Vegetable Science (2018) 45 (1) : 50-54

Influence of type and thickness of packaging film on quality attributes of tomato (*Solanum lycopersicum* L.) treated with 1-methycyclopropene during cold storage

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Received: March 2018 / Accepted: May 2018

Abstract

Present investigation was carried out to find out the influence of type and thickness of packaging films on quality attributes of 1-MCP treated tomato (*Solanum lycopersicum* L.) during cold storage. The packaging films used were of polyfilms of low density polyethylene (LDPE) at 40µ, 50µ and 75µ and polypropylene of 40µ thicknesses along with control (plastic crates). The tomato fruits (var. Punjab Ratta) harvested at breaker stage from a crop grown at Vegetable Research Farm, Punjab Agricultural University, Ludhiana, India were treated with 1-methylcyclopropene at 18 mg/L of distilled water. The treated fruits were modified atmosphere packed and double sealed using paddle operated sealer machine. The modified atmosphere packed fruits were kept in cold stoarge maitained at 13±2^{0}C and relative humidity of 85-90%. During storage fruits were analysed for quality parameters like color (a*value), hue angle, titratable acidity (% citric acid) and firmness(N) at weekly intervals i.e. on 1st, 8th,15th, 22nd 29th and 36th day after treatment. Tomato fruits packed in LDPE of 50µ and polypropylene of 40µ thickness showed lower a* values than the fruits packed in LDPE of 40µ and LDPE of 75µ at all the days of storage. At 36th day of storage, tomato fruits packed in polypropylene of 40µ thickness were in red-ripe stage (hue angle 55.12°) while, fruits in LDPE and control were in near over ripe stage. However, fruits packed in LDPE at 40µ, 50µ and 75µ proved to be better in retaining higher titratable acidity and firmness over control.

Key words: Tomato, MAP, Polypropylene, LDPE, thickness, hue angle

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Introduction

Tomato *(Lycopersicon esculentum L.)* is highly perishable crop and even after harvest, tomato fruits are biologically active and carry out transpiration, respiration, ripening and other biochemical activities, which deteriorate the quality of the produce. Packaging has a great significance in reducing the wastage of fresh fruits and vegetables. Modified atmosphere packaging (MAP) is a simple and cheap method of prolonging shelf life of many fruits and vegetables including tomato (Geeson et al. 1985, Exama et al. 1993) through creation of a modified atmosphere that has higher levels of CO_2 and water vapor and a lower level of O_2 than ambient levels due to the respiration and moisture loss from the commodity (Pesis et al. 2000). Use of an appropriate packaging film and storing at an appropriate storage temperature resulted in higher ratio of carbondioxide (CO_2) to oxygen (O_2) due to the interaction of the fruit respiration and gas diffusion through the packaging film. Packaging film also acts as barrier to movement of water vapour and helps to maintain a high level of relative humidity (RH) which in turn helps in checking weight loss of the product. However, maintenance of an excessively high level of RH inside the package can result in moisture condensation on the commodity creating conditions favorable for pathogen growth and increasing the risk of fruit decay (Polderdijk et al. 1993). So, MAP involves the use of packaging films which should be selected appropriately according to their gas permeation properties. Many factors influence film permeability, of which polymer type and film thickness are the most important. The choice of packaging films can be from four basic polymers: polyvinyl chloride (PVC), polyethylene terephthalate (PET), polypropylene (PP) and LDPE for packaging of fresh produce (Mangaraj et al. 2009). Guan et al. (2008) reported that at 29th day of storage, minimum lycopene content (6.08 mg/100 g) in mature-red tomato (cv. Pinky World) fruits was observed when packaged with MA film of 0.03 mm at 5°C storage while, maximum firmness (0.49 Kgf) was recorded when packed with MA film of 0.06 mm at 0°C. Similarly, Vanndy et al. (2008) reported that modified atmosphere packaging of tomato with LDPE of 25 µ and HDPE of 25 µ thickness resulted in more reduced weight loss % than the polypropylene of 25µ thickness. However, decay incidence was higher in HDPE than in LDPE, suggesting for large volume of fruits, films less permeable to water vapor like HDPE, are not preferred since, increased accumulation of free water inside the film favorable for decay development. Tomato transplanted during Dec-Jan comes to harvest during May and June and ends by first week of July at prevailing higher temperature conditions of Ludhiana, Punjab. To extend the availability and shelflife of tomato, the present study was conducted to investigate the influence of type and thickness of commercial polymeric packaging films(LDPE and polypropylene) on the quality attributes of breaker stage tomato (1-MCP treated) during cold storage at 13 ±2° C and RH 85-90% along with plastic crates storage as control.

