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Bioprospecting of selected wild mushrooms from the tribal zone of north-west Himalaya, India

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ABSTRACT

Fourteen wild edible and medicinal mushrooms representing ten families were collected from an altitude range of 1,867-4,187 metres above mean sea level form Kinnaur district of Himachal Pradesh, NW Himalaya. The biochemical analysis of sporocarps revealed that the carbohydrate content was the maximum in *Coprinus comatus* and protein was highest in *Auricularia auricula-judae*, while the fibre content was recorded highest in *Ganoderma lucidum*. The energy value was determined using the amount of carbohydrates, protein, and fats present in the sporocarps and was found highest in *Helvella lacunosa* and lowest in *G. lucidum.* The ash content of sporocarps was used to estimate the mineral composition and was found highest in *Sparassis crispa,* closely followed by *Lycoperdon perlatum, Russula brevipes,* and lowest in *R. stricta*. The potassium, phosphorus, magnesium and calcium content in general were recorded higher in majority of mushrooms as compared to zinc, manganese, copper, etc. Despite the variations in nutrient content, these mushrooms appear to have a good overall nutritional profile. They have the potential to greatly fulfil people's requirement of proteins, macro and micronutrients. Therefore, mushrooms may be included in our diets on a regular basis to improve its quality.

Key words: Wild mushrooms, Kinnaur, Nutrition, Northwest Himalaya

Mushrooms have long been considered as a delicacy and a dietary supplement in many cultures. Consumer acceptance of wild edible mushrooms is well-established all across the world because of their distinct flavour and texture, as well as their nutritional composition. They are considered a noble source of proteins, vitamins, fats, carbohydrates, amino acids, and minerals with low-calorie diets (Wani *et al*., 2010; Thakur, 2020). Mushrooms harbour variety of bioactive metabolite also that offer a number of nutritional and health benefits to humans beings (Lakhanpal and Rana, 2005; Cheung, 2010). The biologically active compounds of mushroom origin are known to exhibit antifungal, antibacterial, antioxidant, immune-modulating, anti-hypertensive, anti-cancer, anti-allergic, anti-depressive, anti-diabetic, neuro-protective, and anti-viral properties (Wasser and Weis, 1999; Gargano *et al*., 2017; Li *et al*., 2021). Some researchers asserted that the amino acid levels of mushrooms are comparable to those of animal proteins (Suzuki and Oshima, 1976) while Bano (1976) categorised the nutritional content of mushrooms as falling halfway between vegetables and meat. Edible mushrooms, in particular, are becoming increasingly popular as a functional food and a natural phyto-therapeutic agent. Edible and medicinal mushrooms are a valuable resource for advancement in the domains of food, health, and employment in developing

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countries like India (Rai *et al.*, 2005; Wani *et al.*, 2010).

Wild edible mushrooms build up substantial amounts of mineral elements from the soil in their sporocarps, which are essential for a number of physiological functions (Mallikarjuna *et al.*, 2013). Major mineral constituents in mushrooms are Na, K, Ca, Mg, P, and S, with minor constituents including As, Cd, Cr, Co, Cu, Fe, Mo, Mn, Ni, Pb, Se, and Zn (Bano *et al.*, 1981; Bano and Rajarathanum, 1982). Numerous studies have also found that wild edible mushrooms contain more minerals than cultivated ones (Rudawska and Leski, 2005). Phenol, flavonoids, alkaloids, steroids, saponins, terpenoids, and cardiac glycosides are active components in a range of medicinal mushrooms (Unekwu *et al.*, 2014) and are known to exhibit anti-bacterial, anti-fungal, anti-oxidants, and anti-cancer activities (Cowan, 1999; Sokovic *et al.*, 2016). Therefore, phytochemicals derived from medicinal mushrooms have immense potential in the healthcare system for the prevention of a wide range of degenerative diseases and physiological anomalies. These significant impacts have established medicinal mushrooms as potential nutraceutical agents.

