Bio-active Compounds of Mushrooms: A Review

Akashdeep Sutraddhar¹, Shivam Singh² and Ishani³
¹PG Student, ²Assistant Professor, ³PG Student,
1, 2, 3Department of Plant Pathology, Lovely Professional University, Phagwara, 144411, India.

Abstract: Mushrooms are known for its nutritional and medicinal properties form decades. In ancient Greek history mushrooms were served to soldiers for strength and in Roman Empire they were known as the “Foods of the Gods”. Modern science gives a special seat to mushrooms for its Anti-allergic, Anti-bacterial, Anti-fungal, Anti-viral, Anti-cancer, Anti-inflammatory and other therapeutic uses. Food and Agricultural Organization (FAO) recommend mushrooms for the developing countries as it is full of proteins. There are various species of mushrooms around the world, among which some are edible, some are medicinal and some are highly poisonous so we must be sure about their identity before consumed. Mushrooms are packed of Vitamins, Proteins, Fibres, essential amino acids, anti-fungal, anti-viral, anti-cancer, prebiotic, immune booster, anti-inflammatory, cardiovascular, anti-microbial and anti-diabetic property. Improper nutrition because of current way of life and the progress of daily life span are the two key purposes behind the growth rate of sickness on the earth. Oxidative stress produces by disproportion of dietgestion and aplenty of reactive oxygen species (ROS) result of disorders like digestive disorder, coronary diseases, several neural diseases, i.e., Parkinson’s and Alzheimer’s, early aging and various types of cancers. These ROS are developed inside the cellular organisms, along with different outer sources like ionizing radiation, chemotherapeutics, ultra violet, inflammatory cytokines, and environmental poisons. It’s become unavoidable to breathing in poisonous chemical of environment in today’s world.

Venkatesh and Sood (2009), manufactured some phenolic antioxidants contain butylated hydroxyisole, butylated hydroxytoluene and others e.g. propyl gallate, tert-butylhydroquinone, ethoxyquin, and all adequately hinder oxidation.

Ferreira et. al. (2009), and Kozarskiet. et al. (2014), informed that some synthetic anti-oxidants may bring antagonistic harmful impacts under specific conditions. They also brought BHA and BHT on a quick expanded interest as a natural anti-oxidant substance BHA, which is all the time utilized as an additive in sustenance industry, can negatively affect the control the movement of mitogen-activated protein kinase (MAPK) contingent upon the dose (Kozarskiet. et al., 2014 & Yu et. al., 1997). European Union approved a few synthetic anti-oxidants to be used as an additive (Lundbyeet. et al., 2010).

Ferreira et. al. (2009);Kozarskiet. et al. (2014) and Khatuaet. al. (2013), mentioned there requirement of natural choices of anti-oxidant food substances are derived from shopkeepers. Being late, edible mushrooms now have pulled in consideration as a source of antioxidants.

They may be utilized straightforwardly in improvement of anti-oxidant guards with help of dietary supplementation to lessen the limit of stress of oxidative. Such in vitro methodologies having fewer acceptability.

Chang & Wasser (2012), described that the process inflammation in-human is thought to be a piece of the complex organic reaction that eliminates joints, e.g. pathogens, harmed cells or disturbance. These reactions carry various side effects, for example, fever, swelling and pain, therefore of many related change, for e.g. vasodilation, expanded vascular penetrability and plasma extravasation. Mushroom specialists are now estimated the genuine nutritive estimation of mushrooms. They also find out that Low sodium (Na) percentage of mushroom is valuable for patients having hypertensive and a higher amount of potassium (K) and phosphorus (P), which are totally imperative in orthomolecular perspective.

Along with great taste, mushrooms also have very unique mixture of high measure of total low fat, useful protein along with high extent of polysaturated fatty acids (PUFA), for which they are known as low calorie diets. Mushrooms also serves us all the important vitamins like B1 (thiamine), B2 (riboflavin), B3 (niacin), B9 (folate), B12 (Cobalamin), C (ascorbic acid), D (cholecalciferol), and E (tocopherols). Glycemic record in mushrooms are low along with high serotonin which is very suitable for diabetic patients.

In Asian homes, mushrooms are utilized as critical wellspring of cures against different illness and sicknesses for its oxidative stress nature (Khatuaet. al., 2013).
The future progressing research tasks are planned as advancement of as a new source of craved drugs and to help in the upcoming research work to identify the novel compounds of mushroom species to help in human development.

