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Effect of film thickness on quality characteristics of cucumber during storage under modified atmosphere packaging (MAP)

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Abstract
Cucumbers (*Cucumis sativus* L.) stored in modified atmosphere packaging (MAP) at low temperature (10±1 °C) and ambient temperature (22-26 °C) with 85-90% and 62-66% relative humidity. Effect of low density polyethylene film in 25, 37.5 and 50 micron thickness on quality parameters such as physiological loss in weight, colour change, firmness and sensory were studied. After 6 days of storage, the PLW was changed 14.38% at ambient temperature whereas less than 1% weight loss was found in all samples at 10±1 °C temperature up to 27 days of storage period. The minimum colour change was observed in sample stored at low temperature with 25 micron thickness followed by 37.5 and 50 micron thickness, respectively. Firmness was good at low temperature up to 27 days while firmness loss was highest at ambient storage up to 6 days. The study resulted that best quality of cucumber was found up to 27 days under MAP condition with 25 micron thickness of LDPE film at low temperature and 85-90 % RH.

Keywords: Cucumber; modified atmosphere packaging, low density polyethylene packaging film, quality characteristics

1. Introduction

Cucumber (*Cucumis sativus* L.) is a common fresh vegetable all over the world. Cucumber is a high-value, low-volume crop whose commercial exploitation in a naturally ventilated polyhouse will increase productivity and produce a good profit for growers. Cucumber is a good source of potassium, calcium, antioxidants, magnesium, vitamin A, vitamin C and vitamin K are rich in dietary fiber (Manjunatha & Anurag, 2012; Shi *et al*., 2015) [13, 15]. It belongs to the cucurbitaceous family and originated from south Asia. Since low temperature is the primary means of maintaining the consistency of most fresh produce, they are often shipped and processed at low temperatures like other types of fresh commodities. It an excellent cooling vegetable because of its high water content (about 95 %) and low in calories, fat, cholesterol, and sodium. It can be refreshing and pleasant to eat in hot weather and help prevent dehydration (Kargwal *et al*., 2020; Dhall *et al*., 2012) [14, 5].

Generally the quality of freshly harvested produce decreases with time. The decrease in quality could be attributed to the respiratory activity that continues after harvest. The main deteriorative changes in cucumber during storage and distribution are mostly due to yellowing, loss of moisture leading to shriveling and physiological injury caused by low temperature (Adamicki, 1985) [1]. Cucumbers are prone to shriveling, so humidity levels should be maintained at 90–95 percent during shipping, transportation, and marketing (Dhall *et al*., 2012) [5]. Since there is a developing interest for fresh fruits and vegetables, because of the expanded utilization of these items, numerous enterprises are utilizing various methods to improve the nature of new produce.

To preserve or minimize postharvest losses of fresh cucumber, different ways are used, subsuming temperature management, the use of packaging material, commodity pre-treatment etc.

One of the strategies for preventing and prolonging the shelf life of cucumber is modified atmosphere packaging (MAP) (Wang and Qi, 1997) [16]. MAP is characterized as the packaging of a perishable product in such a way that the natural interaction between the packaged product's respiration and gas transfer through the packaging material results in an environment with higher CO_2 levels and lower O_2 levels.

By minimizing respiration rate, ethylene output, ethanol and acetaldehyde accumulation, and water depletion, these atmosphere compositions have been found to be helpful for preventing the produce (Flores *et al*., 2004) [7].

It's also crucial to choose a packaging film substance whose gas permeability corresponds to the rate of respiration. To date, the trial-and-error method has been widely used in use. Fresh produce is wrapped and stored in a variety of packaging film materials, and then appropriate materials are chosen based on the gas composition in the container and the consistency of the produce after packaging and storage.

2. Materials and Methods

Fresh cucumber was procured from a local farmer of Hisar, Haryana and brought to Agro Processing Centre, department of Processing and Food Engineering, CSS Haryana Agricultural University, Hisar. The crop was manually sorted cleaned, washed, and dried and taken good quality produce for the experimental purpose. During the above mentioned unit operations, cucumbers was properly handled to avoid any mechanical injury.

2.1 Package headspace analysis

The O_2 and CO_2 gas concentrations in the package headspace were analyzed at three days interval by using a portable headspace gas analyzer (Make: Systech Illinois; Model: GS6600 O_2 & CO_2 Headspace Analyzer).

