

Research Article

Storage and Aluminum Foil Packaging Dependent Physical Properties of Tomatoes

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Abstract

Effect of packaging material and storage condition on the physical properties of tomatoes (*Lycopersicon esculentum* Mill) varieties *Himshikhar* and *NS – 524* were observed during study. Tomatoes were packaged in Aluminum Foil Packaging and stored under refrigerator, BOD incubator and ambient temperatures; physical parameters of each tomato were recorded and data was compared for both varieties. During experiment it was observed that physical parameters were decreased but TSS were increased. Under given set of conditions *Himshikhar* variety shows minimum shrinkage as compared to *NS-524*.

Keywords: Physical properties, TSS, Aluminum Foil package, refrigerator, Shape factor

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Introduction

Tomatoes (*Lycopersicon esculentum* Mill) and tomato products are an important part of human diet. It 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 [1, 2]. Use of tomatoes is increasing day by day and a variety of products like puree, syrup, paste, ketchup, juice etc. are made. Viswanathan *et al.* [3] 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. To design and optimization a machine for handling, cleaning, conveying, separation and storing, the physical attributes and their relationships must be known [4]. Designing such equipment without consideration of these properties may yield poor results. Therefore the determination and consideration of these properties have an important role [5]. Among these physical properties, length, width, thickness, mass, volume, projected areas and center of gravity are the most important factors in sizing systems [6]. Varshney *et al.* [7] 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. Taheri-Garavand *et al.* [5] studied on some morphological and physical characteristics of tomato used in mass models to characterize best post harvesting options. Onifade *et al.* [8] investigate some physical properties of local variety of tomatoes that are relevant in the handling and processing of the fruits.

The primary purpose of a manufacturer is to protect the food products, to keep it in good condition and to preserve under suitable form of packaging for a finished product. As aluminum foil acts as a complete barrier to light and oxygen (which cause fats to oxidize or become rancid), odors and flavors, moisture, and bacteria, it is used extensively in food and pharmaceutical packaging. Aluminum foil is used to make long life packs (aseptic packaging) for drinks and dairy products which enables storage without refrigeration. Foil is a very thin sheet of rolled aluminum. The thickness of foil ranges from the thinnest currently produced commercially at about 0.0065 mm (or 6.5 μm) to the defined upper limit of 0.2 mm (or 200 μm). Standard household foil is typically 0.016 mm thick and heavy duty household foil is typically 0.024 mm thick. Thin foils are fragile and are sometimes laminated to other materials such as plastics or paper to make them more useful.

Materials and Methods

Experiment was conducted at Food Analysis Laboratory of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (India). Fresh, ripe, red in color tomatoes, free from disease and insects were procured directly from the farmers of village Dhanju and Lawad. Two varieties of tomatoes viz. *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 [6].

Mass and volume

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 ($1\text{ ml}=1\text{ cm}^3$).

Geometrical and morphological properties viz. AMD, GMD, surface area and sphericity; Density, Shape factor (λ) etc. were measured same as Kumar *et al.*, [9]. TSS of tomatoes were measured using a hand hold refractometer.

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

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 ($^{\circ}\text{Brix}$)
1	4.80 ± 0.16	5.68 ± 0.10	5.35 ± 0.13	5.275 ± 0.07	5.262 ± 0.08	92.740 ± 2.41	83.663 ± 3.55	87.50 ± 2.89	86.941 ± 2.58	0.956 ± 0.02	1.017 ± 0.01	6.025 ± 0.17
2	4.80 ± 0.16	5.58 ± 0.05	5.28 ± 0.10	5.217 ± 0.06	5.206 ± 0.06	93.395 ± 1.95	83.656 ± 3.53	86.75 ± 3.95	85.112 ± 2.06	0.965 ± 0.01	1.013 ± 0.01	N.D.
3	4.80 ± 0.16	5.54 ± 0.07	5.25 ± 0.09	5.196 ± 0.06	5.186 ± 0.06	93.669 ± 1.87	83.651 ± 3.53	85.63 ± 3.30	84.461 ± 2.07	0.977 ± 0.01	1.012 ± 0.01	N.D.
4	4.80 ± 0.16	5.50 ± 0.14	5.23 ± 0.10	5.175 ± 0.07	5.166 ± 0.07	93.962 ± 2.26	83.647 ± 3.53	84.50 ± 4.04	83.806 ± 2.28	0.991 ± 0.04	1.012 ± 0.02	N.D.
5	4.80 ± 0.16	5.45 ± 0.17	5.16 ± 0.14	5.138 ± 0.10	5.129 ± 0.10	94.165 ± 2.43	83.594 ± 3.52	83.50 ± 3.87	82.639 ± 3.18	1.002 ± 0.04	1.006 ± 0.02	N.D.
6	2.40 ± 2.78	2.75 ± 3.18	2.63 ± 3.03	2.592 ± 2.99	2.587 ± 2.99	47.039 ± 54.33	41.593 ± 48.15	42.50 ± 49.14	42.047 ± 48.61	0.489 ± 0.56	0.507 ± 0.59	N.D.
7	2.40 ± 2.78	2.73 ± 3.15	2.63 ± 3.03	2.583 ± 2.98	2.579 ± 2.98	47.324 ± 54.65	41.582 ± 48.13	41.75 ± 48.22	41.800 ± 48.34	0.498 ± 0.58	0.509 ± 0.59	6.375 ± 0.25
CD _{5%}	2.024	2.285	2.150	2.152	2.150	39.758	35.416	35.128	34.419	0.428	0.422	
CV	32.867	32.168	31.906	32.278	32.305	33.061	33.028	32.072	31.754	34.052	32.480	
R ²	0.625	0.673	0.665	0.655	0.654	0.605	0.625	0.684	0.682	0.561	0.635	

