IJPPHT
e ISSN-2231-6426

Volume 8 | Issue 1 | June, 2017 | 29-36
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International Journal of Processing and Post Harvest Technology

RESEARCH PAPER

DOI: 10.15740/HAS/IJPPHT/8.1/29-36

Effect of modified atmosphere packaging on storage life and quality of cherry tomato under ambient conditions

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Research chronicle : Received : 05.04.2017; **Revised :** 10.05.2017; **Accepted :** 23.05.2017

SUMMARY :

Freshly harvest tomato after washing with water packaged in LDPE packages of various thicknesses *viz.*, 25, 37.5 and 50µm and 0, 4 and 8 perforations of 1.0 mm diameter each and a separate sample was taken for comparison under ambient storage conditions (31.2±2°C and 74.5±3% RH) with a view to improve the storage life and quality. Packaged fruit were assessed for Gas concentrations (O_2 and CO_2) and quality parameters such as PLW, colour, firmness, lycopene content, TSS, titrable acidity and sensory evaluation. Results obtained were analyzed statistically with the help of ANOVA and DMRT ($\alpha = 0.05$). Higher O_2 concentration (16.10%), lower CO_2 evolute (7.41%) was observed in 37.5 µm packaging with 8 perforations. Lower PLW was observed to be 3.78 per cent and 3.97 per cent of initial weight in non-perforated 25µm and 37.5µm, respectively. TCD was observed to lowest (8.10) and firmness better retained by 37.5µm with 8 perforation. Among all the treatments, 37.5µm LDPE packages with 8 perforations were found to be the best package and cherry tomato could be stored for upto 12 days ambient storage conditions.

KEY WORDS : Cherry tomato, Modified atmosphere packaging, Total colour difference (TCD), Physiological loss weight (PLW), Sensory evaluation

How to cite this paper : Narang, Rohit, Sharma, S.R., Mittal T. C. and Kumar, Ankit (2017). Effect of modified atmosphere packaging on storage life and quality of cherry tomato under ambient conditions. *Internat. J. Proc. & Post Harvest Technol.*, **8** (1) : 29-36. **DOI: 10.15740/HAS/IJPPHT/8.1/29-36.**

Fruits and vegetables form an essential component of the nourishment in India, where the principal population is vegetarian and thus vegetable cultivation is a remarkable section of the agricultural economy (Chandrasekharam, 2012). Tomato (*Lycopersicon esculentum*, Mill) is one of the most widely consumed vegetables in the world. The production of tomato in India is 18,736,000 million tonnes and the area under cultivation is 882,000 hectare (Anonymous, 2015). Organic products like tomato, post harvest taking care of is as basic as creation practices because of their delicate nature. Post harvest losses may occur at any stage in the handling system from harvesting through storage and marketing to final delivery to the consumer. Due to its climacteric nature, tomato is highly perishable especially in tropical and subtropical areas. Nearly 30-50 per cent of the produce is lost after harvest because of inadequate handling and preservation (Inaba and Crandall, 1986). Fresh-market tomatoes are a well-known and organic product, making remarkable contributions to human nutrition all through the world for their contents of sugar, acid, vitamins, minerals, lycopene and other carotenoids, among different constituents (Simonne *et al.*, 2006 and Toor and Savage, 2006).

Being a climacteric and perishable natural product, cherry tomatoes have a short life expectancy, for the most part 11-14 days (Gharezi *et al.*, 2012). The little nibbling size tomatoes (cherry, grape sort) comprise high convergences of sugars and acids, main provider to tomato aroma, plus now incorporate around 24 per cent of retail offers of tomato in the United States. (Anonymous, 2008). Post harvest proposals demonstrate that tomatoes, containing cherry and grape tomatoes, ought to be put away at 10°C or higher to abstain from chilling damage (Jimenez *et al.*, 1996 and Roberts *et al.*, 2002) also Maul *et al.* (2010) stated that tomato's aroma quality might be hindered if it is stored at 10°C. The rich red colour of tomato is due to the constituent lycopene which is also an antioxidant that diminishes the threat for prostate cancer in males also decrease heart illness.

