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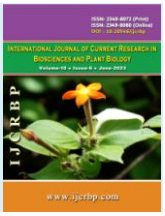

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Nutritional analysis of some wild collected macrofungi from Ayodhya, Uttar Pradesh, India

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Abstract

There is worldwide need for alternative source of high quality and protein rich food components which control food insecurity and malnutrition. Due to the nutritional importance, macrofungi (mushrooms) are utilized and consumed frequently by villagers of Ayodhya district, India. In this district the nutritional value of reported macrofungi has been not studied. In current study, eight selective wild macrofungal samples were collected from different sites of study area such as *Macrolepiota procera*, *Tuber aestivum*, *Auricularia auricula-judae*, *Hygrocybe eburneus* and *Ganoderma leucidum*. The sample was prepared for nutritional analysis and their nutrient composition has been analyzed as findings result. Nutritionally the protein, carbohydrate, lipid, fibre, and ash content were analyzed and ranged from 21.14 – 36.32%, 11.70 – 60.90%, 0.96 – 3.25%, 4.32 – 41.13% and 3.91 – 10.92% respectively. The overall nutrient showed that all collected (selected) macrofungi contains rich protein and carbohydrate content with low lipid (fat) content. The present study expresses and revel the nutritional component as useful awareness to minimize malnutrition for peoples as well as society.

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Introduction

Fungi is the specialized most diversified association on heterotrophic organism and the second largest community after insect, on the earth. Macrofungi are characterized by their fruiting bodies and belonging to the fungal class Ascomycetes and Basidiomycetes. They have thalloid body organization without forming tissues and large enough to be seen by naked eyes and picked by hands (Singh and Singh, 2022; Chandrawati *et al.*, 2014; Bhandari and Jha, 2017). About 70% of macrofungi consider as mushroom world-wide (Singh and Singh, 2022; Tripathi *et al.*, 2017). Mushroom is a seasonal macrofungi that shows very vast and diverse role in nature as well as society (Chaudhary *et al.*, 2015). Mushroom have been existing on earth prior to human and have been used as food before civilization (Singh and Singh, 2022; Paliwal *et al.*, 2013). So, the edible status of mushroom is initial and later become a cultivable mycoflora in favour to need.

Only limited number of species are available in practice to cultivation and remaining are wild (Singh and Singh, 2022). The wild edible mushroom has value as both

edible and medicinal by human, especially local ethnical communities. The edible mushrooms are utilized frequently from ancient era as human food. Most of countries including India, mushrooms are referring as an important nutritional food because of their unique flavour, test, and constituents (Kumari and Srivastava, 2020).

Mushroom is an accepted ideal food item and are also referred to as "Vegetarian Meat" due to rich in protein (35%), low fat and carbohydrates and high fiber which make them enriched food (Tripathi *et al.*, 2017; Chaudhary *et al.*, 2015; Sankarnarayanan and Kumari, 2021).

This study determined eight common wild edible mushrooms for the content of protein, carbohydrate, lipid, fiber, and ash contents thereof and analysed their nutritional value, providing a reference for people to reasonably used and mixed in their diets. It may helpful to poor people relax from their malnutrition and also increase their socio-economic awareness.

Materials and methods

Sample collection, identification and processing

Samples of five wild edible mushroom viz. *Macrolepiota procera* (Scop.) Singer, *Tuber aestivum* Vittad., *Auricularia auricula judae* (Bull.) Schrat, *Hygrocybe eburneus* (Bull.) Fr., and *Ganoderma leucidum* (Curtis) P. Karst. were collected from different sites of district Ayodhya, India. Collected macrofungal samples were identified based on macroscopic and microscopic characters and confirm by following several manuscripts (authors) (Alam *et al.*, 2008; Soosairaj *et al.*, 2012; Chittaragi *et al.*, 2014; Vishwakarma *et al.*, 2016; Singh and Singh, 2022; Singh and Singh, 2023a).

Sample preparation

Collected macrofungal samples were cleaned and dried in shadow at room temperature (25-30 °C) for two weeks. After that, the samples were made into fine powder for their biochemical analysis.

Nutritional analysis

For the determination of nutritional value and composition, following biochemical parameter were studied from the mushroom samples.

Protein contents

Grinned 10 g of mushroom sample was taken with 100 ml. of 0.1 N NaOH and boiled for 30 min. The solution was cooled in room temperature and centrifuged at tabletop centrifuge in the laboratory. The supernatant was collected and total protein content was measured (Lowry *et al.*, 1951; Alam *et al.*, 2008).

Lipid contents

Grinned 10 g of mushroom sample was suspended in 100 ml. of chloroform: methanol (2:1 V/V) solution then mixed thoroughly and let relaxed for 3 days. The solution was filtered and centrifuged at tabletop centrifuge. After centrifugation, the upper layer of methanol was removed by pipette and chloroform was evaporated by heating. After this the remaining was crude lipid (Folch *et al.*, 1957; Alam *et al.*, 2008).

