International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2020; 8(3): 1416-1423

Received: 22-03-2020
Accepted: 24-04-2020

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Processing of mushrooms: A viable option to sustain the growing population of the developing countries

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DOI: https://doi.org/10.22271/chemi.2020.v8.i3s.9396

Abstract
Mushrooms known as *Ksumpa*in in Sanskrit and *Khumbi* or *Kukurmutta* in Hindi have been used by mankind as food and drug since time immemorial. They have also been mentioned in ourreligious scriptures such as the Vedas for their medicinal importance. Romans considered them to be the Foods of the Gods and the Chinese declared these to be the Elixir of life. All over the world around 20 genera of mushrooms are being cultivated for commerce, but in India, there are five mushroom species viz., white button mushroom (*Agaricusbisporus*), oyster (*Pleurotus* spp.), paddy straw (*Volvariella volvacea*), milky (*Calocybe indica*) and shiitake (*Lentinula edodes*) are in commercial cultivation. *Agaricus bisporus*, *Pleurotus* spp. And *Volvariella volvacea* mushrooms are contributing about 96% of total mushroom produced in India (Sharma *et al, 2017).* The need and greed to ensure the regular availability of mushrooms impelled the mankind to domesticate some of the most delicious mushrooms. It started with the domestication of paddy straw mushroom (*Volvariella volvaceae*) and black ear mushroom (*Auricularia polytrica*) in China, but undoubtedly it was the introduction and cultivation of the common white button mushroom (*Agaricus bisporus*) in the lime stone caves in France in late eighteenth century which can be truly termed as biggest milestone in the history of mushroom production. Since then more than 20types of edible and medicinal mushrooms have been domesticated and technologies have been improved to the commercial level. Cultivation of white button mushroom (*A. bisporus*) started in the 16th century. However, on a commercial scale, the cultivation was initiated in Europe around 17th century. In India, the white button mushroom was first cultivated in Solan in the year 1961 under project entitled "Development of mushroom cultivation in Himachal Pradesh" by the Department of Agriculture, H.P. in collaboration with Indian Council of Agricultural Research. The significance of white button mushrooms can be gauged from the fact that these contribute about 85% of the country's production against its global share of about 31 per cent. However, an attempt has been made to discuss only those mushrooms which have considerable commercial importance.

Keywords: Mushroom, value-added products, post-harvest management, storage

Introduction
The mushroom, a form of plant life known as fungus, is a group of organisms, that separate it from plants and animals. It can be defined as a macro-fungus with a distinctive fruiting body (Hawksworth, 2001) [19], which can either be epigeous or hypogeous. Mushrooms are essentially non-green fleshy edible fungi which comprise large heterogeneous groups with various sizes, containing about 90% moisture and are a rich source of protein, essential amino acids, minerals and vitamins (Jandaik and Sharma, 1976) [27]. The recent trends in consumer behaviour forces the agriculture sector to step up and adopt viable agribusiness solutind (Shirur *et al*., 2016) [18]. In nature, mushrooms grow wild in almost all types of soils, on decaying organic matter, wooden stumps, meadows, open fields, marsh edges, garden, lawns and hardwood forests under shade (Mehta *et al*., 2012) [41]. Production and consumption of mushrooms have tremendously increasedin India mainly due to increased awareness of the commercial and nutritional significance of this commodity. Needless to emphasize the relationship between the consumption of such fancied items and the purchasing power of the masses; consumption of mushrooms shall continue to rise with the current phenomenon of rise in the income level of the populace.

