Annals of Agri-Bio Research **28** (2): 278-282, 2023 **Impact Score : 0.28 (Scopus)**

Influence of Different Packaging Materials on Physical and Physiological Attributes of Tomato Fruits during Storage

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(Received : October 28; 2022; Accepted : December 1, 2022)

ABSTRACT

Packaging materials of fruits and vegetables during storage affect the quality of fruits and vegetables. Tomato quality changes continuously after harvesting due to its perishable nature. During this period, tomato fruits ripen and may become overripe depending on their temperature and harvest maturity. Good packaging material helps in extending the shelf lives of vegetables and keeps them in good condition for long duration. The paddy straw was found the best packaging material to save the long duration of tomato. Out of different packing materials used were as newspaper, gunny bag, tissue paper, paddy straw, black polythene, red polythene, transparent polythene, white polythene and yellow polythene.

Key words: Tomato, decay loss, paddy straw, physiological loss in weight, gunny bags, polythene

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is widely consumed as fresh, culinary additive or processed products (Chattopadhyay *et al.,* 2021). The crop is said to be native of Peru and belongs to family Solanaceae and bears fruit which are botanically known as berry (Spehia *et al.*, 2019a). Reports of area under tomato in India are 818 thousand hectares with a production of 20550 thousand metric tonnes (Horticultural Statistics at a Glance, 2019-20). Madhya Pradesh, produces 2478.30 thousand metric tonnes of tomato from 86.53 thousand hectare (Horticultural Statistics at a Glance, 2019-20). Tomato is a good source of vitamins and minerals, compared to the cereals; it possesses 750 I.U. of vitamin A and 25-30 mg of ascorbic acid per 100 g of fresh fruit. Tomato fruit contains 93.1% of water, 1.9% of protein, 0.3 g of fat, 0.7% of fiber, 3.6% of carbohydrates, 23 calorie energy, 320 I.U. of vitamin A, 0.07 mg of vitamin B_1, 0.01 mg of vitamin B_2, 31 mg of vitamin C, 20 mg of calcium, 36 mg of phosphorus and 0.8 mg of iron (Spehia *et al.*, 2019b, 2020).

The post-harvest losses after harvesting of fruits or vegetables contribute significant in economic loss of farmers and Indian economy (Mirza *et al.*, 2016; Singh *et al.,* 2017a). The estimated overall post-harvest distribution system losses in tomato varied from 19.4 to 26.9%, including 10.1% loss at farm level (Padma and Shivashanakar, 2017). Extending the shelf life of the perishable products like tomatoes is very important for domestic and export marketing which can be extended by refrigerated storage (Singh *et al.,* 2016; Singh *et al.,* 2017b) and harvesting at right maturity stage (John *et al.*, 2020). Post-harvest losses refer to the measurable quantitative and qualitative food loss in the post-harvest system (Dhaka *et al.*, 2016a; Singh *et al.,* 2018a). Losses in fresh horticultural produce or the fruit juice are directly related to quality degradation which is result of improper handling and transportation of marketable produce (Bains *et al.* 2017; Singh and Sharma, 2017; Singh, 2018).

Post-harvest losses which average between 24 and 40% in developing countries, and between 2 and 20% in developed countries are a major source of waste. High levels of waste result in higher prices for fresh produce, and the farmer

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increasingly facing poverty. Thus, the reduction of post-harvest losses of perishables is of major importance when striving for improved food security in developing countries (Dhaka *et al.*, 2016b; Singh *et al.,* 2018b). Storage temperature is also very important for shelf-life of tomatoes. The lower the temperature, the longer will be the shelf life of the fruit. The optimum storage temperature of fruits must be higher than the chilling temperature. Among the various techniques developed to extend fruit post-harvest life, the use of plastic film is growing in importance because it is convenient in the many different conditions throughout the chain of handling from producer to consumer. Sealed citrus fruit kept at 20°C lost less weight and was firmer than non-sealed fruit at optimal (lower) temperatures. The LDPE (Low Density Poly Ethylene) film is generally used for the packaging of fresh fruits and vegetables, owing to its high permeability and softness when compared to HDPE (High Density Poly Ethylene) film (Singh *et al.,* 2018c). Polyethylene can be easily sealed with good O_2 and CO_2 permeability, low temperature durability, and good tear resistance and good appearance. Keeping these points in view, the present experiment was conducted to find out the suitable packaging material for enhancing storage life of tomato.

