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Effect of Modified Atmosphere Storage Conditions on Biochemical Parameters of Bell Peppers

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Abstract

The bell pepper presents alterations in its composition and its properties with the progression of storage life. Bell pepper has a very short shelf-life of just 4 to 5 days after maturation at ambient temperature hence they were subjected to Modified Atmosphere Storage (MAS) which reduces respiration rates of the fruits by mechanical manipulations of gas composition of the storage environment. The lack of information on the post-harvest handling of this fruit has resulted in quality deterioration. Present study investigates the effect of different MAS systems on biochemical parameters of the bell pepper during equal intervals of storage period. Fruits were packed in corrugated fiber board boxes in diffusion channel system with different lengths (10cm, 17.5cm and 25cm) and same diameter of 5mm at 33, 20 and 8˚C. Optimum storage conditions for maximum shelf life extension were found to be, 25cm diffusion channel length, 8˚C temperature and 95% RH. Highest percentage retention of ascorbic acid was found for Bell Peppers (20kg) stored in CFB boxes with diffusion channel length of 25cm. As diffusion channel length increased acid value also decreased, silicon membrane window area also had a proportional effect on pH value. TSS increases as the storage time increases in all the treatments.

1. Introduction

Bell Pepper (*Capsicum annuum* L.) is an important agricultural crop, not only because of its economic importance, but also mainly due to the fact that they are an excellent source of ascorbic acid (Howard, & Villalon, 1995; Smith, Wagner, Villalon, & Burns, 1994). Bell pepper (*Capsicum annuum*) is a warm season annual crop which belongs to family *Solanaceae.* Bell peppers are considered “sweet” since they lack the pungent

chemical (capsaicin) present in hot peppers. It is one of the most popular and highly valued vegetable crops grown in tropical and sub-tropical parts of the world.

Proper storage system reduces wastes, adds value and makes the product qualitatively and quantitatively acceptable. Respiration rate and gas exchange through the package material are the processes involved in creating a modified atmosphere inside a package that will extend shelf life of fresh bell peppers (Susana *et al.*, 2002; Wills *et al.*, 1981). Bell peppers are not suitable for long term cold storage; the recommended range of storage temperatures for bell peppers is from 7 to 13 ˚C, depending on the variety and the maturity stage (Paull, 1995; Zagory *et al.*, 1988). Exposing chilling sensitive crops to cold but not freezing temperatures (<12 ˚C), can initiate symptoms such as increased water loss, surface pitting, increased CO_2 and ethylene production upon warming **(**Saltveit & Morris, 1995; Wang, 1993). Manolopoulou *et al.* (2010) concluded in his study that ascorbic acid did not change significantly in peppers packed in the two Poly Ethylene films throughout the cold storage period and the shelf-life. Peppers packed in Low Density Poly Ethylene film, had statistically insignificant higher ascorbic acid values compared to Medium Density Poly Ethylene film at 10 ºC storage. In a study conducted by Opal *et al.* (2004) found in a comparative study between diffusion channel (4, 7 and 10 cm tube length) and silicon membrane (50.29, 98.56 and 158.43 cm^2 silicon membrane window area) system that all diffusion channel treatments were observed to have lower values of total soluble solids than membrane treatments and ripe controls. Literature exists on the evolution of physicochemical parameters during pepper fruit growth and development, such as weight, colour, firmness, total soluble solids, and acidity but there has been no much study on biochemical parameters of bell pepper stored in the bulk modified atmosphere systems for handling them for long distance transportation, the present study was undertaken with the Objective to study the effect of bulk packaging and storage environment on biochemical quality parameters of the Bell pepper during the storage period.

2. Material and Methods

2.1 Collection of Bell peppers

Well developed, matured (firm and bright green) and uniform size Bell pepper were procured from green house (R Ranga Swamy farm), Thanjavur and the produce were transported to the lab immediately after harvest. From the initial sorting, damaged, poor quality (blemishes, sun burn, rottening at tip etc) and non uniform bell peppers were removed. The remaining samples were sorted according to their size, colour and weight.

2.2 Experimental details

Three different set of treatments were applied to study the shelf life extension of bell pepper. The experiments were performed according to a full factorial design using design expert.8.0.4. The experiments are 3^3 factorial design i.e. 27 treatment combinations for each set of treatments.

2.3 Treatment details

Table 1: Treatment details.

