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Effect of modified atmosphere packaging on postharvest quality of broad leaf mustard (BLM) under different storage condition

Abstract

Broad leaf mustard (*Brassica juncea*) is a highly perishable vegetable with short shelf life. In order to evaluate the effect of modified atmosphere packaging on shelf life and quality of broad leaf mustard in different storage condition, a study was conducted at Sudarbazar, Lamjung. A factorial combination of four different perforation (0, 10, 20 and 30) along with open and two storage conditions (ambient and Zero Energy Cool Chamber (ZECC)) using completely randomized design with three replications were used. Data on weight loss%, decay%, chlorophyll content and color was taken on 1 day interval until complete decaying of the crop. Packaging condition as well as different storage condition had significant effect on different quality parameters except chlorophyll content. On 10th day, weight loss and decay in ZECC was less than that of ambient condition. Interaction effect of packaging and storage condition also had significant effect on quality parameters excluding chlorophyll content. On 2nd day , 10 perforation under ZECC gained weight by 16.30% but open lost weight by 4.307%. Until day 3, no decay was observed in all the treatments. On day 4, decay% was lowest in 0 (0%), 20 (0%) and 30 (0%) perforations in comparison to open (3.5%). Similar trend was observed on day 10 as well. None of the treatment had significant effect on chlorophyll content. Shelf life of packaged commodity was prolonged up to 8 days and 10 days under ambient condition and ZECC respectively.

Keywords: ambient condition, chlorophyll content, post harvest, low density polyethylene, shelf life

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Introduction

Broad leaf mustard (*Brassica juncea*) is highly perishable commodity owing to shorter shelf life. Proper handling is required to preserve the quality of BLM as they deteriorate very rapidly after harvest. In developing countries like Nepal, one of the major reason for high qualitative and quantitative losses in vegetables is inadequate knowledge on appropriate practices and technologies.[1] Various biological and environmental factors are also responsible for the high postharvest losses in leafy vegetables. Transpiration water loss is one of the physiological processes that results in deterioration of leafy vegetables. According to Yehosua & Rodov,[2] leafy vegetables are considered as unsalable if they lose more than 3% water.

In case of developed countries, cold storage using refrigeration is an inherent part of postharvest handling of highly perishable leafy vegetables. But, in developing countries, majority of the farmers do not have access to conventional cold storages due to the high cost of purchase and maintenance of such facilities. As a solution to these problems, other low cost cold storage options have been developed based on evaporative cooling. Evaporative cooling, also called Zero energy cool chamber, is premised on the evaporative heat exchange where tremendous heat is exchanged when water evaporates. The working principle of evaporative cooling is based on the principle of the latent heat of evaporation. It can be constructed using locally available raw materials such as bricks, sand, bamboo, dry grass, jute cloth etc. ZECC has maximum efficiency during the summer season wherein the vegetables could be stored afresh for longer period than the conventional storage. The rise in relative humidity (90% or more) and fall in temperature (15-18˚C) from the ambient condition could be achieved by watering the chamber twice a day.

Modified Atmosphere Packaging (M.A.P) is another cheap method for preservation of fruits and vegetables in developing countries. According to Kader,[3] M.A.P. is considered as a gas mixture, which has atmosphere different from that of air, and which surrounds the produce to bring about beneficial effects, for extending the shelf life of the commodity. The mixture atmosphere is composed primarily of oxygen, carbon dioxide and nitrogen.[4] The main objective of M.A.P is to match the commodity's respiratory characteristics with the gas permeability of package system in order that a suitable equilibrium M.A.P can passively evolve through the consumption of oxygen and the evolution of carbon dioxide in the respiration process.[3]

In low income countries like Nepal, farmers can't afford expensive storage structures and refrigeration system. Also, refrigeration system is dependent on availability of reliable supply of electricity which in many areas of developing countries is usually expensive or unavailable. So, M.A.P and ZECC would be the possible solution to this problem as it is cheap and does not require electricity. But still, the adoption of ZECC and M.A.P among smallholder farmers is low. Promotion of these technologies requires evidence of their effectiveness to preserve quality of perishable commodities. Research regarding the effectiveness of these storage conditions on postharvest quality of Broad Leaf Mustard is also inadequate.