In India, mushrooms are produced predominantly in Himachal Pradesh, Jammu and Kashmir, Uttar Pradesh, Punjab, Haryana, Tamil Nadu, Karnataka and Kerala. According to Iqbal *et al*. (2009) [23] the global mushroom industry is expanding in terms of size and higher returns from mushroom cultivation indicate that probably mushrooms have considerable importance all over the world markets. India ranks 15th among the 58 mushroom growing countries in the world. White button mushroom (*Agaricus bisporus* (Lange) Imbach, also called button mushrooms contributes about 1/3rd of total world production (Wakchaure, 2011) [51]. The white button or common mushroom, belonging to family Agaricaceae, is one of the most cultivated and consumed edible mushrooms among the 3000 known mushroom species (Chang, 1999; Singh *et al*., 1999; Boa, 2004) [10, 49, 7]. Fruit bodies (reproductive phase) of Agaricus are appreciated not only for texture and flavour, but also for their chemical and nutritional characteristics (Mattila *et al*., 2002; Xu *et al*., 2002) [40, 52]. Being rich source of various nutrients and several bioactive components, white button mushrooms constitute an important part of our daily life. The components isolated from mushrooms include bioactive polysaccharides (β-glucan, such as lentinan), antioxidants, dietary fibres, ergosterol, vitamins B1, B2 and C, folates and minerals (Mattila *et al*., 2000). The Agaricus are rich in crude protein (3.26%), moderate in crude fibre (1.06%) and ash (0.68%), and low in fat content (0.19%) (Gaur, 2005) [16]. The white button mushrooms are basically a low calorie food, where the carbohydrates are stored as glycogen, chitin and hemicelluloses instead of starch. As a rich source of protein, they contain a significant amount of lysine (0.013%) and tryptophan (0.027%) (Gaur, 2005) [16]. Despite the efforts of agriculture production, classification and packaging is one of the main problems in mushroom production (Aguirre *et al*., 2008) [1]. Mushrooms are mainly marketed in fresh form, thusmushroom marketers often face difficulties in choosing safe storage conditionson receiving different batches of mushroom (Mohapatra *et al*., 2010; Singh *et al*., 2010) [42, 50], owing to its highly perishable nature. Mushroom vary in their harvestingdate and time, variety of cultivated mushroom, harvest batches, storage conditions adapted and cold chain regime followed (Hertog *et al*., 2007; Aguirre *et al*., 2008) [21, 1]. Only about 45 per cent of mushrooms produced are consumed in thefresh form. The other 55 per cent are processed, with 5 per cent in dehydratedform and 50 per cent in canned form (Singh *et al*., 2010) [50]. Hence, they cannot bestored for more than 24 hours at ambient condition and therefore marketed in fresh form. The *Agaricus* mushroom generally requires decomposed organic matter both as substrate for growing and also as a source of essential nutrients. Thus washing of white button mushroom is very important to remove the adhering casing soil from the surface and in reducing the microbial spoilage as it carries about one million bacterial counts per gram of fresh weight (Komanowsky *et al*., 1970) [34]. The simple water based solution containing sodium chloride (common salt, 0.05%) and sodium metabisulphite (0.05%) can be used to immerse andclean debris from mushrooms without aggravating the browning reaction (Hughes, 1959) [22]. During post-harvest period, white button mushroom undergoes a lot of changes, which include growth and maturation causing weight loss, veil opening and external browning. This results not only in low consumer preference but alsoin a loss in nutritive value (Rai and Saxena, 1989) [45]. Fresh mushrooms respire; they take up approximately 90 per cent water and give off large amount of watervapour. The vapour can build up in the package, allowing spoilage bacteria togrow and causing the mushrooms to become brown and spotted (Brennan *et al*., 2000) [8]. Thus, improper packaging and storage conditions result in their deterioration and reduction in their shelf life (Rai and Paul, 2007) [43]. Storage under controlled atmosphere (CA) and modified atmosphere (MA) is known to extend the shelf life of fresh vegetables by retarding their physiological metabolism (Kader, 1985; Kader *et al*., 1989) [29, 30]. However, CA storage technique has been found to be costly for mushrooms as they have shorter shelf life and any beneficial effects of CA storage are lost as soon as the produceis removed from CA (Roy *et al*., 1995). Under MAP, the natural process of respiration of vegetables in conjunction with restricted gas exchange through abarrier is used to control in package partial pressure of O_2 and CO_2 (Cameron *et al*., 1989; Emond *et al*., 1991; Ishikawa *et al*., 1992) [9, 14, 25]. Packages such as lowdensity polyethylene (LDPE), and normal and oriented polypropylene (PP) act asa barrier for a gaseous exchange (Ishikawa and Hasegawa, 1988; Rai *et al*., 2000) [24, 44] as well as help in minimizing the moisture loss and maintaining product quality (Lee *et al*., 1996) [53]. However, creation of suitable atmosphere inside the film packages under MAP has always been a challenge involving repetitive experimentation. Thus, packaging is essential to protect the mushroom during marketing. Therefore, modelling the quality deterioration with respect to storage conditions is of utmost importance as it provides ample opportunity for the mushroom growers and marketers to modify the storage and handling conditionsto have higher shelf life, thereby reducing the economic cost.

