CONCLUSION

For the time immemorial mankind has used traditional medicines for human healthcare with terrestrial plants occupying a significant therapeutic role (Pizzuto, 1997). Recently, the World health Organization has estimated that approximately 80% of the world’s inhabitants still depend on traditional (herbal and fungal) medicines for primary health purposes (Cragg and Newman, 2001). Historically, hot-water-soluble fractions (decoctions and essences) from medicinal mushrooms, that is, mostly polysaccharides, were used as medicine in the Far East where knowledge and practice of mushroom was primarily originated (Hobbs, 1995, 2000). Mushrooms such as *Ganoderma lucidum* (Reishi), *Lentinus edodes* (Shiitake), *Inonotus obliquus* (Chaga) and many others have been collected and used for hundreds of years in Korea, China, Japan and Eastern Russia. Those practices still form the basis of modern scientific studies of fungal medicinal activities. It is notable and remarkable how reliable the facts collected by traditional Eastern medicine are in the study of medicinal mushrooms (Ying *et al.*, 1987; Hobbs, 1995, 2000; Wasser and Weis, 1997a, 1997b; 1999; Stamets, 2000). The number of mushrooms on earth is estimated at 1,40,000, yet may be only 10% (approximately 14,000 named species) are known. Mushrooms comprise a vast and yet largely untapped source of powerful new pharmaceutical products.

Darjeeling Himalaya, a segment of Eastern Himalayas located at the junction of Indo-Malayan and Palaeatric biogeographic realms, along with its complex geomorphology, variations in climatic and vegetation, have made this area flourish with luxuriant growth of mushrooms (Acharya *et al.*, 2005 and Rai *et al.*, 2005).

In recent years, with the development of better technologies and greater realization of their pharmaceutical and nutritional value, mushrooms have occupied an important area in food habit of people in several parts of the world. Mushrooms, apart from being famous for their appetizing flavors offer
themselves as potential protein source. Protein is the most crucial component contributing to the nutritional value of a food. Protein content obtained from the studied mushrooms namely *Auricularia auricula* (Hook.) Underw, *Polyporus grammacephalus* (Berk.), *Fistulina hepatica* (Hunds Fr.), *Ramaria botrytis* (Fr.) Ricken and *Armillaria mellea* Quel are in line with those obtained for other mushroom (Figure 43). The protein of the mushroom contain all amino acids, however, the level of them varies from genus to genus, On the basis of FAO/WHO Protein Standard (1991), methionine and cystine and additionally, according to Shah *et al.,* (1997) and Mlodecki *et al.,* (1967), isoleucine are found to be as the limiting amino acid of the mushroom. The content of lysine is fairly high in them. Cereal protein is characterized by a low level of this amino acid and in this connection the consumption of mushroom with cereal product is recommended for balancing the level of essential amino acid in the diet (Shah *et al.,* 1997).

Fresh mushroom contain relatively large amount of carbohydrates (3-28 %) and crude fiber (3-32 %). The carbohydrate content may consists of large variety of compounds like pentose, methyl pentose, hexoses, disaccharides, amino sugars, sugar alcohol, sugar acid as well as unidentified uronides and methyl sugars (Holtz, 1971; Hughes *et al.,* 1958; McConnell and Esselen, 1947). The total carbohydrate content of the studied materials ranges from 40.14-60.8 g / 100 g dry wt. The values obtained for carbohydrate content are in agreement with those obtained for other mushrooms (Table 3). A considerable portion of the carbohydrate compound occurs in the form of polysaccharides are represented by glycogen and such indigestible forms like as dietary fiber, cellulose, chitin, mannons and glucans (Manzi and Pizzoferrato, 2000; Pizzoferrato *et al.,* 2000 and Manzi *et al.,* 2001) which are important in the proper functioning of elementary tract. Dietary fiber was declared as a nutrient by Nutrition Labeling and Education Act, 1993 (Gordon, 2002). Cheung (1997) indicated that some mushrooms have considerable values as dietary fiber in human nutrition.
All the material showed a significant amount of fiber content (16-28 %) (Figure 43). Fiber is considered to be an important ingredient in a balanced and healthy diet. Anderson and Ward (1979), reported that feeding diabetes patient with high fiber reduce their daily insulin requirement and stabilizes their blood glucose profile, possibly by decreasing the rate of glucose absorption and or delaying gastric emptying.

Crude fat content of the mushroom can comprise less than 1% to as high as 15-21% of the dry matter. The fat content of the studied materials ranges from 2-3 % (Figure 43). In general, presence of low fat content of mushroom and presence of high proportion of unsaturated fatty acids, regarded mushrooms as a health food (Chang and Miles, 1989).

