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A comprehensive review on cultivation of medicinal properties of wood ear mushroom, *Auricularia polytricha* (Mont.) Sacc.

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Abstract

Auricularia polytricha (Mont.) Sacc. is commonly called as wood ear mushroom. It is an medicinal mushroom which offers nutritional prospects for improving the human health. Moreover, *A. polytricha* has highest antioxidant potential which reduces neurogenerative diseases, inflammation, cancers and cutaneous ageing. *A. polytricha* has highest degrading capacity complex which degrades the lignocellulosic wastes. These enzymes of *A. polytricha* narrow down the C: N ratio and ultimately result in better lignocellulosic degradation. The *A. polytricha* have the potential of inhibiting the disease caused by the plant pathogens was tested by dual culture technique. Hence, medicinal mushrooms will be useful for betterment of livelihoods.

1. Introduction

Auricularia polytricha (Mont.) Sacc. is widely distributed throughout the tropical and subtropical regions of the world (Zoberi, 1972). Nowadays, *Auricularia* mushrooms are among the top four most important cultivated mushrooms in the world, grown mainly in China and Southeast Asia, with a world annual production of 4,20,000 tons (Yan *et al.*, 1999). Their unique jelly-like texture and horizontally septated basidium distinguish them in taste and morphology from other cultivated mushrooms such as *Agaricus bisporus*, *Lentinula edodes*, and *Pleurotus* spp. Besides their taste and nutrition, they also have medical functions, such as antitumour, immunostimulating, hypolipidaemic and hypocholesterolemic effects (Zhang *et al.*, 2006). They can grow well on wide ranges of agricultural and industrial organic wastes. Recently, a nature-imitated cultivation method has been developed in China by cultivating *Auricularia* mushrooms in corn fields, and thereafter, using the spent compost as organic fertilizer

and soil conditioner (Yan *et al.*, 2004). Wood ear mushrooms (*Auricularia* spp.) are commonly cultivated in Asia. Due to the scarcity of suitable logs, plastic bag cultivation is becoming popular, as it allows for the efficient cultivation of different *Auricularia* species on sawdust. The technology can be expected to spread in the near future. There are many *Auricularia* species, of which *A. polytricha*, *A. fuscossuccinea* and *A. auriculujudae* are the most commonly grown. *A. polytricha* is most suitable species to cultivate in tropical regions where temperatures are high (Well *et al.*, 1984). In the wood ear mushroom, minimum work has been done on selection of best substrate for spawn production, growth, yield performance of *A. polytricha* and the partial genome sequence. The present study is aimed at finding out the suitability of growing the wood ear mushroom *A. polytricha* in Tamil Nadu low cost substrates and to assess its yield potential at different locations.

2. Collection and maintenance of wood ear mushroom

Surveys were conducted in the hills of Nilgiris, Shervoy's and Lower Pulneys during rainy season. A wood ear mushroom (*Auricularia* sp.) was collected from coffee plantations of Horticultural Research Station, Yercaud. It is identified as GenBank: PQ725439.

3. Natural habitat and distribution

A. polytricha is widely distributed throughout the tropical and subtropical regions of the world (Well, 1984). It belongs to subdivision:

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Basidiomycotina, order: Auriculariales and family: Auriculariaceae (Bandoni, 1984). The sporophores of this fungus are usually found in their large numbers during late July (Figure 1). *A. auricula* was the first artificially cultivated mushroom in China, and also in the world. The Chinese classical agricultural book ‘Tang Ben Cao’, written in

about 600, A.D. described its cultivation method. Nowadays, *Auricularia* mushrooms are among the top four most important cultivated mushrooms in the world, grown mainly in China and Southeast Asia, with a world annual production of 4,20,000 tonnes (Yan *et al.*, 2004).



Figure 1: Habitat of *Auricularia polytricha* (Mont.) Sacc.

