

EFFICACY OF WASHING AND POSTHARVEST TREATMENTS ON SHELF LIFE AND QUALITY OF OYSTER MUSHROOM

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ABSTRACT

An experiment was conducted to study the efficacy of washing (control and 5% hydrogen peroxide) and postharvest treatments (control, hot water treatment, wrapping with unperforated and perforated plastic bags, wrapping with brown paper bag and wrapping with aluminum foil) on shelf life and quality of oyster mushroom. Postharvest treatments caused significant effects to influence weight loss, dry matter and protein contents, disease incidence and shelf life of mushroom. At the 7th day of storage, the highest weight loss (98.08%) was recorded in the untreated mushrooms, whereas the lowest weight loss (33.62%) was observed in mushrooms wrapped in unperforated plastic bag. Protein content was observed to be higher (28.98%) in mushrooms wrapped with unperforated plastic bag followed by perforated plastic bag (25.00%) at the 5th day of storage. Protein content declined dramatically in mushrooms held at ambient conditions. The lowest protein content (2.97%) was recorded in the untreated mushrooms at the 7th day of storage. Unwashed mushrooms held at ambient temperature had the highest incidence of disease. The longest shelf life of 6 days was recorded in mushrooms wrapped in unperforated plastic bag, whereas the shortest shelf life (3 days) was found in the untreated mushrooms.

Key Words: Oyster mushroom *Pleurotus florida*, Shelf life, Washing, Modified atmosphere

INTRODUCTION

Mushroom is a fleshy, spore-bearing fruiting body of a fungus grown above-ground on its food sources. Edible mushroom is one of the most popular food items all over the world. Mushroom contains 20-35% protein, which is higher than those of many vegetables and fruits (Pathak *et al.*, 1997). Mushroom production and processing. It also contains appreciable amounts of vitamin C and B complex, potassium, phosphorus and sodium (Pathak *et al.*, 1997). Mushrooms have high water content (85-95%), which is lost rapidly by evaporation and transpiration. The rate of water loss depends on mushroom structures, and relative humidity, temperature, air movement and atmospheric pressure of the storage environment. The major limitations in mushroom marketing include wilting and shriveling due to rapid water loss, which render them unfit for marketing and consumption. Washing of mushroom is useful to extend shelf life. Different types of washing treatments have been examined in reducing postharvest spoilage of mushrooms.

Types of washing techniques include 0.5% calcium chloride and 0.5% citric acid (Jayathunge and Illeperuma, 2001 & 2005), combination wash with 50 ppm chlorine dioxide, 0.1% sodium erythrobate and 0.05% calcium chloride (Guthire and Beelman, 1989), and 0.5-1.5% potassium metabisulphite (Gothandapani *et al.*, 1997). The storage of mushrooms in modified atmosphere packaging (MAP) is effective in reducing moisture loss. The use of MAP is an inexpensive tool in storing perishables. MAP regulates gaseous exchange, reduces weight loss and spoilage, and maintains quality of mushrooms during postharvest handling. Maximum shipping period of oyster mushroom appeared to be 21 days considering additional 5-day marketing period at low temperature of 7°C while stored in tray type packages (YounMoon *et al.*, 2004). Once the mushroom matures, the degradation process starts, and the mushroom becomes inedible. Development of brown colour is the first sign of deterioration and is a major factor contributing to quality losses. The present study was therefore undertaken to examine suitability of washing and modified atmosphere packaging to extend shelf life and maintain quality of oyster mushroom.

