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Research Review

Review on Commercially Grown *Pleurotus species*: Cultivation and Nutritional Values

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ABSTRACT

Mushrooms are nutritionally low in fat and energy but high in protein and carbohydrate. Polysaccharides, lipopolysaccharides, protein, peptide, glycoprotein, nucleosides, triterpenoids, lectins, lipids, and their derivatives are part of the chemical nature of the bioactive substances present in the mushroom. Pleurotus species can be cultivated easily because of their rapid colonization and biological efficiency in various agro-substrates. Modern pharmacological research reveals a substantial part of traditional knowledge, as well as use as functional foods, the medicinal effects of mushrooms due to their antifungal, antibacterial, antioxidant and antiviral qualities. The present report aims to provide a critical review of aspects related to the cultivation and nutritional values of the genus *Pleurotus*.

***Key words*:** Bioactive, Biological efficiency, Agro-substrate, Pharmacological, *Pleurotus*

Linnaeus originally placed mushrooms in the Division Thallophyta, which included the so-called lower plants. This was partly owing to the structural features being quite simple and anatomically uncomplicated (lack of true roots, true stems, true leaves, true flowers, and true seeds) [1]. Oyster mushroom, because pileus or cap is shell-like, spatulated and the stem eccentric or lateral is often called the Oyster mushroom [2]. Modern research has determined that mushroom biota, like other fungi, have characteristics that are sufficiently and significantly different to place them in a separate fungal kingdom, the Kingdom Myceteae. At various eras and in various nations, the word mushroom has been employed in a variety of ways. All bigger fungi, or fungus with stalks and caps, or all large fleshy fungi are included in a broad definition of the term mushroom. Only larger fungi that are edible and/or medicinally valuable are used in this way. “A mushroom is a macro fungus with a characteristic fruiting body that can be epigeous (above ground) or hypogeous (below ground), and that is large enough to be seen with the naked eye and plucked by hand”.

The world's second largest mushroom is oyster mushroom, which accounts for 25 percent of the global production of farmed mushrooms. Oyster mushrooms were considered one of Korea's most profitable cash crops, representing 65 percent of domestically produced mushrooms. As a crop fungus, the oyster mushroom has numerous advantages: rapid mycelial development, high saprophytic colonization abilities, simple and economical growing procedures and various species suitable for cultivation under varied climatic circumstances [2]. Fungi are heterotrophic, eukaryotic, and osmotrophic. The tube (radiating hyphae making up mycelia or colonies) is quite widespread, branching, and is reproduced by the spores. The word "mushroom" describes a fungus' reproductive or fruiting structure [3]. The *Pleurotus* genus (Oyster mushroom) is a rapidly growing organoleptic fungus belonging to Basidiomycota [4].

Mushrooms and fungi in general are nongreen organisms lacking chlorophyll. They cannot manufacture their own food from simple inorganic materials, such as water, carbon dioxide, and nitrates, using energy from the sun, as is the case with the green plants. They derive their food from complex organic materials found in dead or living tissues of plants and animals. Those obtaining their nutrients from dead organic material, e.g., agricultural crop residues, wood of dead trees, animal dung, etc., are referred to as saprophytic fungi. Parasitic fungus is named those deriving their food from live plants and animals and harmful for hosts. But there are other fungi whose members have a certain kind of relationship in a close physiological association with each partner having some crucial advantages. These are known as mutualistic symbiotic fungus. The nutritional and ecological requirements of saprophytic mushrooms are typically fairly particular species. *Pleurotus* is one of saprophytic fungal examples [5]. Several *Pleurotus species* are distinguished by a white spore print (leaving whole night mushroom spore deposit on the

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paper that gives an idea of the color), attached gill with eccentric stipe or no stipe at all [6].

Mushroom represent an important cultural heritage as they have valued as food and medicine transmitted this traditional knowledge along the generation are a group of fleshy macroscopic fungi, all edible mushrooms are the source of protein, vitamin, minerals, etc. and interest as an important source of biologically active compounds with antibiotics, antimicrobial, antitumor, anti-inflammatory properties. Nutritional and medicinal properties have long been recognized by China and Japan for different genera and species of mushroom [7-8] as well as a wide range of biotechnological and environmental applications, it is a cosmopolitan group of highly nutritious food, therapy and biotechnology uses in addition to a wide range [9]. Mushrooms can be categorized into four groups: 1. Fleshy and edible are categorized as edible mushrooms, e.g., *Agaricus bisporus*; 2. Medicinal mushrooms are called mushrooms that have been regarded to be medicinal applications, e.g., *Ganoderma lucidum*; 3. Those who have been proven or are alleged to be toxic are called toxic mushrooms, e.g., *Amanita phalloides*; 4. Those in a miscellaneous category including a huge variety of mushrooms with less defined features. These may be placed together tentatively as "other mushrooms" [10].

