Postharvest Study on Effect of Modified Atmosphere Storage of *Capsicum annuum* L. (sweet pepper)

Thant Sin Nwe[1], Nwe Oo[2], Bo Bo Zaw[3]

Abstract

Postharvest study on *Capsicum annuum* L. variety, fresh sweet pepper was conducted in East Yangon University Campus during May, 2023. In this study, the sweet peppers were carried out by using modified atmosphere storage (MA) with low and high polyethylene bags. There were altogether seven treatments such as T_1 (LDPE no-perforated), T_2 (LDPE 4-perforated), T_3 (LDPE 8-perforated), T_4 (HDPE no-perforated), T_5 (HDPE 4-perforated), T_6 (HDPE 8-perforated) and T_7 (control) respectively. In this experiment, LDPE 8-perforated is the best result of lesser retaining in percentage of cumulative weight loss, high in total soluble solid (TSS) content, least occurrence of incidence and severity of defects and marketable peel color for 20 days shelf-life. Among the treatments, treated with both LDPE and HDPE had attained the longer shelf-life than the control. Therefore, the use of modified atmosphere storage may prolong the shelf-life and maintain the postharvest quality of fresh sweet peppers.

Keywords: cumulative, shelf-life, incidence, severity, sweet pepper

Introduction

Capsicum annuum L. sweet pepper, family Solanaceae, occupies important rank as a commercial fruit crop in many regions of the world (Rubio, *et al*., 2010). The major difference with the commonly larger bell pepper is that bell peppers are considered “sweet” and chili peppers are “hot” (Tuquero, *et al*., 2016). Sweet pepper is a vegetable appreciated by consumers because of its pleasant, refreshing taste, attractive color and special biochemical composition (Araceli, *et al*., 2011). It deteriorates rapidly during handling and storage due to poor post-harvest handling leading to huge losses (Halloran, *et al*., 1995). The main purpose of post-harvest handling is to deliver fresh and nutritious food to the consumer in an economical manner. The retention of fruit green color, freshness, absence of defects, free diseases and also shelf life are regarded as postharvest quality parameters during handling and storage of fruits and vegetables (Sigge, *et al*., 2001). Modified atmosphere storage technology can significantly maintain the freshness and ensure a long shelf life without microbial pollution of fruits and vegetables. This study intended to retain postharvest quality of sweet pepper along with the reduce of postharvest losses and appropriate choice of storage materials for growers and retailers.

[1] Dr. Thant Sin Nwe, Associate Professor, Department of Botany, East Yangon University.
[2] Dr. Nwe Oo, Associate Professor, Department of Botany, East Yangon University.
[3] M.Sc (Second year), Department of Botany, East Yangon University.

Materials and Methods

Study area

Postharvest study was conducted at Botany Department, East Yangon University, Thanlyin Township during May, 2023.

