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Modified atmospheric packaging of transported and stored tomatoes at cooling temperature

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Abstract
In the process of producing quality fresh fruits and vegetables, post-harvest handling is an essential link which maintains safety and quality of the products and reduces losses. During transportation and storage, product undergoes various mechanical and environmental stresses which leads to deterioration. In order to overcome these losses, modified atmosphere packaging (MAP) system in plastic crates was developed and its effect on physico-chemical analysis and shelf-life of tomato was evaluated. Tomatoes were stored at 10 ±2◦C in crates, wrapped in low-density polyethylene (LDPE) bags and arranged on pallets. After transporting and storing for a period of 0, 7, 14, and 21 days, effects of the storage time and packaging were evaluated. The MAP systems with pallets were assessed using a packaging atmospheric composition of 7 % O_2, 12 % CO_2 and 81 % N_2 extended the shelf-life of the tomato stored at refrigeration temperature. Results showed that MAP delayed color evolution and reduced the firmness loss, physiological loss, biosynthesis of lycopene and increased the quality of tomato.

Keywords: Tomato, modified atmospheric packaging, pallets, physio-chemical parameter, shelf life

Introduction
Tomato (Lycopersicon esculentum) is a climacteric fruit and its ripening process is regulated by ethylene (Carrari and Fernie, 2006) [55]. It is widely cultivated and consumed worldwide, either as a fresh food or a processed product like canned tomatoes, sauce, juice, ketchup, and soup (Domínguez *et al.*, 2016) [6]. Tomatoes include a variety of bioactive and anti-oxidative substances that are helpful to human health, including carotenoids, ascorbic acid (AA), and phenolic compounds. This vegetable is the primary source of lycopene, an antioxidant with the highest antioxidant activity of any antioxidant in the diet. Lycopene is the most abundant carotenoid in tomato, accounting for more than 80% of the total carotenoids content in fully ripe tomatoes (Fagundes *et al.*, 2015) [8].

Post-harvest handling is an essential link in the process of producing quality fresh fruits and vegetables for market or storage (Genanew, 2013) [10]. Fresh produce is exposed to various external forces such as harvesting, handling, processing, storing, and transporting during postharvest operations. Losses in fresh horticultural produce is directly related to quality degradation. Quality loss occurs as a result of improper handling and transportation of marketable produce (Kumar *et al.*, 2015) [15]. The postharvest loss of vegetables in developing countries is 20-50 % and 5-25 % in developed countries (Kader, 2002) [13]. Losses of up to about 20 % are incurred by producers due to transportation delays. Several elements affect postharvest losses during transportation, where fruits and vegetables are frequently subjected to rough handling and transported over poor road conditions, resulting in damage and mechanical injuries that could increase losses throughout the supply chain (Abubakari and Rees, 2011) [2]. During storage, the rate of respiration, transpiration, and ethylene production all increase with a significant increase in temperature. However, a significant drop in storage temperature may be the cause of chilling injuries and quality loss (Kabir *et al.*, 2020) [12].

In order to overcome these losses in transportation and storage, some of the new methods have to be adopted. Modified Atmosphere Storage is a technique which uses Modified Atmosphere Packaging (MAP) in which the respiration of commodities and permeation of gases through the lined polymeric films takes place simultaneously and the film acts as a barrier for the transport of gases (Beckles and Technology, 2012) [4]. To reduce respiration and ethylene production rates, high CO_2 and low O_2 concentrations in MAP are typically achieved. These conditions retained flesh firmness, low acidity and soluble solids concentration and delayed fruit lycopene (Saeed *et al.*, 2010) [28]. Extremely low levels of O_2 and/or high levels of CO_2 may, however, induce anaerobic metabolism, which may result in off-flavors, physiological

and microbial decay. Thus, high O_2 atmospheres have been proposed as an effective method for inhibiting microorganism growth and preventing undesirable anoxic fermentation (Odriozola-Serrano *et al.*, 2009) [20].

The aim of this study is to design a shroud system by using polymeric material with plastic crates and by subjecting it to modify atmospheric condition of certain concentration and to study its effect on the physico-chemical characteristics of tomato stored at refrigeration temperature for shelf life evaluation.

Materials and methods

Raw Material

The tomato of local hybrid CO3 variety was procured from local tomato mandi at firm red ripened stage in Saibaba colony, Coimbatore. The tomatoes were washed, cleaned and then air dried. After procuring, the vegetables were stored in cold storage at 10 ± 2 °C with relative humidity of 90-95%. The Low density polyethylene film of 75 micron thickness was bought from Sakthi poly products Nallampalyam, Coimbatore. The crates were obtained from local market of 15kg capacity and the wooden pallets were made with size of 400 mm×320 mm.

