

Research Article

Modified atmosphere packaging of capsicum for extending shelf life under coolbot condition

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ABSTRACT

Capsicum is one of the high value vegetable crops in Nepal. Its demand in kitchen is increasing due to urbanization and increased awareness on its health benefit. Its commercial cultivation has been started in protected as well as open field conditions. It fetches higher price in market but has very short storage life under ordinary storage condition. An experiment was carried out to evaluate the modified atmosphere packaging (MAP) on extension of shelf-life of capsicum fruit. Fruit were harvested at full mature stage with smooth and shiny appearance from farmer's field grown under protected condition at Chitwan, Nepal. The fruits were brought to postharvest laboratory of National Horticulture Research Centre, pre-cooled for 3-4 hours, cleaned with muslin cloth and packed in 25 micron Low Density Polyethylene (LDPE) packaging with different number of pinhole sized perforations viz. without pinholes, eight pinholes, sixteen pinholes, twenty four pinholes and control (without MAP). The study was conducted in completely randomized block design with five treatments and four replications. Fruits were kept at coolbot storage (9.8±2 °C, 86±5% RH) till 10, 20 and 30 days of storage. The result showed that LDPE packaging influenced on reduction of physiological loss in weight (PLW), spoilage loss, ascorbic acid content, TA, freshness, firmness and shelf life. The modified atmosphere packaging (MAP) without pinholes showed the minimum PWL (1.71%) and the optimum fruit freshness (4.76) but the spoilage loss was the maximum (14%). Among the packaging, MAP with 8 pinholes maintained majority of postharvest quality retention with reduced physiological loss in weight (4.15 %), freshness (4.5) and spoilage loss (2%).

Keywords: Capsicum, coolbot condition, modified atmosphere

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INTRODUCTION

Sweet pepper (*Capsicum annum* L.) commonly known as bell pepper or capsicum, is a solanaceous vegetable. It is a native crop of Mexico. It is an important horticultural crops grown in tropical and sub-tropical climate of the world. In Nepal, the environmental condition of mid hills is favorable for its production during summer and rainy season. In Terai and hills, it is grown during spring and monsoon season respectively (HRD, 2016). It is rich source of essentials

nutrients, vitamin B, vitamin C, , carotene, antioxidants and flavonoids (Mateljan, 2007). Nowadays, demand of capsicum is increasing in festival, functions and ceremony mostly in urban and city areas of Nepal. Beside its use as vegetable, it is widely used in stuffing, baking, pizza, and preparation of soup for imparting flavor. It is a high value crop and fetch good market price to the producer. The consumer demand for this vegetable is year round but due to perishable in nature, it can only be stored for 4-7 days at ambient conditions.

Estimation of postharvest losses is important as it helps in identifying the causal factors and provides ways and means to reduce the losses (Tiwari *et al.*, 2020). The suitable postharvest handling technology development in capsicum is necessary to get good market price after certain weeks of storage when there is lean period of its availability in the market. There is a great role of harvesting technique, pre cooling, cleaning method, packaging and storage facilities in quality maintenance of capsicum for longer period. The low cost packaging and storage facility is of major importance in quality maintenance of capsicum in Nepal as the production is not in bulk. Also the use of modified atmosphere packaging (MAP) is found beneficial to extend the post harvest life of the capsicum up to three to four weeks under reduced temperature storage condition (NHRC, 2020). Also there is a role of perforation in MAP. The four holes per consumer packet are sufficient to store 500 g of capsicum fruit (Pandey & Goswami, 2012). Hence present research under coolbot system is initiated to find out the appropriate perforation number in MAP used to store the capsicum at lower temperature.

MATERIALS AND METHODS

The study was carried out at coolbot storage install at laboratory of NHRC, Khumaltar. The fruits of medium early cv. *Almirante* was grown under semi hi-tech greenhouse at Pithuwa, Chitwan and harvested at green matured stage in the morning on last week of April, 2019 and packed in two cardboard boxes occupying 30 kg of fruits in each and brought to NHRC for experimentation. The fruit was kept at shade condition for pre cooling and the experiment was set up on the same day. The 25 μ Low Density Polyethylene (LDPE) was used as a modified atmosphere packaging (MAP) material with different number of pinhole size perforations was used for fruit packaging under coolbot condition at 9.8° Celsius and 86% (average of daily record) relative humidity. The study comprised of five treatments viz. MAP without perforation, MAP with 8 perforations, MAP with 16 perforations, MAP with 24 perforations and control (without MAP). An experimental unit consisted of 10 fruits. The research was carried out in Completely Randomized Design with 4 replications and altogether there were 20 observations.

