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Quality changes in fresh green chillies (*Capsicum annuum* L) under modified atmospheres

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Abstract
Fresh green chillies were stored at 5, 10 and 15 °C with 85% relative humidity under modified atmosphere packaging to assess the impact of differential in-pack gas atmospheres generated in perforated and non perforated packages on the quality of stored produce. At the end of storage, retention of firmness, total soluble solids and ascorbic acid was better in non perforated packages than in perforated packages. Low in-pack O_2 (4-5.2 kPa) along with the build up of CO_2 (6–7 kPa) seems to have enhanced the retention of antioxidant components, i.e. ascorbic acid, in no perforated packages. This shelped in less weight loss in non perforated in comparison to perforated packages. Thus, O_2 and CO_2 permeability of packaging film or in-pack weight of produce might be such that equilibrated O_2 partial pressures remain near to 3-4 kPa so as to better retention of ascorbic acid.

Keywords: Modified Atmospheric Packaging, Headspace gas analysis, Chilli, Ascorbic acid

1. Introduction

Chilli (*Capsicum annuum* L) belongs to the family *Solanaceae*, are herbaceous or semi-woody annuals or perennials. Fresh chilli is good source of vitamin A, vitamin B and vitamin C (Howard *et al.* 2000) [9]. The high content of carotenoids is the reason for chilli's nutritional value because it acts as pro vitamin A which after digestion is converted into vitamin A. Chilli is highly in demand throughout the year whether in household or as spices in commercial market. The reason for high demand is its varied uses in fresh as well as in cooked and dried form. Chilli is highly perishable in nature having low shelf life and is susceptible to postharvest losses like shrivelling, wilting and is also susceptible to fungal infections (Barkai-Golan 1981) [2]. The reduction in quality causes huge loss to farmers, wholesaler, retailer and consumer. Thus, there is need for reduction of postharvest losses and processing into value added products appears to be an important goal for sustainable development. The colour is the major quality element of vegetables considered to have impact on consumer selection of produce. The colour and texture are affected by many factors such as temperature, relative humidity and other atmospheric conditions. The quality of the produce is improved by low temperature and high relative humidity storage. However, chilli being oversensitive to chilling injury the storage temperature above 5 °C is considered as suitable temperature (Hardenburg *et al.* 1986) [8]. On the other hand, in ambient conditions fruits change colour and deteriorate very quickly by shrivelling and parasitic infections. The packaging in plastic films have been found to help in slowing down crop respiration which leads to delay in ripening, lowering ethylene production and maintain colour thus extending shelf-life (Miller *et al.* 1986) [12]. Packaging provides physical protection against contamination and mechanical damage and it help in providing modified atmosphere where produce creates its own micro-atmosphere which retards the physiological metabolism and extends the shelf life of the crop (Kader *et al.* 1989) [10].

Modified atmosphere packaging (MAP) along with low temperature storage extends the shelf life of fresh produce packaged in polymeric film packages through interaction of the natural process of respiration of produce with the restricted gas exchange across the polymeric film package to control the in-pack O_2 and CO_2. The spoilage agents like bacteria, fungi and yeasts are suppressed in modified atmosphere packaging, thereby maintaining the quality of a perishable food or extend its shelf-life (Church and Parsons 1995) [4]. The different level of CO_2 and O_2 concentration are required, therefore a film is selected on basis of the physiological properties of the crop which can maintain the desired gas concentration during

period of storage (Kader *et al.* 1989) [10]. Storage temperature, number of perforations, perforation locations (described by effective length of the package), and air space thickness are the factors that affect gas concentration levels (Emond and Chau 1990, Emond *et al.* 1991 and Emond 1992) [6, 7, 5]. The products like chillies, mushrooms, broccoli etc having very high rate of respiration which standard films can likely over modify the pack atmosphere resulting in anaerobic conditions and moisture condensation within the package.
The present study was planned to analyze the influence of punnets covered with polypropylene film on physicochemical constituents of fresh chillies stored at three different temperatures.

Materials and Methods
Plant Material
For this study, fresh green chillies (*Capsicum annuum* L) were harvested from the research farm located at Ludhiana district of Punjab state in India. Spoiled or damaged crop were separated and removed, manually. After sorting the crop was washed with water to remove farm dust.

