



Effects of Perforation Mediated-modified Atmospheric Packaging (MAP) on Shelf Life and Quality of Calcium Chloride Treated Bell Pepper (*Capsicum annum*)

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ABSTRACT

Background: Capsicums having high respiration, transpiration, and ethylene production rates along with high susceptibility to microbial growth deteriorate rapidly during storage leading to higher loss. The current study was conducted to assess the effects of Perforation mediated- modified atmospheric packaging (MAP) on shelf life and quality of calcium chloride treated bell pepper (*Capsicum annum*).

Methods: For this purposed green mature fruits *Capsicum annum* variety Indra were pretreated with calcium chloride, weighed 1kg and packed in Low-density polyethylene with no perforation (T1), LDPE with 4 perforations (T2), LDPE with 8 perforations (T3), LDPE with 12 perforations (T4), LDPE with 16 perforation (T5) and open tray (T6) and stored at ambient room temperature of laboratory. Three replications were maintained for each treatment with CRD Design and different parameters were evaluated during the study period.

Result: Capsicum stored in perforated LDPE packet exhibited less weight loss, higher shelf life and higher vitamin C content compared to capsicum kept in an open tray. With less perforations weight loss was less. Moreover, LDPE with 16 perforations can be considered the best treatment because with higher numbers of pores it exhibited comparatively higher shelf life, optimum quality of fruits and also check the spoilage of the fruits as compared to all treatments.

Key words: *Capsicum annum*, LDPE, MAP, Perforation, Shelf life, Storage.

INTRODUCTION

Sweet pepper (*Capsicum annum* L.) is a potential vegetable crop grown extensively in Terai and mid hills of Nepal. Sweet pepper, also known as the bell pepper, is considered as the High value veggie due to its Superior taste, incredibly higher yield for the space they use, enormous health benefits and excellent return. In addition to being an ancestral culinary spice, Capsicum provides with an array of health benefits when consumed; essentially it helps relieve stomach aches, prevents skin-aging, muscle spasms, aches and arthritis. Likewise, it also prevents psoriasis, peptic ulcer and lowers the risk of cardiovascular diseases due to its analgesic properties. However, it has high rate of respiration and thus a shorter shelf-life at room temperature due to various physiological factors and high susceptibility to fungal diseases. Thus, it deteriorates rapidly during handling and storage due to poor post-harvest handling leading to huge losses (Annonymus, 2003). The major changes taking place during its senescence include loss in weight due to moisture loss, degradation of chlorophyll, loss of turgidity and change in texture, loss of nutritional value and reduction in marketability (Sahoo *et al.* 2014)

For those crops like Capsicum having high respiration, transpiration and ethylene production rates along with high susceptibility to microbial growth, the techniques such as atmospheric modification using packaging can be useful supplements to prolong the shelf life among farmers. The Modified atmosphere Packaging

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(MAP) is the practice of sealing actively respiring produce in polymeric film packages to modify the composition of internal atmospheres within the package. The internal atmospheres mainly depend on the respiration of product, and packaging film permeability. The firm permeability varies within low-density polyethylene (LDPE), linear low-density polyethylene (LLDPE), high-density polyethylene (HDPE), polypropylene (PP), polyvinyl chloride (PVC), polyester, *i.e.* poly-ethylene terephthalate (PET), polyvinylidene chloride (PVDC), polyamide (Nylon) and other suitable films (Goswami and Mahajan, 2009). The main principle of MAP is to develop a gaseous equilibrium between the produce and the sealed atmosphere resulting in lower O₂ and higher CO₂ levels which prolong shelf life and improve quality. In addition, MAP mightily enhances water retention capacity preventing dehydration and wilting. However, inside the sealed atmosphere the increase in water

vapor and heat generation may elevate exposure to pathogens and contaminants. Hence, packing films are often perforated with very small holes called micro-perforations to allow the outward movement of water vapor and heat but this method can effect ideal establishment of O₂ and CO₂ concentrations. Therefore, main objective of present study was to evaluate the effect of perforation mediated packaging on enhancing the shelf life and quality of capsicum during storage.