The Food and Agriculture Organization have recognized mushrooms as food contributing protein nutrition to the countries depending largely on cereals. In addition, folic acid and vitamin B_{12}, which are absent in most of the vegetables are also present in mushrooms. Mushrooms are praised and priced for its characteristics meaty biting texture and flavour. The composition of fresh mushrooms reveals that they are rich in crude protein (2.9%) and carbohydrates (5%), moderate in crude fibre (0.9%) and ash (0.8%); whereas low in fat contents (0.3%) (Saxena and Rai, 1990) and contain 86-95% moisture (Chaudhary, 2000) [12]. The white button mushrooms are basically a low-calorie food, where carbohydrates stored as glycogens and chitin instead of starch. Mushrooms assumes considerable importance in human diet being a good source of non-starchy carbohydrate importance in human diet being a good source of non-starchy carbohydrates, dietary fibre, protein, vitamins and protein as major components. Thus the mushrooms are recognized as deliciously palatable, non-convectional source of protein in Indian diet. Mushroom as a good source of no-starchy carbohydrates reported to contain 58% carbohydrates (P. *florida*), 50% (A.*bisporus*) by Bano and Rajarathanam (1986) [5] which includes pentose, methyl penose, hexoses, oligosaccharides and amino sugars. The proximate composition of major components in mushroom reported by different investigators is presented in Table 1.

Table 1: Comparative proximate composition of fresh mushroom (A. *bisporus*) per 100g

	Moisture (%)	Crude Protein (N× 4.83)	Crude Fat (ether extract)	Carbohydrates, (%)	Crude Fibre (%)	Ash (%)
Anderson and Feller, 1942	89.5	3.94	0.19	4.02	1.09	1.26
Hayes and Hadded, 1976	91.0	3.50	0.40	2.45	1.00	0.90
Jain and Singh, 1983	92.3	3.06	ND	ND	ND	1.45
Pruthi*et al.*, 1984	92.8	3.06	ND	0.04	1.17	1.04
Saxena and Rai, 1990	90.1	2.90	0.30	5.00	0.90	0.60
Matilla*et al.*, 2002	92.0	2.09	0.31-0.35	4.50	ND	ND

Freshly harvested mushrooms are highly perishable because of high moisture content, metabolism and susceptibility to enzymatic browning. Mushrooms are susceptible to deterioration by enzymes and the decay development around the bruised portion caused during deterioration by enzymes and the decay development around the bruised portion caused handling. Its quality starts declining soon after harvesting, rendering the produce unsaleable (Bano and Singh, 1972). Development of brown colour is the first sign of deterioration and is a major factor contributing to quality losses. The enzyme, polyphenol oxidase, in the presence of O_2 and the substrate catalysis the oxidation of colourless phenolic compounds into quinines which combine with amino acids derivative to form highly coloured complexes thus making them highly unacceptable, so should be disposed off as soon as possible.

Quality: Good quality, fresh mushrooms should be white to dark brown. White forms are most prevalent. Uniform, well rounded cap with a smooth glossy surface and fully intact veil are indicators of best quality. Stipes is straight and glossy in appearance with an even cut edge. Cleanliness and absence of browning or other discolorations are additional quality factors. Visible, open gills and absence of a stipe are negative factors (Suslow and Cantwell, 2009).

U.S. grade are No. 1 and No. 2 sizes range from
Small button (1.9-3.2 cm/0.75-1.25 inch)
Medium (3.2-4.5 cm/1.25-1.75 inch)
Large (4.5 cm/1.75 cm good large);
"Cap diameter is measured"

Quality loss occurs rapidly at post harvest due to continued mushroom development and nutritional isolation. The mushroom responds quickly to harvesting, stress genes are switched on as a response to the wound damage of harvest and increase in respiration under water stress and nutritional limitation.