Determination of Permeability of Packaging Films

The oxygen and carbon dioxide transmission rates were determined with the help of Manometric permeability tester (Model: PBI Dan Sensor Checkmate II, USA). The rates at which gases penetrate through a film at specific temperatures and relative humidity levels were used to calculate the permeability rates for oxygen and carbon dioxide based on the principle of diffusion-Ficks law (Manometric pressure change via gas transmission through film). Low oxygen and carbon dioxide gas permeability is required for the films under study. The permeability of low density poly ethylene film at 75 µ thickness was found to be 2497 ml/m^2 day and 4937 ml/m^2 day for O_2 and CO_2 gases.

Design of shroud system and Head space gas analysis

A customizable bag of dimensions of 420× 340× 600 mm^3 of 75 µ thickness LDPE film was taken for shroud. A plastic crate of 400× 320× 250 mm^3 was taken for MAP condition. The silicon septum was pasted on the surface of the bag for measuring the gas samples. Two vents were provided at either side of the bag for uniform flow of gases. The fresh tomatoes of approximately 10 kg were taken in the crate and kept in open condition for control and for MAP, it was kept inside the bag. It was then heat sealed and folded at the top. It was then placed on a pallet of size 400× 320 mm^2. The desired gas mixture of 8% O_2, 12% CO_2, and 80% N_2 was filled through the vent and closed. It was then loaded in an open truck and transported to a distance of 40 km and it was stored at cold storage condition of 10± 2 °C. At particular interval the gas was measured in the package using gas analyser (PBI Dan Sensor Checkmate II).

Physico-chemical parameters of fresh tomatoes

After storage, the produce were analyzed for its change in physico-chemical characteristics.

Physiological loss in weight (PLW)

Vegetables were weighed with the help of a weighing balance at regular intervals. The initial and final weights of the samples were recorded and the loss in weight was calculated and expressed as percentage (Workneh *et al.*, 2011) [31].

$$\text{Physiological loss in weight}(\%) = \frac{\text{Initial Weight (g)} - \text{Final Weight (g)} \times 100}{\text{Initial weight (g)}}$$

Determination of colour and firmness

The CIE LAB colour of the tomato samples were measured using Lovibond Tintometer (Lovibond, LC 100/SV 100, The Tintometer Ltd, UK). Readings were provided in terms of L*, a*and b* and the skin surfaces of the fruit were recorded at D 65/10°, under proper lighting at regular intervals. L* measures the value of lightness to darkness, a* measures redness to greenness, and b* measures yellowness to blueness. Firmness of the fruit was determined by using Shimadzu EZ-EX texture analyser and expressed as Newtons (N). A speed of 1 mm/s and penetration distance of 10 mm was used to puncture the samples. A whole tomato was placed in an equatorial position on the analyser stage for each measurement. Puncture force was measured in triplicate for a mean of 5 tomatoes.

Determination of TSS

The fruit pulp was extracted from the fruits and the TSS levels were measured with a hand-held refractometer (ERMA, Japan) with a scale of 0-32 ° Brix (least count 0.2°Brix) at room temperature (25℃). The refractometer was first calibrated with distilled water to have a zero reading. A drop per sample was added to the refractometer prism plate. The readings on the prism plate were expressed in percentage (°Brix). After each test, the prism plate was cleaned with distilled water and wiped with a soft tissue paper (Rab *et al.*, 2012; Saad *et al.*, 2016) [23, 27].

Ascorbic acid content

Determination of ascorbic acid content was estimated by titration method using 2, 6- dichlorophenol indophenol dye solution (Ranganna, 1995; Preetha *et al.*, 2015) [25, 22]. Vegetable of ten gram was made in to pulp and extracted using 10 ml of 4% oxalic acid solution, made up to 50 ml. Then this made up solution of 5 ml was pipetted out in to a concial flask and titrated against dye. The titration was repeated for the concordant values. Quantity of ascorbic acid (mg) present in 100 g of sample was calculated as follows:

$$\text{Ascorbic acid (mg / 100 g)} = \frac{0.5/V1 \times V2/5 \text{ ml} \times 50 \text{ ml}}{\text{weight of sample} \times 100}$$

Where,

V_1= volume of dye obtained by the working standard.

V_2= volume of dye obtained by the sample.

Titratable acidity

Titratable acidity was evaluated by using the procedure reported by Ranganna (1995) [25]. Ten gram of tomato pulp was ground using pestle and mortar and it was extracted using distilled water. Sample of 5ml was taken and it was titrated against 0.1 N NaOH to a permanent pale pink end point using phenolphthalein as an indicator. The amount of NaOH necessary to neutralize the juice sample as well as the titratable acidity were computed and expressed as a percentage of citric acid.

$$\text{Titratable acidity (\%)} = \frac{(N \times V \times \text{Equivalent Weight of Acid} \times 100)}{(\text{Weight of Sample} \times 100)}$$

N = NaOH normality.
V = NaOH volume required to neutralise the juice.

