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Storage and Packaging Dependent Physical Properties of Tomatoes

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The study was conducted to see the effect of packaging material and storage condition on the physical properties of tomatoes (*Lycopersicon esculentum* Mill) varieties (*Himshikhar* and *NS – 524*). These varietal tomatoes were packaged in High Density Poly Ethylene (HDPE) and stored under refrigerator, BOD incubator and ambient temperatures. Tomato variety Himshikhar packed in HDPE showed minimum shrinkage at ambient temperature followed by refrigerator and BOD condition.

Keywords: Physical properties, TSS, HDPE, refrigerator, shape factor.

Tomato (*Lycopersicon esculentum* Mill) is the world's most commercially produced vegetable (Gaware *et al*., 2010). The first known record of tomato is in the year 1554 in South America, after 200 years it gradually spread to other parts of the world (Kumar *et al*., 2012). Tomato is rich source of vitamins A, C, potassium, minerals and fibers. Lycopene is a phytochemical nutrient element found in many fruits and vegetables, but excessively found in tomato that imparts natural red colour (Holden *et al*., 1999). Use of tomatoes is increasing day by day and a variety of products like puree, syrup, paste, ketchup, juice etc. are made. To design and optimization a machine for handling, cleaning, conveying, separation and storing, the physical attributes and their relationships must be known (Mirzaee *et al*., 2008). Designing such equipment without consideration of these properties may yield poor results.

Therefore the determination and consideration of these properties have an important role (Taheri-Garavand *et al*., 2009). Among these physical properties, length, width, thickness, mass, volume, projected areas and center of gravity are the most important factors in sizing systems (Mohsenin, 1986). Viswanathan *et al*., (1997) concluded that properties viz., size, density, moisture and force varied with the variety of the tomato fruits. The per cent seed, pulp and skin content in the fruit also varied with the variety. Varshney *et al.*, (2007) studies the physical and mechanical properties of tomato and revealed that moisture content and weight density of fruits decreased while loss and volume shrinkage increased with storage period. Kaymak *et al.*, (2010) determined the color and several physical characteristics of two common tomato cultivars (Alida F1 and H2274) grown in Erzincan region in Turkey. Taheri-Garavand *et al*., (2011) studied on some morphological and physical characteristics of tomato used in mass models to characterize best post harvesting options. Li *et al*., (2011) studied the structural and geometrical properties; Atallah, (2012) conducted study on three different varieties of tomato, Onifade *et al*., (2013) investigate some physical properties of local variety of tomatoes

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that are relevant in the handling and processing of the fruits.

HDPE (High Density Poly Ethylene) used as storage materials, since packaging of fruits in polyethylene films results in modified atmosphere which reduced the fruit decay, softening and loss soluble solids during storage. Keeping of fruits in the polyethylene package help in extension of storage life and retention of quality (Salunkhe and Wu, 1973). According to Vidigal *et al.*, (1979) packing in polyethylene bags decreased weight loss and controlled atmosphere storage improves keeping quality in fruits. Kumar *et al.*, (1999) and Sammi and Masud, (2007) also used polyethylene packaging in their investigation to improve the shelf life of tomatoes. To our knowledge, detailed investigations concerning physical properties of tomato in relation with storage conditions and storage material have not been published. Therefore, the aim of this research was to see the effect on physical attributes of tomato due to HDPE as storage material and three different storage conditions. This information provides useful insights into design of processing, packing equipments and transportations for tomato.

MATERIALS AND METHODS

The experiment was conducted at Food Analysis Laboratory of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (India). Fresh, ripe, red in colour tomatoes, free from disease and insects were procured directly from the farmers of village Dhanju and Lawad. Two varieties of tomatoes namely *Himshikhar* and *NS-524* were used for the present investigation.

Measurement of dimensions: Three linear dimensions namely polar diameter (D_1), major diameter (D_2) and minor diameter (D_3) for all tomatoes were measured using a Vernier Caliper (least count 0.01mm). Polar diameter is defined as the distance between tomato apex and the stem end. Major and minor diameters of the tomatoes are defined as maximum and minimum width respectively in a plane perpendicular to a polar axis (Mohsenin, 1986).