![Figure 43: Comparative proximate analyses of three important nutrients. Values are the mean of three separate experiments each in triplicate.](image)

Mushrooms are a good source of minerals. The minerals present in the substrate are taken up by the growing mycelia and translocated to the sporophores. Minerals are randomly distributed in all the studied materials as shown in the table 35. As in higher plants the minerals of highest content is potassium followed by calcium, magnesium and iron. Among these five
studied materials, potassium was the most abundant mineral element in *Ramaria botrytis* and *Fistulina hepatica*, phosphorus in *Armillaria mellea* and *Fistulina hepatica*, calcium in *Auricularia auricula*, magnesium and iron in *Ramaria botrytis*. The dietary deficiency in minerals may cause several diseases like ischemia heart disease (Casamitjana, 1978; Suzuki and Ohshima, 1976), diseases of central nervous system, high blood pressure, hypercholesteromia etc. (Seeling and Hegget, 1974; Williams, 1977).

Table 35. Comparative mineral composition among studied materials (mg / 100 g dry wt.):

<table>
<thead>
<tr>
<th></th>
<th>A. auricula</th>
<th>P. grammacephalus</th>
<th>F. hepatica</th>
<th>R. botrytis</th>
<th>A. mellea</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calcium</td>
<td>250</td>
<td>40</td>
<td>120</td>
<td>80</td>
<td>40</td>
</tr>
<tr>
<td>Potassium</td>
<td>1040</td>
<td>1550</td>
<td>1880</td>
<td>2210</td>
<td>940</td>
</tr>
<tr>
<td>Phosphorous</td>
<td>725</td>
<td>1150</td>
<td>1700</td>
<td>1100</td>
<td>1730</td>
</tr>
<tr>
<td>Magnesium</td>
<td>80</td>
<td>120</td>
<td>130</td>
<td>170</td>
<td>130</td>
</tr>
<tr>
<td>Iron</td>
<td>61</td>
<td>15</td>
<td>14</td>
<td>79</td>
<td>25</td>
</tr>
</tbody>
</table>

The reactive oxygen species (ROS) such as superoxide anion radical ($\text{O}_2^-$), hydrogen peroxide ($\text{H}_2\text{O}_2$), Hydroxyl radical ($\text{OH}$) have been implicated in pathophysiology of various disorders, including ischemia, reperfusion injury, atherosclerosis, acute hypertension, hemorrhagic shock, diabetes mellitus and cancer (Hemnani and Parihar, 1998). The results of the investigation revealed that amongst the different extracts the ethanolic extract of *Auricularia auricula*, *Polyporus grammacephalus*, *Fistulina hepatica*, *Ramaria botrytis* and *Armillaria mellea* possess a potential free radical scavenging activity (Figure 44). Antioxidant offers different level of protection (Cadenas and Packer, 1996). Although, the organisms are bestowed with antioxidants and repair systems that have evolved to protect them against oxidative damage, these systems are insufficient to prevent the damage in total, hence, antioxidants in diet are important as possible
protective agents to help the human body to reduce oxidative damage. Recently, a large number of natural antioxidants have been isolated from different plant materials (Packer and Ong, 1997; Jovanovic and Simic, 2000). Mushrooms are functional food and are traditionally used in folk medicines. The presence in the human diet of medicinal mushrooms that possess antioxidant properties would potentially be useful to help the human body to reduce oxidative damage.

![Antioxidant activity of mushrooms](image)

**Figure 44:** Comparative antioxidant potentiality of ethanolic extract of studied mushrooms. A. Hydroxyl radical scavenging activity; B. Inhibition of lipid peroxidation; C. DPPH radical scavenging activity. Values are the mean of three separate experiments each in triplicate.

Nitric oxide is acknowledged as an important multifunctional molecule that mediates a number of diverse physiological functions (Biswa et al., 1998). The highest nitric oxide synthase activity was observed in ethanolic extracts of *Ramaria botrytis* followed by *Auricularia auricula, Armillaria mellea, Polyporus grammaocephalus* and *Fistulina hepatica* (Figure 45).
Studies on pharmacognostic, nutritional, antioxidant and nitric oxide synthase activation properties of some wild edible mushrooms of Darjeeling Himalaya

Because of high nutritional value, antioxidant potentiality and nitric oxide synthase activation properties, standard pharmacognostic parameters are needed to identify the purity of the material. Unlike higher plants, from the dry powdered materials of the mushroom it was very difficult to identify the purity of the material by microscopic study because only the deformed mycelia were found. So, standardization of different qualitative and quantitative pharmacognostic parameters were performed to develop a clear cut picture of the pure dry powdered sample which may act as an identification key for the purity of dried materials. In conclusion, considering all these values, all the five mushrooms are nutritionally rich, having potential antioxidant and significant nitric oxide synthase activation property to elevate them from traditional food to medicinal source.