Determination of lycopene and ß-carotene

The lycopene and β- carotene were estimated using UV- VIS Spectrophotometer (Ranganna, 1997; Javeria *et al.*, 2013; Shahzad *et al.*, 2014; Rayhan *et al.*, 2019) [24, 11, 29, 26]. 10g of sample was weighed and extracted repeatedly with acetone using pestle and mortar until the residue became colourless. The acetone extract was transferred to a separating funnel containing 20 ml of petroleum ether 20 ml 5% sodium sulphate and mixed gently. The lower phase was transferred to another separating funnel and the petroleum ether extract containing pigments is collected to an amber coloured bottle. Extraction was repeated similarly with petroleum ether until it was colourless. To the extract, a small quantity of anhydrous sodium sulphate was added and the volume was made up to 50 ml with petroleum ether. The colour was measured in a quartz cuvette at 503 nm in spectrophotometer (UV-VIS Spectrophotometer) using petroleum ether as a blank. β-Carotene follows the same method of lycopene determination. However, the absorbance was read at 452 nm using 3 % acetone in petroleum ether as blank.

$$\text{mg of lycopene}/100\text{g} = \frac{3.1206 \times \text{OD value} \times \text{volume made up} \times 100}{1 \times \text{weight of sample} \times 1000}$$

$$\text{mg of } \beta - \text{ carotene }/100\text{g} = \frac{\text{concentration of carotene} \times \text{final volume} \times \text{dilution}}{\text{Weight of sample}}$$

Statistical analysis

Statistical analysis was carried out for different parameters to study the effect on all the dependent variables. All the analysis was conducted and results were subjected to two-way analysis of variance (ANOVA) with Completely Randomized block Design (CRD) at $p \leq 0.05$ using the statistical software AGRES version 7.01.

Results and Discussion

Respiration rate of fresh tomato

During respiration, the fresh tomato consumes O_2 and produces CO_2 as a result of metabolic activity. Various external factors such as O_2 concentration, CO_2 concentration, temperature and time affect respiration (Mangaraj and Goswami, 2011) [17]. The respiration rate of tomatoes at 10±2°C was determined experimentally in a shroud system. During this assay, high condensation of water vapor was observed inside the packaging bags covering the MAP crates. This is most likely caused by the development of high RH (90-95%) within the bags due to the low water vapor permeability of the packaging material. These conditions are unsuitable because microbial proliferation might be produced thus reducing quality and safety of the produce (Singh, Giri, & Kotwaliwale, 2014).

Head space gas analysis at MAP condition

Head space gas analysis was done for the packaging film of LDPE 75 µm under refrigerated conditions. The gas concentration at refrigerated condition was measured for an interval of seven days. The effect of gas concentration on the headspace of the pouches containing fresh tomatoes stored at refrigerated condition is shown in Fig.1. This is due to oxygen intake for fruit respiration and release of carbon dioxide as a by- product of respiration. The initial concentration of active MAP was 8% O_2, 12% CO_2, and 80% N_2. The gas concentration of tomatoes under active MAP showed decrease of O_2 concentration from 8% to 1.31% and increase of CO_2 concentration from 12% to 20.6%.

In refrigeration, the samples were in good condition up to 21 days, since O_2 consumption and CO_2 production were less due to low metabolic activity. After 21 days of storage in active MAP, there was presence of fungus formation. This may be due to low O2 content which would have facilitated anaerobic condition. Low oxygen concentrations, in combination with temperature fluctuations, have been reported to result in the production of off-flavour (Forney and Jordan, 1999). Geetha *et al.* (2021) [9] reported that at lower temperature, the oxygen consumption and carbon dioxide generation were less.

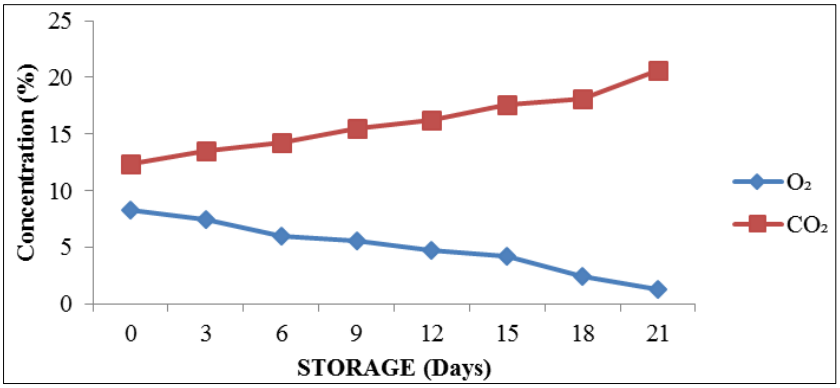

Fig 1: Oxygen and Carbon dioxide concentration of tomatoes in shroud system under refrigerated condition Physico-chemical characteristics of fresh tomatoes in MAP.