Observation was recorded on physiological weight loss, Ascorbic acid, firmness at 10 days intervals up to the last days of the storage. Daily observation was recorded on temperature, relative humidity and spoilage weight loss. The fruit freshness was recorded on 16th and 30th days of storage. The data recording was done from ten non destructive samples kept as each replication in each experimental unit. The research was started on 29th of April and completed on 2nd of May, 2019.

Data Collection

Physiological Weight Loss (PLW)

Ten non destructive samples of sweet pepper fruits were weighed on first day and on every ten days interval using digital balance (SACLTEC SPB42). The difference between initial and final

weight of fruit was considered as total weight loss during storage interval and expressed as percentage.

$$PLW \% = \frac{\text{Initialweight} - \text{finalweight}}{\text{Initialweight}} \times 100$$

Fruit Firmness

Firmness of the fruit was measured using handheld digital penetrometer (model: FR-5120) having cylindrical stainless steel probe of 5.84 mm in diameter. Puncture tests were taken from the three equatorial sides of the same fruit. One fruit was used from each experimental unit.

Spoilage loss (SL)

Fruits were evaluated visually for symptoms of decay at the end of each storage interval. Samples having diseased symptoms were counted. The pathogen causing decay was identified in pathology laboratory.

$$SL \% = \frac{\text{No.of decayed fruits}}{\text{Number of total fruits}} \times 100$$

Ascorbic acid

The ascorbic acid of ripe fruits was measured by volumetric method as per the reference from Sadasivsm and Manickam (1991). Following formula was used to calculate the ascorbic acid content.

$$\text{Amount of ascorbic acid (mg/100 g sample)} = \frac{0.5 \text{ mg} \times V_2 \text{ mL} \times 12 \text{ mL} \times 100}{V_1 \text{ mL} \times 5 \text{ mL} \times \text{wt.of the sample}}$$

Where, V₁ = amount of dye consumed during the titration

V₂ = amount of dye consumed when the supernatant was titrated with 4% oxalic acid

Freshness

Freshness of the fruit was measured using 1 to 5 hedonic scales, 1 for less fresh or highly shriveled and 5 for optimum fresh or less shriveled. The panelist of 10 scientist and technical officer was involved in scoring the freshness of the fruit on the last day of storage under coolbot.

Shelf life

Shelf life of the fruits was evaluated by recording the number of days that the fruit remained to an acceptable level for marketing. It was decided based on the appearance and spoilage of fruits. The record of shelf life was taken till ambient condition storage after removal of fruit from coolbot storage. The fruits lot was considered to reach the end of shelf life when 50% shrinkage or spoilage due to pathogen and other abiotic factor occurred.

Statistical analysis

The collected data were analyzed by using the software of R STAT. The significant differences between treatments were determined using the least significant difference (LSD) test at 1% or 5% level of significance (Gomez & Gomez 1984; Shrestha, 2020).

RESULTS AND DISCUSSION

Transportation loss

The total weight loss in fruit was recorded 6.29% during transportation from Chitwan to Kathmandu in cardboard box inside plastic bag. It was caused due to transpiration and bruising damage. The percentage share of transpiration and bruising during transportation is shown in the figure 1.

The uncontrolled environmental condition cause rapid rate of transpiration and piling of the fruits cause the bruising damage. Devkota *et al.* (2014) reported that 51% of the loss was due to rotting, 22 % was due to mechanical damage and 27% physiological loss during handling, marketing and transportation of fruits.

