



Research Article

EXTEND THE STORAGE LIFE THROUGH COLD CONDITIONS IN CAPSICUM CVS. 'BACHATA F1', 'MASHELIA', 'BOMBAY GREEN' AND 'LOCAL GREEN'

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Received: September 04, 2018; Revised: September 10, 2018; Accepted: September 11, 2018; Published: September 15, 2018

Abstract: Uniform and healthy Capsicum fruits of cv. 'Bachata' (Yellow coloured), 'Mashelia' (Red coloured), 'Bombay Green' (Green coloured) and 'Local Green' (Green coloured) were used for studying the storage-life (days) in cold storage unit of Ecofrost and normal room conditions (RT). Selected fruit of cultivars were kept in cold storage at 10°C and 93% RH conditions. The aim of the study was to determine the effectiveness of cold storage on the post-harvest storage-life (days) of Capsicum cultivars at 10°C and 93% RH. The results showed that keeping the fruit of Capsicum cv. 'Bachata F1' (16 Days), 'Mashelia' (15 days), 'Bombay Green' (14 days) and 'Local Green' (12 days) under cold storage at 10°C and 93% relative humidity, recorded better retention of fruit qualities. Average post-storage-life (days) was observed in cv. 'Bachata F1', 'Mashelia', 'Bombay Green' and 'Local Green' as 2.5 days, 2.5 days, 2.0 days and 2.0 days, respectively under room temperature after taking it from cold storage at the end of day 12 after storage. Weight loss was recorded 44 kg/1000 kg (V1), 42.90 kg/1000 kg (V2), 34.42 kg/1000 kg (V3) and 69.60 kg/1000 kg (V4), at the end of 12th day inside cold storage. Chilling and disease development symptoms were not seen. Shelf life was recorded maximum in 'Bachata F1' cultivar as compared to other cultivars.

Keywords: Capsicum, Cold Storage

Citation: Jadhav P.B. and Gurav N.P. (2018) Extend the Storage Life through Cold Conditions in Capsicum cvs. 'Bachata F1', 'Mashelia', 'Bombay Green' and 'Local Green'. International Journal of Agriculture Sciences, ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 10, Issue 17, pp.- 7092-7101.

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Introduction

Sweet pepper consumption in India is increasing now-a-day due to increasing demand by urban consumers. There is a good demand for export too. The export market needs fruits with longer shelf life, medium size, tetra lobed fruits with an attractive dark colour, mild pungency and good taste. But, the supply is inadequate due to low productivity of the crop. There is increased demand for capsicum by the consumers and lot of farmers are also showing interest in the cultivation of this crop under protected conditions, as this type is having definite qualitative and quantitative advantage over the traditional cultivation. Capsicum, also known as sweet pepper, color capsicum or bell pepper, is a herb. Capsicum is used for various problems with digestion including intestinal gas, stomach pain, diarrhoea, and cramps [1]. An overripe capsicum is withered, shrunken and has the appearance of aged leather. While wrinkled bell peppers are edible, they will not be as sweet or robust as their firm-skinned counterparts. The nutritional values of red and green bell peppers varied. In 2014-15, production share of state of Karnataka was 26.98%, then followed by Himachal Pradesh 18.70%, Jammu and Kashmir 12.69%, Maharashtra 10.24%, Jharkhand 9.51%, Uttarakhand 8.01%, Orrisa 3.19%, Telangana 3.10, Meghalaya 2.41%, Mizoram 1.97%, etc [2].

Materials and Methods

The experiment was carried out in the Agricultural Research Laboratory of Ecofrost Technologies Pvt. Ltd. Tathawade, Pune (MH), India. 2017. Capsicum cvs. were collected at optimum maturity stage (around 90% coloured stage) from farmers of Junnar, Pune. Fruit of each cultivar were selected for their uniform size and quality in the morning hours. Shelf-life (days) was recorded by the number of days held in normal room storage conditions of Capsicum cv. 'Bachata F1' (V₁), 'Mashelia' (V₂), 'Bombay Green' (V₃) and 'Local Green' (V₄) between the time of collection from farmer fields and the end of longevity. Also, Post-harvest life at normal storage conditions was recorded in four cultivars of Capsicum. Capsicum fruits were subjected to cold storage treatment at 10°C and 93% relative humidity

and control treatment to room temperature conditions.

At Ecofrost Technologies Pvt. Ltd., Agricultural Research Laboratory, fruit of four cultivars were kept at normal room temperature and kept at cold conditions (10°C and 93% RH). The data was collected and taken for further investigation. 2 samples of each variety were kept aside in the cold storage and their weight was monitored every day to study weight loss. On 1st, 3rd, 5th, 7th, 9th, 11th and 13th days two fruit of each variety were taken out from cold storage and kept at normal room conditions to measure the weight loss, post-storage life, chilling injury, firmness, and shrivelling percentage.

Results and Discussion

Weight loss, post-storage life, chilling injury, firmness, shrivelling percentage, disease development and shelf life were studied.

Weight loss of fruits taken out from cold storage to room conditions: Weight loss of cv. Yellow (Bachata F1) for four days was recorded as 7.73%, 7.79%, 7.5%, 7.59%, 8.47%, 8.6% and 7.2% on ends of the 1st day, 3rd day, 5th day, 7th day, 9th day, 11th day and 13th day, respectively at room conditions, average weight loss was observed for four days (7.84%) [Table-1A]. Weight loss of cv. Red (Mashelia) was recorded at the end of the 1st day, 3rd day, 5th day, 7th day, 9th day, 11th day and 13th day; 9.66%, 11.49%, 9.97%, 9.33%, 11.62%, 11.48% and 7.69% respectively for four days at room conditions, average weight loss was observed for four days (10.17%) [Table-1B]. Weight loss of cv. Green (Bombay Green) was recorded at the ends of the 1st day, 3rd day, 5th day, 7th day, 9th day, 11th day and 13th day; 8.61%, 7.83%, 6.85%, 7.48%, 7.05%, 9.53% and 6.46% respectively, average weight loss was observed for four days (7.68%) [Table-1C]. Weight loss of cv. Green (Local Green) was recorded 10.75%, 10.11%, 12.88%, 9.85%, 8.73%, 8.22% and 7.55% at the end of the 1st day, 3rd day, 5th day, 7th day, 9th day, 11th day and 13th day, respectively at room conditions, respectively, average weight loss was observed for four days (9.72%) [Table-1D].

Extend the Storage Life through Cold Conditions in Capsicum cvs. 'Bachata F1', 'Mashelia', 'Bombay Green' and 'Local Green'

Table-1A. Weight loss for 4 days for fruit of capsicum cv. 'Bachata' taken out from cold storage to room conditions.

Room storage (fruit taken out from cold storage at the end of)	Yellow (Bachata F1)		Weight in percentage			Weight loss kg/1000 kg
	Initial Weight (gm)	Final weight (gm) after 4 days storage	Initial Weight	Final weight after 4 days storage	Weight loss for 4 days	For 4 days storage
Day-1	197.71	182.42	100	92.27	7.73	77.30
Day-3	203.51	187.65	100	92.21	7.79	77.90
Day-5	226.00	209.06	100	92.5	7.5	75.00
Day-7	239.09	220.95	100	92.41	7.59	75.90
Day-9	193.35	176.97	100	91.53	8.47	84.70
Day-11	196.51	179.61	100	91.4	8.6	86.00
Day-13	196.6	182.45	100	92.8	7.2	72.00

Table-1B. Weight loss of fruits of capsicum cv. 'Mashelia' taken out from cold storage to room conditions.