Many researchers have studied the nutritional composition of wild edible mushrooms from all over the world. In the case of Indian mushrooms, a series of research papers covering the nutritional aspects of wild and cultivated mushrooms have been published (Longvah and Deosthale, 1998; Agrahar-Murugkar and Subbulakshmi, 2005; Jagadeesh *et al.*, 2010; Johnsy *et al.*, 2011; Kumar *et al.*, 2013, 2015; Ravikrishnan *et al.*, 2017; Altaf *et al.*, 2020; Singh *et al.*, 2020). However, there are still a large number of wild edible mushrooms growing in the tribal areas of the country that require special attention for identification and investigation in order to determine their nutritional and therapeutic value. The current study examines the nutritional and mineral contents of some key wild edible and medicinal species collected from the Kinnaur district of Himachal Pradesh in the North-west Himalaya.

MATERIALS AND METHODS

Study area: Kinnaur district of Himachal Pradesh lies in North-west Himalayan region of India with a latitude 31°55′50″–32°05′15″ N and Longitude 77°45′00″–79°00′35″ E (Fig. 1). It has a mountainous topography, ranging in altitude from 1,600 m to 6,816 m above mean sea level. The area has steep valleys and glaciated mountains. Most of the area of the district has a temperate climate, with long winters and short summers. The upper parts of the district fall in the rain shadow area and are considered arid regions. This area has sparse vegetation comprising hardy grasses, dry alpine scrub, and dwarf juniper scrub. While the vegetation in the lower part of the district comprises trees like pine, oak, chestnut, birch, deodar, fir, spruce, grasses, and shrubs.

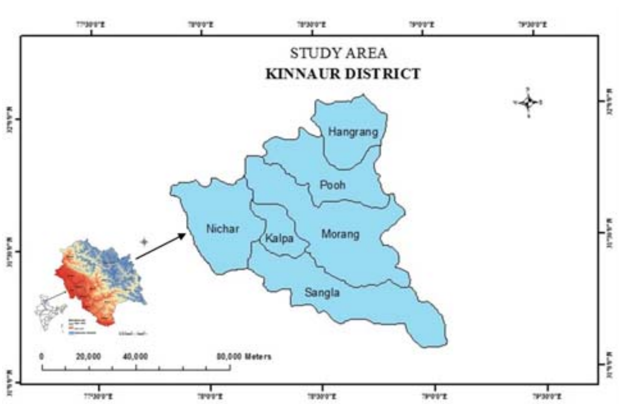

Fig. 1. Study area

Collection of wild mushrooms: The sporocarps of wild mushrooms were collected in paper bags and the field notes like date, location, GPS coordinates, weather conditions, habitat, etc. were recorded. Fresh samples were used to document morphological traits, and the samples were subsequently taken to the lab for taxonomic attribution and culture isolation.

Nutritional analysis: The dried sporocarps of mushrooms were analysed for protein, fat, carbohydrates, ash, crude fibres and minerals using standard proximate analysis methods (AOAC, 1995). The moisture was determined by weight difference method. Crude fibre content was determined by using Acid- Alkali treatment method. The protein content was determined by macro-Kjeldahl method. Total carbohydrate content was determined by anthrone method (John *et al*., 1950). Energy was calculated according to the following equation: Energy (kcal/kg) = 4 × (g protein + g carbohydrate) + 9 × (g fat).

The quantitative estimation of mineral in the mushrooms was done by atomic absorption spectrophotometer (Model: AA 7000, Shimazdu Make) after standardizing with respective elements.

Statistical analysis: Experiments were carried out in triplicate in completely randomized design. The means were compared using one factor analysis of variance (ANOVA). Statistical significance was tested at $p<0.05$.

RESULTS

The sporocarps of 14 wild edible and medicinal mushrooms representing 13 genera in 10 families were collected from diverse locations in the study area (Table 1). The specimens were sun-dried and analysed for nutritional composition, mineral content, and mycochemical analysis.