Materials and Methods

Tomato fruits fruits of uniform size and weight harvested at breaker stage from an unreplicated experimental plot of tomato crop cv. 'Punjab Ratta' raised at Vegetable Research Farm, Punjab Agricultural University, Ludhiana, Punjab, India during 2012-13 season were brought to the Food Packaging and Tranportation Laboratory, Central Institute of Post-Harvest Engineering and Technology, Ludhiana, Punjab, India and washed by dipping in normal tap water to remove the field heat and blemishes on the fruits. Then fruits were air dried on the table and kept overnight at 20°C in cold store. The following day, the fruits were dipped completely in aqueous solutions of 1-MCP ("Soyoung" @ 3.2% active ingredient, Shanghai Soyoung Biotechn.Inc., China) prepared at 18 mg/L concentration for one minute. The entire procedure of 1-MCP treatment was done as per the procedure and care followed by Choi *et al.* (2008). After one minute dip, the fruits were taken out and air dried for 5 minutes. Then fruits were packed in selected packaging films and sealed with paddle operated heat sealer machine. The packaging material includes two types of materials of different thicknesses namely LDPE 40µ, LDPE 50µ, LDPE 75µ and Polypropylene 40µ along with plastic crates (control). The LDPE 40µ, LDPE 50µ, and Polypropylene 40µ thickness films were punctured with 3 pin holes of 0.3mm diameter whereas, LDPE 75µ was punctured with four holes. A total of six MA packs each with tomato fruits of 500±50 g were being maintained per treatment and kept in cold store at 13±2°C and RH of 85-90% for a period of 36 days. Each MA pack was drawn at weekly intervals i.e. on 1st, 8th, 15th, 22nd 29th and 36th day of storage and analysed the quality parameters color (a*value), hue angle, titratable acidity (% citric acid) and firmness(N).

The experiment consisted of three level packaging materials viz,. plastic crates, LDPE and polypropylene with different thicknesses arranged in Completely Randomized Design replicating four times. Statistical design for ANOVA was done using the SAS GLM (v.9.2) and least square means separated by Tukey's test at P d" 1% significance levels.

Firmness was measured using TA-TDi texture analyzer (Stable Microsysytems, UK) equipped with a 50 kg load cell. For the penetration of the tomato fruit 5 mm diameter flat head stainless steel cylindrical probe was used to pierce 5 mm deep from the fruit surface with test speed of 1 mm/sec. For each measurement, three tomatoes were taken and each tomato was punctured two times at opposite sides of the equatorial axis of the fruit. Colour change on the surface of fruits is the most widely used criteria to describe tomato ripeness (Lopez-Camelo & Gomez, 2004). Changes in surface colour of tomato were determined using a Mini Scan XE Plus Hunter colorimeter (D/8S) with a standard C illuminant taking the b* value as a measure of degree of yellowing, L* value as a measure of surface lightness while a* being the measure of red colour. Black and white calibration plates were used for calibration and the values were expressed by the CIE L*a*b* system. Readings were taken around the equatorial point of the fruit at four places and average was taken. In each treatment, average of value of three fruits was recorded. Hue angle was calculated using the formula h° = tan"1 (b*/a*). Titratable acidity was determined by titrating 2 ml of fruit juice against 0.1 N NaOH solution using phenolphthalein indicator. The appearance of light pink colour marked the end point of titration. The percentage of titratable acidity was calculated and expressed in terms of % citric acid.

