28
T_0	1.4±0.3	1.6±0.1	2.0±0.8	2.7±0.8	*	*	*	*
T_1	1.3±0.2	1.6±0.3	2.0±0.8	2.1±0.1	2.5±0.5	*	*	*
T_2	1.5±0.1	1.8±0.5	2.0±0.7	2.2±0.9	2.8±0.1	3.0±0.5	*	*
T_3	1.3±0.8	1.6±0.7	1.7±0.1	1.9±0.2	2.0±0.7	2.2±0.6	3.3±0.6	*
T_4	1.5±0.5	1.6±0.8	2.0±0.7	2.2±0.4	2.4±0.5	2.8±0.1	3.0±0.7	3.1±0.7

T_0: Control T_1:50 ppm T_2: 100 ppm T_3: 150ppm T_4: 200ppm *Discarded due to spoilage
-Assessed by ANOVA and post hoc multiple pair wise LSD test at P<0.05.

The tomato fruits which were exposed to hexanal treatment showed very slight change in TSS except the control fruits which showed rapid change in TSS from 1.4 to 2.7 ^{o}brix within very less shelf life of only 12 days as compared with hexanal treated fruits at 1200 µL/L which was having shelf life of 28 days. The TSS of tomatoes having given the T_4 treatment was 3.1^{o}brix even on 28th day of its storage period which was superior to any other treatments (23, 14).

Effect of Hexanal Treatment on Titrable Acidity (%) of Tomato Fruits

There was a significant difference (P ≤ 0.05) statistically found in titrable acidity which is the most useful parameters which determine the wholesomeness of any fruits as far as the keeping quality fruits is concerned. Table 4 shows the effect of hexanal treatment on percent titrable acidity of the tomatoes.

Table 4: Effect of Hexanal Treatment on Titrable Acidity (%) of Tomato Fruits

Treatments	Storage Period (Days)							
	0	4	8	12	16	20	24	28
T_0	0.40±0.6	0.32±0.5	0.27±0.4	0.13±0.4	*	*	*	*
T_1	0.39±0.1	0.33±0.2	0.28±0.3	0.19±0.9	0.15±0.7	*	*	*
T_2	0.37±0.7	0.32±0.3	0.29±0.5	0.23±0.1	0.21±0.8	0.15±0.3	*	*
T_3	0.41±0.7	0.37±0.5	0.33±0.1	0.29±0.5	0.24±0.7	0.17±0.8	0.15±0.8	*
T_4	0.40±0.7	0.36±0.5	0.34±0.1	0.29±0.5	0.27±0.8	0.23±0.1	0.19±0.2	0.15±0.1

T_0: Control T_1:50 ppm T_2: 100 ppm T_3: 150ppm T_4: 200ppm *Discarded due to spoilage
-Assessed by ANOVA and post hoc multiple pairwise LSD test at P<0.05.

The tomatoes treated with hexanal at 1200 µL/L and stored at 20^{o}C temperature recorded highest shelf life of 28 days with significant decrease in the titrable acidity from 0.40 to 0.15. This change in percent titrable acidity was gradual and acceptable as compared to other treatments. In control fruits which kept good only for 12 days, the acidity changed drastically from 0.40 to 0.13 percent. Similar findings were reported by (24, 25).

Effect of Hexanal Treatment on Ascorbic Acid Content (mg/100g) of Tomato Fruits

Generally ascorbic acid content of any fruits decreases during the length of its storage period, therefore estimation of its content at regular time intervals during storage indicates keeping quality characteristics of the stored fruits at a particular time period. Table 5 shows the ascorbic content of all the treatments during storage study of the fruits.

Table 5: Effect of Hexanal Treatment on Ascorbic Acid Content (mg/100g) of Tomato Fruits

Treatments	Storage Period (Days)							
	0	4	8	12	16	20	24	28
T_0	74.58±0.8	62.61±0.5	41.23±0.6	24.12±0.1	*	*	*	*
T_1	74.19±0.2	64.51±0.4	48.59±0.8	41.81±0.1	23.27±0.3	*	*	*
T_2	73.47±0.5	68.93±0.7	50.19±0.9	45.2±0.1	37.29±0.2	24.12±0.5	*	*
T_3	73.17±0.4	69.27±0.3	55.37±0.7	47.46±0.9	42.94±0.9	36.16±0.1	23.1±0.5	*
T_4	72.98±0.5	67.35±0.9	49.72±0.5	44.07±0.7	40.68±0.5	37.29±0.2	36.42±0.4	31.64±0.5

T_0: Control T_1:50 ppm T_2: 100 ppm T_3: 150ppm T_4: 200ppm *Discarded due to spoilage
-Assessed by ANOVA and post hoc multiple pairwise LSD test at P<0.05.

There was a significant difference ($P \leq 0.05$) in ascorbic acid content among hexanal treated and untreated fruits. Ascorbic acid content in fruits treated with highest hexanal concentration was found to be reduced gradually from 72.98 to 31.64 mg/100g upto 28th day of its storage life. However ascorbic content in in untreated control fruits reduced drastically from 74.58 to 24.12 mg/100g within only 12 days of their shelf life (26-28).