Fiber contents

Fat-free and dried 10 g of mushroom sample was taken in a beaker and 200 ml of boiling 0.255 N H_2SO_4 was added. The mixture was boiled for 30 minutes keeping the volume constant by the addition of water at frequent intervals. The mixture was then filtered through a muslin cloth and the residue washed with hot water till free from acid. The material was then transferred to the same beaker, and 200 ml of boiling 0.313 N NaOH added.

After boiling for 30 minutes and keeping the volume constant as before. The mixture was filtered through a muslin cloth and the residue washed with hot water till free from alkali, followed by washing with some alcohol and ether. After this the residue was transferred to a crucible, dried overnight at 80-100 ºC, and weighed (A) in an electric balance.

The crucible was heated in a muffle furnace at 100 ºC for 5-6 hours, cooled and weighed again (B). The difference in the weights (A-B) represents the weight of crude fiber (Raghuramulu *et al.*, 2003; Alam *et al.*, 2008).

Crude fiber (g/100 g sample)

$$= \frac{[100 - (\text{moisture} + \text{fat})] \times (A - B)}{\text{Weight of Sample}}$$

Carbohydrate contents

For detection of total carbohydrates content, Phenol Sulphuric Acid method (Dubois *et al.*, 1956) was followed. For this, 0.1 ml of the sample, 1 ml phenol solution (5%, v/v) and 5 ml of H_2SO_4 (96%, v/v) were added. The volume of the test sample made 10 ml with adding of distilled water and mixed well followed by incubation for 20 min at 25-30 ℃ in water bath. The absorbance was measured at 490 nm against glucose as standard.

Ash contents

Grinned 10 g of mushroom sample was ashed in muffle furnace in previously ignited and cooled crucible of known weight at 550±5 ℃ for 1 hr. The crucible and its contents were then cooled in desiccators and reweighed. The rate of the incombustible residue accounts for ash content (AOAC, 2000).

$$\text{Ash content} = \frac{\text{Weight of ash}}{\text{Weight of sample}}$$

Statistical analysis

All data expressed in g/100gm and values are given as mean ± standard deviation (SD). Three different observations recorded and their mean value noted for result of particular nutritional content. Standard deviation calculated for the revel the possible deviation of resulted nutritional content (Vishwakarma *et al.*, 2016).

Results and discussion

General description of collected macrofungi such as sample number, date and place of collection with their respective family is given in Table 1. Ecology, nature and morphological description of macrofungi are given in Table 2. It is very much clear that the 4 macrofungi *viz., Macrolepiota procera, Tuber aestivum, Hygrocybe eburneus, Ganoderma leucidum* was saprobic and 1 macrofungi *viz., Auricularia auricula judae* was parasitic in nature (Fig. 1).

Nutritional analysis results of the selected macrofungi such as *Macrolepiota procera, Tuber aestivum, Auricularia auricula-judae, Hygrocybe eburneus* and *Ganoderma leucidum* showed that all specimens have high carbohydrate and protein contents with low lipid content. Comparative nutritional value of all collected (selected) macrofungi is listed in Table 3. Carbohydrate content showed great variation in all tested macrofungi samples and ranged from 11.70 – 60.90%.

Table 1. Collective description of macrofungi.

Macrofungi	Family	Sample ID	Date of sample collection	Place of sample collection
Macrolepiota procera	Agaricaceae	Saket 064	18.08.2022	Village- Sewar, Block- Milkipur, Tahsil- Milkipur
Tuber aestivum	Tuberaceae	Saket 071	09.07.2022	Village- Durgapur, Block- Poora Bazar, Tahsil- Sadar
Auricularia auricula-judae	Auriculariaceae	Saket 047	01.05.2022	Village- Mustafabad, Block- Sohawal, Tahsil- Sohawal
Hygrocybe eburneus	Hygrophoraceae	Saket 074	16.07.2022	Village- Dashrathpur, Block- Bikapur, Tahsil- Bikapur
Ganoderma leucidum	Ganodermataceae	Saket 010	21.11.2021	Village- Chandpur, Block- Masaudha, Tahsil- Sohawal

The lowest carbohydrate content was reported in *Ganoderma leucidum* (11.70%) and highest in *Auricularia auricula-judae* (60.90%). The protein content also showed high variation and ranged from 21.14 – 36.32%, lowest in *Auricularia auricula-judae* and highest in *Macrolepiota procera*.

Tested macrofungi contained low lipid (fat) contents comparatively. In present study lipid content ranged from 0.96 – 3.25%, lowest in *Tuber aestivum* and highest in *Ganoderma leucidum*. Other than major nutrient contents, fibre content also ranged from 4.32 % (*Hygrocybe eburneus*) – 41.13% (*Ganoderma leucidum*) and ash content ranged from 3.91% (*Tuber aestivum*) – 10.92% (*Hygrocybe eburneus*).

The cultivation of mushroom is very profitable agribusiness and it is common to the rural probability with the high nutritional value ever to find anyone (Garuba *et al.*, 2017). The present research investigated

that collected wild macrofungi were rich source of nutritional components. Nutritive value of macrofungi is predominantly related to their protein content as protein is a vital constituent of dry matter of mushrooms (Wang *et al.*, 2014). The protein content in this research, for mushroom species lies between 21.14-36.32% which is in agreement with Yu *et al.* (2020).