Packaging and storage

Aluminum foil packages were used as packaging material and samples were stored under three different storage condition namely ambient temperature, BOD incubator and refrigerator condition.

Results and Discussion

Effect on the physical properties of tomato (var.: *Himshikhar*)

Decrement shown in mean values of all the physical parameters viz. polar diameter (D_1) major diameter (D_2), minor diameter (D_3), AMD, GMD, mass, sphericity, volume, surface area, density and shape factor of tomato (*Himshikhar*) stored under ambient condition in aluminum foil packs with increase in storage period (**Table 1**); however only TSS increased ($6.025 - 6.375$ $^{\circ}\text{B}$) with increase in storage time. Some samples were spoiled on sixth day of storage; same pattern was reported by Kumar *et al.*, [10].

Tomato samples stored under refrigerator condition in aluminum foil packs shows decrement in physical parameters like polar diameter (D_1) major diameter (D_2), minor diameter (D_3), AMD, GMD, mass, volume, shape factor, sphericity and surface area (**Table 2**) whereas density ($1.005 - 1.038$ g/cc) and TSS ($6.625 - 7.000$ $^{\circ}\text{B}$) increased with increase in storage period.

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

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	4.10 ±0.44	4.80 ±0.54	4.70 ±0.54	4.533 ±0.48	4.520 ±0.48	94.228 ±1.95	56.129 ±19.45	56.00 ±19.85	64.696 ±14.11	1.005 ±0.04	1.039 ±0.03	6.625 ±0.19
2	4.09 ±0.45	4.78 ±0.55	4.66 ±0.49	4.508 ±0.47	4.496 ±0.47	94.251 ±2.57	56.121 ±19.44	55.75 ±19.97	63.982 ±13.83	1.010 ±0.03	1.037 ±0.03	N.D.
3	4.08 ±0.46	4.75 ±0.57	4.63 ±0.45	4.483 ±0.46	4.471 ±0.46	94.285 ±3.41	56.112 ±19.44	55.50 ±20.11	63.266 ±13.55	1.015 ±0.02	1.035 ±0.02	N.D.
4	4.06 ±0.47	4.75 ±0.57	4.63 ±0.45	4.479 ±0.47	4.466 ±0.47	94.178 ±3.50	56.098 ±19.44	55.25 ±20.25	63.141 ±13.66	1.020 ±0.02	1.036 ±0.02	N.D.
5	4.05 ±0.49	4.75 ±0.57	4.63 ±0.45	4.475 ±0.47	4.461 ±0.47	94.070 ±3.61	56.084 ±19.44	55.00 ±20.41	63.015 ±13.79	1.026 ±0.02	1.038 ±0.03	N.D.
6	4.05 ±0.49	4.73 ±0.59	4.55 ±0.50	4.442 ±0.50	4.429 ±0.49	93.869 ±3.12	56.030 ±19.47	54.25 ±20.11	62.179 ±14.39	1.038 ±0.02	1.028 ±0.03	7.000 ±0.16
CD _{5%}	N.S.	N.S.	0.061	0.024	0.024	N.S.	0.025	N.S.	0.643	N.S.	N.S.	
CV	0.709	0.940	0.865	0.357	0.356	0.911	0.030	1.461	0.667	1.708	0.760	
R ²	0.951	0.864	0.830	0.925	0.937	0.708	0.848	0.938	0.930	0.964	0.479	

