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Postharvest Processing, Value Addition and Marketing of Mushrooms

Mahesh Prasad Thakur, Harvinder K. Singh and Chandra Shekhar Shukla

Abstract

Mushrooms are macrofungi having a higher content of water (80–90%) and multinutrients. The presence of various phytochemicals, enzymes, primary metabolites and secondary mycometabolites results in poor shelf-life, quick deterioration, and huge postharvest losses (30–35%). Fresh mushrooms are short lived (1–8 days). Value chain management is thus necessary from the production to its harvest to meet the food and nutritional requirements. Every effort was made to extend the shelf-life of mushrooms for either short period or long period of storage. Washing or pretreatment, packaging, transport and marketing were some of the important standardized techniques for short-term storage of mushroom. On the other hand, drying, pickling and steeping preservation methods were some other techniques to extend the shelf-life of mushroom for a longer period of time during storage. Value addition of mushroom enhanced the quality and addressed the demand for ready-made or ready-to-make food products. Fresh/dry oyster mushroom in various proportions (5–10%) was used to prepare mushroom paratha, mushroom suji, mushroom sandwich, mushroom chakli, mushroom seb, mushroom-based biofortified wheat flour, mushroom-based papad, nuggets, mushroom bijoura, biscuits, etc. Several mushroom-based, value-added products like Royal Oyster Capsules were prepared by Self Help Groups women at Kapadah (Kabirdham).

Keywords: post harvest, mushroom processing, preservation, value addition, shelf life *Pleurotus flabellatus*, sporophores, steeping solutions

1. Introduction

Mushrooms are highly perishable in nature and subjected to change in ways that make them unacceptable for human consumption. It has high water content (85–95%), which is lost rapidly by evaporation and transpiration making mushroom discolored, disfigured and unfit for consumption. The rate of water loss depends on mushroom structures, relative humidity, temperature, air movement and atmospheric pressure during storage. Mushrooms represent one of the most perishable commodities, being so delicate by nature and hence need special postharvest treatments. A number of physiological processes take place in freshly cut mushrooms when it is stored (pileus and veil opening, stipe elongation, browning, etc.) resulting in maturation, senesce, and decrease in commercial and nutritional values

[1, 2]. Burton et al. [3] found varying changes in color, size, clearness, firmness, maturity stage, blemish-free, flavor, nutritional value and safety by pre-harvest treatments, postharvest processing and storage conditions. The major limitations in mushroom marketing include wilting and shriveling due to rapid water loss, which render them unfit for marketing and consumption [4]. The shelf life of mushroom can often be extended by pretreatments and/or storage at chilling temperatures (above freezing and below 0°C), chemical preservation, and drying processes. Adsule et al. [5] reported the preservation of *Pleurotus sajor-caju* fruit bodies in steeping solution containing 5% salt, 0.20% citric acid and 0.1% potassium metabisulphite (KMS) up to three months without losing much of its organoleptic quality. *Pleurotus sajor-caju* and *Volvariella volvacea* (24 days) fruit bodies were successfully stored without spoilage at room temperature in chemical solutions consisted of salt, sugars, acids and preservatives [6, 7]. Water blanched white button mushroom can be successfully stored from 2 to 5 weeks to 3 months by preserving in steeping solutions of various concentrations of salt, sugars, acids and preservatives [8, 9]. Gormley and O' Riordain [10] reported the storage of *Pleurotus ostreatus* fruit bodies for 3 months at -30°C. Storage of *Pleurotus flabellatus*, *P. sapidus* and *P. ostreatus* fruit bodies up to 15 days in different thickness of polyethylene films were reported by several workers [11-13]. Spoilage of mushrooms during storage was associated with the presence of microorganisms dominated by bacteria, fungi and enzymes which strongly influenced the physiology and shelf life. Mushrooms need to be properly processed in order to extend their shelf life so that they can be used during off-season and also add value to the product. Value addition of mushroom with several traditional recipes can be achieved by adopting appropriate postharvest technology to process surplus mushrooms into various value-added products (soup powder, pickles, chips, paste and ketchup, pâté, noodles and pasta, biscuits, and nuggets), mushroom-based flavor enhancers or as additives in beverages and beauty products [14, 15]. The value-added products are the urgent need for the mushroom growers not only to reduce the losses, but also to enhance the income by value-addition and boosting mushroom consumption [16]. Biofortification or value addition of mushroom in present days is becoming very common to enhance quality, shelf life, alleviate under or malnutrition and reaching among various sections of the society [15]. Keeping these in view, efforts were made to enhance the shelf life of button mushrooms and its varieties by dipping them in the solutions of ethylene diamine tetra-acetic acid (EDTA) at different concentrations. Effect of packaging materials (thickness) on shelf life of button mushrooms and its varieties with respect to the quality parameters under both ambient/refrigerated conditions was studied. Similarly, studies were conducted on methods of drying of oyster mushroom (*Pleurotus florida*) on weight loss and other quality parameters. It was attempted to examine the shelf life and quality parameters of *P. flabellatus* in further dilutions and different combinations of steeping solutions. Efforts on processing and value addition was also attempted to extend the shelf life and prepare different mushroom based value added products.

2. Enhancement of shelf life of button mushroom

Effect of dipping treatment on the quality and shelf life of the button mushroom (*Agaricus bisporus*) was studied at Mushroom Research Laboratory (AICRP on Mushroom) of the Department of Plant Pathology, Indira Gandhi Krishi Vishwavidyalaya (IGKV), Raipur for two years. The fresh fruiting body of four varieties of button mushroom, S 649, SSI 4035, Pant 31 and NCS 100 of size 25 ± 2 cm or available size fruit bodies were washed in solutions containing EDTA

at 75, 125, 200 ppm & 0.05% of potassium meta bisulfate (KMS) concentration. Thereafter, the fruit bodies were taken out, put in blotter paper to remove moisture and stored at ambient temperature and refrigerated temperature for different durations after packaging in 100 gauge polypropylene bags.

2.1 Shelf life extension of button mushroom varieties/strains

Effect of dipping treatment in different concentrations of EDTA solutions and KMS was studied on weight loss and other quality parameters and shelf life of four varieties/strains of *A. bisporus* viz., S 649, SSI 4035, Pant 31 and NCS 100.

Loss in weight of fruit bodies of *A. bisporus* in cv. S 649 was considerably more under both ambient temperature and refrigerated conditions when it was kept in EDTA between 75 and 125 ppm concentrations. However, it was considerably less when the fruit bodies were subjected to EDTA 500 and 200 ppm under both the conditions. Fruit bodies under refrigerated conditions could be well preserved for longer period of time (11–13 days) and loses less weight (0.58 g) without being much influence on whiteness, texture and opening of the gills. However, there was considerable reduction in weight of fruit bodies (0.96 g), period of storage (3.50–4.50 days) and other quality parameters when the fruiting bodies were preserved under ambient temperature conditions (**Table 1**). Short shelf-life (1–3 days) of mushrooms at ambient temperatures (ca. 22°C) was reported by Burton and Twynning [17] and Wakchaure [18] while longer shelf-life (for about 7–9 days) was reported by Gormley [19] at lower or refrigerated temperature (0–1°C) which are in agreement with the present findings.