Physiological weight loss of tomato

The effect on physiological loss in weight of fresh tomatoes stored in MAP conditions was shown in the Fig 2. PLW increased during storage irrespective of the storage conditions. Control samples experienced 5.63 % of losses at the end of the storage period. Whereas, the MAP reduced the losses and the PLW was about 1.18 % at the 21st day of storage under refrigerated condition (10± 2 ˚C). For the tomatoes stored under refrigerated condition, MAP showed a significant effect ($p \leq 0.05$) on the PLW. The losses were minimum in MAP due to lower respiration rate at lower temperatures and higher humidity inside the container, resulting in a minimal weight loss. Similar findings were reported by Wills *et al.* (1989) and Preetha *et al.* (2015) [22].

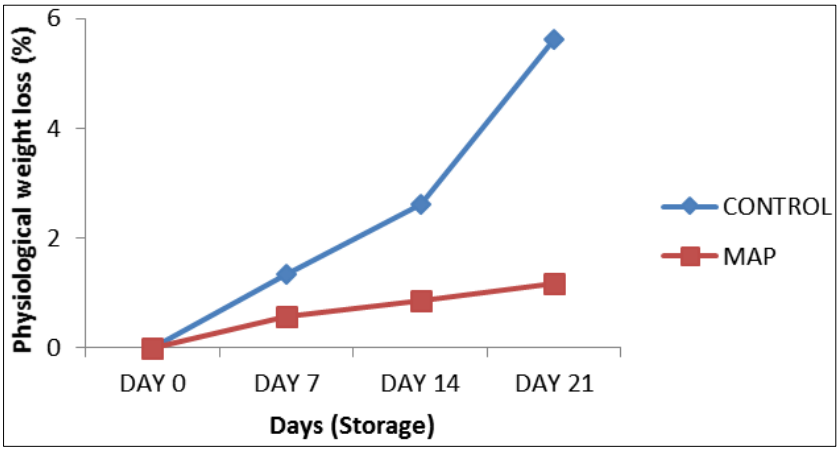

Fig 2: Effect of MAP on physiological weight loss content of tomatoes under refrigerated condition

Colour

The changes in Colour values of L*, a*, b* of fresh tomatoes stored in MAP condition over control is shown in the Table 1. The lightness of the tomatoes occurred on initial day was 22.4 and it gradually decreased for both control and MAP conditions under refrigerated conditions. Packaging films did not influence the lightness (p>0.05) and this prevailed all along with the storage. The effect of transportation on the fresh produce studied by La Scalia *et al.* (2016) [16], stated that lightness was reduced during storage with no significant effect.

The initial redness value for tomatoes was 20.3 and an increase of redness value was observed with increase in storage days under refrigerated condition (10± 2 ˚C). However, a significant effect (p≤0.05) of redness was observed on the 21st day of storage. Olveira-Bouzas *et al.* (2021) [21] stated that MAP retained the colour of the produce for cherry tomatoes stored at cold temperature. The yellowness value at initial condition was 22.3 and it decreased with increase in storage period due to red colour development (Endalew, 2020) [7]. On 14th day of storage, it showed a decrease in significant effect (p≤0.05) of 15.92 for control samples and 16.06 for MAP under refrigerated condition.

Table 1: Effect of MAP on Colour value of tomatoes under refrigerated condition

	Control			MAP				
Parameters	Day 0	Day 7	Day 14	Day 21	Day 0	Day 7	Day 14	Day 21
L*	22.4	23.2	20.24	19.94	22.4	24.36	21.4	20.34
a*	20.3	24.06	25.74	29.62	20.3	22.42	23.8	25.35
b*	22. 3	19.06	15.92	14.2	22. 3	21.88	16.06	14.9

Firmness

Firmness of tomato generally decreases with increasing in the duration of storage period. Fig 3 represents the effect of MAP on the firmness of tomatoes. Firmness of the tomatoes was 15.8 N initially and decreased until spoilage. The maximum loss in the firmness was 9.47 N at the end of control and 11.67 N at the end of MAP condition. Results revealed that the loss in firmness was slow during MAP condition. MAP showed a significant difference (p<0.05). The loss in firmness is mainly due to the water loss, rapid changes in the metabolic activities and due to the activity of cell wall degrading enzymes such as pectinesterase and polygalacturonase (Akbudak *et al.*, 2007; Moneruzzaman *et al.*, 2009) [3, 19]. Vunnam *et al.* (2014) [30] stated that the loss in firmness was minimum during MAP storage compared to perforated non-MA storage. Domínguez *et al.* (2016) [6] stated that modified atmosphere and the high humidity reached inside the packages slow down the process of ripening.