Room storage (Fruit taken out from cold storage at the end of)	Red (Mashelia)		Weight in percentage			Weight loss kg/1000 kg
	Initial Weight (gm)	Final weight (gm) after 4 days storage	Initial Weight	Final weight after 4 days storage	Weight loss for 4 days	For 4 days storage
Day-1	223.05	201.51	100	90.34	9.66	96.60
Day-3	212.9	188.44	100	88.51	11.49	114.90
Day-5	228.88	206.07	100	90.03	9.97	99.70
Day-7	180.14	163.33	100	90.67	9.33	93.30
Day-9	202.96	179.37	100	88.38	11.62	116.20
Day-11	172.39	152.6	100	88.52	11.48	114.80
Day-13	154.97	143.05	100	92.31	7.69	76.90

Table-1C. Weight loss of fruits of capsicum cv. 'Bombay Green' taken out from cold storage to room conditions.

Room storage (Fruit taken out from cold storage at the end of)	Green (Bombay Green)		Weight in percentage			Weight loss kg/1000 kg
	Initial Weight (gm)	Final weight (gm) after 4 days storage	Initial Weight	Final weight after 4 days storage	Weight loss for 4 days	For 4 days storage
Day-1	190.63	174.22	100	91.39	8.61	86.10
Day-3	202.01	186.2	100	92.17	7.83	78.30
Day-5	263.9	245.81	100	93.15	6.85	68.50
Day-7	175.96	162.79	100	92.52	7.48	74.80
Day-9	161.73	150.32	100	92.95	7.05	70.50
Day-11	196.18	177.49	100	90.47	9.53	95.30
Day-13	138.65	129.7	100	93.54	6.46	64.60

Table-1D. Weight loss of fruits of capsicum cv. 'Local Green' taken out from cold storage to room conditions.

Room storage (Fruit taken out from cold storage at the end of)	Green (Local Green)		Weight in percentage			Weight loss kg/1000 kg
	Initial Weight (gm)	Final weight (gm) after 4 days storage	Initial Weight	Final weight after 4 days storage	Weight loss for 4 days	For 4 days storage
Day-1	153.55	137.04	100	89.25	10.75	107.5
Day-3	135.66	121.95	100	89.89	10.11	101.1
Day-5	116.5	101.5	100	87.12	12.88	128.8
Day-7	134.86	121.57	100	90.15	9.85	98.5
Day-9	136.36	124.45	100	91.27	8.73	87.3
Day-11	138.42	127.04	100	91.78	8.22	82.2
Day-13	177.36	163.97	100	92.45	7.55	75.5

Table-2A. Weight loss percentage in cold storage for capsicum cv. 'Bachata F1'.

Cold storage (Same fruit weight at the end of)	Yellow (Bachata F1)		Weight in percentage (%)			Weight loss kg/1000 kg
	Initial Weight (gm)	Final weight (gm) after 1 day's storage	Initial Weight (%)	Final weight (%)	Weight loss (%)	
Day-1	274.21	273.25	100	99.65	0.35	3.50
Day-2	273.25	272.04	100	99.21	0.79	7.90
Day-3	272.04	271.22	100	98.91	1.09	10.90
Day-4	271.22	270.43	100	98.62	1.38	13.80
Day-5	270.43	269.53	100	98.29	1.71	17.10
Day-6	269.53	268.6	100	97.95	2.05	20.50
Day-7	268.6	267.64	100	97.60	2.40	24.00
Day-8	267.64	266.55	100	97.21	2.79	27.90
Day-9	266.55	265.6	100	96.86	3.14	31.40
Day-10	265.6	264.55	100	96.48	3.52	35.20
Day-11	264.55	263.25	100	96.00	4.00	40.00
Day-12	263.25	262.03	100	95.56	4.44	44.40

Table-2B. Weight loss percentage in cold storage for capsicum cv. 'Mashelia'.

Cold storage (Same fruit weight at the end of)	Red (Mashelia)		Weight in percentage			Weight loss kg/1000 kg
	Initial Weight (gm)	Final weight (gm) after 1 day's storage	Initial Weight (%)	Final weight (%)	Weight loss (%)	
Day-1	261.16	260.23	100	99.64	0.36	3.60
Day-2	260.23	259.19	100	99.25	0.75	7.50
Day-3	259.19	258.7	100	99.06	0.94	9.40
Day-4	258.7	258.27	100	98.89	1.11	11.10
Day-5	258.27	257.09	100	98.44	1.56	15.60
Day-6	257.09	256.28	100	98.13	1.87	18.70
Day-7	256.28	255.35	100	97.78	2.22	22.20
Day-8	255.35	254.48	100	97.44	2.56	25.60
Day-9	254.48	253.51	100	97.07	2.93	29.30
Day-10	253.51	252.44	100	96.66	3.34	33.40
Day-11	252.44	251.22	100	96.19	3.81	38.10
Day-12	251.22	249.96	100	95.71	4.29	42.90

Table-2C. Weight loss percentage in cold storage for capsicum cv. 'Bombay Green'.

Cold storage (Same fruit weight at the end of)	Green (Bombay Green)		Weight in percentage			Weight loss kg/1000 kg
	Initial Weight (gm)	Final weight (gm) after 1 day's storage	Initial Weight (%)	Final weight (%)	Weight loss (%)	
Day-1	230.1	229.68	100	99.82	0.18	1.83
Day-2	229.68	228.98	100	99.51	0.49	4.87
Day-3	228.98	228.31	100	99.22	0.78	7.78
Day-4	228.31	227.88	100	99.04	0.96	9.65
Day-5	227.88	227.31	100	98.79	1.21	12.13
Day-6	227.31	226.83	100	98.58	1.42	14.21
Day-7	226.83	226.19	100	98.30	1.70	16.99
Day-8	226.19	225.44	100	97.97	2.03	20.25
Day-9	225.44	224.71	100	97.66	2.34	23.42
Day-10	224.71	223.94	100	97.32	2.68	26.77
Day-11	223.94	223.02	100	96.92	3.08	30.77
Day-12	223.02	222.18	100	96.56	3.44	34.42

Table-2D. Weight loss percentage in cold storage for capsicum cv. 'Local Green'.

Cold storage (Same fruit weight at the end of)	Green (Local Green)		Weight in percentage			Weight loss kg/1000 kg
	Initial Weight (gm)	Final weight (gm) after 1 day's storage	Initial Weight (%)	Final weight (%)	Weight loss (%)	
Day-1	168.86	167.91	100	99.44	0.56	5.60
Day-2	167.91	166.81	100	98.79	1.21	12.10
Day-3	166.81	166.21	100	98.43	1.57	15.70
Day-4	166.21	165.69	100	98.12	1.88	18.80
Day-5	165.69	164.54	100	97.44	2.56	25.60
Day-6	164.54	163.49	100	96.82	3.18	31.80
Day-7	163.49	162.61	100	96.30	3.70	37.00
Day-8	162.61	161.75	100	95.79	4.21	42.10
Day-9	161.75	160.76	100	95.20	4.80	48.00
Day-10	160.76	159.72	100	94.59	5.41	54.10
Day-11	159.72	158.43	100	93.82	6.18	61.80
Day-12	158.43	157.11	100	93.04	6.96	69.60

Table-3A. Post storage life of different capsicum varieties after taken out it from cold Storage and held at room conditions.

