



Combined effect of low temperature and thickness of polypropylene package on shelf life and quality of oyster mushroom (*Pleurotus ostreatus*)

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ABSTRACT

Purpose: An experiment was conducted to determine a suitable thickness of polypropylene bag as a package and appropriate storage temperature that will enhance an extended shelf life and quality of oyster mushroom. **Research method:** The experiment consisted of eight treatments under two factors (temperature and thickness of polypropylene bag). Treatments: T₁P₀= ambient temperature without wrapping (Control), T₁P₁= ambient temperature & 50 µ PP bag, T₁P₂= ambient temperature & 75 µ PP bag, T₁P₃= ambient temperature & 100 µ PP bag, T₂P₀= 3°C temperature without wrapping, T₂P₁= 3°C temperature & 50 µ PP bag, T₂P₂= 3°C temperature & 75 µ PP bag, T₂P₃= 3°C temperature & 100 µ PP bag. The experiment was laid out in a Completely Randomized Design (CRD) with three replications. **Findings:** Highest moisture contents (90.80%) and shelf life (15 days) were observed in low temperature and wrapped in 75µ polypropylene bag (T₂P₂). Highest dry matter content (82.92%) and highest weight loss (30.3%) were observed in ambient temperature and unwrapped condition (T₁P₀) whereas lowest moisture contents (9.20%), lowest dry matter content (17.08%), lowest protein content (7.79%), and lowest shelf life (1.66) were observed in ambient temperature and unwrapped condition (T₁P₀). **Limitations:** No limitations to report. **Originality/Value:** Combination of PP bags of proper thickness and low temperature can help in decreasing moisture loss and disease incidence which increase shelf life and maintain nutritional quality of oyster mushroom.

INTRODUCTION

Oyster mushroom is the second most popular mushrooms after button mushroom throughout the world (Atkins, 1966) and the most popular in Bangladesh. *Pleurotus ostreatus* is generally referred to as 'Oyster Mushroom'. It is a basidiomycete and belongs to the Genus '*Pleurotus*'. The fruit bodies of this mushroom are distinctly shell, fan or spatula shaped with different shades of white, cream, grey, yellow, pink or light brown depending upon the species. Oyster mushrooms grow over a range of temperature of 15-30 °C and thus are suitable for cultivation under both temperate and tropical climatic conditions. In Bangladesh, oyster mushrooms are the most prospective mushrooms (Alam et al., 2007). Mushrooms had long been used for medicinal and food purposes since decades (Wani et al., 2010). The production of three species of oyster mushroom: *Pleurotus ostreatus*, *Pleurotus sajor-caju* and *Pleurotus flabellatus* are cultivated in Bangladesh mostly. A mushroom is the fleshy, spore-bearing fruiting bodies of a fungus, typically produced above ground on soil or on its food source. In the developed countries, mushrooms have become one of the most important of all the horticultural crops. The production of mushroom is increasing everywhere in the world, and now-a-days these are available all the year round and are used in enormous quantities to serve with all kinds of table dishes. There are about 5000 different species of mushrooms of which at least 1250 are reported to be edible (Gupta & Sarma, 2004). In a narrow sense, the word mushroom also refers only to the fruit bodies. Mushrooms belong to the Kingdom Fungi due to unique fungal characteristics. They are not like green plants because they lack chlorophyll, and therefore depend on the preformed food for their nutrition. Though neither meat nor vegetable, mushrooms are known as the "meat" of the vegetable world (Haas & James, 2009). Besides it has good food value. It is medicinally effective as antitumor, antibacterial, antiviral and hematological agents and has significant antioxidant capacity (Weiss, 1999). Mushroom contains higher proportion of moisture (85 to 95%) (Pathak et al., 1998). Like all fleshy fruits and vegetables, mushrooms are highly perishable because of their high moisture content and delicate nature, and cannot be stored for more than 24 hours at ambient temperature (Kaushal & Sharma, 1995). In general, the fruiting bodies of mushrooms contain about 56.8% carbohydrate, 25.0% protein, 5.7% fat and 12.5% ash on a dry weight basis. Importantly, edible mushrooms have gained popularity in modern medicine for their pharmaceutical properties. Mori et al. (1986) observed that mushroom reduces serum cholesterol and high blood pressure. Mushrooms as medicine have been used in China since 100 A.D. (Gunde-Cimmerman, 1999). According to Chang (1992), the protein value of dried mushroom has been found to be 30-40% comprising all the essential amino acids. It is also rich in iron, copper, calcium, potassium, vitamin D and folic acid. Mushroom can be produced in large quantities in a short time, and it provides more protein per unit area than any other crop.