The unique properties of mushroom growth and development in nature result in the accumulation of a wide range of secondary metabolites, some of which have biological functions. *Pleurotus ostreatus* and *Pleurotus pulmonarius* are the two most often farmed *Pleurotus species*. More than 200 species, on the other hand, have already been studied to varying degrees. Basidiomata and *Pleurotus* mycelia are excellent sources of functional foods/nutraceuticals and medicines with antioxidant, antibacterial, anti-inflammatory, anticancer, and immunomodulatory properties that are both renewable and easily accessible. Many chemicals, including polysaccharides, phenolics, terpenes, and sterols, have already been precisely characterized. Intensification of structure determination, on the other hand, is extremely desirable and necessitates significant work. It's also crucial to expand the hunt for novel bioactive to *Pleurotus species* that haven't been studied as thoroughly. The specific growth and development properties of mushrooms in nature lead to a range of secondary metabolites, several with biological functions. Since ancient times, mushrooms have been considered worldwide as gourmet cuisine for their special taste and subtle flavour. They are regarded to be major food sources, in particular vitamin D, including dietary fibre, minerals and vitamins. In nature there are more than 2000 varieties of mushrooms, although few of them are commonly acknowledged for food and commercial cultivation. Their possible therapeutic impacts on human health have recently made them more popular as functional meals. Therefore, both cultivated and wild, edible mushrooms are of particular importance to the food industry. These edible basidiomycetes are commonly considered oyster mushrooms *Pleurotus ostreatus* and *Pleurotus pulmonarius* (Fr.) Quel are the largest cultivated species of *Pleurotus* [11]. Because of its easy production, rapid development but also due to its organoleptic, nutritive and medication properties it also contains immunological activities, anti-tumors, anti-inflammatory activities and anti-microbial activities, *Pleurotus ostreatus*, better known as the "oyster mushroom" or "repolgas", is also among the most consumed of mushrooms in the world [12].

Pictures of *Pleurotus species* (Source-Google, Wikipedia)

The geography of the oyster mushroom depends on its species. In the tropical and subtropical areas for example, *Pleurotus pulmonarius* and *Pleurotus cystidiosus*, whereas *Pleurotus eryngii*, in Southern Europe, North Africa and Central Asia, is known to be dispersed. It has several subspecies and related taxa, including Chinese *Pleurotus fuscus* var. *ferulae*. Because fruit-body forms at relative low temperatures compared with other *Pleurotus species*, *Pleurotus ostreatus* is generally present in temperatures such as Korea and Japan. Most of Equatorial Africa, India, Sri Lanka, Southeast Asia, Northern Australia, and Southern Pacific are included in the geographical distribution of *Pleurotus tuber-regium* [2].

Advantage of growing mushroom

In order to eliminate xenobiotic contaminants including pentachlorophenol (PCP), dioxins and polycyclic aromatic hydro carbohydrates (PAHs), Pleurotus spp. also was utilized to reduce the lignin-cellulose capability. This suggests new use for environmental bioremediation of this fungus. Due to these features, this mushroom has grown enormously over the last few years and is considered second

to the button mushroom [2]. The quality of proteins in mushrooms is superior than most plant proteins with reference to Food and Agriculture Organization (FAO) standards [13]. Mushroom is an organic plant and mushroom farming is environment friendly and economical profitable, yet intensive in work. There is no need for cultivable land and vertically it may be cultivated in the room. Cultivating mushrooms can contribute to reducing poverty vulnerability and enhance livelihoods by generating a fast production and nutritional source of food and a reliable source of income. Commercial cultivation started in Europe at the beginning of the last century, while Bangladesh has a very recent history of mushroom production. Due to its excellent environment, cheap production costs, availability of growing substrates and high market values, Bangladesh is among the most appropriate mushroom-growing countries in the world. Mushroom consumption may in some ways relieve malnutrition since in a short time it produces vast numbers and produces more protein per unit area than any other crop [14].

