Mineral content analysis of four wild edible macrofungi used by five tribes of Assam

MANALEE PAUL, T.C.SARMA AND D.C.DEKA

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MANALEE PAUL*, T.C.SARMA AND D.C.DEKA
Department of Botany, Gauhati University, Guwahati-781014, Assam, India

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The present study deals with the analysis of mineral content of four wild edible macrofungi viz. *Auricularia auricula-judae* (Bull.) J. Schröt, *Pleurotus ostreatus* (Jacq. ex Fr.) P. Kumm., *P. tuber regium* (Rumph. ex Fr.) and *Schizophyllum commune* Fries used as food by four tribes of Assam viz. Bodo, Karbi, Mising, Rabha and Garo. The range of 20 different mineral elements viz. Silver (Ag), Aluminium (Al), Boron (B), Bismuth (Bi), Cadmium (Cd), Cobalt (Co), Chromium (Cr), Copper (Cu), Iron (Fe), Lithium (Li), Manganese (Mn), Nickel (Ni), Lead (Pb), Strontium (Sr), Zinc (Zn), Sodium (Na), Potassium (K), Magnesium (Mg), Calcium (Ca) and Barium (Ba) in the mushrooms were determined using ICP- OES spectrophotometer. The mineral elements include both macro and micro-mineral elements as well as heavy metals. Nineteen mineral elements, except Co, were detected in all the four macrofungal samples. Bi was detected only in *Auricularia auricula-judae* and *Schizophyllum commune*. Among the macro minerals the amount of K was found to be the highest in all the macrofungal species and Fe was found to be the most abundant micro mineral element in all species of macrofungi. The amount of toxic heavy metals viz. Cd and Pb were found to be within the permissible limits.

Key words: Macrofungi, mushroom, mineral content, ICP-OES, heavy metals, ethnomycology

INTRODUCTION

Edible macrofungi or mushrooms form an important part of various cuisines around the world. They are mainly eaten for their palatable taste and flavor. However, very less emphasis is put on their nutritional potential while considering them as food. Along with protein, carbohydrate and fat, mineral content is also a very important factor as far as the nutritional potential of mushrooms is considered. Wild edible mushrooms are advantageous in comparison to vegetables as they commonly grow in uninhabited and unpolluted environment and therefore are considered to be “contaminant free” and therefore very healthy (Dimitrijevic *et al*., 2019).

The consumption of wild mushrooms is increasing, even in the developed world, due to their good contents of proteins and trace minerals (Agrahar-Murugkar and Subbulakshmi, 2005; Gençcelep *et al*. 2009). Proper assessment of mineral contents of mushroom is essential before consuming them as essential metals can also produce toxic effects when the metal intake is excessively elevated (Tüzen *et al*. 2007; Gençcelep *et al*. 2009) and trace elements, both essential and non-essential, if present above threshold concentration levels can lead to morphological abnormalities, growth reduction and increased mutagenic effects (Olumuyiwa *et al*. 2007). Mushrooms are able to store minerals in large quantities even exceeding concentrations found in the medium in which they have grown (Florczak *et al*. 2014; Mleczek *et al*. 2016). Moreover, the fruiting bodies of mushrooms have the ability to bioaccumulate metal ions, and the accumulation of heavy metals in macrofungi has been proven to be affected by environmental and fungal factors.The concentration of minerals in mushrooms depends mainly on the mushroom species and the ecosystem (Gençcelep *et al*. 2009) hence the mineral contents may vary depending on the place from where they have been collected. Various other factors like substrate on which the fungus grew, the place of origin and environmental pollution (Dimitrijevic *et al.* 2019) also affect the mineral content of mushrooms. It has been found that the mineral content of wild edible species of mushrooms is comparatively higher than that of cultivated ones (Kalak, 2010; Liu *et al.* 2011). Five major tribes of Assam viz. Bodo, Karbi, Mising, Rabha and Garo use the wild

* Correspondence :manalee.paul01@gmail.com

edible species of *Auricularia auricula-judae* (Bull.) J. Schröt, *Pleurotus ostreatus* (Jacq. ex Fr.) *P. kumm., P. tuber regium* (Rumph. ex Fr.) and *Schizophyllum commune* Fries as food. Freshly collected wild-grown mushrooms are widely consumed by many people who enjoy life outside of the urban agglomerations (Falandysz *et al*. 2012; Haro *et al.* 2020). The tribal communities residing in and around the forest areas of Assam are also no exception. They use these mushrooms as a part of their regular diet, as they are highly nutritious and can be a major part of fulfilling the lack of essential nutrients including the mineral elements in their diet. As such proper evaluation of the mineral content of these macrofungi is very important from dietary and nutritional point of view.