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

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	4.53 ±0.05	5.23 ±0.38	4.98 ±0.25	4.908 ±0.21	4.898 ±0.20	93.901 ±3.03	67.034 ±7.51	68.00 ±5.72	75.415 ±6.05	0.984 ±0.04	1.015 ±0.01	6.425 ±0.51
2	4.51 ±0.02	5.23 ±0.38	4.95 ±0.25	4.896 ±0.21	4.885 ±0.20	93.657 ±2.97	66.986 ±7.50	67.63 ±5.88	75.028 ±6.06	0.989 ±0.04	1.013 ±0.01	N.D.
3	4.50 ±0.00	5.23 ±0.38	4.93 ±0.25	4.883 ±0.21	4.872 ±0.20	93.411 ±2.92	66.939 ±7.49	67.25 ±6.08	74.640 ±6.08	0.994 ±0.03	1.010 ±0.01	N.D.
4	4.46 ±0.02	5.19 ±0.40	4.91 ±0.25	4.854 ±0.22	4.843 ±0.21	93.536 ±3.01	66.886 ±7.51	66.88 ±6.14	73.761 ±6.53	0.999 ±0.03	1.014 ±0.01	N.D.
5	4.43 ±0.05	5.15 ±0.42	4.90 ±0.26	4.825 ±0.24	4.814 ±0.23	93.663 ±3.11	66.833 ±7.53	66.50 ±6.24	72.888 ±6.99	1.004 ±0.04	1.018 ±0.01	N.D.
6	4.40 ±0.00	5.15 ±0.42	4.90 ±0.26	4.817 ±0.23	4.804 ±0.21	93.496 ±3.40	66.759 ±7.51	65.25 ±8.18	72.583 ±6.47	1.024 ±0.02	1.020 ±0.01	6.700 ±0.48
CD _{5%}	0.048	0.037	0.042	0.029	0.029	N.S.	0.041	1.633	0.850	N.S.	N.S.	
CV	0.707	0.473	0.563	0.389	0.388	0.330	0.040	1.604	0.755	1.850	0.503	
R ²	0.974	0.854	0.913	0.970	0.974	0.342	0.993	0.922	0.974	0.892	0.432	

Values of polar diameter, major diameter, minor diameter, AMD, GMD, mass, volume, sphericity and surface area of samples stored under BOD incubator condition decreased during storage (**Table 3**); however shape factor (1.015 – 1.020), density (0.984 – 1.024 g/cc) and TSS (6.425 – 6.700 ⁰B) increased with increase in storage time.

Effect on the physical properties of tomato (var.: NS - 524)

Data explicit that the decrement shown in mean values of the entire physical parameter of tomato (*NS-524*) stored in aluminum foil packs under ambient temperature (**Table 4**). Half of the samples were spoiled during the storage after day four. Only TSS increased (4.967 – 5.500 ⁰B) with increase in storage period. Almost same pattern was observed in tomato samples stored under refrigerator conditions (**Table 5**). Increments in TSS were found in the range of 5.767 – 6.333 ⁰Brix. Half of the samples were spoiled after five days of storage.

In case of storage under BOD incubator conditions; half of the samples of variety *NS-524* were spoiled during three days of storage and after day four all the samples were got spoiled. Decrement observed in mean values of the entire physical parameters (**Table 6**), however only TSS increased (4.167 – 4.567 ⁰B) with increase in storage time.

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

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	4.47 ±0.32	4.93 ±0.15	4.80 ±0.36	4.733 ±0.25	4.728 ±0.25	95.789 ±2.54	62.444 ±6.73	66.67 ±7.64	70.313 ±7.48	0.937 ±0.01	1.015 ±0.03	4.967 ±1.19
2	4.47 ±0.32	4.92 ±0.16	4.80 ±0.36	4.728 ±0.25	4.722 ±0.25	96.012 ±2.75	62.419 ±6.74	65.83 ±7.42	70.151 ±7.45	0.948 ±0.00	1.016 ±0.03	ND
3	4.47 ±0.32	4.90 ±0.17	4.80 ±0.36	4.722 ±0.25	4.717 ±0.25	96.238 ±3.00	62.393 ±6.75	65.00 ±7.21	69.988 ±7.43	0.960 ±0.00	1.017 ±0.03	ND
4	4.47 ±0.32	4.87 ±0.20	4.77 ±0.34	4.700 ±0.25	4.695 ±0.25	96.463 ±2.75	62.358 ±6.75	64.33 ±6.93	69.350 ±7.39	0.969 ±0.00	1.015 ±0.03	ND
5	1.57 ±2.71	1.57 ±2.71	1.53 ±2.66	1.556 ±2.69	1.555 ±2.69	33.095 ±57.32	20.197 ±34.98	20.67 ±35.80	22.792 ±39.48	0.326 ±0.56	0.329 ±0.57	ND
6	1.57 ±2.71	1.57 ±2.71	1.53 ±2.66	1.556 ±2.69	1.555 ±2.69	33.095 ±57.32	20.190 ±34.97	20.00 ±34.64	22.792 ±39.48	0.336 ±0.58	0.329 ±0.57	5.500 ±1.32
CD _{5%}	2.402	2.652	2.634	2.562	2.557	52.893	35.302	35.685	37.813	0.546	0.563	
CV	37.238	37.956	38.568	37.92	37.891	38.212	39.635	38.409	37.837	39.733	38.873	
R ²	0.685	0.695	0.690	0.691	0.691	0.679	0.686	0.717	0.696	0.652	0.685	