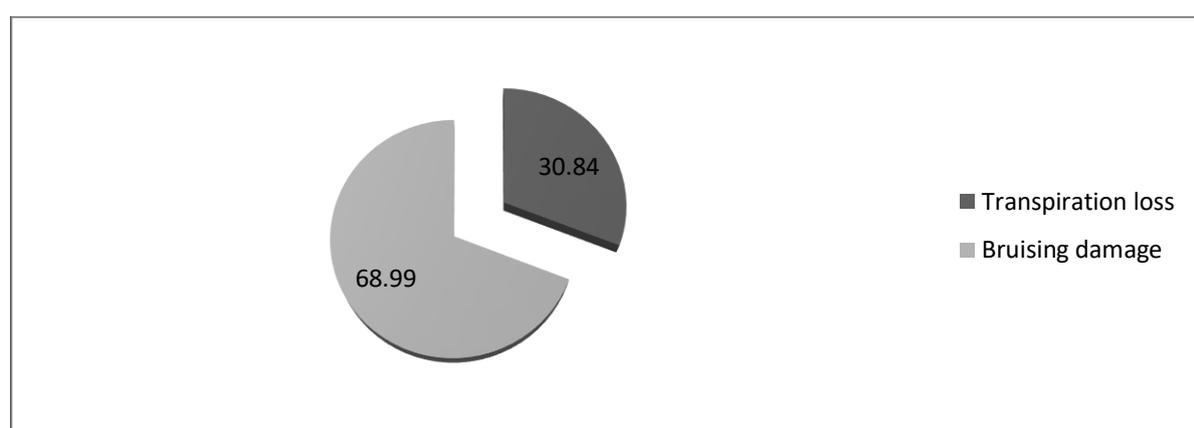


Figure1: The percentage share of transpiration loss and bruising damage in total transportation loss of capsicum fruit from Chitwan to Kathmandu

Physiological weight loss

The influence of modified atmosphere packaging on physiochemical quality of capsicum is presented in Table 1. From the study, it was found that the physiological loss in weight (PLW) was found significantly different between treatments. The minimum PLW was observed in the MAP without pinholes among the treatments while the maximum PLW was noted on control one in each date of observation. The MAP without pinholes showed the lowest weight loss (0.23%) on 11th day, 0.99% on 21th and 1.71% was observed on last day of storage. Similarly, the maximum weight loss was observed in control on 11th (4.95%), 21th (14.06%) as well as 30th (19.32%) day of storage.

The water loss is the cause of weight loss in fruit. The plastic films packaging significantly reduced the rate of water loss in capsicum (Gonzalez *et al.*, 1999). Nyanjage *et al.* (2013) found that sweet pepper packed in bored poly package and stored at ambient temperature recorded the lower weight loss than the without packed fruits on 10th day of storage which was in agreement with the finding of the present study.

Firmness

No significant change in firmness was observed over the storage period of 30 days. The structures present in cell walls such as pectin, cellulose and hemi-cellulose are related to maintaining the firmness of fruit and vegetable. The breakdown of these polymers on the fruit cell are degradable due to enzymes and biological processes hence, firmness of the fruit is reduced during ripening (Pose *et al.*, 2013; Atkinson *et al.*, 2012). The fruit softening is caused by the enzymes cellulase, pectin methyl esterase, polygalacturonase, β -galactosidase, among others (Paniagua *et al.*, 2014). The sweet peppers in perforated polythene bags at reduced temperature condition showed the minimum change in firmness at the end of storage period (Sattar *et al.*, 2019).

Ascorbic acid

No significant effect of packaging on ascorbic acid content of the fruit was found during the storage under coolbot condition. The storage of fruit using MAP at low storage temperatures is advantageous in retaining the ascorbic acid (Manolopoulou *et al.*, 2010). The ascorbic acid content was highest in the fruit packed on perforated poly bag than on non perforated poly bag while the unpacked fruits exhibited the lowest ascorbic acid content at the end of storage period (Sattar *et al.*, 2019). Barbero *et al.*, (2014) elaborate that the total ascorbic acid content of fruit is affected by the packaging throughout the storage period.