MATERIALS AND METHODS

The experiment was carried out at the laboratory of the Department of Horticulture, Bangladesh Agricultural University, Mymensingh. The experiment consisted of two factors, namely washing (no-washing and washing with 5% H₂O₂) and modified atmosphere packaging (unwrap control, hot water treatment @ 40 ± 2°C for 40 seconds, wrapping with plastic bags with or without perforations, brown paper and aluminum foil), and the experiment was laid out in a completely randomized design with three replications of 12 fruiting bodies. The experimental mushrooms were obtained from National Mushroom Development and Extension Center, Savar, Dhaka, Bangladesh. Parameters investigated were freshness, colour, dry matter content, weight loss, total protein, disease incidence and shelf life. Freshness and colour of mushrooms were determined objectively using numerical rating scales. For determination of weight loss, initially the fruiting bodies of each replication of each treatment were weighed. Weight loss was calculated using the following formula, weight loss (%) = (Initial weight – Final weight)/Initial weight × 100. For dry matter estimation, firstly moisture content was determined. For this, 5g of fruiting bodies was weighed in a Petri dish from each replication of each treatment. The Petri dish was placed in an electric oven at 80°C for 72 hrs until a constant weight attained. Moisture content was calculated using the formula, moisture content (%) = (Moist weight – Dry weight)/Moist weight × 100. Then the dry matter content was found out using the formula, dry matter (%) = (100 – % moisture content). Total protein content was estimated using the modified micro-Kjeldahl method (AOAC, 1980). Protein estimation was based on estimating nitrogen content. Total protein was calculated by multiplying nitrogen content by 6.25. This is expressed as crude protein since the non-protein nitrogen was also taken into consideration in the present method of protein determination. Disease incidence was calculated by the formula, disease incidence (%) = (Number of infected fruiting body/Total number of fruiting body) × 100. Shelf life was determined by counting the number of days until which optimum

marketing and eating qualities were retained. Data were statistically analyzed and analysis of variance for the parameters was accomplished by F variance test. The mean separation was done by LSD (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Freshness

Freshness is one of the important qualities of edible mushrooms. The tissues of mushroom fruiting bodies become softer and get spoiled due to water loss. Washing caused significant effect in retaining freshness. Freshness of mushroom at the 3rd day of storage was fair (2.3), which changed to unacceptable stage (4.4) at the 7th day of storage in the unwashed mushrooms. On the other hand, the washed mushrooms had better freshness scores (Table 1). Modified atmosphere (MA) packaging exerted significant effects on freshness changes during storage. Freshness deteriorated with the duration of storage in all MA treatments at varying rates. Freshness score was 2.8 in the untreated mushroom, whereas the mushrooms wrapped in unperforated plastic bags had freshness score 1.5 at the 3rd day of storage (Table 2). The present result was at par with the findings of Choi and Kim (2003) who reported that film packaging prevented the deterioration of mushroom freshness and texture during storage. The degradation of freshness over time would probably be due to the increase in transpiration, dehydration, respiration and disease attack.

Table 1. Effects of washing on freshness and colour of oyster mushroom during storage

Washing	Freshness ^a at different days after storage			Colour ^b at different days after storage		
	3	5	7	3	5	7
Control (unwashed)	2.3	3.3	4.4	2.3	3.2	4.5
Washing with H ₂ O ₂	2.0	3.1	4.1	1.9	3.0	4.1
Level of significance	**	**	**	**	**	**
LSD _(0.05)	0.15	0.11	0.13	0.22	0.10	0.24
LSD _(0.01)	0.26	0.18	0.28	0.37	0.18	0.35

** = significant at 1% level of probability. ^a = Freshness scale (1-1.4 = excellent, 1.5-2.4 = good, 2.5-3.4 = fair, 3.5-4.4 = poor, 4.5-5.0 = unacceptable); ^b = Colour scale (1-1.4 = white, 1.5-2.4 = one-quarter brown, 2.5-3.4 = half-brown, 3.5-4.4 = three-quarter brown, 4.5-5.4 = full brown, 5.5-6.0 = black/rotten)

Colour

Gradual change in colour of mushroom from white to black occurs with the duration of storage. Washing showed significant variation in the retention of colour during storage. The colour score at the 3rd day of storage was 2.3 (one-quarter brown), which increased to nearly 4.5 (unacceptable) at the 7th day of storage in unwashed mushrooms. On the other hand, the washed mushrooms at the 3rd and 7th days of storage had colour scores of 1.9