Pictures of *Pleurotus species* (Source-Google, Wikipedia)

Disadvantage

Three significant drawbacks continue in the production of oyster mushroom besides the usage as food and bioconversion materials. First of all, the Oyster Mushroom is quickly spoiled and just a few days are available on the market. Second, the spore burden formed by pickers in a growing area can represent a possible health risk for workers. Oyster mushroom producers are highly sought for by spore less strains types that tend to have short gills and become thicker and fleshier. Thirdly, farmers have to fight the mushroom flies in a constant way. Oyster mushroom is far more attractive to Sciarid and Phorid than any other mushroom group.

Mushroom cultivation

The cultivation of *Pleurotus ostreatus* mushrooms is quite widespread in India and popular and consumed next to *Agaricus bisporus* mushroom. This combination forms a bulk of the country's edible mushroom (about 100000 tonnes per annum, 2008-09). After establishing the Himachal Pradesh mushroom growing project, the Directorate of Mushroom Research at the ICAR in Solan in 1961, there have been documented sincere efforts to bring mushrooms to agriculture in India [15]. The United Nations Food and Agriculture Organization's worldwide production of mushrooms as updated (2009). As they produced over 1.5 million metric tonnes in 2007 China was revealed to be the largest producers of mushrooms. In ten years, this showed an increase of almost 65%. The United States and Canada were thereafter. The amount of metric tonnes produced throughout a 10-year time period has increased drastically in Israel and India, whereas Singapore and Kazakhstan have been seen as a newcomer since 1997, with the least mushroom produced. Over time, mushroom production appears to grow continuously [16]. Mushrooms can easily cultivate by products from rich organic substrates such as cellulose, hemicellulose and lignin such as sawdust, leaves and other agricultural products [17].

Commercial mushrooms, including forests, are either grown or taken from the wild. All the species produced in cultivation can complete their life cycles on decaying organic matter by decomposing (or saprobes). Most of the mushrooms gathered from forest are ectomycorrhizal, therefore they can only grow with live trees. More difficult life cycles combining the features of decomposers and mycorrhizal fungi are present in others, such as fire-associated funguses. For nourishment, medicine and other ceremonies as well as for useful reasons, such as tinder, smudge, stylus, dyes and textiles, wild fungi are used [18]. Until present, around 70 *Pleurotus species* are recoded but only a few of them grow in industry. *Pleurotus species* perform in various climates and environments a broad range of physical characteristics. The morphological classification leads to misidentification and a complicated taxonomy of *Pleurotus*. This will not lead to a single conclusion on taxonomy investigations. A case in point is white Basidiomata. *Pleurotus eryngii* var. *nebrodensis* is a distinguishing characteristic, but newer reports have also been found in several *ferulae* isolates [19]. The cultivation of mushrooms normally takes place with greenhouse for many years. In order to reduce the production time, increase the volumetric and specific bioactive metabolites, and to decrease the contamination risks during mushroom cultivation, cultivation was now carried out successfully in the complete submerged cultivation system, in addition to the solid-state cultivation system using lignocellulosic biomass residues [20]. Commonly grown mushroom is high in protein, carbohydrate, fiber moderate, low in fat and calories and a good source of vital amino acids, vitamins and minerals [21]. While seventy species of *Pleurotus* are known, there are just a few on the market, such as *Pleurotus florida*, *Pleurotus sajor-caju* and *Pleurotus ostreatus*. Numerous studies focus on the biodiversity of *Pleurotus*. Most research works have been carried out with the purpose of clarifying the genus in terms of morphological appearances and its identification [22].

