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Nutrient value of paddy straw mushroom and wild edible Termitomyces mushrooms from Chhattisgarh

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Abstract
The paddy straw mushroom and Termitomyces mushrooms are very popular among the people of Chhattisgarh. The analysis of proximate components of three species of Termitomyces and paddy straw mushroom with analysis of micronutrients was examined in this study. The study revealed that among the three Termitomyces species, the protein content of *T. heimii* was found to be higher (34.6%). Fiber and carbohydrate percent was found higher in *T. mammiformis* 13.58% and 57.9% respectively. Ash content was found higher in *T. microcarpus* (24.6%). The lowest fat content was found in *T. mammiformis* (1.20%). Although moisture content was found high in Termitomyces species, the *T. microcarpus* found the highest moisture content (92.40%) among these three Termitomyces species. It was found that paddy straw mushroom (IGKV/VV-18/2019) contained 30.41% protein, 5% fat, 5.43% ash, and 90% moisture. The significant amount of micronutrient was found in *Volvariella volvacea* (IGKV/VV-18/2019) *viz*. Phosphorus 9.70%, Potassium 38%, Zinc 1.22%, Iron 0.36%, Manganese 0.47% and Copper 0.13%. The powder from dried fruiting bodies of *T. mammiformis*, *T. heimii*, and *T. microcarpus* remained fresh with its signature flavor and aroma even after six months with no microbial counts.

Keywords: Carbohydrate, fiber, paddy straw mushroom, protein, Termitomyces

Introduction
Wild mushrooms appear to have been consumed by humans from the ancient period, although they were most likely regarded as a meal of the wild at the time, and have subsequently gained popularity in modern diets due to their nutritional benefits. Edible mushrooms are an alternative food source to plants or animal-based foods (Boa, 2004) [6]. Many mushroom genera are edible and Mushrooms are loaded with nutrients such as proteins, fats, vitamins, fiber, minerals, carbohydrates, and a wide range of amino acids (Okwulehie and Odunz, 2000) [18]. Mushrooms have a considerably higher protein level than other animal-based foods, with good quality, and contain a variety of essential amino acids (Julita and Marek, 2007) [12]. Termitomyces is a wild growing mushroom that is symbiotically associated with termites. During the rainy season as a result of the formation of a fruiting structure that emerges straight from spherules on the fungus comb, penetrates the soil, and appears on top of the nest in the form of macrofungi that are safe to eat. On the other hand, the paddy straw mushroom (*Volvariella* sp.) is one of the most commonly cultivated mushrooms around the world, distinguished by its thick, membrane-like volva at the base. Despite its short shelf life, the mushroom has a distinctive flavor and aroma. As a result, mushroom connoisseurs all over the world prefer it. Both termite mushrooms, as well as paddy straw mushrooms, are commonly consumed due to their rapid development during the rainy season, excellent taste, and nutritional content. These two are abundant in this region and are gathered and consumed by locals for their therapeutic and delectable qualities. *Volvariella volvacea* and different Termitomyces species are sold in marketplaces and along roadsides in the old world tropics as a food source and are regarded delicacies. Mushrooms are an excellent addition to the modern diet. Termitomyces species hold high nutritional and economic values among local populations due to traditional folklore (Pahlevanlo and Janardhana, 2012) [20]. According to Kansci *et al*., (2003) [13], the protein content of Termitomyces species ranged from 15 to 19 percent dry weight. *Termitomyces mammiformis* has a significant amount of protein (36.8%) (Adejumo and Awosanya, 2005). In Uganda, The carbohydrate content in *Termitomyces* species ranges from 54.2% - 62% (Mukiibi, 1973) [15]. Ogundana and Fagade (1982) [17] in Nigeria and Parent and Thoen (1977) [21] in Zaire researched the nutritional benefits of Termitomyces species.

In India, several species of Termitomyces have been evaluated for their nutritional value by Bano *et al*., (1964) and Purkayastha and Chandra (1975, 1976). On a dry weight basis, Eguchi *et al*., (2015) [10] found carbohydrate (42.3-49.3 g), protein (32.9-38.9 g), ash (3.2-3.6 g), and fat (3.9-4.9 g) per 100 g of *V. volvacea*. Hence, the present paper provides the results of nutrient analysis of wild Termitomyces spp. and paddy straw mushroom from Chhattisgarh.

Materials and Methods

Mushroom collected from the local market as well as in the field in the monsoon season 2018-19. Based on the availability of *Termitomyces* species, three species of *Termitomyces* namely *T. heimii*, *T. mammiformis*, *T. microcarpus* and *Volvariella volvacea* were collected from different areas of Chhattisgarh subjected for nutritional analysis. The basidiocarps were first carefully washed in clean water to free them from dirt, ferns, and other extraneous materials, cut into small pieces, and carefully mixed and dried in an air-dry oven for 3-4 hours at 50 °C. These dried fruit bodies were ground to a fine powder and kept in an air-tight container for various analyses. The proximate composition of mushrooms was determined using standard procedures published by the AOAC from time to time (carbohydrates, crude fat, proteins, fibers, ash, moisture content). Ashes, lipids, proteins, carbohydrates, and crude fibres are expressed in terms of dry weight (DW), while water is expressed in terms of wet weight (WW).