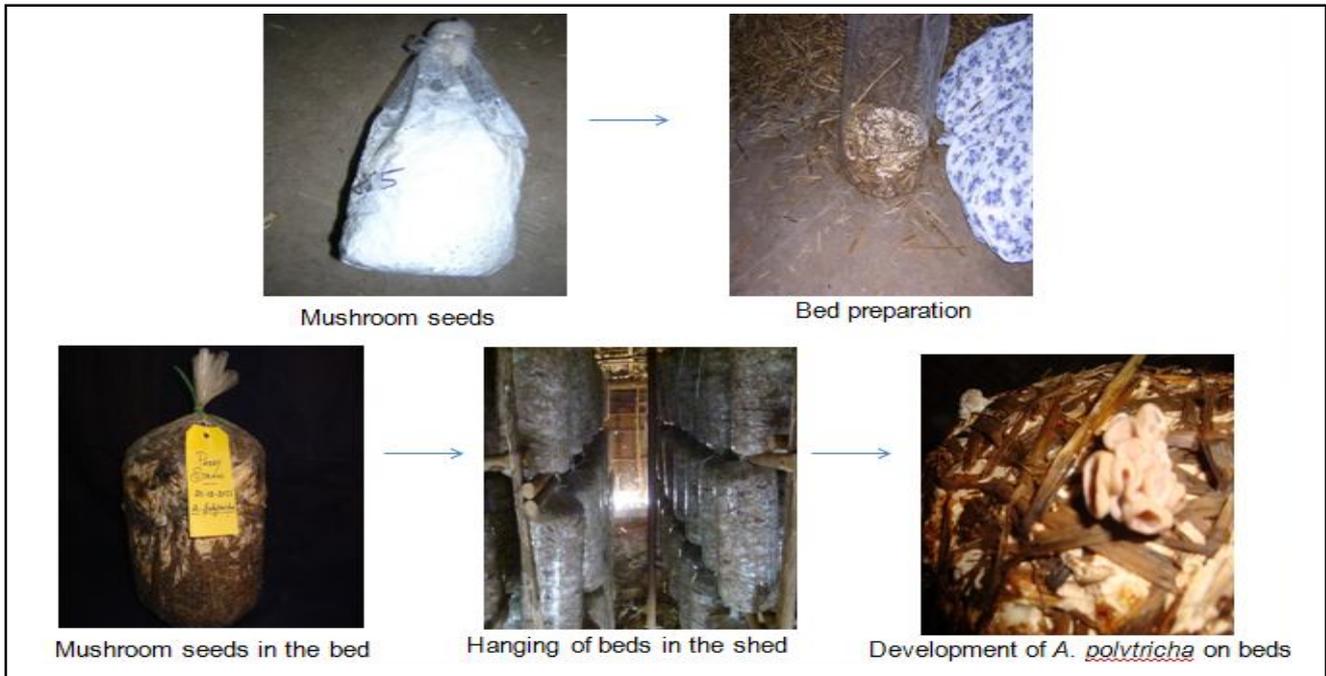


Figure 2: Sequence of events in *A. polytricha* (Mont.) Sacc. cultivation

4. Morphological characters *A. polytricha*

The basidiocarp when fresh is rubbery, gelatinous and ear-like in structure but when dried, it is shapeless and brittle. Jonathan (2002) and Zoberi (1972) reported that *A. polytricha* has a very peculiar consistency. Edible fruiting bodies could be easily identified by pilose upper surface which is strongly capitates with dark brown smooth hymenium (Table 1).

5. Culture media preparation

5.1 Solid media

Susan and Dudley (1999) reported that one per cent malt extract agar recorded best mycelial growth of *A. polytricha*. Mehta and Bhandal (1992) found that *A. polytricha* grew well on wheat agar and potato dextrose agar at 25°C and pH of 5.5-6.0. The work on *A.*

polytricha is very limited and hence the related works in other mushrooms are reviewed. Sharma and Jandaik (1987) found that *Pleurotus eryngii* could grow well on the natural solid media such as potato dextrose agar, glucose yeast agar and carrot agar than the semi-synthetic medium such as Czepek's Dox agar.

5.2 Liquid media

Karthikayini (2009) found that Potato dextrose broth induced high biomass production in *C. indica*. Sharma and Thakur (2010) worked on twelve broth media to find out the suitable medium for biomass production in *Ganoderma* spp. and found that Malt extract broth with sunflower extract recorded maximum biomass production for *Ganoderma* spp. Similarly, among five liquid media tested Potato dextrose broth was found to be the best, which recorded highest dry mycelial weight of *A. polytricha* (Ahila Devi *et al.*, 2013).

Table 1: Mycelial and morphological characters of *A. polytricha*

S. No.	Portion	Portion
1.	Colony character	Initially creamy white, later turning light brown
2.	Spore colour and size	White spore, 16-18 × 6-8 μm in size
3.	Fruiting body and shape	Ear-shaped sometimes flattened types
4.	Stipe	Short stalk (about 7 mm long), lateral, rudimentary
5.	Cap	Rubbery (when fresh), thin, brown, ear-like, 2-15 cm broad
6.	Flesh	Thin and flexible
7.	Veil	Absent

6. Growth requirements/physiological demands

6.1 Temperature

Jonathan *et al.* (2009) reported that *A. polytricha* required 25°C for best biomass production after 15 days of incubation. Susan and Dudley (1999) found that temperature of 12-20°C was the best for fruiting body development in *A. polytricha*. The literature on the physiological demands of *A. polytricha* are very limited and hence the related work on the other mushroom are reviewed.