YounMoon et al. (2004) investigated about storability and shelf life of Oyster mushroom (*Pleurotus ostreatus*) during shipping period and found that maximum shipping period of Oyster mushroom appeared to be 21 days considering additional 5 days marketing period at low temperature around 7°C. Choi and Kim (2003) found that during storage, film packaging (60 µ thickness) prevented or retarded the deterioration of Oyster mushroom (*P. ostreatus*) appearance, texture and discoloration. The reduction of protein, rehydration ratio and the increase in moisture content was comparatively higher in ordinary heat sealed storage (control) against vacuum storage method (Naik et al., 2005). Eseriche et al. (2001) observed that the lowest storage temperature 5°C favored the best quality of mushrooms (*Agaricus bisporus*). Lukasse and Polderdijk (2003) provided result on the predictive modeling of postharvest quality evolution, to mushrooms and found that cold chains are effective for mushroom storage. Enzymes producing fungi degrade complex organic matter and absorb the

soluble substances (Chang & Miles, 2004). After the maturing of the fruiting bodies, the deterioration starts with the formation of brown coloration and hence the quality deterioration and loss of marketability. Polypropylene bag is a kind of packaging materials which can be used to package mushroom after harvest. It creates modified atmospheric condition which show delay in senescence and maintain quality of vegetables or fruits. Introduction of low temperature would further refine the modified atmosphere storage for extending the shelf life of mushroom for quite a longer period. The present piece of research has been undertaken to assess the combined effects of low temperatures (3°C) in combination with proper thickness packaging on physico-chemical properties and shelf life of oyster mushroom.

MATERIALS AND METHODS

The experiment was conducted at the laboratory of Department of Horticulture, Soil Science and Plant Pathology of Bangladesh Agricultural University, Mymensingh, from 10 February to 15 April, 2016. The detailed methodology followed to conduct the experiments is described in the following.

Atmospheric conditions of storage room

During the study period the minimum and maximum temperatures of storage room were 25.3 to 31.3°C, respectively. The minimum and maximum relative humidity was (46 and 80%) respectively.

Experimental materials

Freshly harvested fruiting bodies of cv. Oyster, edible mushroom (*Pleurotus ostreatus*), are used as the materials of this experiment. The fruiting bodies were collected from Mushroom Development institute, Saver, Dhaka and harvested at commercial maturity stage (when the mushrooms are ready for sale in market) with uniform size, shape and free of any visible defects, disease symptoms and insect infestations and transported to the Laboratory of the Department of Horticulture, Bangladesh Agricultural University, Mymensingh with careful handling to avoid damage and injury.

Experimental treatments

This experiment was conducted with two factors.

Factor –A: Storage temperature

T₁=Mushroom stored at ambient temperature (Room temperature), T₂=Mushroom stored at 3 °C temperature.

Factor-B: Thickness of Polypropylene (PP) bag

P₀=Mushroom unwrapped (Control), P₁=Mushroom wrapped in 50 µ PP bag, P₂=Mushroom wrapped in 75 µ PP bag and P₃=Mushroom wrapped in 100 µ PP bag.

Treatment combination of this two factor experiment is (2×4) =8 those are T₁P₀, T₁P₁, T₁P₂, T₁P₃, T₂P₀, T₂P₁, T₂P₂, T₂P₃.

Experimental design

The experiment was laid following completely randomized design with three replications. Five mushroom are placed per replication. A total of 120 of more or less similar shape and size and free of visible disease symptoms fruiting body of oyster mushroom were used as

experimental materials. The postharvest treatments were assigned randomly to the selected fruiting body of oyster mushroom.

Observation

The experiment was observed every day. Data were recorded at an interval of 1 day.

Methods of studying parameters

Color

Color was determined objectively using numerical rating scale of 1-4, where 1 =Pure white, 2= Slightly brown, 3 = Brown, 4 = Black.

Freshness

Freshness was determined using numerical rating scale of, 1-4, where 1 = Excellent, 2 = Good, 3 = Fair, 4 = Poor.

