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MACRO AND MICRO MINERAL COMPOSITION OF FOUR DIFFERENT MUSHROOM SPECIES

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ABSTRACT

Four edible mushroom species viz. *Pleurotusflorida, Pleurotushypsizygusulmarius, Pleurotuseous* and *Calocybeindica* were studied for the macro and micro mineral contents such as sodium (Na), potassium (K), calcium (Ca), magnesium (Mg), manganese (Mn), iron (Fe), zinc (Zn), copper (Cu), selenium (Se) and phosphorous (P). The spawn for all four species were prepared and mushrooms were cultivated in the cultivation chamber maintained in the college. The dried powdered samples were used for the estimation of mineral contents following the standardised protocols. The results on the dry weight basis (mg/100g) demonstrated that all the four samples contained a considerable amount of macro minerals ranging from Na (0.027 - 0.273), K(0.083 - 0.129), Ca (0.168 - 0.294), Mg (0.086 - 0.641), P (0.099 - 0.76) and micro minerals ranging from Mn (0.016 - 0.065), Fe (0.054 - 3.05), Zn -(0.031 - 0.096), Cu (0.014 - 0.084) and Se (0.001 - 0.02). The findings indicate that these four mushroom species are harbouring significant amount of macro and micro minerals which can play a vital role in the biochemical functioning of the system.

INTRODUCTION

Mushrooms are defined as macrofungi with distinctive and visible fruiting bodies that may grow above or below ground (Miles and Chang, 1997). Higher Basidiomycetes represent a taxonomically, ecologically, and physiologically extremely diverse group of eukaryotic organisms. Recently, extensive research on these fungi has markedly increased, mainly due to their potential use in a variety of biotechnological applications, particularly for the production of food, enzymes, dietary supplements, and pharmaceutical compounds (Cohen *et al.*, 2002; Reshetnikov *et al.*, 2001; Ng TB, 2004). It is estimated that there are approximately 1.5 million species of mushrooms in the world of which approximately 70,000 species are described. About 10,000 of the known species belong to the macrofungi of which about 5,000 species are edible and over 1,800 species are considered to have medicinal properties (Bratkovich and Stephen, 2004).

Experimental evidence indicates that mushrooms contain many biologically active components that offer health benefits and protection against degenerative diseases (Barros *et al.*, 2008).Mushrooms are increasingly being recognized as important food products for theirsignificant role in human health, nutrition and disease (Chang and Miles, 1989). Their biochemical composition, with significant contents of proteins, carbohydrates, lipids, enzymes, minerals, vitamins and water, has attracted attention also as functional health promoters (Chang, 2008). Mushrooms have also become an attractive source for the development of drugs and nutraceuticals (LakhanpalandRana, 2008).

Edible mushrooms are widely consumed in many countries as a food. Owing to their attractive taste, aroma and nutritional values, edible mushrooms are valuable components of the diet, whose culinary and commercial value is mainly due to theirorganoleptic properties such as their texture and flavour, being possible to distinguish edible mushroom species on the basis of their characteristic odour or aroma (De Pinho *et al.*, 2008; Zawirska-wojtasiak *et al.*, 2009). Their nutritional value is due to high protein, fiber, vitamin and mineral contents and a low-fat level (Bano and Rajarathnam, 1988; Manzi *et al.*, 1999; Mattilda *et al.*, 2001; Barros *et al.*, 2008). The amino acid compositions of mushroom proteins are comparable to animal protein (Flegg and Maw, 1977; Gruen and Wong, 1982) which is of particular importance to counterbalance a high consumption of protein animal food sources, especially in developed countries. In addition, edible mushrooms characteristically contain many different bioactive compounds such as eritadenine and phenolic compounds (Mattilda *et al.*, 2001; Barros *et al.*, 2008; Barros *et al.*, 2007).

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A greater percentage of mushroom eaters meet the recommended daily allowance (RDA) and daily recommended intake(DRI) for calcium, copper, iron, magnesium, phosphorus, zinc, folate, niacin, riboflavin, thiamin, vitamin A, B6, B12, C, E, energy, carbohydrate, fiber and protein than non-mushroom eaters. Thus they have a better nutrient profile than do those who do not eat mushrooms (Stamets, 2000).