Packaging is one of the fundamental advances for reducing or postponing the physical, chemical and microbiological changes that take part in fruits and vegetables after harvesting, in this manner the loss of quality and acceptability during distribution and marketing. Thus taking into consideration problems related to post harvest storage of cherry tomato, and potential of MAP to overcome these. Two types of MAP are common *viz.*, active packaging and passive packaging (Ahvenainen 1996). Small amount of O_2 (3-5%) atmosphere postpone tomato maturing while high amount of CO_2 (>5%) are viewed as harmful for tomatoes. Little O_2 damage is portrayed by irregular maturing and off-odor because of increment in ethanol and acetaldehyde. CO_2 level more than 5 per cent may bring out surface discoloration, softening, and irregular coloring (Leshuk and Saltveit, 1990 and Sargent and Moretti, 2004). The present research is proposed with these objectives *i.e.* to identify the suitable packaging materials for extending the storage life of cherry tomato and to access the impact of modified atmosphere packaging and storage conditions on enhancing storage life of cherry tomato.

EXPERIMENTAL METHODS

Raw material and sample preparation :

Freshly harvested Punjab red cherry tomato assortment was obtained in April from Vegetable Farm, PAU, Ludhiana. The harvested cherry tomato was transported immediately and carefully loaded and carried in nylon bag so that there was no mechanical injury to the fruit during transportation from farm to Fruits and Vegetables Pilot plant, Department of PFE (Processing and Food Engineering), Punjab Agricultural University. The fruit was then physically washed and sorted out to remove any damaged and diseased fruit. For the experiment 200 g of cherry tomato weighed and packaged in LDPE bags of 25, 37.5 and 50 µm thickness with 0, 4, 8 perforations each having a diameter of 1mm. The packages were then heat sealed with the assistance of sealing machine and the control samples were kept loose.

Experimental design:

Punjab red cherry was a new variety of Punjab and was packed in LDPE packaging material in various thicknesses with 3 types of perforations provided *viz.,* 0, 4 and 8 and stored under ambient temperature of 31.2 ± 2°C and RH was 74.5 ± 3 per cent. Observations were recorded at alternate day such as Gas composition, PLW (Physiological loss in weight), Color, Firmness, Lycopene content, TSS (Total soluble solids), titratable acidity, and sensory evaluation.

Ambient storage condition:

The cherry tomato was stored under ambient storage conditions in the fruits and vegetables pilot plant where the temperature was 31.2 ± 2°C and relative humidity was 74.5 ± 3 per cent. The samples were stored in the packages as well as without packages *i.e.* control.

Storage study of cherry tomato :

In-package gas arrangement examination (as far as O_2 and CO_2 focus), PLW (physiological loss in weight), color, firmness, lycopene content, total soluble solids, titratable acidity and sensory assessment of the cherry tomato were observed. The observations were recorded at an interim of 2 days at ambient storage conditions.

In pack gaseous composition :

The gas composition in the head space of package was dissected with the assisstance of gas analyzer (Make: PBI Dansensor; Model; checkpoint II portable gas analyser).

Physiological loss in weight (PLW) :

The physiological loss in weight (PLW) was examined by measuring the individual package at first and on day of perception using a laboratory level measuring scale. The PLW at each interim was calculated as **(**Moneruzzaman *et al.*, 2009)

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

Total colour differance :

The colour of samples was measured utilizing Miniscan XE plus Hunter lab colorimeter. Three required functions total color difference (ΔE), chroma and hue angle were calculated from the 'L', 'a' and 'b' readings as follows (McGuire, 1992).

$$\Delta E = \sqrt{[(L-L_o)^2+(a-a_o)^2+(b-b_o)^2]}$$

$$\text{Chroma} = \sqrt{(a^2 + b^2)}$$

$$\text{Hue angle} = \tan^{-1}(b/a)$$

where L_o, a_o and b_o represents the respective readings of fresh samples.

Firmness :

The textural characteristics of cherry tomato were studied using texture analyser (Make: Stable Micro Systems, Model: TA.TXT. Plus).

Puncture test :

This test characterized by a penetration of the punch into the fruit sufficient to cause irreversible changes using a 2mm stainless steel probe. The following test settings were used:

Test	Return to start
Probe	P/2N Needle
Pre-test speed	5 mm/s
Test speed	1 mm/s
Post speed	10 mm/s
Distance	10mm

The fruit sample was kept at the centre of the base of the texture analyser, which was exactly beneath the probe attached to the load cell. Puncture force was obtained from peak point of the force-distance curve in the test.