MATERIALS AND METHODS

The experiment was conducted in Agriculture and Forestry University (AFU), Rampur, Chitwan from 2017 December to 2018 February in the Post Harvest Laboratory at the Department of Horticulture. Fruits of *Capsicum annum* variety Indra were harvested at the mature green stage from the commercial Farm in Chitwan, Nepal (longitude 84.3542° E and latitude 27.5291° N,) and Oxalic acid, sodium bicarbonate, 2, 6-dichlorophenolindophenols and ascorbic acid were obtained from biochemistry lab for the measurement of Ascorbic acid and Vitamin C content. The fruits were washed with tap water thoroughly to remove field heat and adhering soil particles on the surface. Then, Fruits were dipped in calcium chloride (CaCl₂) solution of concentration (0.5ml) and left for air drying for a while. In the laboratory, the samples were sorted for uniform size and color, and packed separately, approximately about 1kg per each pack. Different treatments were MAPs with Low-density polyethylene (LDPE) with no perforation, LDPE with 4 perforations, LDPE with 8 perforations, LDPE with 12 perforations, LDPE with 16 perforation and fruit maintained in tray in an open condition. Three replications were maintained for each treatment with CRD design. All the samples bags were packed and stored at ambient room temperature of laboratory.

Assessment of shelf life and post harvest quality Cumulative Weight Loss

Weight loss was recorded in 3 days difference over the storage period using a digital sensitive balance. Initial weight (W₀) of each fruit (marked) at day 0 and the new weight of the same (W_t) was taken for the subsequent days. The weight loss was calculated according to the formula:

$$W1 = [(W_0 - W_t) / W_0] \times 100\%$$

Where

W1 is the percentage weight loss,

W0 is the initial fruits weight and

Wt is the weight of the fruits at the designated time.

Shelf life

The shelf life of sweet pepper fruits were evaluated by counting the number of days required to attain the last stage but up to the stage when fruits remained still acceptable for marketing as described by Rao *et al.* (2011). It was decided based on the appearance and spoilage of fruits.

Total Soluble Solid (°Brix)

Total soluble solids (°Brix) were determined with the help of hand held Refractometer.

Titrateable acidity (TA)

TA of the capsicum was measured by using following formula:

Titrateable acidity (%) =

$$\frac{\text{ml of NaOH used} \times \text{acid factor}}{\text{ml of juice taken}} \times 100$$

Ascorbic acid (Vitamin C) Content

The ascorbic acid of the mature fruit was measured by volumetric method as per the reference from (Sadasivam and Manickam (1991). It was determined by the volumetric method at the day before storage and at the end of the shelf life. The titration was done using 2, 6-dichlorophenolindo phenol method (Antoniali *et al.*, 2007). Amount of ascorbic acid (mg/ 100g sample) =

$$\frac{0.5 \text{ mg} \times V_2 \times 100 \times 100}{V_1 \text{ ml} \times 0.5 \text{ ml weight of the juice}}$$

Where

V₁ = amount of dye consumed during the titration.

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

PH of the sample fruit

PH of the sample fruit were measured with the help of digital pH meter.

Statistical analysis

All the data were subjected to analysis of variance and all the means of the treatments were analyzed with the least significant difference test (LSD) (P<0.05) using the Gen-stat software.

RESULTS AND DISCUSSION

Physiological weight loss percentage.