Materials and methods

Description of experimental site

The experiment was conducted during January at Horticulture laboratory of IAAS, Lamjung (725 masl, 28º7´ to 28º10´ N, 84º24´ to 84º 28´ E). The area has sub-humid type of weather condition with cold winter, hot summer and distinct rainy season. The experiment was conducted during February, 2018.

Construction of ZECC

A zero energy cool chamber (ZECC) was built from locally available materials including earthen bricks, river bed sand and jute sacs. The bricks were arranged to make a double wall. Wet river bed sand was sandwiched between the two walls in the space of 17 cm. The water in the sand was replenished by the application of water through water pipes once a day. The top cover of the ZECC was made from gunny bags which is a thermal insulating material.

Raw material and Packaging procedure

Broad leaf mustard was harvested at its commercial maturity from the nearby farmer's field during February, 2018 and brought to the Horticulture Laboratory of Lamjung Campus, Institute of Agriculture and Animal Science, immediately after harvest. Over matured, damaged and pest infected leaves were discarded. Low density polyethylene (size 60cm*40cm) was used as packaging material and was perforated with 5 mm diameter to restrict the respiration of BLM. 8 leaves were maintained in each replication. Hot needle was used to make the perforation as it melts the plastic to form the hole and redeposit the melt plastic as a large rim around the edges.

Treatment details (Table 1)

Parameters observed

Observations were made on the following parameters:

Table 1 Treatment details

	Modified atmosphere packaging				
Storage condition	**Open**	**0 perforation**	**10 perforations**	**20 perforations**	**30 perforations**
Ambient condition	T1	T3	T5	T7	T9
ZECC	T2	T4	T6	T8	T10

Physiological weight loss (%)

All the packed and the unpacked leaves (control) were weighed before the start of experiment. Then the readings were taken on 1-day interval until complete decay using a digital weighing machine with an accuracy of ±10 mg (Danwer Scales Pvt Ltd., India). Then, data were recorded as the percentage of weight loss.

$$\text{Physiological weight loss\%} = \frac{Initialweight - Finalweight}{Initialweight} * 100\%$$

Decay %

BLM was visually evaluated for symptoms of decay at each 1 day interval based. Treatment with more than 50% decay% was unusable for the consumers.

$$PDP = \left(\frac{WeightofspoiledCilantro}{FreshweightofCilantro}\right) \times 100\%$$

Chlorophyll content

Chlorophyll content of the sample was measured at every 1 day interval with the help of chlorophyll meter or SPAD (Model: SPAD-502 PLUS, KONICA MINOLTA SENSING, INC. Japan). Then the SPAD readings were calibrated to obtain the chlorophyll content of the leaves.

Statistical analysis

Statistical analysis was carried out to study the effect of different treatments on all the dependent variables. Analysis of variance (ANOVA) was conducted with Factorial Completely Randomized Design.

Result and discussion

Effects of different storage conditions in weight loss (%)(Table 2)

During the study, the interaction effect of packaging and storage environment showed the highly significant difference in weight loss of BLM. The highest weight loss was recorded for open BLM stored under ambient conditions whereas the lowest weight loss was observed in 10 perforations stored under ZECC.

On 2nd day, the weight loss of (23.10%) for non-packaged BLM at ambient condition was significantly higher than all other treatments. Similarly, 10 perforated packaged leaf mustard stored under ZECC had lower weight loss% (-16.30%) followed by 30 perforated packaged BLM under ZECC. However, the 30 perforated packaged BLM under ZECC was statistically at par with every packaged treatment stored under ZECC along with 10 and 20 perforations at ambient condition. Same trend was observed on other days also, which is due to the effect of low temperature, high RH, low O_2 and high CO_2 concentrations inside package.[6,7] In general, weight loss of open treatment was significantly higher than the packed treatments both under ambient conditions and ZECC. Similar result was reported on green bell pepper by Manolopoulou et al.[8] The weight loss of packaged BLM was higher under ambient condition than in the ZECC. Thus, the appropriate reason for such reduced rate of weight loss in the ZECC could be the reduced rate of respiration and transpiration at low temperature and higher relative humidity.

