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Research Article

STUDIES ONSHELF LIFE UNDER DIFFERENT STORAGE CONDITIONS OF FRESH OYSTER MUSHROOM (*Pleurotus sajorcaju*)

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Abstract- Storage studies for extension of shelf-life of fresh oyster mushroom in different containers *viz.*, open vessels, polyethylene bags and paper bags at room temperature, house-hold cold storage system and refrigerator conditions revealed that house-hold cold storage system and refrigerator conditions in paper bags gave better results from storage points of view. From sensory point of view, fresh mushroom could not be stored more than two days at room temperature, four days in cold storage system and six days in refrigerated conditions.
Keywords- Shelf-life, Storage, Sensory point, House-hold cold storage system, Refrigerated.

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Introduction

The Pleurotus mushroom which is generally referred to as "Oyster" mushroom world over and as "Dhingri" in India, has its origin form Greek word "Pleuro" which means farmed laterally or in a side way position, referring to the lateral position of the stiple (stem) in relation to pileus (lap), (Jandalik, 1997).Supply is highly seasonal and a glut usually occurs in the peak period (September- March), resulting in enormous losses due to improper post-harvest handling [1].

Materials & Methods

The study was conducted during the year 2004-2006. Oyster mushroom was produced in KVK Jabalpur on wheat straw following standard practices recommended [2] .There were 20 grower involved in the study. There were three storage condition *viz.* at room temperature (C_1), at house-hold cold storage (C_2), at refrigerator (C_3)& three packaging materials used *viz.* without packaging material (P_1), perforated (12 perforations of 4 mm in diameter each) low-density polyethylene (20um thick) bags (P_2). Paper bag (P_3).Fresh oyster mushroom plucked carefully with wearing hand glaives after 21 days of inoculation. Each sample are contained of 100 gm fresh Oyster Mushroom, which were filled in the above three storage condition for 01-05 days of the storage used qualitative study on different sample were conducted the qualitative parameters were Sensory evaluation following the method suggested by Ihekoronye and Ngoddy(1985)[3]. Full-grown fresh mushrooms divided into nine groups. Each group containing 100g were then randomly taken, storage in open vessels, Low density polyethylene bags and paper bags at room temperature 28.±2, house-hold cold storage system and refrigerator conditions according to the following plan.

1. Storage without packaging material at room temperature (C_1P_1)
2. Storage in perforated (12 perforations of 4 mm in diameter each) low-density polyethylene (20um thick) bags at room temperature. (C_1P_2)
3. Storage in paper bag at room temperature (C_1P_3).
4. Storage without packaging material at house-hold cold storage (C_2P_1)
5. Storage in perforated low-density polyethylene at house-hold cold storage (C_2P_2).
6. Storage in paper bag at house -hold cold storage (C_2P_3).
7. Storage without packaging at refrigerator (C_3P_1).
8. Storage in perforated low-density polyethylene in refrigerator (C_3 P_2).
9. Storage in paper bag in refrigerator (C_3 P_3).

House- hold cold storage System

House-hold cold storage was developed using a locally constructed low external input, simple and cheap cooling system. The cooling structure consists of two-burnt clay post, placed one inside the other. The space between the pots were filled with riverbed sand and always kept wet, which provides the cooling medium. While the space inside the inner pot provides the storage chamber. The top is covered with a slab made of the clay tile. Cooling takes place because of heat transfer from the produce (mushroom) in the storage chamber to the wet riverbed sand (the cooling medium), from where the heat is further transferred to the outer surface and eventually dissipated with the evaporating water. The system dose not requires electric power. During storage mushroom at different condition (room temperature 28± 2^0C, house-hold cold storage chamber temperature 15±2^0c and refrigerator temperature is 4^0C±2^0c) weight losses were recorded daily. Sensory evaluation of samples were also done by a 10 member of panellists using the 9 point. Hedonic scale ranging from 1 = dislike extremely to 9 = like extremely. Ihekoronye and Ngoddy (1985) after boiling the samples in boiling water for 15 min.