Variety	After time fruit took out from cold storage and put at room conditions							
	After 16 hours	Day-1	Day-2	Day-3	Day-4	Day-5	Day-6	Day-7
V1	4	4	4	4	3.5	3.5	3.5	3.5
V2	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5
V3	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
V4	3.5	3.5	3.5	3.5	2.5	2.5	2.5	2.5

Table-3B. Post storage life of different capsicum varieties after taken out it from cold storage and held at room conditions.

Variety	After fruit taken out from cold storage and put at room conditions								
	Day-8	Day-9	Day-10	Day-11	Day-12	Day-13	Day-14	Day-15	Day - 16
V ₁	3.5	3.5	3	3	2.5	2.5	2.5	2.5	2
V ₂	3.5	3.5	2.5	2.5	2.5	2.5	2.5	2	1.5
V ₃	2.5	2.5	2.5	2.5	2	2	2	1.5	1
V ₄	2.5	2.5	2	2	2	1.5	1	0.5	0.5

Table-4. Shrivelling percentage of different capsicum varieties at inside cold storage

Shrivelling percentage at the end of day inside cold room												
Variety	On 0 day	Day-1	Day-2	Day-3	Day-4	Day-5	Day-6	Day-7	Day-8	Day-9	Day-10	Day-11
V ₁	0-20%	0-20%	0-20%	0-20%	0-20%	0-20%	0-20%	0-20%	0-20%	0-20%	0-20%	21-40%
V ₂	0-20%	0-20%	0-20%	0-20%	0-20%	0-20%	0-20%	0-20%	0-20%	0-20%	0-20%	21-40%
V ₃	0-20%	0-20%	0-20%	0-20%	0-20%	0-20%	0-20%	0-20%	0-20%	0-20%	21-40%	21-40%
V ₄	0-20%	0-20%	0-20%	0-20%	0-20%	0-20%	0-20%	0-20%	0-20%	0-20%	21-40%	41-60%

Note: Shrivelling %: 1. 00-20% (Very low), 2. 21-40% (Low), 3. 41-60% (Medium/Moderate), 4. 61-80% (High), 5. 81-100% (Very high)

Table-5. Colour appearance of different capsicum varieties at inside cold storage

Colour appearance at the end of day inside cold room												
Variety	On 0 day	Day-1	Day-2	Day-3	Day-4	Day-5	Day-6	Day-7	Day-8	Day-9	Day-10	Day-11
V ₁	81-100%	81-100%	81-100%	81-100%	81-100%	81-100%	81-100%	81-100%	81-100%	81-100%	81-100%	61-80%
V ₂	81-100%	81-100%	81-100%	81-100%	81-100%	81-100%	81-100%	81-100%	81-100%	81-100%	81-100%	61-80%
V ₃	81-100%	81-100%	81-100%	81-100%	81-100%	81-100%	81-100%	81-100%	81-100%	81-100%	81-100%	61-80%
V ₄	81-100%	81-100%	81-100%	81-100%	81-100%	81-100%	81-100%	61-80%	61-80%	61-80%	61-80%	41-60%

Note: Color: 1. 00-20% (Very low), 2. 21-40% (Low), 3. 41-60% (Medium/Moderate), 4. 61-80% (High), 5. 81-100% (Very high)

Table-6. Fruit firmness of different capsicum varieties at inside cold storage

Fruit firmness at the end of day inside cold room												
Variety	On 0 day	Day-1	Day-2	Day-3	Day-4	Day-5	Day-6	Day-7	Day-8	Day-9	Day-10	Day-11
V ₁	81-100%	81-100%	81-100%	61-80%	61-80%	61-80%	61-80%	61-80%	61-80%	61-80%	61-80%	61-80%
V ₂	81-100%	81-100%	81-100%	61-80%	61-80%	61-80%	61-80%	61-80%	61-80%	61-80%	61-80%	61-80%
V ₃	81-100%	81-100%	81-100%	81-100%	81-100%	61-80%	61-80%	41-60%	41-60%	41-60%	41-60%	41-60%
V ₄	81-100%	81-100%	81-100%	61-80%	61-80%	61-80%	61-80%	41-60%	41-60%	41-60%	41-60%	41-60%

Note: Firmness: 1. 00-20% (Very low), 2. 21-40% (Low), 3. 41-60% (Medium/Moderate), 4. 61-80% (High), 5. 81-100% (Very high)

Table-7. Diseased occurrences of different capsicum varieties at inside cold storage

Disease occurrences at the end of day inside cold room												
Variety	On 0 day	Day-1	Day-2	Day-3	Day-4	Day-5	Day-6	Day-7	Day-8	Day-9	Day-10	Day-11
V ₁	No	No	No	No	No	No	No	No	No	No	No	No
V ₂	No	No	No	No	No	No	No	No	No	No	No	No
V ₃	No	No	No	No	No	No	No	No	No	No	No	No
V ₄	No	No	No	No	No	No	No	No	No	No	No	No

Note: Diseases weren't found to be inside cold storage.

Table-8. Chilling injury symptoms for different capsicum varieties at inside cold storage

Chilling injury symptoms at the end of day inside cold room												
Variety	On 0 day	Day-1	Day-2	Day-3	Day-4	Day-5	Day-6	Day-7	Day-8	Day-9	Day-10	Day-11
V ₁	No	No	No	No	No	No	No	No	No	No	No	No
V ₂	No	No	No	No	No	No	No	No	No	No	No	No
V ₃	No	No	No	No	No	No	No	No	No	No	No	No
V ₄	No	No	No	No	No	No	No	No	No	No	No	No

Note: Chilling symptoms weren't found to be inside cold storage.

Table-9A. Post storage of shrivelling % of different capsicum varieties after taken out it from cold storage and held at room conditions

Shrivelling %	After 3 days cold storage fruit taken out and put at room conditions			After 5 days cold storage fruit taken out and put at room conditions			After 7 days cold storage fruit taken out and put at room conditions		
	At the end of 1 st day	At the end of 2 nd day	At the end of 3 rd day	At the end of 1 st day	At the end of 2 nd day	At the end of 3 rd day	At the end of 1 st day	At the end of 2 nd day	At the end of 3 rd day
V ₁	0-20%	21-40%	41-60%	0-20%	0-20%	41-60%	0-20%	21-40%	21-40%
V ₂	0-20%	41-60%	61-80%	0-20%	21-40%	61-80%	0-20%	21-40%	21-40%
V ₃	0-20%	21-40%	61-80%	0-20%	0-20%	61-80%	0-20%	41-60%	41-60%
V ₄	0-20%	41-60%	61-80%	0-20%	41-60%	61-80%	0-20%	41-60%	41-60%

