Research Article

Efficacy of Various Packaging Materials on the Postharvest Life of Hydroponically Grown Tomatoes (*Lycopersicon esculentum*, Mill)

Arshad Iqbal[1], Shahid Javed Butt[1], Zia Ul Haq[2]*, Ismara Naseem[3], Qaisar Ali Khan[4] and Muhammad Sajid[1]

[1]Department of Horticulture, Faculty of Crop and Food Sciences, PMAS Arid Agriculture University Rawalpindi, Pakistan; [2]Department of Farm Machinery and Precision Engineering, Faculty of Agricultural Engineering and Technology, PMAS Arid Agriculture University Rawalpindi, Pakistan [3]Institute of Hydroponic Agriculture, PMAS Arid Agriculture University Rawalpindi, Pakistan; [4]Department of Horticulture, Faculty of Crop Production Sciences, The University of Agriculture, Peshawar, Pakistan.

Abstract | Hydroponics is an innovative off-season vegetable/fruit production technique, especially for water-scarce, urban environments, and uneven weather conditions. Such types of weather conditions decrease the shelf-life of hydroponically grown fruit. Almost 30-40% postharvest losses were recorded for fruits and vegetables. This economic loss imposes growers for the adoption of suitable packing materials. The utility of packaging material enhances the shelf-life of fruit, while the selection of packing material depends on its availability, affordability, and performance. To examine the effects of various packing materials on the postharvest life of hydroponically grown tomatoes and to access the best packing materials used to maintain postharvest quality. An experiment was conducted at the Institute of Hydroponic Agriculture, PMAS Arid University Rawalpindi during the year 2018-19. Three types of packing materials were selected during this study, cardboard boxes, polyethylene bags, and wooden crates. Experimental results show that tomato's pH, reducing sugar, non-reducing sugar, total sugar, and number of decay fruits from day 0 to day 16 were continuously increased while average fruit weight, firmness, total soluble solid, titratable acidity (TA) ascorbic acid from day 0 to day 16 were decreased in all the experimental units. It was concluded from the study that the treatment T3 containing cardboard boxes showed the best results in increasing the self-life of tomatoes.

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***Correspondence** | Zia-Ul-Haq, Department of Farm Machinery and Precision Engineering, Faculty of Agricultural Engineering and Technology, PMAS Arid Agriculture University Rawalpindi, Pakistan; **Email**: zia.ch@uaar.edu.pk
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Introduction

In the modern era, hydroponic agriculture is an alternative food-growing system. This must follow the four criteria of sustainable production, as with every other modern horticulture, protection of public health, concern for farmers' health, and concern for the environment's health. New developments in soilless techniques such as green chemistry are also being opened up to another important hydroponic aspect (Carrasco and Urrestarazu, 2010). The goal of hydroponic agriculture is to create new horizons for other fields of modern farming. It includes covered vegetable roofs, green walls, vertical gardens, horticulture or rural peri-urban and intra-urban landscaping (Urrestarazu, and Burés, 2009). Worldwide tomato is the most important vegetable and its production was 170.8 million tons in 2017 from a cultivated area of 3.9 million hectares. It is a short-duration and high-yield crop as well as its cultivation is promoted day by day (Zahedi and Ansari, 2012).

Hydroponically average tomato production in Pakistan was 162 tons per hectare (Malik *et al*., 2018). Tomato is an important ingredient of human food which provides vitamins A and C (Jones, 2008). Packaging is the materials that cover and preserve the products to reduce environmental bad effects on food as well as improve the product marketability (Sammi and Masud, 2010). Cardboard is the main packing raw material used for food packing that strengthens its mechanical characteristics, humidity barrier and reduce contamination as well. Such materials delay climacteric fruits ripening by the maturity of climacteric fruits by controlling their environmental factors (Taechutrakul *et al*., 2008).

