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RESEARCH ARTICLE

# Nutritional and mineral composition of four wild edible mushrooms from Jammu and Kashmir, India

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## Abstract

Wild edible mushrooms serve as a garnish that can be taken as routine health food or as functional food. They are enriched with myriad nutrients and bioactive compounds that can be developed into food supplements, hence conferring anti-diabetic, cardiovascular and immune-modulating properties. In the present investigation, four wild edible mushroom species viz., *Apioperdon pyriforme*, *Helvella elastica, Morchella conica* and *Rhizopogon luteolus* collected from different locations of Jammu and Kashmir were examined for their nutritional composition. Among these, *Morchella conica* revealed maximum protein (24.5 g/100 g) and crude fibre (4.8%). While the dried sporocarps of *Rhizopogon luteolus* possessed maximum total phenolic content (12.30 mg/g), Other components including total ascorbic acid content (1.71 mg/g) and total flavonoid content (0.78 mg/g) were present in maximum proportion in fruit bodies of *Rhizopogon luteolus* and *Helvella elastica*, respectively. Furthermore, considering the fact that wild mushrooms have good bioaccumulation potential, these wild edible mushrooms were also assessed for their mineral contents such as Cu, Fe, Zn and Mg. Amongst these, Fe was found present in higher concentration ranging from 165.5–547 ppm followed by Zn (22.2–84 ppm) and Mg (22.4–55.5 ppm). Concentration of copper was found to be lowest in the investigated wild edible mushrooms (23.1–44.5 ppm). However, no copper was detected in *Rhizopogon luteolus*. The present study demonstrates that the investigated mushrooms are rich in nutrients and essential minerals specifying that they may be further used as functional elements in the composition of innovative food products.

**Keywords** Edible mushrooms · Functional foods · Health · Nutritional composition

## Introduction

Wild edible mushrooms are appraised as constituent of gourmet cuisines across the world and valued by humankind as a culinary wonder especially for their preferable flavour and aroma. They are a rich repository of proteins, polysaccharides and dietary fibres that confer the status of low calorie nutraceuticals on them (Ao and Deb 2019; Atri et al. 2013; Chadha and Atri 2017; Deb et al. 2018; FAO/WHO 1991). Presence of low amounts of fat but with excellent poly-unsaturated fatty acids (PUFAs). Appreciable amount of essential amino acids and vitamins with high levels of riboflavin and niacin are present in wild mushrooms (Heleno et al. 2010; Mattila et al. 2001). Keeping in view the present scenario of malnutrition in developing countries like India, nutrient rich foods such as mushrooms are valuable. Additionally, wild edible mushrooms also possess low molecular weight secondary metabolites (terpenoids, polyphenols, flavonoids, polyketides, alkaloids, lactones, sterols, nucleotide analogs, metal chelating agents) and bioactive proteins such as lectins, ribosome inactivating proteins, ribonucleases, antimicrobial proteins and laccases (Xu et al. 2011), that further justify the status of edible mushrooms as "nutraceutical" and "functional foods". Furthermore, due to their efficacious mechanism to accumulate minerals from the soil, the sporocarps of wild edible mushrooms contain different minerals (Zn, Cu, Mg, Fe, Se and Ni), that play a vital role in various physiological processes (Mallikarjuna et al. 2013).

Significantly, their recognizable taste, stimulating flavour and aroma, abundance and beneficial role in human health makes variety of cultivated and wild edible mushrooms viz.,

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*Agaricus bisporus, Agaricus campestris, Lentinus edodes, Pleurotus* spp.*, Calocybe indica,* etc. as part of routine diet in India and other parts of the world (Chang and Miles 2004; Lima et al. 2011; Sharma and Atri 2014). However, in Jammu and Kashmir, most of the mushrooms which are consumed are picked up in the wild by the local populace with most preference given to species of *Morchella*, *Lentinus tigrinus* and *Agaricus campestris* followed by *Pleurotus ostreatus*, *Russula brevipes*, *Cantharellus cibarius*, *Geopora arenicola* etc.

Located in the Himalayan mountains in the extreme of North-India, Jammu and Kashmir encompasses a unique bio-geographical location along with wide climatic variations and diverse host substrates supporting enormous and luxuriant growth of wild mushrooms. Limited studies regarding the nutritional composition of wild edible mushrooms have been carried out in Jammu and Kashmir (Lalotra et al. 2016; Wani et al. 2010). Herein, nutritional composition of four locally consumed wild edible mushrooms namely *Apioperdon pyriforme* (Schaeff.) Vizzini, *Helvella elastic* Bull.*, Morchella conica* Pers. and *Rhizopogon luteolus* Fr. collected from different regions of Jammu and Kashmir has been presented.

## Material and methods

### Sample collection

Fresh sporocarps of *Apioperdon pyriforme*, *Helvella elastica*, *Morchella conica* and *Rhizopogon luteolus* were collected from different regions of Jammu and Kashmir. *Apioperdon pyriforme* and *Morchella conica* were found growing on soil in coniferous forests of Anantnag, Kashmir whereas *Helvella elastica* and *Rhizopogon luteolus* were collected from coniferous forests of Patnitop, Jammu. These collected mushrooms were identified by studying their macro- and microscopic details and consulting standard taxonomic keys (Arora 1986; Bessette et al. 1997). The sundried sporocarps of these mushrooms were powdered for nutritional analysis.

