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RESEARCH PAPER

Modified storage conditions for better shelf life of coriander (*Coriandrum sativum* L.)

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Abstract: Green leafy vegetables have a higher rate of respiration, transpiration and undergo deplorable physiological changes after a day of harvest or so. The shelf life is found to be poor even under refrigerated storage. Shelf life of fresh green leafy vegetables may be enhanced by an atmosphere low in O_2 and high in CO_2 *i.e.,* by means of modified atmosphere packaging that slows respiration rate and other biochemical changes associated therein. Therefore, an investigation was carried out to study the influence of Modified atmoshere packaging (MAP) with a suitable packaging material on the storage life of coriander. Fresh and uniformly matured coriander leaves were pretreated with 100 ppm chlorine dioxide (ClO_2) and packed in three different packaging materials *i.e.,* low density polyethylene (LDPE), high density polyethylene (HDPE) and polypropylene (PP) containing three different ratios of MAP gases *i.e.,* 3 % O_2 + 5 % CO_2, 4 % O_2 + 5 % CO2, 5 % O_2+ 5 % CO_2 and stored at 7 ± 1 °C with 80 ± 5 % RH for 7 days. Among the different blends of gases, 3 % O_2+ 5 % CO_2in LDPE bags recorded lower rate of respiration. It has also recorded relatively higher retention of moisture, chlorophyll content with lesser changes in the overall colour and maximum maintenance of vitamin C content for up to 7 days. Visible decaying with water-soaked appearance was observed after 7 days of storage. The combination of 3 % O_2+ 5 % CO_2in LDPE bags presented a better shelf life of 7 days than refrigerated storage alone.

Key words: Chlorophyll, Modified atmosphere packaging, Physiological loss in weight

Introduction

Green leafy vegetables have become a major palate in this era of conscience of health. However, these leaves have a higher rate of respiration and transpiration and undergo rapid senescence thereby becoming unmarketable after a day of harvest or so.

Coriander (*Coriandrum sativum* L.), a tropical spice and herbal plant, belongs to the family Apiaceae. Coriander occupies a supreme position in the Indian flavor, since ancestral times. It is local to Mediterranean and commercially produced in India, Morocco, Russia, East European countries, France, Central America, Mexico and USA (Anon, 2015).

Modified atmosphere packaging (MAP) is one of the packaging technologies, with a constitution disparate from that of normal atmospheric air, surrounding the produce necessary for prolonging the storage life. It reduces the respiration rate of the fresh commodity and tends to extend the shelf life (Caleb *et al*., 2012). Therefore, shelf-life of coriander can be extended by an atmosphere low in O_2 and high in CO_2, which slows deterioration and reduces the respiration rate.

Packaging offers produce protection and greatly influence the movement of air around the commodity, thereby affecting temperature and relative humidity management of produce while in storage and transit. Thus, MAP using different packaging materials provides potential extension of postharvest life. Modifying the gas composition around vegetables with subsequent cold storage could prolong their shelf life. Hence, the present study was conducted to extend the shelf life of coriander under modified atmosphere packaging using different packaging materials.

Material and methods

The study was carried out in the Department of Post-harvest technology, UHS, Bangalore in the year 2018-19. The fresh uniformly matured coriander leaves were procured from a local farmer in Bangalore. The leaves were brought to the laboratory immediately after harvest in large polyethylene bag. They were immediately subjected to precooling at 7 ± 1 °C for 10 min to remove the field heat. The pre-cooled leaves were trimmed, cleaned and shade dried to remove the surface moisture. They were surface disinfected with 100 ppm ClO_2 solution followed by washing with distilled water. Further, they were air dried using electric fan. They were again pre-cooled by placing in the refrigerator (7 ± 1 °C) for 10 min. They were bundled to 100 g each in low density polyethylene (LDPE), high density polyethylene (HDPE) and polypropylene (PP) bags. Later, bags with respective samples were flushed with different concentration of O_2, CO_2 and N_2 using the modified atmosphere packing machine gas mixer (Make: Dan sensor, Model: MAP Mix Provectus 3 Gas. Gas packing Makeak Ramon Model 960 AB). The coriander leaves without MAP forms the control. Finally, the coriander leaves with different gas concentration and different packaging material along with control were stored in a low temperature storage of 7 ± 1 °C and 80 ± 5 % RH for 7 days.