Procedures for postharvest handling operations of sweet pepper

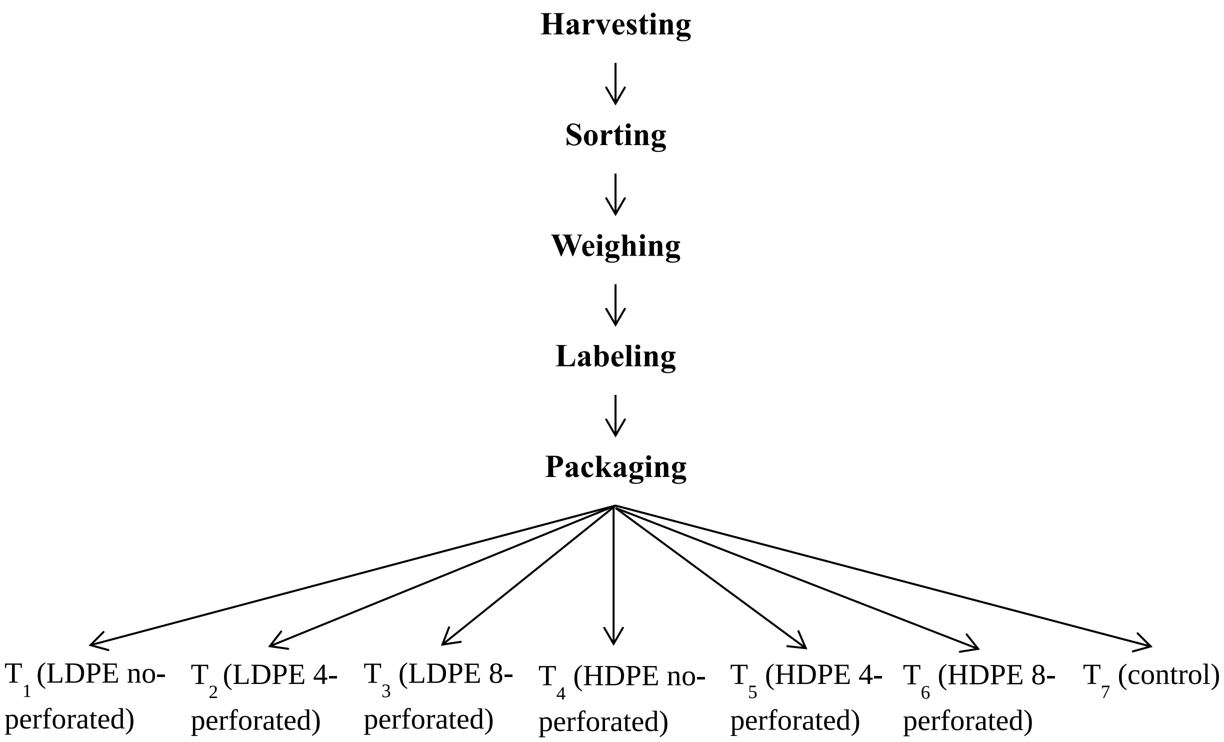

Figure 1. Postharvest handling operations of sweet pepper

Data Collection

The data collected during storage were as follows: cumulative weight loss (%), incidence of defects (%), severity of defects, total soluble solids, pH, peel color and room temperature and relative humidity (%).

Methods

1. **Cumulative weight loss (%)** (Babarinde, 2009)

$$WL\ (\%) = \frac{W_o - W_t}{W_o} \times 100$$

where, W_o = initial weight and W_t = weight at time

2. **Incidence of defects (%)**

$$\text{Incidence of defects (\%)} = \frac{\text{Total numbers of defected fruits}}{\text{Total numbers of intact fruits}} \times 100$$

3. **Severity of defects** (Scores)

1 = excellent in freshness

2 = 25% of defects (minor shrinkage)

3 = 50% of defects (moderate shrinkage)

4 = 75% of defects (unmarketable)

5 = 100% of defects (unmarketable)

4. **Total soluble solids (TSS)** (°Brix)

Total Soluble Solids was determined by using the refractometer reading.

5. **pH**

pH value was measured using a digital pH meter.

6. **Peel color** (Scores)

1 = totally jade green

2 = slightly pale green

3 = slightly occurrence of reddish brown in green

4 = more occurrence of reddish brown

5 = most occurrence of reddish brown

6 = reddish brown more than green

7. Room temperature (°C) and relative humidity (%)

Room temperature and relative humidity were determined with an indicator for Relative Humidity (RH) and temperature, during storage room temperature was ranged from (34-36 °C) and relative humidity was ranged from (73-82%), respectively.

8. Statistical analysis

All results were statistically analyzed using Statistix software version 8.0. Total of seven treatments were carried out by using Completely Randomized Design (CRD). Each treatment consisted of three replications. All treatment means were compared using LSD (Least Significant Differences) at 5% level of significance.

Results

Physiological weight loss and cumulative weight loss (%)

Fresh weight of sweet pepper was drastically decreased in all treatments treated with both LDPE and HDPE. The results showed that, fresh pepper treated with LDPE, 8-perforated (T_3) had obtained (194.33g) the maximal shelf life with lesser physiological weight loss and cumulative weight loss (36.93%) among the treatments for 20-days of storage (Table 1, Fig. 2 and Table 2, Fig. 3). In contrast, the shortest shelf life was found in control (T_7), it was deteriorated at 12-days storage under room temperature.