### Estimation of protein

Protein concentration was determined by following Sudheep and Sridhar (2014) using bovine serum albumin as standard. Dried mushroom powder (0.5 g) was homogenized in a pre-chilled pestle and mortar containing 5 ml of potassium phosphate buffer, then centrifuged at 12,000 rpm for 20 min. 0.1 ml of sample extract was pipetted in a test tube, with volume raised upto 1 ml with distilled water. 1 ml of distilled water in a separate test tube served as blank. Then 5 ml of reagent C [50 ml of reagent A (2% sodium carbonate in 0.1 N sodium hydroxide) + 1 ml of reagent B (0.5% copper sulphate in 1% potassium sodium tartrate)] was added to both the test tubes and allowed to stand for 10 min, followed by addition of 0.5 ml of reagent D (Folin–ciocalteu reagent) to each test tube. The absorbance of blue coloured complex that developed after incubating the reaction mixture for 30 min was measured spectrophotometrically at 660 nm.

### Estimation of total phenolic content

Phenolic concentration was determined by the method described by Barros et al. (2007) with some minor modifications. 0.5 g of dried powdered mushroom was mixed in 10 ml of methanol and stirred on vortex at 150 rpm for 2 h. This was filtered and methanolic extract was then evaporated at 40 °C to dryness. This extract was redissolved in methanol at a concentration of 0.5 g/10 ml. 0.2 ml of this extract was taken and volume was made upto 2 ml by addition of distilled water. 2 ml of water in separate test tube served as blank. 0.5 ml of Folin–Ciocalteu (FC) reagent was added to both the test tubes and kept undisturbed in dark for 10 min, followed by addition of 0.8 ml of sodium carbonate solution. After 30 min, the absorbance of the blue coloured solution was measured spectrophotometrically at 743 nm. Gallic acid was used as standard and results were expressed as mg of gallic acid equivalents (GAEs) per g of dried mushroom.

### Estimation of total flavonoid content

Total flavonoid content was determined following Azieana et al. (2017) with some minor modifications, using quercetin as a standard. 5 ml of deionized distilled water ($ddH_2O$) was added to 1.5 ml of ethanolic mushroom extract. After that, 0.3 ml of $NaNO_2$ (5%) was further added to the mixture, incubated for 5 min at room temperature. Then 1.5 ml of aluminium trichloride (2%) solution was added and after 5 min, 2 ml of 1 M NaOH was added. The mixture was then vigorously shaken for 5 min on orbital shaker at 200 rpm and absorbance was measured at 510 nm against a blank.

### Estimation of total ascorbic acid content

Ascorbic acid content was determined by using 2 g of dried mushroom species and dissolving it in metaphosphoric acid (4.5%) for 6 h at room temperature. The extract was then filtered and 1 ml of the filterate was mixed with 9 ml of 2,6-dichlorophenol indophenol and the absorbance was immediately measured at 520 nm against a blank. Ascorbic acid was calculated on the basis of calibration curve of standard ascorbic acid.

### Estimation of crude fibre

The crude fibre was calculated following Maynard (1970). Briefly, 2 g of dried mushroom powder was taken and boiled in 200 ml of 1.25% sulphuric acid for 40 min. It was then filtered and sample was washed with boiling water until the filterate was no more acidic. Sample was then further boiled in 200 ml of sodium hydroxide (1.25%) solution for 40 min. The solution was then filtered again and remaining sample was washed with boiling water till free from alkali and finally washed with ethanol and ether. The residue was then carefully transferred to a pre weighed crucible and dried in an oven at 120 °C for 2 h until constant weight was obtained and dry weight was taken. The sample was then incinerated in a muffle furnace at 660 °C for 30 min until a grey or greyish white ash was obtained, cooled and reweighed.

### Estimation of ash content

3 g of dried mushroom in powdered form was heated on oxidizing flame till smoke subsided. The sample was then put into muffle furnace at 550 °C for 6 h, cooled in a desiccator and weighed. The ash in the sample was calculated by using formula:

$$\text{Ash content (\%)} = \frac{\text{(weight of ash) g} \times 100}{\text{(Weight of sample taken) g}}$$

### Estimation of minerals

Minerals were estimated following modified method of Mallikarjuna et al. (2013). 2 g of dried mushrooms were kept in muffle furnace for 4 h at 500 °C for their complete combustion, until a white or grey ash residue was obtained. 2 ml concentrated $HNO_3$ was used to dissolve the residues. The resulting solutions were then transferred to a 5 ml volumetric flask and deionized water was added to raise the volume upto 5 ml. Preparation of the blank, in the absence of analytes, was also carried out in a similar manner. Concentration of minerals like iron (Fe), zinc (Zn), copper (Cu) and magnesium (Mg) were then analysed by using atomic absorption spectrophotometer (Perkin Elmer A Analyst 700).

### Statistical analysis

Sample assays were carried out in triplicates and results were expressed as values of mean and standard deviation (SD) of three parallel measurements.