Proximate composition

The moisture content of the fresh sporocarps varied from 83.2 to 93.1 per cent. *Helvella lacunosa* had the maximum moisture content followed by *Russula brevipes* and *Coprinus comatus* while *Cantharellus cibarius* had the lowest. The quantity of carbohydrates ranged from 35.2 to 75.8 g/100g dry weight and it was recorded highest in *C. comatus*, closely followed by *M. conica*, *M. esculenta*, and lowest in *A. auricula-judae*. The protein content varied between 8.5–52.3g/100g of dry weight. It was found to be highest in *A. auricula- judae,* followed by *R. stricta*, *A. augustus,* and lowest in *G. lucidum*. The majority of mushroom species contain low-fat content when compared to carbohydrates and proteins. The crude fat content in the selected species ranged from 0.36.6 g/100g dry weight. *P. ostreatus* had the highest quantity of crude fats, followed by *C. cibarius, H. lacunosa,* and the lowest in *M. conica*. The crude fibre content varied between 1.9–40.3 g/100g of dry weight. It was found maximum in *G. lucidum,* followed by *À. augustus*, *C. cibarius*, and minimum in *C. comatus*. The ash content varied between 4.1-12.2 g/100 g dry weight with highest in the sporocarps of *S. crispa,* closely followed by *L. perlatum, R. brevipes,* and lowest in *R. stricta*. The energy value ranged from 209.80–379.13 Kcal/g of dry weight of sporocarp. *H. lacunosa* had the highest energy value followed by *P. ostreatus, R. stricta* and lowest in *G. lucidum* (Table 2).

Mineral composition

The ash content left behind after complete incineration of the sporocarps was utilized to estimate the mineral content. Results revealed that in majority of the examined mushroom species, K, P, Mg, and Ca were recorded in higher concentration as compared to Fe, Zn, Cu, and Mn (Table 3). Potassium (K) comprises the majority part in the mushroom ash. Potassium concentration ranged between 16,369.00 to 34,473.00 mg/kg. It was the maximum in *Sparasis crispa,* followed by *Lactarius rubidus, P. ostreatus* and minimum in *C. comatus*. The phosphorus (P) concentration showed a wide range from 1,570.67 to 11,121.33 mg/kg and was recorded highest in *C. comatus*, followed by *A. auricular-judae*, *R. stricta* and lowest in *L. perlatum.* The level of Calcium (Ca) ranged from 75.25–41.82 mg/kg with the maximum in *L. rubidus*, followed by *P. ostreatus, M. esculenta,* and minimum in *A. augustus*. The concentration of Magnesium (Mg) was highest

Table 1. List of wild mushrooms collected from different sites in Kinnaur district

Name of fungus	Family	Collection site	Altitude	Geo coordinates of collection site	Uses	Reference
Agaricus augustus Fr.	Agaricaceae	Nichar	2392	31°32'54.50"N, 77°56'18.90"E	Edible	Kaul et al., 2019
Auricularia auricula-judae (Bull.) Quél.	Auriculariaceae	Tangling	2182	31°31'46.1''N, 77°55'18.3''E	Edible	Atri et al., 2019
Cantharellus cibarius Fr.	Cantharellaceae	Chhitkul	4187	31°37'54.6''N, 078°01'14.0''E	Edible, Medicinal	Atri et al., 2019
Coprinus comatus (O.F. Müll.) Pers.	Agaricaceae	Nichar	2116	31°33'13.6"N, 77°56'12.9"E	Edible, Medicinal	Vishwakarma et al., 2011
Ganoderma lucidum (Curtis) P. Karst.	Ganodermataceae	Sangla	3411	31°24'16.40''N, 078°19'34.7"E	Medicinal	Bijalwan et al., 2020
Helvella lacunosa Afzel.	Helvellaceae	Tapri	2588	31°33'15.80"N, 78°13'44.40"E	Edible, Medicinal	Shameem et al., 2016
Lactarius rubidus (Hesler & A.H. Sm.) Methven.	Russulaceae	Pangi	2602	31°37'1.79"N, 78°11'42.14"E	Edible	Kalita et al., 2016
Lycoperdon perlatum Pers.	Agaricaceae	Kilba	1867	31°32'11.30"N, 77°56'38.50"E	Edible, Medicinal	Atri et al., 2019
Morchella conica Pers.	Morchellaceae	Tapri	2588	31°33'15.80"N, 78°13'44.40"E	Edible, Medicinal	Atri et al., 2019; Turkoglu et al., 2006
Morchella esculenta (L.) Pers.	Morchellaceae	Sangla	2762	31°24'34.30"N, 78°16'37.60"E	Edible, Medicinal	Atri et al., 2019; Badshah et al., 2021
Pleurotus ostreatus (Jacq.) P. Kumm.	Pleurotaceae	Reckong Peo	2066	31°31'58.80"N, 77°54'54.20"	Edible, Medicinal	Sheikh et al., 2015
Ramaria stricta (Pers.) Quél.	Gomphaceae	Sangla	3074	31°25'12.50"N, 78°15'43.90"E	Medicinal	Sharma et al., 2017
Russula brevipes Peck. 78°16'37.10"E	Russulaceae	Sangla	3109	31°24'33.80"N,	Edible, Medicinal	Bhatt et al., 2017
Sparassis crispa (Wulfen) Fr.	Sparassidaceae	Bhaba Nagar	1960	31°33'09.7" N, 077°56'15.9" E	Edible, Medicinal	Atri et al., 2019; Le-Ngoc., 2018