Edible mushroom in fresh, cooked or processed forms are nutritionally sound, tasteful food source for most people and can be a significant dietary component for vegetarians (Breene, 1990). The nutritional value of edible mushrooms compares favourably to that of most vegetables. Within a single mushroom species, the nutrient content varies widely depending on habitat, the growing medium and handling procedures subsequent to harvest. Regular consumption of whole medicinal and edible mushrooms could introduce a functional or medicinal contribution within the individual's diet. Medicinal mushrooms may prevent or treat "lifestyle-related diseases". The extent of the health beneficial effect will depend on the level and regularity of consumption and the relevance of whole fresh medicinal mushrooms and concentrates to the particular disease (Zahid *et al*., 2010).

In general, mushrooms are quite high in protein, with an important content of essential amino acid, but low in fat (Mattilda *et al*., 2001). Furthermore, these fungi supply a large amount of carbohydrates and fibre and a nutritionally significant content of vitamins (B_1, B_2, B_{12}, C and D) and mineral elements (Ca, K,Mg, Na, P, Cu, Fe, Mn and Se) (Mattilda *et al*., 2001).

Mineral concentrations in mushrooms are considerably higher than those in agricultural crops. Macrofungi possess a very effective mechanism that enables them readily to take up some minerals from the ecosystem compared to green plants growing in similar conditions (Svoboda *et al.*, 2000).

As compared with vegetables, mushrooms proved to provide a reasonable content of many mineral elements (6-10.5% DW) (Manzi *et al*., 1999; Mattilda *et al*., 2001). The main constituents in the ash are potassium and, depending on the mushroom, phosphorus (Mattilda *et al*., 2001) or magnesium (Manzi *et al*., 1999), in addition to calcium, copper, iron and zinc. Thus, this study was designed to investigate the macro and micro mineral composition of four different edible mushrooms using standardised protocols.

MATERIALS AND METHODS

Selection and collection of mushroom cultures

In the present study, the mushroom cultures of *Pleurotusflorida, Pleurotus hypsizygus ulmarius, Pleurotuseous* and *Calocybeindica* procured from Vijaya mushrooms, Coimbatore, Tamil Nadu, India were used. The cultures were subcultured and stored as agar slants. The chemicals used for the study were of analytical grade and was purchased from HiMedialaboratories, Mumbai, India.

Preparation of mushroom spawn (Kathiravan and Krishnakumari, 2015)

The mushroom spawn was prepared on white sorghum grain. The mature grain procured from local market was well cleaned and boiled in water for 30 min. The boiled grain was mixed with 2% calcium carbonate. 300g of calcium carbonate mixed grain was filled in polypropylene bags of size 11 inch x 5 inch and sterilized for 15 psi for one hour. The sterilized bags were cooled to room temperature and inoculated with the mushroom culture maintained in slants. The culture inoculated bags were kept undisturbed at room temperature and taken for the present study.

Cultivation of mushrooms

The mushrooms were cultivated in the mushroom cultivation unit maintained in the Kongunadu Arts and Science College (Autonomous), Coimbatore and harvested according to the procedure of Krishnakumari *et al*., 2014. The harvested mushrooms were shade dried and grinded to a fine coarse powder and used for experimental analysis.

Estimation of Macro and Micronutrients

Determination of sodium and potassium was done in Flame Photometer (ELICO make, CL361 model), estimation of calcium, magnesium, iron and copper was done by procedure of Raghuramula *et al*., 2003, estimation of phosphorous by Fiske and Subbarow, 1925, estimation of manganese by Willard and Greathouse, 1917 & Piper, 1950 and estimation of selenium by Deepa and Lingappa, 2014, estimation of zinc by procedure of Crystal *et al*., 2010.

Statistical analysis

Statistical comparison was done at significance level, $P<0.05$ using SPSS package version 20.0. One way ANOVA followed by DMRT analysis of LSD was performed.