6.2 Relative humidity

Susan and Dudley (1999) revealed that more than 90 per cent relative humidity is required for better spawn run and mycelial growth of *A. polytricha*. In contrast, Rawal and Sharma (2010) found that at 75-80 per cent relative humidity *A. polytricha* produced maximum and normal sized fruiting bodies. Karthikayini (2009) reported that 80-85 per cent relative humidity gives optimum yield of *C. indica* and *T. lobayense*. Mehta and Jandaik (1989) reported that 80-90 per cent relative humidity was optimum yield of *P. florida* and *P. sapidus*. Popa *et al.* (1999) stated that 85-90 per cent relative humidity is required for better spawn run of *P. florida*.

6.3 Hydrogen ion concentration (pH)

Jonathan *et al.* (2009) reported that the pH of 6.5 was best suitable for the growth of *A. polytricha* in liquid culture medium. Manjunathan and Kaviyaran (2011) revealed that the optimum pH of growth of *L. tuberregium* was found to be 6.5, where the highest vegetative growth was observed. The mycelium of *P. eryngii* grew well at pH of 6.0-6.5 (Sharma and Jandaik, 1987). *Lepiota procera* required the pH of 6.5 for the fast mycelial production in liquid culture media (Jonathan and Fasidi, 2005).

7. Nutritional requirements

7.1 Carbon

The perusal of literature showed only a few works on nutritional requirements of *A. polytricha* and hence related work on other mushrooms are reviewed here under. Luo (1993) reported that fructose, glucose and maltose were the most suitable carbon sources for *A. auricula*. Jonathan *et al.* (2009) reported that among four carbon sources (glucose, manitol, cellulose and fructose), the best mycelial growth of *A. polytricha* was recorded in glucose at 1.6 per cent.

7.2 Nitrogen

Luo (1993) reported that organic nitrogen sources such as yeast extract and peptone were the preferred nitrogen sources for *A. auricula*. Fasidi *et al.* (1994) reported peptone as the best nitrogen source for *L. subnudus*. Jonathan *et al.* (2009) revealed that among four different organic and inorganic nitrogen sources tested at different concentration, peptone was the best for best mycelial growth of *A. polytricha*. The complex nitrogen sources such as yeast extract, peptone and casein, inorganic nitrogen source such as di-hydrogen phosphate and organic nitrogen sources such as tryptophan, asparatic acid and serine were the best for protein production in *V. volvacea* (Banerjee and Samajpati, 1989).

7.3 Carbon: Nitrogen ratio

The ratio of carbon to nitrogen (C:N) balance in the mushroom substrate is very important (Stamets, 2003). Manjunathan and Kaviyaran (2011) reported that C: N ratio of 1:3 and 1:5 supported the best growth of the mushroom and the growth was reduced above or below this levels. Sakthivel (2010) reported that in *A. aegerita* the maximum mycelial dry weight was observed in 3:3 ratio.

8. Substrate selection

8.1 Substrate for spawn preparation

The works on substrate for spawn production of *A. polytricha* is very meagre and hence work on other mushrooms are reviewed. Thiribhuvanamala *et al.* (2005) successfully produced the spawn of *A. polytricha* on sorghum grain, rice bran, wheat bran and saw dust with different combinations. Sharma and Puttoo (2004) reported that the grain substrates were better than the straw substrates for the spawn production of *P. sajorcaju*.

8.2 Substrate for bed preparation and bioefficiency

The maximum bioefficiency of 59.04 per cent in beds with paddy straw + wheat bran at 3:1 ratio in *A. polytricha* (Ahila Devi *et al.*, 2016). Thiribhuvanamala *et al.* (2005) reported that paddy straw, mixed saw dust and wheat bran substrates resulted in early spawn running with uniform mycelial growth of *A. polytricha*, with bioefficiency of 46.4 per cent. Kumar *et al.* (2023) used wheat straw as substrate material with different doses of micronutrients for enhancing the *P. florida* production. Different substrate material have varying degrees of effectiveness in promoting biological efficiency. Sharma *et al.* (1999) revealed that wheat straw when supplemented with 10 per cent wheat bran was the most suitable as it provided 93 per cent bioefficiency in mushroom production (Figure 2). Krishnamoorthy *et al.* (2002) tested agro waste like sorghum stalk, maize stalk, sugarcane bagasse and soybean hay along with paddy straw for the cultivation of white milky mushroom (*C. indica*). They also tested saw dust and coir pith compost for comparison. Paddy straw yielded more whereas saw dust and coir pith compost recorded lowest yields.