Table 1: Effect of packaging on postharvest shelf life and fruit quality of capsicum under coolbot storage, 2019

Treatment	PLW (%)			Firmness (lb)			Ascorbic acid (mg/100g)		
	11 DAS	21 DAS	30 DAS	11 DAS	21 DAS	30 DAS	11 DAS	21 DAS	30 DAS
MAP without pinholes	0.23	0.99	1.71	4.90	4.71	4.57	65.59	58.24	54.93
MAP with 8 pinholes	0.86	2.68	4.15	4.66	4.68	4.38	64.03	57.72	51.19
MAP with 16 pinholes	0.73	3.66	4.93	4.64	4.40	3.61	64.82	57.37	50.90
MAP with 24 pinholes	1.65	4.01	5.54	5.05	4.30	3.79	62.85	56.01	50.56
Control	4.95	14.06	19.32	4.43	3.99	3.76	63.08	55.26	47.01
Mean	1.68	5.08	7.13	4.73	4.42	4.02	64.07	56.92	50.92
Ftest	**	***	***	NS	NS	NS	NS	NS	NS
LSD(0.05)	1.75	1.72	2.01	0.66	0.55	1.23	31.18	33.07	21.35
CV(%)	55.13	18.03	14.99	7.41	6.65	16.23	25.84	30.86	22.27

NS, *** and ** indicate non-significant, significant at $P < 0.001$, and significant at $P < 0.01$, respectively. DAS = days after storage

Freshness

The freshness of capsicum fruit recorded during storage under coolbot is presented in figure 2. On the last day of storage under coolbot the maximum freshness of the capsicum fruit was observed in the MAP without pinholes (4.76 score) followed by MAP with 8 pinholes (4.5 score) and the minimum was found in control (1 score).

Water loss is negatively correlated with the fruit freshness. The low relative humidity inside the coolbot might be the reason for rapid loss of fruit freshness inside the coolbot storage (NHRC, 2020). Rana *et al.*, (2015) reported that the film wrapping preserved the freshness of fruits for whole storage time in contrast to control fruits which was unacceptable by 15 days of

storage. Modified atmosphere packaging reduces the weight loss and maintains fruit freshness (Sharma *et al.*, 2018). Manolopoulou *et al.*, (2012) found that the active packaging maintained the quality indices of fresh-cut sweet peppers at 0°C for 10 days during storage.