(one-quarter brown) and 4.1 (three-quarter brown), respectively (Table 1). Postharvest treatments resulted in significant effects in colour changes during storage. The deterioration of mushroom colour was observed in all treatments at varying rates. At the 3rd day of storage, the mushrooms of control (2.8), aluminum foil (2.4) and brown paper (2.3) were found half-brown (unacceptable), whereas the mushrooms wrapped in unperforated (1.6) and perforated plastic bags (1.9), and those treated with hot water (1.9) remained acceptable in terms of colour. Combined wash with chlorine dioxide, sodium erythorbate and calcium chloride was found effective to reduce the bacterial population and caused less colour deterioration during storage of mushroom (Guthrie and Beelman, 1989). Rajarathnam *et al.* (1983) observed an increase in activities of o-diphenol oxidase and proteases, and a fall in total phenols and an increase in free amino acids, which might have resulted in the increased discoloration of mushroom with the progress in storage duration.

Table 2. Effects of modified atmosphere packaging on freshness and colour of oyster mushroom during storage

Modified atmosphere packaging (MAP)	Freshness ^a at different days after storage			Colour ^b at different days after storage		
	3	5	7	3	5	7
Control (ambient condition)	2.8	4.4	4.9	2.8	4.4	5.2
Hot water treatment (40 ± 2°C)	2.2	3.2	4.3	1.9	2.5	4.3
Wrapping in unperforated plastic bag	1.5	2.1	3.2	1.6	2.1	3.3
Wrapping in perforated plastic bag	1.9	2.7	4.3	1.9	2.5	4.3
Wrapping in brown paper bag	2.3	3.5	4.3	2.7	3.2	4.3
Wrapping in aluminum foil	2.4	3.4	4.5	2.4	3.5	4.5
Level of significance	**	**	**	**	**	**
LSD _(0.05)	0.16	0.19	0.19	0.19	0.16	0.22
LSD _(0.01)	0.20	0.25	0.26	0.26	0.28	0.29

** = significant at 1% level of probability. ^a = Freshness scale (1-1.4 = excellent, 1.5-2.4 = good, 2.5-3.4 = fair, 3.5-4.4 = poor, 4.5-5.0 = unacceptable); ^b = Colour scale (1-1.4 = white, 1.5-2.4 = one-quarter brown, 2.5-3.4 = half-brown, 3.5-4.4 = three-quarter brown, 4.5-5.4 = full brown, 5.5-6.0 = black/rotten)

Total weight loss

Significant variation was observed between washed and unwashed mushrooms in respect of total weight loss. At the 3rd day of storage, total weight loss was 38.89% in unwashed mushrooms which increased to 62.04% at the 7th day of storage (Table 4). Modified atmosphere packaging exhibited pronounced effects in reducing total weight loss of mushroom during storage. At the 7th day of storage, total weight loss was found to be the maximum (89.08%) in the unwrapped mushrooms, whereas the minimum (33.62%) weight loss was observed in mushrooms held in unperforated plastic bag (Table 5). The

combined effects of washing and modified atmosphere packaging were significant in terms of weight loss of mushroom fruiting bodies during storage (Table 6).

Table 3. Combined effects of washing and modified atmosphere packaging freshness and colour of oyster mushroom during storage

Washing × MAP		Freshness ^a at different days after storage			Colour ^b at different days after storage		
		3	5	7	3	5	7
Control (non-washed)	T ₁	2.9	4.6	5.0	2.9	4.6	5.3
	T ₂	2.3	3.3	4.4	2.4	3.3	4.4
	T ₃	1.7	2.2	3.3	1.7	2.2	3.4
	T ₄	2.0	2.7	4.4	2.0	2.6	4.4
	T ₅	2.4	3.6	4.5	2.0	2.8	4.4
	T ₆	2.5	3.7	4.8	2.5	3.7	4.8
Washed with H ₂ O ₂	T ₁	2.7	4.2	4.8	2.7	4.2	5.0
	T ₂	2.1	3.1	4.2	2.2	3.0	4.2
	T ₃	1.4	1.9	3.0	1.4	2.0	3.1
	T ₄	1.9	2.7	4.1	1.7	2.4	4.1
	T ₅	2.2	3.3	4.1	1.7	2.3	4.2
	T ₆	2.3	3.2	4.2	2.2	3.4	4.2
Level of significance		**	**	**	**	**	**
LSD _(0.05)		0.23	0.26	0.27	0.27	0.23	0.31
LSD _(0.01)		0.31	0.35	0.37	0.36	0.31	0.42