Note: Shrivelling %: 1. 00-20% (Very low), 2. 21-40% (Low), 3. 41-60% (Medium/Moderate), 4. 61-80% (High), 5. 81-100% (Very high)

Table-9B. Post storage of shrivelling % of different capsicum varieties after taken out it from cold storage and held at room conditions

Shrivelling %	After 9 days cold storage fruit taken out and put at room conditions			After 11 days cold storage fruit taken out and put at room conditions			After 13 days cold storage fruit taken out and put at room conditions		
	At the end of 1 st day	At the end of 2 nd day	At the end of 3 rd day	At the end of 1 st day	At the end of 2 nd day	At the end of 3 rd day	At the end of 1 st day	At the end of 2 nd day	At the end of 3 rd day
V ₁	0-20%	21-40%	21-40%	0-20%	21-40%	41-60%	21-40%	41-60%	41-60%
V ₂	0-20%	21-40%	21-40%	0-20%	21-40%	41-60%	21-40%	41-60%	41-60%
V ₃	0-20%	41-60%	41-60%	0-20%	21-40%	41-60%	21-40%	41-60%	41-60%
V ₄	21-40%	41-60%	41-60%	21-40%	41-60%	41-60%	41-60%	41-60%	61-80%

Note: Shrivelling %: 1. 00-20% (Very low), 2. 21-40% (Low), 3. 41-60% (Medium/Moderate), 4. 61-80% (High), 5. 81-100% (Very high)

Table-10A. Colour appearance of different capsicum varieties after taken out it from cold storage and held at room conditions

Color	After 3 days cold storage fruit taken out and put at room conditions			After 5 days cold storage fruit taken out and put at room conditions			After 7 days cold storage fruit taken out and put at room conditions			
	Variety	At the end of 1 st day	At the end of 2 nd day	At the end of 3 rd day	At the end of 1 st day	At the end of 2 nd day	At the end of 3 rd day	At the end of 1 st day	At the end of 2 nd day	At the end of 3 rd day
V ₁	81-100%	81-100%	81-100%	81-100%	81-100%	81-100%	81-100%	81-100%	81-100%	81-100%
V ₂	81-100%	81-100%	81-100%	81-100%	81-100%	81-100%	81-100%	81-100%	81-100%	81-100%
V ₃	81-100%	81-100%	81-100%	81-100%	81-100%	81-100%	81-100%	81-100%	81-100%	81-100%
V ₄	81-100%	81-100%	81-100%	81-100%	81-100%	81-100%	61-80%	81-100%	81-100%	61-80%

Note: Color: 1. 00-20% (Very Low), 2. 21-40% (Low), 3. 41-60% (Medium/Moderate), 4. 61-80% (High), 5. 81-100% (Very High)

Table-10B. Colour appearance of different capsicum varieties after taken out it from cold storage and held at room conditions

Color	After 9 days cold storage fruit taken out and put at room conditions			After 11 days cold storage fruit taken out and put at room conditions			After 13 days cold storage fruit taken out and put at room conditions		
	Variety	At the end of 1 st day	At the end of 2 nd day	At the end of 3 rd day	At the end of 1 st day	At the end of 2 nd day	At the end of 3 rd day	At the end of 1 st day	At the end of 2 nd day
V ₁	81-100%	81-100%	81-100%	81-100%	81-100%	61-80%	81-100%	61-80%	61-80%
V ₂	81-100%	81-100%	81-100%	81-100%	81-100%	61-80%	81-100%	61-80%	61-80%
V ₃	81-100%	81-100%	61-80%	81-100%	81-100%	61-80%	81-100%	61-80%	61-80%
V ₄	81-100%	61-80%	61-80%	61-80%	61-80%	41-60%	61-80%	41-60%	41-60%

Note: Color: 1. 00-20% (Very Low), 2. 21-40% (Low), 3. 41-60% (Medium/Moderate), 4. 61-80% (High), 5. 81-100% (Very High)

Table-11A. Fruit firmness of different capsicum varieties after taken out it from cold storage and held at room conditions

Firmness	After 3 days cold storage fruit taken out and put at room conditions			After 5 days cold storage fruit taken out and put at room conditions			After 7 days cold storage fruit taken out and put at room conditions		
	Variety	At the end of 1 st day	At the end of 2 nd day	At the end of 3 rd day	At the end of 1 st day	At the end of 2 nd day	At the end of 3 rd day	At the end of 1 st day	At the end of 2 nd day
V ₁	81-100%	61-80%	41-60%	81-100%	61-80%	41-60%	81-100%	61-80%	41-60%
V ₂	61-80%	61-80%	41-60%	61-80%	61-80%	41-60%	61-80%	61-80%	41-60%
V ₃	61-80%	61-80%	41-60%	61-80%	61-80%	41-60%	61-80%	61-80%	41-60%
V ₄	61-80%	61-80%	41-60%	61-80%	61-80%	41-60%	61-80%	61-80%	41-60%

Table-11B. Fruit firmness of different capsicum varieties after taken out it from cold storage and kept at room conditions

Firmness	After 9 days cold storage fruit taken out and put at room conditions			After 11 days cold storage fruit taken out and put at room conditions			After 13 days cold storage fruit taken out and put at room conditions		
	Variety	At the end of 1 st day	At the end of 2 nd day	At the end of 3 rd day	At the end of 1 st day	At the end of 2 nd day	At the end of 3 rd day	At the end of 1 st day	At the end of 2 nd day
V ₁	81-100%	61-80%	41-60%	61-80%	41-60%	41-60%	61-80%	41-60%	41-60%
V ₂	61-80%	61-80%	41-60%	61-80%	41-60%	41-60%	61-80%	41-60%	41-60%
V ₃	61-80%	61-80%	41-60%	61-80%	41-60%	41-60%	61-80%	41-60%	41-60%
V ₄	61-80%	61-80%	21-40%	61-80%	41-60%	21-40%	61-80%	41-60%	21-40%

Table-12A. Disease occurrences of different capsicum varieties after taken out it from cold storage and held at room conditions

Disease occurrence	3 days cold storage fruit taken out and put at room conditions			After 5 days cold storage fruit taken out and put at room conditions			After 7 days cold storage fruit taken out and put at room conditions		
	Variety	At the end of 1 st day	At the end of 2 nd day	At the end of 3 rd day	At the end of 1 st day	At the end of 2 nd day	At the end of 3 rd day	At the end of 1 st day	At the end of 2 nd day
V ₁	No	No	No	No	No	No	No	No	No
V ₂	No	No	No	No	No	No	No	No	No
V ₃	No	No	No	No	No	No	No	No	No
V ₄	No	No	No	No	No	No	No	No	No

Table-12B. Disease development occurrences of different capsicum varieties after taken out it from cold storage and held at room conditions

Disease development	After 9 days cold storage fruit taken out and put at room conditions			After 11 days cold storage fruit taken out and put at room conditions			After 13 days cold storage fruit taken out and put at room conditions		
	Variety	At the end of 1 st day	At the end of 2 nd day	At the end of 3 rd day	At the end of 1 st day	At the end of 2 nd day	At the end of 3 rd day	At the end of 1 st day	At the end of 2 nd day
V ₁	No	No	No	No	No	No	No	No	No
V ₂	No	No	No	No	No	No	No	No	No
V ₃	No	No	No	No	No	No	No	No	No
V ₄	No	No	No	No	No	No	No	No	No