(1406.20 mg/kg) in *L. rubidus,* followed by *R. brevipes, H. lacunosa* and lowest (400.76 mg/kg) in *L. perlatum.* Manganese (Mn) was found in highest quantity in *R. stricta* (52.70 mg/kg) followed by *S. crispa, G. lucidum* and minimum in *M. esculenta* (5.53 mg/kg). The Iron (Fe) content varied between 48.79–157.07 mg/kg. It was the maximum in *R. stricta*, followed by *M. conica*, *R. rubidus* and the minimum in *L. perlatum*. The quantity of Zinc (Zn) was found maximum *C. cibarius* (125.97mg/kg) followed by *R. brevipes*, *H. lacunosa* and minimum in *G. lucidum* (23.84 mg/kg). Copper (Cu) content ranged from 13.81–92.49mg/kg and it was the maximum in *S. crispa,* followed by *L. perlatum, L. rubidus* and the minimum in *C. cibarius.*

DISCUSSION

Among the analysed mushroom species, nine mushrooms had both edible and medicinal properties, while three were edible and two were medicinal only

Table 2. Proximate composition of wild mushrooms

Name of species	Moisture (%)	Ash	Fibre	Carbohydrate	Protein	Crude Fat	Energy (Kcal/kg)
A. augustus	89.3 ± 0.8^{cde}	8.8 ± 1.6^{bcd}	11.5 ± 0.7^{b}	51.7 ± 1.07^{g}	26.5 ± 1.55^{c}	1.4 ± 0.26^{i}	325.27
A. auricula-judae	89.8 ± 1.1^{cd}	7.6 ± 0.7^{cd}	3.4 ± 0.5^{gh}	35.2 ± 0.89^{j}	52.3 ± 0.97^{a}	1.4 ± 0.31^{i}	362.77
C. cibarius	83.2 ± 2.21^{g}	8.2 ± 1.8^{bcd}	11.2 ± 0.66^{b}	53.2 ± 2.07^{g}	20.8 ± 0.95^{f}	6.5 ± 0.75^{ab}	354.33
C. comatus	91.7 ± 1.2^{abc}	9.6 ± 1.1^{bc}	1.9 ± 0.40^{i}	75.8 ± 1.24^{a}	10.9 ± 1.29^{i}	1.7 ± 0.38^{h}	361.53
G. lucidum	83.3 ± 0.6^{g}	9.8 ± 2.1^{b}	40.3 ± 1.43^{a}	39.3 ± 1.19^{i}	8.5 ± 0.91^{j}	2.1 ± 0.40^{g}	209.80
H. lacunosa	93.1 ± 1.3^{a}	7.1 ± 0.9^{cd}	6.1 ± 0.70^{d}	57.8 ± 1.83^{ef}	22.7 ± 1.01^{e}	6.3 ± 0.42^{bc}	379.13
L. perlatum	90.1 ± 0.8^{bc}	12.1 ± 1.2^{a}	9.5 ± 0.66^{c}	56.2 ± 0.85^{f}	18.4 ± 1.10^{g}	3.8 ± 0.36^{d}	332.73
L .rubidus	86.7 ± 1.4^{f}	7.6 ± 1.1^{cd}	5.1 ± 0.55^{ef}	61.7 ± 1.45^{d}	24.8 ± 1.06^{d}	0.8 ± 0.36^{k}	352.93
M. conica	86.9 ± 1.8^{e}	7.6 ± 1.0^{cd}	5.9 ± 0.76^{de}	74.3 ± 1.71^{ab}	9.2 ± 0.83^{j}	0.3 ± 0.66^{e}	361.00
M. esculenta	85.3 ± 1.7^{fg}	8.5 ± 0.8^{bcd}	4.1 ± 0.45^{fg}	73.2 ± 1.50^{b}	11.6 ± 0.81^{i}	2.5 ± 0.51^{f}	361.67
P. ostreatus	90.4 ± 1.2^{bc}	6.6 ± 1.1^{b}	6.6 ± 0.83^{d}	61.7 ± 0.7^{de}	17.2 ± 0.90^{g}	6.6 ± 0.83^{a}	374.71
R. brevipes	92.3 ± 2.2^{ab}	12.0 ± 1.4^{a}	9.2 ± 0.66^{c}	51.2 ± 1.11^{g}	21.6 ± 0.40^{ef}	5.7 ± 0.44^{c}	342.50
R. stricta	85.9 ± 1.6^{f}	4.1 ± 1.1^{e}	8.7 ± 0.75^{c}	43.6 ± 1.21^{h}	39.5 ± 0.67^{b}	3.8 ± 0.51^{d}	366.43
