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Original Research Papers

Effect of modified atmosphere package on physico-chemical properties of pomegranate (Punica granatum L.) fruits

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Abstract: Pomegranate is an important table and processed fruit owing to its nutritional quality. Extending the fruit life of the plant is very much limited owing to its metabolic activities viz., respiration, transpiration and microbial infection. An experiment was conducted to investigate the effect of different packaging materials on physico-chemical properties of pomegranate fruits during storage. Fruits were harvested with stalk and washed with sodium hypochlorite, air dried and graded. Fruits were stored under modified atmospheric packaging conditions using different packaging materials viz., polyethylene bag, polypropylene bag, Xtend® bag and silver nano bag Hima Fresh®. Fruits without package served as controls. Fruits were stored at low temperature 7±2 °C and 90±5 % RH. MAP treated fruits had higher quality parameters across all packaging treatments. PLW and respiration rate increased while, moisture content, colour, texture and acidity decreased with prolonged storage, but the rate of decrease was highest in unpacked fruits. MAP maintained the quality of pomegranate fruits upto 100 days compared to unpackaged fruits (40 days). Shelf life of stored fruit at ambient condition was 4 to 5 days. Fruit decay was 12 % in polyethylene whereas it was 6 % in Xtend® bag at the end of 100 day of storage.

Keywords: Decay percentage, MAP, pomegranate, shelf life and storage life.

INTRODUCTION

Pomegranate (*Punica granatum* L.), one of the most favorite table fruits is native to Persia. The crop is very hardy and thus thrives well under arid and semi- arid climatic conditions. During the last two decades, the area under pomegranate cultivation is increasing substantially and many growers have taken up it as commercial farming due to the fact that the fruit satisfies the nutritional and medicinal needs of the consumer as the fruits have potent anti-mutagenic, anti-hypertensive, anti-inflammatory properties and ability to reduce liver injury (Holland *et al.,* 2009). In spite of several benefits, the fruit consumption is not to the expected consumption and the availability of pomegranate fruit in the market are largely restricted to the harvesting season due to a high demand and lack of appropriate post-harvest technology to extend the storage life and maintain fruit quality (Erkan and Kader, 2011). Pomegranate being a non-climacteric fruit can be stored for few days under ambient conditions, but has potentiality to be stored for longer duration. But, long-term storage of pomegranate fruit has often been limited by weight loss, decay development, husk scald, loss of aril quality and taste (Porat *et al*., 2016). However, modified atmosphere packaging (MAP) has been found to be successful in reducing water loss, visible shriveling symptoms, husk scald and decay of pomegranate fruit during cold storage, but improper use of MAP will have negative impact (Artés *et al*., 2000; Selcuk and Erkan, 2015). MAP bags have been widely used for pomegranate storage and shipping in pomegranate exporting countries. MAP is most widely used technology to alter the gas composition in package in passive approach. This is achieved by the interaction between the respiration rate of the produce and the transfer of gases through the packaging material (Mahajan *et al*., 2007). In MAP, respiration rate is reduced by increasing CO. and decreasing O. concentration. MAP for pomegranates has been shown to reduce weight loss, shrinkage, scald development, decay, delay senescence and maintain post-harvest fruit quality of pomegranates (Selcuk and Erkan, 2014). The present study aims at extending the storage life of pomegranate fruits by application of modified atmosphere and humidity using different packaging materials.

MATERIAL AND METHODS

The pomegranate fruits cv. Bhagwa were hand-harvested at ripe stage with 0.5 cm stalk intact andwere graded based on the uniformity. Fruits werewashed in 150 ppm sodium hypochlorite. Later, thefruits were washed in running tap water and air driedto remove surface water. Fifteen to twenty uniformfruits weighing 4-5 kg were packed in modifiedatmosphere package bags viz., polyethylene bag (T1),polypropylene bag (T2), Xtend® bag (T3) and silvernano bag Hima Fresh® (T4) along with control unpack(T5) and kept in corrugated fiberboard boxes as pertreatment and stored at low temperature 7±2° C and90 ± 5 % relative humidity (Fig.1). Experiment wascarried out using completely randomized design withfive treatments and five replications