2.2 Physiological loss in weight (PLW, %)

Initial weight of the sample was taken at the time of sample storage. The change in sample weight was observed at regular interval of three days. The weighing was done with the digital balance having least count of 0.01g. Weight loss was calculated as percentage (%) of initial weight. A limit of 6% weight loss was considered as a quality limit for this attribute (Bovi *et al*., 2018) [4]. The PLW at each interval was calculated as:

$$\text{PLW \%} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100 \qquad (1)$$

2.3 Total Colour Difference

The color of cucumber was measured with the help of Hunter Lab colorimeter (Make: Hunter Lab Colorimeter; Model: PCM) (Hunter, 1975) [9]. The color values of cucumber were expressed as Hunter color 'L' value ('100 L' and '0 L' show white and black), 'a' value ('−a' and '+a' values show greenness and redness) and 'b' value ('−b' and '+b' values show blue and yellow). For color analysis of each sample, the reflectance spectra were measured at three different points on the surface of sample and then the mean value was obtained. Total colour difference was measured three days interval by equation (2) given by Gnanasekharan *et al.* (1992) [8].

$$\text{Colour change} = \sqrt{[(L-L_0)^2 + (a-a_0)^2 + (b-b_0)^2]}$$

$$\text{TCD } (\Delta E) = \sqrt{[(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2]} \qquad (2)$$

2.4 Firmness

Market value of cucumber is affected by its firmness during storage and transport. So texture of cucumber (fresh and stored) was tested in terms of firmness (N) by using Texture Analyzer (Make:Food Technology Corporate, Model: TMS Touch) as per the method of Ayhan *et al*.(2008) [2]. Compression probe (P-5) having 5 mm in diameter and test speed of 5 mm/s was used to measure firmness of the cucumber. The firmness was expressed in newton. Measurements were made at three locations (top, middle and bottom) of each sample with peel.

2.5 Sensory evaluation

The samples packed in different films and stored at selected environmental conditions were examined on 3 days interval for the purpose of sensory evaluation. The samples were required to be evaluated immediately when opened. Taste panel members were analyzed the sensory on the basis of visual appearance and odour. The quality characteristics of the samples were examined by using the 7 point hedonic scales proposed by Deza (2003) [6], value 7 is like extremely and 1 is moderate dislike.

2.6 Statistical Analysis

The data was statistically analyzed to determine the differences between treatments during the storage study. The experiments were conducted in triplicate. Analysis of variance (ANOVA) and significant difference of data at $p < 0.05$ was carried out using a statistical package (SPSS, trial version).

3. Results and Discussion

3.1 Package headspace concentration

The concentrations of O_2 and CO_2 in the package headspace under MAP condition at low temperatures and at ambient condition are displayed in Fig.1and 2. A significant reduction in O_2 and a similar increase in CO_2 concentrations were seen during the first 6 days of storage, which might be attributable to the high respiration rate of cucumbers in the transitory condition of stabilization and equilibration. Oxygen concentration within the MAP package during 27 days of storage period reached 16.45 (25µm thickness), 15.60 (37.5 µm thickness) and 14.3 kPa (50µm thickness), with the equivalent CO_2 concentration at 4.20, 5.00 and 5.70 kPa, respectively. After 9 days of storage gas concentration became almost constant. While in case of ambient condition O_2 and CO_2 concentrations became same as standard atmosphere (20.9% O_2 and 0.03% CO_2). Gas concentration was statistically significant at 95% confidence level with p-value < 0.05 which indicate the changes in gas concentration in different thickness of LDPE during storage (Table. 1).

3.2 Physiological loss in weight (PWL, %)

Physiological loss in weight (%) of cucumber under MAP and unpacked sample stored at low temperature is shown in Fig.3. The PWL was significantly lower in all packages stored at low temperature as compared to packages stored at ambient condition. After 27 days of storage PLW was 0.98% in 25 micron thickness sample, 1.03 % in 7.5 micron thickness and 1.06% in 50 micron thickness at 10±1°C temperature whereas in ambient condition weight loss was 14.38 %, respectively. There was no statistically significant difference in PLW on the basis of thickness. After 3 days weight loss was found 6.65 at ambient temperature. The highest PWL was found at ambient stored sample which can be attributed to high respiration rate (Dhall *et al*., 2012 [5]; Wang and Qi, 1997) [16] while cucumber stored under MAP at 10±1°C noticed the lowest due to the effect of low temperature and better in-pack headspace adjustment and relative humidity which is in conformation with the earlier reported results of Manjunatha & Anurag, (2012) [13].

3.3 Total colour difference

Colour is one the most important quality parameters of consumer acceptance. Total colour difference of cucumber was measured with three days interval and to find out the effect of MAP sample at low temperature and unpaked at ambient temperature. Fig.4. shows the TCD was minimum in the samples stored with 25 micron thickness (15.44) followed by 37.5 micron (19.43) and 50 micron thickness (22.12) at low temperature during 27 days storage period. Colour degraded in sample with 50 micron thickness due to the higher concentration of CO_2 and low concentration of O_2. These results are quite comparable with Bastrash *et al*., (1993) [3]. The maximum TCD were noticed 22.27 at ambient temperature after 6 days of storage period. TCD values increased with increase in temperature. After 3 days of interval colour was good. This can be attributed to increase in temperature increases the rate of respiration which accelerates ripening process and thus yellowing. The increase in yellowness in the unsealed sample stored at ambient condition compared to MAP sample at low temperature which is due to maximum effect of light on unsealed sample. Similar results were reported by (Manjunatha & Anurag, 2012) [13].