MATERIALS AND METHODS

The present research work related to effect of different packaging material on physical parameters of tomato was conducted at Department of Horticulture, School of Agriculture, ITM, University Gwalior (M. P.) during the year 2022. The experiment was laid out in the completely randomized design with three replications. Fresh, ripe, red in colour tomatoes, free from diseases and insects were procured directly from farmer field. These fruits were stored at room temperature after using the packaging materials as per the treatment details given. Treatment details were T_0–Control, T_1–News paper, T_2–Gunny bag, T_3–Tissue paper, T_4–Paddy straw, T_5–Black polythene, T_6–Red polythene, T_7–Transparent polythene, T_8–White polythene and T_9–Yellow polythene. Based on the visual observations data were recorded as per standard procedure (physical parameters at 0, 5, 10, 15 and 20 days after storage). The average weight of fruit was calculated after the final picking by dividing the total weight of fruits (g) by number of fruits. The volume of fruit was recorded by water displacement method with the help of measuring cylinder and was expressed in milliliters. The specific gravity was obtained by dividing the weight of the fruit by the volume of the fruit. The equatorial and polar diameter of the fruits was recordedby using Vernier callipers.

The per cent loss in weight (PLW) for each observation was estimated following Singh *et al.* (2018b).

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

Decay loss was calculated on weight basis. Fruits showing rotting due to over ripening and pathogenic infection were considered decayed and weighed on the day of each observation. Weight of decayed fruits included the total weight of fruits decayed up to that date of observation. The per cent decay loss was calculated following Singh *et al.* (2018b).

$$\text{Decay loss (\%)} = \frac{\text{Weight of decayed fruits}}{\text{Initial weight of fruits at the time of packaging}} \times 100$$

The observations were taken from all the three replications and the average values were statistically analyzed. The data obtained from set of observation for each character were subjected to Analysis of Variance.

RESULTS AND DISCUSSION

The present investigations revealed that the different packing material viz., newspaper, gunny bag, tissue paper, paddy straw, black polythene, red polythene, transparent polythene, white polythene and yellow polythene significantly influenced the shelf-life of tomato (Table 1). The maximum fruit weight (52.30, 46.52, 40.13, 40.04 and 39.96 g) at 0, 5, 10, 15 and 20 days after storage was recorded in treatment T_4 (paddy straw) and it was at par with treatment T_2 (gunny bag) only at 10, 15 and 20 days after storage. The maximum fruit volume (49.68, 44.00, 37.51, 37.42 and 36.77 ml) at 0, 5, 10, 15 and 20 days after storage was again found in T_4 (paddy straw) and it was found the best treatment for influencing the shelf life of tomato among all the treatments (Table 2). It was again at par with treatment T_2 (gunny bag) only at 10, 15 and 20 days after storage. Results showed that there was no significant difference found between various packaging treatments on specific gravity of stored tomato fruits. However, the treatment T_4 (paddy straw) was found the best packing material treatment as compared to other treatments as it gave the maximum specific gravity (0.967, 0.961, 0.952, 0.949 and 0.947) at 0, 5, 10, 15 and 20 days after storage (Table 3). The maximum equatorial diameter of the fruit (5.20, 5.15, 5.01, 4.94 and 4.87 cm) at 0, 5, 10, 15 and 20 days after storage was also recorded in treatment T_4 (paddy straw) and it was at par with treatments T_1 (news paper) and T_2 (gunny bag) at 5, 10, 15 and 20 days after storage (Table 4). Similarly, the maximum polar diameter of the fruit (5.09, 4.90, 4.80, 4.73 and 4.68 cm) at 0, 5, 10, 15 and 20 days after storage was observed in treatment T_4 (paddy straw) and it was at par with treatment T_1, T_2 and T_3 (Table 4).

