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Review

Nutritional and medicinal importance of mushrooms

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Mushrooms had long been used for medicinal and food purposes since decades. It is now increasingly recognized that correct diet, controls and modulates many functions of human body and consequently participates in the maintenance of state of good health, necessary to reduce the risk of many diseases. Modern pharmacological research confirms large parts of traditional knowledge regarding the medicinal effects of mushrooms due to their antifungal, antibacterial, antioxidant and antiviral properties, besides being used as functional foods. This paper sums up diverse beneficial health effects of mushrooms to humans, in the form of proteins, carbohydrates, fats, vitamins, minerals, food and drugs, and medicines.

Key words: Mushrooms, medicine, food, properties.

INTRODUCTION

Mushrooms are important constituents of minor forest produce, that grow on the most abundant biomolecule of this biosphere, that is, cellulose. Presently mushrooms are regarded as a macro-fungus with a distinctive fruiting body which can be either epigeous or hypogeous and large enough to be seen with the naked eyes and to be picked by hand (Chang and Miles, 1992). Only fruiting body of the mushroom can be seen whereas the rest of the mushroom remains underground as mycelium.

Geologically, mushrooms existed on the earth even before man appeared on it, as evidenced from the fossil records of the lower cretaceous period. Thus anthropologically speaking, there is every possibility that man used the mushrooms as food when he was still a food gatherer and hunter on the chronology of cultural evolution. Mushrooms offer tremendous applications as they can be used as food and medicines besides their key ecological roles. They represent as one of the worlds greatest untapped resources of nutrition and palatable food of the future. Mushrooms have been found effective against cancer, cholesterol reduction, stress, insomnia, asthma, allergies and diabetes (Bahl, 1983). Due to high amount of proteins, they can be used to bridge the protein malnutrition gap. Mushrooms as functional foods are used as nutrient supplements to enhance immunity in the form of tablets. Due to low starch content and low cholesterol, they suit diabetic and heart patients. One third of the iron in the mushrooms is in available form. Their polysaccharide content is used as anticancer drug. Even, they have been used to combat HIV effectively (Nanba, 1993; King, 1993). Biologically active compounds from the mushrooms possess antifungal, antibacterial, antioxidant and antiviral properties, and have been used as insecticides and nematicides as well. Thus keeping in view the tremendous applications of mushrooms, the present study reviews different aspects of mushrooms towards human health benefits such as food, medicine, minerals, drugs etc.

Mushrooms as a source of food

Man has been hunting for the wild mushrooms since antiquity (Cooke, 1977). Thousands of years ago, fructifications of higher fungi have been used as a source of food (Mattila et al., 2001) due to their chemical composition which is attractive from the nutrition point of view. During the early days of civilization, mushrooms were consumed mainly for their palatability and unique flavors (Rai, 1994, 1997). Present use of mushrooms is totally different from traditional because, lot of research has been done on the chemical composition of mushrooms,

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which revealed that mushrooms can be used as a diet to combat diseases. The early history regarding the use of mushrooms in different countries has been reviewed by number of workers (Buller, 1915; Rolfe and Rolfe, 1925; Singer, 1961; Atkinson, 1961; Bano et al., 1964; Jandaik and Kapoor, 1975; Bano and Rajarathnam, 1982; Abou et al., 1987; Houghton, 1995). The oriental use of mushrooms is older than the European (Lambert, 1938). Rolfe and Rolfe (1925) mentioned that the mushrooms like *Agaricus campestris, Morchella esculenta, Helvella crispa, Hydnum coralloides, Hypoxylon vernicosum* and *Polyporus mylittae* were used much earlier in India. Lintzel (1941, 1943) recommended that 100 to 200 g of mushrooms (dry weight) is required to maintain an optimal nutritional balance in a man weighing 70 kg. Bano et al. (1963) determined the nutritive value of *Pleurotus flabellatus* as 0.974% ash, 1.084% crude fibre, 0.105% fat, 90.95% moisture, 0.14% non-protein nitrogen and 2.75% protein. Bano (1976) suggested that food value of mushrooms lies between meat and vegetables. Crisan and Sands (1978) observed that mushrooms in general contain 90% water and 10% dry matter. More so, the protein content varies between 27 and 48%. Carbohydrates are less than 60% and lipids are between 2 to 8%. Orgundana and Fagade (1981) indicated that an average mushroom is about 16.5% dry matter out of which 7.4% is crude fibre, 14.6% is crude protein and 4.48% is fat and oil. Gruen and Wong (1982) indicated that edible mushrooms were highly nutritional and compared favourably with meat, egg and milk food sources. Of several thousand mushroom species known worldwide, only around 2000 are considered edible, of which about 20 are cultivated commercially with only 4 to 5 under industrial production (Chang, 1990). There is also a significant difference in the nutrient contents of pileus verses stalks (Latifah et al., 1996; Zakia et al., 1993).

