



Research Article

EXTENDING THE SHELF LIFE OF BROCCOLI CV. 'GREEN MAJIC' USING A COLD ROOM (ECOFROST)

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Abstract: Storage at 4°C (-1) with 95% RH (relative humidity) was evaluated as the best condition to maintain the shelf life of the Broccoli cv. 'Green Majic' heads. Broccoli heads were vacuum packed and stored inside cold room of Ecofrost where it retained a maximum storage life up to 13 days and the post-storage life of 1 day after that. Shelf life was recorded to be 2 days in ordinary room condition, in case of heads harvested at unopened florets stage. Some Broccoli heads were also shrink wrapped, and cling wrapped and stored inside cold room of Ecofrost where it retained a maximum storage life up to 10.33 and 7.33 days, respectively. Chilling injury and diseased signs were not observed inside cold room since starting of the experiment.

Keywords: Broccoli, Heads, Shrink, Vacuum

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Introduction

Broccoli is a hardy vegetable of the cabbage family which comes in a variety of colours, ranging from deep sage all the way to dark green and purplish-green. Broccoli is also high dietary fibre and iron and is highly recognized for its anti-cancer nutrients. Broccoli is an excellent source of vitamin K, chromium, and folate. It is a very good source of pantothenic acid, vitamin B6, vitamin E, manganese, phosphorus, choline, vitamin B1, vitamin A (in the form of carotenoids), potassium, and copper. Broccoli is also a good source of magnesium, omega-3 fatty acids, protein, zinc, calcium, iron, niacin, and selenium [1]. Thick stalks will be woody and is a sign of over maturity. Broccoli heads are clusters of flowers. The florets are ready for harvest 10 to 13 weeks after sowing and plants produce buds after 6 to 8 weeks. Storage temperature is very vital for safe storage of Broccoli. High temperature could result in off flavour and mushy florets of broccoli while low temperatures below -1°C could result in chilling injury. While storing in closed plastic bags, bags should be kept open or use perforated bags. The air will help to keep them fresh. Low temperature could slow down the growth of micro-organisms mainly fungi on Broccoli florets. Consume fresh broccoli as soon as you can as it has very low shelf life. Raw broccoli requires proper air circulation. Therefore, during the present study, sample was maintained at optimum level of 4°C with best air circulation.

Materials and Methods

'Green Majic' Variety heads were collected from Loni Kalbhor, Pune Maharashtra, India and harvested at unopened florets stage in the early morning. Harvesting was carried out manually. The broccoli florets should be compact, firmly closed, and of a deep green color. Any heads that showed signs of yellowing or tiny yellow flowers were rejected as this is an indication of age. During harvesting, de-heading was done with the help of sharp sickle and the heads were kept in crates. Such freshly harvested and selected heads were placed under shady conditions for thirty minutes. The cut ends of the stalks were completely fresh and moist. Heads were handled carefully to reduce abrasion and bruising during transit. These plastic crates were loaded in an air-conditioned cab which was then unloaded in the Agri Research Lab. On arrival at the Agri Lab, the heads were sorted based on visual defects. Some heads were placed in crates for control.

Some stem heads were treated with 2% alum and 2% ascorbic acid for 1 minute. Some heads were wrapped in cling paper and shrink-wrapped and kept in 150°C for 10 seconds. The heads were packed in low vacuum bags, air inside the bags was removed using a vacuum pump. All samples were kept inside a cold room at 4°C and 95% RH. Parameters like weight loss, shelf-life, storage life, post-storage-life, chilling injury were recorded on a periodic basis. Each treatment sample was replicated thrice [2-6].

Results and Discussion

Weight loss was highest in open crate placed heads followed by 2% ascorbic acid, 2% alum treated heads and cling and shrink-wrapped produce inside cold room [Table-1]. Lowest weight loss was seen in vacuum packed produce. Vacuum, cling and shrink-wrapping samples were observed with low weight loss inside cold storage. Weight loss increased with increase in hollowness in stem of broccoli. Pithiness increased with increase in storage period. Weight loss of control samples increased inside cold storage as storage period increased. Compared to control, cling and shrink-wrapping; weight loss was very less in case of vacuum packaged heads [Table-1]. Highest weight loss was recorded in 2% ascorbic acid, control, 2% alum treated samples than cling and shrink-wrapped samples when taken out from cold room at the end of day -9 and kept at room conditions for 2 days [Table-2]. Highest storage life was noted in vacuum packed samples as 13 days followed by shrink (10.33 days) and cling wrapped samples (7.33 days) [Table-4] and [Fig-1 to 6]. Compared to control, 2% alum, 2% ascorbic acid, cling and shrink-wrapping; storage life was better in case of vacuum-packed samples. The heads stored at 4°C with 95% RH conditions, recorded 0 percentage chilling symptoms in all the treatments [Table 5]. The diseased symptoms were noted as zero percent in all treatments during experiment period inside cold room [Table-6]. The chilling injury symptoms were noted as zero percentage in all treatments during experiment period at room conditions [Table-7], when treated samples were taken out from cold room. The post storage life was recorded as one day at room conditions for samples of open crate, cling wrap, 2% ascorbic acid, 2% alum and shrink wrapped; when samples were taken out from cold room at the end of day 3, 7, 3, 4 and 11, respectively [Table-8].