The fruiting bodies of *A. bisporus* cv. NCS 100 could be well preserved for little longer period of time (13–16 days) and loses less weight (0.64 g) under refrigerated conditions without being much influence on whiteness, texture and opening of the gills. On the other hand, there was considerable reduction in weight of fruit bodies (0.99 g) and period of storage (3–5 days) influencing whiteness, texture and gill opening under ambient temperature conditions (**Table 2**). Under ambient temperature conditions, the rate of water loss was more resulting in shorter shelf life and change of mushroom structures which are also influenced by relative humidity, temperature, air movement and atmospheric pressure of the storage environment. It ultimately affect the shelf life, quality and had adverse effect on mushroom marketing mainly due to wilting and shriveling rendering mushrooms unfit for marketing and consumption [4].

Effect of dipping treatment with different concentration of EDTA (75, 125, 200 ppm) and KMS (500 ppm) was studied on weight loss and other quality parameters in strain SSI 4035 of *A. bisporus* (**Table 3**). It was noticed that the weight loss (0.94 g) in fruiting bodies preserved under ambient temperature conditions in different concentrations of EDTA and KMS was more during 2–3 days of storage period with no much effect on whiteness (**Table 4**) and texture (**Table 5**) but gill opening (**Table 6**) and condensation (**Table 7**) was greatly influenced. On the contrary, weight loss in fruiting bodies (0.53 g) was less when preserved in different concentrations of EDTA and KMS for 6–10 days of storage under refrigerated conditions with no effect on whiteness and texture but gill opening and condensation was considerably influenced. Pretreatments of mushrooms with (chlorinated) water, dipping in citric acid, sodium chloride, or KMS, blanching in hot water, blanching followed with soaking in whey and curd fermentation, or steam blanching followed by sulfiting and citric acid were used by several workers before drying to stabilize color, flavor enhancement and texture retention [20–23]. The earlier findings also corroborates the present results in stabilizing the whiteness and retention of texture of fruiting bodies of *A. bisporus*.

Treatment	Weight loss %			Texture (days)			Whiteness (days)			Gill opening (days)		
	First year	Second year	Average	First year	Second year	Average	First year	Second year	Average	First year	Second year	Average
Ambient temperature												
EDTA 75 ppm	0.15	2.15	1.15	3	4	3.5	2	6	4	3	5	4
EDTA 125 ppm	0.27	1.78	1.02	3	4	3.5	2	6	4	4	5	4.5
EDTA200 ppm	0.42	1.85	1.13	3	4	3.5	3	6	4.5	4	5	4.5
EDTA 500 ppm	0.33	0.97	0.56	3	4	3.5	2	5	3.5	3	5	4
Refrigerated												
EDTA 75 ppm	0.48	0.82	0.65	10	14	12	11	16	13.5	11	15	13
EDTA 125 ppm	3.41	0.68	2.04	10	14	12	9	16	12.5	10	15	12.5
EDTA200 ppm	0.53	0.55	0.54	11	13	12	11	16	13.5	11	15	13
EDTA 500 ppm	0.50	0.70	0.6	8	13	11	9	11	10	9	15	12

Table 1.
Effect of dipping treatment on weight loss, whiteness, texture and gill opening of *Agaricus boissporus* cv. S 649.

Treatment	Weight loss %			Texture (days)			Gill opening (days)			Whiteness (days)		
	First year	Second year	Average	First year	Second year	Average	First year	Second year	Average	First year	Second year	Average
Ambient temperature												
EDTA 75 ppm	0.76	0.88	0.82	4	4	4	4	5	4.5	3	4	3.5
EDTA 125 ppm	0.84	1.24	1.04	4	4	4	4	5	4.5	3	4	3.5
EDTA200 ppm	0.93	1.23	1.08	4	4	4	4	5	4.5	3	4	3.5
KMS 500 ppm	0.77	1.32	1.04	4	4	4	4	5	4.5	3	4	3.5
Refrigerated												
EDTA 75 ppm	0.93	0.60	0.76	16	14	15	16	13	14.5	16	16	16
EDTA 125 ppm	0.88	0.72	0.8	16	14	15	16	7	11.5	11	16	16
EDTA200 ppm	0.53	0.58	0.55	16	14	15	16	8	12	12	16	14
KMS 500 ppm	0.49	0.48	0.48	16	12	14	16	8	12	16	10	13

Table 2.
Effect of dipping treatment on weight loss, whiteness, texture and gill opening of *Agaricus boissporus* cv. NCS 100.

Treatment	Weight of fruiting bodies (g)																			
	Initial	1DA	2DA	3DA	4DA	5DA	6DA	7DA	8DA	9DA	10DA	11DA	12DA	13DA	14DA	15DA	16DA	17DA	18DA	Over all reduction
Ambient temperature																				
EDTA 75 ppm	40.56	40.29 (0.27)	40.02 (0.27)	39.72 (0.30)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.84
EDTA 125 ppm	38.71	38.38 (0.33)	38.01 (0.37)	37.67 (0.34)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.04
EDTA 200 ppm	47.06	46.78 (0.28)	46.51 (0.27)	46.25 (0.24)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.81
KMS 500 ppm	39.37	38.99 (0.38)	38.65 (0.34)	38.30 (0.35)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.07
Refrigerated temperature																				
EDTA 75 ppm	25.09	25.03 (0.06)	24.99 (0.04)	24.95 (0.04)	24.90 (0.05)	24.86 (0.04)	24.81 (0.05)	24.75 (0.06)	24.72 (0.03)	24.68 (0.04)	26.63 (0.05)	24.57 (0.06)	24.53 (0.04)	24.47 (0.06)	24.40 (0.07)	24.35 (0.05)	24.29 (0.06)	24.20 (0.09)	24.15 (0.05)	0.94
EDTA 125 ppm	33.73	33.67 (0.06)	33.62 (0.05)	33.58 (0.04)	33.54 (0.04)	33.48 (0.06)	33.44 (0.04)	33.38 (0.06)	33.31 (0.07)	33.29 (0.02)	33.23 (0.06)	33.17 (0.06)	33.12 (0.05)	33.07 (0.04)	33.05 (0.03)	33.00 (0.05)	32.90 (0.10)	32.83 (0.07)	32.74 (0.09)	0.99
EDTA 200 ppm	26.47	26.39 (0.08)	26.34 (0.05)	26.30 (0.04)	26.24 (0.06)	26.20 (0.04)	26.14 (0.06)	26.09 (0.05)	26.02 (0.07)	25.99 (0.03)	25.92 (0.07)	25.84 (0.08)	25.79 (0.03)	25.73 (0.06)	25.68 (0.05)	25.64 (0.04)	25.50 (0.14)	25.44 (0.06)	25.35 (0.09)	1.12
KMS 500 ppm	32.25	32.14 (0.11)	32.07 (0.07)	32.01 (0.06)	31.94 (0.07)	31.89 (0.05)	31.83 (0.06)	31.76 (0.07)	31.72 (0.04)	31.67 (0.05)	31.61 (0.06)	31.54 (0.07)	31.48 (0.06)	31.42 (0.06)	31.37 (0.05)	31.32 (0.05)	31.20 (0.12)	31.11 (0.09)	31.01 (0.10)	1.14

Table 3.
Effect of dipping treatments on weight loss of Agaricus bisporus fruit bodies SSI 4035.