S. crispa	89.6 ± 1.9^{cd}	12.2 ± 0.8^{a}	2.3 ± 0.38^{hi}	70.6 ± 1.55^{c}	13.8 ± 1.11^{h}	1.1 ± 0.31^{j}	347.67
CD ($p\leq0.05\%$)	2.46	2.1	1.2	2.28	1.68	0.26	

as per the literature. The mushrooms are considered as rich source of nutrients and variety of immune-modulating phyto-chemicals. The nutritional composition of macro fungi varies depending on the species, substrate, age, fructification and method of preservation (Colak *et al*., 2009; Raman *et al*., 2021; Karatas, 2022).

While evaluating the nutritional composition of the edible mushrooms, arguably the most essential criterion is their dry matter/moisture content, which has a direct impact on the nutrient content of mushrooms (Mattila *et al*., 2002; Ouzouni *et al*., 2009). Majority of wild mushrooms contain high moisture content in their sporocarps. We have recorded the moisture content in the range of 83.2–93.1 percent. Earlier studies have also reported values more than 80% moisture in different mushrooms (Wang *et al*., 2014). The high moisture content is the major reason for the low shelf life of sporocarps and hurdle in the long term storage.

The edible mushrooms are rich source of carbohydrates, protein and variety of minerals. The carbohydrate content of mushrooms makes up the majority part of sporocarp, which account for 35.2–75.8g/100g of the dry weight of the mushroom. A considerable part of carbohydrates occur in the form of polysaccharides represented by glycogen and fibres which is necessary for proper functioning of the alimentary tract (Manzi *et al*., 2001). â-glucans are the main polysaccharides found in mushrooms which are responsible for antioxidant, anti-tumor, anti-cancer, anti-cholesterolemic, immune-modulating and neuro-protective properties of many mushrooms (Khan *et al*., 2013). The data analysis on nutritional composition revealed that highest amount of carbohydrates was recorded in *C. comatus*; this is in agreement with Stojkovic *et al*. (2013), who have reported 76.57g/100g in cultivated while, 76.29g/100g in wild *C. comatus*. *M. esculenta* and *M. conica* also showed high amount of carbohydrates which is in agreement with the findings of previous researchers (Vieira *et al*., 2016). The carbohydrate content was lowest in *A. auricula-judae*, similar results also recorded in earlier studies (Rahman *et al*., 2020; Johnsy *et al*., 2011); but in contrary Islam *et al*. (2021) recorded higher content of total carbohydrates in *A. auricula-judae*.