MATERIALS AND METHODS

Sample collection and identification

Four species of wild edible macrofungi used by various ethnic tribes of Assam were selected for carrying out mineral content analysis on the basis of their uses and importance among the various tribes. The species analyzed include *Auricularia auricula-judae* (Bull.) J. Schröt, *Pleurotus ostreatus* (Jacq. ex Fr.) *P. kumm*., *P. tuber-regium* (Rumph. ex Fr.) and *Schizophyllum commune* Fries. The macrofungi were collected from the fields in wild condition and properly cleaned to ensure that no dirt or soil residue was present in the sample. The samples were brought to the laboratory in sealed plastic bags. They were surface sterilized with alcohol, cut into pieces and then oven dried at 30^{0}C-50^{0}C Proper identification of the collected samples was done on the basis of their micro-morphological and macro-morphological characters. The dried samples were powdered and stored in sealed containers for further analysis. Specimens of the macrofungi were deposited at the herbarium of Gauhati University and accession numbers were obtained for the sample viz. *Auricularia auricula-judae* (Bull.) J. Schröt (GUBH-M-104), *Pleurotus ostreatus* (Jacq.exFr.) P. Kumm (GUBH-M-152), *P. tuber-regium* (Rumph. ex Fr.) (GUBH-M-156) and *Schizophyllum commune* Fries (GUBH-M-122).

Mineral content analysis

The mineral content of the macrofungi were determined using the method described by Liu *et al*. (2011). The preparation of ash solution was done by the following procedure: 1g of dry powdered sample was placed in a porcelain crucible and ashed at 45 ^{0}C for 5-6 h; then the ash was dissolved in 2 mL concentrated HNO_3, and heated on a low heat for 1 min. It was then cooled and filtered through Whatman No. 42 filter paper and the volume was made up to 50 mL with distilled water. Three such replicates were maintained for each of the macrofungal sample studied and a blank was also prepared. The mineral content of the macrofungi were determined using Qtegra, Simple Sample, Thermo Scientific, Thermofisher, iCAP 7000 Series Inductively Coupled Plasma Optical Emission Spectrometer (ICP-OES).

Statistical Analysis

The results were expressed in terms of mean ± standard deviation. All data are of mean values of triplicate measurements (n= 3) obtained from three separate readings.

RESULTS AND DISCUSSION

The fruiting bodies of the macrofungi were analyzed to determine the levels of 20 mineral elements including Silver (Ag), Aluminium (Al), Boron (B), Bismuth (Bi), Cadmium (Cd), Cobalt (Co), Chromium (Cr), Copper (Cu), Iron (Fe), Lithium (Li), Manganese (Mn), Nickel (Ni), Lead (Pb), Strontium (Sr), Zinc (Zn), Sodium (Na), Potassium (K), Magnesium (Mg), Calcium (Ca) and Barium (Ba). Among the essential macro mineral elements K has been found to be the most abundant with its quantity ranging between 13.505-56.316mg/kg dw, Ca was found to be the next abundant element with its range between 3.184-9.652 mg/kg dw. Mg with its quantity ranging between 2.474- 3.602 mg/kg dw was found to be the third most abundant macromineral element. Na with its quantity ranging between 0.735 - 2.672 mg/kg dw is the least abundant macromineral element found in the fruiting bodies of the macrofungi (Table 1). Among the essential micromineral elements Fe was found to occur in the highest amount with its range between 0.470-0.930 mg/kg dw. Zn was found to be the next most abundant element with its range between 0.350- 0.507 mg/kg dw followed by Mn (0.057 -0.334 mg/kg dw), Cu (0.041-0.078 mg/kg dw), B (0.030 -0.056 mg/kg dw) and Cr (0.007- 0.012 mg/kg dw) while Co was not detected in any of the macrofungal specimens (Table 1).

Table 1: Mineral contents of fruiting bodies of the ethnomycologically important macrofungi

Mineral Element (mg/kg dw)	Name of the macrofungi			
	Auricularia auricula-judae (Bull.) J. Schröt	*Pleurotus ostreatus* (Jacq.ex Fr.) P. Kumm.	*Pleurotus tuber-regium* (Rumph. ex Fr.)	*Schizophyllum commune* Fries
Ag	0.002± 0.0	0.002± 0.0	0.002± 0.0	0.008± 0.0
Al	11.242±0.1	24.645±0.3	4.148±0.0	1.443±0.0
B	0.039± 0.0	0.035± 0.0	0.030± 0.0	0.056± 0.0
Bi	0.003± 0.0	N.D.	N.D.	0.035± 0.0
Cd	0.001± 0.0	0.010± 0.0	0.007± 0.0	0.004± 0.0
Co	N.D.	N.D.	N.D.	N.D.
Cr	0.007± 0.0	0.011± 0.0	0.009± 0.0	0.012± 0.0
Cu	0.041±0.0	0.078± 0.0	0.073± 0.0	0.053± 0.0
Fe	0.470±0.0	0.818± 0.0	0.930± 0.0	0.698± 0.0
Li	0.002±0.0	0.003± 0.0	0.001± 0.0	0.007± 0.0
Mn	0.334±0.0	0.081± 0.0	0.133± 0.0	0.057± 0.0
Ni	0.006±0.0	0.057± 0.0	0.007± 0.0	0.006± 0.0
Pb	0.015±0.0	0.017± 0.0	0.011± 0.0	0.018± 0.0
Sr	0.031±0.0	0.037± 0.0	0.011± 0.0	0.026± 0.0
Zn	0.193±0.0	0.507± 0.1	0.378± 0.0	0.350± 0.0
Na	1.169±0.0	2.672± 0.4	0.853± 0.0	0.735± 0.0
K	15.126±0.4	56.316± 0.7	49.334± 0.1	13.505± 0.0
Mg	2.909±0.1	2.826± 0.5	3.602± 0.2	2.474± 0.0
Ca	6.188±0.1	9.652± 0.8	3.184± 0.4	3.722± 0.0
Ba	0.074±0.0	0.130± 0.8	0.011± 0.0	0.052± 0.0