Lycopene content :

Lycopene was a pigment responsible for the color of the cherry tomato. A known weight of tomato was crushed in pestle and mortar and the pigment *i.e.* lycopene were extracted using 10ml of acetone. The extract was covered with aluminum thwart to counteract photo-bleaching. Consolidated blend was at last put on shaker at 140 rpm for 30 minutes and then centrifuged at 12000 rpm for 15 min. Final volume of supernatant was made to 100 ml by adding acetone. Lycopene content was estimated by taking absorbance at 503 nm (Sozzi *et al.*, 1998).

Lycopene content (mg/100g) = (31.206 x A503)/W

where,

A = Absorbance at specific wavelengths

W= Fresh weight of tissue extracted

Total soluble solids :

The TSS content of the product was measured utilizing an advance refractometer (AOAC, 1995). Every specimen was cut into two pieces. Every piece was further isolated into 3 sections, so there were 6 sections (replications) for every estimation per fruit. The juice from every part was separted manually (> 2 drops) and after that put into the refractometer. The value of soluble solids content was communicated in Brix per cent.

Titratable acidity :

A representative sample of 3 tomatoes was taken and juice extracted. About 2 ml of this juice was taken and titrated against N/10 NaOH solution with phenolphthalein as indicator and pink color as end point (Ranganna, 1991). The volume of NaOH used was recorded and acidity was computed as follows:

Acidity (g/100ml of juice) = (0.64 X)/Y

where,

X = ml of N/10 NaOH used

Y = ml of sample taken for titration

Sensory evaluation :

A panel was made and individual members were briefed about the sensory attributes that should be judged. Sensory assessment rating scales were given in light of which the rating was given to various specimen. The normal estimations of the appraisals given by every one of the individual were then calculated.

The specimen was inspected at pre-decided interim by a panel constituted with the end goal of sensory evaluation. The sensory evaluation scale for rating the sensory assessment of stored cherry tomato were created on the basis of three principle parameters *i.e.* visual appearance, odour and water accumulation and these quality attributes of the specimen were analyzed by utilizing the rating scales proposed by Deza (2003); Pernin and Gaye (1986) and Rai *et al.* (1999), respectively. The standard conditions such as excellent, good etc. were defined.

Visual appearance; 9= Excellent, 7= Good: slight (1-5%) browning, 5= Normal: moderate (5-10%) browning, 3= Limited Quality: Severe (10-50%) browning, 1= Not acceptable: Extreme (>50%) browning. Odour was scored as: 1=Normal (no off odour), 2= Slight off odour, 3= Moderate off odour, 4= Severe off odour, 5=Not acceptable. Water accumulation was scored as: 9= no water accumulation, 7= Fruit slightly wetty, 5= Fruit and film slightly wetty, 3= Fruit moderately wetty, 1=Fruit and film moderately wetty, 0= Fruit completely wetty and dripping of water.

Statistical analysis :

The statistical analysis of data obtained was carried out to establish the difference among treatments. All the experiments were performed in triplicate. One way analysis of variance (ANOVA) and Duncan's multiple range tests (DMRT) ($\alpha = 0.05$) were used to determine statistically significant differences between treatments, concerning the Gas concentrations (O_2 and CO_2) and quality parameters such as physiological loss in weight (PLW), color, firmness, lycopene content, TSS, titrable acidity, and sensory attributes. Evaluations were based on a $P = 0.05$ significance level.

EXPERIMENTAL FINDINGS AND ANALYSIS

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Gaseous concentration :

Oxygen:

The O_2 concentration varied from 20.9 per cent to 0.20 per cent irrespective of the packaging material thickness and as well as perforation seen collectively as shown in Table 1. It was evident from the O_2 concentration examined in every non-perforated package that O_2 concentration diminished with rise in the thickness of the package as a result of decrease in the permeability of every package This might be due to the fact that non-perforated packages facilitated very little gas exchange as compared to perforated packages and thus, the O_2 concentration fell drastically. Highest oxygen concentration 16.10 per cent was observed in 37.5 µm LDPE packaging with 8 perforations as it allows better gaseous exchange with the environment.