Results and Discussion

Color (a* value): a* value regarded as the colour for green to redness of tomato fruits. As the storage period proceeded, fruits in packaging films showed significant lower a* value at all days of storage except at 8th day of storage than in plastic crate storage (control) and data is shown in table1. Fruits packed in LDPE of 40µ and LDPE of 75µ recorded positive a* values from 15th day of storage whereas, fruits in LDPE of 50µ and polypropylene of 40µ from 22nd day of storage indicating

LDPE of 50µ and polypropylene of 40µ packaging films retarded the red colour development better than LDPE of 40µ and LDPE of 75µ packging films. Aborisade & Ayibiowu (2010) also reported that 20ì thick LDPE inhibited colour development by 57.5%, 56.4%, 19.6% and 29.2% in mature-green, breaker, turning and pink tomato fruits respectively. However, at 36th day of storage, fruits packed in polypropylene of 40µ maintained the significant lower a* value (17.68) than in other packaging films and plastic crates storage. Reuck et al. (2009) also indicated that gaseous 1-MCP (300nL/L) treated Litchi fruits packed in Bioxially Oriented PolyPropylene (BOPP) packaging film was the most effective treatment in retention of colour after 14 and 21 days of cold storage.

Hue angle (H°): Irrespective of packaging material and thickness, hue angle started decreasing progressively during the period of storage of tomato fruits including storage in plastic crates (control) barring a non-significant increase in LDPE of 40µ from 15th to 22nd day of storage (Table 2). Fruits packed in packaging films showed the significant higher hue angle than in the plastic crates storage (control) at all day of storage but, at 8th day of storage, fruits packed in LDPE of 75µ only showed the significant higher hue angle than in control. Fruits packed in all packaging films retained the fruits in acceptable red-ripe stage (hue angle 55°) till 29th day of storage whereas, in plastic crates storage (control) upto 22nd day of storage (67.98°) only, there after a sharp decrease in hue angle was noticed reaching close to overripe stage at 26th day of storage (41.32°) (Hurr et al. 2005). At 36th day of storage, tomato fruits packed in polypropylene of 40µ thickness were in red-ripe stage (hue angle 55.12°) while, fruits in LDPE and control were in near over ripe stage (hue angle 40°). Higher hue angle in fruits packed in different packaging films indicated that ripening was delayed by MAP films than that of open storage in plastic crates (control). Similar results were also reported by Aguayo et al. (2003) that tomato slices stored in polypropylene of 35 µ thickness showed a greater decrease in hue angle than in control.

Firmness (N): Data in table 3 showed that the firmness (N) values progressively decreased with the advancement of storage period in all the treatments including control. Non-significant differences in firmness

Table 1: Influence of type and thickness of packaging film on fruit colour (a* value) of 1-MCP treated tomato during storage at 13±2°C and RH 85-90%.

Treatment	Day of storage					
	1st	8th	15th	22nd	29th	36th
Plastic crates storage(control)	-1.18	-3.58^{b}	14.48^{a}	17.88^{a}	38.57^{a}	33.13^{a}
LDPE@40µ	-1.18	-0.31^{a}	1.13^{b}	1.765^{c}	27.65^{b}	20.70^{bc}
LDPE@50µ	-1.18	-2.97^{b}	-0.918^{bc}	9.68^{b}	13.89^{c}	26.10^{b}
LDPE@75µ	-1.18	-5.32^{b}	0.195^{bc}	0.978^{c}	11.02^{c}	21.98^{bc}
Polypropylene@40µ	-1.18	-2.90^{b}	-1.78^{c}	0.675^{c}	12.23^{c}	17.68^{c}

(Data in column followed by different letter superscripts are significantly different at P d" 1%)

Table 2: Influence of type and thickness of packaging film on hue angle (H^0) of 1-MCP treated tomato during storage at 13±2°C and RH 85-90%.