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

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	4.20 ±0.53	4.57 ±0.50	4.33 ±0.25	4.367 ±0.41	4.362 ±0.41	95.655 ±3.15	48.123 ±11.60	49.67 ±10.79	60.085 ±11.49	0.966 ±0.02	0.996 ±0.04	5.767 ±0.64
2	4.15 ±0.53	4.53 ±0.48	4.30 ±0.23	4.328 ±0.40	4.323 ±0.40	95.472 ±2.96	48.073 ±11.62	48.33 ±11.43	59.000 ±11.07	0.994 ±0.01	0.997 ±0.04	ND
3	4.10 ±0.53	4.50 ±0.46	4.27 ±0.21	4.289 ±0.39	4.283 ±0.39	95.287 ±2.77	48.022 ±11.64	47.00 ±12.12	57.925 ±10.67	1.024 ±0.03	0.999 ±0.04	ND
4	4.07 ±0.47	4.48 ±0.46	4.27 ±0.21	4.272 ±0.37	4.267 ±0.37	95.299 ±2.64	47.962 ±11.67	46.83 ±11.84	57.459 ±10.20	1.026 ±0.03	1.002 ±0.04	ND
5	4.03 ±0.42	4.47 ±0.47	4.27 ±0.21	4.256 ±0.36	4.250 ±0.36	95.312 ±2.69	47.902 ±11.69	46.67 ±11.55	56.990 ±9.72	1.027 ±0.03	1.006 ±0.04	ND
6	2.50 ±2.17	2.77 ±2.40	2.73 ±2.37	2.667 ±2.31	2.663 ±2.31	64.225 ±55.66	27.270 ±23.65	25.67 ±22.23	33.419 ±28.98	0.708 ±0.61	0.684 ±0.59	6.333 ±0.58
CD _{5%}	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	
CV	28.192	27.553	26.138	27.276	27.286	24.711	32.263	31.340	29.840	26.210	23.895	
R ²	0.518	0.478	0.461	0.487	0.487	0.438	0.437	0.544	0.535	0.260	0.401	

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

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	3.93 ±0.81	4.33 ±0.86	4.30 ±0.82	4.189 ±0.83	4.184 ±0.83	96.564 ±1.70	47.564 ±24.06	46.67 ±25.17	56.409 ±20.88	1.045 ±0.09	1.029 ±0.01	4.167 ±0.31
2	3.93 ±0.81	4.32 ±0.86	4.23 ±0.83	4.161 ±0.83	4.157 ±0.83	96.280 ±1.59	47.412 ±24.20	42.67 ±23.80	55.691 ±20.86	1.144 ±0.09	1.019 ±0.02	ND
3	3.93 ±0.81	4.30 ±0.85	4.17 ±0.85	4.133 ±0.83	4.129 ±0.83	95.985 ±1.50	47.261 ±24.33	38.67 ±22.50	54.973 ±20.88	1.267 ±0.11	1.009 ±0.03	ND
4	1.50 ±2.60	1.70 ±2.94	1.67 ±2.89	1.622 ±2.81	1.620 ±2.81	31.761 ±55.01	23.569 ±40.82	20.33 ±35.22	24.716 ±42.81	0.386 ±0.67	0.343 ±0.59	ND
5	Spoiled											4.567
6	Spoiled											±0.35
CD _{5%}	1.905	2.074	2.031	2.001	1.998	41.804	31.252	28.472	31.890	0.539	0.444	
CV	46.643	46.093	46.037	46.177	46.182	42.457	61.371	62.496	54.138	45.664	42.482	
R ²	0.855	0.859	0.868	0.861	0.861	0.854	0.857	0.919	0.867	0.766	0.860	

Conclusion

On the basis of the experimental finding it may be conclude that tomato variety *Himshikhar* packed in aluminum foil packages shows minimum shrinkage at refrigerator condition, then BOD incubator storage and ambient temperature storage condition. Tomato variety *NS – 524* packed in aluminum foil packages shows maximum shrinkage under BOD incubator storage then ambient storage condition and refrigerator condition. Samples under BOD incubator storage, spoiled after four days of storage.

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