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Effect of Modified Atmospheric Packaging on Postharvest Storage Life of Cilantro (*Coriandrum sativum* L.) Stored Under Different Conditions

Panta R* and Khanal A

Institute of Agriculture and Animal Science, Tribhuvan University, Lamjung, Nepal

Abstract

Cilantro is a leafy vegetable commonly used for seasoning purpose that is highly perishable and has high postharvest loss losing 1.03 ml water per gram per day. It is therefore an alternative method of storage is needed to extend storage life of Cilantro. So, the research was carried out to study the effect of Modified Atmospheric Packaging (MAP) on postharvest storage life of Cilantro at different storage conditions. The experiment was laid under Completely Randomized Design (CRD) with ten treatments viz. open in tray along with 0, 5, 10 and 15 perforations (having pore size 5 mm) which are stored both in lab and Zero Energy Cool Chamber (ZECC) with three replications of each treatment during March/April (2018) at the Institute of Agriculture and Animal Science (IAAS) Lamjung Campus. Cilantro bought from market was packed in 250 gauge polyethylene bags, each bag was filled with 200 g Cilantro. Physiological loss in weight (PLW), Chlorophyll content, Colour change and Decay are the parameters that were evaluated. Results revealed that with the increase in number of perforation PLW was increased. Cilantro packed in MAP without perforation and stored in ZECC had minimum PLW (0.75%), no decay development as well as minimum loss of chlorophyll (11.18%) in comparison with Cilantro stored in lab at two days after storage. Decay percentage was however higher, greater than 50% at 6 days after storage in ZECC. Polyethylene bags without perforation were observed to be best packaging materials for extending storage life of Cilantro up to 4 days in ZECC followed by 2 days in lab.

Keywords: Chlorophyll meter; LDPE; PLW; ZECC

Introduction

Coriander (*Coriandrum sativum* L.) is commonly known as Dhaniya in Nepal. Its green leaves are known as Cilantro. It is an important culinary herb mainly used for seasoning. Coriander is extensively grown in Nepal in allotment gardens and is also traded for sale in the domestic market. Antioxidant [1], anti-mutagenic [2], anti-diabetic [3] have been reported. In Nepal, it is grown on an area of 1,554 hectare producing about 11,504 tons of leaf per year. The main Coriander producing districts includes Kailali, Kavre, Kachanpur, Bara, Saptari, Dhading, Kathmandu, Makwanpur, Bhaktapur, etc. [4].

It possesses very high amount of ascorbic acid up to 160 mg per 100 gm [5] and has long prehistory of being used in folk medicine in different civilizations [6]. Postharvest loss (PHL) of fruit and vegetables can be as much as 30-50% of production [7]. In case of leafy vegetables, rate of transpiration is higher as they are characterized by large surface to volume ratio. The amount of water lost from Cilantro is 1.03 ml per gram per day [8]. If more than 3% of the original fresh weight is lost by leafy vegetables, they become unmarketable [9].

MAP is defined as 'the packaging of a perishable product in an atmosphere which has been modified so that its composition is other than that of air' [10,11]. Siddiqui and Dhua [12] reported MAP as a technology that mitigates water loss due to high water vapour in the bag. The deteriorative process occurring in harvested horticultural produces is found to slow down by altering the gaseous composition and amount of water vapour in the package [13]. Also, in MAP Low Density Polyethylene (LDPE) film is highly preferred in packaging of fresh fruits and vegetables due to its high permeability and softness compared with High density polyethylene (HDPE) [14]. The main aim behind this research is to study the effect of Modified Atmospheric Packaging in the postharvest storage life of Cilantro stored under different storage condition (lab and ZECC).

Methodology

Freshly harvested and marketed Cilantro was purchased from local market and was brought to the Horticulture lab of Lamjung Campus where the present research work was carried out during the year March/April (2018). Cleaning, sorting and removal of decayed leaves were done before packaging. Postharvest storage of Cilantro was done both at lab temperature and ZECC. The fresh Cilantro leaves were then packed with 200 g weight in polyethylene (250 gauge having dimension 36 cm × 25 cm with pore size 5 mm) bags with open in tray along with 0, 5, 10 and 15 perforations which are stored in both lab and ZECC in March/April (2018). Samples were weighed accurately at zero (experiment set up day) and alternate days to collect data. The experiment was laid in Single factor, Completely Randomized Design (CRD) in combination of ten different treatments with three replications. Relative Humidity (RH) and Temperature was measured by ERMA in-out measuring instrument. Five treatments were stored in ZECC (13.86 to 15.3°C and 83 to 98% RH) and rest five were stored in lab (20.15 to 22°C and 63 to 65% RH). The stored samples were analysed for Physiological loss in weight, Chlorophyll content, Colour change and Decay parameters. The difference in weight between initial and final weight was considered as physiological loss in weight and percentage was calculated [15]. Chlorophyll content was ascertained by chlorophyll meter as spad unit (Model: SPAD-502 PLUS, KONICA MINOLTA SENSING, INC. Japan). Score was given for colour change ranging from 1 (dark green) to 5 (full yellow). The decayed leaves were separated on alternate days and weighed, and percentage of spoilage was calculated as described by EI-Mougy et al. [16]. The data obtained

