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Enhancing Nutritional and Health Well-Being through Edible Mushrooms

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Abstract
Food is a basic human right. Adequate food is important for growth, development, body and mental health. Human beings need sufficient, safe and nutritious food for their overall well-being. The major challenge to availability of nutrient rich food is over reliance on plant and animal products that rely on rain-fed agriculture that is vulnerable to unfavorable weather conditions and now aggravated by climate change. Mushrooms belongs to the Fungal kingdom can supplement the dietary intake as they are rich in nutrients ensuring healthy wellbeing of individuals. This review paper highlights the importance of mushrooms as a source of food rich in nutrients and valuable medicinal products. Mushrooms are popular valuable foods because they are rich proteins, vitamins and dietary fibre. Mushrooms contain all nine essential amino acid including lysine, tryptophan and methionine, which are normally deficit in vegetables. They are rich in all water-soluble vitamins i.e. Vitamin B groups and Vitamin C. Mushroom is a low-sodium food that is rich in potassium, iron, phosphorous, selenium. They are popular because they are low in calories, carbohydrates, fat, and are cholesterol-free. Mushrooms not only have a long history as food source, but also have important medicinal properties. They are rich in anti-oxidants such as polyphenols and ergotheioneine that act against free radicals that can cause development of chronic and degenerative diseases such as cancer and autoimmune disorders. Beta glucans, a type of polysaccharide found in cell wall of the mushroom and other exopolysaccharides produced in mushrooms boost the immune system. Therefore, mushroom products can be used as a source of nutrients and promote health in human beings. More research needs to be done to discover other mushrooms that are edible and elucidate their nutritional and medicinal potential.

Key words: Food, edible mushroom, nutrients rich medicinal properties.

1. Introduction

Food is a basic human right. Adequate food is important for growth, body health, development and cognitive ability. There is a global food crisis mainly brought by climate change that results in unfavourable weather conditions (Ilaboya *et al.*, 2012). Over all the world individuals unable to afford a healthy diet rose by 112 million to 3.1 billion in 2020 alone (FAO, 2022). At the same time, the world continues to fall short of the minimum standards for healthy and sustainable diets with resulting diet-related non-communicable diseases on the rise (WHO, 2021). Vulnerable communities in developing countries will suffer from hunger and malnutrition. Edible mushrooms can form part of the diet as an alternative source of nutrient.

Most edible mushrooms are classified in the Fungi Kingdom, Division Basidiomycota with only a few species in Ascomycota. Research has shown that all over the world, there are over 200 Genera of Fungi macrofungi which contain species of mushrooms useful to people. However only twelve species are commonly grown for food and/or medicinal purposes (FAO, 2009). They are generally referred to as macrofungi due to the large size of fruiting body that will generally arise above the ground level. Mushroom has a fruiting body made up of a stalk (stipe) and a cap (pileus). Mushroom enhances food nutrition by providing a safe and balanced diet. Mushrooms can supplement the dietary intake ensuring healthy wellbeing of individuals. Edible mushrooms are important sources of proteins vitamins, macroelements and microelements. In this review article, the nutritional and medicinal values of the mushroom are discussed and their potential in enhancing nutrition and health of human beings. The review aims at exploring the nutritional value as well as medicinal properties of mushrooms. This paper aims at creating awareness on nutrient rich and medicinal mushrooms with high potential for improving health and nutrition in human beings.

2.0 Nutritional value of mushrooms

Mushroom have been used as a source of nutrient rich foods from time immemorial (Wasser, 2002). In most developing countries wild mushrooms are collected during the wet season and are eaten fresh as a supplement to meat. Mushrooms are rich in nutrients such as proteins, free amino acids, vitamins, mineral salts and trace elements. They have low amounts of carbohydrates and fats. It is recommended that since diets of people in developing countries are mainly carbohydrates, they should be supplemented with edible mushrooms (FAO, 2006).

Focus on mushrooms as a source of nutrients is an option when food shortages are widely experienced such as during the first world war and later in the 1960s (Khan, 2010).