The treated coriander leaves along with the control were weighed initially, then at 3 days after storage (DAS) and 7 days after storage (DAS) during the storage period to determine the physiological loss in weight percent. The difference between weight of the sample before treatment and weight of the treated sample at the end of specified storage day suggests the percentage loss in physiological

weight. The chlorophyll content was determined spectrophotometrically by a method described by Sadasivam and Manickam (2004). The experimental results were statistically analyzed as per Fisher's analysis of variance technique (Panse and Sukhatme, 1961).

Results and discussion

Physiological loss in weight (PLW %)

Physiological loss in weight is primarily due to transpiration *i.e.,* evaporation of water from plant surface and utilization of substrates during respiration. A carbon atom is lost from the produce in each cycle causing loss in weight of the produce during respiration. Water loss from the surface affects the product appearance. The data pertaining to changes in physiological loss in weight of coriander is presented in Table 1, 2 and 3. A significant difference had been observed among the treated and untreated coriander at the end of storage period. From Table 1, it is seen that coriander samples packed in LDPE had lost moisture to the surrounding during the storage. At 7 DAS, maximum PLW was observed in T_3 (0.88 per cent) followed by T_2 (0.86 per cent), whereas relatively minimum PLW was seen in T_1 (0.81 per cent). Control sample in LDPE had lost maximum moisture of 0.94 per cent to the external atmosphere. HDPE packed MAP treated coriander had lost maximum moisture to the surrounding during the storage and is represented in Table 2. At 7 DAS, maximum PLW was observed in T_5 (1.46 per cent) followed by T_4 (1.45 per cent) which is statistically on par with T_6 (1.45 per cent). Controlsample in HDPE had lost maximum weight of 1.65 per cent. Coriander samples in PP had significantly lost higher moisture to the surrounding during the storage and are represented in Table 3. At 7 DAS, maximum PLW was observed in T_8 (0.95 per cent) while relatively lower PLW was seen in T_7 (0.93 per cent). Control sample in PP had lost maximum weight of 1.26 per cent during storage.

Table 1. Effect of MAP with LDPE on physiological loss in weight (%) of coriander during cold storage at 7 ± 1 °C

Treatments	Physiological loss in weight (%)		
	Storage days		
	Initial day	3 DAS	7 DAS
Control	0.00	0.48	0.94
T_1	0.00	0.31	0.81
T_2	0.00	0.33	0.86
T_3	0.00	0.31	0.88
Mean	0.00	0.36	0.87
	S.Em.±		C. D. (at 1%)
Factor A	0.005		0.017
Factor B	0.005		0.015
Interaction (A×B)	0.009		0.029

*Significant at 1 %

DAS- Days after storage, Control-Package without gas composition, T_1- LDPE with 3 % O_2 + 5% CO_2 + 92 % N_2, T_2- LDPE with 4 % O_2 + 5 % CO_2 + 91 % N_2, T_3- LDPE with 5 % O_2 + 5% CO_2 + 90 % N_2

Table 2. Effect of MAP with HDPE on physiological loss in weight (%) of coriander during cold storage at 7 ± 1 °C

Treatments	Physiological loss in weight (%)		
	Storage days		
	Initial Day	3 DAS	7 DAS
Control	0.00	1.39	1.65
T_4	0.00	1.21	1.45
T_5	0.00	1.24	1.46
T_6	0.00	1.27	1.45
Mean	0.00	1.27	1.50
	S. Em.±		C. D. (at 1%)
Factor A	0.006		0.020
Factor B	0.005		0.017
Interaction (A×B)	0.011		0.034

