



## REVIEW PAPER

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## Lion's mane mushroom; new addition to food and natural bounty for human wellness: A review

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### Abstract

Lion's mane (*Hericium erinaceus*) is an important wild edible mushroom widely distributed throughout North America, Europe, China and Japan having good dietetic and pharmacological activities. *H. erinaceus* is rich source of proteins, carbohydrates, crude fiber, low fats and ash. Moreover it also contains calcium, thiamin, minerals, vitamins, essential amino acids and soluble sugars such as arabitol, glucose, mannitol, inositol and trehalose. *H. erinaceus* is rich source of physiologically important polysaccharides such as Hericenones A-B, Erinacines A-I, Hericenones C-H, Hericirine and polyphenols. These polysaccharides play vital role in regulating and curing various diseases such as blood pressure, cholesterol metabolism, liver problems, cancer, obesity, ulcer and diabetes. *H. erinaceus* or lion mane mushroom have mild pleasant taste and can be used for salads, soups, risottos, or as a delicious side dish (Boddy *et al.*, 2003). This review article is entitled to provide information regarding various nutritional and medicinal uses of lion's mane mushroom.

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## Introduction

Medicinal plants, medicinal herbs have been identified for medicinal treatment and shifted from generation to generation. The World Health Organization (WHO) has been estimated that medicines are gives 65-80% relief in health care to the world population (Gao and Watanabe, 2011). Up to date 14,000 to 15,000 varies species of mushrooms has been identified from different parts of the world, after the chemical analysis, more than 700 medicinal properties have been investigated. However it has been estimated that there are about 1800 species of mushrooms that have medicinal attributes (Chang *et al.*, 1999).

Lion's mane (*Hericium erinaceus*) are considered as source of beneficial medicines properties having nutritional functional foods. Therefore its chemical components have attracted the medical researcher, during the past two decades because of its clinical and biological properties that is also known by many other names such as Yamabushitake, Houtou, hedgehog mushroom, bearded tooth mushroom, dear tail mushroom, monkey's head mushroom, mountain priest mushroom and the pom mushroom. It belongs to class basidiomycetes, order hericiales and family hericiaceae (Jia, 2004). Medicinal properties of Lion's mane (*Hericium erinaceus*) has been reported from the recent studies i.e wound-healing properties, immunomodulation, ischemia (deficient supply of blood to organs), anti (cancer, hypertensive, diabetic, microbial, oxidant), neuro-protective and gastro-protective (Friedman, Mendel 2015).

Lion's mane (*Hericium erinaceus*) was first cultivated on artificial media during 1988, polypropylene bags and bottles was used (Suzuki *et al.*, 1997). But it was not consider suitable for industrialized production due to the long cycle and low yield.

Lion's mane (*Hericium erinaceus*) is usually containing health-promoting compounds and a good source of nutrients (Feeney, 2014, Dwyer, 2014). The aim of this review to provide information regarding various nutritional and medicinal uses, commercial cultivation, natural habits of lion's mane mushroom.

## Natural Habitat

*H. erinaceus* occupies central dead wood of large trees, branches of dead or living tree and fallen broad leaves trees such as walnut, oak and beech. Naturally these are old pollards or developed trees with spread crowns, but it also fruits rarely on injured or damaged younger trees. Bearded tooth mainly founds in United Kingdom, Europe, Japan, East Asia and generally throughout the South temperate latitude locations. Approximately there are 40-45 different tree species that support fruiting bodies of Lion's mane (*Hericium erinaceus*) (Asad *et al.*, 2013).

## Commercial Cultivation

Lion's mane mushroom is rare species therefore its unauthorized collecting of wild fruit bodies in United Kingdom is strictly prohibited. The artificial cultivation of Lion's mane (*Hericium erinaceus*) was first reported in China, and is cultured in artificial log using polypropylene bags and bottles (Imtiaj *et al.*, 2008). Lion's mane is an edible species and grown on temperature from 18-24°C, relative humidity for mycelia growth should be kept 80-90%, fresh air should be provided for 5-8 hours and fruit best in 500-1000 lux light. According to findings, its mild flavor and succulent texture sort it one of the finest palatable mushroom. Even though the rarity of wild fruiting bodies, it is unexpectedly easily cultivated on agricultural waste materials rich in cellulose, such as fibers, rice straw, cotton waste, sawdust beech, sugar cane, crushed grain corn, woodchips, sawdust, Wheat bran and corn waste (Wang, *et al.*, 2001) Various Agriculture waste products used for cultivation of Lion's mane (*Hericium erinaceus*) are described in (Table 1).