Table-13A. Chilling injury (CI) signs in different capsicum varieties after taken out it from cold storage and held at room conditions

Variety	After 3 days cold storage fruit taken out and put at room conditions			After 5 days cold storage fruit taken out and put at room conditions			After 7 days cold storage fruit taken out and put at room conditions		
	At the end of 1 st day	At the end of 2 nd day	At the end of 3 rd day	At the end of 1 st day	At the end of 2 nd day	At the end of 3 rd day	At the end of 1 st day	At the end of 2 nd day	At the end of 3 rd day
V ₁	No	No	No	No	No	No	No	No	No
V ₂	No	No	No	No	No	No	No	No	No
V ₃	No	No	No	No	No	No	No	No	No
V ₄	No	No	No	No	No	No	No	No	No

Extend the Storage Life through Cold Conditions in Capsicum cvs. 'Bachata F1', 'Mashelia', 'Bombay Green' and 'Local Green'

Table-13B. Chilling injury (CI) signs in different capsicum varieties after taken out it from cold storage and held at room conditions

Variety	After 9 days cold storage fruit taken out and put at room conditions			After 11 days cold storage fruit taken out and put at room conditions			After 13 days cold storage fruit taken out and put at room conditions		
	At the end of 1 st day	At the end of 2 nd day	At the end of 3 rd day	At the end of 1 st day	At the end of 2 nd day	At the end of 3 rd day	At the end of 1 st day	At the end of 2 nd day	At the end of 3 rd day
V ₁	No	No	No	No	No	No	No	No	No
V ₂	No	No	No	No	No	No	No	No	No
V ₃	No	No	No	No	No	No	No	No	No
V ₄	No	No	No	No	No	No	No	No	No

Table-14. Shelf life at room conditions

Variety	Shelf-life (Days) at room conditions
V ₁ -Yellow (Bachata F1)	3.5
V ₂ -Red (Mashelia)	3
V ₃ -Green (Bombay Green)	2.5
V ₄ -Green (Local Green)	2.5

Plate-1 Photos taken on different days inside cold storage: V1: Yellow- Bachata F1



Plate-2 Photos taken on different days inside cold storage: V2 : Red Variety (Mashelia)



Plate-3 Photos taken on different days inside cold storage: V3: Bombay Green

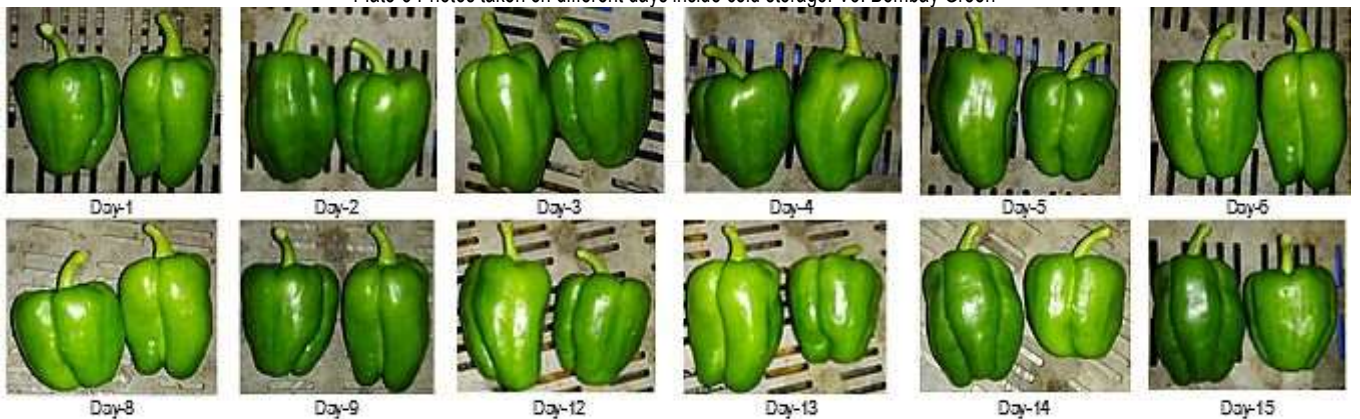


Plate-4 Photos taken on different days inside cold storage: V4: 'Local Green'

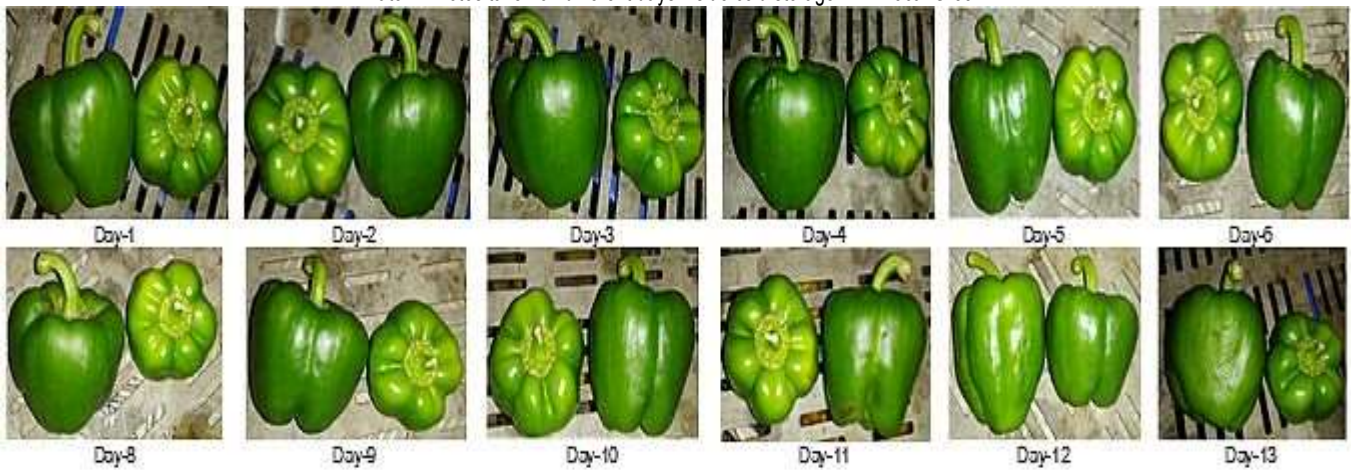


Plate-5 Photos taken at room conditions, fruit taken out from cold storage on day-1