T₁: Control (ambient condition), T₂: Hot water treatment (40 ± 2°C), T₃: Wrapping in unperforated plastic bag, T₄: Wrapping in perforated plastic bag, T₅: Wrapping in brown paper bag, T₆: Wrapping in aluminum foil, **= Significant at 1% level of probability. ^a = Freshness scale (1-1.4 = excellent, 1.5-2.4 = good, 2.5-3.4 = fair, 3.5-4.4 = poor, 4.5-5.0 = unacceptable); ^b = Colour scale (1-1.4 = white, 1.5-2.4 = one-quarter brown, 2.5-3.4 = half -brown, 3.5-4.4 = three-quarter brown, 4.5-5.4 = full brown, 5.5-6.0 = black /rotten).

Dry matter content

The variation in dry matter content between unwashed and washed mushrooms was found to be significant. At the 3rd day of storage, the highest dry matter content (18.75%) was observed in unwashed mushrooms and the lowest (13.47%) in washed mushrooms (Table 4). Modified atmosphere packaging caused significant effects in influencing dry matter content of oyster mushroom during the entire period of investigation. At the 7th day of storage, the maximum (83.32%) and the minimum (8.17%) dry matter contents were found in mushrooms kept unwrapped and those wrapped with unperforated plastic bags, respectively (Table 5). The combined effects of washing and postharvest treatments were significant during of storage (Table 6).

Table 4. Main effects of washing on weight loss (%), dry matter content (%), disease incidence (%), total protein content (%) and shelf life of oyster mushroom during storage

Washing	Weight loss (%) at different days after storage				Dry matter content (%) at different days after storage				Disease incidence (%) at different days after storage				Total protein content (%) at different days after storage				Shelf life (days)
	3	5	7		3	5	7		3	5	7		3	5	7		
Control (non-washed)	38.99 (37.44)	58.34 (51.21)	62.04 (53.50)		18.75	27.06	35.44		14.82 (20.10)	32.59 (33.86)	57.41 (70)		23.56	17.28	11.00		4.29
Washed with H ₂ O ₂	36.30 (34.68)	54.62 (48.44)	57.37 (50.09)		13.47	28.82	30.47		9.26 (12.95)	23.19 (27.66)	43.52 (41.12)		25.49	19.70	13.91		4.98
LSD _(0.05)	5.38	6.67	5.31		1.25	1.47	1.75		NS	NS	NS		0.04	0.03	0.11		0.55

Table 5. Main effects of postharvest treatments weight loss (%), dry matter content (%), disease incidence (%), total protein content (%) and shelf life of oyster mushroom during storage

Postharvest treatments	Weight loss (%) at different days after storage				Dry matter content (%) at different days after storage				Disease incidence (%) at different days after storage				Total protein content (%) at different days after storage				Shelf life (days)
	3	5	7		3	5	7		3	5	7		3	5	7		
T ₁	82.28 (65.09)	89.70 (71.37)	98.08 (70.74)		44.80	64.07	83.32		44.80 (22.09)	76.16 (32.51)	78.62 (50.08)		15.85	8.40	2.97		3.68
T ₂	10.18 (17.85)	25.92 (30.57)	34.64 (36.04)		9.31	13.13	16.95		10.80 (10.10)	24.90 (36.39)	50.34 (46.84)		28.35	22.04	15.72		5.70
T ₃	7.06 (15.35)	29.54 (32.89)	33.62 (35.46)		7.07	7.56	8.17		6.97 (12.33)	7.88 (22.05)	8.48 (38.26)		32.54	28.97	25.38		4.31
T ₄	8.37 (16.79)	26.24 (30.77)	34.02 (35.65)		7.77	10.13	12.45		8.53 (22.07)	16.34 (29.67)	16.57 (45.22)		30.16	25.00	19.85		3.85
T ₅	38.54 (38.33)	77.31 (61.55)	79.07 (62.93)		11.00	19.47	28.11		16.77 (12.03)	40.58 (29.43)	59.17 (45.22)		21.69	15.01	8.31		5.79
T ₆	79.14 (62.94)	87.81 (69.98)	90.18 (71.82)		16.77	32.32	48.73		27.67 (12.33)	56.88 (34.54)	76.33 (46.84)		18.56	11.53	4.51		4.48
LSD (0.05)	1.84	2.29	1.82		3.93	1.47	1.75		NS	NS	NS		0.04	0.03	0.11		0.41