Carbohydrates

The carbohydrate content of mushrooms represents the bulk of fruiting bodies accounting for 50 to 65% on dry weight basis. Free sugars amounts to about 11%. Florezak et al. (2004) reported that *Coprinus atramentarius* (Bull.: Fr.) Fr. contain 24% of carbohydrate on dry weight basis. The mannitol, also called as mushroom sugar constitutes about 80% of the total free sugars, hence it is dominant (Tseng and Mau, 1999; Wannet et al., 2000). Mc-Connell and Esselen (1947) reported that a fresh mushroom contains 0.9% mannitol, 0.28% reducing sugar, 0.59% glycogen and 0.91% hemicellose. Carbohydrates of *Agaricus bisporus* were reported by Crisan and Sands (1978). Raffinose, sucrose, glucose, fructose and xylose are dominant in it. (Singh and Singh, 2002). Water soluble polysaccharides of mushrooms are antitumor (Yoshioka et. al., 1975).

Proteins

Protein is an important constituent of dry matter of mushrooms (Aletor, 1995; Alofe et al., 1995; Fasidi and Kadiri, 1990; Florczak and Lasota, 1995; Zrodlowski, 1995; Chang and Buswell, 1996). Lintzel (1941) reported the digestibility of mushroom protein to be as high as 72 to 83%. The proximate analysis of mushroom mycelia has been reported by a number of workers (Humfeld, 1948; Humfeld and Sugihara, 1949; Block et al., 1953) and that of *Morchella* species by Litchfield et al. (1963). Protein content of mushrooms depends on the composition of the substratum, size of pileus, harvest time and species of mushrooms (Bano and Rajarathnam, 1982). Protein content of the mushrooms has also been reported to vary from flush to flush (Crisan and Sands, 1978). Haddad and Hayes (1978) indicated that protein in *A. bisporus* mycelium ranged from 32 to 42% on the dry weight basis. Abou et al. (1987) found 46.5% protein on dry weight basis in *A. bisporus*. Samajipati (1978) found 30.16, 28.16, 34.7 and 29.16% protein in dried mycelium of *A. campestris, Agaricus arvensis, M. esculenta* and *Morchella deliciosa* respectively. Purkayastha and Chandra (1976) found 14 to 27% crude protein on dry weight basis in *A. bisporus, Lentinus subnudus, Calocybe indica* and *Volvariella volvacea*. On dry matter basis, the protein content of mushrooms varies between 19/100 and 39/100 g (Weaver et al., 1977; Breene, 1990). In terms of the amount of crude protein, mushrooms rank below animal meats but well above most other foods including milk (Chang, 1980). On a dry weight basis, mushrooms normally contain 19 to 35% proteins as compared to 7.3% in rice, 12.7% in wheat, 38.1% in soybean and 9.4% in corn (Crisan and Sands, 1978; Li and Chang, 1982; Bano and Rajarathnam, 1988).

Verma et al. (1987) reported that mushrooms are very useful for vegetarian because they contain some essential amino acids which are found in animal proteins. The digestibility of *Pleurotus* mushrooms proteins is as that of plants (90%) whereas that of meat is 99% (Bano and Rajarathnam, 1988). Rai and Saxena (1989a) observed decrease in the protein content of mushroom on storage. The protein conversion efficiency of edible mushrooms per unit of land and per unit time is far more superior compared to animal sources of protein (Bano and Rajarathnam, 1988). Mushrooms in general have higher protein content than most other vegetables (Bano and Rajarathnam, 1988) and most of the wild plants (Kallman, 1991). Sharma et al. (1988) reported 14.71 to 17.37% and 15.20 to 18.87% protein in the fruiting bodies of *Lactarious deliciosus* and *Lactarious sanguiffus* respectively. Mushrooms contain all the essential amino acids required by an adult (Hayes and Haddad, 1976). Gupta and Sing (1991) reported 41.4% essential amino acids in *Podaxis pistillaris*. Friedman (1996) reported that the total nitrogen content of dry mushrooms is contributed

by protein amino acids and also revealed that crude protein is 79% compared with 100% for an ideal protein.