2.1 Proteins

Protein content of mushroom is 12–35% of its mass on dry weight basis. Seventeen amino acids, including all the essential amino acids, have been identified in mushrooms (Kalac, 2012). Quantitative estimation of essential amino acids showed that, except for methionine and phenylalanine, other essential amino acids are present in fairly high concentration in *Pleurotus* spp. (Bano *et al*, 1963). The reported content of free amino acids range between 0.15-7.20 % in different mushroom species (Barros *et al*, 2007; Beluhan and Ranogoyec, 2011). Most common free amino acids in *Boretus* spp. are arginine, alanine, glutamine and glutamic acid. These amino acids, together with other components, determine the taste of mushrooms (Kalac, 2012).

2.2 Vitamins

Mushrooms are rich in all water-soluble vitamins i.e. Vitamin B groups and Vitamin C (Thakur 2020). The B vitamins are coenzymes that participate in many enzymatic reactions in the body. Vitamin C (Ascorbic acid) for the treatment and prevention of scurvy is present in low amounts in mushrooms (Roberts *et al*, 2008). Ascorbic acid is also an antioxidant; it is involved in elimination of free radicals like hydroxyl, superoxyl and peroxyl radicals, responsible for oxidative stress (Davey, 2000).

Fat soluble vitamins are present in negligible amounts (Roberts *et al*, 2008). However, mushrooms that have been exposed to ultraviolet (UV) light contain large amounts of vitamin D2. When exposed to UV light, mushrooms convert ergosterol, a chemical found in large concentrations in many mushrooms, to vitamin D2 (Koyyalamudi *et al*., 2009). This is similar to the reaction in humans, where Vitamin D3 is synthesized after exposure to UV light (Lee and Lee, 2009; Koyyalamudi *et al*, 2009; Roberts *et al*, 2008). Vitamin B3 in oyster mushroom is 5–10 times higher than in any other vegetable. Vitamin D in mushroom increases 5000 times when exposed to UV light more, than in ordinary light (Taofiq *et al*., 2017).

2.3 Mineral salts

Pottasium, and phosphorous are macro elements that are abundant in mushrooms, while trace elements such as iron and zinc are also found in significant amounts (Khan and Tania, 2012). Vegetarians are generally deprived of calcium and selenium, which are readily available in mushrooms. Studies have shown that *Pleurotus* spp. are an important source of potassium, phosphorous, calcium, iron, zinc, magnesium, manganese, and copper (Patrabansh and Madan, 1999).

3.0 Mushroom as a source of medicine

Edible mushrooms in ancient civilization were used as medicine and in cultural activities as hallucinogens. Mushroom is a traditional remedy for treatment of various physiological disorders in human beings.

Medicinal mushrooms produce metabolites and compounds that are anti-oxidants, anti-inflammatory and anti-tumour that enhance and stimulate the immune system (Wasser, 2002). Other chemical compounds such as enzymes are produced during fungus nutrition and are secreted into the susbtrate. They inhibit other fungi and bacteria that would prevent their growth.

Fiber content of mushroom is 1% of its nutritional component and is made up of Beta glucans, a type of polysaccharide found in the cell wall of mushroom (Chang, 2002). Beta glucans improves insulin resistance in diabetics and has a modulating effect on the immune system (Silva *et al.*, 2012). B-glucans may participate in physiological processes related to the metabolism of fats in the human body. B-glucans decrease the total cholesterol content in blood and contribute to reductions in body weight. Experimental diets containing the two mycelial extracellular polysaccharides from *Volvariella volvacea* had induced a significant reduction in the levels of serum total cholesterol, LDL-cholesterol, and liver total cholesterol in rats (Cheung, 1996). A number of B-glucans, for example pleuran from Oyster (*Pleurotus* spp.) mushrooms and lentinan from Shiitake (*Lentinus edodes*); have shown marked anticarcinogenic activity and immunity-stimulating effect (Manzi and Pizzoferrato, 2000).