T₁ : Control (ambient condition), T₂ : Hot water treatment (40 ± 2°C), T₃ : Wrapping in unperforated plastic bag, T₄ : Wrapping in perforated plastic bag, T₅ : Wrapping in brown paper bag, T₆ : Wrapping in aluminum foil

Table 6. Combined effects of washing and post-harvest treatments on total weight loss (%), dry matter content (%), total protein content (%) and disease incidence (%) of oyster mushroom during storage

Wrapping × Postharvest treatments	Weight loss (%) at different days after storage				Dry matter content (%) at different days after storage				Disease incidence (%) at different days after storage				Total protein content (%) at different days after storage			
	3	5	7		3	5	7		3	5	7		3	5	7	
Control (non-washed)	83.49 (66.01)	91.88 (69.77)	88.31 (70.02)		57.27	72.64	87.93		15.63	8.12	0.63		22.22	34.44	66.67	
T ₁	15.75 (65.87)	31.25 (70.21)	35.03 (74.53)		6.67	13.77	17.91		27.31	29.94	14.56		11.11	27.78	50.00	
T ₂	6.11 (41.07)	23.73 (29.14)	31.96 (59.19)		7.20	7.70	8.30		31.47	27.44	23.38		5.56	22.22	44.44	
T ₃	8.00 (60.02)	24.51 (63.05)	35.27 (65.44)		8.95	10.77	13.34		20.50	23.75	18.00		11.11	27.78	44.44	
T ₄	43.20 (17.39)	79.50 (31.48)	73.80 (37.10)		11.47	21.60	31.74		19.94	13.13	6.31		11.11	38.88	55.55	
T ₅	81.06 (16.41)	88.48 (31.81)	89.85 (36.42)		18.47	35.87	53.45		17.50	14.31	3.13		22.22	44.45	61.11	
T ₆	83.21 (64.18)	91.33 (72.96)	92.89 (71.47)		32.45	55.51	78.71		16.06	8.69	1.33		22.22	27.78	66.67	
Washed with H ₂ O ₂	8.95 (12.33)	28.76 (29.66)	36.42 (35.80)		8.96	12.49	16.01		29.36	23.13	16.88		11.11	22.22	50.00	
T ₁	4.57 (35.58)	23.73 (29.14)	34.25 (66.67)		6.93	7.43	8.03		33.62	30.50	27.38		5.56	11.11	27.78	
T ₂	7.79 (16.19)	27.32 (73.42)	31.63 (34.20)		7.30	9.50	11.60		13.81	26.25	21.69		11.11	22.22	44.44	
T ₃	33.89 (23.37)	75.11 (32.41)	84.34 (36.27)		10.13	17.34	24.49		23.44	16.88	10.31		11.11	33.33	55.55	
T ₄	75.06 (14.29)	88.07 (33.96)	82.73 (34.41)		15.07	28.67	44.00		19.62	12.75	5.88		22.22	22.22	61.11	
T ₅	2.51	3.15	2.52		12.65	2.08	2.47		0.05	0.05	0.15		28.00	25.20	23.96	
T ₆																

T₁ : Control (ambient condition), T₂ : Hot water treatment (40 ± 2°C), T₃ : Wrapping in unperforated plastic bag, T₄ : Wrapping in perforated plastic bag, T₅ : Wrapping in brown paper bag, T₆ : Wrapping in aluminum foil. Figures in the parentheses are the values obtained by Arc-Sine transformation