Rate of respiration

Temperature ml CO_2/kg hr		
^{0}C	^{0}F	
0	32	14-22
5	41	35
10	50	50
15	59	NA
20	68	132-158
25	77	NA

Rate of Ethylene production:>0.1 ul/kg hr at 20 ^{0}C
In nutritional limitations, the reserve of carbohydrates, such as mannital and trehalose, fall rapidly during post harvest and the extra cellular matrix between the cells reduces. The total protein content of the mushroom falls by 80% days after harvest, coinciding with the up-regulation of genes involved in polysaccharide and protein break down. Mushrooms will continue to develop after harvest that is why low temperature and physical post-harvest management is critical. The function of a mushroom is to produce and disperse spores under correct conditions, harvested mushrooms will continue to develop and respiration increases and the cap expands and flattens, causing the protecting veil to break, exposing the mature gills and allowing spore release. The mushrooms ages further, appearing darker and peeling less firm, the gills turn from pink to brown and many cells are senescing.

Spoilage: Mushroom will continue to grow after harvest that is why low temperature and physical post-harvest management is critical. Generally quality may be lost through microbial spoilage, bruising induced discolouration or continued maturation and senescence of the mushroom. The latter two factors cause the greatest wastage of the mushroom crop. The cells or hyphae of the mushrooms are still active and have a function to maintain i.e. spore dispersal. Mushrooms have few bacterial diseases, probably due to defence mechanisms that evolved through living in a rotting environment. However, all mushrooms carry a micro-flora and if humidity control fails during activation the number of *Pseudomonas* spp. (> 10^6cfv cm^{-2}) increasing causing a mottled brown discoloration on the surface of the mushroom, similar to a bruise (Eastwood and Burton, 2002) [13]. The use of modified atmosphere packaging and refrigeration reduces greatly the effects of post-harvest microbial spoilage on the quality.

Bruising-induced discolouration: Mushrooms bruise easily and must be handled with care, this is due to a light weight lattice structure of hyphae in the mushroom that is designed to withstand light mechanical forces and provide flexibility. The skin layer covering the cap may be damaged easily by touch, leading to an enzymatic response and subsequent brown discolouration or bruise. The enzyme tyrosinase, or polyphenol oxidase catalyses the oxidation of phenols to produce the bruise, similar to melanin formation (Barwal, 1991) [6]. Harvested mushroom encompasses a range of physiologies, including hyphal growth, stress responses, senescence and death. As consumers we are less aware of this complexity, seeing only the slightly discoloured, imperfect mushroom.
To overcome these problems, especially during peak season, suitable post-harvest management practices are to be followed to increase the self-life and marketability of mushrooms.

Post harvest management of mushrooms: (Figure-1): The increasing demand for mushrooms increases the need for extending shelf life by adopting appropriate preservation techniques. The gluts in the market can be checked by adopting appropriate Post Harvest techniques to process the surplus mushrooms in to value added products rather than going only for canning or pickling (Rai *et al.*, 2003). Initial steps are proper harvesting time and stage. Mushrooms are generally harvested after 3 weeks of casing. Button mushrooms are to be harvested when the CAP size reaches30-45 mm in diameter, whereas Oyster mushrooms isharvested when the fruiting body becomes curled under edges and well-formed gills.