**Anti-oxidant properties of mushrooms**

A great variety of wild and cultivated mushrooms were reported to having antioxidant qualities. Essenceof fungi contains many ingredients, each of these components having its own determined biological effects (Wasser SP, 2010). The mushroom fruiting bodies, mycelium and broth having antioxidant compounds in the form of ascorbic acid, phenolics, flavonoids, glycosides, poly-saccharides, tocopherols, ergo-thioneine, and carotenoids (Kozarski et. al., 2015; Chen et. al., 2012& 28–105). Different observations were used to determine the mushroom’s anti-oxidative properties and their level of activity. For example, techniques based on the exchange of hydrogen atoms and electrons, the capacity to chelate ferrous (Fe2+) and cupric (Cu2+) particles, the electron spin resonance (ESR) strategy, erythrocyte hemolysis and the observing of the action of SOD, CAT and GPx (Kozarski et. al., 2015; Chen et. al., 2012; 28–98). Mushroom agents can show cast their defensive properties by various mechanisms at various phases of the oxidation procedure. Fundamentally, there are 2 types of anti-oxidants- prime (chain breaking, free radical scavengers) and secondary or preective (Breuer MS, 2011; Ferreira et. al., 2009. Kozarski et. al., 2014; Kozarski et. al., 2015; 28–98, 101–103]. Secondary anti-oxidants can deactivate metals, restraint or breakdown of lipid hydroperoxides, anti-oxidants recovery, singlet oxygen (1O2) extinguishing and so on. For finding the evaluation and recognition different strategies have been used, i.e. gas chromatography (GC) and high performance liquid chromatography (HPLC) combined to reliable detection gadgets, Fourier transform infrared (FTIR), Nuclear Magnetic Resonance (NMR), UV-VIS spectroscopy and various spectrophotometric measures (Kozarski et. al., 2015; Chen et. al., 2012;20-103; Suabjakyong et. al., 2015).

**Analgesic and anti-inflammatory properties of mushrooms**

Inflammation can be described as co-operations between cells and soluble factors that is produced in tissue in case of any injury, poisonous, diseases or post bloodlessness, or damage of immune system (Nathan C, 2002). In generally the information about the function and rebuilding procedure is connected to the activity of important cell. When the cells are open to safe stimulants, the pro-inflammatory cells, eg. Numerous molecular mediators’ stats by various host cells, monocytes, macrophages, to start the inflammation process. It causes many inflammation diseases like Juvenile idiopathic arthritis, multiple sclerosis, gastritis, inflammatory bowel diseases (IBD), rheumatoid arthritis, bronchitis, and artherosclerosis (Levine TB & Levine AB, 2012). Mushroom is a functional food used for its high nutritional values. They also highly appreciated for their high therapeutic and medicinal applications (Wasser SP & Weis SP, 1999; Chang ST & Miles PG, 2004). Various bioactive compounds of mushrooms are tested as significant anti-inflammatory qualities (Table 1).