Data were recorded till the termination of experimentthrough numbering for all non-destructive parameters.The weight loss was recorded by using 10 mgprecision electronic weighing balance (Make: SartoriusGmbH, Gottingen, Germany, Model: GE812). ThePLW was calculated using standard formula andexpressed as per cent. Fruit colour was measuredusing a n instr ument por ta ble color imeterspectrophotometer (Lovibond LC 100, Model RM200,The Tintometer Ltd, Salisbury, UK). Fruit firmnessevalua tion wa s ca r r ied out by pier cing 5 mmcylindrical probe at a speed of 2 mm/s with automaticreturn. The downward penetration at 5 mm is pre-test speed and post-test speed were1 and 10 mm/s,respectively using texture analyzer (Model TA HDplus; Make Stable Microsystems, UK) equipped with

Fig. 1
Effect of MAP bag showing MA/MH conditionduring storage of pomegranate fruits

a 50 kg load cell. Finally, the data were analyzedstatistically. The respiration rate was measured bypiercing the probe of an auto oxygen/ carbon di-oxideanalyzer (Make: Quantek, Model: 902D Dual track)and was calculated using the following formula

$$\text{Respiration rate (mg } CO_2 \text{ kg}^{-1} \text{ h}^{-1}) = \frac{\% \, CO_2 \text{ x Container volume (ml) x 60}}{\text{Fruit weight (kg) x Enclosing time (min) x 100}}$$

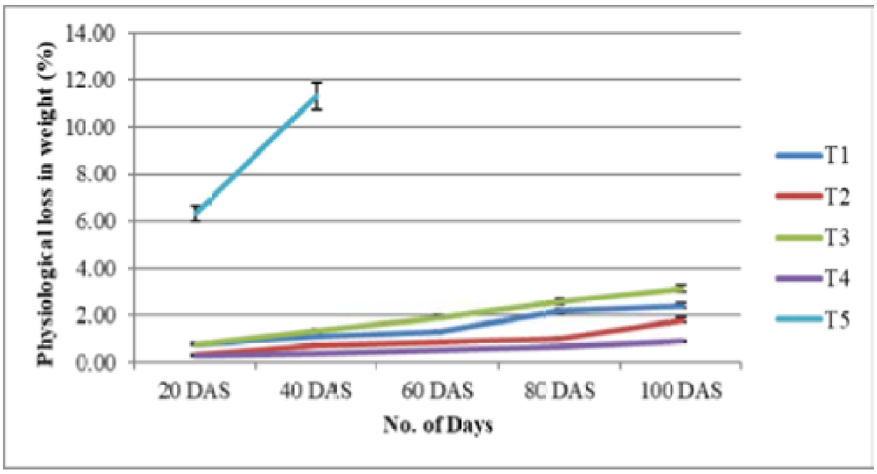
The titratable acidity of pomegranate fruits samplewas determined by visual titration method followingthe protocol (Ranganna, 1986). The fruit decayincidence was visually assessed by counting the totalnumber of rotten fruits. For both external and internaldecay, percentage of discarded fruits was calculatedusing the following formula.

$$\text{Decay incidence (\%)} = \frac{\text{Number of discarded fruits at each sampling date}}{\text{Total number of fruits in treatment}} \times 100$$

The number of days in which the fruits were inacceptable condition was taken as the storage life orkeeping quality of fruits. The fruits were removed from bags and kept in ambient condition at 25±5° C tostimulate the commercial handling operations and todetermine the shelf life.