## Fruit Body Description

The fruit body of Lion's mane (*Hericium erinaceus*) is enormous, unevenly bulbous, compact snowy to creamy mass and width ranges from 5 to 40cm. It includes few determined basal branches and is continuously govern by rubbery, hanging, spore-producing spines having size of 10 to 40mm. The fruit body becomes yellow to brown through maturity. The Lion's mane (*Hericium erinaceus*) hyphae is thin to thick walled, monomitic amyloid, around 3-15µm wide, with clamped septa and frequent gloeoplerous features (filled with oily drops) which extend beyond into the spore-bearing layer (hymenium) as gloeocystidia.

The spores are snowy in structure warty or roughened, short ellipsoid with size ranging from 5-7

x 4-5.5µm whereas the basidia are 25-40 x 5-7 (Siwulski *et al.*, 2010)

**Table 1.** Various Agricultural waste products used to cultivate Lion's mane (*Hericium erinaceus*) at different growth stages.

Developmental Stages	Organs	Agri. Products	References
Vegetative	Mycelia	Yeast malt medium, potato dextrose agar medium, oak saw dust medium	(Imtiaj <i>et al.</i> , 2008)
-		Tofu whey	(Zhang <i>et al.</i> , 2012)
-		Wheat bran, rice bran, barley bran, soybean powder, egg shell Chinese cabbage,	(Ko <i>et al.</i> , 2005)
-		Sunflower seed hulls	(Imtiaj <i>et al.</i> , 2008)
Reproductive	Fruiting Body	Textile industry wastes (rye straw, alder sawdust, hemp, flax shive)	(Siwulski <i>et al.</i> , 2010)
-		Artemisia	(Choi <i>et al.</i> , 2012)
-		Artemisia capillaries	(Choi <i>et al.</i> , 2013b)
-		Agro wastes (rice straw, soybean dregs, sugarcane bagasse)	(Hu <i>et al.</i> , 2008)

#### Nutritional Uses

Lion's mane (*Hericium erinaceus*) is composed of valuable constituents such as protein (42.5%), carbohydrates (60.95%), crude fiber (7.81%), low fats (7.9%), ash (8.9%) and amino acids. There are 17 different amino acids are presents in the mycelium and fruiting body of Lion's mane (*Hericium erinaceus*) (Egwim *et al.*, 2011). The vital amino acids available are threonine, methionine, valine, histidine, isoleucine, arginine, leucine, phenylalanine and lysine whereas; non-essential amino acid includes cysteic acid, tyrosine, alanine, glutamic acid, aspartic acid, serine, proline, and glycine. Approximately 29 micro and macro elements are present in lion mane mushroom. *H. erinaceus* mycelium contains 30.65mg/g amino acids, 2-fold higher than in the fruiting body (14.33mg/g). Lion mane mushroom also contains variable amount of minerals i.e. sodium (157mg), potassium (29163mg), phosphorus (6121mg), zinc (59mg), magnesium (1166mg), copper (13mg), manganese (11mg) and calcium (395mg) (Nachshol *et al.*, 2014). Proximate composition of Lion's mane (*Hericium erinaceus*) is given in (Table 2).

**Table 2.** Proximate composition of Lion's mane (*Hericium erinaceus*).

Proximate	Content (mg/g dry weight)	References
Protein	20.8%	(Cohen <i>et al.</i> , 2014)
Moisture	6.2%	(Egwim <i>et al.</i> , 2011)
Fat	2.8%	(Cohen <i>et al.</i> , 2014)
Carbohydrates	66.9%	(Egwim <i>et al.</i> , 2011)
Ash	32.89%	(Egwim <i>et al.</i> , 2011)
Energy	389%	(Cohen <i>et al.</i> , 2014)