The efficiency of a packaging material in increasing the shelf-life of a food relies on the packaging quality (Shahnawaz *et al*., 2012). Packaging boosts the shelf life of several fresh fruits and vegetables by lowering physiological weakness and weight loss (Risse *et al*., 1985). Packaging of fruit and vegetables with metal films reduces transpiration and changes the environment to protect against surface abrasion. Edible films were used as a substitute for synthetic and non-degradable tools to condense fruit respiration, prevent loss of moisture, color and improve softening and mechanical reliability, retain aroma, and prevent the development of microorganisms (Garcia *et al*., 2010). The aim of the current experiment was to investigate the effects of various packing materials on the postharvest life of hydroponically grown tomatoes and to access the best packing materials use to maintained postharvest quality.

Materials and Methods

To assess the feasibility of packing materials on the quality of harvested tomatoes three different packing materials (wooden crates, polyethylene bags, and cardboard boxes) were selected. All the fruits for the experiment were taken with uniform size, firmness and color.

Study area

The research was conducted in the district Rawalpindi of Pothwar region. The weather of the study area has extremely hot summer days and cold winter nights. This region receives a major portion of its rain in the monsoon season while the winter contributes a minor portion with average annual rainfall exceeding 1000 mm.

Testing of different packaging materials

The tomato cultivar beef stick an indeterminate variety was harvested at a physiologically mature stage. Three types of packaging materials were selected in this study i.e. wooden crates, cardboard boxes, and polythene bags. Each packaging materials have three replications, that contain 30 fruits in each. The fruits were packed in such a way as wheat straw at the bottom of the box as well as placed newspaper on the top with proper care in each type of packing material. They shifted to the Post Harvest Lab of PMAS Arid Agriculture University, Rawalpindi. Following experimental treatments were taken during this study.

Wooden crates

Wooden crates were bought from the local vegetable market, having length 19 inches, width 15 inches, and height 11 inches, with a capacity of 5 kg commodity. Wooden crates were placed in the laboratory at room temperature (20-25 °C) and humidity (40- 60%) for 16 days.

Polyethylene bags

Small-sized plastic bags for tomato packaging were taken from the local vegetable market. All the polythene bags were kept at room temperature for 16 days.

Cardboard boxes

Card boxes having a length of 24 inches, width of 16 inches, and height of 12 inches, having a capacity of 5 kg were used. Cardboard boxes were manually made from corrugated cardboard sheets recycled. Three cardboard boxes were placed in the laboratory at ambient temperature for 16 days.

Physiological and chemical parameters

Different parameters regarding tomato post-harvest life were studied as discussed below.

pH of tomato juice: Five tomato fruits from each packaging material were grinded with the help of a juice grinder. The juice was taken in a glass beaker. With the assistance of a pH meter, pH was calculated. The same process was performed by Rangana's (1979) test.

Firmness: To measure the firmness five fruits from each packing material were taken. Penetrometers were injected in tomatoes and readings were recorded on the screen and their readings were measured in Newton (Kumah *et al*., 2011).

Titratable acidity: From each packaging material, five tomato fruits were grinded by a juice grinder. Juice of 10 ml with 40 ml distilled water was prepared and stirred by a magnetic stirrer. From the 50 ml solution, a sample of 10 ml was obtained in a beaker and added 2-3 drops of phenolphthalein and titrated with 0.1 M of NaOH and a proportion of citric acid (Aylar *et al*., 2010).

Total soluble solid: Five tomato fruits from each packaging material were taken and tomato juice was prepared. Put 1-2 drops of tomato juice on the Digital Refractometer, used for assessing the TSS, and the value was noted as Brix (Nirupama *et al*., 2010).

Ascorbic acid content: Three ml tomato juice, and 3 ml HCl (1%) were mixed and shifted in an Eppendorf tube for vertex. Then, the samples were centrifuged for 10 minutes at 10,000 rpm. 0.2 ml of the mixture was taken and combined with 1.8 ml of distilled water as well as absorbance was measured on a spectrophotometer at a wavelength of 243 nm.

$$AA\ (mg/100mL) = Absorbance\ of\ sample\ at\ 243\ nm \times 10/0.293$$

Reducing sugar: Five ml of Tomato juice was extracted from a 25 ml beaker, then 1 ml of potassium oxalate (7%) and 2.5 ml of lead acetate (2%) were used to generate up to 25 ml of distilled water. Fehling solutions of 10 ml (5 ml of each A and B) were recycled to titrate at a gentle warm temperature against the prepared sample before red precipitates appeared. Fehling A was made by dissolving copper sulfate pentahydrate (69.3 g) in 1 liter of tap water and diluting 100 g anhydrous sodium hydroxide and 345 g of sodium potassium tartrate (KNaC4O4H3) in 1L tap water = 6.25(X)/Y (where X= volume of sample used and Y=standard sugar) (Teka, 2013).