Treatment	Whiteness of fruiting body*																			
	Initial	1DA	2DA	3DA	4DA	5DA	6DA	7DA	8DA	9DA	10DA	11DA	12DA	13DA	14DA	15DA	16DA	17DA	18DA	19DA
Ambient temperature																				
EDTA 75 ppm	1	1	1	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
EDTA 125 ppm	1	1	1	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
EDTA 200 ppm	1	1	1	2	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
KMS 500 ppm	1	1	1	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Refrigerated temperature																				
EDTA 75 ppm	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	3	3
EDTA 125 ppm	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	3
EDTA 200 ppm	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	3
KMS 500 ppm	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	3

1—absolute white, 2—slight dull (cream), 3—light brown and Dark brown.

Table 4.
Effect of dipping treatments on whiteness of *Agaricus bisporus* fruit bodies SSI 4035.

Treatment	Gill opening after days of storage*																			
	Initial	1DA	2DA	3DA	4DA	5DA	6DA	7DA	8DA	9DA	10DA	11DA	12DA	13DA	14DA	15DA	16DA	17DA	18DA	19DA
Ambient temperature																				
EDTA 75 ppm	1	2	5	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
EDTA 125 ppm	1	5	5	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
EDTA 200 ppm	1	1	5	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
KMS 500 ppm	1	3	5	5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Refrigerated temperature																				
EDTA 75 ppm	1	1	1	1	1	1	1	2	3	3	3	3	3	3	3	3	4	4	4	5
EDTA 125 ppm	1	1	1	1	1	1	1	2	3	4	4	5	—	—	—	—	—	—	—	—
EDTA 200 ppm	1	1	1	1	1	2	2	5	5	—	—	—	—	—	—	—	—	—	—	—
KMS 500 ppm	1	1	1	1	1	1	2	2	3	3	3	3	3	4	4	4	4	5	—	—
1—without opening, 2—1/4 opening, 3—1/2 opening, 4—3/4 opening and 5—full open.																				

Table 5.
Effect of dipping treatments on gill opening of *Agaricus bisporus* fruit bodies SSI 4035.

Treatment	Texture after days of storage																			
	Initial	1DA	2DA	3DA	4DA	5DA	6DA	7DA	8DA	9DA	10DA	11DA	12DA	13DA	14DA	15DA	16DA	17DA	18DA	19 DA
Ambient temperature																				
EDTA 75 ppm	1	1	1	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
EDTA 125 ppm	1	1	1	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
EDTA 200 ppm	1	1	1	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
KMS 500 ppm	1	1	1	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Refrigerated temperature																				
EDTA 75 ppm	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2
EDTA 125 ppm	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
EDTA 200 ppm	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2
KMS 500 ppm	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2
1—smooth, 2—rough, 3—not acceptable.																				

Table 6.
Effect of dipping treatments on texture of *Agaricus bisporus* fruit bodies SSI 4035.

Treatment	Condensation																			
	Initial	1DA	2DA	3DA	4DA	5DA	6DA	7DA	8DA	9DA	10DA	11DA	12DA	13DA	14DA	15DA	16DA	17DA	18DA	19DA
Ambient temperature																				
EDTA 75 ppm	1	2	2	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
EDTA 125 ppm	1	2	2	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
EDTA 200 ppm	1	2	3	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
KMS 500 ppm	1	2	3	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Refrigerated temperature																				
EDTA 75 ppm	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
EDTA 125 ppm	1	1	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3
EDTA 200 ppm	1	1	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
KMS 500 ppm	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
1—1/4 of pp. bag, 2—1/2 of pp. bag, 3—3/4 of pp. bag and 4—full of pp. bag.																				

Table 7.
Effect of dipping treatments on condensation of Agaricus bisporus fruit bodies SSI 4035.

Effect of dipping treatment with different concentration of EDTA (75–200 ppm) and KMS (500 ppm) was studied on quality parameters of *Agaricus bisporus* cv. Pant 31 under ambient as well as refrigerated conditions (**Tables 8–11**). It was noticed that the fruiting bodies remained well up to 14–16 days under refrigerated conditions with least effect on whiteness, texture, condensation and opening of the gills of fruiting body whereas, the fruiting bodies remained well up to only 03 days under ambient temperature conditions with least effect on whiteness (**Table 8**), texture (**Table 9**), condensation (**Table 10**) and opening of the gills of fruiting body (**Table 11**). It was surprising to note that the weight loss in fruiting bodies preserved in different concentrations of EDTA (75–200 ppm) and KMS (500 ppm) for 14–16 days of storage were almost same under refrigerated conditions (0.54 g) and 03 days of storage under ambient temperature conditions (0.51 g). Washing of mushroom in different types of washing treatments (0.5%

Treatment	Whiteness of fruiting bodies days after storage																				
	Initial	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ambient temperature																					
EDTA 75 ppm	1	1	1	1	1	2	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—
EDTA 125 ppm	1	1	1	1	1	1	2	3	4	—	—	—	—	—	—	—	—	—	—	—	—
EDTA 200 ppm	1	1	1	1	1	1	2	2	2	3	4	—	—	—	—	—	—	—	—	—	—
KMS 500 ppm	1	1	1	2	3	3	4	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Refrigerated																					
EDTA 75 ppm	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
EDTA 125 ppm	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
EDTA 200 ppm	1	1	1	1	1	1	1	1	2	2	2	3	3	3	4	—	—	—	—	—	—
KMS 500 ppm	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2

Table 8.
Effect of dipping treatments on whiteness of *Agaricus bisporus* fruit bodies CV. Pant 31.

