Mushrooms possess several therapeutic properties such as antioxidant, antifungal, antimicrobial, anticancer, antineoplastic, anti-diabetic, anti-inflammatory, antibacterial, cholesterol-lowering, and immune-stimulating effects. Antioxidants are defined as the molecules which occur in our food and helps in the prevention or reduction of oxidative stress. Antioxidants are known for elevating good health and minimizes the risk of cardiovascular diseases, certain types of cancers, diabetes, cirrhosis, and stroke. The antioxidants are categorized into natural antioxidants and synthetic antioxidants. Various ingredients (like polyols, free amino acids, soluble sugars, and 5′-nucleotides) are present. The common flavor present in mushrooms is named umami taste, also known as the perception of satisfaction which is produced by MSG (Monosodium glutamate). MSG present in the mushroom is responsible for its rich, brothy, or meaty taste.

**Keywords** : Mushrooms, Antioxidants, Free Radicals, Umami Flavor.

**INTRODUCTION**

Mushrooms are recognized throughout the world, not merely for the unique flavor, but also their medicinal and nutritional properties (Heleno et al., 2015). Mushrooms, also known as "boneless vegetarian meat" or "white vegetables" comprises plenty amounts of protein, dietary fiber, various vitamins (especially Vitamin C and B), and minerals (mainly sodium, potassium, and phosphorus) (Huchchannanavar et al., 2020). They are low in carbohydrates and fats, so have low calories (Kakon et al., 2012). Protein content in mushrooms is approximately 20-35% on a dry basis, which is furthermore than those of vegetables and fruits and is of higher quality (Kumari et al., 2015). The consumable carbohydrate content of mushrooms comprises starches, pentoses, hexoses, sugar alcohols, disaccharides, amino sugar, and sugar acid. The amount of carbohydrates in mushrooms is 26-82% varying from species to species. The insoluble carbohydrates i.e., the crude fiber found in mushrooms contain partially digestible chitin and polysaccharides (Manikandan, 2011).

Mushrooms possess several therapeutic properties such as an antioxidant, antifungal, antimicrobial, anticancer, antineoplastic, anti-diabetic, anti-inflammatory, antibacterial, cholesterol-lowering, and immune-stimulating effects (Gan et al., 2013) (Enoma et al., 2018) (Siwulksa et al., 2018) (Sana et al., 2017) (Sharma et al., 2015) (Sánchez, 2017) (Soares et al., 2013). Mushrooms possess several metabolites, such as phenolic compounds, terpenes, polyketides, and steroids (Gan et al., 2013). Moreover, phenolic compounds found in mushrooms are known to be great antioxidants and synergistic which is not mutagenic (Adebayo et al., 2014). Henceforth, mushrooms can act as a good and natural antioxidant source as they are easily available in the market (Enoma et al., 2018).

Antioxidants are defined as the molecules which occur in our food and helps in the prevention or reduction of oxidative stress (Pal et al., 2014). Antioxidants are known for elevating good health and minimizes the risk of cardiovascular diseases, certain types of cancers, diabetes, cirrhosis, and stroke (Atta et al., 2017) (Adebayo et al., 2014). Additionally, the utilization of dietary antioxidants helps in the prevention of free radical damage (Gan et al., 2013). According to Olajire and Azzez (2011), antioxidants can remove free radicals by prohibiting the initiation step or interfering with the propagation step in lipid oxidation.

The antioxidants are categorized into natural antioxidants and synthetic antioxidants. Further, natural antioxidants are sorted into fungal and plant extracts, glutathione, spices (like thyme, oregano, sage, clove, cinnamon, rosemary, marjoram, pepper, and nutmeg), selenium (Se), zinc (Zn), ubiquinol (reduced form of coenzyme Q10), Vitamin A (along with carotenoids), Vitamin E (along with tocotrienols and tocopherols) and Vitamin C. While, synthetic antioxidants comprises of butylated hydroxytoluene (BHT), butylated hydroxyanisole (BHA), etc. Additionally, various synthetic antioxidants have negative impacts under certain conditions (Kozarski et al., 2015).
Overall, mushrooms contain the entire features of food-taste, nutrition, and physiological features. For the first feature of taste, mushrooms have a unique and subtle flavor. The flavor of mushroom contains some taste components (i.e., water-soluble taste components) concluding 5′-nucleotides and free amino acids. For the second feature of nutrition, mushrooms are enriched with proteins, chitin, polysaccharides, vitamin D₂, and minerals; lack cholesterol; and have less fat and calories. The third feature of physiological effects, along with various physiologically active substances, also consists of therein, which makes mushrooms-a valuable and healthy food (Mau, 2005).

Free Radicals and Their Sources

Free radical or pro-oxidant is described as any species efficient for independent existence consisting of one or more unpaired electrons (Webb et al., 2008). These are generally produced during oxidation reactions, subsequently begin the chain reactions, which causes damage to the cells (Lawal et al., 2017). These are very reactive molecules and normally unstable. Major sources of free radicals are represented in figure 1.