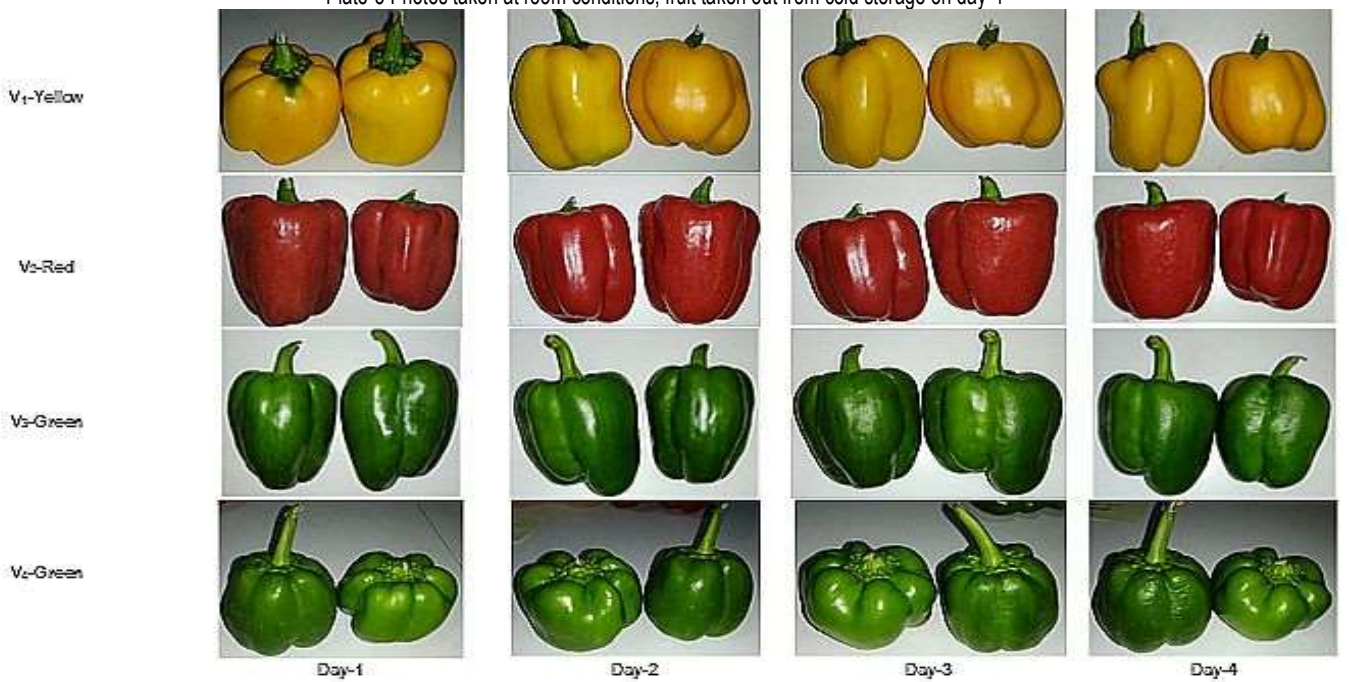


Plate-6 Photos taken at room conditions, fruit taken out from cold storage on day-3

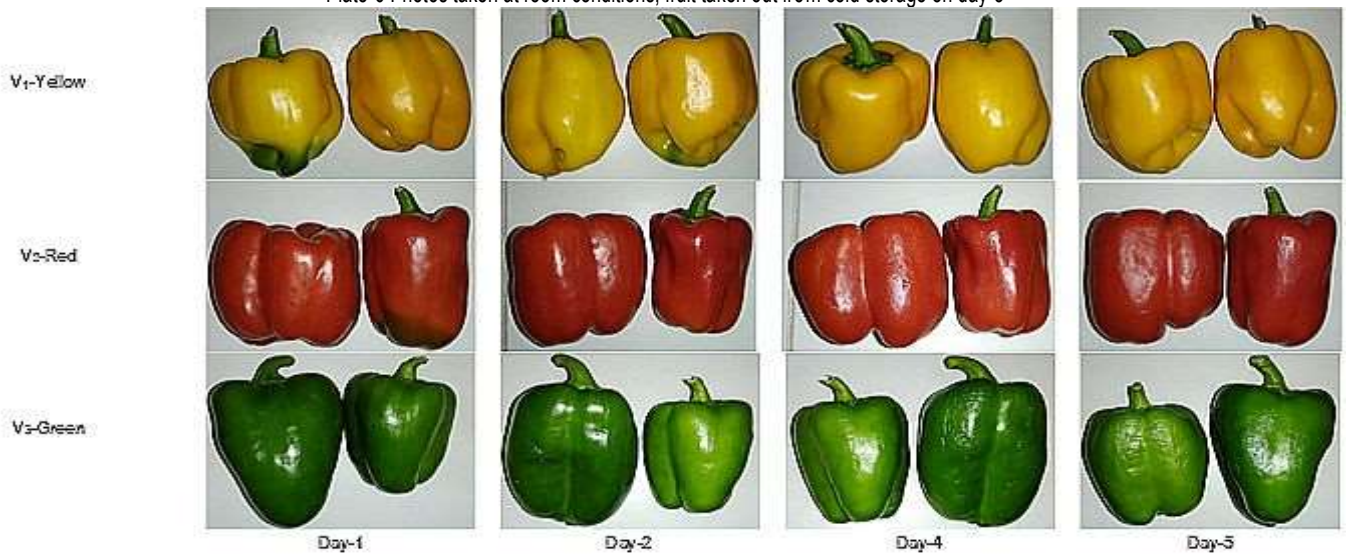


Plate-7 Photos taken at ambient conditions, fruit taken out from cold storage on day-7