**Table 1: Anti-inflammatory activities of different mushroom species:**

<table>
<thead>
<tr>
<th>Mushroom species</th>
<th>Extracting solvent</th>
<th>references</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agaricus blazein (Himematsutake)</td>
<td>WM</td>
<td>Chloroform</td>
</tr>
<tr>
<td>Agaricus bisporus</td>
<td>WM</td>
<td>Ethanol</td>
</tr>
<tr>
<td>Agaricus subrufescens</td>
<td>WM</td>
<td>Water</td>
</tr>
<tr>
<td>Agrocybeaegerita</td>
<td>FB</td>
<td>Methanol</td>
</tr>
<tr>
<td>Agrocybeocularis</td>
<td>FB</td>
<td>Water</td>
</tr>
<tr>
<td>Albatrellus caeruleoporus</td>
<td>FB</td>
<td>Methanol</td>
</tr>
<tr>
<td>Amanita muscaria</td>
<td>FB</td>
<td>Water,Methanol, Ethanol</td>
</tr>
<tr>
<td>Boletus edulis (Penny bun)</td>
<td>WM</td>
<td>Methanol</td>
</tr>
<tr>
<td>Cantharellus (Chanterelle)</td>
<td>WM</td>
<td>Methanol</td>
</tr>
<tr>
<td>Cantharellus (Chanterelle)</td>
<td>WM</td>
<td>Methanol</td>
</tr>
<tr>
<td>Cordyceps militaris</td>
<td>SC/FB</td>
<td>Ethanol</td>
</tr>
<tr>
<td>Cordyceps militaris</td>
<td>FB</td>
<td>Methanol</td>
</tr>
<tr>
<td>Caripiamonagin</td>
<td>FB</td>
<td>Methanol</td>
</tr>
<tr>
<td>Cyathus africanus</td>
<td>SC</td>
<td>Ethyl acetate</td>
</tr>
<tr>
<td>Cyathus hookeri</td>
<td>SC</td>
<td>Ethyl acetate</td>
</tr>
<tr>
<td>Daldinia chihudiae</td>
<td>FB</td>
<td>Not mentioned</td>
</tr>
<tr>
<td>Elaphomycesgranulatus</td>
<td>FB</td>
<td>Ethanol</td>
</tr>
<tr>
<td>Flammulinae latipes (Enokitake)</td>
<td>WM</td>
<td>Ethanol</td>
</tr>
<tr>
<td>Fomitopsis spinoccola (Red belted con)</td>
<td>SC</td>
<td>Ethanol</td>
</tr>
<tr>
<td>Grifolafrondosa (Hen of woods)</td>
<td>SC</td>
<td>Ethyl acetate, Acetone</td>
</tr>
<tr>
<td>Ganoderma lucidum (Reishi Mushroom)</td>
<td>FB</td>
<td>Ethanol</td>
</tr>
<tr>
<td>Geastrumssaccatum</td>
<td>FB</td>
<td>Ethanol</td>
</tr>
<tr>
<td>Inonotus obliquus</td>
<td>FB</td>
<td>Petroleum ether, Ethyl acetate</td>
</tr>
<tr>
<td>Lactarius deliciosus</td>
<td>WM</td>
<td>Methanol</td>
</tr>
<tr>
<td>Lactarius sarufus</td>
<td>FB</td>
<td>Water, Ethanol, Ethyl acetate</td>
</tr>
<tr>
<td>Lentinusedodes (Shiitake)</td>
<td>FB</td>
<td>Water</td>
</tr>
</tbody>
</table>
Mushrooms is a good source of analgesic medicines which are vastly use as pain relief as it a part of inflammation process. In the list given below we enlist some major edible mushrooms with their active compound (Table 2).

### Table 2: Analgesic activities of mushroom species:

<table>
<thead>
<tr>
<th>Mushroom species</th>
<th>Active compounds</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agaricus bisporus var. Hortensis</td>
<td>Fucogalactan</td>
<td>161</td>
</tr>
<tr>
<td>Agaricus brasiiliensis</td>
<td>Fucogalactan</td>
<td>161</td>
</tr>
<tr>
<td>Agaricus macrospores</td>
<td>Agaricoglycerides</td>
<td>162-164</td>
</tr>
<tr>
<td>Cordyceps sinensis</td>
<td>Cordymin</td>
<td>173-175</td>
</tr>
<tr>
<td>Coriolus versicolor</td>
<td>Polysaccharopeptides</td>
<td>168-172</td>
</tr>
<tr>
<td>Grifola frondosa</td>
<td>Fucogalactan</td>
<td>180</td>
</tr>
<tr>
<td>Inonotus obliquus</td>
<td>Methanol extract</td>
<td>177</td>
</tr>
<tr>
<td>Lactarius rufus</td>
<td>Soluble β-glucans</td>
<td>179</td>
</tr>
<tr>
<td>Pleurotus eous</td>
<td>EtOH extract</td>
<td>178</td>
</tr>
<tr>
<td>Pleurotus florida</td>
<td>Methanol and aqueous extract</td>
<td>160</td>
</tr>
<tr>
<td>Pleurotus pulmonarius</td>
<td>Hydroethanolic extract</td>
<td>159</td>
</tr>
<tr>
<td>Pleurotus pulmonarius</td>
<td>β-glucans</td>
<td>155-158</td>
</tr>
<tr>
<td>Termotomycas albuminosus</td>
<td>Crude saponin and polysaccharide extract</td>
<td>176</td>
</tr>
</tbody>
</table>

### Mushrooms: the nutrient all-rounder

Mushrooms are re-honoured globally by mankind for its unique flavour and supernatural powers. Almost 2000 mushroom species are identified and out of them only 25 species are known to be edible and only few commercial cultivation techniques are known. Till the day, mushrooms or fungi are still underutilized compare with other conventional dietary fibre, like cereals, legumes, vegetables, and fruits (O'Shea et al., 2012 & Elleuchet et al., 2010). Mushrooms are a type of fungi that have distinctive fruiting bodies of both edible and medicinal types. The edible fruiting body of mushrooms can be consuming in fresh and dried from and medicinal mushrooms which are considered as fungi that cannot be eaten, having bio-pharmaceutical quality for having the components like triterpenoids and polysaccharides. Novel dietary fibres (DFs) having so many beneficial effects to human health. These DFs are mainly found in plant cell, mushroom cell wall is also considered as DF. The composition of mushroom cell wall contains fibrillar (hairly like)and matrix components including chitin (straight-chain (1→4)-β-linked polymer of N-acetyl glucosamine) and polysaccharides like (1→3) - β-D-glucans and mannans, respectively (Bartnicki-Garcia S, 1970). The cell wall of these mushrooms are made up of non-digestible carbohydrates (NDCs) which are considered as source of DF and these are resistance to human enzymes. These mushrooms have great nutritional values with rich protein and essential amino acid, poor fat and fibre.