Table 1. Effects of modified atmosphere storage on physiological weight loss of sweet pepper under room temperature

Treatments	Weight loss (g/fruit)					
	Storage Period (day)					
	0 day	4 day	8 day	12 day	16 day	20 day
T_1 (LDPE no-perforated)	273.33	263.67	243.33	196.00	176.67	149.00
T_2 (LDPE 4-perforated)	289.00	285.00	276.00	254.67	208.67	176.33
T_3 (LDPE 8-perforated)	301.67	293.33	283.33	273.33	223.67	194.33
T_4 (HDPE no-perforated)	264.67	240.67	217.33	178.33	147.67	72.00
T_5 (HDPE 4-perforated)	280.67	273.33	254.33	219.67	181.00	159.67
T_6 (HDPE 8-perforated)	270.67	251.67	233.33	188.67	156.33	143.33
T_7 (control)	253.33	233.33	196.33	140.67	-	-
F-test	ns	*	**	**	ns	*
5% LSD	14.17	14.19	15.07	17.99	31.30	30.31
CV (%)	8.89	9.35	10.70	14.47	33.03	40.53

Each value represented the mean from 3 replications. Mean differences in each column was determined by LSD.
* = significant at 5% level, ** = highly significant at 1% level, ns = non-significant

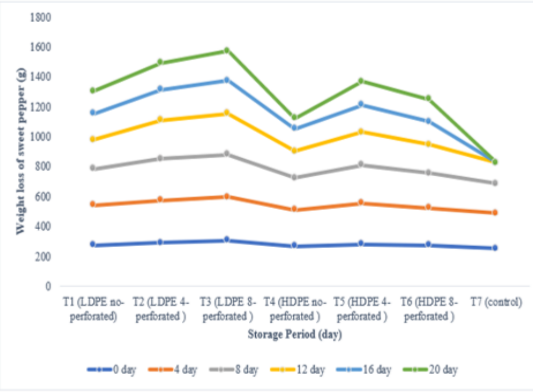

Figure 2. Effects of modified atmosphere storage on physiological weight loss of sweet pepper under room temperature

Table 2. Effects of modified atmosphere storage on cumulative weight loss (%) of sweet pepper under room temperature

Treatments	Cumulative Weight Loss (%)	
	Sweet pepper	
	12 day	20 day
T_1 (LDPE no-perforated)	21.47	47.22
T_2 (LDPE 4-perforated)	11.99	39.25
T_3 (LDPE 8-perforated)	9.38	36.93
T_4 (HDPE no-perforated)	30.28	65.57
T_5 (HDPE 4-perforated)	19.25	45.55
T_6 (HDPE 8-perforated)	28.82	51.77
T_7 (control)	35.31	

Each value represented the mean from 3 replications

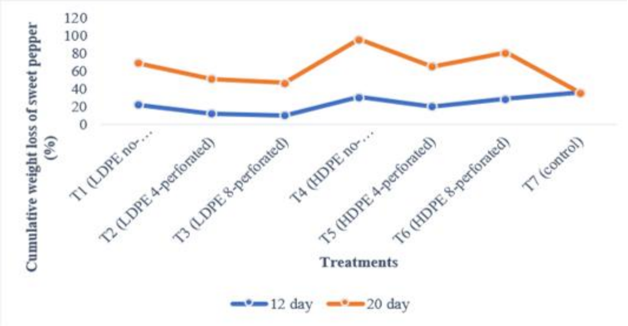

Figure 3. Effects of modified atmosphere storage on cumulative weight loss (%) of sweet pepper under room temperature

Incidence and severity of defects

There was no incidence and severity of defects in all treatments at initial day of fresh sweet pepper fruits during storage at ambient temperature. The results showed that, lowest percentage of incidence and scores of severities was found in LDPE, 8-perforated (T_3) which were (53.33% and 3.25 score) respectively. In contrast, the level of decay and severity was highest in control T_7 (75.55% and 4.86 score), without treatment which was observed unmarketable quality at 12-days of storage period under ambient temperature.

Table 3. Effects of modified atmosphere storage on incidence of defects of sweet pepper under room temperature

Treatments	Incidence of defects (%) Storage Period (day)					
	0 day	4 day	8 day	12 day	16 day	20 day
T_1 (LDPE no-perforated)	0.00	36.66	39.99	47.77	64.44	75.55
T_2 (LDPE 4-perforated)	0.00	36.66	39.33	43.66	51.66	72.21
T_3 (LDPE 8-perforated)	0.00	36.66	39.00	43.33	45.55	**53.33**
T_4 (HDPE no-perforated)	0.00	39.99	43.33	52.22	68.66	83.33
T_5 (HDPE 4-perforated)	0.00	36.66	39.66	46.66	52.22	73.32
T_6 (HDPE 8-perforated)	0.00	39.99	41.33	49.99	66.66	76.21
T_7 (control)	0.00	39.99	46.66	**75.55**	-	-

Each value represented the mean from 3 replications.