*Significant at 1%

DAS- Days after storage, Control-Package without gas composition, T_4- HDPE with 3 % O_2 + 5 % CO_2 + 92 % N_2, T_5- HDPE with 4 % O_2 + 5 % CO_2 + 91 % N_2, T_6- HDPE with 5 % O_2 + 5 % CO_2 + 90 % N_2

Table 3. Effect of MAP with PP on physiological loss in weight (%) of coriander during cold storage at 7 ± 1 °C

Treatments	Physiological loss in weight (%)		
	Storage days		
	Initial day	3 DAS	7 DAS
Control	0.00	0.81	1.26
T_7	0.00	0.66	0.93
T_8	0.00	0.67	0.95
T_9	0.00	0.68	0.94
Mean	0.00	0.70	1.02
	S. Em.±		C. D. (at 1%)
Factor A	0.008		0.024
Factor B	0.007		0.021
Interaction (A×B)	0.013		0.042

*Significant at 1%

DAS- Days after storage, Control-Package without gas composition, T_7- PP with 3 % O_2 + 5 % CO_2 + 92 % N_2, T_8- PP with 4 % O_2 + 5 % CO_2 + 91 % N_2, T_9- PP with 5 % O_2 + 5 % CO_2 + 90 % N_2

Condensation of water molecules were noticed in every treatment. In general, PLW per cent gradually increased and was significantly higher in the package without modification of gases *i.e.,* control samples during 7 days of storage. Refrigeration also results surface evaporation of water from the surface of plant part (Goel *et al.,* 2007). Loss of water from the leaf surface is associated with increased weight loss resulting from the combined effect of trans-evaporation and respiration (Chitravathi *et al.,* 2015). Minimum PLW per cent was observed in those samples which were packed in LDPE throughout 7 days of storage. It is because, LDPE has a good gas barrier property and doesn't allow gases to move in or move out along the package to bring out respiration. Low O_2 and elevated CO_2 in the LDPE had also contributed to the reduced rate of transpiration and respiration. Further, decrease in PLW per cent could be due to low temperature storage which reduces metabolic activities and evapo-transpirational losses (Rana *et al*., 2018) of the leaves thereby delaying the physiological processes.

Chlorophyll content

The data pertaining to influence of MAP on chlorophyll content of coriander is presented in Table 4, 5 and 6. The retention of chlorophyll largely depends on the in-package atmosphere. The result regarding chlorophyll content of coriander leaves decreased with the increase in storage period. Coriander leaves packed in LDPE, HDPE and PP showed no marked significant difference among the treated samples. Degradation of chlorophyll significantly increased with increase in storage time. Relatively maximum chlorophyll content was observed in the sample packed in LDPE *i.e.,* T_1 with a value of 1.27 mg g^{-1} at 7 DAS. Maximum chlorophyll degradation was observed in the sample packed in HDPE *i.e.,* T_6 (1.07 mg g^{-1}) which was significantly on par with T_5 and T_6 with a total chlorophyll content of 1.08 mg g^{-1}. Untreated samples in all the three different packaging materials have shown larger degradation of chlorophyll during the whole storage period. The chlorophyll content was minimal in the untreated sample packed in HDPE with a total value of 0.96 mg g^{-1} followed by 0.99 mg g^{-1} at 7 DAS. An initial rapid fall in the chlorophyll content was observed in the untreated sample for coriander at 7 DAS. This could be attributed to the movement of air inside the package that favors degradation and the lower temperature that causes chilling injury to the green leaves. Chlorophyll is also very sensitive to both heat and light. Respiration of the leaves takes places continuously where the heat produced also had significantly affected the chlorophyll. Chlorophyll content was significantly higher in T_1 coriander (1.27 mg g^{-1}) which had lower level of O_2 *i.e.,* 3 per cent packed in LDPE. Lower O_2 level or higher CO_2 level with LDPE does not hasten the process of chlorophyll degradation (Manolopoulou *et al.,* 2012). Treatments with higher O_2 level had led to poor chlorophyll retention. This could be due to the pronounced activity of chlorophyll oxidase catalyzed by sufficient levels of O_2. Chitravathi *et al.,* 2015 reported that the overall degradation of chlorophyll of the treated samples were minimal due to decreased respiration rate caused by low levels of O_2 and subsequent low temperature storage.