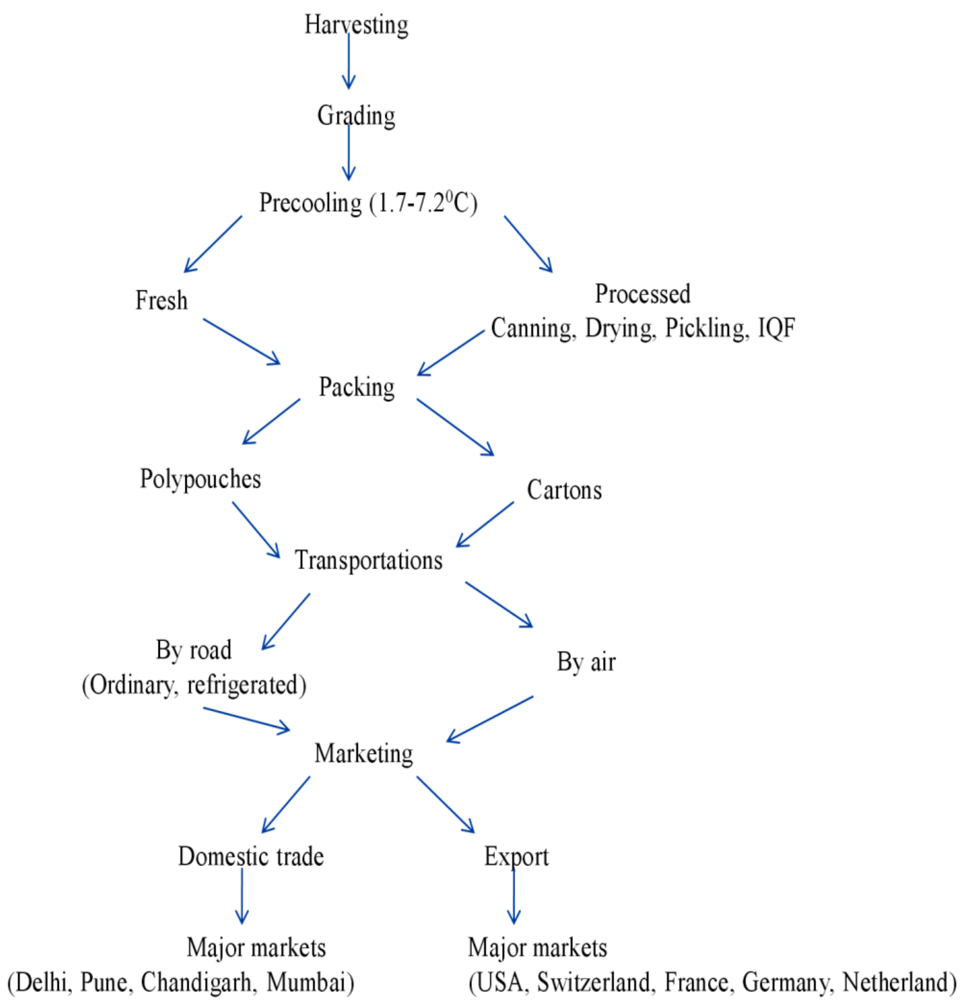

Fig 1: Post Harvest Practices of Mushroom

Pre-cooling: After harvesting another important step is pre-cooling; in this case the produce is kept in a plastic bag and stored in cooling unit. Vacuum cooling is another cooling system where water existing in cell walls and inters hyphal space of produce is evaporated under pressure which lowers the temperature.
But it is cost oriented system and involves inevitable loss of fresh weight. Grading is another important step for marketing. Various grade standards as A, B and C are as per the market demand (Mushroom Grading and Marketing Rules).

Packing: Mushrooms are sensitive to desiccation and drought, consequently a suitable package is very important during storage. Mushrooms are usually packed in polypropylene bags of 250-500g capacities. Quantities more than this have a tendency to loose acceptability. Some researchers have suggested 100 guage polyethylene bags with 0.5% venting area for packing of mushroom for refrigerated storage, while other studies shows that polyethylene bags should not be perforated and be carefully sealed air-tight. For long distance transport, pulp board punnets wrapped with PVC film should be used instead of polyethylene bags. Sometimes, pre-cooled mushrooms are packed in insulated containers having ice in it, so those mushrooms remain fresh, healthy during long transport. These overwrapping create modified atmosphere in punnets producing an atmosphere at about 10% CO_2 and 2% O_2.

Transportation: The pre-cooled mushrooms should be packed in insulated ice containers for 8-9 hrs for distant transport. The effect of pre-cooling is lost partially in post pre-cooling period. Hence for long distance transport, speedy refrigerated transport system is essential in which CFB cartons containing polyethylene pouches of mushroom may be transported by refrigerated trucks. For short distance markets, pre-cooling fresh mushrooms are dispatched in wooden boxes with sufficient crushed ice in poly-packs. For local retailer’s markets mushrooms are packed in poly-pouches and dispatched by easiest mode.