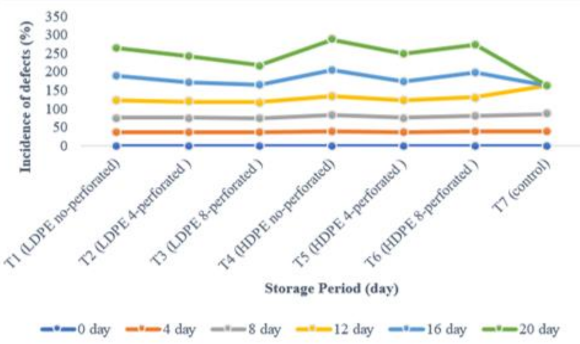

Figure 4. Effects of modified atmosphere storage on incidence of defects of sweet pepper under room temperature

Table 4. Effects of modified atmosphere storage on severity of sweet pepper under room temperature

Treatments	Severity (Scores) Storage Period (day)					
	0 day	4 day	8 day	12 day	16 day	20 day
T_1 (LDPE no-perforated)	1	1.6	2.83	2.93	4.45	5.5
T_2 (LDPE 4-perforated)	1	1.3	2.65	2.76	3.54	4.67
T_3 (LDPE 8-perforated)	1	1.2	2.32	2.56	3	**3.25**
T_4 (HDPE no-perforated)	1	1.8	3.12	3.26	4.95	5.93
T_5 (HDPE 4-perforated)	1	1.5	2.79	2.84	4.23	5.2
T_6 (HDPE 8-perforated)	1	1.7	3.01	3.15	4.83	5.78
T_7 (control)	1	1.9	3.25	**4.86**	-	-

Each value represented the mean from 3 replications.

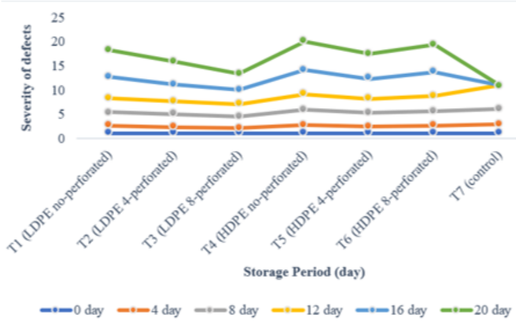

Figure 5. Effects of modified atmosphere storage on severity of sweet pepper under room temperature

Total soluble solid

Total soluble solid (TSS) content of fresh sweet pepper showed gradually increased over time during the storage period. In contrast, the fresh sweet pepper treated with both LDPE and HDPE were revealed more TSS content than control. Among the treatments, LDPE-8perforated (T_3) had showed the highest content of TSS (3.70 °Brix) for 20 days of storage period.

Table 5. Effects of modified atmosphere storage on total soluble solid of sweet pepper under room temperature

Treatments	Total Soluble Solid (°Brix)					
	Storage Period (day)					
	0 day	4 day	8 day	12 day	16 day	20 day
T_1 (LDPE no-perforated)	1.23	2.03	2.30	2.73	2.75	2.80
T_2 (LDPE 4-perforated)	1.67	2.23	2.80	2.90	3.10	3.20
T_3 (LDPE 8-perforated)	1.77	2.33	3.00	3.20	3.67	3.70
T_4 (HDPE no-perforated)	1.17	1.33	1.73	2.03	2.30	2.53
T_5 (HDPE 4-perforated)	1.50	2.23	2.50	2.87	3.00	3.17
T_6 (HDPE 8-perforated)	1.17	1.97	2.23	2.30	2.50	2.67
T_7 (control)	1.10	1.27	1.60	1.97	-	-
F-test	**	**	**	**	**	**
5% LSD	0.12	0.13	0.14	0.13	0.10	0.08
CV (%)	15.50	11.77	10.8	8.70	7.51	4.74

Each value represented the mean from 3 replications. Mean differences in each column was determined by LSD.