Moisture: The moisture content was estimated using the AOAC (2003) technique. The difference between the sample weight before the drying and after the drying was used to measure the moisture content percentage.

$$\text{Moisture \%} = \frac{\text{Loss of weight (g)}}{\text{Weight of samples taken}} \times 100$$

Fat: The AOAC (2000) recommended solvent extraction technique (in a Soxhlet apparatus) was used to assess the fat content in wild edible mushroom samples. The fat % in the mushroom was determined using the formula below.

$$\text{Fat \%} = \frac{\text{Weight of ether extract}}{\text{Weight of sample}} \times 100$$

Fiber: The crude fiber content was estimated by using the AOAC (2000) protocols.

$$\text{Crude fiber \%} = \frac{\text{Loss of weight on ignition}}{\text{Weight of samples taken}} \times 100$$

Protein: Kjeldahl method of estimation for nitrogen was followed according to A.O.A.C (2000). Powdered samples of 0.5 g from each mushroom species were digested in 98 percent sulphuric acid before being steam-distilled. The resultant distillate was titrated with 0.5 M sulphamic acid and total nitrogen was multiplied by 6.25 as a constant factor the crude protein content was determined.

$$\text{Protein \%} = \frac{N \times 14.007 \times (Vs - Vb) \times 6.25}{W \times 1000} \times 100$$

Where N is the normality of acid, Vs is the volume of acid used to titrate a sample, and Vb is the volume of acid used to titrate a blank. W is the weight(g) of the dry sample used.

Ash: Following the AOAC (2003) [4] methodology, Samples are weighed, placed in porcelain crucibles, and burned at 600°C in an ash muffle furnace for 4-5 hours until white ash is obtained, the ash content was measured as a residue after incineration and estimated using the formula below.

$$\text{Ash \%} = \frac{\text{Weight of the ash}}{\text{Weight of sample taken}} \times 100$$

Carbohydrate: AOAC protocol (1990) [2] used for estimation of the total carbohydrate content of samples by difference method (Subtracting the total components excluding carbohydrate from 100 g of mushroom samples) the percentage of carbohydrate was calculated.

Carbohydrate % = 100 - (Protein + Fat + Fiber + Ash Content)

Digestion of mushroom samples for phosphorus, Potassium, and micronutrient estimation.

Upon overnight pre-digestion, 5 grams of powdered material was digested with a 10 ml di-acid solution (nitric acid and 10:4 perchloric acid). After filtration, the white residue left at the bottom of the flask was diluted to a known volume with water. This extract was used in P, K, and micronutrient estimation.

Estimation of phosphorus content

Phosphorus content of mushroom samples was measured by the Vanadomolybdo phosphoric acid yellow color method using an aliquot of diacid digested sample. A spectrophotometer was used to assess the intensity of yellow colour development at 430 nm. (Jackson, 1973) [11].

Estimation of potassium content

The di-acid digested extract was used to evaluate the potassium content of mushroom samples. The reading of potassium was taken with the help of a flame photometer (Chapman and pratt, 1961) [8].

Estimation of micronutrient content

The di-acid digested extract was used to evaluate the micronutrient profile of mushroom samples. The reading of iron, manganese, zinc, and copper was taken with the help of atomic absorption spectrophotometer (Zasoki and Buran, 1977) [25].

Result and Discussion

Nutritional analysis of Termitomyces and Paddy straw mushroom was carried out. The proximate analysis under investigation was moisture percentage, ash, fat, protein, crude fibre and carbohydrate. The dried grinded samples were used for analysis except for moisture percentage. The detailed research outcome for proximate analysis had been tabulated in Table 1.

Moisture: The moisture content in *T. mammiformis*, *T. heimii*, *T. microcarpus*, and IGKV/VV-18/2019 was found to be 90.30%, 88.90%, 92.40%, and 90% respectively.

Protein: The protein content in *T. mammiformis*, *T. heimii*, *T. microcarpus* and IGKV/VV-18/2019 was found to be 21.10%, 34.60%, 24.6%, and 30.41% respectively.

Fat: The fat content in *T. mammiformis*, *T. heimii*, *T. microcarpus* and IGKV/VV-18/2019 was found to be 1.20%, 5.23%, 3.27%, and 5.00% respectively.

Carbohydrates: The carbohydrates content in *T. mammiformis*, *T. heimii*, *T. microcarpus* were found to be 57.90%, 48.60%, and 53.40% respectively.

Fibers: The fibers content in *T. mammiformis*, *T. heimii* and *T. microcarpus* was found to be 13.58%, 4.49%, and 7.04% respectively.