Treatment	Texture after days of storage																				
	Initial	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ambient temperature																					
EDTA 75 ppm	1	1	1	1	1	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
EDTA 125 ppm	1	1	1	1	1	1	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—
EDTA 200 ppm	1	1	1	1	1	1	1	1	1	1	—	—	—	—	—	—	—	—	—	—	—
KMS 500 ppm	1	1	2	2	2	2	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Refrigerated temperature																					
EDTA 75 ppm	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
EDTA 125 ppm	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
EDTA 200 ppm	1	1	1	1	1	1	1	1	1	2	2	3	4	4	4	5	—	—	—	—	—
KMS 500 ppm	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Table 9.
Effect of dipping treatments on texture of *Agaricus bisporus* fruit bodies CV. Pant 31.

Treatment	Condensation days after storage																				
	Initial	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ambient temperature																					
EDTA 75 ppm	1	1	1	2	2	2	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—
EDTA 125 ppm	1	1	1	2	2	3	3	3	—	—	—	—	—	—	—	—	—	—	—	—	—
EDTA 200 ppm	1	1	1	2	2	3	3	3	3	3	—	—	—	—	—	—	—	—	—	—	—
KMS 500 ppm	1	1	1	2	2	2	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Refrigerated temperature																					
EDTA 75 ppm	1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3
EDTA 125 ppm	1	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
EDTA 200 ppm	1	1	2	2	2	2	2	2	2	—	—	—	—	—	—	—	—	—	—	—	—
KMS 500 ppm	1	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3

Table 10.
Effect of dipping treatments on condensation of *Agaricus bisporus* fruit bodies CV. Pant 31.

Treatment	Gill opening days after storage																				
	Initial	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Ambient temperature																					
EDTA 75 ppm	1	1	1	1	1	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
EDTA 125 ppm	1	1	1	1	2	2	3	5	—	—	—	—	—	—	—	—	—	—	—	—	—
EDTA 200 ppm	1	1	1	1	1	1	1	1	1	1	1	—	—	—	—	—	—	—	—	—	—
KMS 500 ppm	1	1	1	1	1	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Refrigerated temperature																					
EDTA 75 ppm	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2
EDTA 125 ppm	1	1	1	1	1	1	1	1	1	1	1	2	3	4	5	—	—	—	—	—	—
EDTA 200 ppm	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
KMS 500 ppm	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Table 11.
Effect of dipping treatments on gill opening of *Agaricus bisporus* fruit bodies CV. Pant 31.

calcium chloride and 0.5% citric acid, combination wash with 50 ppm chlorine dioxide, 0.1% sodium erythroate and 0.05% calcium chloride, and 0.5–1.5% potassium metabisulphite) was also examined by others with fairly good results [4, 24, 25] to reduce postharvest spoilage of mushrooms.

2.2 Effect of packaging thickness on quality parameters of button mushroom

2.2.1 Effect of packaging thickness on quality of cv. S 649 of A. bisporus

Effect of packaging thickness on quality parameters of two button mushroom cv. S 649 and cv. NCS 100 was studied under ambient temperature and refrigerated conditions at Mushroom Research Laboratory of the Department of Plant Pathology, IGKV, Raipur. Transparent polyethylene bags of three thickness (75,100 and

S. no.	Treatments	At ambient temperature							
		Weight (% weight loss)		Veil opening			Color		
		Initial	After 24 h	Initial	After 24 h	After 48 h	Initial	After 24 h	After 48 h
1	75 Gauge	34.63	34.50 (0.37)	+	++	+++	+	+++	++++
2	100 Gauge	39.16	39.08 (0.20)	+	++	+++	+	+++	++++
3	125 Gauge	45.00	44.61 (0.86)	+	++	+++	+	+++	++++
4	100 PE (control)	38.56	38.29 (0.70)	+	++	+++	+	+++	++++
For color –+: absolute white, ++: dull white, +++: dull yellow, ++++: not acceptable. For veil opening –+: intact fruit body, ++: veil opening up to 25%, +++: veil opening up to 50%, ++++: veil opening up to 100%.									

Table 12.
Packaging for button mushroom cv. S 649 (washed 0.05% KMS).

125 gauge) along with one control (100 PE) was used. The fruiting bodies of 25 ± 2 cm or available size fruit bodies of cv. S 649 of *A. bisporus* were first washed for 10 min in washing solution containing 0.05% KMS and stored at ambient temperature and refrigerated temperature conditions for different durations.

The effect of packing thickness on weight loss, veil opening and color of the fruit bodies of cv. S 649 of *A. bisporus* was studied at ambient temperature and the results are presented in **Table 12**. At Ambient temperature, the weight loss in fruiting bodies of strain cv. S 649 of *A. bisporus* varied from 0.20 to 0.86% in varying thickness of polyethylene bags. The weight loss was maximum (0.86%) in 125 gauge thickness while, it was minimum (0.2%) in 100 gauge of thickness after 24 h of storage. The color became dull yellow and veil opening was also noticed in all the treatments after 24 h. The maximum weight loss (98.08%) in the untreated oyster mushroom was also recorded at the 7th day of storage by Das et al. [4]. However, the lowest weight loss (33.62%) was observed in oyster mushrooms when it was wrapped in unperforated plastic bag. Similarly, quality parameters like protein content was found to be higher (28.98%) in oyster mushrooms wrapped with unperforated plastic bag followed by perforated plastic bag (25.00%) at the 5th day of storage.

At refrigerated temperature conditions, maximum weight loss (6.78%) in fruit bodies of strain cv. S 649 was recorded in 75 gauge pp. bags and minimum weight loss (2.72%) was noticed in 125 gauge after 5 days of storage (**Table 13**). In general, weight loss in fruiting bodies of *A. bisporus* was less under refrigerated conditions and more under ambient temperature conditions but the trend here was just reversed which is difficult to explain under same set of conditions. The fruit bodies of *A. bisporus* retained absolute white color up to 24 h in all the treatments. The color was then changed from absolute white to dull white after 48 h in all the treatments except 100 gauge pp. bags. Dull white color was consistently retained up to 5 days in all the treatments. Veil opening was not noticed in any of the treatments up to 24 h except control. Thereafter, veil opening was observed up to 25% in 75 and 125 gauge PP bags whereas 50% veil opening was observed in 100 gauge pp. bags and control up to 5 days of storage. The storage of oyster mushrooms in modified atmosphere packaging (MAP) was found by Das et al. [4] to be very effective in reducing moisture loss. It may be mainly due to storing perishables in MAP which regulates gaseous exchange, reduces weight loss, spoilage, and maintains quality of mushrooms during postharvest handling.