Treatment	Day of storage					
	1st	8th	15th	22nd	29th	36th
Plastic crates storage(control)	92.76	97.65^{b}	71.17^{c}	69.78^{c}	41.32^{c}	36.01^{d}
LDPE@40µ	92.76	91.28^{d}	88.89^{a}	89.22^{a}	57.70^{b}	50.62^{b}
LDPE@50µ	92.76	94.22^{c}	90.57^{b}	77.82^{b}	74.50^{a}	48.75^{c}
LDPE@75µ	92.76	99.65^{a}	88.64^{a}	89.46^{a}	84.84^{a}	48.44^{c}
Polypropylene@40µ	92.76	93.35^{c}	92.75^{a}	89.03^{a}	78.88^{a}	55.16^{a}

(Data in column followed by different letter superscripts are significantly different at P d" 1%)

Table 3: Influence of type and thickness of packaging film on firmness (N) of 1-MCP treated tomatoes during storage at 13±2°C and RH 85-90%.

Treatment	Day of storage					
	1st	8th	15th	22nd	29th	36th
Plastic crates storage(control)	30.35	28.77^{b}	23.02^{c}	24.87^{ab}	17.77^{b}	2.57^{b}
LDPE@40µ	30.35	27.46^{c}	24.26^{c}	27.04^{ab}	20.30^{ab}	3.64^{a}
LDPE@50µ	30.35	29.89^{b}	31.05^{a}	21.76^{b}	21.90^{a}	3.08^{ab}
LDPE@75µ	30.35	31.74^{a}	28.78^{ab}	29.63^{a}	22.58^{a}	3.24^{ab}
Polypropylene@40µ	30.35	25.87^{d}	26.69^{b}	25.83^{ab}	21.33^{a}	3.41^{ab}

(Data in column followed by different letter superscripts are significantly different at P d" 1%)

Table 4: Influence of type and thickness of packaging film on titratable acidity (TA) of 1-MCP treated tomato during storage at 13±2°C and RH 85-90%.

Treatment	Day of storage					
	1st	8th	15th	22nd	29th	36th
Plastic crates storage(control)	1.1	1.32^{a}	0.93^{b}	1.01^{a}	0.97^{b}	0.75^{c}
LDPE@40µ	1.1	1.08^{d}	0.93^{b}	1.18^{a}	0.59^{d}	0.87^{b}
LDPE@50µ	1.1	0.91^{a}	1.29^{a}	0.98^{a}	1.33^{a}	0.97^{a}
LDPE@75µ	1.1	1.12^{b}	1.01^{ab}	1.12^{a}	1.04^{b}	0.88^{b}
Polypropylene@40µ	1.1	0.99^{c}	0.92^{b}	1.29^{a}	0.76^{c}	0.72^{c}

(Data in column followed by different letter superscripts are significantly different at P d" 1%)

Table 5: Influence of type and thickness of packaging film on TSS (^{0}Brix) of 1-MCP treated tomato during storage at 13±2°C and RH 85-90%.

Treatment	Day of storage					
	1st	8th	15th	22nd	29th	36th
Plastic crates storage(control)	5.03	5.36^{d}	5.36^{c}	4.93^{d}	4.83^{c}	3.86^{d}
LDPE@40µ	5.03	5.90^{b}	5.33^{c}	5.63^{a}	4.56^{d}	4.60^{a}
LDPE@50µ	5.03	6.23^{a}	5.33^{c}	5.13^{c}	5.23^{a}	4.63^{a}
LDPE@75µ	5.03	5.90^{b}	5.90^{b}	5.40^{b}	5.00^{b}	4.36^{c}
Polypropylene@40µ	5.03	5.70^{c}	6.16^{a}	5.60^{a}	4.40^{e}	4.46^{b}

(Data in column followed by different letter superscripts are significantly different at P d" 1%)

between control (storage in plastic crates) and other packaging treatments was observed at 22 days after treatment. Tomato fruits packed in LDPE of 75µ showed significant higher firmness over control at all the days of storage except at 22nd day of storage. The decrease of firmness of tomato fruit is correlated with the weight loss rate and reduced lossess in firmness was recorded when tomato modified atmosphere packed in LDPE film of 0.02mm thickness by Superlon and Itoh (2003). Similarly, Akbudak et al. (2007) also reported significant higher firmness values when cherry tomato fruits packed in polyethylene of 50µ and given hot water treatment which was attributed to slower rate of softening.