## Results and discussion

Table 1 shows the nutritional composition of four wild edible mushrooms viz., *Apioperdon pyriforme*, *Helvella elastica*, *Morchella conica* and *Rhizopogon luteolus*. Although the nutritional composition of *Morchella conica* is known from Turkey, Serbia and Portugal (Gursoy et al. 2009; Ozturk et al. 2010; Vieira et al. 2016) but fragmentary information regarding nutritional composition of *Apioperdon pyriforme* and *Rhizopogon luteolus* has been reported so far (Dursun et al. 2006; Uzun et al. 2011) while there is no such report on nutritional composition of *Helvella elastica.*

### Protein

Among the samples evaluated, protein content was found to be maximum in dried sporocarps of *Morchella conica* (24.5 g/100 g) in comparison to other three species of *Rhizopogon luteolus* (18.2 g/100 g), *Helvella elastica* (18.0 g/100 g) and *Apioperdon pyriforme* (11.5 g/100 g). The protein content observed in *Morchella conica* (24.5 g/100 g) was in parallel with results of different authors who documented it in the range of 7.5 and 35 g/100 g for the same species (Magrati et al. 2011; Vieira et al. 2016). Comparing *Apioperdon pyriforme* with *Lycoperdon echinatum*, the latter showed higher concentration of protein (Kalac 2012). The protein content observed in *Rhizopogon luteolus* (18.2 g/100 g) was close to the value previously reported for *Rhizopogon roseolus* (20.55 g/100 g) by Akata et al. (2012). Toledo et al. (2016) documented protein content ranging from 3.35 – 22.29 g/100 g in nine wild edible mushrooms of native *Nothofagus* species forest, Argentina. Chadha and Atri (2017) analysed three wild edible mushrooms and found highest concentration of protein content in *Calocybe gambosa* (20.22 g/100 g) and lowest in *Lentinus squarrosulus* (14.5 g/100 g). Ao and Deb (2019) and Butkhup et al.

**Table 1** Nutritional composition of wild edible mushrooms on dry weight basis (mean ± standard deviation, n = 3)

| Mushroom species | Proteins (g/100 g) | Total phenolic content (mg/g) | Total flavonoid content (mg/g) | Ascorbic acid (mg/g) | Crude fibre (%) | Ash content (%) |
|---|---|---|---|---|---|---|
| *Apioperdon pyriforme* | 11.5 ± 1.25 | 8.78 ± 1.22 | 0.44 ± 0.04 | 1.23 ± 0.85 | 4.21 ± 0.22 | 9.5 ± 0.54 |
| *Helvella elastica* | 18.0 ± 1.45 | 7.50 ± 1.94 | 0.78 ± 0.13 | 1.36 ± 0.45 | 2.60 ± 1.21 | 10.4 ± 1.10 |
| *Morchella conica* | 24.5 ± 1.92 | 12.3 ± 2.86 | 0.62 ± 0.15 | 1.0 ± 0.37 | 3.50 ± 1.05 | 14.7 ± 1.08 |
| *Rhizopogon luteolus* | 18.2 ± 1.41 | 5.0 ± 1.35 | 0.70 ± 0.13 | 1.71 ± 0.25 | 4.82 ± 0.51 | 11.0 ± 0.88 |

(2018) reported protein concentration in wild edible mushrooms such as *Lentinus sajor-caju*, *Lentinus squarrosulus* etc. ranging from 18.77 to 62.27 g/100 g and *Termitomyces clypeatus*, *Volvariella volvacea* etc. ranging from 7.3 to 48.71 g/100 g, respectively.

Proteins are valuable nutritive components and provide structure to cells, tissues and organs thus are needed in diet for cell repair and growth (Wani et al. 2010). Proteins in wild edible mushrooms primarily consist of both essential and non essential aminoacids with glutamic acid, arginine, leucine, aspartic acid present in abundance and phenylalanine, tryptophan in reduced amounts (Mdachi et al. 2004; Ouzouni et al. 2009).

## Total phenolic content

During the present investigation, total phenolic content found in the methanolic extracts of the studied wild edible mushrooms ranged from 5.0 to 12.3 mg of gallic acid equivalents per gram of dried mushroom (Table 1). The quantity of total phenolic content was highest in *Morchella conica* (12.3 mg/g), followed by *Apioperdon pyriforme* (8.78 mg/g), *Helvella elastica* (7.50 mg/g) and *Rhizopogon luteolus* (5.0 mg/g). Previous studies by Puttaraju et al. (2006) and Ramesh and Pattar (2010) reported 4 mg/g and 6.25 mg/g of total phenols in *Helvella crispa* and *Lycoperdon perlatum* respectively, which was comparatively lower than our studies in *Helvella elastica* (7.50 mg/g) and *Apioperdon pyriforme* (8.78 mg/g). While working with *Morchella conica*, Gursoy et al. (2009) reported 25.38 mg/g of total phenolic content which was higher than recorded in the present investigation (12.30 mg/g). Comparatively, very high values of total phenolic content (73–187 mg/g) were reported by Ao and Deb (2019).

Wild edible mushrooms are rich sources of antioxidants as shown by correlation between phenolic compounds and their antioxidant properties (Ferreira et al. 2009). The methanolic and aqueous extracts of various wild edible mushrooms such as *Grifola frondosa*, *Hericium erinaceus*, *Lentinula edodes*, *Flammulina velutipes*, *Tricholoma giganteum*, *Pleurotus ostreatus* etc. rich in phenolic compounds showed *invitro* antioxidant activities such as lipid peroxidation inhibition, scavenging of free radicals, ferric reducing power (Cheung et al. 2003). Some of the phenolic compounds stimulate the production of endogenous antioxidants (peroxidase, superoxide dismutase, catalase) that prevent damage to the cells by inhibiting excessive levels of free radicals (Oyetayo et al. 2007). Therefore, these wild edible mushrooms are potential reservoirs of natural antioxidants due to the presence of heavy amount of phenolic compounds and can be used to protect human body against oxidative damage caused by harmful free radicals that get produced during physiological stress.