Non- reducing sugar: Non-reducing sugar was determined from total sugar and reduced sugar.

Formula = Non-sugar reduction (g/100ml) = total sugar – x sugar reduction (0.95) (Teka, 2013)

Total sugar: A 5 ml arranged sample (25 ml reduced sugar) was poured into a beaker, 4 ml distilled water, and 1 ml of concentrated HCl and placed in the dark overnight. After overnight, 2-3 drops of phenolphthalein were added and neutralized with NaOH, after that it was titrated to Fehling solution as performed for reducing sugar. Total sugar (g/100ml) = 25 (X)/ Y (where X = volume of sample used and Y = standard sugar (Teka, 2013).

Statistical analysis

Experimental data were analyzed statistically and the conclusions were shown as mean and associated by two-way analysis of variance (ANOVA), by statistical software 8.1. Statistical differences were indicated at 5% significance by Duncan's multiple range tests. Critical differences in treatments, storing period, and relations were calculated at $P<0.05$ (Yadav and Singh, 2012).

Results and Discussion

Packaging materials of fruit and vegetables are usually used postharvest training, keeping different carriages as well as storing food, contamination, and market demand of the produce. The influence of the various wrapping tools on the postharvest tomatoes is discussed next.

pH of tomato juice

The mean values of pH (Table 1) were continuously increased from day 0 to 16. The highest pH was recorded on the 16th among all the treatments. Cardboard box T3 at day 16 showed the highest pH (4.5) and cardboard box treatment T3 at day 4 showed the lowest pH (3.34). Statistical analysis shows that treatment T0 and T3 were significant while T1 and T2 are non-significant from each other, at a 5% level of probability with respect to packing materials, while the treatment T0, T1, T2 and T3 are significant at a 5% level of probability with respect to number of days.

Table 1: *Effect of various packaging materials on pH of hydroponic tomatoes (day 0 to 16).*

Treatment (Packing material)	Days					Mean
	Day 0	Day 4	Day 8	Day 12	Day 16	
T0 (Control)	3.51 q	3.74 m	4.11 i	4.29 e	4.5 a	4.03 a
T1 (Wooden carets)	3.45 r	3.69 n	3.88 k	4.19 g	4.39 c	3.92 b
T2 (Polyethene bags)	3.39 s	3.63 o	3.83 l	4.24 f	4.44 b	3.90 b
T3 (Cardboard carets)	3.34 t	3.57 p	3.93 j	4.15 h	4.35 d	3.86 c
Mean	3.42 d	3.65 e	3.93 c	4.22 b	4.42 a	

Table 2: *Effect of various packaging materials on fruit firmness of hydroponic tomatoes (day 0 to 16).*

Treatment (Packing material)	Days					Mean
	Day 0	Day 4	Day 8	Day 12	Day 16	
T0 (Control)	3.83 a	3.45 h	3.21 l	2.97 p	2.73 t	3.24 d
T1 (Wooden carets)	3.79 b	3.57 f	3.33 j	3.09 n	2.85 r	3.32 b
T2 (Polyethene bags)	3.75 c	3.51 g	3.27 k	3.03 o	2.79 s	3.27 c
T3 (Cardboard carets)	3.69 d	3.63 e	3.39 i	3.15 m	2.91 q	3.35 a
Mean	3.76 a	3.54 b	3.30 c	3.06 d	2.82 e	

Table 3: *Effect of different packaging materials on total soluble solids of hydroponic tomatoes (day 0 to 16).*