Independent variables	Temperature & RH	33˚C & 65%
		20^{o}C & 75%
		8 ^{o}C & 95%
	Tube dimension	10 cm
		17.5 cm
		25 cm
	Weight	5 kg
Dependent variable	Shelf life	Based on visual observation for microbial spoilage

2.4 Diffusion channel storage system

Bell peppers were stored in experimental chambers having diffusion channels of different lengths 10, 17.5 and 25 cm and 5mm diameter each respectively. Samples of uniform size, with fresh and disease free were selected and trimmed to remove the leaves and stalk edges. The samples were put into corrugated fiber board boxes and packing tape was wrapped around the edges so that the pack is airtight. The diffusion channels were fixed vertically on the CFB boxes such that one end of the tubes protrude outside for exchange of gases with atmosphere. Septa were firmly fixed on one corner to facilitate sampling of the gas composition inside the diffusion chamber for analyzing O_2 and CO_2 concentrations. About 5 kg of bell peppers were put in each box and 50g of silica gel enclosed in a cloth bag was also placed in between each layer to absorb moisture released during storage. The control fruit were packed in cartons without the diffusion channel.

2.5 Gas Composition

The gas composition (O_2 and CO_2) inside the modified atmosphere packages was measured using PBI-Dansensor O_2-CO_2 Analyzer (PBI-Dansensor, UK), at regular intervals. The probe (needle) of the O_2-CO_2 Analyzer was pierced through the septa and the head space gas composition expressed as per cent O_2 and per cent CO_2 was directly noted from the instrument screen by touch of a button.

2.6 Ascorbic acid

Ascorbic acids content of bell pepper pulp samples were determined by 2, 6-dichlorophenol indophenol visual titration method (AOAC, 1995**)** and was expressed in mg per 100g of the initial fruit mass. A 5 ml of filtered sample and 5 ml of 3 % metaphosphoric acid-acetic acid mixture were taken in a conical flask and titrated against the standard dye solution. The end point was light pink colour, which persisted for 5-10 seconds.

2.6.1Calculation

Titre value X Dye factor X Volume made up

$$\text{Ascorbic acid, (mg/100g)} = \frac{\text{Titre value X Dye factor X Volume made up}}{\text{Volume taken X Weight of the pulp taken for titration}} \times 100$$

2.7 pH

The pH of the sample was determined by using a microprocessor based pH tester (Eutech Instruments Pvt, Ltd., Singapore). The pH meter was dipped inside the pulp for few seconds and the stabilized pH reading was recorded. Before every observation, the bulb of the pH meter was washed with running tap water and then with distilled water to eliminate any residual effect.

2.8 Total soluble solids (TSS)

Total Soluble Solids is an index of soluble sugars content in fruit. TSS of the sample pulp was recorded in ^{0}Brix by using a Hand Refractometer (Erma Optical Works Ltd., Japan) with necessary temperature corrections.

3. Results and Discussion

In all experiments, visual inspection showed that the incidence of bacterial and fungal rots was considerably reduced by storage under Modified Atmosphere. This reduction was primarily due to the low O_2 concentration within the storage chamber which slowed both produce and microbial respiration. Here T_1,T_2 and T_3 are 5kg of sample at 33 ºC & RH 65% with diffusion channel of 10cm length , 5kg of sample at 33 ºC & RH 65% with diffusion channel of 17.5cm length and 5kg of sample at 33 ºC & RH 65% with diffusion channel of 25cm length respectively.T_4,T_5 and T_6 are 5kg of sample at 20 ºC & RH 95% with diffusion channel of 10cm length, 5kg of sample at 20 ºC & RH 75% with diffusion channel of 17.5cm length and 5kg of sample at 20 ºC & RH 75% with diffusion channel of 25cm length. Also, T_7, T_8 and T_9 are 5kg of sample at 8 ºC & RH 95% with diffusion channel of 10cm length, 5kg of sample at 8 ºC & RH 95% with diffusion channel of 17.5cm length and 5kg of sample at 8ºC & RH 95% with diffusion channel of 25cm length.

3.1 Progression of O_2 and CO_2 in the Experimental Chambers

The gas composition in the storage chamber was analyzed periodically by using PBI Dansensor O_2-CO_2 analyzer. The progression of O_2 and CO_2 concentration as a function of time is presented.

3.1.1 Changes in O_2 and CO_2 concentrations during ambient storage of bell Pepper with diffusion channel system.

Experimental results clearly indicated that the respiration rate was high at the beginning of the experiment causing fast depletion of O_2 and increase of CO_2 inside the closed chamber Fig. 1depicts progression pattern of O_2 and CO_2 within 28 days of storage at 8ºC and 95% RH.