Weight loss in the crop not only lead to physical weight loss but also results in change in appearance, color, the texture of produce which decreases the market value as well as consumer preferences. It is a physiological process that can be controlled by storage temperature and humidity and also using appropriate packaging. In this study, Treatments have shown a highly significant difference in physiological weight loss (Cumulative weight loss) of CaCl₂ treated Capsicum throughout the storage period. The highest percentage weight loss was observed in CaCl₂ treated Capsicum kept in the open tray (9.13%) while the lowest percentage weight loss was found in the LDPE packet with no perforation (0.45%) at the end of respective shelf life. Lownds *et al.* (1994) demonstrated that packaging with perforated bags reduced the postharvest weight loss by up to 20 times in

several pepper genotypes. Unperforated bags reduced the weight loss in Jalapeño peppers up to 37 times (Ornelas-Paz *et al.* 2012). Among the perforated LDPE packets, packets with 16 perforations showed higher percentage weight loss (2.73%) at the end of shelf life. CaCl₂ treated Capsicum kept in LDPE packet with 8 and 12 perforations showed lower percentage weight loss of 1.90% and 1.63% respectively and were successful in lowering the weight loss by approximately 7.23% and 7.5 % respectively than the open tray at the end of shelf life. The reduction in weight loss in film-packed fruits is attributed to restricted respiratory process of fruits inside the packing films. We can infer that weight loss in an open could due to direct exposure to the environment, which caused more moisture loss. Moreover, the shelf life of CaCl₂ treated Capsicum kept in LDPE packet with 4,8,12 and 16 perforations were 8 and 4 days longer than Capsicum kept in LDPE packet with no perforation and open tray respectively. Results are presented in (Table 1).

Biochemical properties

The biochemical properties of Capsicum like TSS, TA, pH, and vitamin C were significantly influenced by various treatments during storage. The highest TSS (3.75° Brix) was recorded in Capsicum kept in the open tray while the lowest TSS (2.30° brix) was found in those kept in LDPE packet with no perforation and was also found statistically similar with capsicum kept in LDPE packet with 4,8,12 and 16 perforation. The increase in TSS content for all the sweet peppers throughout the storage in ambient conditions (Open) indicates continuous metabolic conversion of sugars from starch (Samira *et al.* 2013). Likewise, highest TA (0.79) was found in Capsicum kept in LDPE packet with 16 perforations while lower TA (0.22) was found in open tray. The higher loss of TA in control fruits could be due to depletion of organic acids as a result of relatively faster respiration and ripening rate of fruits at ambient storage (Wills *et al.* 1989). The atmospheric modification created when fruits are packaged with Polyethylene bags may delay respiration and as a direct effect, the consumption of

respiration substrates such as organic acids and sugars is retarded. Consequently, as the fruit respire, the O₂ level could decrease and the CO₂ level increases in the bags (Kader, 1985). Similarly, the highest pH value (6.46) was recorded in Capsicum kept in the open tray and lowest (5.87) in capsicum kept in the LDPE packets with no perforation. Moving towards Vitamin C, it was found the highest (19.03) in LDPE packet with 16 perforations which were found at par with LDPE packet with 12 perforations (17.76) and the LDPE packets with 8 perforations (17.54) consequently. Meanwhile, the lowest vitamin C was seen in capsicum kept in the open tray (8.03) and was found statistically similar with the LDPE packets with no perforations with value of 9.08. Vitamin C was lower in sweet pepper kept in the open tray compared to the LDPE packets due to direct exposure to the environment while the LDPE packet storage reduced respiration rate, delayed ripening, reduced ethylene production and maintained higher vitamin C (Day, 1993; Farber, 1991). Also, Pankotai *et al.* (2007) showed that Vitamin C contents in unpacked and packed (unperforated and perforated bags) peppers were similar during refrigerated storage. Results are presented on (Table 2).