RESULTS AND DISCUSSION

Mushrooms represent one of the world's greatest untapped resources of nutrition and palatable food and its growing is at present gaining momentum in our country (Bahl, 1984). Mushrooms are an important source of minerals which are removed from the substrate by the mycelium, being supplied during mycelium growth of the fungus and translocated to the fruiting body during its formation process (Chang and Miles, 1989).The minerals such as sodium, potassium, calcium, magnesium, manganese, iron, zinc, copper, selenium and phosphorous were estimated in four types of mushrooms and the values are tabulated in the table. 1 and table. 2.

Table 1 Macro mineral concentrations (mg/100g on dry weight basis) of various *mushrooms*

Mineral (mg/g)	Pleurotus florida	Pleurotus hypsizygus ulmarius	Pleurotus eous	Calocybe indica
Sodium (Na)	$0.157±0.001^{bcd}$	$0.027±0.001^{acd}$	$0.061± 0.001^{abd}$	$0.273± 0.001^{abc}$
Potassium (K)	$0.129±0.001^{bcd}$	$0.123±0.001^{acd}$	$0.097±0.001^{abd}$	$0.083±0.001^{abc}$
Calcium (Ca)	$0.168±0.002^{bcd}$	$0.218±0.001^{acd}$	$0.294±0.001^{abd}$	$0.195±0.002^{abc}$
Magnesium (Mg)	$0.091±0.001^{bcd}$	$0.197±0.001^{acd}$	$0.641±0.001^{abd}$	$0.086±0.001^{abc}$
Phosphorous (P)	$0.327±0.001^{bcd}$	$0.099±0.001^{acd}$	$0.27±0.001^{abd}$	$0.76±0.002^{abc}$

All the values are expressed as mean ± SD; n=3

Mean values in the same row followed by different alphabets (a-d) in the superscripts are significantly different ($P<0.05$, ANOVA, DMRT).

Table 2 Micro mineral concentrations (mg/100g on dry weight basis) of various mushrooms

Mineral (mg/g)	*Pleurotusflorida*	*Pleurotushypsizy-gusulmarius*	*Pleurotus eous*	*Calocybe indica*
Manganese (Mn)	0.053± 0.001[bcd]	0.016± 0.001[acd]	0.065± 0.001[abd]	0.034± 0.001[abc]
Iron (Fe)	2.06± 0.015[bcd]	2.53± 0.015[acd]	0.054± 0.001[abd]	3.05± 0.015[abc]
Zinc (Zn)	0.096± 0.001[bcd]	0.039± 0.001[acd]	0.031± 0.001[abd]	0.079± 0.001[abc]
Copper (Cu)	0.027± 0.001[bcd]	0.084± 0.001[acd]	0.014± 0.001[abd]	0.051± 0.001[abc]
Selenium (Se)	0.002± 0.000[bc]	0.02± 0.002[acd]	0.006± 0.001[abd]	0.001± 0.000[bc]

All the values are expressed as mean ± SD; n=3

Mean values in the same row followed by different alphabets (a-d) in the superscripts are significantly different (P<0.05, ANOVA, DMRT).

Among the macro minerals phosphorous was found to be present in large amounts in all mushrooms with highest level of 0.76 mg/100g in *Calocybeindica* followed by *Pleurotusflorida* and other mushrooms. Potassium was found to be present in lower amount in all the mushrooms ranging from 0.083 to 0.129 mg/100g. Among the minor elements, Iron was found to be present in large amounts in all the four mushroom species ranging from 0.054 - 3.05 mg/100g with highest level in *Calocybeindica* followed by other species. And the lowest level was selenium ranging from 0.001 to 0.02 mg/100g on dry weight basis. Among the mushroom species selected for the study, *Calocybeindica* possesses maximum levels of both macro and micro minerals when compared to other species. The low levels of mineral elements present in some mushrooms doesn't mean that they are not rich sources of required minerals, rather supplementation of those mushrooms in large quantities can substantiate the requirement of the system. The variation in the levels of mineral contents observed in different mushrooms species may also be influenced by environmental conditions, nutrient availability etc. On the whole, all the selected mushroom species are rich in important minerals required for the biochemical processes of individuals. Living organisms require varying amounts of "heavy metals". Iron, cobalt, copper, manganese, molybdenum, and zinc are required by humans, but excessive levels can be damaging to the organism. Other heavy metals such as mercury, plutonium, and lead are toxic metals and their accumulation overtime in the bodies of animals can cause serious illnesses (Obodai *et al*., 2014). Copper (Cu) as stated is an essential metal, which serve as a constituent of some metalloenzymes, and is required in haemoglobin synthesis and catalysis of metabolic growth (Silvestre *et al*., 2000). Iron (Fe) is an essential metal involved in biochemical processes. Heme is the major iron containing substance in ferrous or ferric state which is present in hemoglobin, myoglobin, and cytochrome. Heme forms covalent bonds with the globin protein to form hemoglobin which is the major oxygen carrying pigment in RBCs of mammalians. It takes part in a myriad of metabolic cycles such as in the energy producing reactions in all the cells and activates the energy producing oxidizing enzymes. Apart from participation in maintaining innumerable physiological and metabolic processes, it is also necessary for DNA, RNA, collagen, antibody synthesis, and so forth (Satyanarayana and Chakrapani, 2008).