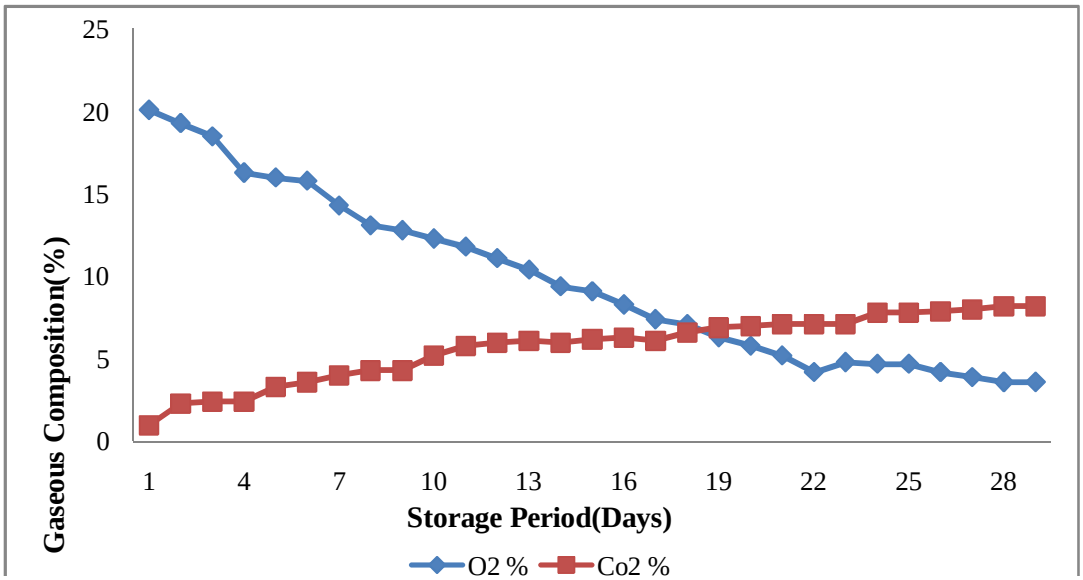

Figure 1: Progression of O_2 and CO_2 concentration of 5kg sample at 8ºC with 25cm length diffusion channel.

3.2 Change in ascorbic acid content of stored bell pepper fruits

Ascorbic acid content was reduced as storage temperature and period increased. Ascorbic acid retention can be related to weight loss. Treatments in which less weight loss was observed due to less respiration rate had more retention of ascorbic acid also concluded by Manolopoulou *et al.* (2010). Initial ascorbic acid content was 156.2 ± 0.20 mg/100 g. At 33ºC maximum ascorbic acid retention was found to be 109.6 mg/100g in 5kg sample with diffusion channel of 25cm length and minimum (90.0mg/100g) was found in 20kg sample with diffusion channel of 10cm length whereas, in case of control fruits decline in ascorbic acid content to 78.6 mg/100 g was observed after 8 days of storage, respectively.

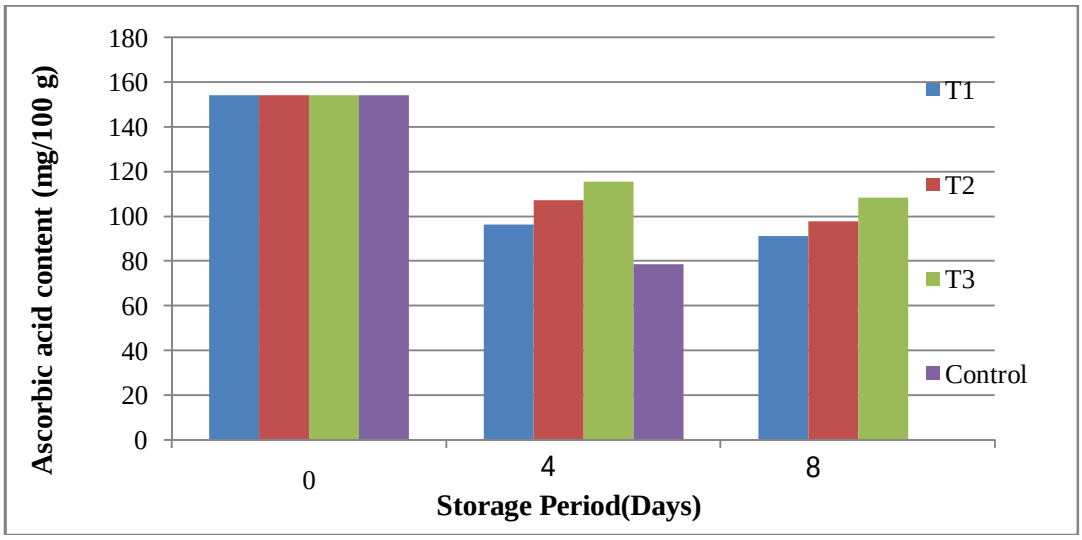

Figure 2: Effect of diffusion channel dimensions on ascorbic acid content at 33ºC.