Fats

In mushrooms, the fat content is very low as compared to carbohydrates and proteins. The fats present in mushroom fruiting bodies are dominated by unsaturated fatty acids. Singer (1961) determined the fat content of some mushrooms as 2.04% in *Suillus granulatus*, 3.66% in *Suillus luteus* and 2.32% in *A. campestris.* Hugaes (1962) observed that mushrooms are rich in linolenic acid which is an essential fatty acid. Total fat content in *A. bisporus* was reported to be 1.66 to 2.2/100 g on dry weight basis (Maggioni et al., 1968). Ogundana and Fagade (1981) indicated that mushrooms have 4.481% fats on dry weight basis. Kanwar et al. (1990) has reported a fat content of 11.52% in the *Amanita ceasarea* fruiting bodies on dry weight basis. In 100 g fresh matter of *A. bisporus* (Lange) Sing and *Pleurotus ostreatus* (Jacq: Fr.) Kumm, the content of fatty compounds were found to be 0.3 and 0.4 g respectively (Manzi et al., 2001), but on dry weight basis, it is 2 and 1.8 g respectively (Shah et al., 1997). Aletor (1995), Manzi et al. (2001), Sanme et al. (2003) and Manzi et al. (2004) worked on the fibre content of different mushrooms. Mushrooms are considered good source of fats and minerals (Jiskani, 2001). Yilmaz et al. (2006) and Pedneault et al. (2006) reported that fat fraction in mushrooms is mainly composed of unsaturated fatty acids.

Vitamins

Mushrooms are one of the best sources of vitamins especially Vitamin B (Breene, 1990; Mattila et al., 1994; Zrodlowski, 1995; Chang and Buswell, 1996; Mattila et al., 2000). Vitamin content of edible mushrooms has been reported by Esselen and Fellers (1946), Block et al. (1953) and Litchfield (1964). Manning (1985) gave a comprehensive data of vitamin content of mushrooms and some vegetables. According to Mattila et al. (1994), wild mushrooms contains much higher amounts of vitamin D_2 than dark cultivated *A. bisporus.* Mushrooms also contain vitamin C in small amounts (Sapers et al., 1999; Mattila et al., 2001) which are poor in vitamins A, D, and E (Anderson and Fellers, 1942).

Mineral constituents

The fruiting bodies of mushrooms are characterized by a high level of well assimilated mineral elements. Major mineral constituents in mushrooms are K, P, Na, Ca, Mg and elements like Cu, Zn, Fe, Mo, Cd form minor constituents (Bano and Rajarathanum, 1982; Bano et al., 1981; Chang, 1982). K, P, Na and Mg constitute about 56 to 70% of the total ash content of the mushrooms (Li and Chang, 1982) while potassium alone forms 45% of the total ash. Abou-Heilah et al. (1987) found that content of potassium and sodium in *A. bisporous* was 300 and 28.2 ppm. respectively. *A. bisporus* ash analysis showed high amount of K, P, Cu and Fe (Anderson and Fellers, 1942). Kaul (1978) reported that *M. esculenta* contains Ca (0.5776 mg), P (3.313 mg), Fe (1.213 mg) and K (3.831 mg). Varo et al. (1980) reported that *A. bisporus* contains Ca (0.04 g), Mg (0.16), P (0.75 g), Fe (7.8 g), Cu (9.4 mg), Mn (0.833 mg) and Zn (8.6 mg) per kilogram fresh weight. Mushrooms have been found to accumulate heavy metals like cadmium, lead, arsenic, copper, nickel, silver, chromium and mercury (Schmitt and Sticher, 1991; Mejstrick and Lepsova, 1993; Wondratschek and Roder, 1993; Kalac and Svoboda, 2000; Svoboda et al., 2001; Issilogglu et al., 2001; Malinowska, 2004). The mineral proportions vary according to the species, age and the diameter of the fruiting body. It also depends upon the type of the substratum (Demirbas, 2001). The mineral content of wild edible mushrooms has been found higher than cultivated ones (Aletor, 1995; Mattilla et al., 2001; Rudawska and Leski, 2005).