Oxidative Stress

Oxidative stress originates from the variance in a redox system. It is a common process occurred by either excessive formation of Reactive Oxygen Species (ROS) or abnormality in the antioxidant defense system (Saleem et al., 2020). Howsoever, ROS production in high concentrations is extremely important source of ROS, due to which ROS comprehends not merely free radicals (like hydroxyl radical, superoxide radical), but also molecules (like singlet oxygen, hydrogen peroxide and, 4-hydroxy-2-nonenal (HNE). Out of these, superoxide anion is recognized as the primary ROS because it creates by adding one electron in molecular oxygen (Khatua et al., 2013). Additionally, in an aqueous environment, the hydroxyl radical is considered as extremely reactive ROS with a half-life smaller than 1 ns (Jomova et al., 2011).

Antioxidant Components in Some Species of Mushrooms

Phenolic compounds are those compounds that contain aromatic rings attached with one or more hydroxyl groups. Mainly, phenolic acid is present as the main phenolic compound. Tocopherols contain α, β, γ and δ tocopherol. Tocopherols are the main components found in the biological membrane (Khatua et al., 2013).

Palacios et al. (2011) observed the antioxidant activity in phenolic compounds of various species like Agaricus bisporus, Cantharellus cibarius, Calocybe gambosa, Lactarius deliciosus, and Pleurotus ostreatus. It was found that Cantharellus cibarius and Pleurotus ostreatus showed the highest effect as compared to other species.

According to Sharma et al. (2015), the phenol content in Agaricus arvensis is 2.83±0.09 (mg/g). The values of some antioxidant components in various species like Amanita porphyria, Collybia fusipes, Fomitopsis pinicola, Heleboma sinapicans, Lactarius hepicus are evaluated by Reis et al. (2011) as mentioned in table 1. Additionally, Barros et al. (2007) have evaluated the various antioxidant components in species like Agaricus arvensis, Lentinus tigrinus, Leucopaxillus giganteus, and Sarcodon imbricatus have also mentioned in the table 1.

Taste Ingredients Present in Mushrooms

Various ingredients (like polysils, free amino acids, soluble sugars, and 5′-nucleotides are present (Mau, 2005). Chen (1986) carried several sensory evaluations on some extracts of synthetic mushroom, which is formed by addition and removal of soluble components, and observed that the taste-active ingredients which are mostly found in mushrooms are oxalic, citric, malic, glutamic acids, alanine, glycine, threonine, mannitol, 5′-guanosine monophosphate (5′-GMP), 5′-inosine monophosphate (5′-IMP), and 5′-xanthosine monophosphate (5-XMP). Out of them, organic acids and mannitol found in mushrooms contribute to sour and sweet flavor.

The common flavor present in mushrooms is named umami taste, also known as the perception of satisfaction which is produced by MSG (Monosodium glutamate) (Mau, 2005). MSG present in the mushroom is responsible for its rich, brothy, or meaty taste. The name “umami” was termed for the scrumptious and palatable taste and was distinguished as a basic taste including the amino acid, glutamic acid (Phat et al., 2016). However, along with four basic tastes like sweet, bitter, salty, hot, and sour taste, the umami taste is considered as sixth taste (Mau, 2005). Umami was first reported by Ikeda in the year 1908, who coined the term. The umami taste helps in the improvement of satiety and regulation of appetite (Sun et al., 2020).

Effect of Processing on Umami Taste of Mushrooms

For various purposes like increasing the shelf life, taste, and utilization efficiency, processing is required for edible mushrooms. The processing method, heating is applied for the improvement in availability and digestibility of various nutrients. Though, the heating method was not much as beneficial in the preservation of umami components in soups
made of edible mushrooms. In other methods like autoclaving, microwave cooking, and boiling, loss of 5'-nucleotides and MSG-like amino acids were noticed in button mushroom soup. Autoclaving showed an immense loss of umami tastes, while microwave cooking showed minimum loss and boiling stands in the middle. Irradiation gave good results and has low effects on the quality of mushrooms. Whereas, gamma irradiation reduced 5'-GDP and 5'-AMP nucleotides contents in button mushrooms (Zhang et al., 2013). Pukkila et al (2013) told the effect of cooking on different species of mushrooms like Cantharellus cibarius, Lactarius trivialis, Suillus variegatus, Cantharellus tubaeformis, and Agaricus bisporus. 5'-GMP nucleotide was observed in cooked samples only. Saito et al. (2020) told that half-dry processing applied in various species of mushrooms and vegetables by exposure to the sunlight does not improve the umami flavor. Additionally, it has also been reported that there may be chances of increasing the umami taste in some species. Also, Pei et al. (2014) observed the effect of processing in umami taste. Methods like freeze-drying in the combination with microwave vacuum drying or only freeze-drying were used. After the application of the method, there was seen no changes in the contents of 5'-nucleotides.