Table 1. Fruit weight (g) of tomato fruits at 0, 5, 10, 15 and 20 days after storage under different packaging treatments

Treatment	Fruit weight (g)				
	0 DAS	5 DAS	10 DAS	15 DAS	20 DAS
T_0	39.17	36.17	32.09	32.02	31.96
T_1	49.81	44.36	38.78	38.71	38.66
T_2	50.91	45.40	39.62	39.55	39.47
T_3	48.66	43.60	37.23	37.16	37.08
T_4	52.30	46.52	40.13	40.04	39.96
T_5	46.56	42.96	36.58	36.50	36.41
T_6	43.05	40.08	35.74	35.66	35.57
T_7	41.92	39.54	34.85	34.76	34.67
T_8	40.92	38.02	33.36	33.27	33.19
T_9	45.41	41.81	36.04	35.95	35.87
S. Em±	0.282	0.209	0.251	0.251	0.251
C. D. (P=0.05)	0.837	0.622	0.745	0.745	0.745

Table 2. Fruit volume (ml) of tomato fruits at 0, 5, 10, 15 and 20 days after storage under different packaging treatments

Treatment	Fruit volume (ml)				
	0 DAS	5 DAS	10 DAS	15 DAS	20 DAS
T_0	36.87	33.97	29.99	29.91	29.13
T_1	47.51	42.16	36.38	36.30	35.52
T_2	48.61	42.80	37.22	37.13	36.48
T_3	46.04	41.00	34.83	34.74	34.09
T_4	49.68	44.00	37.51	37.42	36.77
T_5	43.94	40.44	33.96	33.86	33.02
T_6	40.43	37.61	33.12	33.02	32.12
T_7	39.30	37.07	32.60	32.51	31.61
T_8	38.30	35.38	31.11	31.02	30.35
T_9	42.97	39.17	33.79	33.69	32.96
S. Em±	0.282	0.209	0.251	0.251	0.251
C. D. (P=0.05)	0.837	0.622	0.745	0.745	0.745

Table 3. Specific gravity (g/ml) of tomato fruits at 0, 5, 10, 15 and 20 days after storage under different packaging treatments

Treatment	Specific gravity (g/ml)				
	0 DAS	5 DAS	10 DAS	15 DAS	20 DAS
T_0	0.960	0.950	0.942	0.937	0.933
T_1	0.966	0.959	0.949	0.946	0.942
T_2	0.966	0.960	0.951	0.948	0.946
T_3	0.964	0.958	0.948	0.944	0.942
T_4	0.967	0.961	0.952	0.949	0.947
T_5	0.964	0.957	0.947	0.943	0.941
T_6	0.963	0.954	0.944	0.940	0.938
T_7	0.962	0.953	0.943	0.940	0.937
T_8	0.961	0.953	0.943	0.940	0.937
T_9	0.963	0.955	0.945	0.942	0.939
S. Em±	0.001	0.003	0.003	0.003	0.003
C. D. (P=0.05)	NS	NS	NS	NS	NS

The significant variation in various physical attributes during storage might be due to the use of different packaging material like *newspaper, gunny bag, tissue paper, paddy straw* and polythene providing the fruit with the best environment possible because of the soft cushion and temperature/transport vibration resistant material, which revealed the fruit's highest shelf life without mechanical damage. Fruit shipping is advised due to low cost and benefit of unrestricted air flow. A significant factor in influencing post-harvest losses up until it reaches its destination is the climatic interaction of the transport vehicle and kind of packing. These results were supported by the findings of Ashenafi (2018), Dahiya and Singh (2018) and Relhan *et al.* (2021).

It was recorded that there was no *physiological loss in weight and decay, or spoilage* recorded at 0 days after storage in tomato (Table 5). The minimum *physiological parameters (viz., physiological loss in weight and decay or spoilage)* at 0, 5, 10, 15 and 20 days after storage were found in treatment T_4 (paddy straw) and it was found the best treatment for influencing the shelf-life of tomato among all the treatments. However, the maximum *physiological loss in weight and decay or spoilage* at 0, 5, 10, 15 and 20 days after storage were recorded in treatment T_0 (control), respectively.