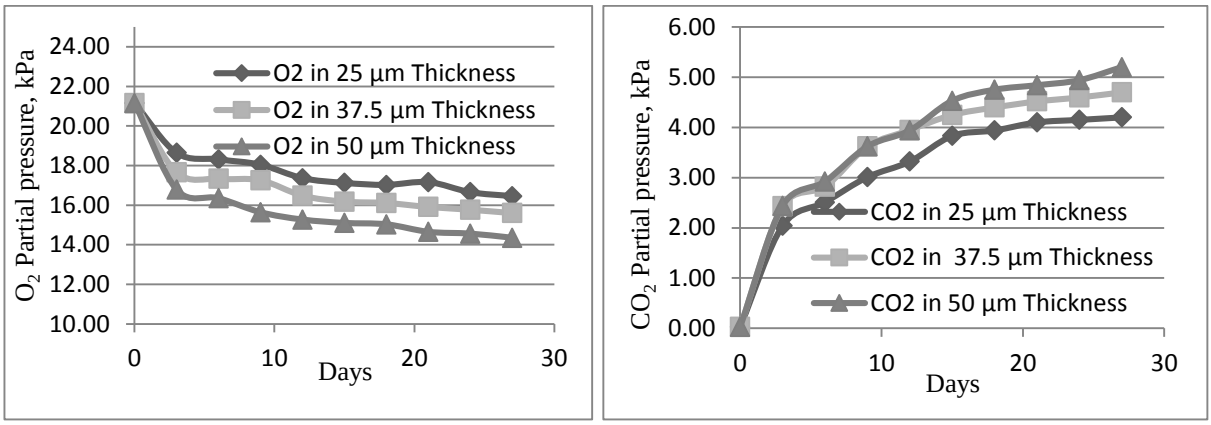

Fig 1, 2: In-pack gas concentration of stored cucumber under MAP with different thickness of film

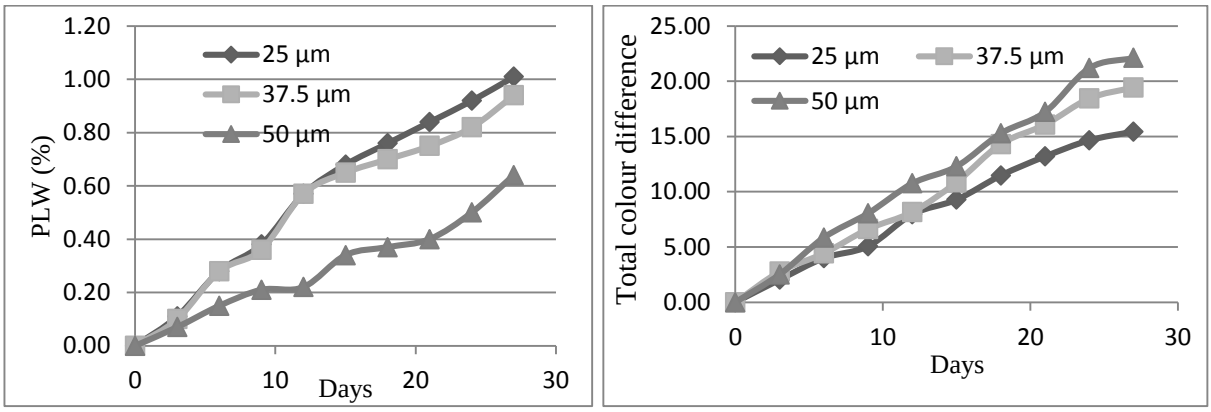

Fig 3, 4: PLW (%) and total colour difference of stored cucumber under MAP with different thickness of film