Titratable Acidity (% citric acid): Data presented in table 4 indicated that significant higher titratable acidity (TA) was obtained during 15, 29 and 36 days after treatment when tomato fruits packed in LDPE of 50µ compared to plastic crates storage(control) but non-significant at 8 and 15 days after storage. At 36th day of storage, fruits packed in LDPE of 40µ, 50µ and 75µ thickness showed significant higher titratable acidity than in polypropylene of 40µ and plastic crates storage. The higher titratable acidity in LDPE packed fruits than in polypropylene was attributed to slower rate of oxidative breakdown of acids and reduced respiration induced by modified atmosphere packaging (Rokhade et al. 1995). It was observed that a lower titratable acidity was recorded in tomato fruits packed in polypropylene of 40µ film throughout the storage period than in the control and Gaspar *et al*. (1997) also reported similar findings of low acidity in treatments packed in Bi-axially Oriented Polypropylene bags as compared to those in control. Present study conclude that the packing of tomato fruits in polymeric films retained the quality of tomato fruits compared to storage in plastic crates during their storage at 13±2°C and RH of 85-90%. However, LDPE proved to be better in retaining higher titratable acidity and firmness values than in the control and polypropylene but, polypropylene of 40µ maintained the fruits with higher hue angle (red-ripe stage) compared to other treatments at the end of the storage period (36 days).

TSS (^{0}Brix)): The significant differences were observed among the treatments (Table 5) at all the days of storage. Of all the treatments, the LDPE@40µ maintained the higher TSS contents at all the days of storage followed by LDPE@50µ while, polypropylene @40 µ showed higher TSS contents up to 14 days only (Gaspar et al. 1997).

Lkkjka'k

टमाटर के शीतगृह में भण्डारण हेतु पैकेजिंग फिल्म एवं प्रकार को ज्ञात करने के लिए वर्तमान अध्ययन किया गया। पैकेजिंग फिल्म के रूप में कम सघनता वाली पालीथीन (एल डी पी ई) पाली फिल्मस जिसकी मोटाई 40 माइक्रान 50 माइक्रान व 75 माइक्रान एवं पाली प्रो–पालीन की 40 माइकान का प्रयोग नियंत्रक (प्लास्टिक क्रैट्स) के साथ किया गया। टमाटर के प्रजाति पंजाब रत्ना के फल बेकर अवस्था में प्राप्त कर 1– मेथी एवं साइक्लोप्रोपेन की 18 मिग्रा./लीटर आसुत में डालकर शोधित किया गया। शोधित फलों को परिवर्तित वातावरण में पैंक किया गया तथा हस्त चालित सिलने वाली मशीन से दो बार सिलाई की गयी। परिवर्तित वातावरण में पैक किये गये फलों को शीतगृह में 13 ± 2 डिग्री सेन्टीग्रेड तापमान पर रखा गया तथा सापेक्ष आर्द्रता 85–90 प्रतिशत बरकरार रखा गया। भण्डारण के दौरान फलों के गुणवत्ता घटकों जैसे–रंग (ए वैल्यू), ह्यू

एंगिल अनुमाख्य अम्लता (प्रतिशत सिटरिक एसीड) व कसवटपन (एन) को सप्ताह अन्तराल जैसे शोधन के 1,8,15, 22, 29 व 36 दिन उपरान्त विश्लेषण किया गया। टमाटर के फल जो 50 माइक्रान एल डी पी ई व 40 माइक्रान पाली प्रोपेलिन माटाई के प्रयोग से ''ए वैल्यू'' में एल डी पी ई 40 माइक्रान व एल डी पी ई 75 माइक्रान से भण्डारण के दौरान कम पाया गया। टमाटर के 40 माइक्रान मोटाई वाले पालीप्रोपेलीन में पैक फलों को लाल–परिपक्व अवस्था (ह्यू एंगिल 55.12 डिग्री) पाया गया जबकि एल डी पी ई एवं नियंत्रिक में ज्यादा पकाव अवस्था देखी गयी। तथापि एस डी पी ई के 40 माइक्रान 50 माइक्रान व 75 माइक्रान में पैक फलों में उत्तम अनुमाज्य अम्लता व कसावटपन, नियंत्रक भी तुलना में अच्छा पाया गया।