Packaging and Storage
After washing, fresh green chillies were packaged (200 g) in punnets covered with perforated (four perforations) and non perforated cling film (12.5 μm) to vary the headspace volume as well as the in-pack gaseous atmospheres. Macroperforations are known to provide additional gaseous diffusion across the film packages (Techavises and Hikida 2008) [18], and hence can be used to increase the gas permeability of ordinary polymeric films. The diameter of each perforation was 0.5 mm (Rai *et al.* 2008) [14]. Packaging process was carried out inside the cold room to minimize the respiration changes. The packages containing fresh green chillies were then heat sealed for storage at 5, 10 and 15°C and 85% relative humidity (RH) inside an environmental control chamber (Vista Biocell Ltd., New Delhi, India). The qualitative analysis of the stored packages (in triplicate) was carried out at alternate days. The in-pack headspace gas composition (O_2 and CO_2) was also analysed.

Package Headspace Gas Analysis
The headspace partial pressures were analyzed using a portable headspace gas analyzer (Make: SYSTECH INSTRUMENTS; Model: Gaspace Advance; UK). Basically it is an oxygen/carbon dioxide analyser used for the measurement of O_2 and CO_2 in food packages. The instrument uses an electrochemical and an infrared sensor to evaluate the package headspace partial pressures of O_2 and CO_2. The instrument was calibrated with standard gases before actual experimentation. The components of this instrument are oxygen sensor, LCD readout, internal sampling pump and sampling probe. The end of sampling probe was fitted with a particulate filter and a replaceable needle having tip with dual side-port holes to prevent plugging. The internal sampling pump used for taking gas sample from package headspace was having electronically controlled timing. When the pump was turned on sample is drawn through the probe and tubing and then simultaneously to the O_2 and CO_2 sensors. The oxygen, carbon dioxide and remaining gases were read on the display screen. Sensor signals were converted to concentration values of O_2 and CO_2, which were directly read on the digital display panel.

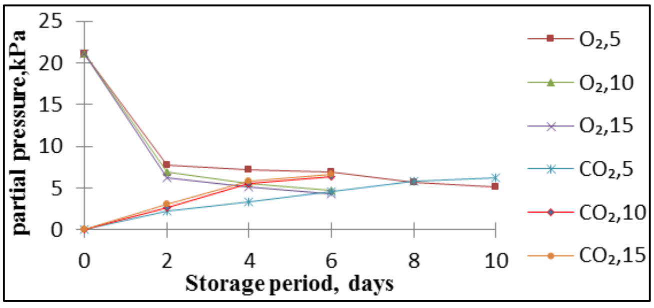
Physiological Loss in Weight
Initial weight of the sample was noted at the time of packaging for storage. Weight of all the samples (replicated in triplicate) kept in punnets was recorded daily using an electronic weighing balance having least count 0.001 g. Physiological loss in weight (PLW) (%) was estimated on a daily basis as percent of initial weight of fresh green chillies.

Texture analysis
The texture of green chilli (fresh and stored) was evaluated in terms of firmness (g) by using Texture Analyser (Make: Stable Micro Systems, Model: TA XT plus). The analyser consists of the basic components namely hardware (load cell) with platform to hold sample and moving head for holding the probe, and software for recording and calculating the results of the tests. The green chilli kept horizontal under the Warner/Blatzer (HDP/BS) blade with test speed of 5 mm/s and penetration distance of 30 mm (Ayhan *et al.* 2008), and the firmness was expressed as maximum cutting force (g).

Total soluble solids (TSS)
Measurement of TSS of green chillies (fresh and stored) was done by extracting juice and few drops of juice were poured over designated platform of the refractrometer (Make: ERMA) ranges from 0-32 °brix and then allowing the light to pass through the prism. The TSS was directly recorded from the scale.

Ascorbic acid
Ascorbic acid was measured as per the method described by Ranganna (1999) [15]. Ten grams of sample was macerated using 3% meta-phosphoric acid and volume was made up to 100ml with meta-phosphoric acid. An aliquot of 10 ml of the extract was taken and titrated with standard dye (2,6-dichlorophenol indophenol) till pale pink end point was observed which persisted for 15-20 s.