Proximate	Content (mg/g dry weight)	References
Folic Acid	5.51%	(Egwim <i>et al.</i> , 2011)
N. Essential Amino Acids		
Cystic acid	0.32%	(Mau <i>et al.</i> , 2001)
Aspartic acid	1.30%	(Mau <i>et al.</i> , 2001)
Tyrocine	2.04%	(Cohen <i>et al.</i> , 2014)
Serine	1.66%	(Cohen <i>et al.</i> , 2014)
Proline	0.83%	(Cohen <i>et al.</i> , 2014)
Glycine	1.36%	(Cohen <i>et al.</i> , 2014)
Alanine	0.89%	(Cohen <i>et al.</i> , 2014)
glutamic acid	0.53%	(Cohen <i>et al.</i> , 2014)
Essential Amino Acids		
Valine	0.90%	(Mau <i>et al.</i> , 2001)
Isoleucine	0.77%	(Mau <i>et al.</i> , 2001)
Leucine	0.85%	(Mau <i>et al.</i> , 2001)
Threonine	0.46%	(Mau <i>et al.</i> , 2001)
Lysine	0.97%	(Cohen <i>et al.</i> , 2014)
Histidine	0.53%	(Cohen <i>et al.</i> , 2014)
Arginine	1.07%	(Mau <i>et al.</i> , 2001)
Total	14.3%	(Cohen <i>et al.</i> , 2014)
Monosaccharide		
Xylose	7.8%	(Wang <i>et al.</i> , 2001b)
Mannose	10.84%	(Egwim <i>et al.</i> , 2011)
Galactose	0.94%	(Egwim <i>et al.</i> , 2011)
Glucose	68.4%	(Wang <i>et al.</i> , 2001b)
Arbinose	11.3%	(Wang <i>et al.</i> , 2001b)
Ribose	2.7%	(Wang <i>et al.</i> , 2001b)
Glucuronic acid	0.12%	(Egwim <i>et al.</i> , 2011)
Fucose	0.10%	(Egwim <i>et al.</i> , 2011)
Oxalate (mg/100 g DW)		
Calcium	1.35	(Nile and park 2014)
Phosphorus	3.62	(Nile and park 2014)
Potassium	22.1	(Nile and park 2014)
Magnesium	1.92	(Nile and park 2014)

#### Medicinal Uses

Mushrooms have been existed from thousands of centuries in traditional Chinese medicine and other different countries of the globe for their important medicinal properties (Wasser, 2011).

Lion mane mushroom from a pharmaceutical point of view contains biologically active substances in fruit bodies and cultured mycelia. Lion's mane (*Hericium erinaceus*) has several mental regenerative abilities unlike any other mushrooms such as neurogenesis, glutaminergic, neurotransmission, neuron-protection, cognition and nerve Injury (Kim *et al.*, 2013). It has been reported from various pharmacological studies that Lion's mane (*Hericium erinaceus*) possess polysaccharides which is indispensable to different diseases such as blood pressure, gastric ulcer, liver problems, Diabetes, lipids, cholesterol metabolism, cancer problem, obesity and lipoproteins, neurodegenerative diseases. Lion's mane (*Hericium erinaceus*) also have a vital role in curing tumor, wounds, interventions, Inflammation, gastric ailments, immunology, colon, skin diseases, respiratory failure, alzheimer disease and boosting of immune system (Ulziijargal *et al.*, 2011). Different metabolites present in Lion's mane (*Hericium erinaceus*) are given in (Table 3).