** = highly significant at 1% level

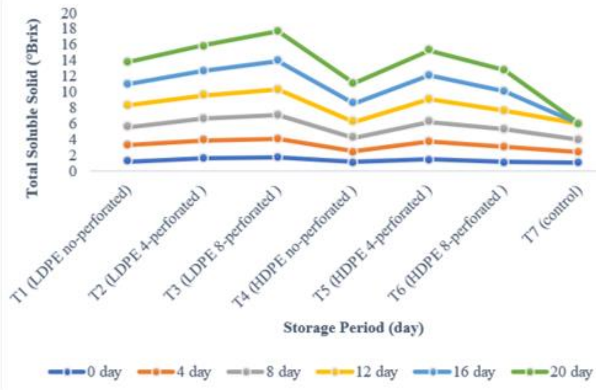

Figure 6. Effects of modified atmosphere storage on total soluble solid of sweet pepper under room temperature

pH level

The hydronium ions concentration of pH value was gradually increased over time during the storage period. The higher pH value considered as the lower acidity content in was found LDPE-8perforated (T_3) (5.56) of fresh sweet pepper at 20-days.

Table 6. Effects of modified atmosphere storage on pH level of sweet pepper under room temperature

Treatments	pH Level					
	Storage Period (day)					
	0 day	4 day	8 day	12 day	16 day	20 day
T_1 (LDPE no-perforated)	4.42	4.56	4.83	5.18	5.22	5.26
T_2 (LDPE 4-perforated)	4.87	5.22	5.26	5.27	5.41	5.49
T_3 (LDPE 8-perforated)	5.22	5.23	5.26	5.36	5.48	5.56
T_4 (HDPE no-perforated)	4.64	4.74	4.81	4.87	5.09	5.14
T_5 (HDPE 4-perforated)	4.75	4.94	5.16	5.23	5.28	5.32
T_6 (HDPE 8-perforated)	4.54	4.76	4.84	5.13	5.16	5.21
T_7 (control)	4.58	4.87	5.25	5.84	-	-
F-test	**	**	**	**	**	**
5% LSD	0.06	0.06	0.06	0.05	0.06	0.02
CV (%)	2.29	2.24	2.05	1.74	2.1	0.71

Each value represented the mean from 3 replications. Mean differences in each column was determined by LSD.

** = highly significant at 1% level

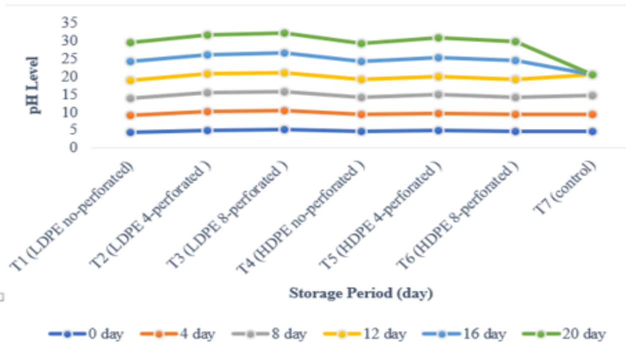

Figure 7. Effects of modified atmosphere storage on pH level of sweet pepper under room temperature

Peel color

The peel color of the fresh sweet pepper was totally jade green in all treatments at initial day of storage period. The peel color of the fresh sweet pepper was gradually changed from totally jade green to reddish brown in color. The appearance of small color patches or streaks of reddish brown were increased mostly in control (T_7). The least occurrence of reddish brown in jade green was found in LDPE-8perforated (T_3) which can be hold the marketable quality of freshness among the treatments.

Table 7. Effects of modified atmosphere storage on peel color of sweet pepper under room temperature

Treatments	Peel Color (Scores)					
	Storage Period (day)					
	0 day	4 day	8 day	12 day	16 day	20 day
T_1 (LDPE no-perforated)	1	1.7	2.5	3.5	4.4	4.6
T_2 (LDPE 4-perforated)	1	1.6	2.3	2.3	3	3.5
T_3 (LDPE 8-perforated)	1	1.5	1.9	1.9	3	3.5
T_4 (HDPE no-perforated)	1	2.2	3	3.7	4.5	5.2
T_5 (HDPE 4-perforated)	1	1.6	2.5	3.3	4.3	4.6
T_6 (HDPE 8-perforated)	1	1.8	2.6	3.5	4.4	4.9
T_7 (control)	1	2.4	3.3	4.8	-	-

Each value represented the mean from 3 replications.