Shelf life

There was highly significant effect of various treatments on shelf life of CaCl₂ treated Capsicum annum during storage. The Higher Shelf life of Capsicum was observed in LDPE packet with 16 perforations, meanwhile lower shelf life was observed in Capsicum kept in Open tray and LDPE packet with no perforation. Lower respiration and ethylene production rates, reduced ethylene action, delayed ripening and senescence, retarding the growth of decay causing pathogens and insects due to modification of the gas atmosphere inside the package could be possible reason to extend the storage life of fruits (Exama *et al.* 1993; Kader *et al.* 2004). Whereas in perforated packages, it was observed that perforations significantly reduced the extent of decay. So, perforations had an advantage over unperforated packages and open tray to extend the shelf

Table 1: Physiological weight loss (cumulative weight loss) of CaCl₂ treated *Capsicum annum* in four days interval from first day (day of packaging) until the end of shelf life.

Treatments	5 th day	9 th day	13 th day	17 th day	21 st day
T1	0.18 ^d	0.30 ^e	0.45 ^f	-	-
T2	0.21 ^d	0.64 ^d	0.79 ^e	0.90 ^e	1.03 ^d
T3	0.48 ^c	0.89 ^c	1.14 ^d	1.45 ^d	1.63 ^c
T4	0.61 ^b	1.08 ^c	1.60 ^c	1.80 ^c	1.90 ^{bc}
T5	0.70 ^b	1.35 ^b	1.96 ^b	2.50 ^b	2.73 ^a
T6	1.79 ^a	4.48 ^a	6.30 ^a	9.13 ^a	-
SEM	0.04	0.08	0.08	0.09	0.10
LSD _{0.05}	0.12***	0.24***	0.26***	0.27***	0.32***
CV (%)	12.8	11.2	8.7	6.3	6.7

Note: T1= LDPE packet with no perforation; T2= LDPE packet with 4 perforations; T3= LDPE packet with 8 perforations; T4= LDPE packet with 12 perforations; T5= LDPE packet with 16 perforations; T6= Open tray. SEM±, Standard Error of mean; CV, Coefficient of variation; LSD, Least significant difference. Means in the column with the same letter (s) in superscript indicate no significant difference between treatments at 0.05 level of significance; '***' Significant at 0.001 level of Significance.

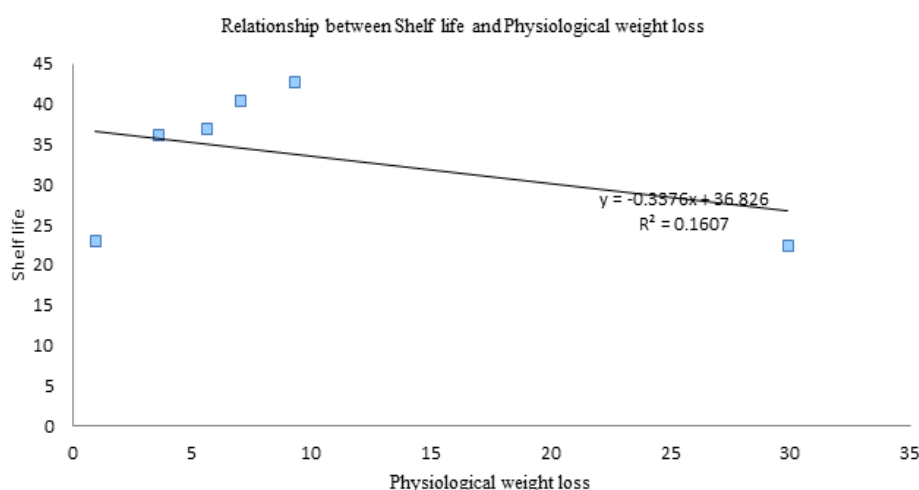


Fig 1: Relationship between Shelf life and Physiological weight loss.

Table 2: Biochemical analysis of CaCl_2 treated *Capsicum annum* at the end of shelf life.