Treatment (Packing material)	Days					Mean
	Day 0	Day 4	Day 8	Day 12	Day 16	
T0 (Control)	5.13 a	4.94 c	4.69 f	4.45 ij	4.26 mn	4.69 a
T1 (Wooden carets)	5.10 a	4.88 d	4.63 g	4.40 jk	4.21 n	4.64 b
T2 (Polyethene bags)	5.04 b	4.81e	4.57 h	4.35 kl	4.15 o	4.58 c
T3 (Cardboard carets)	4.84 de	4.74 f	4.51 i	4.2 lm	4.09 o	4.49 d
Mean	5.02 a	4.84 b	4.60 c	4.37 d	4.17 e	

These results are in parallel with the finding by Borji *et al.* (2012) that with advancement in maturity, the pH value of tomato increased from mature green to full ripe. At various maturity stages of tomatoes, the value of pH is significantly varied. The minimum and maximum pH of the tomato were noted in mature green to fully ripe.

Firmness

The mean values of firmness (Table 2) were calculated for all the treatments at intervals of four days. The firmness gradually decreased during the storage of tomatoes. All the treatments showed the highest firmness on the day first and the lowest firmness was noted on16th day. T0 (Control) on day first showed the highest firmness (3.8367) while T3 (Cardboard boxes) on day 16 showed the lowest firmness (2.7300). Statistical analysis shows that treatments T0, T1, T2, and T3 are significant at a 5% level of possibility according to packing materials while treatments T0, T1, T2, and T3 significantly differ at a 5% level of probability with respect to days.

These results are parallel with the findings by Mathew *et al.* (2007) high temperature and packaging tools are actual in the maturing of tomatoes resulting in reduced firmness. Advancement in maturity, color of tomato changed from green to pink and pink to red, the chlorophyll pigment starts to decline and beta carotene production wasinitialized.

Total soluble solid

The mean values of total soluble solid (Table 3) were noted for all the treatments at interval of four days. During storage the TSS were decreased among all the treatments. Treatment T0 (Control) indicate the highest TSS (5.1300) and treatment T3 (Cardboard boxes) indicate the lowest TSS (4.0933) value. Statistical analysis shows that treatment T0,T1, T2 and T3 were significantly differ at 5% level of possibility according packing materials, while treatment T0, T1, T2 and T3 were significant at 5% level of probability according to days.

Table 4: *Effect of various packaging materials on titratable acidity of hydroponic tomatoes (day 0 to 16).*

Treatment (Packing material)	Days					Mean
	Day 0	Day 4	Day 8	Day 12	Day 16	
T0 (Control)	1.89 c	1.78 e	1.62 h	1.46 l	1.30 p	1.61 c
T1 (Wooden carets)	1.96 b	1.78 e	1.68 fg	1.54 j	1.37 n	1.66 b
T2 (Polyethene bags)	1.93 b	1.78 e	1.65 gh	1.50 k	1.34 o	1.64 c
T3 (Cardboard carets)	2.00 a	1.85 d	1.71 f	1.58 i	1.42 m	1.71 a
Mean	1.94 a	1.80 b	1.66 c	1.52 d	1.36 e	

Table 5: *Effect of various packaging materials on ascorbic acid of hydroponic tomatoes (day 0 to 16).*

Treatment (Packing Material)	Days					Mean
	Day 0	Day 4	Day 8	Day 12	Day 16	
T0 (Control)	10.77 d	10.5 h	10.29 j	8.30 o	8.06 s	9.62 d
T1 (Wooden carets)	10.89 b	10.65 f	10.41 i	8.42 l	8.18 q	9.71 b
T2 (Polyethene bags)	10.83 c	10.5 g	10.35 j	8.36 m	8.12 r	9.65 c
T3 (Cardboard carets)	10.95 a	10.71	10.53	8.48 k	8.24 p	9.74 a
Mean	10.86 a	10.62 b	10.39 c	8.39 d	8.15 e	

These results are parallel with the findings by Shehla and Tariq (2009) and Abdullah *et al*. (2004), conducted that in tomato at various stages, temperature and packing materials the amount of total soluble solid is increased. Clarke and De Moor (1997) reported that the decreased in TSS contents of tomato ripening were delayed by packaging, the variation in TSS content was by natural phenomenon in maturing and correlated with hydrolytic variations in starch concentration throughout postharvest period.