Storage: Freshly harvested mushrooms should be immediately processed by any of the following method.

1) **Short term storage**
2) **Long term storage**
1) **Short term storage:** The shelf life of mushrooms may vary from 1 day to 2 weeks at 1-4^{0}C. Low temperature is effective in the short term preservation because it retards the growth of m/o, reduces the rate of post harvest metabolic activities of mushroom tissues and minimizes moisture loss. Different treatments are effective in

increasing shelf-life of the mushrooms and are discussed as under:

Treatment with solution of salt (2%) and potassium met-bisulphite (015%) has been effective in reducing discolouration. The treatment of lower concentration of potassium meta-bisulphite was found suitable for short time storage (24 hrs) (Maini *et al.,* 1987), while for long time storage citric acid (0.1%) and potassium meta-bisulphite (0.03%) treatment was found better. Rai and Saxena (1988) studied the effect of storage temperature on vitamin-C content of *Agaricus bisporus*. The mushrooms in perforated polyethylene packets at different temperature and relative humidity can stored up to 4 days. After 4 days of storage, the mushroom lost 12-25%vitamin C with loss being highest at 15 ^{0}C and 55-60% relative humidity. Some of researchers studied the effect of pre-harvest aqueous spray of honey, citric acid and *Euphorbia royleana* latex in different combination (Chopra *et al.,* 1985) [11] and they reported that mushrooms treated wide honey (0.5 and 1.0%) 18±2 hrs before harvest, air dried to remove surface moisture, packed in 100 gauge polyethylene pouches with 0.5% venting area and stored at 3 to 5^{0}C, reduced the physiological weight loss and polyphenol oxidase activity. Veil opening and negligible shrivelling was reported even after 21 days of storage. Various concentrations of acetic and citric acid, ascorbic acid and potassium metabisulphite was utilized for steeping preservation of mushrooms and water balanced mushrooms steeped in 0.5% citric acid was the best treatment (Pruthi *et al.*, 1984), while steeping mushrooms in 0.5% calcium chloride, 0.5% citric acid and 0.5% KMS was reported better along with water blanching for storing mushroom at refrigerated conditions for a period of 15 days with negligible physiological loss in weight and minimum changes in phenol content (Vaidya *et al.,* 2008). Irradiation with gamma rays (250 Krad) helps in increasing the storage life for 9-10 days at 15^{0}C (Roy and Bahl 1984). During the prolonged storage elongation of stalks, toughening of texture, opening of veils and loss of whiteness are deteriorative changes were observed.
Responses to Controlled Atmospheres (CA): Extended storage (~12 to 15 days) in 3% O_2 and 10% CO_2 at 0^{0}C has been controlled demonstrated. Elevated CO_2 at 10-15% in air is beneficial in atmosphere (CA) preventing decay and reducing the rate of blackening of stipe and gills. The beneficial effect is most pronounced if temperatures cannot be maintained below 5^{0}C. A short exposure to high CO_2 concentration (20%) is safe and beneficial if temperature can be maintained at 0^{0}C-1^{0}C. Improper contest of CA or improper packaging can rapidly lead to depletion of O_2 resulting in conditions favourable for *Clortridium botulinum.* For this reason, primarily the use of CA and MA is not common.

2) **Long term storage:** It includes canning, freezing, freeze drying and pickling (Kaul, 1983) [31]. Pickling and sun drying are economically viable methods of preservation.

Canning: Canning is the most common process for preserving mushrooms, particularly *Agaricus* mushroom. Canning is divided into six operations; cleaning, grading, blanching, canning, sterilization, cooling, packing and labelling. Canning means to preserve mushroom pieces in brine, oil or vinegar with hermetically sterilized conditions. Following the steps immediately after harvest can reduce browning and blemishes of *Agaricus.* If these are not canned immediately then should be refrigeration at 15^{0}C along with high RH which will help in retaining colour and texture. Soaking for 30 minutes either in sodium/potassium meta-bisulphite or ascorbate, may increase canning yield as well as improves the colour. The mushrooms are then rinsed and blanched for 2 minutes. Blanching is used to reduce the activity of enzymes. After blanching, the mushrooms are placed in cans containing 2.5% sodium chloride and 0.25-0.50% citric acid. The cans are then sealed and sterilized at 120±10^{0}C for an hour, then cooled and stored. Some reported the use of tomato juice medium to be better for retaining the mushroom quality then the brine solution.