Results & Discussion

In this investigations, raw fresh oyster mushroom (*P. sajorcaju*) were stored for 5 days at room temperature, house-hold cold storage system and refrigerated conditions using three types of packaging materials *viz.*; open vessels, polyethylene bags and paper bags. Each day the losses in weight and sensory quality characteristics like flavour, tenderness, colour and overall acceptability were evaluated on 9 points hedonic scale. The obtained results have been

reported and discussed hereunder [4].

Effect on the colour

[Table-1] shows that the mean score values for colour of raw fresh mushroom under different storage conditions and packaging materials were 5.9,6.5 and 6.6 at room temperature, 7.9,7.8 and 7.9 in house-hold cold storage system and 8.0,8.0 and 8.0 in refrigerated storage conditions with respect the different packaging materials *viz.*, open vessels polyethylene bags, and paper bags respectively on first day of storage period. There was no significant difference between all type of packaging materials, However, storage methods have significant differences with a higher values in house-hold cold storage system and refrigerated conditions.

Table-1 *Changes in mean score values for Colour, of oyster mushroom (Pleurotus sajorcaju) during different storage conditions*

Storage Method	Storage period (days)																			
	Ist day				2nd day				3rd day				4th day				5th day			
	P1	P2	P3	Mean	P1	P2	P3	Mean	P1	P2	P3	Mean	P1	P2	P3	Mean	P1	P2	P3	Mean
C_1	5.9	6.5	6.6	6.3	5.6	5.9	5.8	5.76	4.80	4.90	4.50	4.73		-	-	-	-	-	-	-
C_2	7.9	7.8	7.9	7.87	6.06	6.2	6.3	6.19	5.70	6.10	6.20	6.00	5.2	5.1	5.0	5.10	-	4.10	4.0	2.7
C_3	8.0	8.0	8.0	8.0	7.90	7.7	7.8	7.80	7.2	7.0	7.1	7.10	6.20	6.30	6.10	6.20	5.8	6.1	5.9	5.90
Mean	7.27	7.43	7.50		6.52	6.60	6.63		5.9	6.0	5.9		3.80	3.80	3.70		1.93	3.40	3.30	
SEM±	C	P	CXP		C	P	CXP		C	P	CXP		C	P	CXP		C	P	CXP	
	0.15	0.15	0.24		0.14	0.14	0.25		0.08	0.08	0.15		0.06	0.06	0.11		0.07	0.07	0.12	
CD at 5%	0.46	NS	NS		0.43	NS	NS		0.25	NS	NS		0.19	NS	NS		0.20	0.200	0.36	

C_1 At room temperature
C_2 House hold cold storage
C_3 Refrigerator

P_1 Open vessels
P_2 Polyethylene bags
P_3 Paper bags

On second day of storage period, the mean score values for colour were 5.6,5.9, and 5.9 and 5.8 at room temperature, 6.6,6.2 and 6.3 in house-hold cold storage system and 7.9,7.7 and 7.8 in refrigerated conditions with respect to the different packaging materials *viz.*, open vessel, polyethylene bags and paper bags respectively. There was no significant difference between packaging materials as shown in the [Table-1]. However, the values for colour under various storage methods had significant differences. On third day of storage period, the mean score values for colour were 4.8,4.9 and 4.5 at room temperature, 6.19,5.70 and 6.10 in house-hold cold storage systems and 7.80,7.20 and 7.0 in refrigerated conditions with respect to different packaging materials *viz.*, open vessels, polyethylene bags and paper bags, respectively. There were no significant differences between packaging materials as shown in the [Table-1]. However, the values for colour under various storage methods had significant differences.

On fourth day of storage period, the mushrooms stored at room temperature were dull in colour and also not fit for consumption. The mean score values for colour were 5.2,5.1 and 5.0 in house-hold cold storage systems and 6.20,6.30 and 6.10 in refrigerated conditions with respect to different packaging materials viz, open vessels, polyethylene bags and paper bags, respectively. There were no significant differences between packaging materials. However, the values for colour under various storage methods had significant differences.