## Total flavonoid content

Total flavonoid content (mg of quercetin equivalents/g of dried mushroom) in these four wild edible mushrooms is shown in Table 1. The results indicated that the total flavonoid content was highest in *Helvella elastica* (0.78 mg/g) followed by *Rhizopogon luteolus* (0.70 mg/g), *Morchella conica* (0.62 mg/g) and *Apioperdon pyriforme* (0.44 mg/g). Similar results were presented by Gursoy et al. (2009) who reported 0.60 mg/g of total flavonoid content in fruit bodies of *Morchella conica*. Total flavonoid content of wild edible mushrooms was reported to be ranging from 1.06 to 9.05 mg/g in ethanolic extracts and 1.62 to 7.29 mg/g in water extracts and total flavonoid content to be varying depending on extractant used as more flavonoid contents get dissolved in polar extractants (Boonsong et al. 2016). Several other authors also reported flavonoids in wild edible mushrooms (Azieana et al. 2017; Butkhup et al. 2018).

Flavonoids are now recognized as important phenolics in mushrooms that possess antioxidant properties and their mechanism of antioxidant action involves scavenging of reactive species, inhibition of lipoxygenase enzymes and chelate trace metal ions involved in production of reactive species and regeneration of tocopherol, a membrane bound antioxidant (Buruleanu et al. 2018; Kozarski et al. 2015).

## Ascorbic acid content

The present study is the first report of ascorbic acid in the investigated mushrooms. In the present investigation, total ascorbic acid content ranged from 1.0 to 1.71 mg/g (Table 1). Dried basidiocarps of *Rhizopogon luteolus* showed highest value (1.71 mg/g) followed by *Helvella elastica* (1.36 mg/g). The concentration of ascorbic acid in *Morchella conica* (1.0 mg/g) was lower than found in *Apioperdon pyriforme* while previous studies by Sharma and Atri (2014) on different species of *Lentinus* showed higher values of ascorbic acid content, Ramesh and Patter (2010) on the other hand revealed comparatively lower values (0.06–0.15 mg/g) than observed during the present investigation (1.0–1.71 mg/g). Variable amount of ascorbic acid has been detected in wild edible mushrooms such as *Laetiporus sulphureus* (Acharya et al. 2016), *Pleurotus ostreatus*, *P. erygnii*, *Leccinum scabrum*, *Calvatia gigantea* (Gasecka et al. 2016, 2018), *Macrocybe lobayensis* (Khatua et al. 2017) etc. The antioxidant potential shown by mushroom extracts is enhanced by low molecular weight compounds including ascorbic acid. Being water soluble, ascorbic acid can inhibit activities of free radicals both inside and outside of cells, thereby showing anti-tumor properties, reduction in cardio-vascular diseases etc. and slowing down ageing processes (Sanchez 2017). Therefore, the selected mushrooms having significant amount of ascorbic acid content can be harnessed as an

accessible source of natural antioxidants and some of them (*Cantharellus cibarius*, *Laetiporus sulphureus*, *Morchella esculenta*, *Pleurotus ostreatus, Russula delica, Sparassis crispa* etc.) are already in vogue (Gasecka et al. 2018; Keles et al. 2011).

## Crude fibre

Crude fibre content of these wild edible mushrooms ranged from 2.60% in *Helvella elastica* to 4.82% in *Rhizopogon luteolus*. Significantly, very high concentration of crude fibre (28.8%) was shown in *Morchella conica* by Magrati et al. (2011) in comparison to our findings for the same mushroom species (3.50%). However, the values of crude fibre in this study were in the close range as reported by Lalotra et al. (2016) and Ao and Deb (2019). As a non digestible carbohydrate, crude fibre performs various physiological activities including attenuation of blood glucose and lipids. It prevents constipation and coronary diseases by lowering LDL cholesterol concentration in serum. In addition, it confers sensation of fullness thus helps in weight control. Hence, the inclusion of these wild edibles would putatively confer wide spectrum of health benefits to the humankind.

## Ash content

Ash content also showed variation between mushroom species and ranged from 9.5% in *Apioperdon pyriforme* to 14.7% in *Morchella conica*. While the values documented by Kalac (2012) in *Lycoperdon echinatum* (9.4%) were similar to that of *A. pyriforme*. *Morchella conica* showed higher values (14.7%) in our studies than those reported by Magrati et al. (2011) (8.2%), but were in conformity with values reported by Vieira et al. (2016). Similarly, *Rhizopogon luteolus* showed higher ash content of 11% than reported by Akata et al. (2012). Ash content found in above selected species (9.5–14.7%) was higher to a small degree than reported by Ao and Deb (2019) (3.1–10.6%).