***Corresponding author:** Panta R, Institute of Agriculture and Animal Science, Tribhuvan University, Lamjung, Nepal, Tel: +977 1-4331076; E-mail: rajendrapanta3@gmail.com

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for quantitative and qualitative parameters was analysed for statistical significance by using 15th edition of GenStat.

Results and Discussion

Effect of packaging materials on postharvest storage of Cilantro was found significantly different as depicted in Table 1.

Physiological loss in weight (PLW) %

At the end of 2 days after storage, maximum PLW was recorded in T1 (open in lab) which is 32.44% followed by T2 (open in ZECC) which is 7.5% while T7 (15 perforations in lab) recorded minimum PLW (0.53%) followed by T8 (15 perforations in ZECC) which is 0.75% and T10 (0 perforation in ZECC) which is 0.75% (Table 1). At the end of 4 days of storage maximum PLW was recorded in T2 (12.1%) followed by T6 (10 perforations in ZECC) which is 2.01% while minimum PLW was observed in T3 (5 perforations in lab) which is 0.51% followed by T9 (0 perforation in lab) which is 0.73% (Table 1). At the end of 6 days after storage maximum PLW was seen in T2 (8.76%) followed by T8 (1.53%) while minimum PLW was found in T9 (1.02%) (Table 1).

From above result it can be found that samples stored inside ZECC has less PLW as compared to samples stored at lab. Presence of perforations also had significance effect on PLW of Cilantro. Treatment stored in polyethylene bags without perforations have comparatively less PLW than polyethylene bags with perforations stored both inside lab and ZECC. With the increase in the number of perforations the PLW was found to be increased. The reason behind increase in weight loss is due to higher permeability which influences respiration and transpiration rate. These findings of increase in PLW are in accordance with the observations of previous work done in different packaging and storage conditions [17-20]. The higher percentage of weight loss in lab condition and less in ZECC is also related to RH and temperature surrounding the produce. ZECC is cooler and had high air humidity than lab storage conditions, thereby can reduce moisture loss from the packaged samples as observed by Samira et al. [21].

Chlorophyll content

At the end of 2 days after storage, maximum loss of chlorophyll content was recorded in T4 (5 perforation in ZECC) which is 58.93% followed by T6 (10 perforations in ZECC) which is 54.64% while minimum loss of chlorophyll content was however recorded in T10 (0 perforation in ZECC) which is 11.18% followed by T7 (15 perforations in lab) which is 12.86%. At the end of 4 days after storage maximum loss of chlorophyll content was recorded in T7 (31.44%) followed by T6 (30.31%) while minimum loss of chlorophyll content was recorded in T9 (0 perforation in lab) which is 10.45% followed by T8 (15 perforations in ZECC) which is 11.14%. At 6 days after storage maximum loss of chlorophyll was recorded in T8 (58.34%) followed by T6 (47.69%) while minimum loss was however recorded in T10 (15.92%) which was followed by T9 (34.08%) (Table 1).

Treatments	Detail of Treatment
T1.	Open in lab condition
T2.	Open in ZECC
T3.	5 perforations in lab condition
T4.	5 perforations in ZECC
T5.	10 perforations in lab condition
T6.	10 perforations in ZECC
T7.	15 perforations in lab condition
T8.	15 perforations in ZECC
T9.	0 perforations in lab condition
T10.	0 perforations in ZECC

Table 1: Details of the treatment.

Loss of chlorophyll content in sample of Cilantro stored inside ZECC was found comparatively lower than those sample stored in lab. With the increase in the number of perforation the loss of chlorophyll rises simultaneously with highest loss recorded in control condition and lowest in zero perforations. The reason behind this might be due to low O_2 and high CO_2 concentration in non-perforated polyethylene bags and such amount of gases effects the ethylene production. Presence of perforations fails to increase CO_2 concentration and thus retards the chlorophyll content. Also, when the temperature rises it tends to increase in loss of chlorophyll content to great extent. These findings of increase in loss of chlorophyll content with storage concur with the previous work done by different researchers [22-25].