9. Molecular markers studies in Mushrooms

It is difficult to isolate DNA from *Auricularia* strains because their mycelia contain high amounts of polysaccharides. After comparing several methods, CTAB method was slightly modified to obtain good quality DNA from liquid cultures of mycelia for RAPD (Yan *et al.*, 1999). Molecular characterization studies on *A. polytricha* using ITS primers exhibited similarity in ITS lengths among the mushrooms. On gel electrophoresis, all the mushrooms amplified a fragment between 600-700 bp (Veeralakshmi *et al.*, 2014). Mushrooms are recognized as natural and healthy foods originating from an environmentally friendly organic farming system (Moore *et al.*, 2001). To make mushroom cultivation sustainable and highly productive, novel improved strains with improved characteristics are greatly needed. However, mushroom strains are very difficult to discriminate, due to lack of clearly distinguishable characters. This makes strain protection problematic, and impedes strain improvement. Molecular markers of rDNA sequencing, RFLP (restriction fragment length polymorphism), RAPD (random amplified polymorphic DNA), microsatellite and mitochondrial genotypes have all been used to discriminate mushroom species or strains of *Agaricus* (Khush *et al.* 1992; Moore *et al.* 2001), *Auricularia* (Yan *et al.* 1999), *Ganoderma* (Hseu *et al.* 1996) and *Volvariella* (Chiu *et al.* 1995). These technologies provide ways to obtain reliable data for mushroom strain identification and protection.

The work on molecular marker studies in *A. polytricha* is almost absent. Singh *et al.* (2006) characterized eighteen specialty mushroom germplasm accessions using DNA fingerprinting and ribosomal rRNA

gene sequencing. Phylogenetic analyses based on RAPD profiles and nucleotide sequence of 5.8S rRNA gene along with its spacer regions revealed variation of inter-generic and intra-species isolates among accessions. Genetic diversity of *A. polytricha* by using random amplified polymorphic DNA (RAPD), inter-simple sequence repeat (ISSR) and sequence-related amplified polymorphism (SRAP) markers was also reported (Yan *et al.*, 2004; Zhang *et al.*, 2006). Most of these studies, however, are mainly on cultivated strains, but almost no study on the diversity among wild strains.

Biochemical and molecular markers have been used to study the relationships between different *A. bisporus* strains and with other *Agaricus* species. Isozymes were used to discriminate among genotypic classes of *A. bisporus*, to confirm crosses between lines, and to identify new alleles and new genotypes in a wild population. Khush *et al.* (1992) studied DNA amplification polymorphism of *A. bisporus* and reported that RAPD markers identified seven distinct genotype among eight heterotrophic strains.

Yan *et al.* (2004) demonstrated that RAPD can be helpful in phylogenetic resolution of edible mushrooms at species and sub species level. Singh *et al.* (2006) reported that phylogenetic analysis based on random amplified polymorphic DNA (RAPD) profiles and direct sequencing of 5.8S rRNA gene region revealed intergeneric, inter and intraspecific variations in *Volvariella*, *Lentinula*, *Ganoderma* and *Calocybe*.

The allozyme markers have been used to estimate genetic diversity and divergence in *Agaricus bisporus*. The most popular locus for DNA-based mycological studies at the sub generic level, and for species identification, is the internal transcribed spacer (ITS) region of the nuclear ribosomal repeat unit, This multi-copy, tripartite, and roughly 550-basepair (bp) segment combines the advantages of resolution at various scales with the ease of amplification of a multi-copy region into a readily obtainable product whose variability typically reflects synapomorphies at the species level.

Kensuke *et al.* (2007) analysed the internal transcribed spacer (ITS) region of ectomycorrhizal fungi and designed species-specific PCR primers for eight ectomycorrhizal *Tricholoma* species. PCR amplification with the specific primers generated fragments of the expected sizes from DNA extracted from the strains of each species but gave no amplified products from the strains of the other 16 species in eight genera. These results suggested that sequence of the ITS region is appropriate to be used for species-level identification of ectomycorrhizal fungi.

10. Protein profiling of edible mushrooms

Proteins and amino acids are the most important constituents of fruiting bodies than other nutrients such as carbohydrates, vitamins and minerals. Considerable amount of work has been done on the estimation of amino acids and proteins of fruiting bodies but relatively very little work has been done on qualitative and quantitative changes in proteins during morphogenesis of basidiocarps and protein patterns of edible fungi, most preferably in *A. polytricha*.