Carbon-dioxide:

It was evident from the CO_2 concentration examined in every non-perforated package that CO_2 concentration increased with an increase in the thickness of the package because of the decrease in the permeability of each package, which posed restriction to the CO_2 for its dissipation from the package. The CO_2 concentration varied from 0.03 per cent to 18.30 per cent irrespective of the packaging material thickness and as well as perforation seen collectively as shown in Table 2. Low carbon-dioxide evolution was observed 7.10 per cent and 7.41 per cent in 25 µm and 37.5 µm LDPE packaging with 8 perforations as it better interact with gaseous environment.

Table 1 : Oxygen concentration (%) in LDPE packages of various thicknesses under ambient storage conditions of cherry tomato

	O_2 concentration (%)								
	Treatments								
Storage period	100 µm LDPE package			37.5 µm LDPE package			50 µm LDPE package		
(days)	A	B	C	D	E	F	G	H	I
0	20.90	20.90	20.90	20.90	20.90	20.90	20.90	20.90	20.90
2	14.80	19.10	20.20	12.90	18.70	19.90	9.02	18.10	19.75
4	11.80	17.90	18.70	10.50	17.30	18.54	5.90	17.04	18.40
6	8.90	16.70	18.10	8.40	16.40	17.80	3.40	16.10	17.50
8	6.45	15.80	17.40	5.30	15.70	17.40	1.70	14.40	16.60
10	4.90	14.30	16.90	3.70	13.90	16.70	0.90	12.10	15.20
12	2.50	12.50	15.80	1.80	11.80	16.10	0.20	9.90	14.40

Physiological loss in weight (PLW):

The PLW in different LDPE packages having cherry tomato was examined at predefined interims of time throughout the ambient temperature storage condition and was conveyed in percentage as shown in Table 3. It was perceived that with the increase in storage period, the physiological loss in weight (%) increased. The PLW was maximum (25.20% on the 12th day) in the control samples *i.e.* for unwrapped cherry tomato. PLW ranges from 0.23 per cent to 4.79 per cent on different packages seen collectively. Lower PLW was observed to be 3.78 per cent and 3.97 per cent in non-perforated in 25 µm and 37.5 µm, respectively. The reason might be that polyethylene packages restricted the moisture removal by creating a barrier to transpiration but unpacked cherry tomato loses their moisture to the surroundings rapidly.

Total color difference (aE):

The TCD (ΔE) values in different LDPE packages having cherry tomato were examined at predefined interims of time during the ambient storage condition as shown in Table 4. The rise in ΔE values indicated colour variation. It was perceived that as the storage period increase the ΔE value too increase. The ΔE Value was maximum among (36.25) in the control samples *i.e.* for unpacked cherry tomato. Lower ΔE (8.10) was observed in 37.5 µm LDPE packaging with 8 perforations. Total colour difference showed variation from 3.42 to 36.25 seen collectively. It was obvious from the ΔE values measured for cherry tomato in each package that the non-perforated LDPE packages showed maximum variation after control package. Minimum variation being seen in 37.5 µm LDPE package with 8 perforations followed by 25 µm LDPE package with 8 perforations.

Firmness:

The firmness in distinct LDPE packages having tomato was examined at predefined interims of time during ambient storage condition as shown in Table 5. The firmness was observed to be decreasing with increase in the storage period the firmness value decreased rapidly under ambient temperature storage condition and was observed to be lowest in the control sample *i.e.* for unwrapped cherry tomato (0.12 kg on the 12th day). Better firmness 5.61 and 4.68 was retained by 37.5 µm and 25 µm LDPE packaging with 8 perforations. In all the

Table 2 : Carbon-dioxide concentration (%) in LDPE packages of various thicknesses under ambient storage conditions of cherry tomato

Storage period (days)	CO_2 concentration (%) – Treatments: 25 µm LDPE package			37.5 µm LDPE package			50 µm LDPE package		
	A	B	C	D	E	F	G	H	I
0	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
2	6.70	2.90	2.64	6.81	3.20	2.71	9.50	5.50	3.70
4	9.50	4.50	4.15	9.90	4.80	4.23	12.40	8.50	5.10
6	11.60	6.40	4.90	12.10	7.10	5.10	14.70	10.20	6.90
8	12.80	7.50	5.60	13.20	8.60	5.90	16.20	12.80	8.50
10	15.30	10.90	6.34	15.80	11.50	6.64	16.80	15.00	9.30
12	17.00	13.40	7.10	18.10	14.30	7.41	18.30	17.20	11.90