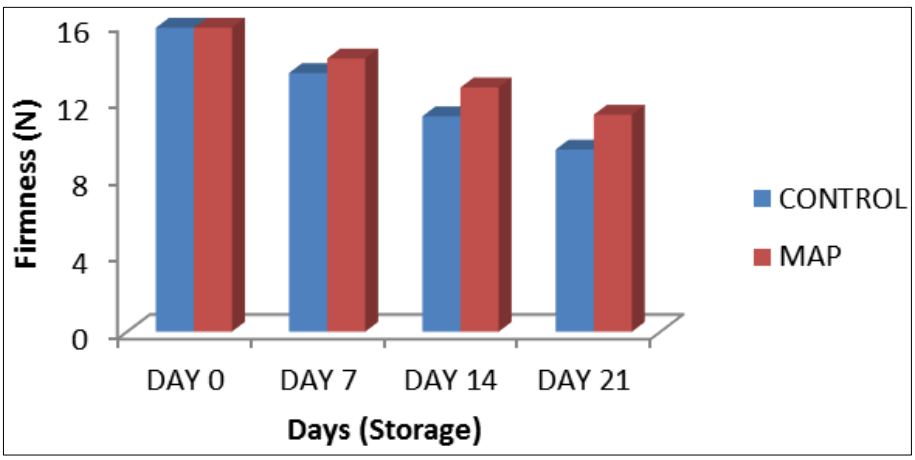

Fig 3: Effect of MAP on firmness content of tomatoes under refrigerated condition

Titratable Acidity, pH and TSS

The effects of storage period on Titratable acidity, pH and TSS of fresh tomatoes stored in MAP conditions are shown in the Fig 4. TSS and pH showed an increasing trend whereas the titratable acidity decreased with the storage period. TSS of tomatoes increased from 4.05 to 5.16 for control samples and an increment up to 4.86 was observed for the MAP stored samples. The increase in TSS was due to the hydrolysis of the starch which is converted into sugar (Kaewklin *et al.*, 2018) [14]. The effect of TSS was not significant ($p>0.05$) under storage condition.

The value of pH was 4.36 at the time of harvest and gradually increased, at the end of storage period. Results showed that pH did not show any significant effect ($p>0.05$) under storage condition. The increase in the pH was due to the conversion of acid to sugar and the utilization of acid as a substrate for the respiration. The titratable acidity decreased from 0.57% to 0.25 % for the control samples whereas the map storage showed an acidity of 0.32 % at the end of storage period. This may be due to the conversion of acid to sugar by the enzyme invertase. Results showed a significant difference ($p\leq0.05$) on the titratable acidity during storage.