Texture

Using numerical rating scale of 1-4, where 1 =Firm, 2 = Slightly soft, 3 = Soft, 4 = Very soft texture were determined.

Flavor

Following rating scale of 1-4 where, 1 =Excellent, 2 = Slightly odor (Acceptable), 3 = Odor, 4 = Rotten were used for flavor.

Total weight loss

Percent total weight loss was calculated at 3rd and 6th days of storage using the following formula (1):

$$\text{Weight loss (\%)} = \frac{\text{IW} - \text{FW}}{\text{IW}} \times 100 \quad (1)$$

Where, IW= Initial weights (g) of fruiting bodies and FW= Final weight (g) of fruiting bodies.

Moisture content

Percent moisture content was calculated by using this formula (2):

$$\text{Moisture content (\%)} = \frac{\text{PW} - \text{LW}}{\text{PW}} \times 100 \quad (2)$$

Where, PW= Primary weights (g) of mushroom fruiting bodies and LW= Last weight (g) of mushroom fruiting bodies.

Dry matter content

Percent dry matter content of the pulp was calculated from the data obtained during moisture estimation using the following formula (3):

$$\text{Dry matter (\%)} = (100 - \% \text{ moisture content}) \quad (3)$$

Total protein percentage

Chemical analysis was performed in the laboratory of the Department of Soil Science, Bangladesh Agricultural University, Mymensingh. The total protein was estimated using the modified micro-Kjeldahl method (AOAC, 1980).

The amount of nitrogen was calculated according to the following equation (4):

$$\text{Nitrogen \%} = \frac{\text{Ts} - \text{Tb} \times \text{strength of HCL acid} \times 0.014 \times 7.5}{\text{weight of sample}} \times 100 \quad (4)$$

Where, Ts= Titre value of the sample in ml, Tb = Titre value of the blank in ml, Strength of the HCl acid = 0.1N.

The % nitrogen of the sample was multiplied by 6.25 to obtain the total crude protein present in the sample.

Shelf life

It was calculated by counting the days required to consumption fully as to retaining, optimum marketing and eating qualities. Shelf life of mushroom is continued up to it remains for suitable consumption. Shelf life is the length of time for which an item remains usable, fit for consumption, or saleable. End of shelf life is occurred by the change in sensory attributes (e.g. odor, taste, appearance, and texture) and can indicate consumer rejection.

Statistical analysis

The data were analyzed using MSTAT statistical package following analysis of Variance (ANOVA) test. The pair of comparisons were performed by Least Significant Difference (LSD) test at 5% and 1% level of probability (Gomez & Gomez, 1984).

RESULTS**Color**

Due to postharvest treatment the color is changed from pure white to black. The combined effects of temperature with thickness of PP bags were statistically significant to influence color changes of mushroom fruiting bodies during 2 to 7 days after storage. The highest color change (4.00) was observed in the combined effect of ambient temperature and unwrapped condition (T₁P₀) and the lowest color change (1.00) was observed at the combined effect of low temperature (3°C) and wrapped in 75 µ PP bags (T₂P₂) up to 7 days after storage (Table 1).

Freshness

The combined effects of thicknesses of PP bags and temperature were statistically significant to influence freshness score of mushroom during 2 to 7 days after storage. The highest freshness score (4.00) at 2nd days after storage was observed in the combined effect of ambient temperature and unwrapped condition (T₁P₀) and the lowest freshness score (1.00) was observed at the combined effect of low temperature (3 °C) and wrapped in 75 µ PP bags (T₂P₂) up to 7 days after storage (Table 2).

Flavor

The combined effects of temperature with thickness of PP bags were statistically significant to influence flavor of mushroom during 2 to 7 days after storage. The highest flavor score (4.00) was found at the combined effect of ambient temperature and unwrapped condition

(T₁P₀) and the lowest score (1.00) was found at the combined effect of low temperature (3 °C) and wrapped in 75 µ PP bags (T₂P₂) up to 7 days after storage (Table 3).