**Table 3.** Metabolite profile of Lion Mane Mushroom.

Metabolites	Molecular formula	References
Erinacine A,B,E,F	C <sub>25</sub> H <sub>36</sub> O <sub>6</sub>	(Bhandari <i>et al.</i> , 2014)
Erinacine K,Q	C <sub>27</sub> H <sub>42</sub> O <sub>8</sub>	(Bhandari <i>et al.</i> , 2014)
Erinacine A, hericenone B	C <sub>27</sub> H <sub>31</sub> NO <sub>4</sub>	(Bhandari <i>et al.</i> , 2014)
Hericenone A, I	C <sub>19</sub> H <sub>22</sub> O <sub>5</sub>	(Bhandari <i>et al.</i> , 2014)
Hericenone C, F	C <sub>35</sub> H <sub>54</sub> O <sub>6</sub>	(Bhandari <i>et al.</i> , 2014)
Hericenone D, G	C <sub>37</sub> H <sub>58</sub> O <sub>6</sub>	(Bhandari <i>et al.</i> , 2014)
Hericenone E, H	C <sub>37</sub> H <sub>54</sub> O <sub>6</sub>	(Ma <i>et al.</i> , 2010)
Hericerin,	C <sub>27</sub> H <sub>33</sub> NO <sub>3</sub>	(Ma <i>et al.</i> , 2010)
Erinacine C	C <sub>25</sub> H <sub>38</sub> O <sub>6</sub>	(Ma <i>et al.</i> , 2010)
Erinacine D	C <sub>27</sub> H <sub>42</sub> O <sub>7</sub>	(Ma <i>et al.</i> , 2010)
Erinacine I	C <sub>22</sub> H <sub>32</sub> O <sub>4</sub>	(Ma <i>et al.</i> , 2010)
Erinacine J	C <sub>25</sub> H <sub>38</sub> O <sub>8</sub>	(Ma <i>et al.</i> , 2010)
Erinacine P	C <sub>27</sub> H <sub>40</sub> O <sub>8</sub>	(Ma <i>et al.</i> , 2010)
Erinacine R	C <sub>27</sub> H <sub>38</sub> O <sub>9</sub>	(Ma <i>et al.</i> , 2010)
Erinacine B	C <sub>19</sub> H <sub>24</sub> O <sub>5</sub>	(Bhandari <i>et al.</i> , 2014)
Hericenone J	C <sub>19</sub> H <sub>32</sub> O <sub>4</sub>	(Bhandari <i>et al.</i> , 2014)
Linoleic acid	C <sub>18</sub> H <sub>32</sub> O <sub>2</sub>	(Bhandari <i>et al.</i> , 2014)
N-De phenylethyl isohericerin	C <sub>19</sub> H <sub>25</sub> NO <sub>3</sub>	(Kawagishi and Zhuang, 2008)
1-D-arbitinol-monolinoleate	C <sub>24</sub> H <sub>44</sub> O <sub>6</sub>	(Kawagishi and Zhuang, 2008)
Hericine A	C <sub>35</sub> H <sub>56</sub> O <sub>5</sub>	(Kawagishi and Zhuang, 2008)
3-Hydroxyhericenone F	C <sub>35</sub> H <sub>54</sub> O <sub>7</sub>	(Kawagishi and Zhuang, 2008)

#### Bioactive compounds and Polysaccharides

Likely maximum medicinal mushrooms Lion's mane (*Hericium erinaceus*) seems to have bioactive compounds such as polysaccharides, phenolic acids (Gallic, p-coumaric acids and p-hydroxybenzoic), Tocopherols (a-tocopherol, b-tocopherol, d-tocopherol, g-tocopherol, oxalic acid, malic acid and fumeric acid) and organic acids which regulate several metabolic (Wang *et al.*, 2005). There are several polysaccharides extracted from fruit body of Lion's mane (*Hericium erinaceus*) such as galactoxyloglucans, heteroxyloglucans, xylans and glucoxylans. Whereas,  $\beta$ -1, 3-glucan and  $\beta$ -1, 3-branched glucan with a molecular mass of 13kDa are responsible for activation of macrophages in immune system. A hetero-polysaccharide composed of glucose, rhamnase, fructose and galactose. Other polysaccharides extracted from the fruiting body of lion mane mushroom are  $\beta$ -1, 3-branched,  $\beta$ -1, 3 linked D-glucoopyranosyl, and  $\beta$ -1, 2-mannan are also components of Lion's mane (*Hericium erinaceus*) fruiting body. The ratio of polysaccharides in the fruit bodies seems to be around 20%, overall structure of these polysaccharides comprises of ribose (2.7%), glucose (68.4%), arabinose (11.3%), xylose (7.8%), galactose (2.5%) and mannose (5.2%). Based on potency basis Lion's mane (*Hericium erinaceus*) contains 3-hydroxyhericenone, Hericenone B, D-mannose and L-pipecolic acid (Jia *et al.*, 2004). Different bioactive compounds and their activities are given in (Table 4 & 5).

**Table 4.** Polysaccarides profile of *Hernicium erinaceus*.

Polysaccharides	Extracts	References
Xylans	Fruiting bodies	(Mizuno <i>et al.</i> , 1992)
Cervical carcinoma	Fruiting bodies	(Kawagishi <i>et al.</i> , 1990b)
Galactoxyloglucans	Fruiting bodies and Mycelia	(Kim <i>et al.</i> , 2013)
Heteroxyloglucans	Fruiting bodies	(Ma <i>et al.</i> , 2012)
Glucoxylans	Mycelia	(Li <i>et al.</i> , 2014a)