After 20 days of storage at 20ºC ascorbic acid content of Bell Peppers (20kg) stored in CFB boxes with diffusion channel length of 25cm was found to be highest (113.0 mg/100 g). Bell Peppers (5kg) stored in CFB boxes with diffusion channel length 10cm showed less ascorbic acid retention (77.6 mg/100g) by the end of storage period of 20 days. The initial ascorbic acid concentration was 156.2 ± 0.18 mg/100 g for all the treatments. Decrease in ascorbic acid was observed after 28 days of storage under 8 ºC for 5, 10 and 20kg of sample stored in boxes with diffusion channel of length 10, 17.5 and 25cm respectively to 87.2, 92.1, 95.4, 93.6, 100.6, 107.6, 95.0, 98.6 and 100.8 mg/100 g from the initial ascorbic acid content, respectively. In case of control fruits the ascorbic acid was 75.2 mg/100 g after 16 days of storage.

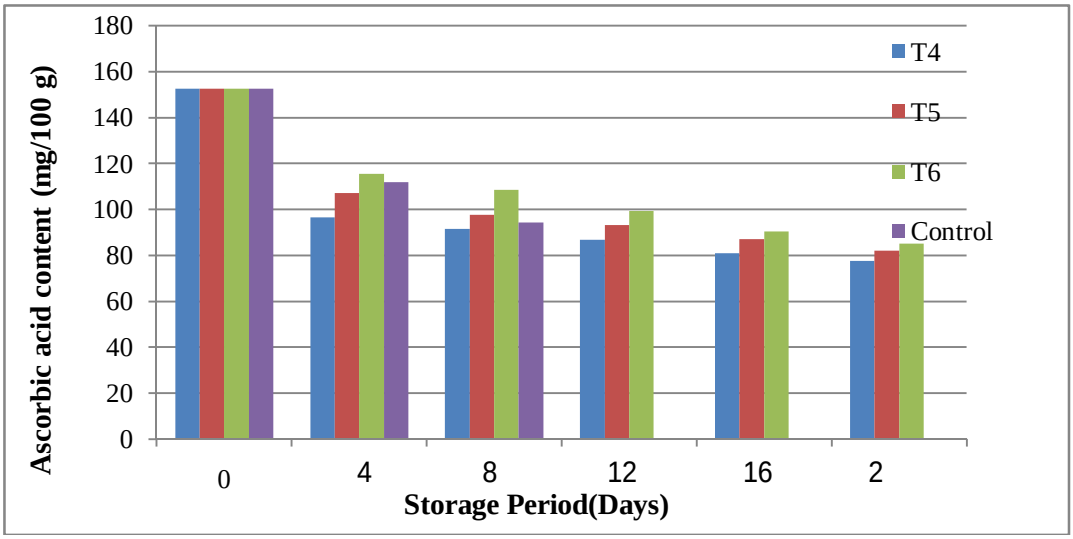

Figure 3: Effect of diffusion channel dimensions on ascorbic acid content at 20ºC.