The protein content reported for macrofungi is very much similar to Kumari and Srivastava (2020). The present research results were very much similar to work of Johnsy *et al.* (2011) who determined nutritional values of 10 edible mushrooms from Western Ghats of Kanyakumari district and reported that edible mushrooms were highly valued as a good source of protein ranged from 28.93 to 39.1% of dry weight. Work of Wani *et al.* (2010) reported rich nutritional value of mushrooms with high content of proteins, vitamins, minerals, fibers, trace elements and low cholesterol.

Fig. 1: (a) *Macrolepiota procera,* (b) *Tuber aestivum,* (c) *Auricularia auricula-judae,* (d) *Hygrocybe eburneus*, and (e) *Ganoderma leucidum*

Table 2. Ecology, morphological features and edibility nature of collected macrofungi.

Macrofungi	Ecology	Fruiting body	Edibility nature
Macrolepiota procera	Saprophytic; Found in Group on decaying matters; in forest	Pileus umbonate; Stipe with Ring; Gill free; Spore 15-18 × 9-12 µm, smooth and white.	Edible
Tuber aestivum	Saprobic, in group, gregariously on decaying wood	Pileus globus, covered in pyramidal warts, blackish brown in colour; stipe unrecognized; spore 7.16 × 7.10 µm, ovoid reticulate.	Edible
Auricularia auricular-judae	Parasitic on *Tecoma stans*, in group, on healthy tree	Pileus floppy ear shaped or cup shaped, gelatinous, elastic, reddish brown colour, smooth; stipe unrecognized; spore 15-22 × 5-7 µm, thick walled dark.	Medicinal
Hygrocybe eburneus	Saprobic, solitary, on humus rich soil and on straw heap	Pileus convex with in-rolled margin, pinkish white, smooth, slimy; stipe 3.5-5 cm. long; gill decurrent; spores 5-7 × 2-4 µm.	Edible
Ganoderma leucidum	Saprobic and dead wood (hard wood), solitary or in group of fewer	Pileus hoof like, 7-15 cm, dark yellowish to brown; stipe unrecognized; spore 9-10 × 6-5 µm, yellowish to brown.	Medicinal

Table 3. Nutritional value of collected macrofungi (N = 3, mean ± SD).

Mushroom species	Protein (%)	Carbohydrate (%)	Lipid (%)	Fibre (%)	Ash (%)
Macrolepiota procera	36.32 ± 1.08	56.03 ± 0.63	1.02 ± 0.72	7.31 ± 0.39	7.14 ± 0.21
Tuber aestivum	31.40 ± 0.68	40.25 ± 0.67	0.96 ± 0.09	17.16 ± 0.73	3.91 ± 0.31
Auricularia auricula-judae	21.14 ± 1.25	60.90 ± 0.58	1.18 ± 0.08	5.67 ± 1.20	7.24 ± 0.18
Hygrocybe eburneus	35.16 ± 1.01	41.30 ± 1.31	2.48 ± 0.18	4.32 ± 1.11	10.92 ± 0.88
Ganoderma leucidum	24.95 ± 0.40	11.70 ± 0.15	3.25 ± 0.18	41.13 ± 0.39	9.60 ± 0.38

The present investigation on nutritional potential of wild macrofungal species has shown that carbohydrate content of wild mushrooms varying from 11.70% (11.70 ± 0.15) in *Ganoderma leucidum* to 60.90% (60.90 ± 0.58) in *Auricularia auricula-judae*, but these values were in similar to value reported for *Ganoderma leucidum* (11.70 ± 0.25) by Sifat *et al*. (2020) and little lower (65.00 ± 0.44) reported for *Auricularia auricula-judae* by Vishwakarma *et al*. (2016). Gruen and Wong, 1982 reported that edible mushrooms were highly nutritional and can be easily compared with egg, meat and milk food sources confirms that they are rich source of protein. Similarly, all the analysed nutritional content were confirmed and verified by Vishwakarma *et al*., (2016); Garuba *et al*. (2017); Khanna *et al*. (1992); Kumari and Srivastava (2020); Singh and Singh (2023a); Singh and Singh (2023b).

Conclusions

In present days mushroom is taking important position with plant and animal nutritional products world widely. In the Ayodhya district many macrofungi are widely used as food during the rainy season especially by local villager's peoples and also play major role in their socio-economic life. Some of the macrofungi are even in local market has high rate.

In present study clearly revelled that all the tested mushroom species contained considerable high amount of protein which can be used as good nutrient supplement for human beings. The protein, carbohydrate, fiber, fat, and ash content in mushrooms make them a much sought-after ideal vegetable by diabetic, cancer, and cardiac patients. The production of protein rich food source is required to fulfil the demand of protein and overcome malnutrition in the country. Hence macrofungi are highly recommended as alternative food source for providing adequate nutrition to the India's increasing population.

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