Physiological weight loss% increased with increase in ventilation. This might be due to higher permeability which influences respiration and transpiration rate. These findings are in accordance to the observations of previous workers worked on different packaging and storage conditions.[9–11]

Table 2 Effect of M.A.P on weight loss of BLM stored under different condition at IAAS, Lamjung, 2018

Treatments		Weight loss% @ day2	Weight loss% @ day4	Weight loss% @ day6	Weight loss% @ day8	Weight loss% @ day10
Ambient condition	Open	23.01[a]	42.08[a]	53.50[a]	70.02[a]	84.12[a]
	0 perforation	0.27[de]	0.42[c]	0.91[de]	1.44[ef]	1.74[de]
	10 perforation	12.27[b]	10.95[b]	13.48[b]	14.49[c]	15.18[c]
	20 perforation	0.79d[e]	1.82[c]	2.69[cd]	4.32[de]	5.35[d]
	30 perforation	0.95[d]	2.13[c]	3.24[c]	5.27[d]	6.44[d]
ZECC	Open	4.30[c]	8.40[b]	13.88[b]	19.40[b]	24.31[b]
	0 perforation	0.79d[e]	10.90[b]	-0.10[e]	0.02[fg]	-0.10[e]
	10 perforation	-16.30[f]	-13.19[d]	-13.78[f]	-14[h]	-12.92[f]
	20 perforation	-0.71[de]	0.42[c]	0.42[e]	-0.72[fg]	1.43[e]
	30 perforation	-1.29[e]	-0.32[c]	0.53[e]	-2.62[g]	0.73[e]
	Significance	**	**	**	**	**
	CV%	50.4	50.4	14.5	19.1	14.3
	LSD	1.93	5.46	1.84	3.17	3.08
	SEm ±	0.93	2.62	0.88	1.52	1.48
	Grand mean	2.2	6.4	7.5	9.8	12.6

Means in the column followed by similar letter/s are not significantly different.

**, Highly significant at 0.01% level of significance

*, Significant at 0.05% level of significance

NS, Non significant

PWL%,Physiological weight loss%

DAS, Days after storage

Effect of different storage conditions in decay% (Table 3)

Interaction effect of packaging and storage condition had highly significant effect on the decay% of BLM. Decay was not observed on any treatment up to 2 days of storage. On 4thday, decay% of open stored under ambient condition, i.e. 12.66%, was significantly higher followed by 20 perforations at ambient condition. Similarly, 0, 20 and 30 perforations stored under ZECC had the lowest decay% (0%) followed by 30, 10 and 0 perforations under ambient condition. On day 10, open under ambient condition had significantly higher decay% (100%) followed by 30 perforations under ambient condition which was statistically at par with 20, 10 and 0 perforations under ambient condition. Significantly lowest decay% (30%) was observed in 0 perforations under ZECC which was statistically at par with 30, 20 and 10 perforations under ZECC.

Generally, the decay% of open is significantly higher than other treatments. Faster transpiration rate at relatively higher temperature could be the reason in shriveling of non-packaged BLM. All the packaged BLM stored under ZECC had significantly lower decay% than those stored under ambient condition which is due to lower temperature inside ZECC in comparison to ambient condition. Similar result was reported by on papaya. MAP was found to be efficient in decreasing decay of BLM than open as it slows down respiration, reduce moisture loss and decay and/or extend the shelf life of the products.[12,13]

Open BLM under ZECC was better for consumption up to 8thday. It means that packaged BLM under ZECC could be preserved for more than 10 days but all the treatments decayed early. This might be due to the infestation of mustard by bacterial rot, which is the common postharvest disease in brassica family. Proper sanitization of leaves is required before storage.

Effect of different storage conditions on chlorophyll content (Table 4)

Packaging and storage condition has no significant effect on the chlorophyll content of BLM. On 2ndday, the trend of chlorophyll content was found to be highest in 10 perforated packaged BLM stored under ZECC whereas lowest was in open BLM stored at ambient condition.

Similarly, from 6thday onwards, 30 perforations under ZECC had highest chlorophyll content. Lowest chlorophyll content was observed in open BLM stored at ambient condition. Higher the rate of perforation, higher will be the rate of chlorophyll degradation. This result was in contrary to the findings of Indore et al.