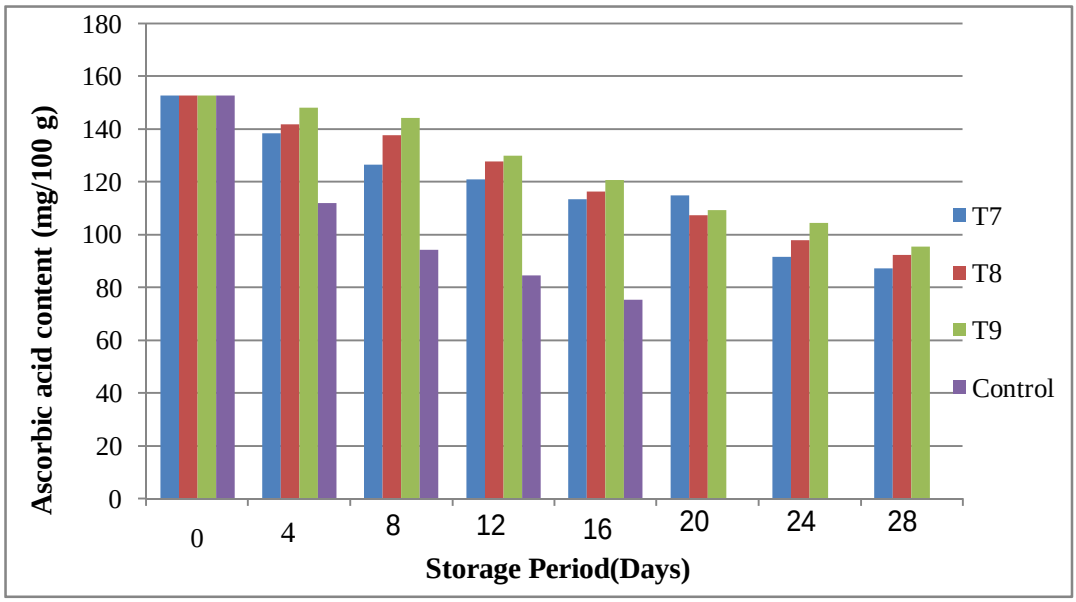

Figure 4: Effect of diffusion channel dimensions on ascorbic acid content at 8ºC.

3.3. Effect of different treatments on pH

Among all the treatments it was observed that there was decrease in pH value as the storage time increases. Acid value increases as the produce ripens, Bell Peppers are non-climatric fruit hence they cannot ripen after harvest. As diffusion channel length increased acid value also decreased (Table 2). The results were on par with the results obtained by Ranganna, B *et al*. (2009).

3.4. Effect of different treatments on Total Soluble Solids (TSS)

TSS increases as the storage time increases in all the treatments. As diffusion channel length increased TSS decreased, silicon membrane window area had a proportional effect on TSS value (Table 2). Temperature had a significant effect on TSS value, as temperature decreases there is very less variation in TSS value. The results were on par with the results obtained by Opal *et al*. (2005).

Table 2: Effect of Treatments on TSS and PH.

Treatment	**At 33 ° C**		**At 20 ° C**		**At 8 ° C**	
Parameter	**TSS**	**pH**	**TSS**	**pH**	**TSS**	**pH**
	Mean±SE	**Mean±SE**	**Mean±SE**	**Mean±SE**	**Mean±SE**	**Mean±SE**
T_1	6.23±0.31	3.66±0.17	6.08±0.04	2.56±0.12	5.50±0.05	3.80±0.05
T_2	5.40±0.20	3.89±0.36	5.73±0.16	3.33±0.08	5.10±0.05	3.56±0.28
T_3	4.76±0.26	4.06±0.12	5.09±0.02	3.09±0.12	4.13±0.08	4.46±0.08
T_4	6.18±0.12	3.38±0.17	6.23±0.22	3.73±0.12	5.26±0.03	3.80±0.05
T_5	5.60±0.08	3.05±0.14	5.70±0.04	3.41±0.54	5.70±0.05	4.10±0.05
T_6	5.51±0.04	2.92±0.23	5.73±0.41	3.02±0.06	4.13±0.03	4.20±0.05
T_7	5.81±0.04	4.21±0.12	5.89±0.02	4.12±0.12	4.30±0.05	3.03±0.03
T_8	4.52±0.15	3.89±0.41	5.21±0.15	3.61±0.26	5.50±0.05	4.03±0.03
T_9	4.06±0.28	3.04±0.63	4.54±0.03	2.89±0.55	3.66±0.03	4.36±0.18
Control	6.82±0.05	3.03±0.05	6.12±0.02	-	5.89±0.25	2.9±0.05

4. Conclusion

Best results were obtained using diffusion channel of length of 25 cm, bell peppers stored at 8º C and 95% RH, under these Conditions had harvest-fresh appearance, good colour, and excellent marketability conditions in terms of firmness. Physiological loss in weight (PLW) due to respiration and transpiration was <5% which has been reported in literature as the lowest limit for shrivelling appearance. Modified Atmosphere storage was found to extend the shelf-life of Bell peppers. The shelf-life of fruits could be safely stored up to 10 days in modified atmosphere packaging (diffusion channel) at ambient condition (33ºC) and 28 days at 8ºC temperature, thus enhancing the shelf-life of bell peppers.

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