S. no.	Treatments	At refrigerated temperature																	
		Weight (% weight loss) after hours						Color after hours						Veil opening after hours					
		Initial	24	48	72	96	120	Initial	24	48	72	96	120	Initial	24	48	72	96	120
1	75 Gauge PP	34.50	33.26 (2.50)	33.06 (4.17)	32.80 (4.92)	32.63 (5.42)	32.16 (6.78)	+	+	++	++	++	++	+	+	++	++	++	++
2	100 Gauge PP	38.00	37.81 (0.50)	37.63 (0.97)	37.19 (2.13)	36.98 (2.92)	36.78 (3.21)	+	+	+	++	++	++	+	+	++	++	++	+++
3	125 Gauge PP	51.40	51.08 (0.62)	50.75 (1.26)	50.38 (1.98)	50.13 (2.47)	50.00 (2.72)	+	+	++	++	++	++	+	+	++	++	++	++
4	100 PE (control)	38.63	38.50 (0.33)	38.10 (1.37)	37.76 (2.52)	37.18 (3.75)	36.93 (4.40)	+	+	++	++	++	++	+	++	++	++	+++	+++
For color –+: absolute white, ++: dull white, +++: dull yellow, ++++: not acceptable.																			
For veil opening –+: intact fruit body, ++: veil opening up to 25%, +++: veil opening up to 50%, ++++: veil opening up to 100%.																			

Table 13.
Packaging for button mushroom (*Agaricus bisporus* cv. S 649) (washed 0.05% KMS).

Treatments	At room temperature								
	Weight (% weight loss)			Color			Veil Opening		
	Initial	After 24 h	After 48 h	Initial	After 24 h	After 48 h	Initial	After 24 h	After 48 h
75 Gauge	33.4	32.89 (1.52)	32.54 (2.57)	+	+	++++	+	+	++
100 Gauge	44.77	43.91 (1.92)	43.29 (3.30)	+	+	++++	+	+	++
125 Gauge	39.36	38.89 (1.19)	38.55 (2.05)	+	+	++++	+	+	+++
100 PE (control)	41.8	41.33 (1.12)	41.00 (1.91)	+	+	++++	+	+	+++
For color: +: absolute white, ++: dull white, +++: dull yellow, ++++: not acceptable. For veil opening: +: intact fruit body, ++: veil opening up to 25%, +++: veil opening up to 50%, ++++: veil opening up to 100%.									

Table 14.
Packaging for button mushroom cv. NCS 100 washed with KMS (0.05%).

2.2.2 Effect of packaging thickness on quality strain cv. NCS 100 of *A. bisporus*

Effect of packaging thickness on weight loss, color and veil opening of the fruiting bodies of strain cv. NCS 100 of *A. bisporus* was studied at ambient temperature and refrigerated conditions (**Table 14**). At room temperature, maximum weight loss (3.30%) was recorded in 100 gauge pp. bags while, it was minimum (1.91%) in control but the extent of losses in cv. NCS 100 was more compared to cv. S 649. The fruit bodies of *A. bisporus* retained absolute white color up to 24 h in all treatments. Thereafter, they were not acceptable. No veil opening was observed up to 24 h in all the treatments. However, 25% veil opening was noticed in 75 and 100 gauge and it was 50% in 125 gauge and control after 48 h. The quality parameters in cv. NCS 100 were better compared to the cv. S 649 except weight loss of the fruiting bodies.

At refrigerated temperature, maximum weight loss (1.39%) in cv. NCS 100 was recorded in 75 gauge pp. bags and minimum weight loss (1.05%) was noticed in control after 5 days of storage (**Table 15**) which was remarkably less compared to the fruit bodies of cv. S 649. The fruit bodies of cv. NCS 100 of *A. bisporus* retained absolute white color up to 4 days in 125 gauge pp. bags while 2 days in other treatments. Thereafter, the fruit bodies changed to dull white color in 125 gauge on 5th day and other treatments from 3 to 4 days. The color was further changed to dull yellow in other treatments on 5th day. Veil opening was not at all noticed in any of the treatments up to 5 days of storage. In all the quality parameters, the fruiting bodies of cv. NCS 100 was far better than cv. S 649. Thus, it can be very well said that the fruiting bodies of cv. NCS 100 can be very well preserved up to 5 days under refrigerated conditions with least influence on different quality parameters compared to cv. S 649. Longer shelf life of fruiting bodies of cv. S 649 might be due to slow respiration rate under refrigerated conditions noticed during present investigation.

2.3 Evaluation of different methods to enhance the shelf life of oyster mushroom

Drying is one of most broadly-practiced and oldest methods for preserving agricultural products to maintain the quality against decaying. It is done mainly in warmer areas such as the kitchen, near the stove or fireplace. These are used as heat sources and often drying is completed in the sun [26]. Three methods of oyster

Treatments	At refrigerated temperature																	
	Weight (% weight loss)						Color						Veil opening					
	Initial	After 24 h.	After 48 h.	After 72 h.	After 96 h.	After 120 h.	Initial	After 24 h.	After 48 h.	After 72 h.	After 96 h.	After 120 h.	Initial	After 24 h.	After 48 h.	After 72 h.	After 96 h.	After 120 h
75 Gauge	37.35	37.26 (0.24)	37.19 (0.42)	37.07 (0.74)	37.01 (0.91)	36.83 (1.39)	+	+	+	++	++	+++	+	+	+	+	+	+
100 Gauge	36.76	36.69 (0.19)	36.63 (0.35)	36.48 (0.76)	36.40 (01.97)	36.29 (1.27)	+	+	+	++	++	+++	+	+	+	+	+	+
125 Gauge	37.8	37.73 (0.18)	37.67 (0.34)	37.60 (0.52)	37.44 (0.84)	37.3 (1.32)	+	+	+	+	+	++	+	+	+	+	+	+
100 PE (control)	36.91	36.86 (0.13)	36.78 (0..35)	36.72 (0.51)	36.63 (0.75)	36.52 (1.05)	+	+	+	++	++	+++	+	+	+	+	+	+
For color: +: absolute white, ++: dull white, +++: dull yellow, ++++: not acceptable. For veil opening : +: intact fruit body, ++: veil opening up to 25%, +++: veil opening up to 50%, ++++: veil opening up to 100%.																		

Table 15.
Packaging for button mushroom (*Agaricus bisporus* cv. NCS 100) washed with KMS (0.05%).

mushroom preservation/drying were evaluated under farmers conditions. The oyster mushroom (200 g) were first blanched at 75°C for 2 min in water. Thereafter, it was kept in two steeping solutions of 5% salt, 0.2% citric acid, 0.15% potassium meta bisulfite (KMS). In the second treatment, the same quantity of mushroom was dried using mechanical dryer at 45–50°C for 8 h. In third treatment, the same quantity of oyster mushroom was blanched and sun dried. Blanching with the use of hot water or steam is an important treatment applied after washing to inhibit tissue browning by inactivation of polyphenol oxidase and production of off flavors. It also removes trapped air and decreases weight losses to induce mushroom shrinkage [27]. These were then observed for color, texture and overall acceptability. In another experiment, freshly harvested fruiting body (500 g) of oyster mushroom (*Pleurotus florida*) was wrapped in muslin cloth and blanched in chemical solution (0.2% salt and 0.1% citric acid) at 75°C for 2 min. The fruiting bodies so obtained were sun dried and also dried in cabinet dryer at 60°C for 6.30 h. The freshly harvested fruiting body were also immersed in plain water and dried by sun as well as by cabinet dryer and the results are presented in **Table 16**.