Table 3 : PLW (%) in LDPE packages of various thicknesses under ambient storage conditions for cherry tomato

Storage period (days)	Physiological loss in weight (PLW) – Treatments: 25 µm LDPE package			37.5 µm LDPE package			50 µm LDPE package			Control
	A	B	C	D	E	F	G	H	I	J
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.23	0.42	0.74	0.28	0.56	0.85	0.33	0.75	1.15	6.29
4	0.76	1.24	1.48	0.95	1.42	1.74	1.04	1.68	2.05	11.54
6	1.53	1.95	2.14	1.75	2.26	2.49	1.97	2.64	2.84	17.71
8	2.15	2.85	3.54	2.34	3.12	3.21	2.53	3.39	3.46	21.23
10	2.87	3.67	4.12	3.09	3.57	3.8	3.31	3.72	3.87	23.70
12	3.78	4.53	4.79	3.97	4.20	4.35	4.16	4.53	4.75	25.20

packages of various thicknesses, the cherry tomato in non-perforated packages had the lowest firmness as compared to cherry tomato in packages having perforation. The reason might be that the anaerobic condition prevailing in packages damaged the tissue and hence a significant loss in firmness took place.

Lycopene content:

The lycopene content (mg/100g fw) in distinct LDPE packages having cherry tomato was examined at predefined interims of time during the ambient storage condition as shown in Table 6. The lycopene content was observed to be increase with increase in storage period. The lycopene content was maximum in open sample *i.e.* for unpacked cherry tomato.

Lycopene content was better retained (9.2 mg/100g fw) in 37.5 µm LDPE packaging with 8 perforations. It was observed from the lycopene content measure for cherry tomato in each non-perforated package that lycopene content increase with an increase in thickness of package. It was also observed that lycopene content was less in non-perforated than in perforated packages. It might be due to desirable O_2 and CO_2 concentration which led to ripening of the cherry tomato.

Table 4 : 'aE' values in LDPE packages of various thicknesses under ambient storage conditions for cherry tomato

Storage period (days)	Total colour difference (ΔE)									
	Treatments									
	25 µm LDPE package			37.5 µm LDPE package			50 µm LDPE package			Control
	A	B	C	D	E	F	G	H	I	J
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	6.62	5.63	3.63	6.24	5.27	3.42	7.05	5.83	4.09	13.54
4	10.75	6.62	4.38	8.76	7.01	4.15	11.25	7.06	5.24	19.79
6	14.84	8.03	5.67	12.18	7.85	5.19	15.04	8.54	6.53	22.28
8	16.45	10.14	6.59	15.74	9.57	5.97	16.96	10.72	7.67	27.28
10	18.21	12.27	7.69	16.64	11.15	7.05	18.79	12.64	8.41	33.46
12	20.18	14.62	8.45	18.92	13.41	8.10	20.95	15.01	9.23	36.25

Table 5 : Firmness (kg) for cherry tomato in LDPE packages of various thicknesses under ambient storage conditions

Storage period (days)	Firmness (puncture test)									
	Treatments									
	25 µm LDPE package			37.5 µm LDPE package			50 µm LDPE package			Control
	A	B	C	D	E	F	G	H	I	J
0	10.51	10.51	10.51	10.51	10.51	10.51	10.51	10.51	10.51	10.51
2	5.32	8.15	9.18	7.19	9.02	9.77	5.25	7.18	8.06	3.05
4	4.25	6.21	7.96	5.36	6.97	9.10	3.25	4.91	7.04	1.97
6	2.55	5.05	6.94	4.24	5.63	7.89	1.97	3.74	6.49	1.45
8	1.31	3.98	5.89	3.35	4.52	6.85	1.62	2.56	4.87	0.54
10	0.88	2.83	5.05	2.80	3.97	6.17	1.04	1.63	3.41	0.29
12	0.54	2.04	4.68	2.23	3.34	5.61	0.76	1.14	2.26	0.12

Table 6 : Lycopene content for cherry tomato in LDPE packages of various thicknesses under ambient storage conditions