## Minerals

Concentration of mineral elements (Fe, Zn, Cu and Mg) of four wild edible mushrooms are presented in Table 2. This is the first report on mineral composition of *Helvella elastica*. The level of iron in this study was found to be highest with maximum concentration found in *Rhizopogon luteolus* (547 ppm) followed by *Morchella conica* (531 ppm) and *Apioperdon pyriforme* (423 ppm). The lowest concentration of iron was found in *Helvella elastica* (165.5 ppm). The iron content in the studied mushrooms was found to be higher than the previous reports (Dursun et al. 2006; Gursoy et al. 2009; Sharma and Gautam 2017) and also within the range given by Rahi and Malik (2016) (0.94–118.2 ppm) and Salvador et al. (2018) (18–311 ppm). The iron content varied in pileus and stipe with higher levels in the pileus (Kalac 2010). Abundant iron has been reported in European truffles (Saltarelli et al. 2008). Iron is an essential mineral required in diet for production of blood, production of energy within the cell and maintenance of normal immune system.

In the present study, zinc was detected to be highest in *Rhizopogon luteolus* (84 ppm), followed by *Apioperdon pyriforme* (42 ppm) and *Helvella elastica* (35 ppm). Lowest concentration of zinc was found in *Morchella conica* (22.2 ppm). Concentration of zinc in *Apioperdon pyriforme* (45 ppm) reported by Uzun et al. (2011) was found to be quite comparable with values found in our study (42 ppm). Zinc concentration (17.5 ppm) as reported by Dursun et al. (2006) in *Rhizopogon luteolus* was found to be considerably lower than found during our investigation (84 ppm). Gursoy et al. (2009) reported quite high concentration of zinc (126 ppm) in *Morchella conica* than our study (22.2 ppm). The zinc content in selected wild edible mushrooms was in the range (0.68–89.4 ppm) given by Rahi and Malik (2016) but lower than (51–246 ppm) given by Niedzielski et al. (2017) and Salvador et al. (2018) (16–104 ppm). Isiloglu et al. (2001) has reported mushrooms, especially the parts below the soil to be rich in zinc content. These results indicate that the mushrooms are good accumulators of zinc and the fruiting body: substrate ratio has been found to be 1:10 ppm. Pileus, specifically the hymenium, of mushrooms contain significantly higher levels of zinc than rest of the fruiting body (Alonso et al. 2003; Rudawska and Leski 2005). Zinc is necessary for breakdown of carbohydrates as it enhances insulin action and wound healing due to its role in synthesis of collagen. Moreover, it is important for cell division, cell growth and enzymatic activity. Since human body is devoid of natural zinc, mushrooms or their derived products become an important alternative source.

**Table 2** Mineral concentrations of the mushroom species (mean ± standard deviation, n = 3)

| Mushroom species | Zn (ppm) | Cu (ppm) | Fe (ppm) | Mg (ppm) |
|---|---|---|---|---|
| *Apioperdon pyriforme* | 42.0 ± 1.53 | 23.1 ± 1.77 | 423 ± 8.99 | 22.4 ± 1.99 |
| *Helvella elastica* | 35.0 ± 2.76 | 44.5 ± 1.55 | 165.5 ± 5.26 | 51.6 ± 1.02 |
| *Morchella conica* | 22.2 ± 1.65 | 29.9 ± 1.90 | 531 ± 20.00 | 55.5 ± 3.10 |
| *Rhizopogon luteolus* | 84.0 ± 4.80 | nd | 547 ± 19.88 | 31.2 ± 1.90 |

*Nd* not detected

Maximum and minimum values of copper were 44.5 ppm and 23.1 ppm in *Helvella elastica* and *Apioperdon pyriforme*, respectively. While as *Morchella conica* showed 29.9 ppm of copper, it could not be detected in *Rhizopogon luteolus*. In comparison, Dursun et al. (2006) and Uzun et al. (2011) reported 4.5 ppm and 79 ppm of copper in *Rhizopogon luteolus* and *Apioperdon pyriforme*, respectively. The values of copper found during present investigation in *Morchella conica* was higher than documented by Gursoy et al. (2009). Distribution of copper also varies within mushroom tissues as spore forming part contains elevated levels of copper than rest of the fruiting body (Alonso et al. 2003). In species of Boletaceae family the pileus contains copper content 2 or 3 times greater than stipe. Interestingly, mushrooms are known to possess copper higher than what has been found in many tissues of plants, implying that mushrooms may selectively accumulate some mineral elements (Isiloglu et al. 2001). Irrespective of higher copper content in mushrooms, for people, the bioavailability of copper is low due to limited absorption from small intestines (Schellmann et al. 1980). But the research on certain edible forms such as *Grifola frondosa* resulted in identification of an acidic peptide that is able to increase absorption of soluble copper from the intestines (Kalac and Svoboda 2000). Copper is a microelement essential for normal development of brain, has a role in insulating nerve cells by production and maintenance of myelin thus ensuring proper transmission of nerve impulses (Kalac and Svoboda 2000). In addition, it also plays important role in proper functioning of circulating blood cells and production of white blood cells (WBCs).