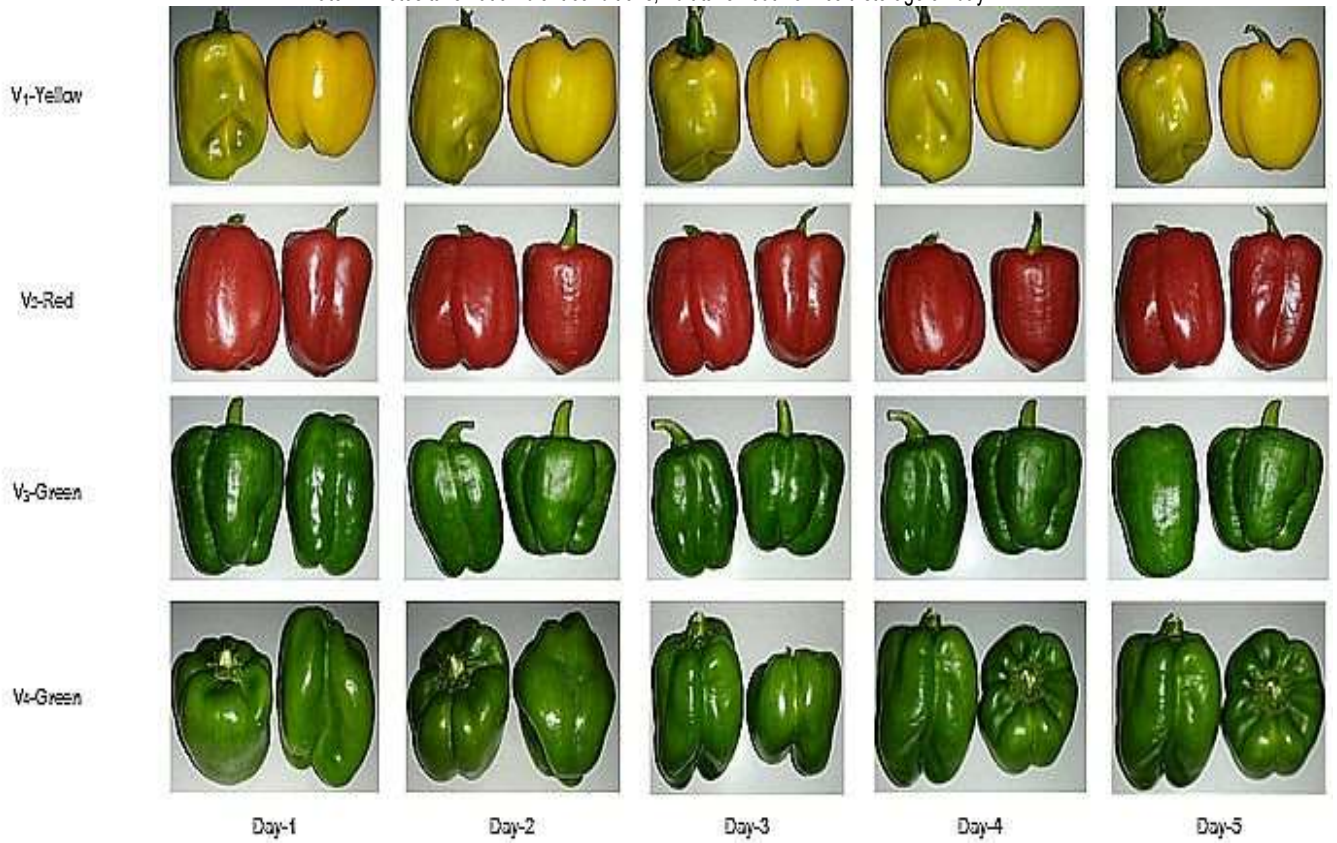


Plate-8 Photos taken at room conditions, fruit taken out from cold storage on day-9

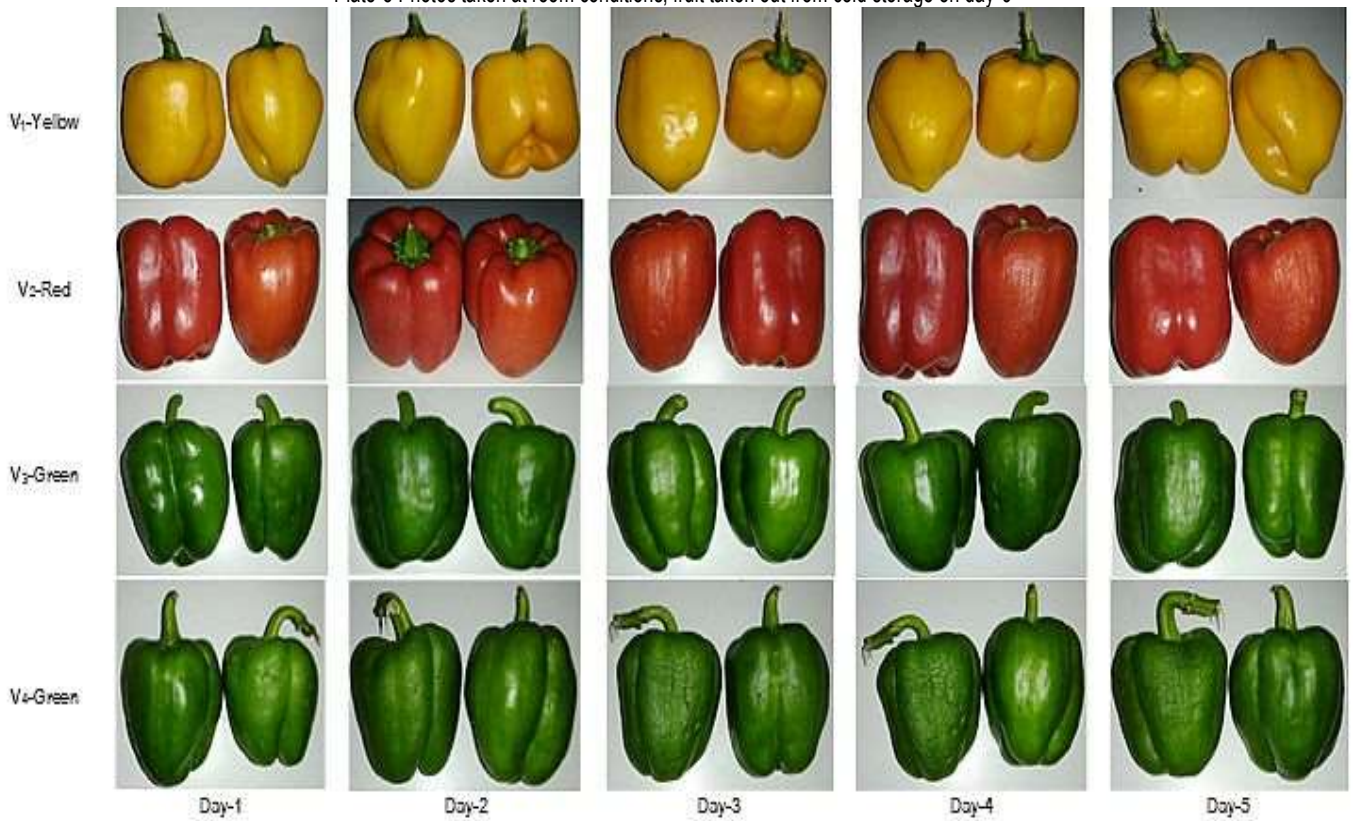
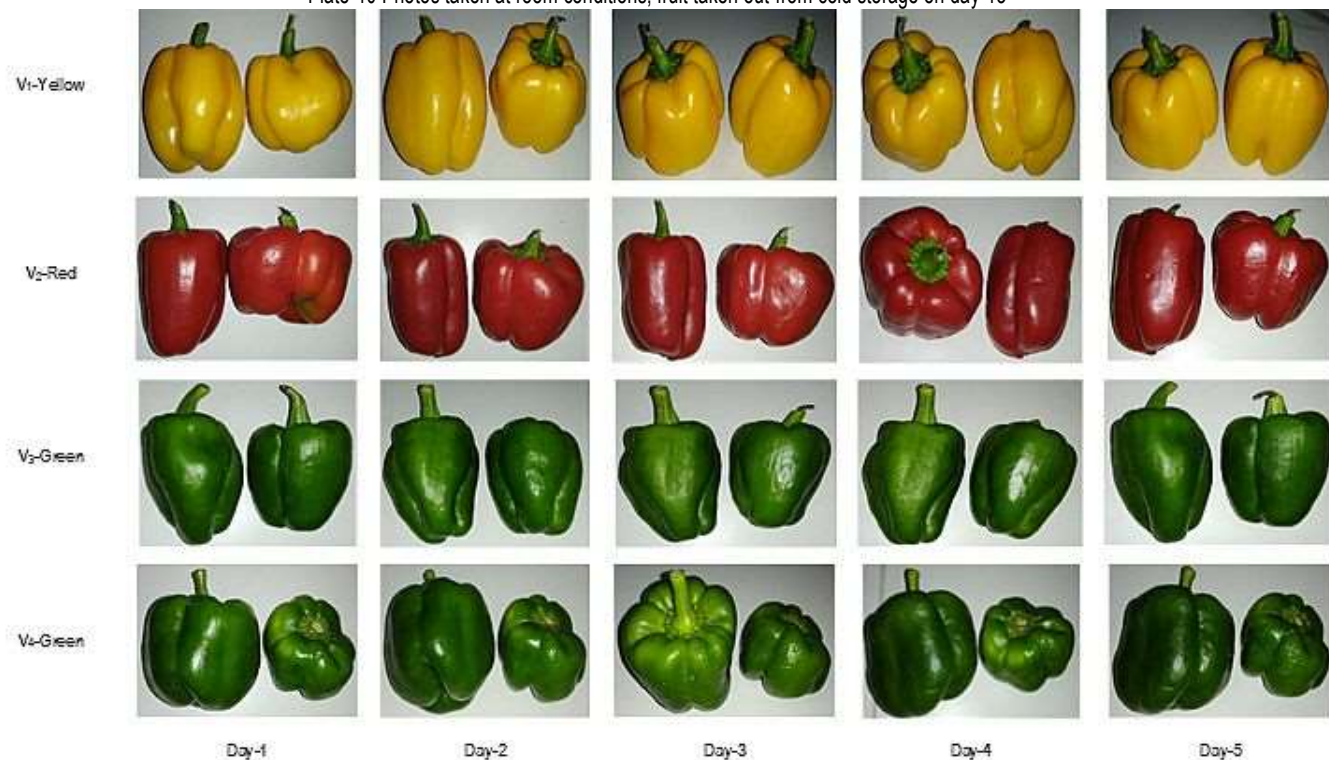