**CONCLUSION**

Overall, it has been concluded that mushrooms contain various properties like antioxidant, antifungal, antimicrobial, anticancer, antineoplastic, antidiabetic, anti-inflammatory, antibacterial, cholesterol-lowering, and immune-stimulating effects. Phenolic compounds found in mushrooms are known to be great antioxidants and synergistic which is not mutagenic. Henceforth, mushrooms can act as a good and natural antioxidant source as they are easily available in the market. Additionally, the taste-active ingredients which are mostly found in mushrooms are oxalic, citric, malic, glutamic acids, alanine, glycine, threonine, mannitol, 5'-guanosine monophosphate (5'-GMP), 5'-inosine monophosphate (5'-IMP), and 5'-xanthosine monophosphate (5-XMP). Out of them, organic acids and mannitol found in mushrooms contribute to sour and sweet flavor.

Fig. 1 : Sources of free radicals and their occurrence.
Table 1: Antioxidant content of different species of mushrooms.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Species Name</th>
<th>Common name</th>
<th>Total tocopherol</th>
<th>Phenols</th>
<th>Ascorbic Acid</th>
<th>β-carotene</th>
<th>Lycopene</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td><em>Agaricus arvensis</em></td>
<td>Horse mushroom</td>
<td>3.01 ± 0.00d</td>
<td>2.83±0.09</td>
<td>0.35±0.0015</td>
<td>2.97±0.12</td>
<td>1.0±0.049</td>
<td>(Sharma et al., 2015) (Barros et al., 2007)</td>
</tr>
<tr>
<td>2.</td>
<td><em>Amanita porphyria</em></td>
<td>Grey veiled Amanita</td>
<td>245.58±27.29 e</td>
<td>-</td>
<td>211.17±30.08 d</td>
<td>0.13±0.00 d</td>
<td>0.01±0.00 d</td>
<td>(Reis et al., 2011)</td>
</tr>
<tr>
<td>3.</td>
<td><em>Collybia fusipes</em></td>
<td>Gymnopus fusipes</td>
<td>7.75±0.7ef</td>
<td>-</td>
<td>278.15±12.70 a</td>
<td>0.24±0.009</td>
<td>nd</td>
<td>(Reis et al., 2011)</td>
</tr>
<tr>
<td>4.</td>
<td><em>Fomitopsis pinicola</em></td>
<td>Red-belted fungus</td>
<td>125.25±10.13 ed</td>
<td>-</td>
<td>108.97±2.24 g</td>
<td>0.22±0.00 b</td>
<td>nd</td>
<td>(Reis et al., 2011)</td>
</tr>
<tr>
<td>5.</td>
<td><em>Heleboma sinapizans</em></td>
<td>Rough-stalked heleboma</td>
<td>71.62±3.11 ef</td>
<td>-</td>
<td>280.55±7.46 a</td>
<td>0.01±0.001</td>
<td>0.06±0.00 e</td>
<td>(Reis et al., 2011)</td>
</tr>
<tr>
<td>6.</td>
<td><em>Lactarius hepaticus</em></td>
<td>Birch milkcap</td>
<td>30.56±2.22 f</td>
<td>-</td>
<td>149.07±1.76 f</td>
<td>Nd</td>
<td>0.19±0.00 b</td>
<td>(Reis et al., 2011)</td>
</tr>
<tr>
<td>7.</td>
<td><em>Leuco-paxillus giganteus</em></td>
<td>Giant leucopax</td>
<td>-</td>
<td>6.29±0.20</td>
<td>3.76±0.11</td>
<td>1.88±0.900</td>
<td>0.69±0.034</td>
<td>(Barros et al., 2007)</td>
</tr>
<tr>
<td>8.</td>
<td><em>Lentinus tigrinus</em></td>
<td>Tiger sawgill fungus</td>
<td>716.77±79.22a</td>
<td>-</td>
<td>248.13±1.34c</td>
<td>6.15±0.00c</td>
<td>nd</td>
<td>(Reis et al., 2011)</td>
</tr>
<tr>
<td>9.</td>
<td><em>Piptoporus betulins</em></td>
<td>Birch polypore</td>
<td>577.62±52.95b</td>
<td>-</td>
<td>87.9±3.09h</td>
<td>0.09±0.00f</td>
<td>0.23±0.00a</td>
<td>(Reis et al., 2011)</td>
</tr>
<tr>
<td>10.</td>
<td><em>Sarcodon imbricatus</em></td>
<td>Shingled hedgehog</td>
<td>-</td>
<td>3.76±0.11</td>
<td>0.16±0.0072</td>
<td>2.53±0.11</td>
<td>1.30±0.070</td>
<td>(Barros et al., 2007)</td>
</tr>
</tbody>
</table>

REFERENCES


The antioxidant components and umami molecules in mushrooms: A Review