Table 1. Combined effect of temperature and PP bag on color of mushroom (*Pleurotus ostreatus*)

Temperature	PP bag	Color at different days after storage (DAS)						
		D ₁	D ₂	D ₃	D ₄	D ₅	D ₆	D ₇
T ₁	P ₀	1.00	4.00	4.00	4.00	4.00	4.00	4.00
	P ₁	1.00	1.00	1.33	2.00	2.67	3.00	3.67
	P ₂	1.00	1.00	1.00	1.33	2.00	2.67	3.00
	P ₃	1.00	1.00	1.33	2.33	2.67	3.33	3.67
T ₂	P ₀	1.00	1.00	1.33	2.67	3.33	4.00	4.00
	P ₁	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	P ₂	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	P ₃	1.00	1.00	1.00	1.00	1.00	1.00	1.67
LSD _{0.05}			0.13	0.26	0.31	0.43	0.56	0.59
LSD _{0.01}			0.19	0.36	0.43	0.60	0.77	0.81
Level of significant		ND	3.38**	2.29**	0.33**	0.38**	1.56**	2.00**

** = Significant at 1% level of probability and ND= Statistical analysis not done.

1= Pure white, 2 = Slightly brown, 3= Brown and 4 = black.

Table 2. Combined effect of temperature and polypropylene bag on freshness of mushroom (*Pleurotus ostreatus*)

Temperature	PP bag	Freshness at different days after storage (DAS)						
		D ₁	D ₂	D ₃	D ₄	D ₅	D ₆	D ₇
T ₁	P ₀	1.00	4.00	4.00	4.00	4.00	4.00	4.00
	P ₁	1.00	1.00	1.33	2.67	3.00	3.67	4.00
	P ₂	1.00	1.00	1.00	1.33	2.00	2.67	3.00
	P ₃	1.00	1.00	1.67	2.67	3.33	3.67	4.00
T ₂	P ₀	1.00	1.00	1.33	2.67	3.33	4.00	4.00
	P ₁	1.00	1.00	1.00	1.00	1.00	1.00	1.33
	P ₂	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	P ₃	1.00	1.00	1.00	1.00	1.00	1.00	1.00
LSD _{0.05}			0.26	0.31	0.40	0.45	0.59	0.56
LSD _{0.01}			0.36	0.43	0.55	0.62	0.81	0.77
Level of significant		ND	3.37**	2.16**	0.60**	0.94**	2.38**	2.71**

** = Significant at 1% level of probability and ND= Statistical analysis is not done.

1 = Firm, 2 = Slightly soft, 3= Soft, 4= Very soft and totally unfit for consumption.

Table 3. Combined effect of temperature and PP bag on flavor of mushroom (*Pleurotus ostreatus*)

Temperature	PP bag	Flavor at different days after storage (DAS)						
		D ₁	D ₂	D ₃	D ₄	D ₅	D ₆	D ₇
T ₁	P ₀	1.00	3.67	4.00	4.00	4.00	4.00	4.00
	P ₁	1.00	1.00	1.67	2.00	2.33	3.33	3.67
	P ₂	1.00	1.00	1.00	1.33	1.67	2.00	2.33
	P ₃	1.00	1.00	1.67	2.33	3.00	3.67	3.67
T ₂	P ₀	1.00	1.00	1.00	1.67	3.00	4.00	4.00
	P ₁	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	P ₂	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	P ₃	1.00	1.00	1.00	1.00	1.00	1.00	1.33
LSD _{0.05}			0.19	0.31	0.33	0.38	0.37	0.49
LSD _{0.01}			0.26	0.43	0.46	0.52	0.51	0.68
Level of significant		ND	2.67**	2.59**	1.04**	0.48**	2.28**	2.16**

** = Significant at 1% level of probability and ND= Statistical analysis is not done.

1 = Excellent, 2 = Good, 3 = Fair and 4 = Poor.

Texture

The combined effects of temperature with thickness of PP bags were statistically significant (up to 2 to 7 days) to influence the texture of mushroom fruiting bodies at different days after storage. The highest score of texture (4.00) was observed at ambient temperature without PP bags and the lowest texture (1.00) was observed at 3°C temperature of 75 µ PP bags (7 DAS) (Table 4).

Moisture content and dry matter content

The combined effects of temperature with thickness of PP bags were statistically significant to influence moisture content and dry matter content of mushroom at 3 and 6 days after storage. The highest moisture score (90.80%) was found at the combined effect of low temperature (3°C) and wrapped in 75 µ PP bags (T₂P₂) at 3 DAS and the lowest moisture content (17.08%) was found at the combined effect of ambient temperature and unwrapped condition (T₁P₀) at the 6 day of storage (Table 5). The highest dry matter content (82.92%) was found at the combined effect of ambient temperature and unwrapped condition (T₁P₀) at the 6 day of storage and the lowest dry matter content (9.20%) was found at the combined effect of low temperature (3°C) and wrapped in 75 µ PP bags (T₂P₂) at 3 day of storage (Table 5).