Decay %

At the end of 2 days after storage maximum decay (51.67%) was seen in T1 (open in lab) while other treatment doesn't show any sign of decay during this very day. At the end of 4 days after storage maximum decay (53.5%) was found in T3 (5 perforations in lab) which was followed by T5 (10 perforations in lab) which is 51.33% while minimum decay (1.93%) was seen in T10 (0 perforation in ZECC) followed by T8 (15 perforations in ZECC) which is 4.7%. At the end of 6 days after storage maximum decay was recorded in T8 (64.60%) followed by T6 (10 perforations in ZECC) which is 62.50% while minimum decay was recorded in T9 (0 perforation in lab) which is 38.89% followed by T2 (open in ZECC) which is 51.18%.

At 2DAS T1 (open in lab) has maximumly wilted and decayed while other treatment had remained decay less. In comparison of ZECC, the treatment stored in lab showed higher decay percentage at 4DAS. But after six days of storage the samples stored in ZECC started to show higher decay percentage than those samples stored in lab. With the increase in days of storage, the samples stored in ZECC started showing condensation inside the polyethylene bags. This might be due to the reason that high air humidity and low O_2 situation inside polyethylene bags resulted in the accumulation of moisture, a by-product of respiration thus leading to condensation which favours conducive environment for growth of microorganisms to cause decay. Low O_2 levels favours the fermentation process that might cause formation of acetaldehyde resulting in off flavour compounds that enhance rotting [26]. Also, water condensation inside the package is reported to occur due to temperature fluctuation. The above-mentioned results that are obtained on increased decaying concurs with the observations of earlier research performed on different packaging and storage conditions [27-29].

Different treatments had significant result in colour change during several DAS. At 2DAS no colour change was observed in T2 (open in ZECC), T6 (10 perforations in ZECC), T8 (15 perforations in ZECC), T9 (0 perforations in lab) and T10 (0 perforations in ZECC) by retaining their dark green colour as such while T3 (5 perforations in lab) had maximum loss of colour (yellowish-green) at this day. At 4DAS T2, T9 and T10 had similar change in colour (light green) while T3, T4, T5, T6 and T7 had similar colour change (greenish-yellow). And at the same day T8 had remained yellowish-green in colour. But at 6DAS T4, T6 and T8 had turned to full yellow in colour thus remaining less desirable in purchasing by consumers. T2 and T10 had similar change in colour (greenish-yellow) while T9 was more desirable by remaining yellowish-green.

The reason behind retention of colour in ZECC may be due to increase in concentration of CO_2 and decreased in O_2 level inside the package which help in reduction of colour change of green leafy

Treatments	2DAS			4DAS			6DAS		
	PLW%	Ch L%	Decay%	PLW%	Ch L%	Decay%	PLW%	Ch L%	Decay%
T1 (open in lab)	32.43^{a}	47.44^{bc}	51.66^{a}	NE	NE	NE	NE	NE	NE
T2 (open in ZECC)	7.50^{b}	45.42^{c}	0.00^{b}	12.06^{a}	17.68^{cd}	21.85^{b}	8.75^{a}	37.32^{c}	51.18^{b}
T3 (5 perforations in lab)	3.78^{c}	29.13^{d}	0.00^{b}	0.51^{d}	19.89^{bc}	53.50^{a}	NE	NE	NE
T4 (5 perforations in ZECC)	2.28^{cd}	58.93^{a}	0.00^{b}	1.50^{bc}	25.89^{ab}	6.67^{cd}	1.02^{b}	37.40^{c}	53.44^{b}
T5 (10 perforations in lab)	3.49^{c}	35.50^{d}	0.00^{b}	0.83^{cd}	30.61^{a}	51.33^{a}	NE	NE	NE
T6 (10 perforations in ZECC)	1.61^{cd}	54.64^{ab}	0.00^{b}	2.01^{b}	30.53^{a}	7.50^{cd}	1.03^{b}	47.69^{b}	62.50^{a}
T7 (15 perforations in lab)	0.53^{d}	12.86^{ef}	0.00^{b}	1.75^{b}	31.44^{a}	50.51^{a}	NE	NE	NE
T8 (15 perforations in ZECC)	0.75^{d}	19.08^{e}	0.00^{b}	1.50^{bc}	11.14^{d}	4.70^{de}	1.53^{b}	58.34^{a}	64.60^{a}
T9 (0 perforations in lab)	3.36^{c}	18.54^{ef}	0.00^{b}	0.73^{cd}	10.45^{d}	9.60^{c}	1.02^{b}	34.07^{c}	38.89^{c}
T10 (0 perforations in ZECC)	0.7^{5}d	11.18^{f}	0.00^{b}	1.74^{b}	11.37^{d}	1.93^{e}	1.02^{b}	15.92^{d}	52.37^{b}
CV%	21.2	12.7	17.7	17.3	21.6	10	15.3	5.7	4.8
GM	5.65	33.27	5.17	2.52	21	23.07	2.40	38.46	53.83
LSD (5%)	2.03	7.21	1.55	0.74	7.79	3.96	0.65	3.86	4.62
Sig.	**	**	**	**	**	**	**	**	**