### Table 3: Food values of different species of mushrooms:

<table>
<thead>
<tr>
<th>Mushroom Species</th>
<th>Protein (%)</th>
<th>Fat (%)</th>
<th>Ash (%)</th>
<th>Carbohydrates (%)</th>
<th>Energy (kcal/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agaricus bisporus (Button Mushroom)</td>
<td>14.1</td>
<td>2.2</td>
<td>9.7</td>
<td>74.0</td>
<td>325</td>
</tr>
<tr>
<td>Agaricus blazei (Himematsutake)</td>
<td>31.3</td>
<td>1.8</td>
<td>7.5</td>
<td>59.4</td>
<td>379</td>
</tr>
<tr>
<td>Lentinus edodes (Shiitake Mushroom)</td>
<td>4.5</td>
<td>1.73</td>
<td>6.7</td>
<td>87.1</td>
<td>772</td>
</tr>
<tr>
<td>Pleurotus eryngii (King Oyster)</td>
<td>11.0</td>
<td>1.5</td>
<td>6.2</td>
<td>81.4</td>
<td>421</td>
</tr>
<tr>
<td>Pleurotus giganteus</td>
<td>17.7</td>
<td>4.3</td>
<td>_</td>
<td>78.0</td>
<td>364</td>
</tr>
<tr>
<td>Pleurotus ostreatus (Oyster Mushroom)</td>
<td>7.0</td>
<td>1.4</td>
<td>5.7</td>
<td>85.9</td>
<td>416</td>
</tr>
<tr>
<td>Pleurotus sajor-caju</td>
<td>37.4</td>
<td>1.0</td>
<td>6.3</td>
<td>55.3</td>
<td>_</td>
</tr>
</tbody>
</table>

Adopted from Carneiro et al. 2013 [185]; Kala c 2013 [186]; Phan et al. 2012 [186]; Reis et al. 2012 [188].
Fatty acid content of different species of mushrooms (g/100g fresh weight)

<table>
<thead>
<tr>
<th>Species</th>
<th>Palmitic</th>
<th>Stearic</th>
<th>Oleic</th>
<th>Linoleic</th>
<th>Linolenic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agaricus bisporus (Button Mushroom)</td>
<td>11.90</td>
<td>3.10</td>
<td>1.10</td>
<td>77.70</td>
<td>0.10</td>
</tr>
<tr>
<td>Agaricus blazei (Himematsutake.)</td>
<td>11.38</td>
<td>2.8</td>
<td>1.85</td>
<td>72.42</td>
<td></td>
</tr>
<tr>
<td>Lentinus edodes (Shiitake Mushroom)</td>
<td>10.3</td>
<td>1.6</td>
<td>2.3</td>
<td>81.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Pleurotus eryngii (King Oyster)</td>
<td>12.8</td>
<td>1.7</td>
<td>12.3</td>
<td>68.8</td>
<td>0.1</td>
</tr>
<tr>
<td>Pleurotus ostreatus (Oyster Mushroom)</td>
<td>11.2</td>
<td>1.6</td>
<td>12.3</td>
<td>68.9</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Collected from Carneiro et al. 2013 [185]; Reis et al. 2012 [186].

Conclusion

Few mushroom species are put up as a source of bioactive compounds due to their dietary values and all these dietary values can be a great source food supplements if we keep mushroom in our regular eating routine. Advanced and pro-efficient biotechnological strategies could be used to obtain highest yield and metabolites from medicinal mushrooms. Studies and experiments observed that mushroom can prevent distinctive types of diseases. More dedicated research work should undertake to isolate, purify, and to know more about the novel antioxidant, nutraceutical, anti-inflammatory, and analogesic compounds. This review discusses the potentiality of natural anti-oxidants, analogesic metabolites, and anti-inflammatory compounds that are present in mushrooms. Apart from these uses, these metabolites can use as a cosmeceuticals as a safe and natural products without any side effects. Still we need more detailed studies to understand more about these active compounds and the process which is lead us to the place where we can take these bio active compounds in place of drugs to make human life a more healthy and wealthy with less side effects.

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