Gel electrophoretic analysis of fruiting bodies of *C. indica* at developmental stages revealed that 20, 18 and 16 protein bands were present in button, stipe with well differentiated pileus and stipe with tiny pileus respectively. Kumar *et al.* (1991) compared six strains of *A. bisporus* for their protein contents, contents of non

protein nitrogenous compounds and their protein heterogeneity with respect to solubility behaviour and electrophoretic pattern.

Singh *et al.* (2006) compared protein profiles of different strains of *Agaricus* using SDS-PAGE and reported that the mycelial protein profiles showed minor differences in protein banding patterns with each strain. Protein profiling of strains of *A. bisporus* and *A. bitorquis* revealed the presence of 18 protein bands in pileus and stipe of each of the strains. Sangeetha (2002) reported that there is no variation in the mycelial protein profile pattern of different strains of *V. volvacea*. Ammarellou (2007) analyzed protein extracts from a species of desert truffle (*Terfezia clavaryi* chatin) using polyacrylamide gel electrophoresis (PAGE) method. Electrophoresis of native proteins gave more than 13 bands in the 15-205 k Da molecular weight range with mobilities of 4.6, 10.7, 15.3, 21.5, 25.7, 27.6, 30.7, 36.9, 40, 52.3, 53.8, 58.4 and 64.6 per cent. There were one major band, 4 prominent bands and 8 minor bands. The major band L, which corresponded to the truffles important storage protein, was focused to about 20 k Da.

11. Enzymatic activities of mushroom fungi

Enzymes are protein molecules that catalyze the chemical reaction taking place in any living cell. Extra cellular enzymes play a vital role in substrate utilization and colonization in case of saprophytes and facultative parasites. Extra cellular enzymes are produced to degrade the large insoluble lignocellulosic molecules into small soluble molecules which the mycelium could easily utilize (Kalaiselvan, 2007). Since fungi are saprotrophic, conversion of the growth substrate into fungal biomass will be determined by the capacity of the fungus to synthesize the hydrolytic enzymes required to convert the polymeric components of the growth substrate into low molecular weight nutrients. Only a very limited information was available on the enzymatic potential of *A. polytricha* and hence the related works on other mushrooms are reviewed under this chapter.

11.1 Cellulolytic enzymes

A characteristic trait of the composition of mushrooms is the occurrence of various enzymes, which are never or only rarely found in other organisms. According to Ratcliffe *et al.* (1994), various species of mushroom manifest different enzymatic activity. The major components of agro wastes like cellulose, hemicelluloses and lignin were degraded by a variety of extracellular enzymes produced by mushroom fungi.

The cellulolytic enzymes play an important role in degradation of plant residues (Wood and Smith, 1987). Efficient degradation of complex lignocellulosic wastes largely depends on the synergistic action of cellulases and lignases. These enzymes narrow down the C: N ratio and ultimately result in better lignocellulosic degradation. Ansu *et al.* (2003) showed that content of mycelium in the substrate and yield at the end of first flush in case of *P. sajorcaju* could be directly correlated with their capacity for utilization of the substrate components based upon their capacity to produce the hydrolytic enzymes. Rawal *et al.* (1981) showed that the cellulase activity was higher in *Pleurotus sajorcaju* after 11 days of inoculation in the spawn and it could further increase up to 26 days after inoculation that matched with initiation of fruiting bodies in the spawn bottle. Arun Kumar (2008) reported that calcium carbonate amended medium results in more lignocellulosic production of *L. edodes*. Karthikayini (2009) reported that increases in cellulase activity resulted in increase of biomass production of *T. lobayense*.

Natarajan and Kaviyaran (1991) established a positive correlation between the biomass production and lingo cellulolytic enzymes production in synthetic media. They observed that the fungal biomass production was increased with increase in lignocellulosic enzymes. Reduction in cellulose content of substrate by 20 per cent and hemicellulose content by 50 per cent through the action of *P. sajorcaju*, *P. sapidus*, *P. ostreatus* and *P. cornucopiae* was reported by Tsang *et al.* (1987). Sharma *et al.* (1999) found that *P. ostreatus* strain (WC 595) had higher biological efficiency and longer crop duration as compared to *P. djamor* due to higher cellulase activity.