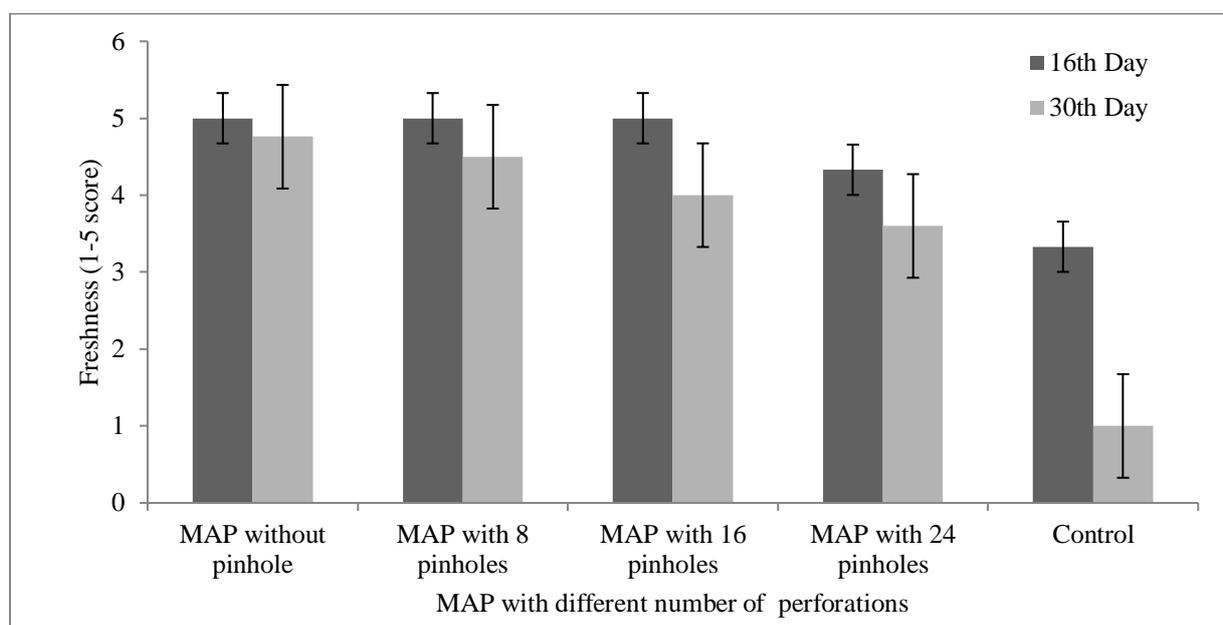


Figure 2: Freshness of capsicum fruits at different dates of storage under coolbot storage

Spoilage loss

The spoilage loss of capsicum fruit recorded during storage under coolbot is illustrated in figure 3. The maximum spoilage loss was observed in MAP without pinholes (14%) followed by other three packaging with 8, 16 and 24 pinholes(2%) while no spoilage of fruit was observed in control one. The fruit rot was observed during experimentation.

Accumulation of very high level of CO₂ led to formation of fermenting odour and decay of fruits inside LDPE film. The fruits packed in LDPE film recorded the maximum spoilage loss of fruits (Mahajan *et al.*, 2016). Excessive water droplets inside the LDPE package might be the reason for the higher disease incidence due to restricted water movement through the film (Yekula *et al.*, 2013). The fruit spoilage was found higher in LDPE lined crates than HDPE lined crates and CFB boxes. This might be due to permeability difference of polyethylene films (Kaur *et al.*, 2013). The lower temperature and relative humidity inside the coolbot might prevent the spoilage in control treatment (NHRC, 2020). Sandhu and Singh (2000) elaborate the increased fruit spoilage percentage with the advancement of storage period. The use of moisture absorbent inhibits the decay by reducing the water vapor inside the package (Singh *et al.*, 2014).

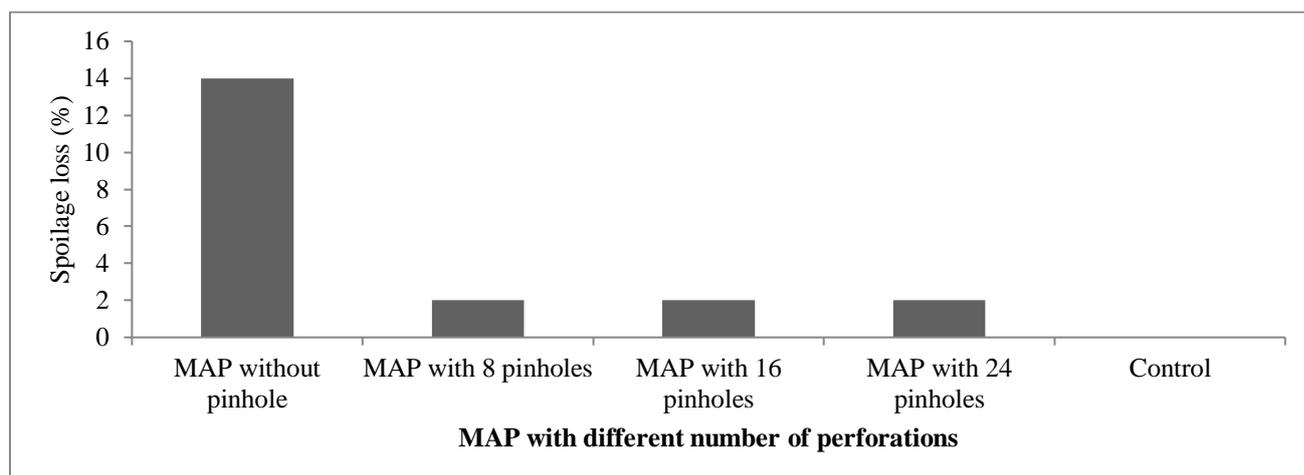


Figure 3: Spoilage loss of capsicum fruits during 30 days storage period under Coolbot storage condition

Shelf Life

The fruit was transfer to the ambient condition and the fruit was removed to see the time required to dispatch it to the market after a month of storage in coolbot. From the table 4 it was found that the fruit stored under coolbot using MAP showed significantly higher shelf life than that of control one. It was observed that fruit in MAP with 16 and 24 pinholes should be marketed within a day after removal from the coolbot storage to get at least half price for the produce due to fruit shrinkage whereas fruit in MAP with 8 pinholes is to be marketed within 2 days to get maximum market value and that of without pinholes within 4 days after the storage in coolbot.