Of three treatments assessed, the fresh oyster mushroom steeped in solutions of above chemicals with or without blanching were of good quality for the period of 105 days without much loss in color, texture and acceptability. Mushroom dried in a mechanical dryer at 45–50°C for 8 h. With blanching though changed in to blackish color but the loss in weight, brittleness and quality of the fruiting body remained least influenced followed by without blanching which were of excellent quality even up to 3 months of storage. The sun dried product when dipped in plain water and kept in pp. bags after 55 days at ambient temperature lost maximum weight of the fruiting body (3.12%) than any other treatment. The fruiting body became soft and developed brown color. Thus, it can be said that the oyster mushroom steeped in solutions of above chemicals and mechanically dried can be very well preserved for the period of 105 days without much influence on quality parameters. The increase in the drying temperature though helped to accelerate the drying rate but, high temperatures (70°C) are not generally recommended because, it causes browning in the samples and deteriorates the quality which are important from customer's viewpoint [28]. In another experiment conducted at AICMIP, Raipur center on different methods of drying of oyster mushroom exhibited drying by cabinet dryer

S. no.	Treatments	Weight gain /loss		Change in Color	Brittle ness *	Quality parameters (3 months)**
		Initial	After 3 months (% wt. loss)			
1.	Sun drying with blanching (0.2% salt +0.1% CA for 2 min)	29.63	29.0 (2.12)	Blackish	+	++
2.	Sun drying without blanching (0.2% salt +0.1% CA for 2 min)	37.07	36.03 (2.80)	Light Brown	++	+
3.	Cabinet drying with blanching	33.11	32.75 (1.08)	Blackish	+	+
4.	Cabinet drying without blanching	32.07	31.44 (1.96)	Yellowish	+	+
5.	Dipping in plain water followed by sun drying (Control)	36.50	35.36 (3.12)	Light Brown	++	+

NB. There was no rottagge and insect attack within the storage period of 3 months.

*+ Brittle, ++ Soft,

**Quality parameters: + Pleasant flavor ++ Off flavor.

Table 16.
Studies on methods of drying of oyster mushroom (*Pleurotus florida*) on weight loss and other quality parameters.

with and without blanching to be excellent as there was minimum reduction in weight, color was retained, fruit body was brittle and pleasant flavor was noticed within the period of 3 months of storage (**Table 16**). Other methods of drying were not that much effective as the per cent reduction in weight was more, fruit body started turning yellowish in color, became soft and developed off flavor. The results obtained on the preservation method had significant effects on the nutrient and mineral compositions of the mushroom samples [29]. In contrast to present investigation, the lowest weight values were obtained from the sundried mushroom samples while the highest value was obtained from the fresh samples by Jonathan et al. [30] which is difficult to be explained.

2.4 Post harvest treatments and its effect on shelf life of *Pleurotus flabellatus*

In order to study the quality and storage, the sporophores of *P. flabellatus* with and without blanching were steeped in solutions of different chemicals (**Tables 17–20**). The fresh sporophores (150 g) were blanched at 98°C for 2 min. Using double layer of

Treatment		**Color of sporophores in 1–5 scale at different time intervals (days)								
Number	Treatment details*	1	5	25	50	75	100	125	150	175
T-1	5% salt, 0.2% C.A., 0.1% KMS (WOB)	1	4	5						
T-2	5% salt, 0.2% C.A., 0.1% KMS (WB)	1	3	5						
T-3	2% salt, 1% sugar, 0.3% C.A., 0.1% KMS (WB)	1	3	5						
T-4	2% salt, 1% sugar, 0.3% C.A., 0.1% KMS (WOB)	1	3	5						
T-5	2.5% salt, 0.1% A.A., 0.2% C.A., 0.1% S.B. 0.1% KMS (WB)	1	1	1	1	2	2	2	3	3
T-6	2.5% salt, 0.1% A.A., 0.2% C.A., 0.1% S.B. 0.1% KMS (WOB)	1	3	5						
T-7	0.2% A.A., 0.2% C.A., 0.2% KMS (WB)	1	1	1	1	2	2	2	3	3
T-8	0.2% A.A., 0.2% C.A., 0.2% KMS (WOB)	1	3	5						
T-9	0.5% C.A. (WB)	1	4	5						
T-10	Simple boiled water (WB)	1	4	5						
T-11	0.1% A.A., 0.2% P.A., 0.1% KMS (WB)	1	1	1	1	1	1	2	3	
T-12	5% salt, 0.2% C.A., 0.1% KMS (WB)	1	1	1	1	1	1	2	2	3
T-13	0.1% A.A., 0.3% C.A., 0.1% KMS, 1% ASA (WB)	1	2	3	4					
T-14	1% salt, 0.1% A.A., 0.1% C.A., 0.05% S.B. 0.05% KMS (WB)	1	1	1	1	1	1	2	2	3
T-15	0.1% A.A., 0.1% C.A., 0.1% KMS (WB)	1	1	1	1	1	1	2	3	
T-16	1% Salt, 0.1% C.A., 0.05% KMS (WB)	1	3	4						
T-17	0.1% KMS, 0.2%, A.A. (WB)	1	2	4						
T-18	0.3% A.A. (W.B.)	2	4	5						
T-19	0.2% KMS (WB)	2	4	5						

*SB—sodium benzoate, ASA—ascorbic acid, C.A.—citric acid, KMS—potassium metabisulphide.
**Scale white—1, like white—2, slight dull—3, A.A.—acetic acid, P.A.—propionic acid, W.B.—with blanch, WOB—without blanch, light brown—4, dark brown—5.

Table 17.
Effect of different steeping solution on color and storage of the sporophores of *Pleurotus flabellatus*.