N.D.= Not detected

The rest of the mineral elements analyzed includes Silver (Ag), Aluminium (Al), Bismuth (Bi), Cadmium (Cd), Nickel (Ni), Lithium (Li), Lead (Pb), Strontium (Sr) and Barium (Ba) among which Cd and Pb are toxic heavy metals. Among these metals Al was found to be present in the highest amount (1.443-24.645 mg/kg dw) in all the macrofungi. The next most abundant metal was found to be Ba (0.011-0.130 mg/kg dw) followed by Ni (0.006-0.057 mg/kg dw), Sr (0.011-0.037 mg/kg dw), Bi (0.003-0.035 mg/kg dw), Pb (0.011-0.018 mg/kg dw), Cd (0.001-0.010 mg/kg dw) and Li (0.001- 0.007 mg/kg dw), while Ag (0.002-0.008 mg/kg dw) was found to be present in the least amount. Bi was detected only in *Auricularia auricula-judae* (Bull.) J. Schröt and *Schizophyllum commune* Fries (Table 1). The mineral content of all the macrofungal species were found to be lower than that reported previously. The range of Na content (0.735- 2.672 mg/kg dw) was found to be lower than the previous reports (Gençcelep *et al*., 2009; Kathiravan and Krishnakumari, 2017). K content (13.505- 56.316 mg/kg dw) was found to be the highest among all the macrofungi. Similar observations were made by previous workers who found the K content to be the highest among all the mineral elements (Falandysz *et al*., 2001, Gençcelep *et al*., 2009; Uzun *et al*. 2011). Both Na and K are very essential elements as they are a part of the Na+ / K+ - ATPase pump which maintains the transmembrane gradient of Na and K in the cells. The content of K was found to be much higher as compared to Na; this is particularly favourable from nutritional point of view as it is one of the main electrolyte and major cation inside the cell (Nakalembe *et al*. 2015). Mg content (2.474 - 3.602 mg/kg dw) was also found to be lower than that of previous reports (Mallikarjuna *et al*. 2012; Nakalembe *et al*. 2015). Ca intake is one of the most important factors that influence peak bone mass. The low bone mass is connected to the increased extent of osteoporotic fractures (Yildiz *et al*. 2019). The amount of Ca found in the experimental macrofungi ranges between 3.184 -9.652 mg/kg dw which is lower than the previous reports (Roy *et al.,* 2015, Su *et al.,* 2018). The trace elements like B, Cr, Fe, Cu and Zn were found to be lower than that reported by previous workers (Cefalu*et al*., 2004; Prashanth *et al.,* 2015, Rahi and Malik, 2016; Sharif *et al*. 2016). The Mn content of the macrofungi was found to be similar to that reported by Uzun *et al*. (2011). Although Fe, Cu, Zn and Mn are essential metals and play important roles in living systems but their excess consumption may have toxic effects (Kaya and Bag, 2013). Though the content of these minerals in the mushrooms is significantly low yet they can fulfill the daily mineral requirement of human body to some extent. Ag, Al, Ba, Ni, Li, Sr have also been found to occur in amounts lower than reported by previous workers (Falandysz *et al*. 2001; Sharif *et al.* 2016; Tel-Çayan *et al*. 2015; Su *et al.*2018). Bi was detected only in *Auricularia auricula-judae* and *Schizophyllum commune* and the amount of mineral in both the mushrooms was found to be lower than that reported earlier (Falandysz *et al*. 2001). Cd and Pb are both toxic metals and their content above permissible limits may prove to be fatal. Cd is known as a principal toxic metal, since excessive cadmium exposure may give rise to renal, pulmonary, hepatic, skeletal, reproductive effects and cancer and Pb is highly toxic and has no benefit to human metabolism (Quarcoo and Adotey, 2013). Both Cd and Pb were found to be lower than previous reports (Ouzouni *et al*. 2009; Quarcoo and Adotey, 2013) and within the permissible limits. The levels of essential minerals were found to be higher than that of toxic elements and the level of toxic metals were also within the permissible limits. The four wild edible mushrooms used by the ethnic tribes of Assam have been found to contain fair amount of macro and micro mineral elements which can be useful in partially fulfilling the daily RDA of essential minerals for an adult human. The amount of toxic heavy metals was also found to be within the permissible limits making the four wild edible mushrooms used by the five ethnic tribes of Assam safe for human consumption.

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