Worldwide distribution

The second most important commercial mushroom is in the Pleurotaceae family. It is mainly because of its high nutritional content which can be used as a human diet and medicines. As wild mushrooms of this genus are distributed worldwide, *Pleurotus species* may be cultivated in wild temperate or tropical locations [23]. Mushroom is cultivated all around the world, and China is the biggest producer. First grown in the USA in 1900 and in India after the late 1940s numerous additional oyster mushroom species, such as *Pleurotus sajor-caju*, were initially grown [2]. Mushroom farming is an economically significant biotechnology sector which has developed significantly around the world. More than 10 million tonnes of edible and medicinal mushroom in 2004 are estimated to have been produced in various nations. Expanded in the past decade, after strains and advances in technology, coupled with improved acceptability of mushrooms and derivatives. The conversion of mushrooms was called the 'non-green revolution.' But the mushroom science is very new and, with limited investments in the mushroom research, the mushroom industry is minor compared to many plant crops. As a result, scientific mushroom study is often behind the plant and animal research**.** In terms of history, Chinese people have introduced mushroom as an important and healthy diet or, in other words, "the elixir of life." Moreover, in a spiritual ceremony, Mushroom is prescribed by Mexican Indians as a remedy for hallucinogens' use. The people of Greek were supposed to have given the soldier or fighter power to mushrooms. Many mushroom species worldwide attracted a significant amount of attention since they are a significant source of delicious foods with strong nutritional characteristics and medicinal potential [24].

Cultivation of different species

Mushroom Oyster is considered to be one of the world's market-specific edible mushrooms. It is composed of a variety of different species including *Pleurotus ostreatus*, *Pleurotus sajor-caju*, *Pleurotus cystidiosus*, *Pleurotus cornucopius* and *Pleurotus flabellatus*. Most hardwoods are grown and wood-based by-products such as sawdust, paper, cereal straws, maize and maize cobs, coffee residues such as cafés, hulls, sticks and leaves, bananas, and waste cotton often containing plastic sacks and bottles are grown.

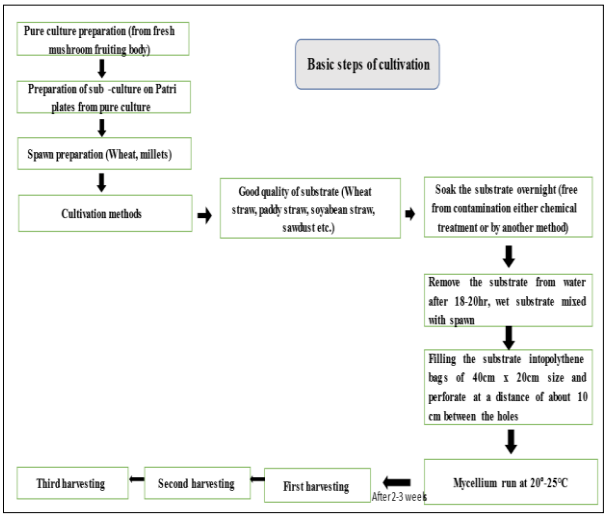

Fig 1 Basic steps of cultivation

Pleurotus sajor-caju was cultivated on pseudo-system and paddy straw in India successfully. The use of expensive substrate for producing oyster mushrooms increases production costs. Rice straw, ragi straw, hulled maize cap, waste paper, have been proven through many research. Therefore, some alternative materials have to be searched which should be sufficiently available at a comparatively cheap price. In West Bengal, the hyacinth (*Eichornia crassipes* Solms.) in India, a low-cost supplement for oyster mushroom growth (*Pleurotus florida*) is reported to be grown easily in a range of unconventional substrates. Higher yields in mixed beds (paddy straw and water hyacinths) followed by paddy straw alone (698.1g and 139.6% BE) and water hyacinth alone were recorded in P. florida of 184.7% with a high yield (923.7 g) of biological efficiency (614.1g and 122.8 percent BE). Agro wastes are recycled through growing of mushrooms. In Chhattisgarh, the inhabitants in the village practiced paddy straw as a substratum in their own style and brought it to the local market where it is priced attractive, with tribal occupations notably in the rainy season being pursued in mushroom hunting [25]. China is the biggest producer, accounting for 87% of Pleurotus species' total world production. The majority of Chinese oysters are *Pleurotus ostreatus* and *Pleurotus cornucopiae* of two species.

However, over the last five years or so the production of *Pleurotus eryngii* and *Pleurotus nebrodensis* has increased considerably. In Japan, *Pleurotus spp*. production grew almost 200% (13,3 million kg) from 1997 to 2010. (39.6 million kg). In terms of a percentage (+453 per cent), *Pleurotus eryngii* saw the highest production gains from 6.7 million kg in 2000 to over 37 million kg in 2009. Most of *Pleurotus eryngii* is cultivated with sawdust, bran and polypropylene bottles, of Japanese cedar or soil corncobs [26]. *Pleurotus* has approximately 40 species across a variety of tropical and temperate regions. There are 26 species known to be cultivated utilizing various forms of lignocellulose wastes, including *Pleurotus eryngii*, *Pleurotus citrinopileatus*, *Pleurotus ostreatus*, *Pleurotus ostreatus*, *Pleurotus djamor* var. *roseus* and *Pleurotus florida* [27].