Medicinal importance

Medical mycology is as old as traditional uses of mushrooms. They have been used in medicine since the Neolithic and Paleolithic eras (Samorini, 2001). First century Greek physician Dioscorides, included the lurch polypore, (*Fomitopsis officinalis* (Villars: Fr.) Bond and Singer, *Polyporaceae*; syn. *Laricifomes officinalis* (Villars: Fr.) in his *De Materia medica* known then as *Agaricum* and latter as the Quinine conk. It was used for the treatment of “consumption”, a disease now known as tuberculosis. Although mushrooms as medicine have been used in China since 100 A.D. (Gunde, 1999), but it was only in 1960 that scientists investigated the basic active principles of mushrooms which are health promoting. Mushrooms have been used in health care for treating simple and age old common diseases like skin diseases to present day complex and pandemic disease like AIDS. They are reputed to possess anti-allergic, anticholesterol, anti-tumor and anti-cancer properties (Jiskani, 2001). Aqueous extracts from *Pleurotus sajor caju* proves good in renal failure (Tam et al., 1986). The first successful research discovered the antitumor effects of the hot water extracts from several mushrooms (Ikekawa et al., 1969). The main components proved to be polysaccharides especially β–D- glucans. Chihara et al. (1969) isolated from the shiitake fruiting bodies, an antitumor polysaccharide, which was named *lentinan*. Bahl (1983) reported that mushrooms cure epilepsy, wounds, skin diseases, heart ailments, rheumatoid arthritis,

cholera besides intermittent fevers, diaphoretic, diarrhea, dysentery, cold, anesthesia, liver disease, gall bladder diseases and used as vermicides. Most of the mushroom drugs are now available in tablet form in China (Yang et al., 1993). In underdeveloped countries where protein malnutrition has taken epidemic proportions, Food and Agricultural Organization (F. A. O.) has recommended mushroom foods to solve the problem of malnutrition (Sohi, 1988). Mannentake (*Ganoderma lucidum*) are known to lower blood pressure and serum cholesterol concentration of hypertensive rats (Kabir et al., 1988). *Lentinus tigrinus* and *G. lucidium* are proved anticholesterolmic (Ren et al., 1989). *Lentinus edodus* has been used to enhance vigour, sexuality, energy and as an anti aging agent (Gareth, 1990). Lentinan sulphate obtained from *Lentinus* species inhibits HIV (Gareth, 1990). Jong et al. (1991) reported that mushrooms cause regression of the disease state. Mushroom medicines are without side effects (Sagakami et al., 1991). Puffballs have been used in urinary infections (Buswell and Chang, 1993). Maitake extract has been shown to kill HIV and enhance the activity of T-helper cells (Nanba, 1993; King, 1993). *Ganoderma* nutriceuticals have exhibited promising antiviral effects like, anti-hepatitis B (Kino et al., 1989), anti-HIV (Kim et al., 1993; Liu and Chang, 1995). Dreyfuss and Chapela (1994) reported hundreds of secondary metabolites of fungal origin possessing biological activity. Mushrooms act as biological response modifiers by promoting the positive factors and eliminating the negative factors from the human body and thus regarded as the fourth principal form of the conventional cancer treatment (Yang et al., 1993). *G. lucidium* (Fr.) Karst is believed to act as an anti-inflammatory agent (Stavinoha et al., 1991); acts as anti-diabatic (Teow, 1997). It is also used by Indian tribals for treating joint pain (Harsh et al., 1993). Hobbs (1995) reported various medicinal uses of mushrooms like reishi, cordyceps, enoki, maitake, lion's mane and splitgill for cancer treatment; shiitake, blazei, reishi, enoki, cordyceps, maitake, mesima and oyster were found effective against cholesterol reduction. Reishi, cordyceps, shiitake and maitake is used for reducing stress. Lion's mane has been used for memory improvement; reishi for inducing sleep, cordyceps for physical endurance and sexual performance, reishi, cordyceps, chaga and lion's mane for asthma and allergy treatment. Shiitake, cordyceps, chaga, shiitake and turkey tail as liver protectants; reshi, maitake, turkey tail and shitake for treating diabetes. It is also believed to be a good health elevator (Mizuno, 1996). *Auricularia* species were used since times for treating hemorrhoids and various stomach ailments (Chang and Buswell, 1996). *Pleurotus tuber-regium* mushroom have been used for curing headache, high blood pressure, smallpox, asthma, colds and stomach ailments (Oso, 1997; Fasidi and Olorumaiye, 1994). It has been reported that *P. ostreatus* lowers the serum cholesterol concentration in rats (Bobek et al., 1996). PSK, an anticancer drug from the mushroom, *Coriolus versicolor* accounted for 25.5% of the country's total sales in Japan in 1987 as anticancer drug (Chang and Buswell, 1996). Puffballs (*Clavatia*, *Lycoperdon*) have been used for healing wounds (Delena, 1999). Pharmaceutical substances with potent and unique health enhancing properties have been isolated from mushrooms (Wasser and Weis, 1999). Fresh mushrooms are known to contain both soluble and insoluble fibres; the soluble fibre is mainly beta-glucans polysaccharides and chitosans which are components of the cell walls (Sadler, 2003). Soluble fibre present in mushrooms prevents and manages cardiovascular diseases (Chandalia et al., 2000). Wasser (2005) reported that mushroom health supplements are marketed in the form of powders, capsules or tablets made of dried fruiting bodies, extracts of mycelium with substrate, biomass or extract from liquid fermentation. *P. sajor-caju* has been found to be inductive for growth of probiotic bacteria (Oyetayo et al., 2005). *Cordyceps sinensis* also treated as half caterpillar and half mushroom has been known and used for many centuries in traditional Chinese medicine. *Cordyceps* has been used to induce restful sleep, acts as anticancer, antiaging, and antiasthama agents besides proved effective for memory improvement and as sexual rejuvenator (Sharma, 2008).