Results and Discussions
Headspace Partial Pressures of O_2 and CO_2
The headspace O_2 and CO_2 levels in all the samples were observed to be in unsteady state only until the second day of storage and they arrived at steady state thereafter. A perusal of Fig. 1a and 1b shows that the headspace O_2 partial pressure arrived at 7.8, 6.9 and 6.2 kPa in non perforated samples and 7.5, 5.6 and 5.3 kPa in perforated samples at 5, 10 and 15 °C respectively after the second day of storage. The headspace O_2 partial pressure in all samples could be maintained above anaerobic levels of 0.5 kPa (Beaudry 2000) [3] till the end of storage. However, the CO_2 partial pressures arrived at 6.2, 6.4 and 6.7 kPa in non perforated samples and 6.5, 6.8 and 6.9 kPa in perforated samples at 5, 10 and 15 °C respectively at the end of storage. Throughout the storage period, headspace O_2 partial pressure remained higher than that of CO_2, which suggested that small amounts of water vapor could also be produced along with CO_2.



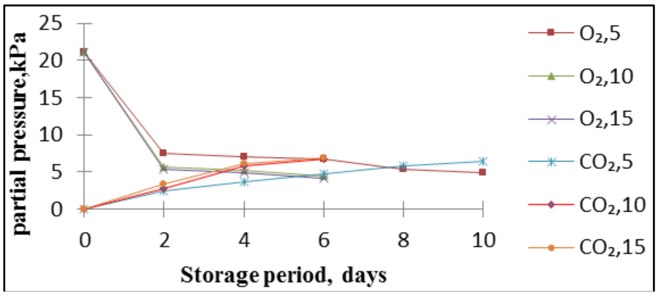


Fig 1: Headspace partial pressures of O_2 and CO_2 inside (a) non perforated and (b) perforated packages containing green chillies kept for storage under modified atmospheres.

Weight Loss

The weight loss in crop not only lead to physical weight loss, but also results change in appearance of the produce like change in texture make it shrivelled, colour etc., which causes reduction in consumer acceptance. It is a physiological process that can be controlled by controlling storage temperature and humidity and also by using appropriate packaging. In this study, the effect of temperature on percentage PLW (Fig. 2a and 2b) for chillies in perforated and non perforated samples was analysed. The percentage PLW at the end of storage is lower in non perforated than in perforated ones. The weight loss increases with the increase in temperature. The weight loss is 15.6% more in perforated samples than non perforated at 15 °C.

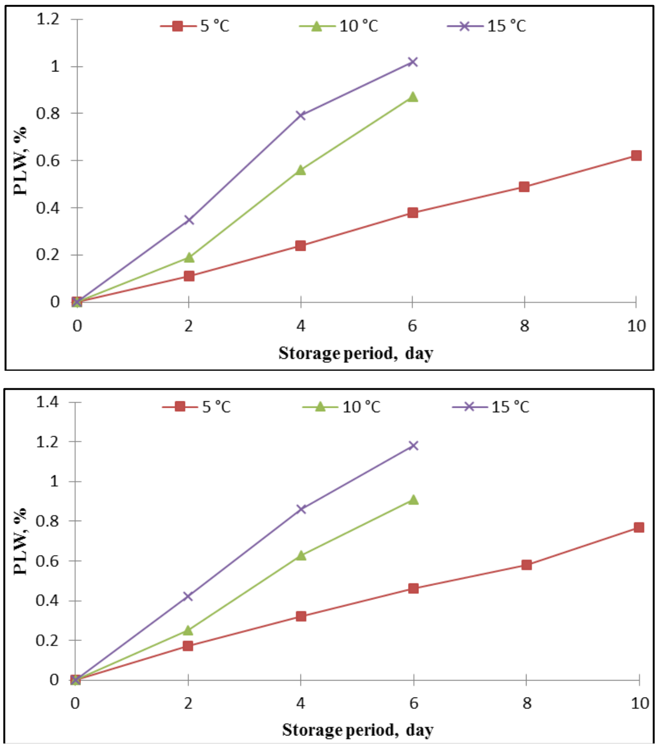


Fig 2: Physiological loss in weight of green chillies samples kept for storage in (a) non perforated and (b) perforated packages