Storage period (days)	Lycopene content									
	Treatments									
	25 µm LDPE package			37.5 µm LDPE package			50 µm LDPE package			Control
	A	B	C	D	E	F	G	H	I	J
0	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7	4.7
2	5.3	6.0	6.3	5.4	6.2	6.8	5.6	6.4	6.7	6.7
4	6.0	6.9	6.7	6.1	7.1	7.3	6.3	7.3	7.5	7.6
6	6.6	7.3	7.2	6.7	7.5	7.8	6.1	7.8	7.9	9.4
8	7.5	7.9	7.9	7.4	8.0	8.4	5.8	7.5	8.3	10.2
10	7.1	7.5	8.1	6.9	8.3	8.8	5.3	7.3	8.1	9.6
12	6.7	7.2	7.6	6.5	8.1	9.2	5.2	7.0	7.8	9.2

Total soluble solids:

It was observed that the value of TSS goes on decreasing as the storage period increases. The TSS of fresh cherry tomato was 7.2 ^{0}Brix and it goes to 3.5 during storage period in LDPE packages seen collectively as shown in Table 7. It was also observed that there no particular trend in which it decreasing with reference to perforation and also with reference to thickness of the LDPE packaging material.

Odour:

The odour score of cherry tomato in different LDPE packages was noted down at predefined interims of time throughout the ambient storage condition as shown in Table 8. These LDPE packages were of different thicknesses *viz.*, 25, 37.5 and 50 µm having 0, 4 and 8 perforation. The odour score of cherry tomato was observed to be increase with the increase in storage period. Odour best retained by 37.5 µm LDPE packaging with 8 perforation as it had only slight off odour the end of storage period.

Conclusion:

Highest oxygen concentration 16.10 per cent and Low carbon-dioxide evolution 7.41 per cent was observed in 37.5µm LDPE packaging with 8 perforations as it allows better gaseous exchange with the environment. Lower PLW was observed to be 3.78 per cent and 3.97 per cent in non-perforated in 25 µm and 37.5 µm, respectively. Minimum variation in TCD being seen in 37.5 µm LDPE package with 8 perforations followed by 25 µm LDPE package with 8 perforations. Better firmness 5.61 and 4.68 was retained by 37.5 µm and 25 µm LDPE packaging with 8 perforations. Lycopene content was better retained (9.2 mg/100g fw) in 37.5 µm LDPE packaging with 8 perforations. Odour best retained by 37.5 µm LDPE packaging with 8 perforation as it had only slight off odour the end of storage period.

Acknowledgement:

The author is grateful to the Advisor, Head, and all the members of advisory committee of Department Processing and Food Engineering, College of Agricultural Engineering and Technology, Punjab Agricultural

Table 7 : Total soluble solids (°Brix) in LDPE packages of various thicknesses under ambient storage conditions for cherry tomato

Storage period (days)	Total soluble solids (TSS)									
	Treatments									
	25 µm LDPE package			37.5 µm LDPE package			50 µm LDPE package			Control
	A	B	C	D	E	F	G	H	I	J
0	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2	7.2
2	5.6	5.2	6	6.5	5.4	6.2	5.6	5.5	6.2	6.0
4	5.4	5.0	4.5	5.1	5.1	5.7	4.9	4.9	5.1	5.0
6	4.5	4.2	4	4.2	4.4	5.4	4.7	4.5	4.9	4.5
8	4.5	4.3	4.3	4.5	4.6	5.1	4.5	4.2	4.6	4.3
10	4.2	4.2	4.4	4.2	4.5	4.5	4.2	3.8	4.4	3.8
12	4.1	3.8	4.3	3.9	4.2	4.3	3.9	3.5	4.1	3.5

Table 8 : Odour in LDPE packages of various thicknesses under ambient storage conditions for cherry tomato

Storage period (days)	Odour									
	Treatments									
	25 µm LDPE package			37.5 µm LDPE package			50 µm LDPE package			Control
	A	B	C	D	E	F	G	H	I	J
0	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	2	2	2	2
4	2	2	1	2	2	1	3	2	3	3
6	2	2	2	2	2	1	4	3	3	3
8	3	3	2	3	3	1	4	4	3	3
10	4	3	2	3	3	2	5	5	4	4
12	4	4	3	4	3	2	5	5	5	5

University Ludhiana, for their guidance and constant supervision as well as for providing necessary facilities.

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