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Table-1 Weight loss (%) of broccoli cv. 'Green Majic' inside cold room conditions

Treatments	After 1 Day	After 2 Days	After 3 Days	After 4 Days	After 5 Days	After 6 Days	After 7 Days	After 9 Days	After 10 Days	After 11 Days	After 13 Days	After 14 Days
Open Crate	2.98	3.97	5.30	5.96	6.13	6.62	7.12	7.28	7.62	8.44	9.27	9.60
Cling Wrap	1.04	1.21	1.56	2.08	2.43	2.77	3.12	3.47	3.64	3.81	3.81	3.81
2% Ascorbic Acid	2.02	4.04	5.05	6.06	6.06	6.06	7.07	7.07	7.07	8.08	8.08	8.08
2% Alum	2.02	3.03	4.04	5.05	5.05	6.06	6.06	7.07	7.07	8.08	8.08	8.08
Shrink Wrap	0.81	0.97	1.30	1.62	1.94	2.27	2.43	2.76	3.24	3.57	3.57	3.57
Vacuum Pack	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.31	0.31	0.46	0.46	0.46

Table-2 Post-storage weight loss (%) of broccoli cv. 'Green Majic' at room condition, treated samples were taken out from cold room condition

Treatments	After 1 Days	After 2 Days	After 3 Days	After 4 Days	After 5 Days	After 6 Days	After 7 Days	After 9 Days	After 10 Days	After 11 Days	After 13 Days	At end of Day – 1
	At the end of Day – 2											
Open Crate	12.83	13.16	12.24	11.72	9.46	9.23	8.91	9.90	12.50	7.81	8.57	
Cling Wrap	0.66	1.22	0.59	0.93	0.75	0.85	2.11	2.17	1.52	1.69	3.37	
2% Ascorbic Acid	12.36	11.48	11.11	-	9.71	-	9.09	10.87	-	-	-	
2% Alum	12.00	10.00	11.76	-	10.67	-	9.80	9.89	-	-	-	
Shrink Wrap	1.23	1.20	0.74	1.98	0.85	0.95	1.16	1.10	1.92	2.08	3.64	
Vacuum pack	-	-	-	-	-	-	-	-	-	-	-	1.23

Table-3 Shelf life of broccoli cv. 'Green Majic' heads at room condition

Treatment	Shelf life; Days
Control-Open Crate	2

Shelf life was noted as 2 days at room conditions [Table-3]

Table-4 Storage life of broccoli cv. 'Green Majic' heads at cold room condition

Treatments	Storage life; days
Open Crate	3.00
Cling Wrap	7.33
2 % Ascorbic Acid	3.67
2% Alum	4.00
Shrink Wrap	10.33
Vacuum Pack	13.00

Table-5 Chilling injury percentage inside cold room

Treatments	Percentage
Open Crate	0
Cling Wrap	0
2% Ascorbic Acid	0
2% Alum	0
Shrink Wrap	0
Vacuum Pack	0

Table-6 Diseased percentage inside cold room

Treatments	Percentage
Open Crate	0
Cling Wrap	0
2% Ascorbic Acid	0
2% Alum	0
Shrink Wrap	0
Vacuum Pack	0

Table-7 Chilling injury symptoms at room conditions, when treated samples of broccoli cv. 'Green Majic' were taken out from cold room

Treatments	After 1 Days	After 2 Days	After 3 Days	After 4 Days	After 5 Days	After 6 Days	After 7 Days	After 9 Days	After 10 Days	After 13 Days	
	Treated samples were taken out from cold room										
	At Room Conditions (Storage life, Days)										
Open Crate	0	0	0	-	-	-	-	-	-	-	
Cling Wrap	0	0	0	0	0	0	0	0	0	-	
2 % Ascorbic Acid	0	0	0	0	-	-	-	-	-	-	
2% Alum	0	0	0	0	-	-	-	-	-	-	
Shrink Wrap	0	0	0	0	0	0	0	0	0	-	
Vacuum Pack	-	-	-	-	-	-	-	-	-	0	