Drying and dehydration: Drying refers to the removal of water by heat to such a level that the biochemical and microbial activity is checked due to reduced water activity in the produce. Mushrooms are dried/dehydrated by air-drying as well as freeze drying techniques.
Dehydration by cabinet drier equipment wherein hot air circulation found superior than sun drying (Mudahar and Bains, 1982). Kumar (1992) [35] reported dehydration time of about 9 hrs at 60^{0}C as compared to sun drying. Dehydration ratio is the indication of yield, while rehydration ratio is an indicator of quality. Pruthi *et al* (1978) reported rehydration ratio of 10.0 for untreated and 10.6 for blanched mushrooms.
Mushroom slices are dried at 45^{0}C for the initial 6 hours followed by raising the temperature to 60^{0}C for another 4-5 hours so as to reach the moisture level of 5% in the final product. Freeze drying was reported to be best drying method but not economically viable (Gaur, 2005) [16] while the further reported that drying in cabinet-air drier at 60±2^{0}C results in high per cent of yield along with dehumidified drier (50±2^{0}C). Dried mushrooms are highly hygroscopic and are opting to absorb moisture from the air, so should be properly stored. If moisture content of dried mushroom reached about 20%, insect and mould will infest the mushrooms. So dried mushrooms should be packed in polyethylene bags or can be further utilized for development of other value added products. Gaur (2005) [17] reported development of value added products like mushroom noodles, instant soup mix, instant tikki mix and instant cutlet mix from dried mushroom powder. These products were reported nutritionally enrich and economically viable. Sun drying is not being popularized because of inefficiency of water removal and dependence on weather, which is uncertain. Steps involve in dehydration are as follows:

1. **Selection of mushrooms:** Cap diameter from 1-2.5 inch and stalk length does not exceed 3/4th of an inch, gills develop but veil remains intact.

2. **Washing:** Soaking of mushrooms in solution containing 400 ppm of sodium chloride for 10 minutes prior to drying suggested by Griffins (1989). Whereas, Lin *et al* (2001) [37] suggested washing of whole mushrooms in 500 mg Sodium pyrosulphate solution/kg mushroom for 5 minutes followed by washing with tap water for 10 minutes and drying.

3. **Pre drying treatment:** Different pre treatments are discussed as under

a) Mushroom sliced in 3/8th inch thick slices are blanched by immersing in water or steam. Blanching improves colour because of reduction in enzymatic browning (Singh *et al.,* 2001). Mudahar and Bains (1982) reported

25.2-26.9% loss in weight during blanching whereas Pruthi *et al.* (1984) reported 33.3% loss in weight. Water soluble vitamins may be lost due to leaching, thermal destruction and enzymatic oxidation during water blanching therefore steam blanching reported more preferable.

b) Sulphuring or sulphating known to prevent enzyme catalysed oxidation changes, inhibits microbial deterioration and facilitate drying (Tanga, 1974).

4. **Drying and dehydration methods:** Drying is the age old and a popular method of preserving mushrooms. It is a more economically viable way during the surplus periods. By this process, mushrooms and different spices/condiments according to preference are fried separately. After that these are allowed to cool and filled in bottles/containers. With the advancement of technology, different kinds of trying and dehydration processes have been developed e.g. Sun drying, mechanical drying, air drying, micro-wave oven drying, etc. Among these the microwave oven drying is the best method. Vacuum drying process is followed in reduced pressure. In this process, the produce is subjected to a vacuum drier in which steam is present at about 1.0 to 1.5 bar. A vacuum pump is used to reduce pressure inside the product. The end product is obtained after completion of vacuum drying process.