Means separation in columns followed by same letter(s) are not significantly different at P=0.05

Note: NE means not evaluated as decayed completely. GM means Grand Mean. CV means Coefficients of Variation. LSD means Least Significant Difference. ** means highly significant at 0.01%. Sig. means Significant.

Table 2: Effect of MAP on PLW%, Chlorophyll Loss% (Ch L%) and Decay% of Cilantro at two, four and six days after storage (DAS) in lab and ZECC at IAAS, Lamjung during March/April (2018).

Treatments	2DAS	4DAS	6DAS
	Change in colour	Change in colour	Change in colour
T1 (open in lab)	Light green	NE	NE
T2 (open in ZECC)	Dark green	Light green	Greenish-yellow
T3 (5 perforations in lab)	Yellowish-green	Greenish-yellow Greenish- yellow	NE
T4 (5 perforations in ZECC)	Light green	Greenish-yellow	Full yellow
T5 (10 perforations in lab)	Light green	Greenish-yellow	NE
T6 (10 perforations in ZECC)	Dark green	Greenish-yellow	Full yellow
T7 (15 perforations in lab)	Light green	Yellowish-green	NE
T8 (15 perforations in ZECC)	Dark green	Light green	Full yellow
T9 (0 perforations in lab)	Dark green	Light green	Yellowish-green
T10 (0 perforations in ZECC)	Dark green		Greenish-yellow

Table 3: Effect of MAP on Colour change of Cilantro at two, four and six DAS stored in lab and ZECC at IAAS, Lamjung during March/April (2018).

vegetables mainly from green to yellow because of chlorophyll breakdown. This effect was documented on broccoli as well [30]. They also stated that an increase in CO_2 is more effective than a reduction in O_2 to slow down the colour change. Similar result of reduction of colour loss was reported by Apeland [31] in Parsley. Also, the storage temperature was found to affect in the colour change in vegetables. Low temperature of ZECC favours more retention of colour as compared to lab condition. With the elevation of temperature, chlorophyll and green colour retards and thus more loss of colour occurs. Similar result was reported by Koca et al. [32] in green peas. Green colour is due to the presence of green pigment called chlorophyll. The control in loss of chlorophyll by low O_2 and elevated CO_2 in many green tissues might be due to effects of these gases on ethylene production [33] which ultimately leads to senescence by losing the colour (Tables 2 and 3).

Conclusion

The effect of different treatment was significant for each of the parameters tested. During the entire storage period, a maximum of 32.44% PLW was observed in T1 (open in laboratory) while a minimum (0.53%) was observed in T7 (15 laboratory perforations) in the laboratory at the end of 2DAS. A maximum loss of chlorophyll content (58.93%) was observed in T4 (5 perforations in ZECC) at 2DAS and minimum (11.14%) in T8 (15 perforations in ZECC) at 4DAS throughout the period of storage. Treatments that have decreased by more than 50% are eliminated from experiment. The maximum decay (64.60%) was detected in T8 at the end of 6DAS, while, except T1 all other treatments remain less decreasing without any sign of development at 2DAS decay. Then after, minimal decay (1.93%) was observed in T10 at the end of 4DAS throughout the research period. Maximum retention of colour was observed in treatment stored in ZECC up to 4 DAS. After 4 days, the zero-perforation treatment stored at laboratory temperature retained more colour compared to other treatment stored in ZECC.

This current research reported that Cilantro packed in MAP without perforation and kept inside ZECC showed PLW minimum compared to samples kept in the laboratory. Storing in lab (control) will tend to increase the weight loss by more than 30% during 2nd day of storage. The loss of chlorophyll content also tends to increase within the laboratory temperature. In conclusion, the results of this study showed that coriander packed in a 250-gram polyethylene bag without Perforation proved to be the best material to extend the shelf life of coriander up to 4 days in ZECC followed by less than 2 days in the laboratory.

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