Mass, volume and density: Mass of fresh tomatoes was determined using high accuracy electronic balance. As the tomatoes were numbered the weight of individual tomatoes were recorded every day. The volume of tomato was determined individually by water displacement method using a cylinder of 1 liter capacity. The mass and volume were expressed in 'g' and 'ml' respectively (1 ml=1cm^3). Densities for tomatoes were calculated using the following equation:

$$Density = \frac{weight(g)}{volume\ (cm^3)} \quad ...(1)$$

Geometrical and morphological properties: Arithmetic mean diameters (AMD), geometric mean diameter (GMD), surface area and sphericity for tomatoes were calculated by using the following equations as suggested by Mohsenin (1986):

$$AMD = \frac{D_1 + D_2 + D_3}{3} \quad ...(2)$$

$$GMD = \sqrt[3]{D_1 D_2 D_3} \quad ...(3)$$

$$Surface\ area = \pi (GMD)^2 \quad ...(4)$$

$$Sphericity = \frac{GMD}{D_1} \quad ...(5)$$

(For sphericity D_1 = largest diameter)

Shape factor (λ): Shape factor based on volume & surface area of tomatoes was determined (McCabe and Smith, 1984) as;

$$Shape\ factor = \frac{a}{b} \quad ...(6)$$

Where,

$$a = \frac{V}{(D_3)^3}$$

$$b = \frac{S}{(6D_3)^2}$$

$$V = \frac{\pi GMD^2 {D_2}^2}{6(2D_2 - GMD)} \quad S = \frac{\pi GMD {D_2}^2}{(2D_2 - GMD)}$$

Where, V= volume

S= surface area

TSS: Total soluble solids of tomatoes were measured using a hand hold refractrometer.

Packaging and storage

High density poly ethylene (HDPE) as packaging material was used and then samples were stored under three different storage condition viz. ambient temperature, BOD incubator and refrigerator condition.

Statistical analysis

The data obtained from various experiments were recorded during the course of study and subjected to statistical analysis as per the method of "Analysis of variance". The significance and non significance of data obtained from various experiments was judge with the help of F (Variance ratio) table. OPSTAT software and spreadsheet software (Microsoft Office excel-2007) were used to analyze the recorded data.

RESULTS AND DISCUSSION

Tomato of variety Himshikhar stored under ambient and BOD incubator condition in HDPE shows a gradual decrement in mean values of entire physical parameters viz. polar diameter (4.80 – 3.63 cm), major diameter (5.80 – 4.28 cm), minor diameter (5.35 – 3.90 cm), AMD (5.317 – 3.933 cm), GMD (5.299 – 3.922 cm), mass (87.218 – 66.640 g), volume (90.00 – 64.50 ml), sphericity (91.438 – 68.873%), surface area (88.181 – 64.422 cm^2), density (0.973 – 0.773 g/cc) and shape factor (1.011 – 0.746), which increase with increase in storage period. Similar trends were reported by Varshney *et al.* (2007). Some samples were spoiled after day five of storage. Tomato (Himshikhar) stored under refrigerator condition shows decrement in mean values of polar diameter (4.28 – 4.18 cm), major diameter (4.98 – 4.78 cm), minor diameter (4.80 – 4.60 cm), AMD (4.68 – 4.52 cm), GMD (4.673 – 4.508 cm), mass (59.219 – 59.065 g), volume (61.25 – 54.50 ml), shape factor (1.027 – 1.019) and surface area (69.171 – 64.557 cm^2) with increase in storage period. Whereas the values of sphericity (94.006 – 94.510 %) and density (0.971 – 1.093 g/cc) shows increment. Result data explicit that the TSS increased (6.200 – 6.575 ^{0}brix) with increase in storage time for all the storage conditions. Tomato variety NS-524 stored under ambient temperature in HDPE shows decrement in mean values of physical parameters like major diameter (4.47 – 4.38 cm), minor diameter (4.27 – 4.25 cm), AMD (4.322 – 4.289 cm), GMD (4.320 – 4.288 cm), mass (50.478 – 50.221 g), volume (52.33 – 48.67 ml), surface area (58.842 – 57.975 cm^2). Although the samples were spoiled after four days of storage. Whereas the values of shape factor (0.989 – 0.992), density

Table 1. Effect of packaging material (HDPE) and storage condition (ambient temperature) on the physical properties of tomato (variety: Himshikhar)