On fifth day of storage period, the mushrooms stored in house-hold cold storage system and in open vessels were not fit for consumption. However, paper and polyethylene packed mushroom were better in colour.

Effect on the tenderness

[Table-2] shows that the mean score values for tenderness of raw fresh mushroom under different storage conditions and packaging materials were 5.9,5.7 and 5.8 at room temperature, 7.4,7.2 and 7.3 in house-hold cold storage systems and 8.0, 8.2 and 8.1 in refrigerated storage conditions with respect to different packaging materials *viz.*, open vessels, polyethylene bags and paper bags, respectively. On first day of storage period there was a no significant differences between all types of packaging materials. However, storage methods had significant differences with a higher value in house-hold cold storage system and refrigerated conditions.

Table-2 *Changes in means score values for Tenderness, of oyster mushroom (Pleurotus sajorcaju) during different storage conditions.*

Storage Method	Storage period (days)																			
	Ist day				2nd day				3rd day				4th day				5th day			
	P1	P2	P3	Mean	P1	P2	P3	Mean	P1	P2	P3	Mean	P1	P2	P3	Mean	P1	P2	P3	Mean
C_1	5.9	5.7	5.8	5.8	4.9	4.7	4.8	4.8	-	4.3	4.4	2.9	-	-	-	-	-	-	-	-
C_2	7.4	7.2	7.3	7.3	6.9	6.7	6.8	6.8	6.3	6.5	6.4	6.4	4.3	4.8	3.03	-	-	-	-	-
C_3	8.0	8.2	8.1	8.1	7.8	7.6	7.2	7.5	6.9	7.0	6.8	6.9	5.9	5.5	5.0	5.46	5.2	5.0	4.9	5.03
Mean	7.1	7.0	7.06		6.53	6.33	6.27		4.4	5.93	5.86		1.96	3.27	3.27		1.73	3.03	2.96	
SEM±	C	P	CXP		C	P	CXP		C	P	CXP		C	P	CXP					
	0.13	0.13	0.23		0.11	0.11	0.18		0.14	0.37	0.24		0.09	0.09	0.16		0.05	0.05	0.09	
CD	0.39	NS	NS		0.32	NS	NS		0.41	0.41	0.70		0.27	0.27	0.47		0.16	0.16	0.28	

C_1 At room temperature
C_2 House hold cold storage
C_3 Refrigerator

P_1 Open vessels
P_2 Polyethylene bags
P_3 Paper bags

On second day of storage period, the mean scare values for tenderness were slightly decreased in all the packaging materials and different storage systems. The values were 4.9,4.7 and 4.8 at room temperature, 6.9, 6.7 and 6.8 in house-hold cold storage system and 7.8, 7.6 and 7.2 in refrigerated storage conditions with respect different packaging materials *viz.*, open vessels, polyethylene bags and paper bags, respectively. There was no significant difference between packaging materials as shown in the [Table-2]. However, the values for tenderness under various storage methods had significant differences.

On third day of storage period, mushrooms stored at room temperature were not fit for consumption due to decrease in tenderness. However, the values for tenderness of stored mushroom were 6.3,6.5 and 6.4 in house-hold cold storage system and 6.9,7.0 and 6.8 in refrigerated storage conditions with respect to different packaging materials viz., open vessels, polyethylene bags and paper bags , respectively. On fourth day of storage period, the mean score values for tenderness were 4.3,4.8 and 3.03 in house-hold cold storage systems and 5.9,5.5 and 5.01 in refrigerated storage conditions with respect to the different packaging materials *viz.*, open vessels, polyethylene bags and paper bags, respectively. There was a significant difference between packaging materials and storages methods. On 5th day refrigerated mushroom showed better results.