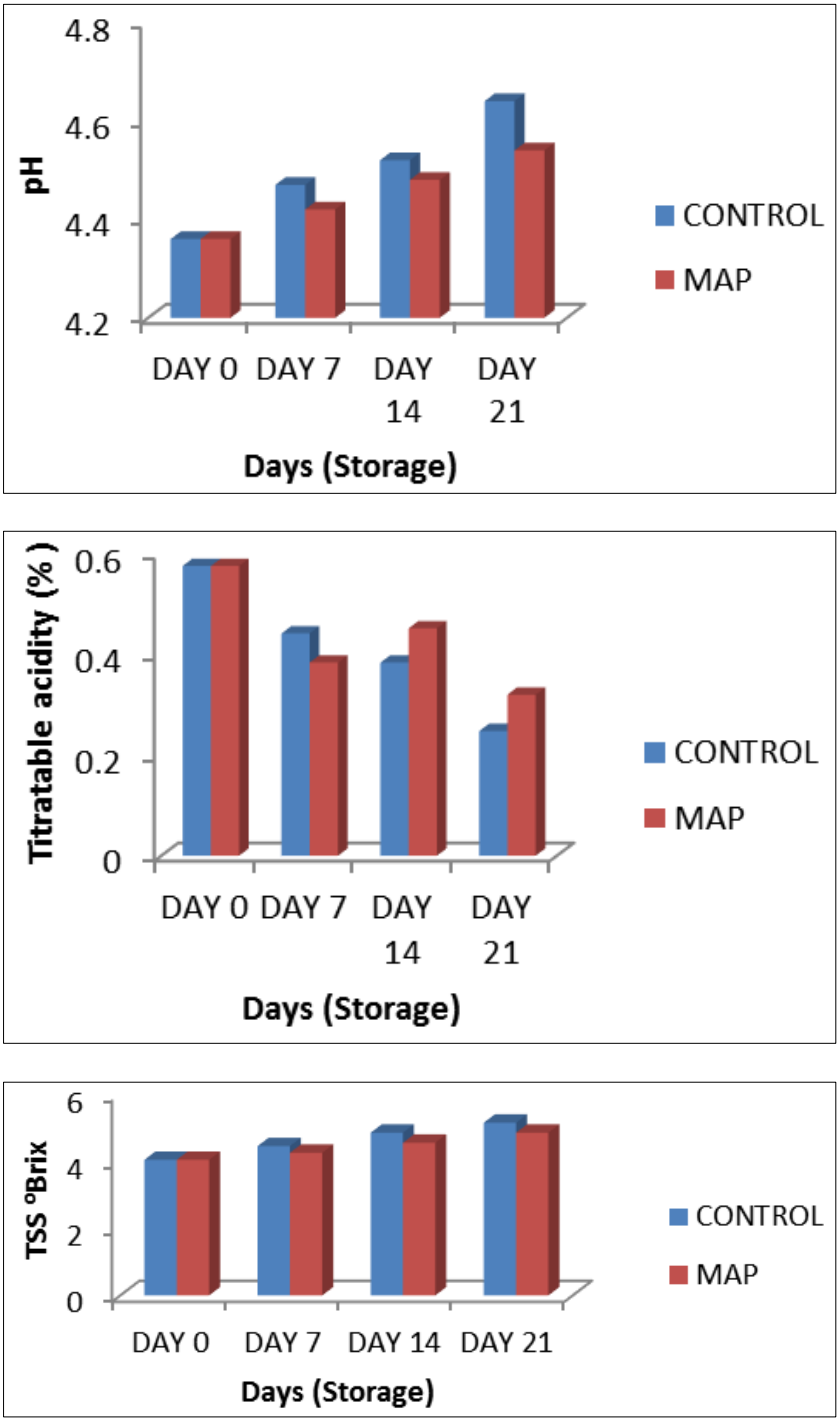

Fig 4: Effect of MAP on titratable acidity, pH and total soluble solids content of tomatoes under refrigerated condition

Ascorbic acid

Ascorbic acid decrease with the advancement of storage period irrespective of the storage condition. The Fig 5 depicts the effect of the storage condition on the ascorbic acid content of the tomatoes. The ascorbic acid content of the tomatoes was 24.3 mg/100g initially. The decline in ascorbic acid was

observed up to 10.3 mg/100g for control and 12.96 mg/100g for the map storaed samples. The decline was due to the conversion of ascorbic acid to dehydroascorbic acid by the enzyme ascorbinase (Mapson, 1970) [18]. Statistical analysis showed that the effect of map was significant ($p \leq 0.05$) on the ascorbic acid stored under refrigerated condition (10± 2 ˚C).

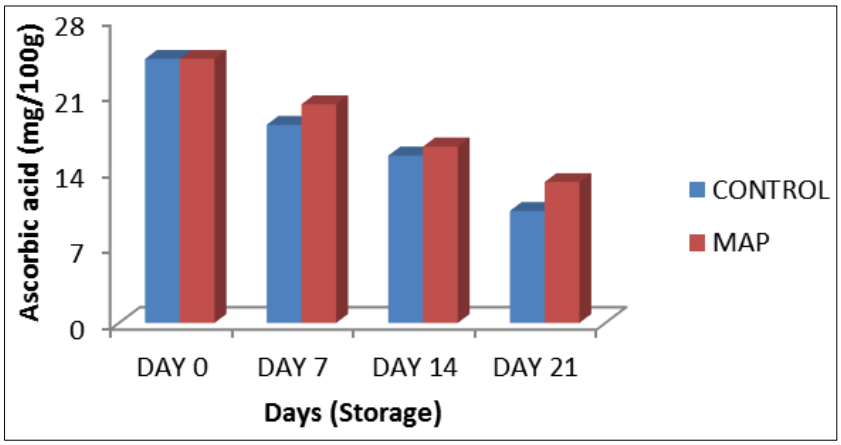

Fig 5: Effect of MAP on ascorbic acid content of tomatoes under refrigerated condition

Lycopene and β- carotene

The effects of storage period on physiological loss in weight of fresh tomatoes stored in MAP conditions are shown in the Fig. 6. The lycopene and b-carotene showed a significant effect ($p \leq 0.05$) on the samples irrespective of the storage condition. The lycopene content was 6.23 mg/100g and the β-carotene content was 0.25 mg/100g initially. The lycopene and the b-carotene increased with increase in storage period. The lycopene and β-carotene increased up to 12.2 mg/100g and 1.18 mg/100g for the control samples whereas, for the MAP storage a gradual increase was observed up to 10.76 mg/100g and 0.82 mg/100g. The MAP storage showed a significant effect on the lycopene and β-carotene content. The increase may be due to the development of ripening and maturity processes resulted in the rapid accumulation of carotenoids as chloroplasts are converted to chromoplasts (Abiso *et al.*, 2015) [1].