11.2 Lignolytic enzymes

Traditionally, crop residues are used for purposes that have high demand such as animal feed, fodder, fuel, thatching roofs, packaging, and composting (Kumar *et al.*, 2014). Arundathi *et al.* (2024) found that various lignocellulosic waste materials as substrates for mushroom cultivation, chemical composition and enzymes for degradation of agricultural waste. About 500 species of Basidiomycotina fungi are found to be capable of degrading lignin. Kerrigan and Ross (1988) used extracellular laccases as a biochemical marker for the systematics of *Agaricus*. The stable dikaryon of *P. florida* formed by compatible crossings between hyperlaccase monokaryon with hypercellulase monokaryon yielded higher quantity of both the enzymes. The comparative evaluation of parents, mutants lacking the production of aforesaid enzymes and the fusants showed a linear relationship between their laccase activity and period of vegetative growth, fruiting and yield. This revealed that the laccase as one of the important markers to develop high yielding strains, due to its role in determining the pattern of growth, fruiting and yield (Ahila Devi *et al.*, 2016; Dhaliwal *et al.*, 1992).

The *A. polytricha* mushroom samples collected from the beds prepared with paddy straw + wheat bran 3:1 ratio recorded the highest level of Exo β -1,4 glucanase (48 μ mol of glucose/ml) and Endo β -1,4 glucanase (47 μ mol of glucose/ml), followed by beds prepared with paddy straw + wheat bran 3:1 ratio (43.00 and 41.30 respectively). (Ahila Devi *et al.*, 2015) Contrastingly, the activity of laccase was the highest (56.60 change in absorbance/min/ml) in the *A. polytricha* mushroom samples for paddy straw + rice bran 1:1 ratio (Ahila Devi *et al.*, 2016). Polyphenol oxidase activity was the maximum paddy straw + rice bran 3:1 ratio (2.71 change in absorbance/min/ml). On the whole, the cellulolytic enzyme activity was high in paddy straw + wheat bran 3:1 ratio beds and lignolytic enzyme activity was high in beds prepared into paddy straw + rice bran 1:1 ratio.

The production of laccase was high in black gram haulms, soybean haulms, paddy straw, groundnut haulms and maize stalks inoculated with *C. indica* (Krishnamoorthy, *et al.*, 2002). Chen *et al.* (2004) indicated that laccase production by *V. volvacea* occurred only in the later stages of growth. Low levels of laccase production observed during substrate colonization increased on the onset of fruit body initiation. Anandh (2001) reported that the laccase activity of *Tricholoma lobayense* increased from the day of inoculation in beds up to first harvest and declined slowly at the later stages. In case of uncased beds, the activity increased up to the spawn running period and declined steadily.

12. Nutritive value of mushrooms

Mushrooms are rich sources of nutraceuticals (Elmastasa *et al.*, 2007). They are excellent source of high quality proteins as compared to

most vegetables. *A. polytricha* is rich in protein (13.8%), fat (1.41%), carbohydrate (71.6%), fiber (4.24%) and ash (5.43%) (Ahila Devi *et al.*, 2016) (Table 2). It is also rich in vitamins, minerals, and calories (Upadhyay, 2005). Rai *et al.* (2000) stated that mushrooms are rich sources of carbohydrates, protein, minerals, fiber, vitamins, essential amino acids and enzymes with low fat and calories. Diez and Alvarez (2001) reported the dietary fiber content, protein content, essential

amino acid content of *Tricholoma portentosum* as 45 per cent, 16 per cent and 61.8 per cent, respectively, on dry weight basis. Anandh (2001) studied the nutritive value of *Tricholoma lobayense* and indicated that it contained 85.20 per cent moisture, 33.25 per cent crude protein, 12.13 per cent carbohydrates, 0.91 per cent crude fat and 21.81 per cent crude fibre. He also reported the calorific value of *T. lobayense* as 189.71 kcal/kg.

Table 2: Nutraceutical values of *A. polytricha*

S. No.	Parameters	Composition
1.	Carbohydrate (%)	72.27
2.	Protein (%)	11.09
3.	Fat (%)	1.33
4.	Crude fibre (%)	2.87
5.	Ash (%)	5.94
6.	Moisture (%)	6.50
7.	Calcium (%)	2.51
8.	Calorific value (kcal/100 g)	345.41
9.	Ascorbic acid (mg/g)	12.57
10.	Phenol (mg/g)	70.0
11.	Total antioxidant activity ($\mu\text{g/g}$)	715.20

Sivaprakasam *et al.* (1981) analyzed the proximate composition of *C. indica* and reported the carbohydrate, protein, fat and ash content as 7.60, 2.40, 0.84 and 1.08 per cent, respectively. They also indicated the calorific value of *C. indica* as 48.0 kcal.

Gbolagade *et al.* (2006) collected young and matured carpophores of twelve common wild edible mushrooms from different locations of Nigeria. These fungi were analyzed for proximate and mineral element composition. The results showed that all the tested samples contained appreciable amount of essential nutrients. Of the entire wild mushroom tested, *T. globulus* was the richest containing highest amount of protein, ash, calcium, phosphorus and iron. This was followed by *T. microcarpus*, *V. esculenta*, *L. giganteum* and *L. pusillum*.