Total protein content

Protein content of mushrooms decreased gradually with storage duration. It decreased from 25.49 to 13.91% and 23.56 to 11.00% in the unwashed and washed mushrooms at the 3rd and 7th days of storage, respectively (Table 4). Modified atmosphere packaging exerted significant effects in influencing protein content of oyster mushroom. At the early part of storage, protein content was the highest (32.54%) in mushrooms held in unperforated plastic bag and the lowest (15.85%) was found in mushrooms held unwrapped. Protein contents dramatically declined in untreated mushrooms (15.85 to 2.97% from 3rd to the 7th day of storage, respectively). The rates of decrease in total protein contents were significantly slower in those mushrooms stored in plastic bags without perforation (25.38%) and with perforations (19.85%) at the 7th day of storage (Table 5). In case of the combined effects of washing and different modified atmosphere packaging, significant variation was observed in relation to total protein content (Table 6).

Disease incidence

The disease level progressed with the duration of storage of oyster mushrooms. No significant variation in disease incidence was observed between unwashed and washed mushrooms under different postharvest treatments on different dates of counting. However, the washed mushrooms had lesser disease as compared to unwashed mushrooms (Table 4). Non-significant variation was also found in respect of postharvest storage treatments to influence disease incidence except at the 7th day of storage. Mushrooms held in unperforated plastic bags maintained lower levels of infection during the entire period of investigation (Table 5).

Shelf life

Washing resulted in significant extension of shelf life of oyster mushroom. The shelf lives of the washed and unwashed mushrooms were 4.98 and 4.29 days, respectively. The effects of modified atmosphere packaging were also significant in extending shelf life of mushroom (Table 4). The shortest (3.68 days) and the longest (5.79 days) shelf lives were observed in mushrooms kept unwrapped and those wrapped in unperforated plastic bag, respectively (Table 5). The combined effects of washing and postharvest treatments were significant in relation to shelf life extension. The longest shelf life (6.2 days) was found in mushrooms that were washed and sealed in unperforated plastic bag (Fig. 1).

In conclusion, the shelf life of oyster mushroom would significantly be extended using modified atmosphere packaging, especially using unperforated plastic bags. This packaging also reduced the rates of protein degradation of mushroom after harvest.

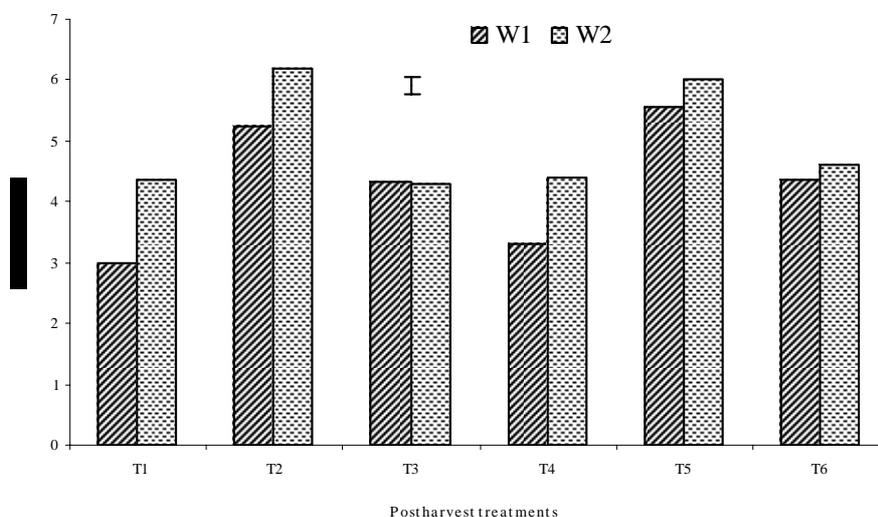


Fig. 1. The combined effects of different postharvest treatments and washing on changes of shelf life of oyster mushroom. Vertical bars indicate LSD at 5% level of significance. W1 = Control (non-washed), W₂ = Washed with H₂O₂, T₁: Control (ambient condition), T₂: Hot water treatment (40 ± 2°C), T₃: Wrapping in unperforated plastic bag, T₄: Wrapping in perforated plastic bag, T₅: Wrapping in brown paper bag, T₆: Wrapping in aluminum foil.

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