Tomato: Himshikhar	Storage material & condition: HDPE, ambient temperature											
Days	D_1 (cm)	D_2 (cm)	D_3 (cm)	AMD (cm)	GMD (cm)	Sphericity (%)	Mass (g) (%)	Volume (ml)	Surface area(cm^2)	Density (g/cc)	Shape factor	TSS (^{0}Brix)
1	4.80 ±0.23	5.80 ±0.24	5.35 ±0.10	5.317 ±0.10	5.299 ±0.10	91.438 ±2.91	87.218 ±10.71	90.00 ±14.14	88.181 ±3.46	0.973 ±0.04	1.011 ±0.03	6.550 ±0.58
2	4.80 ±0.23	5.65 ±0.26	5.20 ±0.18	5.217 ±0.16	5.203 ±0.16	92.151 ±2.01	87.215 ±10.70	89.00 ±13.22	85.067 ±5.17	0.983 ±0.03	1.000 ±0.03	N.D.
3	4.79 ±0.25	5.65 ±0.26	5.20 ±0.18	5.213 ±0.16	5.198 ±0.16	92.068 ±2.06	87.200 ±10.70	88.63 ±13.28	84.912 ±5.17	0.987 ±0.03	1.001 ±0.03	N.D.
4	4.78 ±0.26	5.65 ±0.26	5.20 ±0.18	5.208 ±0.16	5.194 ±0.16	91.985 ±2.12	87.184 ±10.70	88.25 ±13.38	84.757 ±5.19	0.991 ±0.04	1.002 ±0.03	N.D.
5	4.78 ±0.26	5.63 ±0.29	5.18 ±0.21	5.192 ±0.18	5.178 ±0.18	92.114 ±2.12	86.969 ±10.83	86.75 ±11.84	84.254 ±5.84	1.004 ±0.02	1.000 ±0.03	N.D.
6	3.63 ±2.43	4.28 ±2.86	3.93 ±2.62	3.942 ±2.63	3.930 ±2.62	69.016 ±46.06	66.654 ±45.57	65.75 ±44.78	64.712 ±43.34	0.760 ±0.51	0.749 ±0.50	N.D.
7	3.63 ±2.43	4.28 ±2.86	3.90 ±2.61	3.933 ±2.62	3.922 ±2.62	68.873 ±45.97	66.640 ±45.56	64.50 ±43.56	64.422 ±43.10	0.773 ±0.52	0.746 ±0.50	6.825 ±0.57
$CD_{5\%}$	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	
SE(d)	0.791	0.953	0.877	0.873	0.870	15.775	14.103	13.070	13.795	0.186	0.174	
SE(m)	0.559	0.674	0.620	0.617	0.615	11.154	9.972	9.242	9.754	0.131	0.123	
CV	25.104	25.545	25.562	25.408	25.401	26.129	24.533	22.585	24.548	28.414	26.421	
R^2	0.637	0.682	0.688	0.674	0.672	0.612	0.631	0.706	0.717	0.536	0.645	

Mean values are 3 replicates

Table 2. Effect of packaging material (HDPE) and storage condition (refrigerator) on the physical properties of tomato (variety: Himshikhar).

Tomato: Himshikhar						Storage material & condition: HDPE, ambient temperature						
Days	D_1 (cm)	D_2 (cm)	D_3 (cm)	AMD (cm)	GMD (cm)	Sphericity (%)	Mass (g) (%)	Volume (ml)	Surface area(cm^2)	Density (g/cc)	Shape factor	TSS (^{0}Brix)
1	4.28	4.98	4.80	4.68	4.673	94.006	59.219	61.25	69.171	0.971	1.027	6.200
	±0.43	±0.58	±0.54	±0.51	±0.51	±1.38	±19.22	±20.56	±14.56	±0.02	±0.01	±0.32
2	4.26	4.94	4.74	4.65	4.636	93.905	59.185	60.13	68.147	0.988	1.021	N.D.
	±0.46	±0.56	±0.60	±0.53	±0.53	±1.68	±19.19	±20.07	±15.03	±0.03	±0.02	
3	4.25	4.90	4.68	4.61	4.599	93.809	59.151	59.00	67.124	1.006	1.014	N.D.
	±0.48	±0.55	±0.66	±0.55	±0.55	±2.53	±19.17	±19.63	±15.51	±0.05	±0.02	
4	4.21	4.88	4.66	4.58	4.573	93.790	59.137	58.63	66.380	1.013	1.017	N.D.
	±0.47	±0.56	±0.66	±0.55	±0.55	±2.76	±19.16	±19.46	±15.47	±0.05	±0.02	
5	4.18	4.85	4.65	4.56	4.548	93.773	59.124	57.75	65.646	1.028	1.020	N.D.
	±0.46	±0.57	±0.66	±0.55	±0.55	±3.00	±19.14	±19.26	±15.51	±0.04	±0.02	
6	4.18	4.78	4.60	4.52	4.508	94.510	59.065	54.50	64.557	1.093	1.019	6.575
	±0.46	±0.63	±0.63	±0.56	±0.56	±2.00	±19.12	±18.56	±15.69	±0.06	±0.02	±0.43
CD5%	0.068	0.115	0.091	0.071	0.071	N.S.	0.060	1.712	1.993	0.028	N.S.	
SE(d)	0.032	0.053	0.042	0.033	0.033	0.756	0.028	0.796	0.927	0.013	0.007	
SE(m)	0.023	0.038	0.030	0.023	0.023	0.535	0.020	0.563	0.655	0.009	0.005	
CV	1.066	1.547	1.282	1.015	1.012	1.139	0.067	1.922	1.960	1.804	1.000	
R2	0.951	0.971	0.940	0.993	0.994	0.160	0.954	0.899	0.995	0.863	0.239	
Mean values are 3 replicates?												