Table 3. Mineral composition (mg/kg) in wild mushroom species

Name of species	K	P	Ca	Mg	Mn	Fe	Zn	Cu
A. augustus	21610.21 ± 535.82 h	2104 ± 21.79 i	75.25 ± 4.38 m	1113.19 ± 13.80 e	6.83 ± 1.07 k	108.95 ± 2.34 d	93.62 ± 6.54 e	15.26 ± 2.84 h
C. comatus	17561.17 ± 514.16 i	11121.33 ± 140.61 a	112.76 ± 3.55 l	803.73 ± 1.90 f	15.44 ± 2.46 j	115.41 ± 3.49 cd	44.59 ± 4.35 h	23.57 ± 3.57 g
L. perlatum	25263.67 ± 634.28 g	1570.67 ± 53.52 k	324.57± 6.12 e	400.76 ± 1.92 l	22.45 ± 2.36 i	48.79 ± 4.41 g	83.07 ± 5.88 f	88.82 ± 3.23 a
A.auricula-judae	16369 ± 665.84 j	10643.33 ± 60.71 b	253.50 ± 3.59 h	579.84 ± 8.91 k	29.39 ± 5.06 g	78.11 ± 3.08 f	113.55 ± 5.60 bc	78.47 ± 3.31 b
C. cibarius	26213.33 ± 659.83 fg	4866.33 ± 14.36 e	133.18 ± 5.23 k	791.12 ± 4.11 g	35.42 ± 1.66 d	115.48 ± 4.72 cd	125.97 ± 6.01 a	13.81 ± 2.30 h
G. lucidum	26530 ± 625.53 f	7109.33 ± 185.46 d	228.8 ± 2.24 i	790.91 ± 7.35 gh	43.85 ± 2.29 c	88.84 ± 3.66 e	23.84 ± 4.31 g	70.26 ± 4.22 c
R. stricta	29602.33 ± 811.48 d	9350 ± 37.24 c	144.50 ± 2.51 j	1205.27 ± 4.09 d	52.70 ± 1.50 a	157.07 ± 7.35a	114.65 ± 5.00 bc	72.14 ± 3.48 c
H. lacunosa	28268 ± 604.97 e	2166.33 ± 49.03 i	291.93 ± 3.40 f	1303.09 ± 5.31 c	42.29 ± 2.49 d	95.24 ± 5.18 e	120.54 ± 6.61 ab	49.93 ± 5.82 e
M .conica	22143.33 ± 356.00 h	1652.67 ± 41.36 k	297.74 ± 3.71 f	580.31 ± 6.81 k	34.37 ± 1.12 e	151.64 ± 7.06 a	105.12 ± 6.52 d	35.85 ± 2.31 f
M. esculenta	29229.67 ± 418.18 de	1847.67 ± 37.69 j	373.87 ± 6.94 c	606.66 ± 5.85 j	5.53 ± 0.50 k	117.88 ± 3.68 c	101.77 ± 4.75 de	74.51 ± 2.88 bc
P. ostreatus	30729.67 ± 567.86 c	6993.67 ± 87.08 d	383.30 ± 5.44 b	790.76 ± 8.85 gh	27.14 ± 1.63 h	129.55 ± 5.15 b	66.97 ± 2.35 g	56.61 ± 3.82 d
L. rubidus	33312.33 ± 839.85 b	3218.67 ± 74.57 f	401.82 ± 4.40 a	1406.20 ± 3.24 a	23.91 ± 2.02 i	134.68 ± 4.70 b	111.38 ± 5.22 c	80.32 ± 5.17 b
R. brevipes	18108 ± 476.40 i	2343 ± 92.67 h	345.97 ± 6.37 d	1379.42 ± 11.73 b	33.28 ± 2.12 f	71.38 ± 2.90 f	120.98 ± 5.74 ab	57.36 ± 5.35 d
S. crispa	34473 ± 594.62 a	2910.67 ± 53.98 g	277.19 ± 1.85 g	708.42 ± 6.92 i	46.28 ± 2.12 b	71.89 ± 3.27 f	105.84 ± 6.60 cd	92.49 ± 3.68 a
CD (P≤0.05%)	1015.01	136.26	7.63	12.22	3.79	7.66	9.22	6.45