Cultivation using different substrate

Three factors, namely reliable spawn, a good substrate and a conducive environment, must be considered for successful mushroom growing. Mushroom substrates play the same role as soil in plant production. Sterile, rich in vital nutrients including nitrogen (N) phosphorus (P), potassium (K), magnesium (Mg) and iron (Fe) are the essential agents for cultivating edible fungi. Supplementation of nitrogen sources, such as manure from animals, which provides substantial amounts of important plant nutrients that minimizes costs of production [28]. The advantage of the mushroom-substrate modification of plant manure is the high amount, in addition to the primary nutrients, of Calcium, Copper, Manganese and Iron. For the cultivation of oyster mushrooms the compost treatment with calcium is desirable. The advantages of manganese and iron on cultivation of oyster mushrooms are well documented. Sawdust is utilized as the main altered ingredient in Sri Lanka, with the usage of rice bran and protein as growing substrate, for oyster mushrooms, and soya and green grammes are the most common ingredients used in the substrate production for protein supplements [29].

In India, several edible mushrooms grow naturally on wood. *Pleurotus sajor-caju* was reported to be cultured in logs of nine different trees. With the logs *Mangifera indica* L. and *Artocarpus lakoocha* L. researchers have achieved the best results [30]. *Pleurotus spp*. cultivation on agro-residues helps to efficiently dispose of this waste [31]. Sawdust, cotton seed straw, grain strokes, corn, sugar cane stroke and other high cellulose plant fibres are most frequently utilized substrates. These have been documented for their development, yield and composition, however an ideal substrate material for rapid growing mushroom should contain nitrogen (supplement) and carbohydrates [32]. Different agricultural materials are utilized as substrates to the cultivation of oyster mushrooms, such as leaves of banana, peanut pulp, maize leaves, wheat and rice straw, mango and seed. The lowest and most suitable substrate, generated mostly by cotton spinning industry, is cotton waste substrate [33]. Based on the local availability of agricultural waste, different substrates may be recommended by region [34]. In Nepal, rice straw is the main substrate for the cultivation of oyster mushrooms [35].

Parameters for oyster mushroom (Raman *et al*. [33])

Species	Common name	Temp. range (°C)	Humidity (%)
Pleurotus pulmonarius	Phoenix oyster	21-29	90-95
Pleurotus sajor caju	Gray oyster	20-28	65-80
Pleurotus ostreatus	Black oyster	18-22	85-90
Pleurotus cystidiosus	Brown oyster	21-27	85-90
Pleurotus eryngii	King oyster	15-21	85-90
Pleurotus tuberregium	King tuber	30-35	85-90
Pleurotus flabellatus	Strawberry oyster	25-30	65-70
Pleurotus florida	White oyster	20-28	80-90
Pleurotus citrinopileatus	Golden oyster	18-29	70-80
Pleurotus djamor	Pink oyster	20-30	75-85

Nutritional value

According to DeFelice and similar sources, “a nutraceutical is any substance that is a food or a portion of food that delivers medical or health advantages, including the prevention and treatment of disease” [36]. Nutrient composition assessment comprised protein, lipids, ash, fibre, moisture and carbohydrates. The composition evaluation included the identification of phenolics, flavonoids, carotenoids and alkaloids [37]. Oyster mushroom is also rich in protein, carbohydrate, fibre, vitamins and minerals, and low in calories, fat and cholesterol. These nutritional features make this mushroom a nutritious food [2]. The terpenes, lactones, amino acids, and carbohydrates of their composition determine a range of precious aromas and flavour characteristics to their fruiting body and mycelial biomass**.** However, their nutritional supremacy in relation to the vegetarian diet is also virtue of their chitin rich cell wall that acts as a source of dietary fiber, along with their vitamin content (including thiamine, riboflavin, ascorbic acid, ergosterine, and niacin), considerable contents of micro and macro-elements as phosphorus and iron, carbohydrates and very low-fat tenor [38].