Table 3. Effect of packaging material (HDPE) and storage condition (BOD incubator) on the physical properties of tomato (variety: Himshikhar)

Tomato: Himshikhar						Storage material & condition: HDPE, ambient temperature						
Days	D_1 (cm)	D_2 (cm)	D_3 (cm)	AMD (cm)	GMD (cm)	Sphericity (%)	Mass (g) (%)	Volume (ml)	Surface area(cm^2)	Density (g/cc)	Shape factor	TSS (^{0}Brix)
1	4.50	5.15	4.90	4.850	4.842	94.085	66.287	68.75	73.874	0.961	1.012	6.100
	±0.26	±0.40	±0.36	±0.33	±0.33	±1.62	±14.76	±13.77	±10.05	±0.04	±0.01	±0.59
2	4.50	5.13	4.86	4.829	4.822	94.180	66.185	68.38	73.263	0.965	1.008	N.D.
	±0.26	±0.43	±0.34	±0.34	±0.33	±1.92	±14.75	±13.79	±10.13	±0.03	±0.01	
3	4.50	5.10	4.83	4.808	4.801	94.279	66.082	68.00	72.651	0.969	1.005	N.D.
	±0.26	±0.46	±0.33	±0.34	±0.34	±2.29	±14.74	±13.83	±10.21	±0.03	±0.01	
4	4.50	5.06	4.83	4.796	4.790	94.731	65.917	67.50	72.298	0.975	1.008	N.D.
	±0.26	±0.45	±0.33	±0.34	±0.34	±1.97	±14.82	±14.39	±10.15	±0.02	±0.01	
5	3.45	3.88	3.68	3.667	3.662	70.941	52.855	53.75	56.310	0.737	0.752	N.D.
	±2.31	±2.61	±2.47	±2.46	±2.46	±47.31	±37.07	±37.69	±38.37	±0.49	±0.50	
6	3.43	3.85	3.68	3.650	3.645	71.125	52.760	53.50	55.789	0.739	0.756	6.475
	±2.29	±2.60	±2.47	±2.45	±2.44	±47.46	±37.01	±37.42	±38.03	±0.49	±0.50	±0.61
CD5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	
SE(d)	0.764	0.847	0.833	0.815	0.814	17.538	9.510	9.804	11.368	0.177	0.187	
SE(m)	0.540	0.599	0.589	0.576	0.575	12.401	6.725	6.932	8.039	0.125	0.132	
CV	26.058	25.531	26.414	25.983	25.995	28.655	21.805	21.898	23.866	28.142	28.609	
R2	0.688	0.730	0.719	0.714	0.714	0.669	0.702	0.739	0.743	0.649	0.692	
Mean values are 3 replicates?												