Other mushroom species produce a variety of other polysaccharides. Exopolysaccharides bound on the cell surface or are excreted into the extracellular medium. Chemically these polysaccharides are either made up of simple sugars (glucose, glucose epimer galactose and mannose, xylose) or sugar derivatives (sugars attached with different groups like protein, phosphate, sulfate) (Choudhary, 2020). Protein and peptide bound polysaccharides are common in mushrooms. Protein bound polysaccharides found in *Coliorus versicolor*

stimulate the nonspecific immunity and exert antimicrobial and antitumour activity through the stimulation of the host's defence. Polysaccharides complexes such Polysaccharide krestin (PSK), isolated from *Trametes versicolor* inhibit HIV and cytomegalovirus (Ng, 1998). *Lentinus edodes* fruiting bodies and mycelium have a protein-bound polysaccharide derived only from the mycelium reported to have anticancer activity (Kurashige *et al*., 1997).

3.1 *Agaricus* spp.

Agaricus genus represents the most important cultivated edible mushrooms. Commonly referred to as 'button mushrooms', *A. bisporus* is the most widely cultivated all over the world. *A. brasiliensis* another button mushroom is cultivated all around the world for its medicinal properties (Llarena-Hernández *et al*., 2013). It is antitumor, antimicrobial, immunomodulatory, as well as an antioxidant (Ferreira *et al*., 2010; Jeong *et al.*, 2010).

3.2 *Ganoderma* spp.

Ganoderma spp. is widely researched because of its medicinal properties and is referred to as king of the herbs (Gao *et al*., 2004). Several hundreds of metabolites have been obtained from the different species in this genus. *Ganoderma lucidum* is the most sought after species (Dong and Han, 2015). Polysaccharides, steroids and triterpenes, alkaloids, fatty acids, glycoproteins, inorganic elements, lignin, nucleosides, nucleotides, peptides, phenols, proteins, sterols and vitamins have been isolated from *G. lucidum* (Boh 2013; Baby *et al.*, 2015). *Ganoderma lucidum* triterpenes and ganoderic acid are anti cancer (Hse *et al*., 2008; Sliva, 2006). Its Proteoglycans and triterpenoids have proven anti-diabetic activity (Ma *et al*., 2015). Its polysaccharides inhibit inflammation (Li *et al*., 2017). Its B glucans are antineoplastic, immunomodulatory and lowers cholesterol. Compounds that are anti-microbial and anti-oxidants have been isolated in this species (Mehta, 2014).

3.3 *Pleurotus* spp.

One of the widely cultivated mushroom varieties after the button mushrooms are the oysters belonging to *Pleurotus* genus. These mushrooms have a high medicinal value. Some of the cultivated species include *Pleurotus citrinopileatus, P. ostreatus, P. florida, P. sajor-caju, P. tuber-regium* (Reddy and Bahadur, 2015). *Pleurotus citrinopileatus* has neoplastic and anti-bacteria activity and cures pulmonary oedema. *Pleurotus florida* modulates the action of the

immune system. *Pleurotus sajor–caju* produces a protein containing antineoplastic activity and lowers blood pressure. *Pleurotus tuber-regium* produces a polysaccharide that cures Fever, high blood pressure and stomach pain**.** The hypocholesterolemic effect of *P. florida, P. ostreatus* and *P. sajor-cau* has also been documented (Khan, 2010).

4. Conclusion

Mushrooms are rich in nutrients. Moreover, due to high nutritional values, they may alleviate malnutrition in vulnerable communities. Cases of nutrient deficiency and health issues all over the world, can be solved by regular mushroom consumption. The realization that mushrooms are nutrient rich and medicinal will increase their demand. Mushrooms production will increase cognizance of the fact that mushroom are an all season food that are easily grown in urban and rural areas. Mushrooms are grown indoors using agricultural wastes, unlike crop production that requires expensive inputs. The food processing and manufacturing industry have a variety of agricultural wastes such as sugar bagasse, cotton and coffee husks that are increasing by the day. However, more research is required to unveil other mushrooms that have nutritional and

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