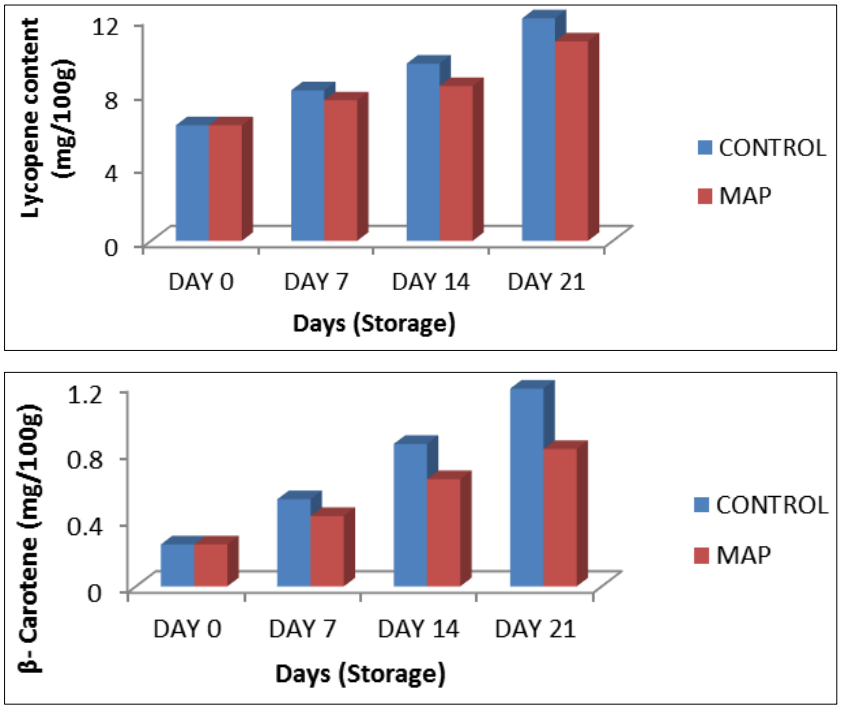

Fig 6: Effect of MAP on lycopene content and β-carotene of tomatoes under refrigerated condition

Conclusion

In order to increase the shelf life of tomatoes, studies on modified atmospheric packaging was carried out as an improved method for tomatoes. It was observed that the film permeability of LDPE 75µm (300 gauge) for O_2 was 2497 ml/m^2/day and CO_2 permeability was 4937 ml/m^2/day. The tomatoes were stored for a period of 21 days. On the 21st day, LDPE 75 µm had an increase in physiological weight loss of 1.18 %, L*, a*, b* values of 20.34, 25.35, 14.9, firmness value of 11.N, TA value of 0.32 %, ascorbic acid of 12.96 mg/100g, TSS of 4.86 ºBrix, lycopene content and β-carotene value 10.76 and 0.82 mg/100g. By analyzing the physico-chemical parameters, it is inferred that the quality and shelf life of tomatoes is enhanced in shroud system while compared

with control during logistics and storage.

Conflict of Interest

The authors have not declared any conflict of interests.