13. Shelf-life and post harvest storage studies

Mushrooms are highly perishable in nature. They keep on respiring after harvest and changes like browning, liquefaction, loss of moisture and texture occurs, resulting in reduced market value and acceptability (Amuthan *et al.*, 1999). At ambient conditions, mushrooms have a short shelf- life up to 2 days (Table 3). Post harvest storage of *Pleurotus flabellatus* at ambient temperature resulted in decrease in soluble carbohydrates and water content (Rajaratnam *et al.*, 1983). Researchers who studied the spoilage of fresh mushrooms earlier believed that the primary cause of mushroom spoilage was due to the enzymatic reaction in the tissues. Later, it was suggested that it may be caused by the action of bacteria and browning of the mushroom due to a combination of enzymatic and microbial action on tissues (Beelman, 1988).

Table 3: Packaging and preservation of *A. polytricha*

S. No.	Methods of preservation	Conditions	Shelf-life
1.	Short term preservation	Natural condition	1-2 days
		Refrigerator	Up to one month
2.	Long term preservation	Sun drying	6 months
		Powder	>6 months

Practically, no work was done on the shelf-life studies of *A. polytricha*. The firmness is a critical factor that determines the post harvest quality of mushroom (Loon *et al.*, 2000). Most of the consumers especially in United States appeared to favour tight mushrooms (Beelman, 1988). The extended shelf - life of 7 days of *Tricholoma lobayense* was due to the firmness of the sporophore. *T. lobayense* was found to be superior to *Calocybe indica* in terms of firmness and nutrients (Anandh, 2001).

14. Preservation of mushrooms

14.1 Short term preservation of mushrooms

The perusal of literature revealed that no work was attempted on the preservation studies of *A. polytricha*. Fresh mushrooms have very limited shelf-life. The advantage of low temperature storage in perishables is well known as it reduces the activity of enzymes and retards the growth. This is most responsible for better keeping quality

or storage of fruiting bodies. Rajarathnam *et al.*, 1983 found that mushrooms stored in 2.5 µm polythene bags (with one pinhole per side) maintained quality for one week at ambient temperature and upto three weeks at $5 \pm 2^\circ\text{C}$. Karthikayini (2009) who worked on that

C. indica and *T. lobayense* indicated that the loss of weight (after 10 days of storage) was low under refrigerated condition when compared to storage at room temperature. Sakthivel (2010) tested the shelf life of *A. aegerita* was studied under natural and refrigerated conditions (4°C). The shelf-life was much better in refrigerated condition recorded about 20-30 days when compared to natural condition which was about 1-2 days only. Mehta and Jandaik (1989) reported that freshly harvested fruit bodies of *P. sapidus* can be easily stored upto 72 h at room temperature ($20-30^\circ\text{C}$) and at low temperature ($0-5^\circ\text{C}$) up to 15 days. Karthikeyan (1999) reported that *P. flabellatus* (82 and 192 h) had more shelf-life followed by *P. eous* (72 and 96 h) and *P. citrinopileatus* (12 and 96 h) under room temperature and refrigerated condition, respectively. Popa *et al.* (1999) stated that storage of edible fungi (*Agaricus bisporus* and *Pleurotus*) at 4°C lead to greatest inhibition of microbial contamination. *A. bisporus* showed better shelf-life in non-perforated packs as compared to perforated packs, at 15 and 20°C for six days with little change in quality. Storage in perforated bags resulted in weight loss, veil opening, browning and spoilage (Dhar, 1992). He also reported that the colour of the mushroom was also changed later the weight of the mushrooms was also drastically reduced and some bad odour comes out of the mushroom.

14.2 Long term preservation of mushrooms

Drying is a simple process that has been used for many years as a means to preserve and increase the shelf- life of products. Milky mushroom was found to be highly suitable for dehydration and pickle preparation (Sarojini, 2003). Kumar *et al.* (1991) reported that blanched or sugar treated and dehydrated *P. flabellatus* had no visible browning up to 6 months, whereas the unblanched dehydrated mushrooms had shelf life of one month. Sakthivel (2010) tested the shelf life of *A. aegerita* after under sun drying, and found that the shelf life of *A. aegerita* was recorded as six months and in case of powder form it was recorded more than six months.