Titratable acidity

The mean values of Titratable acidity (TA) (Table 4) were gradually decreased for all the treatments from day 0–16 day at interval of four days. Treatment T0 (Control) showed highest TA value (2.0067) and treatment T3 (Cardboard boxes) showed the lowest TA value (1.3067). Statistical analysis shows that treatment T0 and T3 significant while T1 and T2 are non-significant from each other at 5% level of probability with respect to packing materials while the treatment T0, T1, T2 and T3 are significant at 5% level of probability with respect to number of days.

These results are parallel with the finding of (Shehla and Tariq, 2009), reported that during ripening and storage of tomatoes tritatable acidity were decreased. These findings were also supported by Bhattacharya and Sen (2004), who conducted a study indicating that acidity decreased tomato maturity. During ripening malic acid evaporates first then citric acid results decrease titratable acidity in tomatoes.

Ascorbic acid

The mean values of ascorbic acid (Table 5) calculated day 0-16 day at interval of four days. Treatment T0 (Control) showed the highest value for ascorbic acid (10.95 and treatment T3 (Cardboard boxes) showed the lowest value (8.06). Statistical analysis shows that treatment T0, T1, T2 and T3 are significant at 5% level of possibility according packing materials while treatment T0, T1, T2 and T3 significant at 5% level ofprobability according to days.

These results are parallel with the findings by (Ullah, 2009), reported that nutrient depletion and deterioration is mainly due to respiration and transpiration. Harvested fruits still keep on their life processes there is no more transfer of food items and water from the mother plant so it depends on reserve food for sustainability. Commodity deterioration is due deficiency of vitamin c which cause Declay. Moneruzzaman *et al*. (2008), reported that, tomato matures ascorbic acid content reductions therefore to control fast maturing of fruit has a huge effect on the nutrient holding as well as delay of storing life.

Reducing sugar

The mean values of reducing sugar (Table 6) were increased among all the treatments from day 0-16 day at interval of four days. On 16th day treatment T3 (Cardboard boxes) showed the highest value of reducing sugar (4.48) and treatment T0 (Control) showed the lowest value (3.19) on day 0. Statistical analysis shows that treatment T0, T1, T2 and T3 are significant at 5% level of possibility according packing materials while treatment T0, T1, T2 and T3 are significant at 5% level of probability according to days.

These results parallel the findings of Moneruzzaman *et al*. (2009), who observed that reducing sugar increased with ripeness improvement. Harvesting of tomato at various levels occurred changes in reducing sugar (RS) as well as effected by different ripening stages. Full ripe fruit having maximum quantity of reducing sugar and mature green tomato having lowest. It is noted that reducing sugar content was enlarged with advancement in ripeness.

Total sugar

The mean values of total sugar (Table 7) increased in all experimental units from day 0-16 day at interval of four days. Treatment T3 (Cardboard boxes) were found value (5.26) on 16th day which is the highest one among all the treatment, and treatment T0 (Control) showed the lowest value (4.13) on first day. Statistical analysis shows that treatment T0, T1, T2 and T3 are significant at 5% level of possibility according packing materials while treatment T0, T1, T2 and T3 are significant at 5% level of probability according to days.

These results are parallel with the finding by Moneruzzaman *et al*. (2009) who conducted that advancement in maturity of tomato increased total sugar content as well as significantly changes in fruits. The highest as well as lowest total sugar content estimated in full ripe as well as matured green fruit (Wills and Golding, 2016), conducted the rise in sugars reduces the tomato abundant sweeter and satisfactory. Harvesting of tomato at full ripe stage having best aroma and flavour.