Magnesium (Mg) being an essential macro-mineral is required by human body in large quantities and hence must be included in human diet. The values of magnesium in the sporocarps of investigated mushrooms ranged from 22.4 to 55.5 ppm asserting these resources as good source of magnesium. Highest concentration was found in *Morchella conica* (55.5 ppm) followed by *Helvella elastica* (51.6 ppm). In *Apioperdon pyriforme*, Mg was observed to be lower (22.4 ppm) than in *Rhizopogon luteolus* (31.2 ppm). Previously several reports of Mg exist in literature (Brzezicha-Cirocka et al. 2016; Dursun et al. 2006; Gasecka et al. 2018; Gursoy et al. 2009). Magnesium in mushrooms accumulate only through absorption from soil as they lack chlorophyll which constitutes magnesium. As one would expect, the Mg content in fruiting bodies has been reported to be lower than organic soil horizons, from which mycelium uptakes the nutrients (Nakalembe et al. 2015). Mallikarjuna et al. (2013) reported Mg concentration ranging from 231 to 407 ppm, emphasizing mushrooms to be excellent source of magnesium. Recommended dietary allowance in adult males and females for magnesium is 260 and 220 mg/day, respectively (FAO/WHO 1998). Magnesium acts as a cofactor for various enzymes and has a role in reactions that produce and utilize ATP. Moreover, it plays part in producing new proteins from amino acids and efficient communication between neurons by regulating action of neurotransmitters.

Mushrooms that are part of various cuisines in the world are considered as an important source of minerals similar to vegetables and fruits while the accumulation of both macro- and micro- mineral elements is essential for the life-cycle of mushrooms that significantly add to their economic potential as well. Mineral composition in mushrooms seems to be dependent on the type of species and substrate biochemistry as pH and organic matter of substrate have strong influence on mineral composition (Nikkarinen and Mertanen 2004). The information regarding uptake and accumulation of minerals in mushroom species is limited. In European coniferous forests, within the soil horizons, were observed macrofungal hyphae inside numerous minute pores of mineral grains suggesting that the mushrooms may uptake mineral elements directly from pores of mineral grains (Jongmans et al. 1997). Mineral absorption is affected by internal structure of the mushroom tissues and is directly proportional to their water capacity. Also, Kalac and Svoboda (2000) reported that younger fruiting bodies were higher in mineral elements than the mature fruiting bodies as during the fructification process minerals get transported from mycelium to the fruit bodies and mineral concentration decreases with increase in the mass of fruit bodies. The distribution of minerals in mushrooms is uneven as highest levels have been observed in the sporophore except spores, less in the rest of pileus and lowest in the stipe. Even same mushroom species collected from areas with physiographic variations show considerable difference in mineral element concentration as minerals show relationship between mushroom species and geochemistry (Nikkarinen and Mertanen 2004).

## Conclusion

This study concerning nutritional composition of the selected edible mushroom species was executed to quantitatively analyze different nutritional and mineral components. To the best of our knowledge, no extensive studies have been conducted regarding the nutritional composition of these selected mushrooms. The nutritional composition of the four wild edible mushroom species (*Apioperdon pyriforme, Helvella elastica, Morchella conica* and *Rhizopogon luteolus*) showed the presence of considerable amounts of proteins, total phenolic content, total flavonoid content, ascorbic acid, crude fibre, ash content and minerals could be used to bridge the gap of malnutrition arising due to limited food resources and continuously expanding population. Results of mineral analysis of these mushroom species are in consonance with the desired range, thus making them acceptable for human consumption. As human body is not able to

manufacture these minerals, mushrooms or their functional products producing significant amount of these minerals can act as a good source of different minerals. Considering these facts more of these mushrooms should be introduced in the diet. Such startling divulgence of nutritional profiling make these wild edible mushrooms an important source of nutrition especially during the winters in the inaccessible areas of Himalayas when availability of other seasonal vegetables and fruits are scarce.

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## References

Acharya K, Ghosh S, Khatua S, Mitra P (2016) Pharmacognostic standardization and antioxidant capacity of an edible mushroom *Laetiporus sulphureus*. J Cons Prot Food Saf 11:33–42

Akata I, Ergonul B, Kalyoncu F (2012) Chemical compositions and antioxidant activities of sixteen wild edible mushroom species grown in Anatolia. Int J Pharm 8:134–138

Alonso J, García MA, Perez-Lopez M, Melgar MJ (2003) The concentrations and bioconcentration factors of copper and zinc in edible mushrooms. Arch Environ Cont Toxicol 44:180–188

Ao T, Deb CR (2019) Nutritional and antioxidant potential of some wild edible mushrooms of Nagaland, India. J Food Sci Tech 56:1084–1089

Arora D (1986) Mushroom demystified. A comprehensive guide to fleshy fungi. Ten Speed Press, Berkeley

Atri NS, Sharma SK, Joshi R, Gulati A (2013) Nutritional and nutraceutical composition of five wild culinary-medicinal species Of genus *Pleurotus* (Higher Basidiomycetes) from Northwest India. Int J Med Mush 15:49–56

Azieana J, Zainon MN, Noriham A, Nor RM (2017) Total phenolic and flavonoid content and antioxidant activities of ten Malaysian wild mushrooms. Open Access Lib J 4:1–9

Barros L, Calhelha RC, Vaz JA, Estevinho LM, Ferreira ICFR, Baptista P, Estevirho LM (2007) Antimicrobial activity and bioactive compounds of Portuguese wild edible mushrooms methanolic extracts. Eur Food Res Technol 225:151–156

Bessette AE, Bessette AR, Fischer DW (1997) Mushrooms of Northeastern North America. Syracuse University Press, Hong Kong

Boonsong S, Klaypradi W, Wilaipun P (2016) Antioxidant activities of extracts from five edible mushrooms using different extractants. Agric Nat Res 50:89–97