Table 4. Effect of packaging material (HDPE) and storage condition (ambient temperature) on the physical properties of tomato (variety: NS-524)

Tomato: Himshikhar						Storage material & condition: HDPE, ambient temperature						
Days	D_1 (cm)	D_2 (cm)	D_3 (cm)	AMD (cm)	GMD (cm)	Sphericity (%)	Mass (g) (%)	Volume (ml)	Surface area(cm^2)	Density (g/cc)	Shape factor	TSS (^{0}Brix)
1	4.23 ±0.42	4.47 ±0.35	4.27 ±0.25	4.322 ±0.33	4.320 ±0.33	96.738 ±1.10	50.478 ±10.79	52.33 ±11.68	58.842 ±9.09	0.966 ±0.01	0.989 ±0.02	4.467 ±0.06
2	4.23 ±0.42	4.45 ±0.35	4.27 ±0.25	4.317 ±0.33	4.315 ±0.33	96.976 ±0.69	50.441 ±10.79	51.17 ±10.80	58.699 ±9.11	0.986 ±0.02	0.990 ±0.02	ND
3	4.23 ±0.42	4.43 ±0.35	4.27 ±0.25	4.311 ±0.34	4.310 ±0.34	97.219 ±0.31	50.405 ±10.79	50.00 ±10.00	58.555 ±9.14	1.007 ±0.04	0.991 ±0.02	ND
4	4.23 ±0.42	4.38 ±0.38	4.25 ±0.25	4.289 ±0.34	4.288 ±0.34	97.859 ±1.30	50.221 ±10.83	48.67 ±10.07	57.975 ±9.30	1.033 ±0.07	0.992 ±0.02	ND
5						Spoiled						5.067
6						Spoiled						±0.12
CD5%	0.396	0.341	0.240	0.321	0.320	1.046	10.281	10.298	8.722	0.052	0.021	
SE(d)	0.176	0.151	0.106	0.142	0.142	0.463	4.555	4.563	3.864	0.023	0.009	
SE(m)	0.124	0.107	0.075	0.101	0.100	0.328	3.221	3.226	2.732	0.016	0.007	
CV	7.618	6.267	4.577	6.059	6.056	0.876	16.608	16.586	12.132	4.215	1.716	
R2	0.685	0.696	0.688	0.689	0.689	0.679	0.688	0.726	0.693	0.646	0.684	

Mean values are 3 replicates

Table 5. Effect of packaging material (HDPE) and storage condition (refrigerator) on the physical properties of tomato (variety: NS-524)

Tomato: Himshikhar						Storage material & condition: HDPE, ambient temperature						
Days	D_1 (cm)	D_2 (cm)	D_3 (cm)	AMD (cm)	GMD (cm)	Sphericity (%)	Mass (g) (%)	Volume (ml)	Surface area(cm^2)	Density (g/cc)	Shape factor	TSS (^{0}Brix)
1	4.33 ±0.31	4.50 ±0.20	4.37 ±0.32	4.400 ±0.27	4.399 ±0.27	97.708 ±2.12	50.662 ±11.84	51.67 ±10.41	60.921 ±7.49	0.976 ±0.04	0.992 ±0.02	5.733 ±0.92
2	4.32 ±0.33	4.50 ±0.20	4.33 ±0.33	4.383 ±0.28	4.382 ±0.29	97.323 ±2.50	50.580 ±11.83	51.17 ±10.77	60.466 ±7.77	0.985 ±0.03	0.988 ±0.02	ND
3	4.30 ±0.36	4.50 ±0.20	4.30 ±0.35	4.367 ±0.30	4.365 ±0.30	96.936 ±2.89	50.498 ±11.81	50.67 ±11.15	60.011 ±8.05	0.995 ±0.02	0.985 ±0.02	ND
4	4.23 ±0.35	4.50 ±0.20	4.30 ±0.35	4.344 ±0.29	4.342 ±0.30	96.431 ±2.76	50.336 ±11.82	49.50 ±11.30	59.387 ±7.96	1.017 ±0.04	0.990 ±0.02	ND
5	4.17 ±0.35	4.50 ±0.20	4.30 ±0.35	4.322 ±0.29	4.319 ±0.29	95.920 ±2.64	50.174 ±11.83	48.33 ±11.55	58.759 ±7.87	1.041 ±0.07	0.995 ±0.02	ND
6	2.77 ±2.42	2.93 ±2.55	2.73 ±2.39	2.811 ±2.45	2.809 ±2.45	63.785 ±55.28	32.381 ±30.33	30.00 ±27.84	37.345 ±33.21	0.717 ±0.62	0.648 ±0.56	6.467 ±0.90
CD5%	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	
SE(d)	0.819	0.847	0.841	0.836	0.835	18.973	10.290	10.064	11.406	0.201	0.194	
SE(m)	0.579	0.599	0.595	0.591	0.591	13.416	7.276	7.116	8.065	0.142	0.137	
CV	24.962	24.466	25.404	24.932	24.937	25.437	26.566	26.288	24.880	25.714	25.415	
R2	0.522	0.428	0.465	0.471	0.472	0.475	0.451	0.569	0.511	0.246	0.420	

Mean values are 3 replicates?