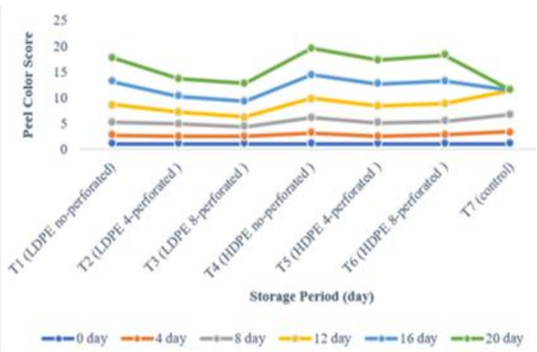

Figure 8. Effects of modified atmosphere storage on peel color of sweet pepper under room temperature

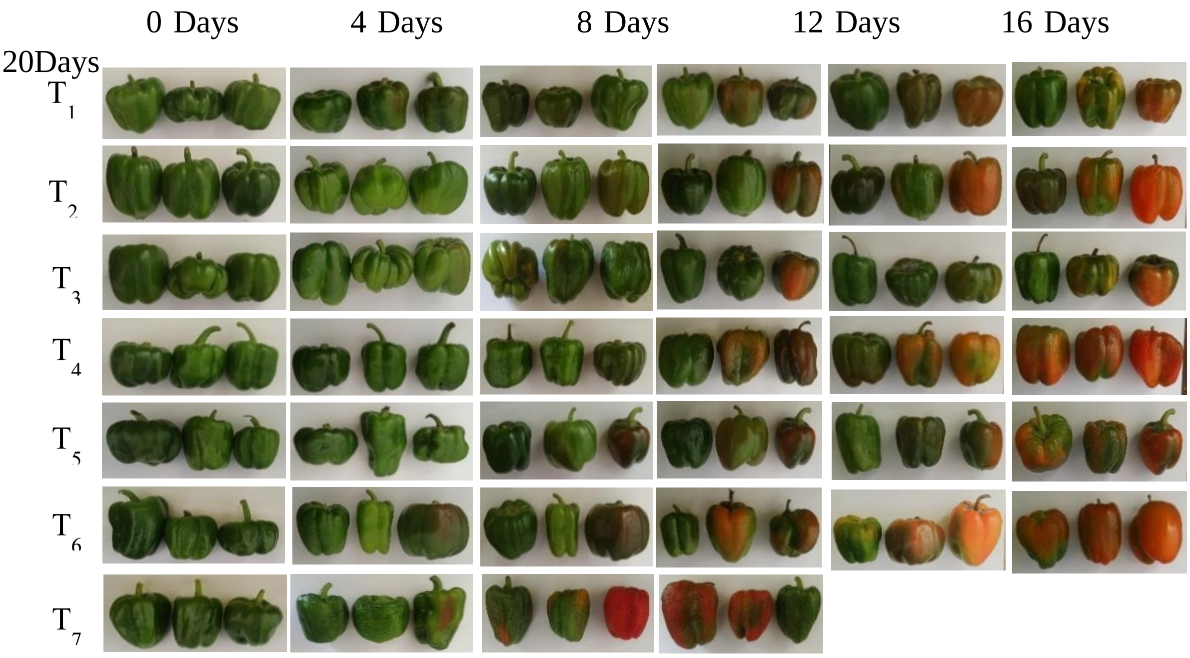

Figure 9. Effects of modified atmosphere storage on peel color of sweet pepper

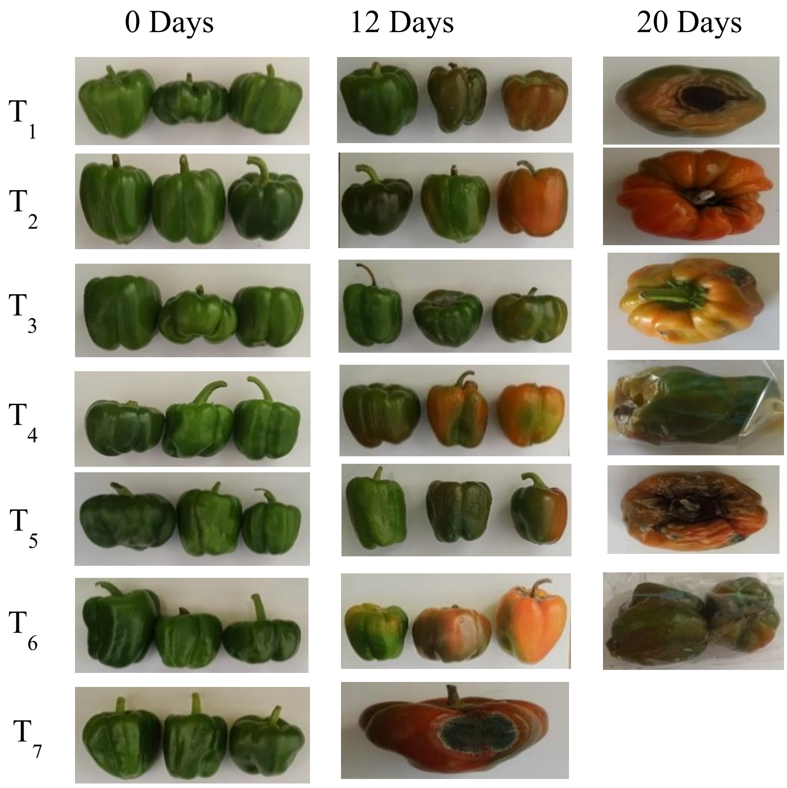

Figure 10. Effects of modified atmosphere storage on decay fruit of sweet pepper

Room temperature (°C) and relative humidity (%)

The most important environmental factors of temperature and relative humidity were ranged from (34-36 °C) and (73-82%) during postharvest studied on fresh sweet pepper.

Table 8. Room temperature and relative humidity during storage of sweet pepper under room temperature

Parameters	Storage Period (day) (May,2023)					
	0 day	4 day	8 day	12 day	16 day	20 day
Room temperature (°C)	36	35	36	34	35	34
Relative humidity (%)	75	73	80	76	82	79

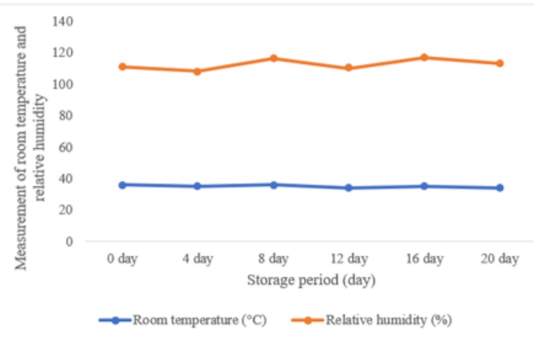

Figure 11. Room temperature and relative humidity during storage of sweet pepper under room temperature

Discussion and Conclusion

In this study, the sweet peppers storage with low density polyethylene bags (LDPE): T_1 (LDPE no-perforated), T_2 (LDPE 4-perforated), T_3 (LDPE 8-perforated) and high-density polyethylene bags (HDPE): T_4 (HDPE no-perforated), T_5 (HDPE 4-perforated), T_6 (HDPE 8-perforated) were compared and contrasted with T_7 (control) without treatment. Among the treatments, the treatments treated with low- and high-density polyethylene bags were achieved more prolong shelf life and marketable quality (20 days) than control, which was unmarketable after 12 days.

It is agreed with Samjate (2006) who reported that modified atmosphere storage or packaging is very effective in retaining freshness and of fruit and vegetables quality and for extending shelf-life. During the storage period, the physiological weight of sweet pepper was decreased significantly. Incidence and severity of defects on fresh sweet pepper increased over time in all treatments. It is due to the postharvest water loss and it may cause deterioration and decrease visual quality over time. It was agreed with Kinhal (2021) who stated that weight loss occurs due to respiration, water loss and evaporation, all of which parameters are depend on temperature and relative humidity.

In contrast between both LDPE and HDPE treatments, the occurrence of decay incidence and scores of severities were increased over time might be due to the accumulation of excessive water vapour inside the package of LDPE and HDPE during storage under ambient temperature because of the restricted movement of water through the film (Yekula *et.al*., 2013). The hue of sweet pepper is also an important factor in the visual appeal of the fruit for customers. Loss in jade green color may be due to the degradation of chlorophyll and appearance of reddish-brown streaks may be subsequent synthesis of carotenoids during ripening and causing decrease in visual quality (Nunes and Emond 2007).