Fruit deterioration is influenced by packing and cushioning materials. By utilizing the right

Table 4. Equatorial and polar diameter (cm) of tomato fruits at 0, 5, 10, 15 and 20 days after storage under different packaging treatments

Treatment	Equatorial diameter (cm)				Polar diameter of the fruit (cm)			
	5 DAS	10 DAS	15 DAS	20 DAS	5 DAS	10 DAS	15 DAS	20 DAS
T_0	4.95	4.80	4.01	3.94	4.80	4.65	4.60	4.53
T_1	5.11	4.96	4.90	4.83	4.88	4.77	4.72	4.67
T_2	5.13	4.98	4.91	4.85	4.89	4.79	4.72	4.68
T_3	5.09	4.94	4.86	4.79	4.87	4.74	4.69	4.63
T_4	5.15	5.01	4.94	4.87	4.90	4.80	4.73	4.68
T_5	5.07	4.92	4.86	4.77	4.86	4.73	4.67	4.61
T_6	5.00	4.85	4.79	4.70	4.84	4.71	4.65	4.58
T_7	4.99	4.84	4.74	4.65	4.83	4.70	4.63	4.56
T_8	4.97	4.82	4.03	3.96	4.82	4.67	4.60	4.56
T_9	5.05	4.90	4.81	4.73	4.85	4.72	4.67	4.59
S. Em±	0.018	0.018	0.018	0.018	0.019	0.023	0.023	0.023
C. D. (P=0.05)	0.053	0.055	0.055	0.055	0.057	0.068	0.068	0.068

Table 5. Physiological loss in weight (PLW %) and decay loss (%) in tomato fruits at 0, 5, 10, 15 and 20 days after storage under different packaging treatments

Treatment	Physiological loss in weight (%)				Decay or spoilage (%)			
	5 DAS	10 DAS	15 DAS	20 DAS	5 DAS	10 DAS	15 DAS	20 DAS
T_0	3.90	9.10	15.71	20.43	5.10	15.52	29.06	43.56
T_1	2.86	8.13	14.32	18.63	3.63	13.75	25.47	38.44
T_2	2.77	8.05	14.13	18.10	3.33	13.43	24.95	37.27
T_3	2.98	8.33	14.50	19.05	4.02	13.95	25.52	38.47
T_4	2.70	7.90	14.05	17.92	3.10	13.10	23.75	36.67
T_5	3.08	8.45	14.89	19.15	4.27	14.36	27.30	39.04
T_6	3.42	8.72	15.33	19.85	4.81	14.86	27.66	41.40
T_7	3.67	8.90	15.35	19.99	4.95	15.06	27.95	41.76
T_8	3.74	9.01	15.45	20.21	5.02	15.35	28.56	42.95
T_9	3.21	8.65	15.08	19.58	4.65	14.57	27.59	41.26
S. Em±	0.034	0.059	0.059	0.059	0.047	0.051	0.051	0.051
C. D. (P=0.05)	0.101	0.176	0.175	0.175	0.141	0.152	0.152	0.152

combination of packaging materials, it is possible to extend the shelf-life of products by individually wrapping them or by grouping them together and placing them in an inert environment or mixture of gases. To achieve favourable barrier properties while packing fresh vegetables, it is required to manage the permeability of specific combinations of packaging materials. The quality of the colour, flavour volatiles, sugars and organic acids in tomatoes are influenced by ethylene and CO_2 generation, which affect the concept of fruit quality. Changes in the pattern of climacteric ethylene production take place as fruit ripens to rot. These results are also in accordance with the findings of Asem *et al.* (2016), Sualeh *et al.* (2016) and Ashenafi (2018).

CONCLUSION

The present study confirmed that the treatment T_4 (paddy straw) was found the best packaging material treatment among all the treatments, and it gave the maximum retention of quality fruits based on the physical and physiological attributes after 20 days of storage of tomato fruits.

ACKNOWLEDGEMENT

The authors thank Department of Horticulture, School of Agriculture, ITM University Gwalior (M. P.) for providing the required materials and research lab for the conduct of research trail.

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