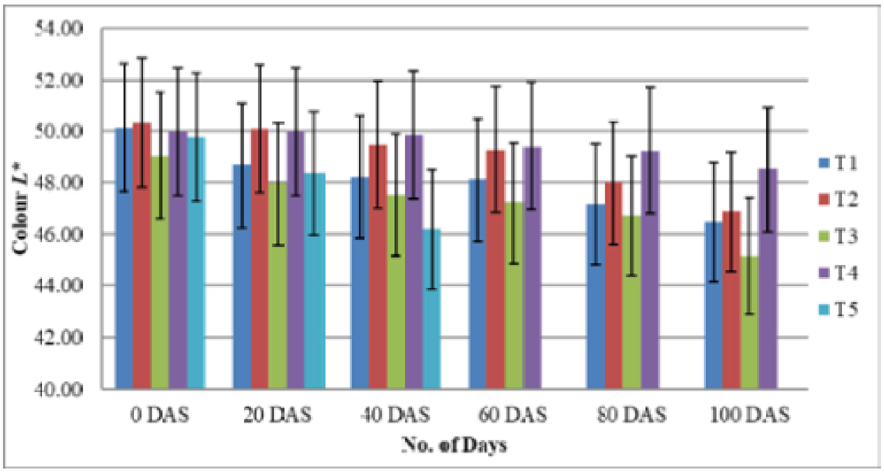
RESULTS AND DISCUSSION

The PLW significantly increased with prolonged storage in all the treatments (Fig. 2). However, PLW was maximum in the control fruits as there was 11.32 per cent loss in weight at 40 days of storing while, the PLW was 0.87 and 3.12 % in the fruits packed in silver nano bag Hima Fresh® and Xtend® bag, respectively even after 100 days of storage. It can be assumed that the packaging materials act as barriers to moisture loss by way of establishing a micro- environment with high relative humidity similar to fruit moisture content 80-85 per cent causing a very low vapour pressure difference between fruits and external environment. All these factors help in slowing down the respiration and transpiration rates. The present results are in confirmation with the previous findings of Nanda *et al.* (2001) and Porat *et al.* (2016).

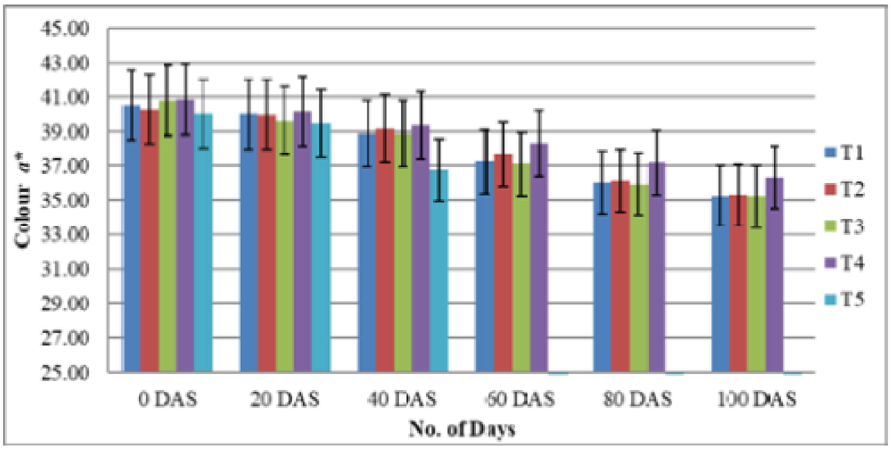


T - Polyethylene bag; T - Polypropylene bag; T - Xtend® bag; T Silver nano bag; T5- Control (unpack) DAS: days after storage Fig. 2. Effect of modified atmosphere package on physiological loss in weight (%) of pomegranate fruits under low temperature storage (7±2o C) T - Polyethylene bag; T - Polypropylene bag; T - Xtend® bag; T - Silver nano bag; T5- Control (unpack) DAS: days after storage Fig. 3c. Effect of modified atmosphere package on colour value (b*) of pomegranate fruits under low temperature storage (7±2o C)

Pomegranate fruits at the final stage of senescence become less intense and this characteristic visual change seems to be associated with a gradual decrease in the parameters: *L**, *a** and .* (Fig. 3a, 3b and 3c). Decrease in *L**, *a** and .* values was found to be more prominent in control unpacked fruits indicating the change in colour of pomegranate fruits from red to brown colour. Minimum colour change was observed in fruits packed in silver nano bag while, highest color change was observed in control. Minimum colour change in MAP fruits might be attributed to minimum moisture loss and lesser rate