References

Aborisade AT and Ayibiowu AF (2010) Effect of Polyethylene thickness, photoperiod and initial stage at harvest on ripening of two tomato (*Lycopersicon esculentum* Mill.) cultivars. Acta Hort 858:179-184.

Aguayo E, Escalona VH, Artes F (2003) Quality improvement of fresh-cut tomato under active and passive modified atmosphere packaging. Acta Hort 628:351-356.

Akbudak B, Akbudak N, Seniz V and Eris A (2007) Sequential treatments of hot water and modified atmosphere packaging in cherry tomatoes. J Food Qual 30:896-910.

Choi ST, Tsouvaltzis P, Lim CI and Huber DJ (2008) Suppression of ripening and induction of asynchronous ripening in tomato and avocado fruits subjected to complete or partial exposure to aqueous solutions of 1-methylcyclopropene. Postharvest Biol Technol 48:206-214.

Exama A, Arul J, Lencki RW, Lee LZ and Toupin C (1993) Suitability of plastic films for modified atmosphere packaging of fruits and vegetables. J Food Sci 58:1365-1370.

Gaspar JW, Flavio AAC and Luiz CCS (1997) Effect of low temperature and plastic films on postharvest life of tomato (*Lycopersicon esculentum*). Acta Hort 452:107-114.

Geeson JD, Browne KM, Maddiso K, Shepher J and Guradi F (1985) Modified atmosphere packaging to extend the shelf life of tomatoes. J Food Technol 20:339-349.

Guan JF, Park HW, Kim YH, Kim SH, Park HR, Lee SA and Yoon JY (2008) The effect of MA film packaging on storage of mature-red tomato. Acta Hort 804:469-476.

Hurr BM, Huber DJ and Lee JH (2005) Differential responses in colour changes and softening of Florida 47 tomato fruit treated at green and advanced ripening stages with the ethylene antagonist 1-methylcyclopropene. Hort Technol 15(3):617-622.

Lope CAF and Gomez PA (2004) Comparison of colour indexes for tomato ripening. Horticultura Brasileira 22(3):534–37.

Mangaraj S, Goswami TK and Mahajan PV (2009) Applications of plastic films for modiûed atmosphere packaging of fruits and vegetables: A review. Food Engi Rev 1:133-158.

Pesis E, Aharoni D, Aharon Z, Ben Arie R, Aharoni N and Fuchs Y (2000) Modified atmosphere and modified humidity packaging alleviates chilling injury in mango fruit. Postharvest Biol Technol 19:93-101.

Polderdijk JJ, Boerrigte HAM, Wilkinson EC, Mejer JG and Janssens MFM (1993) The effects of controlled atmosphere storage at varying levels of relative humidity on weight loss, softening and decay of red bell peppers. Sci Hort 55(3-4):315–321.

Reuck KD, Sivakumar D and Korsten L (2009) Integrated application of 1-methylcyclopropene and modified atmosphere packaging to improve quality retention of litchi cultivars during storage. Postharvest Biol Technol 52(1):71-77.

Rokhade AK and Jagdeesh SL (1995) Effect of postharvest treatments on the keeping quality of tomato fruits. J Agri Sci Technol 5(1):39-41.

Superlan K and Itoh K (2003) Combined effects of hot water treatment (HWT) and modified atmosphere packaging (MAP) on quality of tomatoes. Packaging Technol Sci 16:171–178.

Vanndy M, Buntong B, Acedo JrA and Weinberger K (2008) Modified atmosphere packaging to improve shelflife of tomato fruit in Cambodia. Acta Hort 804:453-458.