Brzezicha-Cirocka J, Medyk M, Falandysz J, Szefer P (2016) Bio-and toxic elements in edible wild mushrooms from two regions of potentially different environmental conditions in Eastern Poland. Env Sci Pol Res 23:21517–21522

Buruleanu LC, Radulescu C, Georgescu AA, Danet FA, Olteanu RL, Nicolescu CM, Dulama ID (2018) Statistical characterization of the phytochemical characteristics of edible mushroom extracts. Anal Lett 51:1039–1059

Butkhup L, Samappito W, Jorjong S (2018) Evaluation of bioactivities and phenolic contents of wild edible mushrooms from Northeastern Thailand. Food Sci Technol 27:193–202

Chadha M, Atri NS (2017) Nutritional and nutraceutical characterization of three wild edible mushrooms from Haryana, India. Mycosphere 8:1035–1043. https://doi.org/10.5943/mycosphere/8/8/4

Chang ST, Miles PG (2004) Mushrooms cultivation, nutritive value, medicinal effect and environmental impact, 2nd edn. CRC Press, Boca Raton, p 480

Cheung LM, Cheung PCK, Ooi VEC (2003) Antioxidant activity and total phenolics of edible mushrooms. Food Chem 81:249–255

Deb U, Jagannath A, Anilkumar KR, Mallesha CS (2018) Nutritional studies and antioxidant profile of pickled oyster mushrooms of North East India. Def Life Sci J 3:64–70

Dursun N, Ozcan MM, Kasik G, Ozturk C (2006) Mineral contents of 34 species of edible mushrooms growing wild in Turkey. J Sci Food Agric 86:1087–1094

FAO/WHO (1991) Protein quality evaluation: report of the joint FAO/WHO expert consultation, FAO Food and Nutrition Paper 51. FAO, Rome

FAO/WHO (1998) Vitamin and mineral requirements in human nutrition: report of a joint FAO/WHO expert consultation, Bangkok, Thailand, pp 21–30

Ferreira ICFR, Barros L, Abreu RMV (2009) Antioxidants in wild mushrooms. Cur Med Chem 16:1543–1560

Gasecka M, Mleczek M, Siwulski M, Niedzielski P (2016) Phenolic composition and antioxidant properties of *Pleurotus ostreatus* and *Pleurotus eryngii* enriched with selenium and zinc. Eur Food Res Technol 242:723–732

Gasecka M, Siwulski M, Mleczek M (2018) Evaluation of bioactive compounds content and antioxidant properties of soil-growing and wood-growing edible mushrooms. J Food Proces Preser 42:1–10

Gursoy N, Sarikurkcu C, Cengiz M, Solak MH (2009) Antioxidant activities, metal contents, total phenolics and flavonoids of seven *Morchella* species. Food Chem Toxicol 47:2381–2388

Heleno SA, Barros L, Sousa MJ, Martins A, Ferreira ICFR (2010) Tocopherols composition of Portuguese wild mushrooms with antioxidant capacity. Food Chem 49:1443–1450

Isiloglu MMM, Merdivan M, Yilmaz F (2001) Heavy metal contents in some macrofungi collected in the Northwestern part of Turkey. Arch Environ Contam Toxicol 41:1–7

Jongmans AG, Van Breemen N, Lundstrom U, Van Hees PAW, Finlay RD, Srinivasan M, Unestam T, Giesler R, Melkerud PA, Olsson M (1997) Rock-eating fungi. Nature 389:682–768

Kalac P (2010) Trace element contents in European species of wild growing edible mushrooms: a review for the period 2000–2009. Food Chem 122:2–15

Kalac P (2012) Chemical composition and nutritional value of European species of wild growing mushrooms. In: Andres S, Baumann N (eds) Mushrooms: types, properties and nutrition. Nova Science Publishers, New York, pp 130–151

Kalac P, Svoboda L (2000) A review of trace element concentrations in edible mushrooms. Food Chem 69:273–281

Keles A, Koca L, Genccelep H (2011) Antioxidant properties of wild edible mushrooms. J Food Process Technol 2:130–135. https://doi.org/10.4172/2157-7110.1000130

Khatua S, Ghosh S, Acharya K (2017) Chemical composition and biological activities of methanol extract from *Macrocybe lobayensis*. J App Pharm Sci 7:144–151. https://doi.org/10.7324/JAPS.2017.71021

Kozarski M, Klaus A, Vunduk J, Zizak Z, Niksic M, Jakovljevic D, Vrvic MM, Griensven LJLD (2015) Nutraceutical properties of the methanolic extract of edible mushroom *Cantharellus Cibarius* (Fries): primary mechanisms. Food Func 6:1875–1886

Lalotra P, Bala P, Kumar S, Sharma YP (2016) Biochemical characterization of some wild edible mushrooms from Jammu and Kashmir. Proc Natl Acad Sci India Sect B Biol Sci 88:539–545

Lima JA, Tellesa CBS, Sabrya DA, Costaa MSSP, Melo-Silveiraa RF, Trindade ES, Sassaki GL, Wisbeck E, Furlan SA, Leita EL, Rocha HAO (2011) Sulfation of the extracellular polysaccharide produced by the edible mushroom *Pleurotus sajor-Caju* alters its antioxidant, anticoagulant and antiproliferative properties in vitro. Carb Pol 85:514–521

Magrati TP, Tripathee HP, Devkota KP (2011) Nutritional analysis of *Morchella conica* and its role on rural livelihood. Nep J Sci Technol 12:119–126