T - Polyethylene bag; T - Polypropylene bag; T - Xtend® bag; T - Silver nano bag; T5- Control (unpack) DAS: days after storage Fig. 3a. Effect of modified atmosphere package on colour value (L*) of pomegranate fruits under low temperature storage (7±2o C) T - Polyethylene bag; T - Polypropylene bag; T - Xtend® bag; T -1 2 3 4 Silver nano bag; T5- Control (unpack) DAS: days after storage Fig. 3b. Effect of modified atmosphere package on colour value (a*) of pomegranate fruits under low temperature storage (7±2o C)



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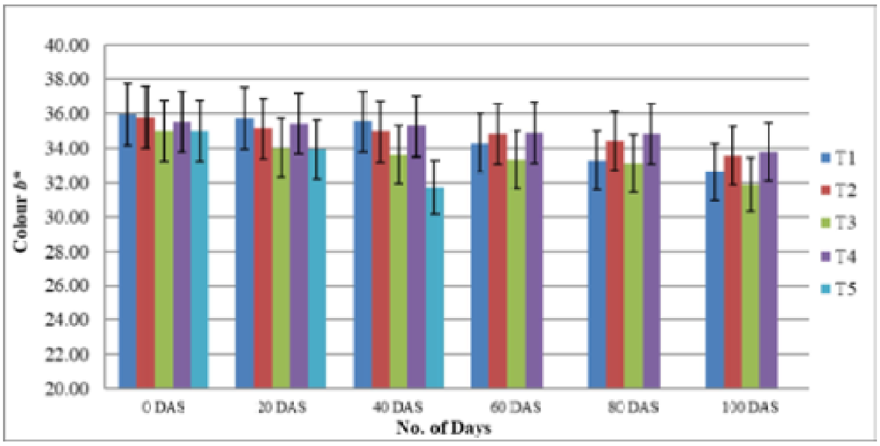

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of respiration delaying senescence in pomegranate fruits. Naik et al. (2017) also reported that the Hunter color (L*, a* and b*) values of pomegranate fruits gradually decreased with each successive storage period. From the data (Fig.4), it was observed that the respiration rate of pomegranate fruits packed in modified atmosphere packaging materials decreased initially after harvest but increased gradually with

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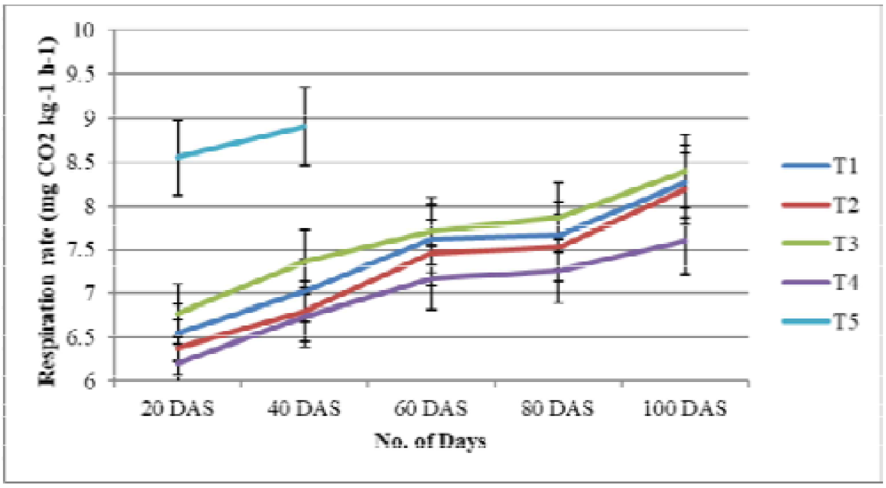
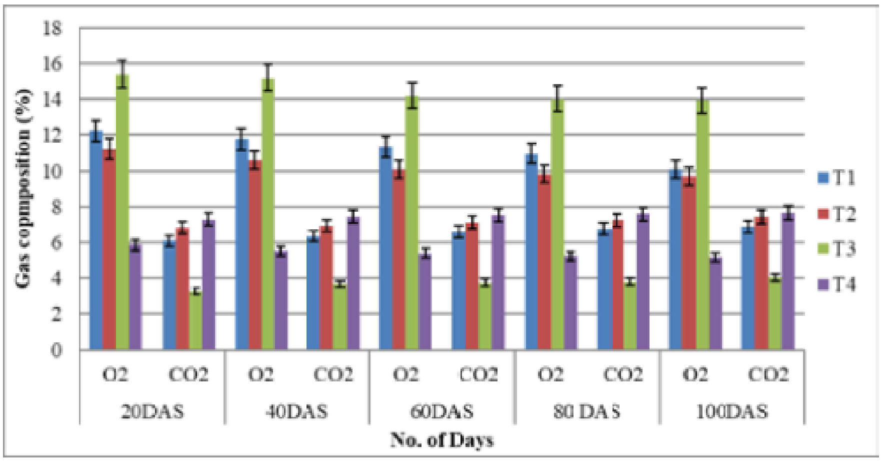