In this study, the temperature and relative humidity were ranging from (34-36 °C) and (73-82%) respectively. Halloran, *et al*., (1995) reported that the quality parameters are functions of temperature, relative humidity and air composition of the handling or storage environment. When the TSS content increased during storage, it is due to the maturity status of the fruit increased which could be seen with peel color changed of sweet pepper (Halloran, *et al*., 1995). The pH value was increased gradually in all treatments may be resulted in depletion of acidity, this was agreed with report of Kinhal (2021). According to the results, sweet peppers treated with LDPE 8- perforated (T_3) had performed the lesser weight loss (194.33g), lesser occurrence of incidence (53.33) and severity of defects (3.25), increased in total soluble solids content (3.70°Brix), pH (5.14) and marketable peel color (3.5).

Based on the statistical analysis, the interaction effect of packaging materials with physiological weight loss over storage days showed among treatments were not significant statistically in each day of measurement. Total Soluble Solid (TSS) is considered as a primary quality attribute of sweet pepper as high TSS content enhances the flavor and palatability of the fruit. The changes in TSS content during the time was a highly significance ($p \leq 0.05$) effect of different packaging materials on the TSS values which varied between 2.53-3.70°Brix under ambient conditions. pH, the hydronium ions concentration in a fruit, which is fundamental to assess the ability of a microorganisms to grow and the tendency of fresh fruit to prolong its shelf life. The pH level was highly significant at ($p \leq 0.05$) of different packaging materials on sweet pepper.

In conclusion, losses after harvest are distributed throughout the entire marketing chain from the farmer to the consumer. Losses may be increased within a few days to a few weeks of traditional handling of horticultural crops. Postharvest technology has become necessary to improve food quality and safety for appropriate handling, packaging, transportation and storage reduce postharvest losses of fruits and vegetables. This study may enhance the need of growers, retailers and consumer to expand shelf-life and improve quality of sweet pepper by using appropriate packaging material.

Acknowledgements

I would like to express my sincere gratitude to Dr, Htay Htay Lwin, Professor and Head, Department of Botany, East Yangon University, for the permission to use various department facilities during the study period. I also acknowledge to Dr. Thaw Maw Moe and Dr. Thandar Oo, Professors, Department of Botany, East Yangon University, for their interesting advices and suggestions on this study. Finally, I would like to express my sincere thanks to Project Team of Jeonbuk National University, Republic of Korea for their support and valuable guidance.

References

Araceli, M.V.G., J.L. Chavez-Servia, J.C. Carrillo-Rodriguez and G.L. Mercedes. 2011.Phytochemical Evaluation of Wild and Cultivated Pepper (*Capsicum annuum* L. and *C. pubescens* Ruiz & Pav.) From Oaxaca, Mexico, Chilean. Journal of Agricultural Research, 71(4), 578-585.

Babarinde, G.O. and O.A. Fabunmi. 2009. Effects of packaging materials and storage temperature on quality of fresh vegetables. Science World Journal, Vol. (2), No. (2).

Halloran, N., R. Yanmaz and R. Cagiran. 1995. Effects of different packaging materials on the storage of peppers (*Capsicum annuum* L. Longum).

Kinhal, V. 2021. Studying the influence of Storage Conditions, 1-MCP, and Packaging Films on Quality of Sweet Dalilah Green and Red Stage Peppers (*Capsicum annuum* L.). Journal of Food Science and Technology 6(2): 356-370.

Nunes, C. and J. Emond. 2007. Relationship between weight loss and visual quality of fruits and vegetables.

Rubio, J.S., F. Garcia-Sanchez, P. Flores, J.M. Navarro and V. Martinez. 2010. Yields and fruit quality of sweet pepper in response to fertilization with Ca+ and K+, Spanish. Journal of Agricultural Research, 8(1), 170-177.

Samjate, S. 2006. Packaging and Transportation of fruits and vegetables for the better marketing. In: APO, 2006. Postharvest management of fruits and vegetables in the Asia-Pacific Region. Asian Productivity Organization (APO) and FAO. P.15-22.

Sigge, G.O., C.F. Hansman and Joubert. 2001. Effects of storage conditions, packaging material and metabisulphite treatment on the color of dehydrated green bell pepper (*Capsicum annuum* L.). J. Food Quality, 24, 3, 205.

Tuquero, J and J. Bamba. 2016. Bell pepper (*Capsicum annuum*) a potential commercial crop for guam. Food Plant Production: Cooperative Extension & Outreach College of Natural & Applied Sciences, University of Guam.

Yukela, B., D. Srihari and J. D. Babu. 2013. Extension of gherkin shelf life through the use of reduced temperature and poly ethylene packaging. Vegetable Science 40(2); 174-7