Table 6: *Effect of various packaging materials on reducing sugar of hydroponic tomatoes (day 0 to 16).*

Treatment (Packing material)	Days					Mean
	Day 0	Day 4	Day 8	Day 12	Day 16	
T0 (Control)	3.19 t	3.53 o	3.77 l	4.05 h	4.29 d	3.76 d
T1 (Wooden Carets)	3.25 s	3.59 p	3.84 k	4.11 g	4.35 c	3.82 c
T2 (Polyethene Bags)	3.31 r	3.65 n	3.91 j	4.17 f	4.41 b	3.89 b
T3 (Cardboard Carets)	3.43 q	3.71 m	3.98 i	4.23 e	4.48 a	3.96 a
Mean	3.26 e	3.62 d	3.87 c	4.14 b	4.38 a	

Table 7: *Effect of various packaging materials on total sugar of hydroponic tomatoes (day 0 to 16).*

Treatment (Packing material)	Days					Mean
	Day 0	Day 4	Day 8	Day 12	Day 16	
T0 (Control)	4.03 r	4.55 l	4.61 k	4.85 g	5.07 cd	4.62 d
T1 (Wooden Carets)	4.09 q	4.43 n	4.67 j	4.91 f	5.13 c	4.64 c
T2 (Polyethene Bags)	4.12 q	4.49 m	4.73 i	4.97 e	5.23 b	4.70 b
T3 (Cardboard Carets)	4.31 p	4.37 o	4.79 h	5.03 d	5.35 a	4.77 a
Mean	4.13 e	4.46 d	4.70 c	4.94 b	5.19 a	

Table 8: *Effect of various packaging materials on non-reducing sugar of hydroponic tomatoes (day 0 to 16).*

Treatment (Packing material)	Days					Mean
	Day 0	Day 4	Day 8	Day 12	Day 16	
T0 (Control)	1.04 t	1.29 p	1.53 l	1.77 h	2.19 a	1.52 d
T1 (Wooden carets)	1.10 s	1.35 o	1.59 k	1.83 g	2.07 c	1.58 c
T2 (Polyethene bags)	1.17 r	1.41 n	1.65 j	1.89 f	2.13 b	1.65 b
T3 (Cardboard carets)	1.23 q	1.47 m	1.71 i	1.95 e	2.01 d	1.71 a
Mean	1.13 e	1.38 d	1.62 c	1.86 b	2.10 a	

Non-reducing sugar

The average readings of non-reducing sugar (Table 8) were gradually increased among all the treatments from day 0-16 day at interval of four days. Treatment T3 (Cardboard boxes) expressed the highest value among all the treatments on day 16 (2.1900), and treatment T0 (Control) showed the lowest value on day 0 (1.0400). Statistical analysis shows that treatment T0, T1, T2 and T3 are significant at 5% level of significance according to packing materials while treatment T0, T1, T2 and T3 are significant at 5% level of probability according to days.

Above findings are in agreement with the finding of Winsor *et al.* (1962), who conducted that non-reducing sugar content improved in tomato at mature green to full ripe stage is because breakdown of starch in sucrose and further sugars as well as shows significant difference among different maturity stages. The lowest and highest reducing sugar content of tomato was noted in mature green and full ripe tomato. Similar result was reported by Teka (2013), that reduction in starch content attended by rise in soluble solids, total sugar and sucrose is change in climacteric fruit such as tomato.

Number of decayed fruits (No.)

The healthy fruit of identical/uniform size were selected. For measuring number of decayed fruits including the soft fruits with defect including internal rot, stem spot, and blemishes were taken into consideration. The number of rejected/decayed fruit were removed from 0-16 (0, 4, 8, 12 and 16) days and only the fruit were recommended for marketing which are above than any defects. To measure the performance of packing material, the number of decayed fruits from each treatment was counted. The decayed tomatoes were removed after they were counted. The mean values of the number of decay fruits (Table 9) were gradually increased for day0 – 16 at interval of four days. Treatment T0 (Control) expressed the highest number ofdecay fruits on day 12 (2.0000) and number of decay fruit lowest value was (0.0000) atday 0 among all the treatments. Statistical analysis shows that treatment T0 and T1 are non-significant while T2 and T3 significant differ at 5% level of possibility according to packing materials while the treatment T0 and T1, are non-significant while T2 and T3 significant at 5% level of probability according to days.