Effect on the flavour

[Table-3] shows that the values for flavour of raw mushrooms stored in different

packaging materials under different methods were 6.60,6.20,6.00 at room temperature 7.20, 6.90 and 7.10 in house-hold cold storage system and 7.50,7.40 and 7.60 in refrigerated storages conditions with respects to different packaging materials *viz.*, open vessels, polyethylene bags and paper bags, respectively. On first day, there was no significant difference between packaging materials. However, methods of storage system had significant variations. The house-hold cold storage system and refrigerated storage exhibited better result as compared to the materials stored at room temperature. On second day the values for flavour were 5.50, 4.50 and 4.20 at room temperature, 6.70,5.80 and 5.70 in house-hold cold storage system and 5.80,5.80 and 5.90 in refrigerated storage conditions with respect to different packaging materials *viz.,* open vessels, polyethylene bags and paper bags, respectively. The results reveal that there were no significant differences between packaging materials and storage methods.

Table-3 *Changes in mean score values for flavour, of oyster mushroom (Pleurotus sajorcaju) during different storage conditions.*

Storage Method	Storage period (days)																			
	I st day				2nd day				3rd day				4th day				5th day			
	P1	P2	P3	Mean	P1	P2	P3	Mean	P1	P2	P3	Mean	P1	P2	P3	Mean	P1	P2	P3	Mean
C_1	6.60	6.20	6.00	6.26	5.50	4.50	4.20	4.73	4.90	-	4.50	3.13	-	-	-	-	-	-	-	-
C_2	7.20	6.90	7.10	7.07	5.60	5.70	5.80	5.70	5.80	5.20	5.30	5.43	4.80	4.50	4.60	4.63	4.50	4.30	4.10	4.30
C_3	7.50	7.40	7.60	7.50	5.80	5.80	5.90	5.83	5.60	5.20	5.40	5.40	5.20	5.10	5.30	5.20	5.0	4.90	4.90	4.93
Mean	7.10	6.83	6.90		5.63	5.33	5.30		5.43	3.46	5.06		4.66	3.20	3.30		3.16	3.06	3.00	
$SE_M\pm$	C	P	CXP		C	P	CXP		C	P	CXP		C	P	CXP		C	P	CXP	
	0.10	0.10	0.17		0.13	0.13	0.22		0.10	0.10	0.17		0.12	0.12	0.20		0.11	0.11	0.18	
CD	0.30	NS	NS		0.31	0.31	0.53		0.35	0.35	0.60		0.35	0.35	0.60		0.32	NS	NS	

C_1 At room temperature
C_2 House hold cold storage
C_3 Refrigerator

P_1 Open vessels
P_2 Polyethylene bags
P_3 Paper bags

On third day of storage period, the mushroom stored in polyethylene bags at room temperature gave off flavour and were not fit for consumption. However, the values for flavour in open vessels and paper bags were 4.90 and 4.50 respectively at room temperature. In house-hold cold storage system and in refrigerated conditions, the values for flavour were 5.80,5.20 and 5.30 and 5.60,5.20 and 5.40, respectively with respect to different packaging materials viz., open vessels, polyethylene bags and paper bags. The results reveal that there was a significant difference between packaging materials and storage methods.

On fourth day of storage period, mushroom stored at room temperature in polyethylene bags and paper bags gave off flavour and were not fit for consumption. However, in open vessels the value for flavours was 4.0 .The mushrooms stored under different storage methods showed lower values for flavour i.e. 4.80,4.50, and 4.60 in open vessels, polyethylene bags and paper bags respectively in house-hold cold storage system and 5.20,5.10 and 5.30 in refrigerated storage conditions. The statistical analysis showed that there was a significant difference in both packaging materials and storage methods.

On fifth day of storage period, the mushroom stored at room temperature gave off flavour and were not fit for consumption. However, the mean score values for flavor were 4.50,4.30 and 4.10 in house-hold cold storage system and 5.0, 4.9 and 4.9 in refrigerated storages conditions with respect to the different packaging materials *viz.*, open vessel, polyethylene bags and paper bags , respectively. There was a significant difference between packaging materials and storages methods.

Effect on overall acceptability

[Table-4] reveals that the values for the overall acceptably of raw fresh mushroom were 5.50,7.1 and 7.2 at room temperature, 7.7,7.7 and 7.7 in house-hold cold storage system and 7.8,7.8 and 7.8 in refrigerated storage conditions with respect to the different packaging materials. The results reveal that there was a significant difference between packaging materials and storage methods on first day of storages period Ekanem(1998) [5].