Jandaik and Sharma (1987) reported that sun dried fruit bodies have three to four per cent moisture with slight change in colour in comparison to fruit bodies dried at $55-60^\circ\text{C}$ which turns to dark brown colour. Amuthan *et al.* (1999) showed that osmo air drying of milky mushroom was superior to air drying. They also reported that complete rehydration of mushrooms osmosed with 25 per cent salt concentration was achieved within one hour. Karthikayini (2009) stated that sun drying was found to be the best as it retained the keeping quality of all the strains of *C. indica* and *T. lobayense*.

Nehru *et al.* (1995) studied the solar drying characteristics of oyster mushroom (*P. florida*) and the drying time required to dry the mushroom from 92.6 to 10 per cent moisture content (weight basis) was found to be 5.5 to 6.5 h. The mushroom treated with preservatives such as potassium metabisulphite (KMS) and sodium benzoate at 0.5 per cent concentration for 15 min and dried, had the same amount of nutrients as fresh mushrooms. The maximum rehydration ratio of 5.2 was obtained for KMS treated samples which are 46 per cent of the maximum rehydration ratio obtainable. The

organoleptic evaluation of the dried product indicated that the mushroom dried for 15 min after 0.5 per cent KMS treatment was superior to other treatments.

Suguna *et al.* (1995) studied the drying characteristics of oyster mushroom under sun drying, thin layer drying and fluidized bed drying conditions. A batch type fluidized bed drier (50°C with an air flow rate of 35 m/sec) gave a satisfactory shelf-life of five months. The edible fungi *P. sajorcaju* and *P. citrinopileatus* were preserved by sun drying for three days or dehydration in a hot air drier at 60°C (Das and Anuradha, 1999).

15. Antioxidant and antimicrobial compounds

Foods rich in antioxidants have been shown to play an essential role in the prevention of cardiovascular diseases (Fuhrman *et al.*, 1995), cancers (Dragsted *et al.*, 1993; Renaud *et al.*, 1999), neurodegenerative diseases (Clarke, 1999; Joseph *et al.*, 1999), inflammation (Joseph *et al.*, 1999) and problems caused by cell and cutaneous ageing (Ames *et al.*, 1993). Antioxidant supplements or antioxidant-containing foods may be used to help the human body to reduce oxidative damage or to protect food quality by preventing oxidative deterioration (Elmastasa *et al.*, 2007). In recent years, the restriction in the use of synthetic antioxidants, such as BHA (2-tert-butyl-4-methoxyphenol) and BHT (2,6-ditert-butyl-4-methylphenol), has caused an increased interest towards natural antioxidant substances (Ames, 1983).

Mushrooms such as *A. bisporus*, *L. edodes*, *A. auricula* and many *Pleurotus* species have been shown to possess antagonistic effects against bacteria, fungi, and viruses (Stamets, 2003). Jonathan and Fasidi (2005) tested the activities of some selected mushrooms such as *A. bisporus*, *L. edodes*, *A. auricula* and *Pleurotus* species on bacteria and reported inhibitory responses against some bacteria including acid fast bacterium (*M. smegmatis*) and pathogenic strains of yeast (*Candida albicans*), *Ganoderma*, *Polyporus* and *Cordyceps sinensis* are mushrooms of medicinal importance in China.

16. In vitro evaluation of the antifungal potential of the *A. polytricha*

A. polytricha were tested by dual culture technique (Dennis and Webster, 1971). The minimum mycelial growth was observed in *G. lucidum*, *Fomes lignosus*, *P. florida* against *A. niger*, *A. flavus* Eunjeon *et al.* (1997). Jonathan and Faisidi (2005) reported that *P. florida* against *Candida albicans* and *Microsporium bouldardii*.

16.1 Extraction of antifungal compounds by solvent extraction systems

Bioactive compounds derived from medicinal mushrooms are widely used for controlling pathogenic diseases of crops and trees (Gayathiri *et al.*, 2021). Moller *et al.* (1996) reported that plates of siliga gel 60 (Merck) were used to detect the extracts that have antifungal activity. The aliquots of chloroform extract of three popular edible mushrooms; *L. edodes* (Shiitake mushroom), *V. volvacea* (paddy straw mushroom) and *A. polytricha* (cloud ear fungus) were analysed by TLC qualitative test. The separation were studied in nonprotein fractions by mobile phase systems.

17. Conclusion

In this paper, research findings during the past decades have been summarized, including the morphological characters media for *A. polytricha* growth, protein profiling and enzymatic reaction The

aim is not only to give a comprehensive insight into cultural and morphological characters, but also provide knowledge that will lead to more development and applications of *A. polytricha*, and stimulate interests in the relationships between their structural features and biological activities.

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Conflict of interest

The author declares no conflicts of interest relevant to this article.

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