Haile (2018) reported that decay ratio was effect by various wrapping materials as well as the un-marketability of fruits was because of losses produced by microorganisms. Packaging separates produce from outside atmosphere and supports to confirm situations that, at least less contact to pathogens and impurities that prolong the shelf life of product but it does not decrease the supply of microorganism inside the wrapping tools as well as significantly influenced by temperature. The effect of temperature in falling the development of microorganisms throughout storing, since deterioration may be related with the development of microorganisms.

Table 9: *Effect of various packaging materials on number of decay fruits (mg) of hydroponic (day 0 to 16).*

Treatment (Packing Material)	Days					Mean
	Day 0	Day 4	Day 8	Day 12	Day 16	
T0 (Control)	0.0 d	0.6 bcd	0.6 bcd	0.3 cd	2 a	0.53 ab
T1 (Wooden carets)	0.0 d	0.3 cd	0.0 d	1.3 ab	0.6 bcd	0.46 ab
T2 (Polyethene bags)	0.0 d	0.3 cd	0.6 bcd	1.0 bc	1.3 ab	0.8 a
T3 (Cardboard carets)	0.0 d	0.0 d	0.6 bcd	0.3 cd	0.33 cd	0.26 b
Mean	0.0 c	0.3 c	0.4 bc	1.0 a	0.83 ab	

Table 10: *Effect of various packaging materials on average fruit weight (mg) of hydroponic (day 0 to 16).*

Treatment (Packing material)	Days					Mean
	Day 0	Day 4	Day 8	Day 12	Day 16	
T0 (Control)	279.3 a	257.4 d	233.4 h	209.5 l	163.3 r	228.6 a
T1 (Wooden carets)	268.9 c	239.4 g	215.4 k	190.8 0	176.8 q	227.8 b
T2 (Polyethene bags)	268.9 c	245.4 f	221.4 j	197.4 n	176.8 q	221.98 c
T3(Cardboard carets)	273.5 b	251.5 e	227.3 i	203.4 m	183.4 p	218.2 d
Mean	272.6 a	248.4 b	224.4 c	200.2 d	175.1 e	

Average fruit weight (mg)
The mean values of fruits weight (Table 10) from day 0–16 at interval of four days. The highest fruit weight were recorded at treatment T° (Control) (279.30) on day 0 and the lowest weight was also recorded at treatment T0 (Control) (163.33) on day 16. Statistical analysis shows that treatment T0, T1, T2, T3 significant at 5% level of possibility according to packing materials while treatment T0, T1, T2, T3 significant at 5% level of probability according to days.

Getinet *et al.* (2008) conducted that weight loss of fresh crops has economical effect. In this regard, ripeness stage at harvest and covering material exhibited significant contact in terms of weight loss as related to control with prolonged storage time. For example pectin and chitosan films covered fruits exhibited less weight loss in green mature and turning stages than tomato harvested at light red stage. But, a major weight loss was detected from mature green uncoated fruits than covered ones at light red stage.

Conclusions and Recommendations

In the current study three kinds of packaging materials were used to overcome the post-harvest losses of hydroponically grown tomatoes. The tomatoes were stored for 16 days under room temperature. Fruits packed in cardboard boxes showed best results in all parameters followed by wooden crates and polyethylene bags. The physical damage in wooden crates were due to inadequate fastening of wooden pieces with iron nails while polyethylene bags have no proper aeration therefore more chance of decaying. It is concluded that cardboard boxes is best packing materials for tomatoes.

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Novelty Statement

Good packing material plays a vital role for getting fair prices and enhance the shelf life of tomatoes.

Author's Contribution

Arshad Iqbal: Conducted experiment and wrote first draft of manuscript.
Shahid Javed Butt: Supervised the experiment and helped in technical writing.
Zia Ul Haq: Technical guidance throughout the paper.
Ismara Naseem: Corrected this manuscript.
Qaisar Ali Khan: Formatted the manuscript and helped statistical analysis.
Muhammad Sajid: Helped in data collection.

Conflict of interest
The authors have declared no conflict of interest.

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