In comparison with vegetarian diets, higher Basidiomycetes mushrooms have specific natural advantages as regards dietary superiority. This includes high protein content, essential amino acids that replace the meat diet, the rich chitinous wall that works as a source of dietary fibre, vitamin (B_1, B_2, B_{12}, C, D and E), micro and macro elements, carbohydrates, low fat and zero cholesterol content. Because of the high protein value, mushroom contributions can be used to bridge the protein malnutrition gap and a low content of carbohydrate and cholesterol that are acceptable for people with diabetes and cardiac disease. The bioaccumulation potential of fungi-enriched nutrients with important health components was therefore explored [39]. Several mushroom species include a wide range of free radicals or reactive oxygen breeders that

have enhanced the attractiveness of mushrooms as nutritional and pharmaceutical sources. There was high β-carotene-linoleate bleaching inhibition and radical scavenging in the presence of phenol components in two mushroom extracts [40]. The low-fat content of *Pleurotus spp*. mushrooms, of the genus highly appreciated, varies between 112.2 and 118.2 g/kg and is therefore also regarded as an essential dietary fibre source [41]. Potassium macro element supports normal cardiac rhythm, fluid balance, blood pressure, nervous function and blood cholesterol [42].

Medicinal impact of edible mushrooms and bioactive substances

Fungal species	Active compound	Medicinal effect	Reference
Pleurotus sajor-caju	Lovastatin	Lower cholesterol	Golak-Siwulska *et al*. [43]
		Anti-hypercholesterolemic	Khan *et al*. [44]
		Anti-arthritic	Patel *et al*. [45],
	B-glucans	Hypoglycemic	Kanagasabapathy *et al*. [46]
Pleurotus ostreatus	Protein	Antiviral	Wang *et al*. [47]
		Antifungal	Erjavec *et al*. [48]
		Anti- cancer	Wang *et al*. [47]
	B-glucans	Antibacterial	Karaman *et al*. [49]
		Anti-arthritic	Rovenský *et al*. [50]
		Anti-cancer	Jedinak *et al*. [51]
	α-glucan	Anti-cancer	Lavi *et al*. [52]
	Proteoglycans	Anti-tumour	Sarangi *et al*. [53]
	Heteroglycan	Immunomodulatory	Devi *et al*. [54]
	Polysaccharides	Anti-oxidative	Jayakumar *et al*. [55]
		Anti-inflammatory	Gunawardena *et al*. [56]
		Anti-tumour	Tong *et al*. [57]
	Pleuran	Anti-atopic dermatitis	Park *et al*. [58]
	Lectin	Anti-tumour	Wang *et al*. [47]
	Lovastin	Anti-hypercholesterolemic	Alam *et al*. [59]
		Anti-atherogenic	Abidin *et al*. [60]
	Ergosterol	Anti-hypercholesterolemic	Dissanayake *et al*. [61]
	Chrysin	Anti-atherogenic	Abidin *et al*. [60]
	Not specified	Hypoglycemic	Ravi *et al*. [62]
		Anticataractogenic	Isai *et al*. [63]
Pleurotus nebrodensis	Protein	Anti-cancer	(Lv *et al*. [64]
		Anti-viral	
Pleurotus abalonus	Polysaccharides	Anti-viral	(Wang *et al*. [65]
	Polysaccharides-peptides	Hypoglycemic	(Chen *et al*. [66]
Pleurotus citrinopileatus	Lectin	Anti-tumour	(Li *et al*. [67]
		Anti-viral	(Hassan *et al*. [68]
	Phenols	Anti-oxidative	(Lee *et al*. [69]
Pleurotus cornucopiae	Peptides	Antihypertensive	(Jang *et al*. [70]
	D-mannitol	Antihypertensive	(Hagiwara *et al*. [71]
	Angiotensin inhibitor peptide converting enzyme	Anti-atherogenic	(Abidin *et al*. [60]
Pleurotus florida	Lovastatin	Anti-hypercholesterolemic	(Khan *et al*. [44]
	Lectin	Anti-oxidative	(Bera *et al*. [38]
	Polysaccharides	Anti-inflammatory	(Ghazanfari *et al*. [73]
Pleurotus eryngii	Ergothioneine	Anti-atherogenic	(Tong *et al*. [57]
	Protein	Antifungal	(Erjavec *et al*. [48]
	Glucan	Immunomodulatory	(Vetvicka *et al*. [74]
		Anticancer	(Vetvicka *et al*. [74]
Pleurotus eous	B-glucans	Antinociceptive	(Sr *et al*. [75]
	Fatty acid esters	Antibacterial	(Saral [76]
Pleurotus cystidious	Ergosterol	Antifungal	(Menikpurage *et al*. [77]
Pleurotus tuber-regium	Polysaccharides	Anti-oxidative	(Wu *et al*. [78]
Pleurotus ostreatoroseus	B-glucans	Anti-inflammatory	(Corrêa *et al*. [9]
Pleurotus pulmonarius	B-glucans	Antinociceptive	(Baggio *et al*. [79]
		Anti-inflammatory and analgesic	(Smiderle *et al*. [80]