Table 4. Combined effect of temperature and PP bag on texture of mushroom (*Pleurotus ostreatus*)

Temperature	PP bag	Texture at different days after storage (DAS)						
		D ₁	D ₂	D ₃	D ₄	D ₅	D ₆	D ₇
T ₁	P ₀	1.00	4.00	4.00	4.00	4.00	4.00	4.00
	P ₁	1.00	1.00	1.33	1.67	2.00	2.67	3.67
	P ₂	1.00	1.00	1.00	1.68	2.00	2.33	2.67
	P ₃	1.00	1.33	1.67	2.33	2.67	3.00	3.67
T ₂	P ₀	1.00	1.00	1.67	2.33	3.33	4.00	4.00
	P ₁	1.00	1.00	1.00	1.00	1.00	1.33	1.67
	P ₂	1.00	1.00	1.00	1.00	1.00	1.00	1.00
	P ₃	1.00	1.00	1.00	1.00	1.33	1.67	2.00
LSD _{0.05}			0.31	0.43	0.34	0.20	0.71	0.62
LSD _{0.01}			0.43	0.59	0.47	0.27	0.98	0.85
Level of significant		ND	3.17**	1.61**	0.37**	0.11**	0.67*	1.22**

** = Significant at 1% level of probability, ND=statistical analysis is not done.

1 =Firm, 2 =Slightly, Soft, 3 = Soft and 4 = Very soft.

Table 5. Combined effect of temperature and PP bag on moisture content and dry matter content percentage of mushroom (*Pleurotus ostreatus*)

Temperature	PP bag	Moisture content (%) at different days after storage		Dry matter content (%) at different days after storage	
		D ₃	D ₆	D ₃	D ₆
T ₁	P ₀	54.42	17.08	45.58	82.92
	P ₁	83.79	81.19	16.21	18.81
	P ₂	83.33	80.68	16.67	19.32
	P ₃	85.61	80.05	14.39	19.95
T ₂	P ₀	70.85	45.15	29.15	54.85
	P ₁	89.00	82.65	11.00	17.35
	P ₂	90.80	88.95	9.20	11.05
	P ₃	89.48	84.09	10.52	15.91
LSD _{0.05}		0.65	0.634	1.85	1.24
LSD _{0.01}		0.90	0.87	2.54	1.71
Level of significant		47.97**	218.56**	47.97**	218.56**

** = Significant at 1% level of probability.

Weight loss of mushroom

The highest weight loss (30.33%) was found at the combined effect of ambient temperature and unwrapped condition (T_1P_0) at the 6th day of storage and the lowest weight loss (2.03%) was found at the combined effect low temperature (3°C) and wrapped in 75 μ PP bags (T_2P_2) at 3rd day of storage (Table 6).

Total protein percentage

The combined effects of temperature and thickness of PP bags were statistically significant to influence protein content of mushroom at 3 and 6 days after storage. The highest protein content (29.37%) was found at the combined effect of ambient temperature and wrapped in 75 μ PP bag (T_1P_2) at the 3 days of storage and the lowest protein content (7.79%) was found at the combined effect of ambient temperature and unwrapped condition (T_1P_0) at the 6 day of storage (Table 7).

Shelf life

The combined effects of temperature and thickness of PP bags were statistically significant to influence shelf life of mushroom. The highest shelf life (15.00%) was found at the combined effect of low temperature and wrapped in 75 μ PP bag (T_1P_2) and the lowest shelf life (1.66%) was found at the combined effect of ambient temperature and unwrapped condition (T_1P_0) (Fig. 1).