Treatment		**Texture of sporophores in 1–7 scale at different time intervals (days)								
Number	Treatment details*	1	5	25	50	75	100	125	150	175
T-1	5% salt, 0.2% C.A., 0.1% KMS (WOB)	1	7							
T-2	5% salt, 0.2% C.A., 0.1% KMS (WB)	1	5							
T-3	2% salt, 1% sugar, 0.3% C.A., 0.1% KMS (WB)	1	5							
T-4	2% salt, 1% sugar, 0.3% C.A., 0.1% KMS (WOB)	1	5							
T-5	2.5% salt, 0.1% A.A., 0.2% C.A., 0.1% S.B. 0.1% KMS (WB)	1	1	2	2	2	2	2	3	3
T-6	2.5% salt, 0.1% A.A., 0.2% C.A., 0.1% S.B. 0.1% KMS (WOB)	1	4							
T-7	0.2% A.A., 0.2% C.A., 0.2% KMS (WB)	1	1	2	2	2	2	2	3	3
T-8	0.2% A.A., 0.2% C.A., 0.2% KMS (WOB)	1	4							
T-9	0.5% C.A. (WB)	1	7							
T-10	Simple boiled water (WB)	1	7							
T-11	0.1% A.A., 0.2% P.A., 0.1% KMS (WB)	1	2	2	2	2	2	3	3	
T-12	5% Salt, 0.2% C.A., 0.1% KMS (WB)	1	2	2	2	2	2	2	3	3
T-13	0.1% A.A., 0.3% C.A., 0.1% KMS, 1% ASA (WB)	1	2	2	4					
T-14	1% salt, 0.1% A.A., 0.1% C.A., 0.05% S.B. 0.05% KMS (WB)	1	2	2	2	2	2	2	3	3
T-15	0.1% A.A., 0.1% C.A., 0.1% KMS (WB)	1	2	2	2	2	2	3	3	
T-16	1% salt, 0.1% C.A., 0.05% KMS (WB)	1	5							
T-17	0.1% KMS, 0.2%, A.A. (WB)	1	2	4						
T-18	0.3% A.A. (W.B.)	1	7							
T-19	0.2% KMS (WB)	1	7							

*SB—sodium benzoate, ASA—ascorbic acid, C.A.—citric acid, KMS—potassium metabisulphide.
**Scale fresh—1, like fresh—2, less soggy—3, more soggy—4, A.A.—acetic acid, P.A—propionic acid, W.B—with blanch, WOB—without blanch, coarse—5, rotting—6, leathery—7.

Table 18.
Effect of different steeping solution on texture and storage of the sporophores of *Pleurotus flabellatus*.

muslin cloth. Thereafter, the sporophores were transferred in the steeping solutions prepared from various chemicals and their concentrations forming sum of 19 treatments. The steeping solution of 500 ml was taken in a plastic container of 1 L capacity and lid was screwed. These containers were then stored at room temperature and observations on colors, texture, appearance and overall acceptability (in days) were recorded following different scales at different time intervals.

2.4.1 Effect of steeping solution on color

The observations of the study indicated that the treatments, T12 and T14 can retain good color (2) of the sporophores of *P. flabellatus* till 150 days (Table 17). Thereafter, it became slight dull (3) but it was too acceptable up to 175 days. It was followed by T5, T7, T11 and T15 which could equally preserve the sporophores till 125 days and up to the acceptable color by 150 days. In remaining treatments, the acceptable color of the sporophores could not be maintained even up to 5 days. The sporophores kept under these treatments started quick deterioration. The steeping

Treatment		**Appearance of sporophores in 1–6 scale at different time intervals (days)								
Number	Treatment details*	1	5	25	50	75	100	125	150	175
T-1	5% salt, 0.2% C.A., 0.1% KMS (WOB)	2	6							
T-2	5% salt, 0.2% C.A., 0.1% KMS (WB)	2	4							
T-3	2% salt, 1% sugar, 0.3% C.A., 0.1% KMS (WB)	2	4							
T-4	2% salt, 1% sugar, 0.3% C.A., 0.1% KMS (WOB)	2	4							
T-5	2.5% salt, 0.1% A.A., 0.2% C.A., 0.1% S.B. 0.1% KMS (WB)	1	2	2	2	2	2	3	3	3
T-6	2.5% salt, 0.1% A.A., 0.2% C.A., 0.1% S.B. 0.1% KMS (WOB)	2	4							
T-7	0.2% A.A., 0.2% C.A., 0.2% KMS (WB)	1	2	2	2	2	2	3	3	3
T-8	0.2% A.A., 0.2% C.A., 0.2% KMS (WOB)	2	4							
T-9	0.5% C.A. (WB)	2	6							
T-10	Simple boiled water (WB)	2	6							
T-11	0.1% A.A., 0.2% P.A., 0.1% KMS (WB)	1	2	2	2	2	2	3	3	
T-12	5% salt, 0.2% C.A., 0.1% KMS (WB)	1	2	2	2	2	2	3	3	3
T-13	0.1% A.A., 0.3% C.A., 0.1% KMS, 1% ASA (WB)	1	2	2	6					
T-14	1% salt, 0.1% A.A., 0.1% C.A., 0.05% S.B. 0.05% KMS (WB)	1	2	2	2	2	2	3	3	3
T-15	0.1% A.A., 0.1% C.A., 0.1% KMS (WB)	1	2	2	2	2	2	3	3	
T-16	1% Salt, 0.1% C.A., 0.05% KMS (WB)	2	4							
T-17	0.1% KMS, 0.2%, A.A. (WB)	2	2	6						
T-18	0. 3% A.A. (W.B.)	2	6							
T-19	0.2% KMS (WB)	2	6							

*SB—sodium benzoate, ASA—ascorbic acid, C.A.—citric acid, KMS—potassium metabisulphide,
**Scale fresh—1, very good—2, good—3, fair—4, A.A.—acetic acid, P.A—propionic acid, W.B—with blanch, WOB—without blanch, slight fermented smell—5, unacceptable—6.

Table 19.
Effect of different steeping solution on appearance and storage of the sporophores of *Pleurotus flabellatus*.

solutions became turgid, less transparent and profuse growth of the fungal contaminants occurred on the top of the steeping solution. It was observed that the sporophores kept after blanching could better retain the color in comparison to without blanched sporophores. It was also noticed that the lower concentration of the steeping solutions (T15) worked equally well compared to that of higher concentration (T7).

2.4.2 Effect of steeping solutions on texture

The texture of the sporophores preserved in steeping solutions of T12 and T14 was almost fresh (2) up to 125 days and was acceptable (3) up to 175 days (Table 18). In T11 and T15, the sporophores were like fresh (2) till 100 days and up to the acceptable period of 150 days. In rest of the treatments, the sporophores preserved in steeping solutions of different chemicals showed more sogginess (4), rotted (6) leathery (7) and became unacceptable for consumption within 5 to 25 days. In T2, T9, T10, T18, T19, the sporophores of *P. flabellatus* exhibited fast