Table 6. Effect of packaging material (HDPE) and storage condition (BOD incubator) on the physical properties of tomato (variety: NS-524)

Tomato: Himshikhar				Storage material & condition: HDPE, ambient temperature								
Days	D_1 (cm)	D_2 (cm)	D_3 (cm)	AMD (cm)	GMD (cm)	Sphericity (%)	Mass (g) (%)	Volume (ml)	Surface area(cm^2)	Density (g/cc)	Shape factor	TSS (^{0}Brix)
1	4.37 ±0.15	4.50 ±0.36	4.40 ±0.36	4.422 ±0.27	4.420 ±0.27	97.537 ±0.75	52.375 ±9.51	51.67 ±10.41	61.501 ±7.38	1.018 ±0.05	0.995 ±0.03	4.700 ±0.20
2	4.32 ±0.19	4.50 ±0.36	4.37 ±0.31	4.394 ±0.27	4.393 ±0.27	97.721 ±1.98	52.313 ±9.48	49.33 ±10.13	60.744 ±7.37	1.065 ±0.05	0.994 ±0.02	ND
3	4.27 ±0.23	4.50 ±0.36	4.33 ±0.25	4.367 ±0.27	4.365 ±0.27	97.097 ±1.83	52.251 ±9.46	47.00 ±9.85	59.982 ±7.36	1.118 ±0.06	0.993 ±0.02	ND
4						Spoiled						5.033
5						Spoiled						±0.21
6						Spoiled						-
CD5%	0.200	0.364	0.316	0.274	0.272	1.722	9.571	10.228	7.441	0.055	0.028	
SE(d)	0.089	0.161	0.140	0.121	0.121	0.763	4.241	4.532	3.297	0.024	0.013	
SE(m)	0.063	0.114	0.099	0.086	0.085	0.540	2.999	3.205	2.331	0.017	0.009	
CV	5.022	8.777	7.844	6.760	6.727	1.918	19.857	22.502	13.295	5.591	3.102	
R2	0.779	0.771	0.776	0.775	0.775	0.773	0.772	0.801	0.779	0.737	0.772	

Mean values are 3 replicates

(0.966 – 1.033 g/cc), sphericity (96.738 – 97.859 %) and TSS (4.467 – 5.067 ^{0}brix) increased continuously and polar diameter (D_1) remain unchanged (4.23 cm) before samples get spoiled. The decrement was observed in entire physical parameters viz. polar diameter (4.33 – 2.77 cm), major diameter (4.50 – 2.93cm), minor diameter (4.37 – 2.73 cm), AMD (4.400 – 2.811 cm), GMD (4.399 – 2.809 cm), mass (50.662 – 32.381 g), volume (51.67 – 30.00 ml), surface area (60.921 – 37.345 cm^2), density (0.976 – 0.717 g/cc) and shape factor (0.992 – 0.648) under refrigerator storage conditions. Half the samples were spoiled after five days of storage. Only TSS increased (5.733 – 6.467 ^{0}brix) continuously. Data explicit that the tomato (NS-524) stored under BOD incubator condition showed decrement in mean values of the entire physical parameter. The samples were spoiled after 3 days of storage under BOD incubator condition. Density (1.018 – 1.118 g/cc) and TSS (4.700 – 5.033 ^{0}brix) increased with increase in storage time but major diameter (D_2) shows no change (4.50 cm) during storage.

CONCLUSION

On the basis of the experimental finding it may be conclude that tomato variety Himshikhar packed in HDPE shows minimum shrinkage at ambient temperature then refrigerator and BOD incubator storage condition. Tomato variety NS – 524 packed in HDPE shows maximum shrinkage under refrigerator condition then BOD incubator and ambient storage condition; however samples under BOD incubator spoiled after three days and under ambient temperature storage condition spoiled after four days of storage. Tomato variety Himshikhar was found superior over tomato variety NS – 524.

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