Antioxidant activity

Antioxidants are chemical compounds that protect cells from the damage caused by unstable molecules known as free radicals. Free radicals are powerful oxidants and those chemical entities that contain unpaired electrons. They are capable of randomly damaging all components of the body, viz. lipids, proteins, DNA, sugars and are involved in mutations and cancers (Przybytniak et al., 1999). The nascent oxygen is trapped by enzymes like superoxide dismutase, catalase and glutathione peroxidase. Over production of free radicals creates oxidative stress. The antioxidants are an important defense of the body against free radicals and mushrooms which are rich sources of these antioxidants (Mau et al., 2004; Puttaraju et al., 2006; Ferreira et al., 2007; Oyetayo et al., 2007). Waxy cap mushroom extracts (*Hygrocybe coccinea)* are inhibitory to sarcoma (Ohtsuka et al., 1997). Immunoceticals isolated from more than 30 mushroom species have shown anticancer action in animals (Wasser and Weis, 1999). Schizophyllan from *Schizophyllum commune* is effective against head and neck cancer (Kimura et al. 1994; Borchers et al., 1999). Antioxidant property of compounds is correlated with their phenolic compounds (Velioglu et al., 1998). Kim and kim (1999) reported that mushroom extracts possess DNA protecting properties. *G. lucidum* extracts can trap number of free radicals

(Jones and Janardhanan, 2000). Mau et al. (2001) found antioxidant properties of several ear mushrooms. Many species of mushrooms have been found to be highly potent immune enhancers, potentiating animal and human immunity against cancer (Wasser and Weis, 1999; Borchers et al., 1999; Kidd, 2000; Feng et al., 2001). Tyrosinase from *A. bisporus* is antioxidant (Shi et al., 2002). Lakshmi et al. (2005) determined antioxidant activity of *P. sajor caju*. Russell and Paterson (2006) observed that triterpenoides are the main chemical compounds in *G. lucidium*. Camptothecin is responsible for antioxidant properties in *G. lucidum* (Zhou et al., 2007).

Conclusion

We may conclude about the diverse benefits of mushrooms towards humans by the words of the father of medicine that is, Hippocrates “Let food be your medicine and medicine be your food”. This saying aptly suits mushrooms, as they have tremendous medicinal food, drug and mineral values, hence they are valuable asset for the welfare of humans.

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