Mallikarjuna SE, Ranjini A, Haware DJ, Vijayalakshmi MR, Shashirekha MN, Rajarathnam S (2013) Mineral composition of four edible mushrooms. J Chem 1:1–5

Mattila P, Konko K, Eurola M, Pihlava JM, Astola J, Vahteristo L, Hietaniemi V, Kumpulainen J, Valtonen M, Piironen V (2001) Contents of vitamins, mineral elements, and some phenolic compounds in cultivated mushrooms. J Agric Food Chem 49:2343–2348

Maynard AJ (1970) Extraction methods and separation processes in methods of food analysis. In: Joslyn AM (ed) A series of monographs, 2nd edn. Academic Press, New York, pp 141–155

Mdachi SJM, Nkunya MHN, Nyigo VA, Urasa IT (2004) Amino acid composition of some Tanzanian wild edible mushrooms. Food Chem 86:179–182

Nakalembe I, Kabasa JD, Olila D (2015) Comparative nutrient composition of selected wild edible mushrooms from two agro-ecological zones, Uganda. Springerplus 4:433–448

Niedzielski P, Mleczek M, Budka A, Rzymski P, Siwulski M, Jasińska A, Gąsecka M, Budzyńska S (2017) A screening study of elemental composition in 12 marketable mushroom species accessible in Poland. Eur Food Res Technol 243:1759–1771

Nikkarinen M, Mertanen E (2004) Impact of geological origin ontrace element composition of edible mushrooms. J Food Comp Anal 17:301–310

Ouzouni PK, Petridis D, Koller WD, Riganakos KA (2009) Nutritional value and metal content of wild edible mushrooms collected from West Macedonia and Epirus, Greece. Food Chem 115:1575–1580

Oyetayo FL, Akindahunsi AA, Oyetayo VO (2007) Chemical profile and amino acids composition of edible mushrooms *Pleurotus sajor-Caju*. Nutr Health 18:383–389

Ozturk I, Sahan S, Sahin U, Ekici L, Sagdic O (2010) Bioactivity and mineral contents of wild-grown edible *Morchella conica* in the Mediterranean region. J Cons Prot Food Safety 5:453–457

Puttaraju NG, Venkateshaiah SU, Dharmesh SM, Urs SMN, Somasundaram R (2006) Antioxidant activity of indigenous edible mushrooms. J Agric Food Chem 54:9764–9772

Rahi DK, Malik D (2016) Diversity of mushrooms and their metabolites of nutraceutical and therapeutic significance. J Myco 10:1–18. https://doi.org/10.1155/2016/7654123

Ramesh C, Pattar MG (2010) Antimicrobial properties, antioxidant activity and bioactive compounds from six wild edible mushrooms of Western Ghats of Karnataka, India. Pharm Res 2:107–112. https://doi.org/10.4103/0974-8490.62953

Rudawska M, Leski T (2005) Macro- and microelement contents in fruiting bodies of wild mushrooms from the Notecka forest in west-central Poland. Food Chem 92:499–506

Saltarelli R, Ceccaroli CP, Barbieri E, Stocchi V (2008) Effect of storage on biochemical and microbiological parameters of edible truffle species. Food Chem 109:8–16

Salvador C, Martins MR, Vincente H, Caldeira AT (2018) A data mining approach to improve inorganic characterization of *Amanita Ponderosa* mushrooms. Int J Anal Chem 20:1–18

Sanchez C (2017) Reactive oxygen species and antioxidant properties from mushrooms. Syn Syst Biotech 2:13–22

Schellmann B, Hilz MJ, Optiz O (1980) Cadmium-Und Kupferausscheidung Nach Aufnahme Von Champignon-Mahizeiten. Z Lebensm Unters Forsch 171:189–192 **(In German)**

Sharma SK, Gautam N (2017) Chemical and bioactive profiling and biological activities of coral fungi from Northwestern Himalayas. Sci Rep 7:46570–46583

Sharma SK, Atri NS (2014) Nutraceutical composition of wild species of genus *Lentinus* Fr. from Northern India. Cur Res Env App Mycol 4:11–32

Sudheep NM, Sridhar KR (2014) Nutritional composition of two wild mushrooms consumed by the tribals of the Western Ghats of India. Mycology 5:64–72

Toledo CV, Barroetavena C, Fernandes A, Barros L, Ferreira ICFR (2016) Chemical and antioxidant properties of wild edible mushrooms from native *Nothofagus* Spp. Forest, Argentina. Molecules 21:1201–1216

Uzun Y, Genccelep H, Kaya A, Akcay ME (2011) The mineral contents of some wild edible mushrooms. Ekoloji 20:6–12. https://doi.org/10.5053/ekoloji.2011.802

Vieira V, Fernandes A, Barros L, Glamoclija J, Ciric A, Stojkovic D, Martins A, Sokovic M, Ferreira ICFR (2016) Wild *Morchella Conica* Pers. from different origins: a comparative study of nutritional and bioactive properties. J Sci Food Agric 96:90–98

Wani BA, Bodha RH, Wani AH (2010) Nutritional and medicinal importance of mushrooms. J Med Plants Res 4:2598–2604

Xu X, Yan H, Chen J, Zhang X (2011) Bioactive proteins from mushrooms. Biotech Adv 29:667–674