Table-8 Post-storage life at room conditions, when treated samples of broccoli cv. 'Green Majic' were taken out from cold room

Treatments	After 1 Days	After 2 Days	After 3 Days	After 4 Days	After 5 Days	After 6 Days	After 7 Days	After 9 Days	After 10 Days	After 11 Days	After 13 Days
	Treated samples were taken out from cold room										
	Post-storage life at Room Conditions (Days)										
Open Crate	2.0	1.5	1.0	-	-	-	-	-	-	-	-
Cling Wrap	2.5	2.5	2.5	2.0	2.0	1.5	1.0	1.0	-	-	-
2 % Ascorbic Acid	2.0	1.5	1.0	1.0	-	-	-	-	-	-	-
2% Alum	2.0	1.5	1.5	1.0	-	-	-	-	-	-	-
Shrink Wrap	2.5	2.5	2.5	2.0	2.0	2.0	1.5	1.5	1.5	1.0	-
Vacuum pack	-	-	-	-	-	-	-	-	-	-	1.0

Table-9 Diseased percentage up to 2 days at room conditions, treated samples of cv. 'Green Majic' were taken out from cold room

Treatments	After 1 Days	After 2 Days	After 3 Days	After 4 Days	After 5 Days	After 6 Days	After 7 Days	After 9 Days	After 10 Days	After 11 Days	After 13 Days
Open Crate	0	0	0	-	-	-	-	-	-	-	-
Cling Wrap	0	0	0	0	0	0	0	-	-	-	-
2% Ascorbic Acid	0	0	0	0	-	-	-	-	-	-	-
2% Alum	0	0	0	0	-	-	-	-	-	-	-
Shrink Wrap	0	0	0	0	0	0	0	0	0	0	-
Vacuum pack	-	-	-	-	-	-	-	-	-	-	0



Day-1

Day-4

Fig-1 Photos of Control inside cold room



Day-1

Day-4

Fig-2 Photos of 2% Ascorbic Acid inside cold room



Day-1

Day-4

Fig-3 Photos of 2% Alum inside cold room



Day-1

Day-4



Day-8

Fig-4 Photos of cling wrapping inside cold room

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Fig-5 Photos of shrink wrapping inside cold room



Fig-6 Photos of vacuum packaging inside cold room

Lowest post storage life was noted in case of control, 2% ascorbic acid and 2% alum treated samples. The disease signs were noted as zero percentage in all treatments at room conditions up to 2 days [Table-9], when treated samples were taken out from cold room. The heads which were stored at 4°C with 95% RH with vacuum pack retained highest storage life up to 13 days, whereas shelf-life was recorded as 2 days in ordinary room conditions. Visual appearance of broccoli heads is shown in figure 1 to 6. Alum promotes the proper healing of the wound at stem end and controls pathogens [3]. Ascorbic acid acts as anti-oxidant. The conversion of green colour of the heads into yellow takes place because of chlorophyll degradation which is an indicator of senescence that is enhanced by

high rate of respiration which in turn is regulated by temperature, ethylene, O₂ and CO₂ gases [4]. Shrink-wrap packaging is a new technique for post-harvest handling of vegetables. The technology delays physiological deterioration and prevents condensation of droplets within the package. Individual shrink-wrapping of the produce provides optimum gas and humidity for maintaining quality of the produce during the transit and storage. As a result, it doubles or sometimes triples storage life of the fruits under proper storage conditions. Such unit packs also provide protection against abrasion and maintain attractive appearance of the product [5]. With polyethylene bags having more control over the gas exchange with the surrounding air, the levels of CO₂ and O₂ around the produce might have

further slowed down conversion of starch to sugars [6]. Heads stored in the cold conditions had maintained a greener colour, no chilling injury symptoms, no decay incidence and no rot. Storage at low temperatures reduces metabolism, and delay senescence during storage of head florets.

Conclusion

In conclusion, the visual quality of the head of cv. 'Green Majic' is evident from the images collected at various stages of this experiment. This activity establishes that the selected storage conditions have high impact in terms of shelf life of broccoli head of cv. 'Green Majic'. Vacuum pack in combination with low temperature storage significantly maintains the quality of broccoli heads. Post storage life was recorded as 1 - 2.5 days.

Application of research: Research is applicable for storage of highly perishable broccoli heads under low temperature with different packaging to extend storage life.

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