T - Polyethylene bag; T - Polypropylene bag; T - Xtend® bag; T4- Silver nano bag; T5- Control (unpack) DAS: days after storage; Initial respiration rate: 18.17 mg CO_2 KG^{-1} H^{-1}
Fig. 4. Effect of modified atmosphere package on respiration by silver nano bag recorded highest firmness (6.24 kg rate (mg CO2 kg-1 h-1) of pomegranate fruits under low cm-1) on day 40 than other treatments while, control temperature storage (7±2 C)

recorded with respect to respiration rate in the control fruits at 20 and 40 days after storage while, no difference was noticed at 60, 80, and 100 days among MAP packed fruits. The increase in respiration rate of fruits during storage could be an indication of increase in stress including presence of physiological disorders and metabolic reactions. Low respiration in MAP bag fruits may be due to lower moisture loss, lower stress and low availability of O2 inside the package and recorded lower firmness (5.04 kg cm-1) on the same day of storage. With prolonged storage, the firmness of the fruit was decreased. Silver nano bag maintained higher firmness (5.81 cm-1) while, lower firmness (5.62 kg cm-1) was observed in Xtend® bag after 100 days of storage. This could be attributed to slow degradational changes during initial period and also less moisture loss in MAP fruits maintaining better firmness compared to control. These results agree with Mshraky et al. (2016) and Kumar et al. (2013). maximum accumulation of CO2 in the bags. The above ûndings agree with Meighani et al. (2014) and Mphahlele et al. (2016).

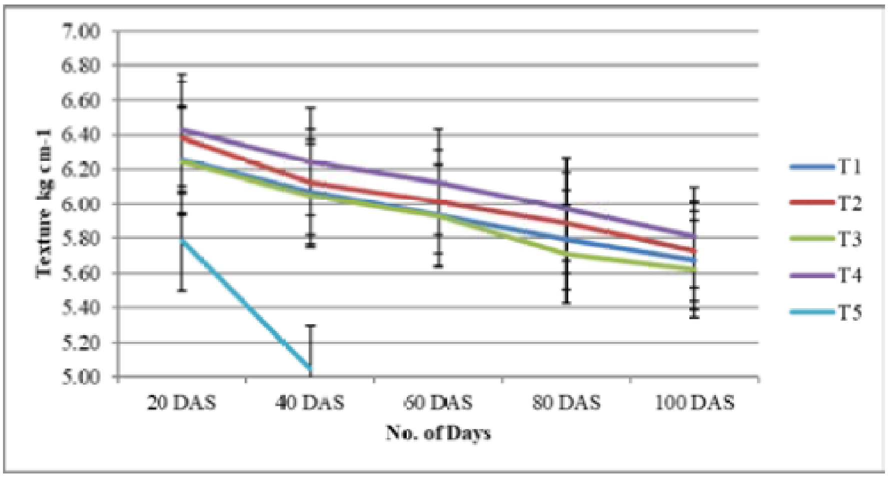
The results on changes in headspace oxygen and carbon di-oxide concentration as influenced by modified atmosphere packing of pomegranate fruits during storage are presented in Fig. 5. As the storage period progressed, the oxygen concentration was significantly decreased and carbon dioxide increased due to respiration. The highest oxygen (13.92 %) and



T1- Polyethylene bag; T2- Polypropylene bag; T3- Xtend® bag; T4- Silver nano bag; T5- Control (unpack) DAS: days after storage
Fig. 5. Effect of modified atmosphere package on gascomposition inside MAP bags of pomegranate fruits underlow temperature storage (7±2o C)