Table 3 Effect of M.A.P in decay% of BLM stored under ambient condition and ZECC during February 2018 at IAAS, Lamjung

Treatments		Decay% @day4	Decay% @day6	Decay% @day8	Decay% @day10
Ambient condition	Open	12.667^{a}	50^{a}	93.3^{a}	100^{a}
	0 perforation		15^{c}	23.33^{efg}	50^{bcd}
	10 perforation	3.66^{bc}	26.67^{b}	42.33^{c}	45^{cde}
	20 perforation	4.66^{b}	27.5^{b}	35^{cde}	57.33^{bc}
	30 perforation	1.33^{de}	13^{c}	60^{b}	67.33^{b}
ZECC	Open	3.5^{bcd}	7.5^{cd}	36.67^{c}	60^{bc}
	0 perforation	0^{e}	1.83^{d}	15^{g}	30^{e}
	10 perforation	1.5^{cde}	8^{cd}	20^{fg}	37.67^{de}
	20 perforation	0^{e}	9^{cd}	27.33^{def}	37.33^{de}
	30 perforation	0^{e}	2.5^{d}	12.5^{g}	35de
	Significance	**	**	**	**
	CV%	42.6	28.9	18.2	18.5
	LSD	2.092	7.919	11.35	16.38
	SEm±	1.003	3.796	5.44	7.58
	Grand mean	2.88	16.10	36.5	52

Means in the column followed by similar letter/s are not significantly different.

**, Highly significant at 0.01% level of significance

*,Significant at 0.05% level of significance

NS, non-significant

Table 4 Effect of M.A.P on chlorophyll content of BLM stored under ambient condition and ZECC during February 2018 at IAAS, Lamjung

Treatments		Chlorophyll content@day2	Chlorophyll content@day4	Chlorophyll content@day6	Chlorophyll content@day8	Chlorophyll content@day10
Ambient condition	Open	37.83^{a}	33.60^{e}	NE	NE	NE
	0 perforation	41.97^{a}	39.32^{abc}	40.23^{ab}	30.80^{a}	30.60^{a}
	10 perforation	39.17^{a}	37.87^{bcd}	30.70^{ab}	27.30^{a}	22.43^{a}
	20 perforation	40.10^{a}	34.70^{de}	34.07^{ab}	27.27^{a}	26.70^{a}
	30 perforation	42^{a}	42.27^{a}	29.27^{b}	30.87^{a}	27.47^{a}
ZECC	Open	41.43^{a}	37.20^{cde}	38.98^{ab}	32.97^{a}	31.47^{a}
	0 perforation	41.43^{a}	39.70^{abc}	37.73^{ab}	33.93^{a}	32^{a}
	10 perforation	43.70^{a}	41.47^{ab}	34.80^{ab}	27.03^{a}	27.50^{a}
	20 perforation	41.77^{a}	35.10^{de}	31.23^{ab}	29.10^{a}	22.73^{a}
	30 perforation	39.43^{a}	40.57^{abc}	41.57^{a}	38.87^{a}	33.80^{a}
	Significance	NS	NS	NS	NS	NS
	CV%	10	5.7	17.7	23.9	30.1
	LSD	6.934	3.276	10.73	12.67	14.62
	SEm ±	3.324	1.786	5.11	6.03	6.96
	Grand mean	40.88	38.18	35.4	30.9	28.3

Means in the column followed by similar letter/s are not significantly different.

**, Highly significant at 0.01% level of significance

*, Significant at 0.05% level of significance

NS, Non-significant

Since low O_2 and high CO_2 concentration can prevent chlorophyll degradation, MAP maintained low CO_2 inside the package leading to reduction of chlorophyll degradation. Increased level of CO_2 inside the package was found to reduce browning and other discolorations of cut or broken surfaces of Brussels sprouts,[14] green beans,[15,16] lettuce[17] and sweet corn on the cob.[18] In general, chlorophyll content was better maintained under ZECC than ambient condition which may be due to lower temperature and high relative humidity as degradation of chlorophyll is accelerated by exposure to higher temperature and low humidity.[19]

Conclusion

The interaction effect of M.A.P and ZECC was found to be highly significant in every parameter except chlorophyll content. During the entire storage period, minimum weight loss% was observed in 10 perforated packaged treatment stored under ZECC. Decay% was significantly lower in 0 perforated packaged treatment stored under ZECC and chlorophyll content was better maintained in 30 perforated packaged BLM stored under ZECC.