References

1. Abiso E, Satheesh N, Hailu AJAFS, Technology. Effect of storage methods and ripening stages on postharvest quality of tomato (*Lycopersicom esculentum* Mill) cv. Chali. 2015;6(1):127-137.
2. Abubakari M, Rees DJAJofs. The effects of postharvest handling and storage temperature on the quality and shelf of tomato. 2011;5(7):340-348.
3. Akbudak B, Akbudak N, Seniz V, Eris AJJoFQ. Sequential treatments of hot water and modified atmosphere packaging in cherry tomatoes. 2007;30(6):896-910.
4. Beckles DMJPB, Technology. Factors affecting the postharvest soluble solids and sugar content of tomato (*Solanum lycopersicum* L.) fruit. 2012;63(1):129-140.
5. Carrari F, Fernie ARJJoeb. Metabolic regulation underlying tomato fruit development. 2006;57(9):1883-1897.
6. Domínguez I, Lafuente MT, Hernández-Muñoz P, Gavara RJFC. Influence of modified atmosphere and ethylene levels on quality attributes of fresh tomatoes (*Lycopersicon esculentum* Mill.). 2016;209:211-219.
7. Endalew E. Postharvest Loss Assessment of Tomato (*Lycopersicon esculentum* Mill) (Galilea Cultivar) along the Postharvest Supply Chain, Northwest Ethiopia, 2020.
8. Fagundes C, Moraes K, Pérez-Gago MB, Palou L, Maraschin M, Monteiro AJPB, Technology. Effect of active modified atmosphere and cold storage on the postharvest quality of cherry tomatoes. 2015;109:73-81.
9. Geetha P, Preetha P, Ganapathy SJMAJ. Shelf Life Extension of Cashew apple by Modified Atmospheric Packaging. 2021;108(7-9):1.
10. Genanew TJWJoAS. Effect of post-harvest treatments on storage behavior and quality of tomato fruits. 2013;9(1):29-37.
11. Javeria S, Masud T, Sammi S, Tariq S, Sohail A, Butt S, *et al*. Comparative Study for the Extraction of B-carotene in Different Vegetables. 2013;12(11):983-989.
12. Kabir MSN, Rasool K, Lee W-H, Cho S-I, Chung S-OJAA, Food. Influence of delayed cooling on the quality of tomatoes (*Solanum lycopersicum* L.) stored in a controlled chamber. 2020;5(2):272-285.
13. Kader AA. Postharvest technology of horticultural crops. University of California Agriculture and Natural Resources, 2002, 3311.
14. Kaewklin P, Siripatrawan U, Suwanagul A, Lee YSJIJoBM. Active packaging from chitosan-titanium dioxide nanocomposite film for prolonging storage life of tomato fruit. 2018;112:523-529.
15. Kumar V, Shankar R, Kumar GJIJSER. Strategies used for reducing postharvest losses in fruits and vegetables. 2015;6(5):130-137.
16. La Scalia G, Aiello G, Miceli A, Nasca A, Alfonzo A, Settanni LJJoFPE. Effect of vibration on the quality of strawberry fruits caused by simulated transport. 2016;39(2):140-156.
17. Mangaraj S, Goswami TJIjofp. Measurement and modeling of respiration rate of guava (CV. Baruipur) for modified atmosphere packaging. 2011;14(3):609-628.
18. Mapson L. Vitamins in fruits in: Hulme, ac (ed.) the biochemistry of fruits and their products. Academic Press, London, 1970, 1.
19. Moneruzzaman K, Hossain A, Sani W, Saifuddin M, Alenazi MJAJoCS. Effect of harvesting and storage conditions on the post harvest quality of tomato (Lycopersicon esculentum Mill) cv. Roma VF. 2009;3(2):113.
20. Odriozola-Serrano I, Oms-Oliu G, Soliva-Fortuny R, Martín-Belloso OJJoa, Chemistry F. Effect of high-oxygen atmospheres on the antioxidant potential of fresh-cut tomatoes. 2009;57(15):6603-6610.
21. Olveira-Bouzas V, Pita-Calvo C, Vázquez-Odériz ML, Romero-Rodríguez MÁJFC. Evaluation of a modified atmosphere packaging system in pallets to extend the shelf-life of the stored tomato at cooling temperature. 2021;364:130309.
22. Preetha P, Varadharaju N, Vennila PJAJoAR. Enhancing the shelf life of fresh-cut bitter gourd using modified atmospheric packaging. 2015;10(17):1943-1951.
23. Rab A, Haq I-uJTJoA, Forestry. Foliar application of calcium chloride and borax influences plant growth, yield, and quality of tomato (*Lycopersicon esculentum* Mill.) fruit. 2012;36(6):695-701.
24. Ranganna S. Plant Pigments in Manual Analysis of Fruit and Vegetable Products; Ranganna, S., Ed. TaTa McGraw-Hill Publishing Co., Ltd.: New Delhi, India, 1997.
25. Ranganna SJL. New Delhi. Hand book of analysis and quality control for fruits and vegetable products. 2nd McGraw Hill publishing Co, 1995.
26. Rayhan M, Mumtaz B, Motalab M, Zubair M, Haque M. B.J.A.J.F.N. Saha. "Extraction and Quantification of Lycopene, β-Carotene and Total Phenolic Contents from Papaya (Carica papaya) and Formulation of Lycopene Enriched Fruit Drinks. 2019;7:55-63.
27. Saad AM, Ibrahim A. N.J.A.E.I.C.J. El-Bialee. Internal quality assessment of tomato fruits using image color analysis. 2016;18(1):339-352.
28. Saeed A, Khan SN, Sarwar A, Tahira JJJM. Effect of packing materials on storage of tomato. 2010;8(2):85-89.
29. Shahzad T, Ahmad I, Choudhry S, Saeed MK. M.N.J.I.J.o.P. Khan, and P. Sciences. DPPH free radical scavenging activity of tomato, cherry tomato and watermelon: Lycopene extraction, purification and quantification. 2014;6(2):223-228.
30. Vunnam R, Hussain A, Nair G, Bandla R, Gariepy Y, Donnelly D, Kubow S. G.J.J.o.f.s. Raghavan, and technology. Physico-chemical changes in tomato with modified atmosphere storage and UV treatment. 2014;51(9):2106-2112.
31. Workneh T, Osthoff G. M.J.A.J.A.R. Steyn. "Influence of preharvest and postharvest treatments on stored tomato quality. 2011;6(12):2725-2736.