Texture analysis

The firmness is vital factor used to determine quality and postharvest shelf-life is hardness or crispness of chilli during storage (Tanada-Pamu and Grosso 2005) [17]. The postharvest changes in texture primarily results from enzymatic degradation of the components responsible for the structural rigidity of the fruit, primarily the insoluble pectin and proto-pectin (Moalemiyan and Ramaswamy 2012) [13]. The textural changes result in the progressive softening of the fruit during ripening and the physiological changes result in typical climacteric rise in respiration (Yang 1985) [19]. Texture of fresh chillies was measured in terms of hardness (firmness) by cutting test. Hardness is the force required to deform the product to a given percentage of strain. It is evident from the Fig. 3a and 3b that firmness of fresh chillies decreased as the storage period progressed both in perforated and non perforated samples. This may be attributed to rapid water loss and comparatively higher rates of respiration at 15 °C samples. Better texture was maintained at 5 °C as compared 10 ˚C and 15 °C samples. As the temperature increased from 5 to 15 °C, a clear difference was observed in firmness in all samples throughout the storage.

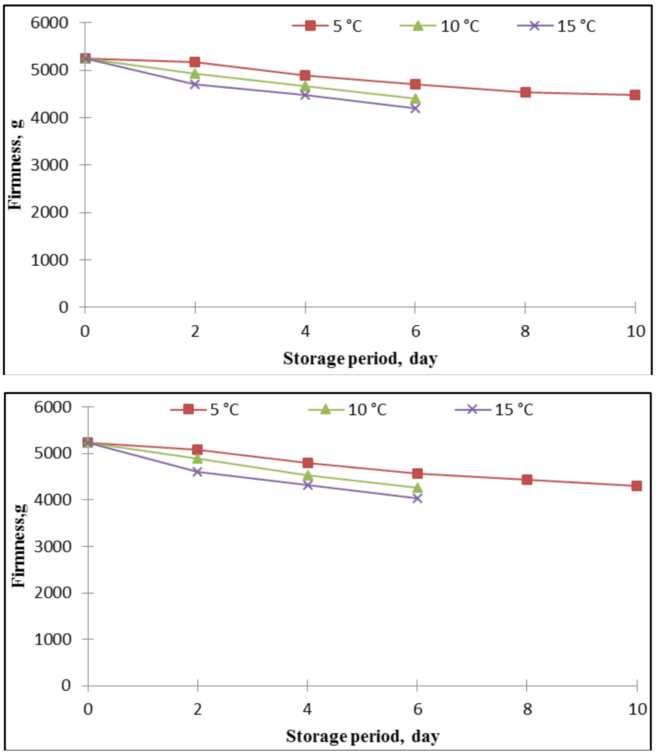
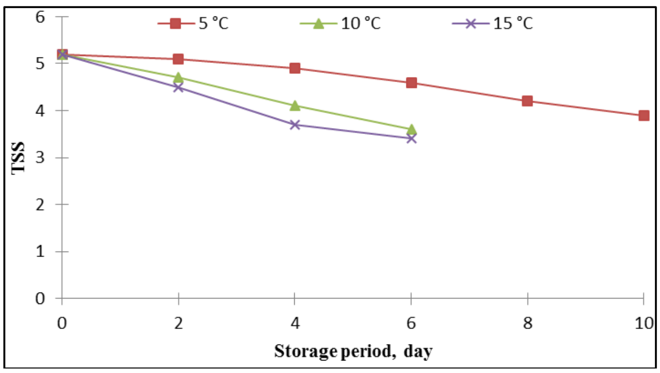


Fig 3: Firmness of green chillies samples kept for storage in (a) non perforated and (b) perforated packages

MAP effects on total soluble solids (TSS)

The effect of temperature on total soluble solids of fresh chillies in perforated and non perforated samples during storage was analysed. A perusal of Fig. 4a and 4b shows that there is sharp decline in the total soluble solids. The TSS was reached at 3.9, 3.6 and 3.4 °brix in non perforated samples and 3.7, 3.3 and 3.1 °brix in perforated samples at 5, 10 and 15 °C respectively at the end of storage. As the storage temperature increased from 5 °C to 15 °C, total soluble solids decreases during the storage period.