Table-4 *Changes in mean panel score values for Overall acceptability of oyster mushroom (Pleurotus sajorcaju) during different storage conditions.*

Storage Method	Storage period (days)																			
	Ist day				2nd day				3rd day				4th day				5th day			
	P1	P2	P3	Mean	P1	P2	P3	Mean	P1	P2	P3	Mean	P1	P2	P3	Mean	P1	P2	P3	Mean
C1	5.50	7.1	7.2	6.60	4.3	5.3	5.0	4.2	-	4.0	2.73	-	-	-	-	-	-	-	-	-
C2	7.70	7.70	7.70	7.70	6.9	6.9	6.8	6.89	6.2	6.30	6.4	6.30	5.0	4.90	4.50	4.80	4.2	-	-	-1.40
C3	7.80	7.80	7.80	7.80	7.0	7.0	7.0	7.0	5.9	6.8	6.8	6.50	5.50	5.30	5.90	5.57	4.0	4.5	4.1	4.2
Mean	7.00	7.53	7.57		6.06	6.4	6.42		5.43	4.36	5.73		3.5	3.4	3.46		2.73	1.50	1.37	
SEM±	C	P	CXP		C	P	CXP		C	P	CXP		C	P	CXP					
	0.08	0.08	0.14		0.08	0.08	0.15		0.09	0.09	0.16		0.10	0.10	0.18		0.04	0.04	0.08	
CD	0.23	0.23	0.41		0.25	0.25	0.44		0.27	0.27	0.47		0.30	NS	NS		0.13	0.13	0.23	

C_1 At room temperature
C_2 House hold cold storage
C_3 Refrigerator

P_1 Open vessels
P_2 Polyethylene bags
P_3 Paper bags

On second day of storage period, the mean score values for overall acceptability of the mushroom were 4.3,3.3 and 5.0 at room temperature, 6.9,6.9 and 6.8 in house-hold cold storage systems and 7.0,7.0 and 7.0 in refrigerated storage conditions with respect to different packaging materials *viz.*, open vessels, polyethylene bags and paper bags, respectively. The results reveal that there was a significant difference between packaging materials and methods.

On third days of storage period, mushroom stored in open vessels and polyethylene bags at room temperature were not good for consumption purposes. However, materials stored at room temperature in paper bags were better from quality point of view. During different storage methods, the values for overall acceptability were 6.2, 6.3 and 6.4 in house-hold cold storage system and 6.9, 6.8, 6.8 in refrigerated storage conditions with respect to the different Packaging materials *viz.*, open vessels, polyethylene bags and paper bags respectively. These results reveal that there was a significant difference among both packaging materials and methods of storage.

On fourth day and fifth day of storage periods, mushroom stored in different packaging materials at room temperature were not suitable for consumption, However, under different storage methods, the values for overall acceptability were 5.0,4.9 and 4.5 in house-hold cold storage system and 5.5,5.3 and 5.3 in refrigerated storage conditions with respect to the different packaging materials. There was no significant differences were observed in packaging materials. However, methods of storage showed significant differences.

Effect on the weight

[Table-5] represents that the percentage of weight loss during storage of fresh mushroom was 18.20, 6.89 and 6.53 at room temperature, 5.92,5.12 and 5.10 in house-hold cold storage system and 4.48 4.12 and 4.2 in refrigerated storage conditions with respect to the open vessels, polyethylene bags and paper bags respectively. Statistical analysis showed that there was a significant difference between packaging materials and methods of storage on first day of storage period. However, loss of weight was more at room temperature than the other methods of storage.