Effect of Hexanal Treatment on Total Phenolic Content of Tomato Fruits

During storage of the hexanal treated tomato fruits, the total phenolic contents of the fruits didn't showed any drastic changes.

Table 6: Effect of Hexanal Treatment on Total Phenolic Content (mg GAE/g) of Tomato Fruits

Treatments	Storage Period (Days)							
	0	4	8	12	16	20	24	28
T_0	3.73±0.3	3.39±0.5	3.01±0.6	2.87±0.8	*	*	*	*
T_1	3.68±0.5	3.63±0.8	3.42±0.2	3.21±0.1	2.91±0.5	*	*	*
T_2	3.85±0.8	3.78±0.5	3.67±0.7	3.53±0.8	3.29±0.5	3.11±0.1	*	*
T_3	3.97±0.1	3.74±0.7	3.63±0.8	3.56±0.8	3.38±0.2	3.27±0.1	3.18±0.5	*
T_4	3.82±0.2	3.73±0.3	3.66±0.8	3.59±0.8	3.51±0.7	3.43±0.4	3.34±0.2	3.22±0.5

T_0: Control T_1:50 ppm T_2: 100 ppm T_3: 150ppm T_4: 200ppm *Discarded due to spoilage
-Assessed by ANOVA and post hoc multiple pairwise LSD test at P<0.05.

However, the decrease in total phenolic content of the untreated fruits was slightly rapid as compared with treated fruits as shown in Table 6. Moreover, the fruit treated with 1200 µL/Lhexanal concentration had shown significant retention of total phenolic content and decrease in the total phenolic was very gradual i.e. least significant difference observed ($P > 0.05$) from 3.82 to 3.22 mg GAE/g at the end of its shelf life of 28 days which found closely related with the research findings published by (29).

Effect of Hexanal Treatment on Lycopene Content of Tomato Fruits

From the lycopene values mentioned in Table 7, it clearly depicts that the untreated tomato fruits showed a sudden increase in lycopene content due to rapid ripening.

Table 7: Effect of Hexanal Treatment on Lycopene Content (mg / 100 g) of Tomato Fruits

Treatments	Storage Period (Days)							
	0	4	8	12	16	20	24	28
T_0	6.98±0.3	8.25±0.5	10.63±0.8	12.19±0.3	*	*	*	*
T_1	7.02±0.1	8.01±0.8	9.89±0.3	11.63±0.7	12.22±0.6	*	*	*
T_2	6.89±0.8	7.87±0.7	9.13±0.5	10.69±0.8	11.13±0.9	12.20±0.1	*	*
T_3	6.94±0.7	7.73±0.1	8.97±0.2	9.98±0.1	10.87±0.8	11.46±0.9	12.23±0.1	*
T_4	6.98±0.3	7.59±0.9	8.48±0.7	9.73±0.2	10.59±0.5	11.31±0.2	11.97±0.7	12.08±0.1

T_0: Control T_1:50 ppm T_2: 100 ppm T_3: 150ppm T_4: 200ppm *Discarded due to spoilage
-Assessed by ANOVA and post hoc multiple pairwise LSD test at P<0.05.

The fruits treated with hexanal showed a gradual increase in lycopene content which was statistically significant(P ≤ 0.05) specifically in case of 1200 µL/L treated fruits the lycopene content was increased gradually from 6.98 to 12.08 mg/100 g which shows the enhanced length of tomato ripening which increased its shelf life up to 28 days and found best as compared with control and other treatments. Similar findings were reported by (30-33) in tomatoes stored in different conditions.

CONCLUSIONS

From the present investigations it was concluded that when hexanal concentration was increased from 300 to 1200 µL/L, there was increase the shelf life. It was observed that the shelf life was recorded higher (28 days) in the fruit. The effect of storage temperatures of treated fruits (20 ^{o}C) on shelf life was also investigated and recorded the highest shelf life (28 days) at 20 ^{o}C storage temperature as compared to the control sample storage (12 days) as shown in Table 7. Hexanal has potential to maintain the physico-chemical properties by delaying the ripening process and retarding the internal gaseous changes which occurs during storage. It can be concluded from the current experiment that hexanal is a valuable for postharvest treatment for enhancing the shelf life of tomato fruit. Furthermore, it could be suggested for usage in international markets as well as local for extending shelf life of horticultural product. Hexanal treatment can be easily and safe usage to delaying/shifting ripening processes of tomato with improving fruit quality during shelf-life.

ACKNOWLEDGEMENTS

The authors are highly thankful to CSIR, MHRD, Government of India, New Delhi for providing fellowship as SRF to the research scholar.

Author's Contributions

All authors have contributed equallyin data collection, experimental trials, analytical procedures, writing manuscript, corrections in the manuscript, statistical analysis, cross checking the data with respect to accuracy and precision of the findings.

Conflicts of Interest/Competing Interests

There is neither competing interest nor any conflict between the authors for publication of this original research work.

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