M.A.P alone was not able to retain the quality of BLM for longer period. So, combination of M.A.P and ZECC was found to be effective for retaining the postharvest quality of BLM. To be precise, perforated packaged treatment stored under ZECC was found to be most effective for the retaining the post-harvest quality of BLM and can be used at Lamjung condition.

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Conflicts of interest

The authors declare that there is no conflict of interest.

References

1. J.N.Kinyuru, SO Konyole, GM Kenjietal. Identification of traditional foods with public health potential for complementary feeding in western Kenya. *Journal of Food Research (JFR)*. 2012;(1):148–158.
2. SBen-Yehoshua, V Rodov. "Transpiration and water stress," in postharvest physiology and pathology of vegetables, JA Bartz & JK Brecht, editors. 2nd ed. Marcel Dekker, New York, USA; 2002:111–159.
3. Kader AA. Modified atmospheres: an indexed reference list with stress on husbandry commodities. Postarvest Hort Sci. 1985;3(4).
4. DR Dilley. Historical aspects and perspectives of controlled atmosphere storage, In Food preservation by modified atmosphere calderon M & Barkai- Gloan R. editors. *CRC Press*, Boca Raton, FL. 1990;187–196.
5. Kader AA, Zagory D, Kerbel EL, et al. Modified atmosphere packaging of fruits and vegetables. *Critical Reviews in Food Science & Nutrition*. 1989;28(1):1–30.
6. Sharma SR, Gupta American state (2006) Packaging of shelled peas in high density synthetic resin. *J Res Punjab Agri Uni*. 2006;43(3):208–213.
7. Sandhya, Singh American State (2004) Packaging of shelled peas in high-density polyethylene. *J Res Punjab Agri Uni*. 2004; 41(1):110–118.
8. Manolopoulou H, Xanthopoulos G, Douros N, et al. Modified atmosphere packaging of green bell peppers: quality criteria. *Biosyst Eng*. 106(4):535–543.
9. Reddy JB, Bharati P, Naik KR, et al. Effect of packaging materials on shelflife of minimally processed rajagira leaves (Amaranthuspaniculatus). *Karnataka Journal of Agricultural Science*. 2013;26(2):285–287.
10. Negi PS, Roy SK. Changes in nutrient content of fresh amaranth and fenugreek leaves during storage by low cost technique. *Plant Foods for Human Nutrition*. 2003;58:225–230.
11. Koraddi V. Methods of storage of vegetables within the white goods at unit level. M.Sc. thesis submitted to University of Agricultural Sciences, Dharwad (Karnataka); 2005.
12. Scetar M, Kurek M, Galic K. Trends in fruit and vegetable packaging–a review. *Croatian J Food TechnolBiotechnolNutri*. 2010;5(3–4):69–86.
13. Day A. High O_2 modified atmosphere packaging for recent ready turn out. *Postharvest News Inf*. 1996;7(3):31–34.
14. Weichmann J. Effect of controlled atmosphere on different cultivars of Brussels sprouts (Brassica oleracea L vargemmifera DC). *Congr Refrig*. 1983;287–291.
15. Buescher RW, J Henderson. Reducing discoloration and quality deterioration in snap beans (Phaseolus vulgaris) by CO_2 enriched atmosphere. Acta Hort. 1977;62:55–60.
16. Herner RC. High carbon dioxide effects on plant organs, in: postharvest physiology of vegetables, J Weichmann, editor. *Marcel Dekker Inc*. New York; 1987;239–254.
17. Singh B, CC Yang, DK Salunkhe, et al. Controlled atmosphere storage of lettuce. 1. Effects on quality and the respiration rate of lettuce heads. *J Food Sci*. 1972;37:48–51.
18. Spalding DH, PL Davis, WF Reeder. Quality of sweet corn stored in controlled atmosphere or under low pressure. J Amer Soc Hort Sci. 1978;103:592–595.
19. Pariasca JAT, Miyazaki T, Hisaka H, et al. Effect of MAP and CA storage on the quality of snow peapods (pisumsativum L. var. saccharatum). *Postharvest BiolTechnol*. 2001;21(2):213–223.