Protein and amino acids

The *Pleurotus* genus can, especially for vegetarians, be seen as a rich source of tasty proteins. Amino acids, chitin, and nucleic acids constitute nitrogen molecules that are not protein. The most general coefficient values are between 3.45 and 4.38, which makes total nitrogen a protein. This value is better. The assimilability of mushroom protein depends on the species of 9.29 to 37.4 g/100 g fruit organisms (DW) [27]. Relatively rich in amino acids, mushroom protein is threonine (41–95 mg/g DW), valine (36–89 mg/g DW), glutamic acid (130–240 mg DW) and aspartic acid, respectively (91–120 mg/g DW); and arginine, but poor in methionine (1.2–22 mg/g DW) and cysteine (16–19 mg/g protein). Protein is also a common source of protein [13].

Carbohydrate

Pleurotus mushrooms include significant quantities from 24.95 to 75.88% of carbohydrates. Most of the mushroom nutrients are made from polysaccharides and chitins found in mushrooms. The greater amount of celluloid, which includes rich dietary fiber, causes mushrooms to fight and reduce obesity as a low-calorie diet with a better therapeutic value for diabetic patients. The percentage of carbohydrates was between 34.0 and 63.3% [27]. Mushroom dietary fibre consists largely water insoluble fibre with low water-soluble dietary fibre levels, mainly chitin and b-glucan (less than 10%) [13].

Lipids

In general, edible mushrooms are low in lipids and linolenic acid level is generally low. Low lipids, good fats such as linoleic acid and oleic acid are found in *Pleurotus species*. In PE and PTR correspondingly the maximum fat level (7.5%) and the minimum fat content (1.06%) were reported. The average fat content in PEO (4.73%) and PC (3.9%) has been reported [27].

Vitamins and minerals

The nutrients that are not generated in the body and must be provided via the diet, are extremely high in folic acid (B9), commonly known as folic acid found in *Pleurotus* mushroom. It includes most essential nutrient minerals such as high potassium, remarkable phosphorus levels and low levels of sodium. Some 90 percent of iron (Fe) bioavailability is easily absorbed in the edible mushroom [27].

CONCLUSION

As compared to medicinal plants, no considerable attention is paid to research programs on medicinal mushrooms in India. The therapeutic potential of some of the mushrooms have been extensively studied in different countries of the world especially in Korea, Japan, China, Russia and America, but not much work has been done on the tropical countries like India especially in central part of India (Madhya Pradesh). Bundelkhand region is somewhat a backward region in the means of awareness of mushroom uses. There is a need for encouragement of different uses of mushrooms like food, medicine, pharmaceutical uses, therapeutical uses, fuel etc. Research have shown that many nutraceuticals, functional foods and naturally occurring chemicals have had a strong influence on metabolic pathway and often have little harmful effect unlike today's drugs that have many side effects are available. These products have been investigated and reported intake of these mushrooms may be indicated as a protection against certain diseases. *Pleurotus species* cultivation as well as its nutraceuticals value anti-oxidative, antimicrobials as well as anticancer in India have been noted in review studies reviewed in this article. For the development of nutraceutical products, in particular in India, more strategies are needed to use the bioactive constituents of mushrooms. This review can assist in understanding the essential components of mushrooms and the daily needs of nutraceuticals. Mushroom production and their bioactive compounds could help the researchers for additional studies of nutraceuticals.

Conflict of interest

There is no conflict of interest.

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