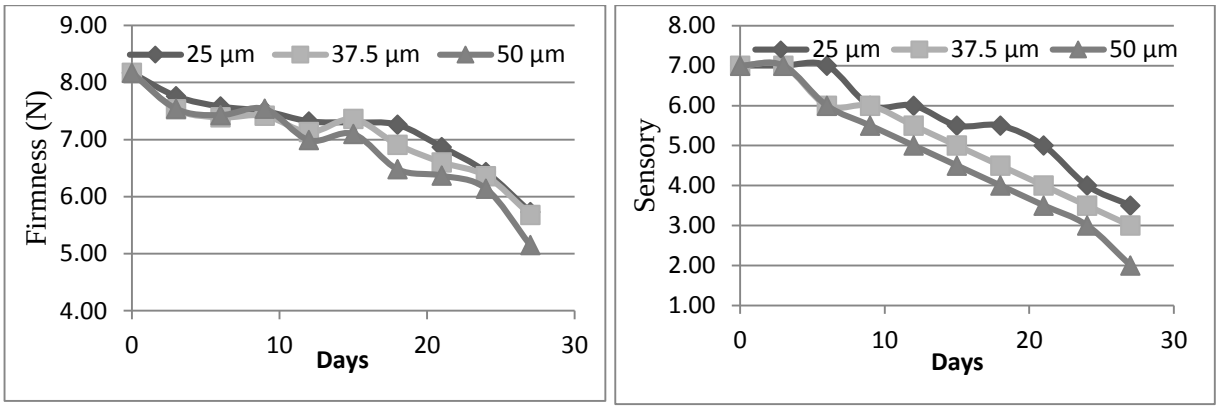

Fig 5, 6: Firmness and sensory of stored cucumber under MAP with different thickness of film

3.4 Firmness

Fruit firmness is another key criterion for determining fruit quality, and it is well understood that postharvest handling and treatments have an impact on fruit firmness. The average fruit hardness at the start of the trials was 8.17 N. The findings revealed that fruit firmness decreased as storage time progressed (Fig. 5). Table.1 indicates there was no statistically difference in firmness of stored sample with different thickness of LDPE. Fruit firmness was highest in sample with 25 micron thickness (5.32 N) followed by 37.5

micron (5.30 N) and 50 micron thickness (5.01 N) of LDPE at 10±1°C temperature. The firmness of unpacked sample was examined 3.8 N after 6 days at ambient temperature. This may be due to shriveling of cucumber on loss of more moisture content. Pectin depolymerization is the principal cause of firmness loss in fruits and vegetables. MAP decreases O_2 levels while raising CO_2 levels in the surrounding environment of fruits, which, according to Maftoonazad and Ramaswamy (2005) [12], lowers pectinesterase activity and permits fruit firmness to be retained.

3.5 Sensory

Sensory quality is most important parameter for consumer's acceptability approach. Sensory property of cucumber was measured on the basis of visual appearance and odour. The sensory score was highest in sample packed with 25 micron (3.5) and 37.5 micron (3) thickness compared to 50 micron thickness (2) of LDPE during 27 days of storage period. Sensory score of sample packed in 50 micron thickness was not acceptable (odour was created in packages) due to the high CO_2 and low O_2 as seen in Fig. 6. While in case ambient temperature the overall sensory score was 2 (appearance was not good) up to 6 days. However, fruits kept in MAP bags with 25 micron thickness were found better quality, as examined by sensory scale. Konopacka and Plocharski, (2004) [11] examined that the MAP bags were of better quality than the others, as concluded by lower sensory score. The loss of green color of cucumber peels (yellowing) was found at ambient temperature. This may be due loss of chlorophyll content in light; which is visible decay (Kahramanoglu and Usanmaz, 2019) [10].

Table 1: ANOVA indicating the effect of thickness of packaging material on quality parameters

		Sum of Squares	df	Mean Square	F	Sig.
O_2	Between Groups	20.341	2	10.171	3.590	.040
	Within Groups	84.984	30	2.833		
	Total	105.325	32			
CO_2	Between Groups	2.113	2	1.056	.524	.051
	Within Groups	60.526	30	2.018		
	Total	62.638	32			
PLW	Between Groups	.142	2	.071	.537	.590
	Within Groups	3.965	30	.132		
	Total	4.107	32			
Colour	Between Groups	64.428	2	32.214	.637	.536
	Within Groups	1516.155	30	50.539		
	Total	1580.583	32			
Firmness	Between Groups	.290	2	.145	.173	.842
	Within Groups	25.114	30	.837		
	Total	25.404	32			

4. Conclusion

Modified atmosphere packaging (MAP) was found significant effects for preserving the quality parameters of cucumber fruits. Modified atmosphere packaging (MAP) having 25 micron thickness LDPE at low temperature had maintained atmosphere in package, which was beneficial for the physical properties of cucumber. At ambient condition cucumber was not good up to 6 days and after 3 days shriveling was started. On 3rd day the PLW was 6.65% and shriveling started but colour was good, therefore the experiment at ambient temperature was continued until colour loss. Thickness of LDPE plays a vital role in prolonging the shelf life of cucumber during storage period. The bags with 25 micron thickness at 10±1 °C temperature and 85-90% RH maintained all the qualities such as minimum loss of weight and colour and highest firmness and sensory score of stored cucumber and prolonging the shelf life up to 27 days.

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