Table 6. Combined effect of temperature and polypropylene bag on weight loss percentage of mushroom (*Pleurotus ostreatus*)

Temperature	Polypropylene bag	Weight loss (%)	
		D ₃	D ₆
T ₁	P ₀	20.77	30.33
	P ₁	6.47	10.51
	P ₂	5.04	8.12
	P ₃	10.76	12.17
T ₂	P ₀	5.55	9.85
	P ₁	3.67	5.30
	P ₂	2.03	3.71
	P ₃	4.76	7.47
LSD _{0.05}		0.74	1.47
LSD _{0.01}		1.02	2.03
Level of significant		50.95**	92.68**

** = Significant at 1% level of probability.

Table 7. Combined effect of temperature and PP bag on percent protein content of mushroom (*Pleurotus ostreatus*)

Temperature	PP bag	Protein content (%)	
		D ₃	D ₆
T ₁	P ₀	16.18	7.79
	P ₁	27.77	17.85
	P ₂	29.37	21.05
	P ₃	25.24	13.72
T ₂	P ₀	25.61	16.89
	P ₁	21.17	13.26
	P ₂	25.17	18.79
	P ₃	18.84	11.59
LSD _{0.05}		0.63	1.23
LSD _{0.01}		0.87	1.70
Level of significant		87.99**	56.76**

** = Significant at 1% level of probability.

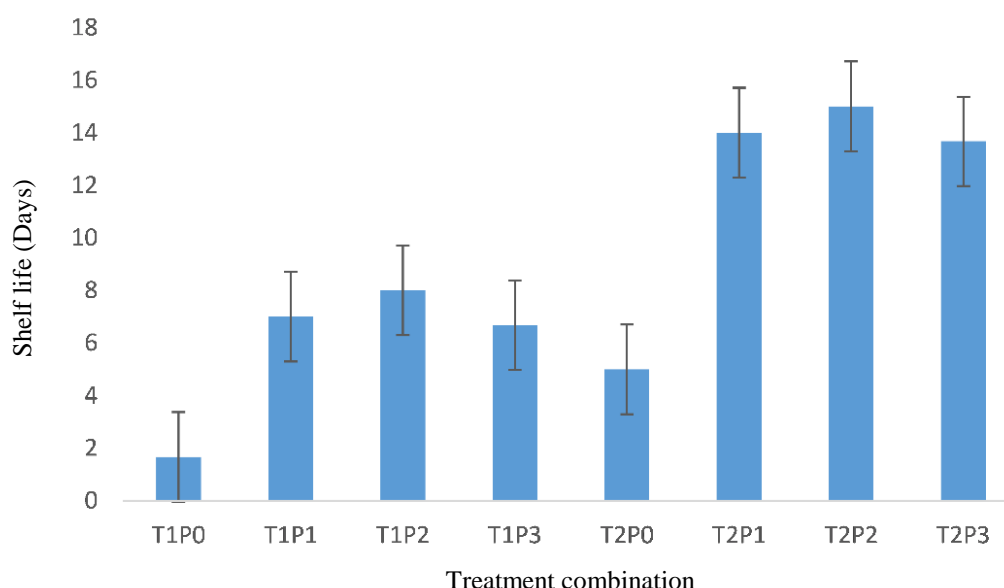


Fig. 1. Combined effect of temperature and thickness of PP bags on shelf life (days) of mushroom (*Pleurotus ostreatus*).

DISCUSSION

Color is one of the most significant criteria of edible mushroom. It was investigated that color changes of mushroom depend on various postharvest treatments. The raise in color score during storage might be due to series of physico-chemical changes like the rapid respiration rate and temperature, increase in microbial attack of the fruiting bodies, caused by enzymatic oxidation and degradation. It is recognized that high temperature caused rapid respiration and low temperature slow respiration. For this reason, mushroom kept in low temperature is slow rate in color change but in ambient condition fast change in color. Mohapatra et al. (2008) reported that a steady increase in the color pattern was obvious as storage time progressed. The browning index values increased with storage time (Hosseini & Moradinezhad, 2018).

At 2nd days after storage, mushroom attained freshness score of 4.00 in unwrapped treatments condition. Freshness was best at mushrooms that held in polypropylene bag of 75 μ and stored at 3 $^{\circ}$ C. The present result was at part with the findings of Choi and Kim (2003) who reported that film packaging prevented the degradation of mushroom freshness and texture during storage. In compare between frizzing and ambient condition, most satisfactory result was come in frizzing due to slower rate of change of chemical and microbial activity. This result is similar to Alikhani-Koupaei et al. (2014).