Table-5 *Percentage weight loss in oyster mushroom (Pleurotus sajorcaju) during different storage condition*

Storage Method	Storage period (days)																			
	Ist day				2nd day				3rd day				4th day				5th day			
	P1	P2	P3	Mean	P1	P2	P3	Mean	P1	P2	P3	Mean	P1	P2	P3	Mean	P1	P2	P3	Mean
C_1	18.20	6.89	6.53	10.54	39.8	25.89	24.6	30.9	7.08	25.89	60.12	31.03	72.35	25.89	60.12	57.78	72.35	25.89	60.12	52.78
C_2	5.92	5.12	5.10	5.38	16.70	9.35	10.62	12.22	27.7	11.54	20.80	20.01	31.95	20.32	23.50	25.92	36.20	29.10	30.20	31.83
C_3	4.48	4.12	4.20	4.27	8.25	8.00	7.32	7.86	10.26	10.20	10.10	10.18	11.56	10.71	10.50	10.92	12.86	11.22	10.89	11.66
Mean	9.53	5.38	5.28		21.58	14.41	14.18		15.01	15.87	30.34		38.62	18.97	32.04		40.47	20.07	33.73	
	C	P	CXP		C	P	CXP		C	P	CXP		C	P	CXP		C	P	CXP	
$SE_M\pm$	0.04	0.04	0.07		0.30	0.30	0.52		0.27	0.27	0.47		0.36	0.36	0.63		0.43	0.43	0.74	
CD	0.13	0.13	0.22		0.90	0.90	1.55		0.81	0.81	1.40		1.07	1.07	1.86		1.28	1.28	2.21	

C_1 At room temperature
C_2 House holds cold storage
C_3 Refrigerator

P_1 Open vessels
P_2 Polyethylene bags
P_3 Paper bags

On second day, the percentage weight loss was 39.8,25.89 and 24.6 at room temperature 16.70, 9.35 and 10.62 in house-hold cold storage systems and 8.2,7.3. and 8.0 in refrigerated storage conditions in open vessels, polyethylene bags and paper bags respectively, Statistical analysis showed that there was a significant differences between packaging materials during different storage periods. The weight loss was minimal in polyethylene bags as compared to open vessels and paper bags the storage methods also showed significant effect .The minimal loss of weight was observed in refrigerated storage system. On third day, the percentage of weight loss was 70.08,60.12 and 25.89 at room temperature, 27.7, 20.80 and 11.54 in house-hold cold storage system and 10.26, 10.10 and 10.20 in refrigerated storage conditions in open vessels, paper bags and polyethylene bags, respectively. The results reveal that there was a significant difference between methods of storage and also in packaging materials. On fourth day, the percentage of weight loss was 72.35, 60.12, and 25.89 at room temperature, 31.95,25.50 and 20.32 in house-hold cold storage system and 11.56, 10.50 and 10.7 in refrigerated storage conditions in open vessel polyethylene bags and paper bags, respectively. The results reveal that there were also statistically significant differences between methods of storage and packaging materials. On fifth day, the percentage of weight loss was stable in all the packaging materials at room temperature during storage of fresh mushroom. However, in house-hold cold storage system and refrigerated storage conditions, the percentage of weight loss was 36.20 32.20,29.10 and 12.86,10.89 and 11.20, respectively in open vessels, polyethylene bags and paper bags. Similarly, there were also significant differences among methods of storage and packaging materials The above results reveal that low temperature had a marked effect on the shelf-life of the mushroom samples stored in house-hold cold storage system (15 $\pm$ 3^{0}C) and refrigerated storage conditions (4$\pm$ 2^{0}C) during storage of mushroom. Mushroom is reported to have a higher protease activity, which may cause deterioration accompanied by undesirable changes. Thus, it was concluded that for enhancing the shelf-life of mushroom upto the period of five days house-hold cold storage system could be recommended in rural area and refrigeration in urban area depending on the socio-economic conditions of the population. The various packaging materials used during storage of mushroom showed that paper bags were good for storage of mushroom due to the absorption of extra moisture, which checks the spoilage Ekanem *et al* (1994) [6,7]

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Conclusion

The Household cold storage a traditional cooling system, is demonstrated to be effective in extending the shelf life of the oyster mushroom. Recommendation and widespread adoption of this traditional device in the handling of mushrooms can markedly reduce the egony, frustration and losses suffered by rural mushroom harvesters, handlers and distributors) during gluts.

Conflict of Interest: None declared

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