Freeze-drying is a novel development in food dehydration, but the cost of removal of water is reported to be ten times higher than the conventional air-drying. The drying mushrooms are cut longitudinal ¾ of inch thick slices and blanched to inactive the enzymes. Different kinds of dehydration processes have been developed as sun drying, mechanical drying, air drying and oven-drying etc. Gaur (2005) [17] recommended the water blanching of mushroom (*Agaricus bisporus*) for 5 minutes along with 0.5 citric acid, 0.1% KMS and 125 ppm Ethylene diamine tetra acetic acid to improve colour and texture of mushroom slices. In case of freeze drying the product is 1st frozen and then water is removed by sublimation. The frozen dried mushrooms gaining recognition in the market because of their highly preserved quality (Ray and Bastein, 1962).

Vacuum freeze drying (V.F.D) is a further development in mushroom processing. In this process the original shape, quality, colour size, texture, freshness properties of thermal produce are retained. This process technique involves the cooling of mushroom mush below the freezing point i.e. -40 ^{0}C where moisture present in mushroom is connected to tiny ice molecules which further directly sublime into vapour when subjected to vacuum with a slight rise in temperature resulting a dried end product.

Use of chemicals: In this case mushrooms slice are steeped in solution containing 2.5% common salt, 0.2% citric acid, 0.1% ascorbic acid, 0.1% sodium bicarbonate and 0.1% potassium meta-bisulphite and mushroom can be kept fresh for 10 days. The mushrooms are steeped after blanching in the solution of (1:2) and put into clean glass containers, covered with lids and sealed with lids and sealed with paraffin wax and stored at room temperature (21-28^{0}C). This method of preservation can be used at places where facilities for canning, freezing and dehydration do not exist.

Freezing: Individual quick freezing (IQF) is another popular processing method followed in large industrial units. In thus process, raw materials are washed at processing units after receipt from farm, and the mushrooms are inspected, sliced and graded according to quality. After that, blanched and water cooled mushroom are subjected to tunnel freezing stage. At this stage are cooled in a system having temperature around -40^{0}C and core areas of mushroom pieces acquire a temperature of around -18^{0}C. Subsequently packed in multi-layer polybags and stored in a cold storage having temperature -20^{0}C to -35^{0}C.

Pickling: Pickling of mushroom is also a popular method of preserving. It is more economically viable way during the during the surplus periods. Joshi *et al.* (1991) [28] reported a sweet chutney from edible mushroom having a shelf life of over a year with better sensory quality. Pickle prepared from paddy straw mushroom was also reported with better quality. Mushrooms can be preserved by steeping in 10-12% salt solution.

In addition to these products, mushroom can be utilized for the preparation of weaning food, biscuits etc. Several recipes of mushrooms like mushroom vegetable, mushroom salad, cheese sand wiches, pizza tappings, stuffed morels, meat sluffects, mushrooms, mushroom hot dog, burgers, mushroom omelette, mushroom manchusin etc. are very common now a days.

Value-added products: Drying is the most commonly used technique in button mushrooms to prepare mushroom powder for formulation of value added products (Saxena and Rai, 1990). The dried mushroom powder mainly used in soup mixes, sauces and gravies (King, 1978) [33]. It can be utilized in soup powder. Singh *et al.* (2003) reported development of mushroom-whey soup powder, which reconstituted by boiling in water for 2 minutes. Gaur (2005) [17] reported different value added products as mushroom based noodles, tikki mix and soup powder mix from mushrooms and standardize the recipes for different products (Table 2).

Table 2: Different recipes for value added products from mushroom

Recipe-1: Mushroom Noodle	**Recipe-3:** Mushroom Soup Powder
Dehumidified dried mushroom flour=20g	Dehumidified dried mushroom flour = 20g
Wheat flour= 40g	Potato Starch = 15g
Potato flour=20g	Milk Powder = 35g
Corn flour=20g	Corn flour = 7g
Baking powder=0.2g	Mushroom chunk = 2g
Edible oil=2ml	Dried carrot cubes = 2g
Recipe-2: Mushroom Tikki Mix	Dried cauliflower = 1g
Mushroom flour = 30g	Dried peas = 1g
Potato flour = 50g	Garlic and ginger powder = 0.5g
Corn flour = 8.5g	Salt = 8g
Arraroat = 6g	Sugar = 1g
Onion powder = 4g	Edible oil = 2ml
Garlic powder = 0.5g	Citric acid = 0.5g
Common salt = 3g	

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