The higher relative humidity inside the packaging might play crucial role in minimizing the rate of respiration and thus reducing the rate of fruit shrinkage. The reduced level of respiration due to lower level of O₂ and higher level of CO₂ inside the active packaging during storage might be the reason for retarding the senescence and extending the shelf life of the fruit up to 28 days (Devgan *et al.*, 2019). The pre-storage packing of sweet pepper in perforated bags and holding for two days at ambient condition resulted in maintenance of fruit quality at the end of the storage period (Mier *et al.*, 1995).

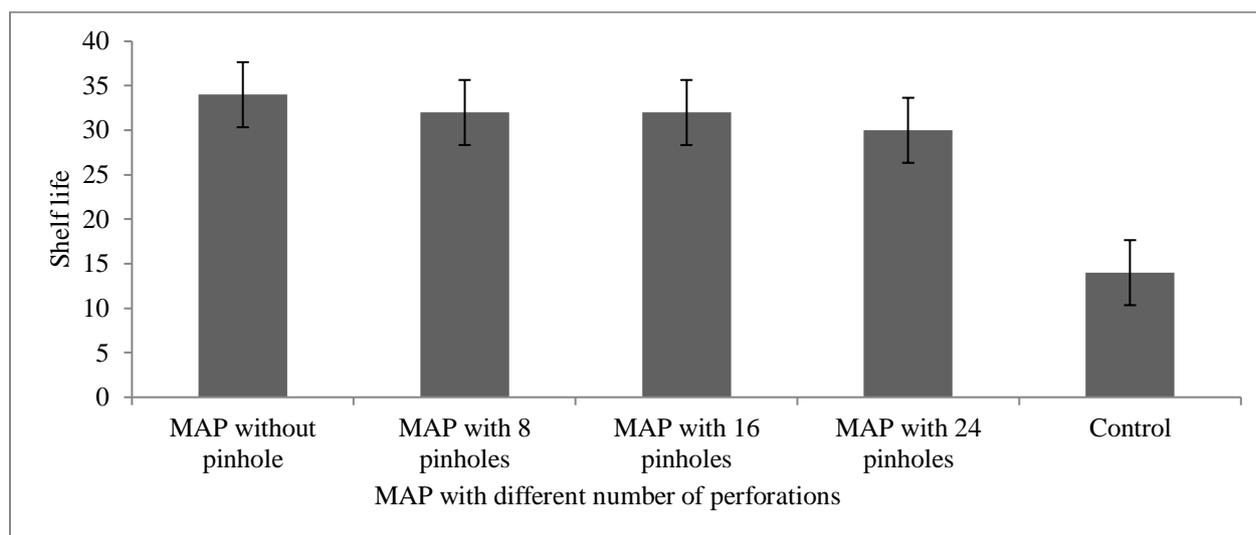


Figure 3: Shelf life of capsicum fruits for 30 days storage in coolbot storage condition and then after under ambient condition before marketing of fruits

CONCLUSION

Use of modified atmosphere packaging viz., 25 micron low density polyethylene to modify the atmospheric condition have shown to maintain the quality of sweet pepper during storage at reduced temperature of 8 to 10° C. The storage of about one kg of fruits on modified atmosphere packaging without perforation cause higher fruit decays even though the fruit weight loss was the minimum and fruit freshness was optimum in MAP without perforation. The fruits packed in MAP with sixteen and twenty four perforations has shown greater physiological weight loss and reduced quality parameters. The MAP with eight perforations showed the minimum spoilage and optimum fruit freshness.

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Authors' Contributions

SP and IPG conceptualized the activity. SP drafted the paper, IPG and Revised. SP, DG, SP and MD implemented activities in the laboratory, collected data and RR analyzed.

Conflict of interest

The author declares no conflicts of interest regarding publication of this manuscript.

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