Treatments	Treatment details*	Storage period of quality sporophores (days)
T-1	5% salt, 0.2% C.A., 0.1% KMS (WOB)	3–4
T-2	5% salt, 0.2% C.A., 0.1% KMS (WB)	4–5
T-3	2% salt, 1% sugar, 0.3% C.A., 0.1% KMS (WB)	4–5
T-4	2% salt, 1% sugar, 0.3% C.A., 0.1% KMS (WOB)	4–5
T-5	2.5% salt, 0.1% A.A., 0.2% C.A., 0.1% S.B. 0.1% KMS (WB)	165–175
T-6	2.5% salt, 0.1% A.A., 0.2% C.A., 0.1% S.B. 0.1% KMS (WOB)	5–6
T-7	0.2% A.A., 0.2% C.A., 0.2% KMS (WB)	165–175
T-8	0.2% A.A., 0.2% C.A., 0.2% KMS (WOB)	5–6
T-9	0.5% C.A. (WB)	2–3
T-10	Simple boiled water (WB)	2
T-11	0.1% A.A., 0.2% P.A., 0.1% KMS (WB)	150–155
T-12	5% Salt, 0.2% C.A., 0.1% KMS (WB)	165–175
T-13	0.1% A.A., 0.3% C.A., 0.1% KMS, 1% ASA (WB)	45–48
T-14	1% salt, 0.1% A.A., 0.1% C.A., 0.05% S.B. 0.05% KMS (WB)	165–175
T-15	0.1% A.A., 0.1% C.A., 0.1% KMS (WB)	150–155
T-16	1% Salt, 0.1% C.A., 0.05% KMS (WB)	5–6
T-17	0.1% KMS, 0.2%, A.A. (WB)	20–21
T-18	0.3% A.A. (W.B.)	2
T-19	0.2% KMS (WB)	2

*SB—sodium benzoate, ASA—ascorbic acid, C.A.—citric acid, KMS—potassium metabisulphide. A.A.—acetic acid, P.A—propionic acid, W.B—with blanch, WOB—without blanch.

Table 20.
Effect of steeping solution on storage and quality of sporophores of Pleurotus flabellatus.

deterioration starting from 2 to 3 days. The part of the sporophores get rotted and dissolved in steeping solutions.

2.4.3 Effect of steeping solution on appearance of sporophorus

Sporophores of *P. flabellatus* preserved in steeping solutions of T5, T7, T11, T12, T14 and T15 appeared well (2) up to 100 days and were good up to 150–175 days of storage period (**Table 19**). In other treatments, the sporophores kept with and without blanching and steeped in solutions of different chemicals seemed to be fair (4) and became unacceptable (6) in appearance within 5–25 days of storage. The appearance of the sporophores after blanching and steeping in lower concentrations of the chemical was extremely good.

2.4.4 Effect of steeping solutions on quality and shelf life during storage

It is evident from **Table 20** that T5, T7, T12 and T14 preserved the mushroom (*P. flabellatus*) up to 165–175 days (5.5 months) followed by T-11 and T-15

(150–155 days) without any adverse effect in color, texture, appearance and overall acceptability.

Mushroom preservation was reported to be of great importance due to off-season household consumption among geographically spread groups of the society [31]. The shelf life of *P. flabellatus* fruit bodies were almost doubled and that too with lower concentration of chemical solutions and without much change in color, texture appearance and acceptability (5.5 months). It may possibly be due to more toughness, leatheryness and bigger size of *P. flabellatus* fruit bodies which might have sustained the effect of chemicals for longer period of time as against the fruit body of *P. sajor-caju* which remained comparatively smaller, thinner and less leathery due to which it could have preserved well only up to 3 months [5]. The present results are also in contradiction with the work of earlier scientists who reported higher shelf life (24 days) of paddy straw mushroom with higher concentration of chemicals and lower shelf life (13 days) with lower concentration of chemicals [32]. In T 13, the fruit bodies of *P. flabellatus* were well preserved for 45–48 days which is in agreement with the findings of Sethi et al. [8] and Pruthi et al. [9]. Blanching of oyster mushroom in present investigation was found to be the most important process in avoiding the microbial and other deteriorations which was also reported by Absule et al. [5] and Bano and Singh [33] with respect to oyster and white button mushrooms respectively.

2.5 Mushroom processing and value addition

The rural women were very well aware with the naturally growing edible mushrooms which they do collect during monsoon season. In the villages, it is a common practice to dehydrate naturally growing mushroom in a local Bhatti and use it in a season when it is not available. With this background, the interested women were selected for training programme on Mushroom Processing Technology. Before selection, they were interviewed for necessity of such training programs. They emphasized that the fresh mushroom is not being sold many a times and it becomes difficult for them to preserve it. Oyster mushroom which were cultivated by them was sun dried as per our directives.

Seventy-six women from Tarra, Dondekhurd and Matia villages were selected for the training on Mushroom Processing Technology. For establishment of processing units at Tarra and Dondekhurd, solar dryers and mechanical tray dryers for drying of mushrooms were procured which are used by the women for drying of edible mushrooms. Oyster mushroom after dehydration was grind into powder, sieved and added @ 10–25% in preparation of various mushroom processed products. Mushroom powder was added in preparation of some of the local products like murku, bijoura, chakli etc. by Thakur [14, 15]. The training programs on Mushroom Processing Technology was mainly imparted to the women in preparation of Mushroom Mung Papad, Mushroom Urd Papad, Steamed Rice Mushroom Papad, Mushroom Badi, Mushroom Soup, Mushroom Bijora, Mushroom Murku, Mushroom Chakli, Mushroom Biscuits, Mushroom Pickles. The women of all the villages very much liked the training on this aspect. The mushroom dishes prepared by the women were highly appreciated during Peer Review Team. They were willing to sale the processed mushroom products in the local market. Mushroom pickle, mushroom badi and mushroom papad became very much popular among the women and they see very good future of these products in Chhattisgarh Market.

An attempt was made to establish the linkages with the mushroom entrepreneurs working in different parts of Chhattisgarh. The persons involved in this business were called at the villages, samples were given to them and they assured the disposal of their fresh and processed mushroom products. It has also been tried

to display their products in Business Counseling Centers to be established by Swa Shakti Project in the rural areas.

2.6 Conclusion

It was found that the button mushrooms and their varieties when steeped in solutions of different chemicals (EDTA and KMS) and packaging materials (thickness) were able to sufficiently enhance the shelf life under both ambient and refrigerated conditions. Similarly, drying methods particularly cabinet drying at 45–60°C with blanching or without blanching did play an important role in extension of shelf life of oyster mushroom for 3 months under ambient conditions without much influence on quality parameters. Oyster mushroom when preserved in different chemical solutions of lower concentrations, it was found to prolong the shelf life of fresh oyster mushroom up to 6 months without much influencing the quality parameters. Similarly, the shelf life of dried oyster mushroom was also enhanced for 105 days even preserving at ambient temperature conditions. Processing of mushroom and their value addition in preparing various local or traditional dishes incorporating mushrooms had a great role to play in extending the shelf life and minimizing the existing problem of under nourishment and mal nourishment prevailing in several states of India particularly in weaker section of the society. Thus, there is an urgent need to promote mushroom processed products like royal oyster capsule, mushroom fortified wheat flour, mushroom based mung/urid nuggets, mushroom based mug/urid papad, mushroom rice papad, mushroom instant soup, mushroom pickle, mushroom powder, mushroom soup etc. so as to popularize them among the mankind and promote marketing of these products.

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