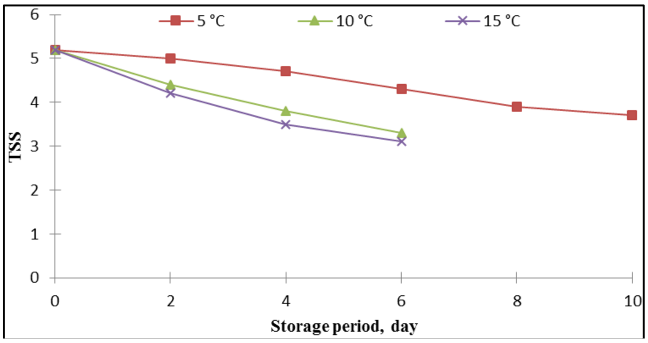


Fig 4: Total soluble solids of green chillies samples kept for storage in (a) non perforated and (b) perforated packages

Changes in Ascorbic Acid Content

It is very clear from the Fig. 5 that the ascorbic acid content was decreased more in perforated than non perforated samples. The similar results were stated by Manurakchinakorn *et al.* (2004) [14] wherein degradation of ascorbic acid is related to the non-enzymatic oxidation. Higher levels of oxygen lead to faster depletion of ascorbic acid. Better retention was observed in 5 °C stored samples and content decreased considerably as temperature increased from 5 to 15 °C. Similar results were reported by Singh *et al.* (2014) [16] that losses in ascorbic acid are reduced and delayed in non perforated in comparison to perforated samples.

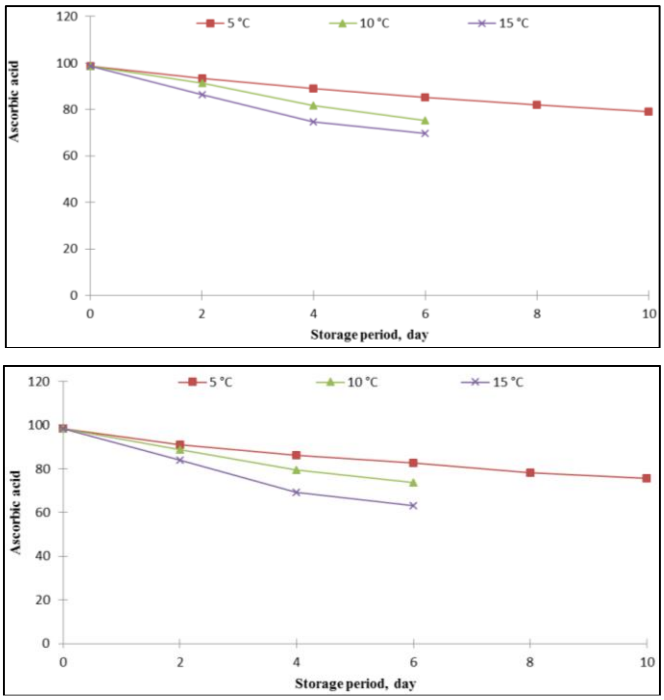


Fig 5: Ascorbic acid of green chillies samples kept for storage in (a) non perforated and (b) perforated packages

Conclusions

Under MAP, the ascorbic acid content was largely influenced by the dynamics of in-pack gaseous atmosphere inside the film packages used in this study. At the end of storage, the firmness, total soluble solids and ascorbic acid was considerably higher in perforated packages. Better retention of ascorbic acid was observed in 5 °C stored samples and content decreased considerably as temperature increased from 5 to 15 °C. The higher headspace levels of CO_2 (6-7 kPa) with low O_2 partial pressure of 4-5.2 kPa was observed. As the storage temperature increased from 5 °C to 15 °C, total soluble solids decreases during the storage period. Firmness of fresh chillies decreased as the storage period progressed both in perforated and non perforated samples due to rapid water loss. The weight loss is 15.6% more in perforated samples than non perforated at 15 °C. The permeability of packaging film must be in equilibrium with the green chillies so as to better retention of quality parameters.

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