Phosphorus-containing compounds have important roles in cell structure (maintenance of cell membrane integrity and nucleic acids), cellular metabolism (generation of ATP), regulation of subcellular processes (cell signaling through protein phosphorylation of key enzymes), maintenance of acid-base homeostasis (urinary buffering), and bone mineralization (Amanzadeh and Reilly, 2006; Alizadeh and Reilly, 2010).

Calcium in the circulatory system, extracellular fluid, muscle, and other tissues is critical for mediating vascular contraction and vasodilatation, muscle function, nerve transmission, intracellular signaling, and hormonal secretion. Bone tissue serves as a reservoir for and source of calcium for these critical metabolic needs through the process of bone remodelling (IOM, 2011).

Manganese (Mn) is an essential metal needed for biological systems such as metalloproteins (Unak *et al*., 2007).Zinc (Zn) is an essential metal and a component of a wide variety of different enzymes in which it isinvolved in catalytic, structural and regulatory roles (Obodai *et al*., 2014). Fe, which is essential for the biosynthesis of the oxygen-carrying pigment of red blood cells (haemoglobin) and the cytochromes that function in cellular respiration (Wani *et al*., 2010), is also present in good amounts in the mushrooms. Na and K are important in the maintenance of osmotic balance between cells and the interstitial fluid in animal systems. Phosphorus, an important constituent of nucleic acids and essential for bone and tooth formation and for acid-base balance, is one of the dominant minerals in the mushroom species (Celestine *et al*., 2013).

Selenium is a vital trace element which is an important component of the antioxidant enzymes such as glutathione peroxides and thioredoxinreductase (Rayman, 2012). Selenium is known to possess immunomodulating and antiproliferative properties and may effect immune response by altering the expression of cytokines and their receptors or making immune cells more resistant to oxidative stress (Serwin *et al*., 2003; Kuo *et al*., 2002).

Mg, Mn and Zn, which are indispensable in numerous biochemical pathways as important co-factors for certain enzymes were equally present in the mushroom species analysed. The presence of calcium in significant amounts in these mushrooms makes it a valuable food for formation and maintenance of bone and normal function of nerves and muscles in humans and other vertebrates (Wani *et al.,* 2010). The finding in this study is comparable to the previous studies (Alam *et al*., 2008). The statistical analysis showed that the composition of both macro and micro mineral composition in different mushrooms are significantly different indicating the fact that each mushroom has a distinct composition of nutrients present in them.

Despite the differences in the nutritive content, the overall nutritive picture of these mushrooms appears to be quite sound. They hold out a promise to contribute significantly to the intake of micro-nutrients amongst our people.

CONCLUSION

In today's scenario, the mushrooms are a product for both nutrition and for pharmaceutical preparations. Apart from being consumed as a nutritious product, the medicinal and therapeutic potential of mushrooms have been recognised and exploited. Hence, the mushrooms have become an indispensable product in today's context. Generally, the results obtained in this study indicate that the macro and micro elements are present in all four mushroom species but in varying levels. *Calocybeindica*, Indian milky mushroom possesses maximum levels of minerals analysed in this study. Milky mushroom is very apt species for commercial cultivation in our region and gaining popularity in recent times and its production has increased in many folds. The nutritional significance of this mushroom upon exposure may lead to increased consumption by the common mass which can deliver a nutrition rich food supplement.

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