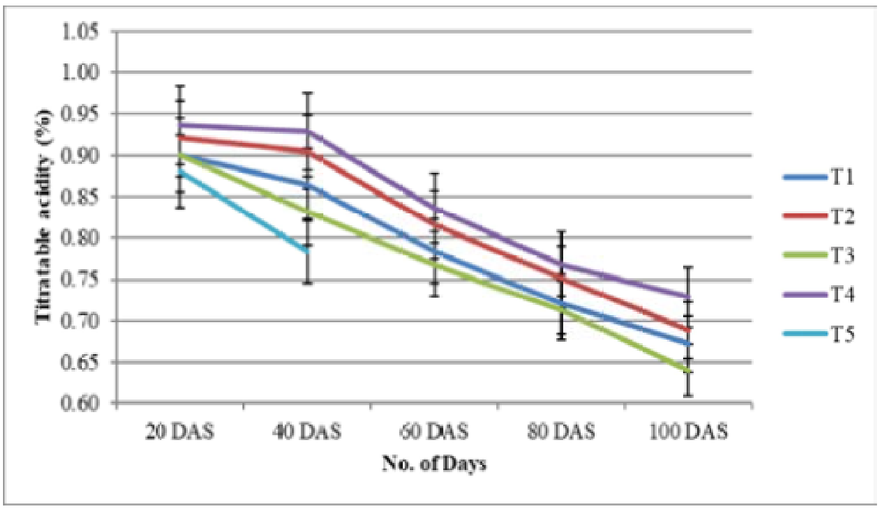
lowest carbon dioxide (4.04 %) concentration wasrecorded in Xtend® bag while, the lowest oxygen (5.18%) and highest carbon dioxide (7.68 %) were recordedin silver nano bag at 100 days after storage comparedto other treatments. This might be due to the lowerpermeability to gases by the silver nano bag comparedto Xtend® bag which had micro-perforation resultingin optimum water vapor and gas transmission rate.Our results agree with Mphahlele et al. (2016) andMshraky et al. (2017)

T he firmness of pomegr ana te fr uits decrea sedsignificantly with prolonged storage period (Fig. 6).However, the pomegranate fruits which were packedby silver nano bag recorded highest firmness (6.24 kgcm-1) on day 40 than other treatments while, controlrecorded lower firmness (5.04 kg cm-1) on the sameday of storage. With prolonged storage, the firmnessof the fruit was decreased. Silver nano bag maintainedhigher firmness (5.81 cm-1) while, lower firmness (5.62kg cm-1) was observed in Xtend® bag after 100 daysof stora ge. This could be attr ibuted to slowdegradational changes during initial period and alsoless moisture loss in MAP fruits maintaining betterfirmness compared to control. These results agree withMshraky et al. (2016) and Kumar et al. (2013)



T1- Polyethylene bag; T2- Polypropylene bag; T3- Xtend® bag;T4- Silver nano bag; T5- Control (unpack)DAS: days after storage; Initial texture: 6.51 kg cm-1
Fig. 6. Effect of modified atmosphere package on texture (kg cm-1)of pomegranate fruits under low temperature storage (7±2o C)