The crude fibre is a group of indigestible carbohydrates that can improve the function of the alimentary tract and also lower blood glucose and cholesterol levels. We have recorded highest crude fibre in *G. lucidum*, which was significantly higher than all the other mushrooms studied. This is consistent with previous findings (Sharif *et al*., 2016; Salamat *et al*., 2017), nevertheless, different studies showed varied amounts of crude fibre in *G. lucidum* (Singh *et al*., 2020; Rahman *et al*., 2020). A relatively high proportion of insoluble fibre, comprised of chitin and other structural polysaccharides, seems to be nutritionally profitable.

From nutritional point of view, the mushrooms are highly valued due to high proteins and other nutrients than most of the plants (Chang, 1980). Protein content of mushrooms varies with species, composition of the substratum, size of pileus, part and stage of fruiting body and environmental factors (Bano and Rajarathnam, 1982; Colak *et al*., 2009). Protein is a key component of mushroom dry matter and their nutritional value is mostly determined by the protein content. Mushroom protein is considered to have higher nutritional quality than that of plant proteins. In the present investigation, the protein content varied from 8.5 – 52.3 g/100g of dry weight of mushrooms. *A. auricula-judae* had the highest protein content among the mushroom studied, which is at par with the findings of Ao and Deb (2019). *R. brevipes*, *A. augustus* and *L. perlatum* likewise had high protein contents, which is consistent with earlier investigations of Sharma *et al*. (2017) with *R. brevipes*. The protein content was recorded comparatively lower in *G. lucidum*, *M. conica* and *M. esculenta*. This is parallel to prior studies that reported the almost similar range of protein content in these species (Vieira *et al*., 2016; Singh *et al*., 2020). Mushrooms proteins contain all nine essential amino acids required by humans and can be used as a substitute for meat (Kakon *et al*., 2012). Studies have revealed that the protein content in dry mushrooms is much higher than other protein sources.

Mushrooms are a low calorie, low fat food. The fats present in mushroom fruiting bodies are dominated by unsaturated fatty acids. Crude fat in mushrooms includes several classes of lipid compounds, i.e. free fatty acids, mono, di, and triglycerides, sterols, sterol esters and phospholipids (Crisan and Sands, 1978). Various species are especially high in ergosterol, which is the precursor of vitamin D_2 (Mattila *et al*., 2002). The fat content of the fourteen mushrooms studied ranged from 0.8 to 6.6 g/100g of dry weight of fruiting bodies comparable to previous research (Wang *et al*., 2014). *H. lacunosa*, *P. ostreatus* and *R. stricta* showed relatively higher quantity of fat, while *L. perlatum* and *A. auricula-judae* showed the least fat content, which is comparable to previous studies (Kadnikova *et al*., 2015). The high protein and low fat characteristics of the edible wild mushrooms have been previously reported by many workers (Aletor, 1995; Longvah and Deosthale, 1998; Die´z and Alvarez, 2001).