**Table 5.** Bioactive compounds and their biological functions of *Herinicium erinacium*.

Compounds	Biological activity	References
4-chloro-3,5-dimethoxybenzoic acid-O-arabitol ester	Immunomodulatory	(Thongbai <i>et al.</i> , 2015)
2-hydroxymethyl-5- $\alpha$ -hydroxy-ethyl- $\gamma$ -pyranone	Immunomodulatory	(Thongbai <i>et al.</i> , 2015)
6-methyl-2,5-dihydroxymethyl- $\gamma$ -pyranone	Immunomodulatory	(Thongbai <i>et al.</i> , 2015)
4-chloro-3,5-dihydroxybenzaldehyde	Anti-microbial	(Qian <i>et al.</i> , 1990)
4-chloro-3,5-dihydroxybenzyl alcohol	Immunomodulatory	(Thongbai <i>et al.</i> , 2015)
2,3,4,7-tetrahydro-5-methoxy-2-methyl-2-(4-methyl-2-oxo-3-pentenyl)-9H-furo[3,4-h]-1-benzopyran-9-one	Anti-microbial	(Okamoto <i>et al.</i> , 1993)
2,6-dimethoxy-4-methyl-chlorobenzene	Anti-microbial	(Okamoto <i>et al.</i> , 1993)
3,5-dimethoxy-4-chloro-benzyl alcohol	Anti-microbial	(Okamoto <i>et al.</i> , 1993)
3,5-dimethoxy-4-chloro-benzaldehyde	Anti-microbial	(Okamoto <i>et al.</i> , 1993)
3 $\beta$ ,5 $\alpha$ -dihydroxy-6- $\beta$ -methoxyergosta-7,22-diene	Anti-microbial	(Okamoto <i>et al.</i> , 1993)

#### Volatile and Aromatic compounds

The taste of lion mane is often designated as seafood like and is best characterized by taste of lobster or shrimp. The specific odor and flavor experienced from Lion's mane (*Herinicium erinaceus*) eating mushroom come from various aromatic compounds. Various components involved in taste of Lion's mane (*Herinicium erinaceus*) mushroom are 5-nucleotides and volatile oils such as linoleic acid, hexadecanoic acid and phenyl acetaldehyde (Mau *et al.*, 2001). The main volatile compounds present in lion mane mushroom are hydrocarbon, alcohol, aldehyde, ketone, acids, esters, nitrogen and Sulphur containing substances. The principal components 2-Methyl-3-furanthiol, cis- $\beta$ -terpineol, 2-ethylpyrazine, menthol, dihydrotagetone, phenyl-acetaldehyde, benzaldehyde and 2-6-diethylpyrazine are responsible for aroma of lion mane mushroom (Miyazawa *et al.*, 2008). Various volatile and flavoring compounds detected in Lion's mane (*Herinicium erinaceus*) are described in (Table 6).

**Table 6.** Classification of the volatile compounds profile of Lion's mane mushroom.

Compounds	Concentration (%)	References
Hydrocarbon	7.6%	(Miyazawa <i>et al.</i> , 2008)
Alcohol	6.0%	(Miyazawa <i>et al.</i> , 2008)
Aldehyde	16.1%	(Miyazawa <i>et al.</i> , 2008)
Ketone	9.5%	(Miyazawa <i>et al.</i> , 2008)
Acids	41.1%	(Miyazawa <i>et al.</i> , 2008)

Compounds	Concentration (%)	References
Esters	1.8%	(Miyazawa <i>et al.</i> , 2008)
Nitrogen containing substances	3.2%	(Miyazawa <i>et al.</i> , 2008)
Sulphur containing compounds	1.0%	(Miyazawa <i>et al.</i> , 2008)
Miscellaneous	1.3%	(Miyazawa <i>et al.</i> , 2008)

#### Uses and Consumption

Lion's mane (*Herinicium erinaceus*) mushroom are known for their mild flavor and meaty texture, they are great substitutes in most dishes and outstanding when baked, broiled or grilled. Lion's mane (*Herinicium erinaceus*) mushroom are staple food in several countries such as America, China due to their specific flavor and taste. They also add plenty of flavors to soup, chicken toppings, make for tasty side dishes or an easy addition to vegetable stir-fries.

#### Conclusion

This overview provide enough information regarding various nutritional and medicinal uses, commercial cultivation, natural habits, of lion's mane mushroom. *H. erinaceus* mushrooms has both nutritional and medicinal properties to be added in human nutrition on the commercial bases for the improvement of health in developing country. The studies recommended lead to discovery new beneficial, chemical composition of *Herinicium* species with health promoting potential.

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