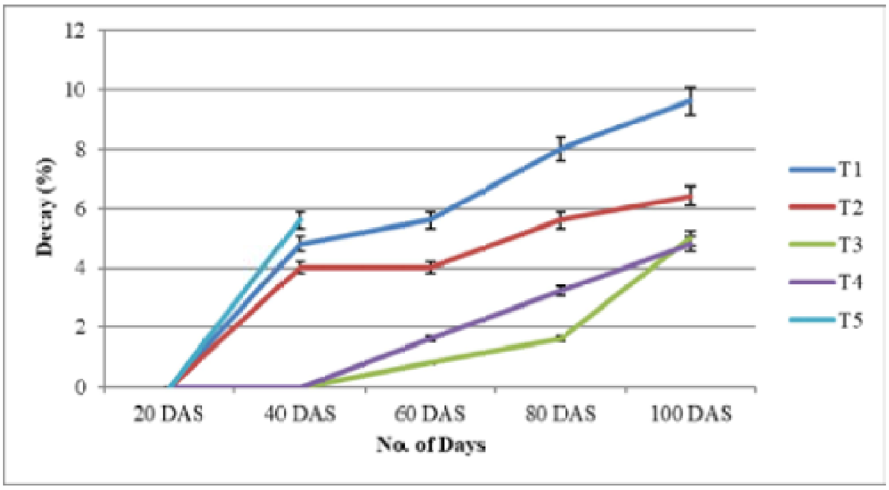
Data pertaining to the effect of different treatments on titratable acidity are presented in Fig. 7. Significant difference was recorded among treatments at 40 days after storage. The least (0.78 %) acidity was recorded in unpacked control fruits whereas maximum (0.93 %) acidity was recorded in silver nano bag. Thereafter, no difference was observed till 100 days indicating constant titratable acidity in MAP pomegranate fruits which might be due to reduction in metabolic



T - Polyethylene bag; T - Polypropylene bag; T - Xtend® bag; T4- Silver nano bag; T5- Control (unpack) DAS: days after storage; Initial titratable acidity: 0.95 per cent
Fig. 7. Effect of modified atmosphere package on titratable acidity percentage of pomegranate fruits under low temperature storage (7±2o C)

changes of organic acid into carbon dioxide and water as reported by Arendse et al. (2014) Nanda et al. (2001).

The decay percentage was significantly increased with extended storage as depicted in the Fig. 8.



There was no microbial decay of fruits at 20 days after storage irrespective of treatments. The highest decay (7.00 %) was noticed in unpacked fruits while there was no decay in silver nano bag and Xtend® bag fruits at 40 days of storage. Thereafter, control fruits were terminated. Later, minimum decay of 1, 2 and 6 per cent was recorded in fruits packed in Xtend® bag at 60, 80and 100 days after storage, respectively whereas maximum per cent decay of 7, 10 and 12 was observed in fruits packed in polyethylene bag at 60, 80and 100 days of storage, respectively. This high decay incidence might be due to high availability of moisture inside the package providing congenial environment for the growth of micro-organisms. Xtend® bag reduced decay on account of the modified atmosphere and modified humidity which might be due to moisture vapor and gas transmission preventing accumulation of moisture. Our results are in confirmation with that of Samar et al. (2017).

The pomegranate fruits packed with different packaging materials delayed metabolic activity and increased shelf life. The pomegranate fruits packed in MAP bags had 100 days of storage life compared to unpacked fruits which recorded only 40 days (Table 1). Shelf-life simulation of stored fruits (7±2° C) at ambient condition (25±5° C) was 4 to 5 days. The increase in storage life might be due to reduced metabolic activity and optimum gas and water vapor transmission rate in MAP bags Silver nano bag; T5- Control (unpack) DAS: days after storage Fig. 8. Effect of modified atmosphere package on decay percentage of pomegranate fruits under low temperature storage (7±2o C) creating optimum conditions along with low temperature storage for fruits.

Table 1
Effect of modified atmosphere package on storage and shelf life of pomegranate fruits under low temperature storage (7±2o C)

Treatment	Storage life (Days) at low temperature (7±2^0 C)	Shelf life (Days) at ambient condition (25±5^0 C)		
		60 DAS	80 DAS	100 DAS
T_1- Polyethylene bag	100	5.00	4.50	4.00
T_2- Polypropylene bag	100	5.00	5.00	4.00
T_3- Xtend bag 100 ®	5.00	4.50	4.00	
T_4- Silver nano bag	100	5.00	5.00	4.00
T_5- Control (unpack)	40	—	—	—

DAS Days after storage —: End of storage life

CONCLUSION

Pomegranate fruits packed with different MAP bags and stored in low temperature (7±2° C and relative humidity of 90±5 %) were found to have prolonged the storage and shelf life. The MAP bags such as polyethylene, polypropylene, Xtend® bag and silver nano bag (Hima fresh®) had shown to increase the storage life upto 100 days with minimum losses of (6 %) microbial decay in case of Xtend® bag whereas, unpacked (control) fruits had a storage life of only 40 days.

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