Ash is the completely incombustible inorganic salts in a sample. It gives a rough idea about the mineral content of mushrooms. Potassium (K) and phosphorus (P) are recognised as the main ash constituents in mushrooms and are higher than or comparable to those of most vegetables (Mattila *et al*., 2001). The results of the studies carried out on selected mushroom species showed that dry weight of mushrooms is composed of 4.1-12.2 % of ash. This is comparable to previous studies, which have reported 0.18- 15.73% ash of dry matter of mushroom fruiting bodies (Thatoi and Singdevsachan, 2014). Mushrooms are rich in potassium, calcium, phosphorus and magnesium. Sodium is relatively less in mushrooms and hence they are thought to be a good option amongst other vegetables for the hypertensive people (Rajarathnam *et al*., 1998). According to the results, K, P, Mg, and Ca were significantly higher in comparison to Fe, Mn, Cu, and Zn in majority of the mushrooms.

The level of Calcium in this study ranged from 75.25 - 401.82 mg/kg which is comparable to previous studies (Seeger and Huttner, 1981; Kalac, 2019). The phosphorus concentration also exhibited a wide range; it varied from 1570.67 - 11121.33 mg/kg. In similar study, Quinche (1997) had also reported 6100 - 13700 mg/kg phosphorus in dry weight of mushrooms. Mushrooms have ability to bioaccumulate phosphorus extensively in their fruiting bodies. Highest concentration of Magnesium (1406.20 mg/g) was recorded in *R. stricta* whereas minimum quantity was recorded in *C. cibarius* (400.76 mg/kg), which is comparable to previous studies (Seeger and Huttner, 1981; Kalac, 2019). Potassium concentration varied from 16369.00 mg/kg in *C. comatus* to 34473.00 mg/kg in *S. crispa*. Potassium comprises the majority part in the mushroom ash. Kalac (2019) reported 10-35 mg/g potassium in fruiting bodies of mushrooms. Manganese ranged from 5.53 mg/kg (*M. esculenta*) comparable to Keles *et al*. (2017) 52.70 mg/kg in the sporocarps of *L. rubidus*.

When comparing to most vegetables, mushrooms are richer in Potassium and Phosphorus. Mushrooms are often compared with meat and can serve as a substitute for it. Cullere and Dalle (2018) analyzed rabbit meat, as one of the healthiest, and reported the average concentrations for potassium (4300 mg/kg), and phosphorus (2280 mg/kg). Mushrooms are richer with potassium and phosphorus, and contain less sodium, making them healthier for human consumption. Concerning the effects on blood pressure, the low concentration of sodium and the presence of a high amount of K supports the utilization of mushroom as an antihypertensive diet. Some of our results of nutritional composition and mineral contents of mushrooms show minor differences when compared with previous literature. These differences might be due to growth conditions, geographical variations, genetic differences, analytical procedures, climatic circumstances, soil conditions, pollution levels, metal accumulations etc. (Rudawska and Leski, 2005). The differences can also be partly the result of the different stages of fruit body development (Kalac, 2013). Pearson correlation coefficients (r-values) between total ash and the mineral concentrations of the mushrooms were analyzed. It was observed that the quantity of total ash was positively correlated ($r=0.51$) with K levels ($P>0.05$), which is in agreement with Haro *et al*. (2020). The concentration of other elements was not significantly correlated with ash content.

CONCLUSION

The present study attempts to contribute knowledge of nutritional properties of wild edible and medicinal mushrooms of tribal belt of NW Himalaya. Despite the differences in their nutrient content, the overall nutritive picture of these mushrooms appears to be quite sound. These mushrooms may be employed as significant food sources because of their high protein, carbohydrate, and mineral contents, as can be seen from the data presented. Its potential as a nutraceutical is also increased by the presence of numerous mycochemicals. They hold out a promise to contribute significantly to the intake of micro-nutrients amongst people. Therefore, adding more mushrooms to our meals would definitely increase the standard of our regular diets. This endeavour will certainly improve our micronutrient intake, improving the overall health and ensuring the general wellbeing of the people. These high nutritional qualities and distinct flavours of the mushrooms are likely to be lost if not documented, It is critical that a nutritional database of these mushrooms be established in order to improve the characteristics of the species and eventually domesticate them.

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