Oyster mushroom possesses a very pleasant flavor and piquant taste (Strmiskova et al., 1992). Flavor is depended on many factors (like microbial growth, chemical properties and vitamin). At harvesting, mushroom had a specific excellent flavor. During storage the flavor was changed. Mushroom held in polypropylene bag of 75 μ and stored at 3 $^{\circ}$ C the flavor was preserved better. Low temperature (3 $^{\circ}$ C) is one of the major causes for long time flavor preservation. Mushroom kept in uncontrolled treatment only 2 days the flavor is preserved. Thick polypropylene bag causes higher respiration and high temperature. So, rapid deterioration of flavor occurred. The result was similar to Beit-Halachmy and Mannheim (1992).

Due to postharvest treatment the texture was changed from firm to very soft. After harvesting due to rapid respiration, high temperature and rapid microbial growth the texture

was changed. Mushroom held in polypropylene bag of 75 μ and stored at 3 °C had lower rate of respiration and transpiration. So, in T₂P₂ the texture can preserved long time but mushroom held in control treatment the texture can stay only 2 days. Murr and Morris (1975) reported that changes to texture were delayed in non-perforated film as the respiration rate decreases. Lopez-Briones et al. (1993) reported that texture losses decrease when the carbon dioxide concentration increases which resembles to this studies. Mushroom firmness was comprehensively influenced by cooling rate, additional packaging barrier and their interaction (Salamat et al., 2020).

Due to different postharvest treatment the moisture content was gradually decreased. Narayana and Pal (1993) reported that Polyethylene wrapping reduces the rate of respiration by creating modified atmosphere around the vegetable, fruits and reduce moisture loss than ambient condition. As for dry matter content, the percent dry matter content increased with the increase in storage duration. Due to losses of moisture content the dry content is increased. Mushrooms with a high dry matter content have a better shelf life. Numerically the dry matter percent of fruiting body ranged from 9.80-10.53 (Bhattacharjya et al., 2015).

Temperature is the most important factor in preserving the quality attributes of mushrooms over time (Gholami et al., 2017). For high rate of respiration and temperature the weight loss of mushroom is occurred. Inside the thicker polypropylene bag, higher temperature and higher respiration rate were observed. Mushroom kept in 100 μ thickness of polypropylene bag have higher rate of respiration and rapid weight loss. Kreditsu et al. (2003) reported that the higher weight loss occurred in unwrapped fruits than the packed ones. According to Singh et al. (2003) high moisture loss in perforated films can be caused by high rate of transpiration and respiration through un-interrupted atmospheric column and under higher temperature and lower relative humidity compared to wrapped fruits.

Protein content of mushrooms decreased gradually with storage time. Modified atmosphere packaging exerted significant effects in influencing protein content of oyster mushroom. Lopez et al. (1992) reported that protein reduced throughout the storage time from 20.28% to 18.54% at modified atmospheric condition.

Effects of modified atmosphere packaging were also significant in extending shelf life of mushroom. The longest shelf life as obtained for mushroom kept in polypropylene bag of 75 μ and stored at 3 °C was possibly due to the reduced rate of physico-chemical changes, reduced weight loss and minimal disease severity. The mushroom packed in medium oxygen packaging (MOP) with active layer successfully increased the shelf-life of mushroom up to 11 days (Lyn et al., 2020). Burton and Twynning (1989) reported that mushroom have a short shelf-life of 1–3 days at ambient temperature and 8–10 days under refrigeration conditions. They are highly perishable for their thin and porous epidermal structure resulting in high respiration rates which induce degradation immediately after harvest. Gormley and MacCanna (1967) reported that the shelf-life of mushrooms might be prolonged by wrapping with polyvinyl chloride (PVC) films. Villaescusa and Gill (2003) reported that fresh mushrooms are known perishable commodity, with a short shelf life of 1-3 days when compared to maximum vegetables at ambient temperature, due to high respiration rate and low ethylene production. They have no cuticle to protect them from physical or microbial changes or water loss. The optimal conditions for prolonging the shelf life of mushrooms were found for packaging with medium oxygen level and film of higher permeability (Gantner et al., 2017).

CONCLUSION

Mushroom kept in polypropylene bag of 75 μ and stored at 3 °C gave the best result especially in relation to the peel color, Freshness, Flavor, Texture, moisture and dry matter content,

weight loss, total protein percentage compared to other treatments, and which ultimately resulted in prolonged shelf life of mushroom.

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Conflict of interest

The authors declare that they have no conflict of interest.

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