Table 4. Effect of MAP with LDPE on chlorophyll content (mg g^{-1}) of coriander during cold storage at 7 ± 1 °C

Treatments	Chlorophyll content (mg g^{-1})		
	Storage days		
	Initial day	3 DAS	7 DAS
Control	1.49	1.27	1.01
T_1	1.49	1.43	1.27
T_2	1.49	1.42	1.24
T_3	1.49	1.41	1.24
Mean	1.49	1.38	1.19
	S.Em.±	C. D. at 1%	
Factor A	0.001	0.003	
Factor B	0.001	0.003	
Interaction (A×B)	0.004	0.004	

* Significant at 1 %

DAS- Days after storage, Control-Package without gas composition, T_1- LDPE with 3 % O_2 + 5 % CO_2 + 92 % N_2, T_2- LDPE with 4 % O_2 + 5 % CO_2 + 91 % N_2, T_3- LDPE with 5 % O_2 + 5 % CO_2 + 90 % N_2

Table 5. Effect of MAP with HDPE on chlorophyll content (mg g^{-1}) of coriander during cold storage at 7 ± 1 °C

Treatments	Chlorophyll content (mg g^{-1})		
	Storage days		
	Initial day	3 DAS	7 DAS
Control	1.49	1.12	0.96
T_4	1.49	1.46	1.08
T_5	1.49	1.44	1.08
T_6	1.49	1.38	1.07
Mean	1.49	1.35	1.05
	S.Em.±	C. D. at 1%	
Factor A	0.009	0.028	
Factor B	0.008	0.024	
Interaction (A×B)	0.016	0.048	

* Significant at 1%

Control-Package without gas composition, DAS- Days after storage, T_4- HDPE with 3 % O_2 + 5 % CO_2 + 92 % N_2, T_5- HDPE with 4% O_2 + 5 % CO_2 + 91 % N_2, T_6- LDPE with 5 % O_2 + 5% CO_2 + 90 % N_2

Table 6. Effect of MAP with PP on chlorophyll content (mg g^{-1}) of coriander during cold storage at 7 ± 1 °C

Treatments	Chlorophyll content (mg g^{-1})		
	Storage Days		
	Initial day	3 DAS	7 DAS
Control	1.49	1.24	0.99
T_7	1.49	1.42	1.18
T_8	1.49	1.41	1.17
T_9	1.49	1.41	1.16
Mean	1.49	1.37	1.12
	S.Em.±	C. D. at 1%	
Factor A	0.001	0.003	
Factor B	0.001	0.003	
Interaction (A×B)	0.001	0.004	

* Significant at 1%

Control-Package without gas composition, DAS- Days after storage, T_7- PP with 3 % O_2 + 5 % CO_2 + 92 % N_2, T_8- PP with 4 % O_2 + 5 % CO_2 + 91 % N_2, T_9- PP with 5 % O_2 + 5 % CO_2 + 90 % N_2

Fresh coriander leaves were disinfected in 100 ppm ClO_2, packed in LDPE, HDPE and PP bags with different levels of O_2, CO_2 and $N_2$and stored at refrigeration temperature (7±1 °C with 80±5 % RH) for a period of 7 days. The physiological loss in weight and chlorophyll content were recorded during storage at different time intervals for a period of 7 days.Fresh coriander leaves packed in LDPE with 3 % O_2 + 5% CO_2 + 92 % N_2 followed by 3 % O_2+5 % CO_2+92 % N_2 in polypropylene (PP) recorded minimum physiological loss in weight per cent with maximum retention of moisture throughout the storage period. Degradation of chlorophyll was prominent throughout the storage period. However, it was prone to lesser degradation in the LDPE package having a gaseous atmosphere of 3 % O_2 + 5 % CO_2 + 92 % N_2.

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