Treatments	TSS	TA	pH	Vitamin C
T1	2.30 ^b	0.36 ^b	5.87 ^c	9.08 ^c
T2	2.35 ^b	0.38 ^b	6.02 ^{bc}	14.87 ^b
T3	2.70 ^b	0.26 ^{bc}	6.02 ^{bc}	17.54 ^a
T4	2.45 ^b	0.26 ^{bc}	6.30 ^{ab}	17.76 ^a
T5	2.60 ^b	0.79 ^a	6.23 ^{ab}	19.03 ^a
T6	3.75 ^a	0.22 ^c	6.46 ^a	8.03 ^c
SEM	0.20	0.11	0.09	0.51
LSD _{0.05}	0.61***	0.03***	0.28**	1.53***
CV (%)	15.3	20.7	3.2	7.2

Note: T1= LDPE packet with no perforation; T2= LDPE packet with 4 perforations; T3= LDPE packet with 8 perforations; T4= LDPE packet with 12 perforations; T5= LDPE packet with 16 perforations; T6= Open tray. SEM±, Standard Error of mean; CV, Coefficient of variation; LSD, Least significant difference. Means in the column with the same letter (s) in superscript indicate no significant difference between treatments at 0.05 level of significance; '***' Significant at 0.001 level of Significance.

Table 3: Effects of different treatments on the shelf life of *Capsicum annum*.

Treatments	Shelf life
T1	23 ^c
T2	36.25 ^b
T3	37 ^b
T4	40.50 ^{ab}
T5	42.75 ^a
T6	22.50 ^c
SEM	1.64
LSD _{0.05}	4.8***
CV (%)	9.8

Note: T1= LDPE packet with no perforation; T2= LDPE packet with 4 perforations; T3= LDPE packet with 8 perforations; T4= LDPE packet with 12 perforations; T5= LDPE packet with 16 perforations; T6= Open tray. SEM±, Standard Error of mean; CV, Coefficient of variation; LSD, Least significant difference. Means in the column with the same letter (s) in superscript indicate no significant difference between treatments at 0.05 level of significance; '***' Significant at 0.001 level of Significance.

life. Ben Yehoshua and Rodov (1998) from his experiment also suggested that changing the perforations per package in effect changes the transmission capability thereby reducing the water condensation and decay. Results are present in (Table 3).

Relationship between Shelf life and Physiological weight loss

The correlation between Shelf life and Physiological weight loss ($r = -0.779$) were highly significant shown in (Fig 1). The coefficient of determination (R^2) value was 0.607 which means that Physiological weight loss had only 60.7% contribution to reduce the shelf life of CaCl_2 treated *Capsicum annum* and the remaining contribution was due to other factors. Packaging of fruits and vegetables in plastic films is common for reducing excessive water loss that aids in prolonging the postharvest life of fresh produce. Low O_2 and elevated CO_2 concentrations in the modified atmosphere (MA) of the package reduce the respiration rate and hence improve storage life. Alleviation of water stress is the main factor extending postharvest life of pepper sealed in plastic

film (Hughes *et al.* 1981). Other factors could be involved in this phenomenon (e.g., initial water content, surface area, surface morphology and fruit weight).

CONCLUSION

In accordance with the different observations made on physiological weight loss, physiochemical analysis and shelf life of CaCl_2 treated *Capsicum annum* throughout the research period, it can be concluded that the *Capsicum* kept in perforated LDPE showed lower weight loss, higher vitamin C content, and higher shelf life compared to the open tray. Similarly, the accumulation of water vapor inside the packets was high with the lesser number of perforations resulting in microbial growths, decay, and reduced shelf life. Even though physiological weight loss was much less in the LDPE with no perforation, it could not maintain quality and shelf life due to restriction for movement of oxygen and carbon dioxide (anaerobic condition). LDPE packets with 8, 12, and 16 perforations were almost similar as they maintained optimum quality and the higher shelf life. Likewise, weight loss from the LDPE packets with 16 perforations was slightly higher than LDPE packets with 8 and 12 perforations; it was able to maintain higher vitamin C content and less accumulation of water inside the packet than those with 8 and 12 perforations. Conclusively, the LDPE packet with 16 perforations were best technology to store *Capsicum annum*.

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