Plate-9 Photos taken at room conditions, fruit taken out from cold storage on day-11



Plate-10 Photos taken at room conditions, fruit taken out from cold storage on day-13



Weight loss percentage of fruits inside cold storage: Weight loss was recorded as 44 kg/1000 kg (V1) [Table-2A], 42.90 kg/1000 kg (V2) [Table-2B], 34.42 kg/1000 kg (V3) [Table-2C] and 69.60 kg/1000 kg (V4) [Table-2D], at the end of 12th day inside cold storage. Average weight loss per 1000kg was recorded in 3.70 kg/day (V1), 3.58 kg/day (V2), 2.87 kg/day (V3) and 5.80 kg/day (V4), respectively. Average weight loss for four varieties was 3.99 kg/1000kg/day for 12 days storage inside cold room.

Post storage life: Post-storage varied with commodity [Table-3A] and [Table-3B]. Post storage life was observed to be higher in the early days of storage as compared to later days.

Shrivelling percentage inside cold storage: Shrivelling percentage increased with increase in storage time. Shrivelling was lower in earlier stages of storage as compared to later stages [Table-4]. Shrivelling is inversely proportional to shelf life. Shrivelling percentage varied with variety. Bachata F1 variety of Capsicum showed less shrivelling as compared to other varieties. The variety is also low temperature resistant genetically. Sugar content also affects shrivelling rate of produce.

Colour appearance percentage inside cold storage: Colour appearance varied with commodity [Table-5 and [Plate-1 to 4]. Colour appearance was observed to be higher at early days of storage as compared to later days.

Fruit Firmness percentage inside cold storage: Fruit firmness decreased with increase in storage time in the cold storage. Firmness was higher at early days of storage as compared to later days [Table-6].

Disease development and the chilling injury inside cold storage: During experimentation, disease development and chilling injury symptoms were not found among different cultivars of capsicum, when held inside cold storage at 10°C and 93% relative humidity [Table-7] and [Table-8].

Post storage shrivelling and colour appearance percentage: Shrivelling increased after capsicum was taken out from cold storage and held at room conditions [Table-9A] and [Table-9B]. This is mostly due to increased water-loss. Colour appearance varied with cultivar [Table-10A, 10B] and [Plate-5 to 10].

Post storage fruit firmness percentage: Firmness decreased after capsicum was taken out from cold storage and held at room conditions [Table-11A] and [Table-11B].

Post storage disease development: During experimentation, no disease development symptoms were found among different cultivars of capsicum after it was taken out from the cold storage and held at room conditions [Table-12A] and [Table-12B].

Post storage chilling injury: During experimentation, no chilling injury symptoms were found among different cultivars of capsicum after it was taken out from the cold storage and held at room conditions [Table-13A] and [Table-13B].

Shelf life: Shelf life among different capsicum varieties was found to be highest in V1 (3.5 Days) followed by V2 (3.0 Days), V3 (2.5 Days) and V4 (2.5 Days) at room conditions [Table-14]. Yellow coloured Bachata F1 variety of capsicum had the best storage performance at room conditions during the experimental period. Both Green coloured cultivars of capsicum had lesser life than V1 and V2. The rate of shrivelling percentage was high for green cultivars as compared to yellow and red coloured cultivars.

Temperature was the major factor in determining the post-harvest performance of sweet pepper. Low temperature could be attributed to the slowdown of physiological processes such as respiration and transpiration [3]. High temperatures increased the rate of respiration and other metabolic processes that caused depletion of substrates like sugars and proteins resulting into further weight loss [4]. As water evaporates from the tissue, turgor pressure decreases, and the cells begin to shrink, and collapse thus leading to loss of freshness. Higher loss in green colour at room temperatures may be caused by increased breakdown of chlorophyll and synthesis of β -carotene and lycopene pigments, which occur during ripening [5 and 6]. Lowering the temperature of non-climacteric fruits like sweet pepper also lowers their rate of ripening and deterioration. Symptoms of soft rot start as water-soaked lesions which rapidly spread deteriorates the fruit further into a slimy and foul-smelling mass. The bacteria responsible for soft rot produce cellulolytic and pectolytic enzymes that rapidly breakdown cell walls.

However, if the temperature goes extremely low, a change in the physical properties of cell membrane occur due to changes in the physical state of membrane lipids. This results in chilling injury which causes the release of metabolites such as amino acids, sugars and mineral salts from cells that together with the degradation of the cell structure provide an excellent substrate for the growth of pathogenic organisms, especially fungi [7].

Conclusion

The storage-life of Capsicum fruit cv. 'Inspiration F1', 'Mashelia', 'Bombay Green' and 'Local Green' can be extended up to 15, 14, 14 and 12 days under low temperature 10°C and 93% relative humidity conditions, respectively. Average weight loss for four varieties was 3.99 kg per 1000 kg per day for initial 12 days inside cold room. Post-storage life was recorded as highest for Capsicum fruit cv. 'Bachata F1' at room conditions, after the fruit was taken out from the cold storage. Disease development and chilling injury symptoms were not found. Firmness was maintained by using the cold storage.

Application of research: Research is applicable for storage of different cultivars of capsicum under low temperature to extend storage life.

Research Category: Vegetable Science

Acknowledgement / Funding: Author thankful to the Director, Ecofrost Technologies Pvt. Ltd., Jeevan Nagar, Tathawade, Pune, Maharashtra, 411 033 for providing excellent facilities for conducting this research. Financial assistance provided by the Ecofrost Technologies Pvt. Ltd. Pune, Maharashtra, India is highly appreciated.

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Research project name or number: Research station study

Author Contributions: All author equally contributed

Author statement: All authors read, reviewed, agree and approved the final manuscript

Conflict of Interest: None declared

Ethical approval: This is the research work of company of Ecofrost Technologies Pvt., Ltd. and approval has been taken from The Director, Ecofrost Technologies Pvt., Ltd., Tathawade, Pune, 411 033

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