Ash: The ash content in *T. mammiformis*, *T. heimii*, *T. microcarpus*, and IGKV/VV-18/2019 was found to be 5.58%, 6.50%, 11.10%, and 5.43% respectively.

The significant amount of micronutrient was found in *Volvariella volvacea* (IGKV/VV-18/2019) *viz*. Phosphorus 9.70%, Potassium 38%, Zinc 1.22%, Iron 0.36%, Manganese 0.47% and Copper 0.13%.

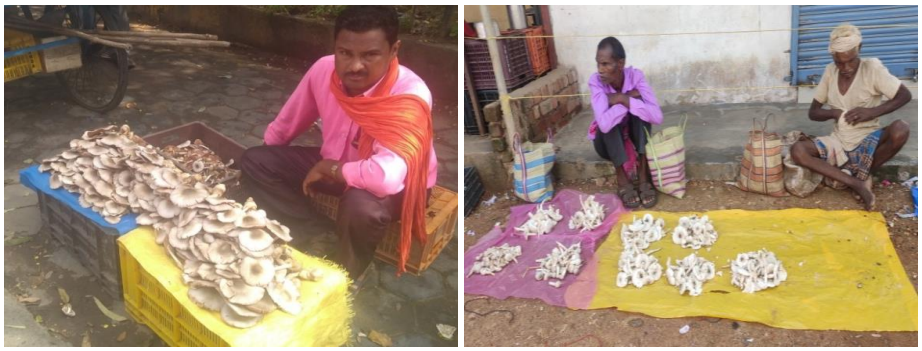

Fig 1: Paddy straw mushroom and *Termitomyces heimii* on the roadside market for sale

Table 1: Proximate analysis of Termitomyces species and Paddy straw mushroom from Chhattisgarh.

Sample Name	Proximate analysis on DW basis expressed as a percentage					Moisture % (WW)
	Protein (%)	Fat (%)	Ash (%)	Fiber (%)	Carbohydrate %	
T. mammiformis	21.1	1.20	5.58	13.58	57.9	90.30
T. heimii	34.6	5.23	6.50	4.49	48.60	88.90
T. microcarpus	24.6	3.27	11.10	7.04	53.40	92.40
IGKV/VV-18/2019	30.41	5.00	5.43	ND	ND	90.00

*ND-Not determined, DW-Dry weight, WW-Wet Weight

In the rainy season, there are plenty of paddy straw mushrooms grown on a heap of paddy straw and Termitomyces in the forests as well as fields. As these two mushrooms are found abundant in Chhattisgarh, villagers harvest and consume or sell them. Villagers get a good income by selling these mushrooms as people are urged to buy these mushrooms in the season because of their delicious qualities. The powder from dried fruiting bodies of *T. mammiformis*, *T. heimii*, and *T. microcarpus* remained fresh with its signature flavor and aroma even after six months (Fig. 2) with no microbial counts. In several studies on nutritional parameters of termitophilous mushrooms has the maximum protein content of 33-45 g per 100 g dry weight (Parent and Thoen, 1977) [21]. *T. clypeatus* comprises 31% protein, 32% starch, and 10 -14% ascorbic acid (Ogundana and Fagade, 1982) [17]. The protein level of *T. microcarpus* on a dry weight basis was 25.8% (Olila *et al*., (2008) [19]. *T. heimii* contains 23.75% of crude protein about 3.58% of crude fat, 11.59%, 7.40% moisture, 54.70% total carbohydrate, and an energy value of 345.90 kcal/100 g (Due *et al.*, 2016) [9]. On a fresh weight basis, Brinda *et al*., (2017) [7] revealed a high moisture content (90.11%) in *V. volvacea*, and on a dry weight basis, the protein content was 41.36%, carbohydrate 22.17%, fiber 16.98%, lipids 4.98% and ash content was 7.25%. Karnan *et al.*, (2016) [14] analyzed *V. Volvacea* for chemical composition (moisture, protein, fat, carbohydrates, and ash). Moisture 82.20%, proteins 52.12%, fat 6.03%, carbohydrates 43.45% and ash 5%. Nasir and Shiva (2019) [16] observed that in comparison to other stages of *V. volvacea*, the button stage had more protein (27.67%) and minerals (Mg (9.16 ppm), K (47.23 ppm), Zn (0.68 ppm), Fe (1.59 ppm), and Ca (2.52 ppm).

(A) (B) (C)

Fig 2: Powder of *Termitomyces* mushrooms A) *T. mammiformis* B) *T. heimii* C) *T. microcarpus*

Conclusion

The nutritional study of paddy straw mushrooms and Termitophilous mushrooms from Chhattisgarh indicated that they are high in protein, fiber, and carbohydrate, but low in fats. The dried powders of these Termitomyces mushrooms were found fresh with their signature aroma and no microbial counts. The significant amount of micronutrient found in *V. volvacea* which makes it much better food than many plant and animal-based food. Protein content in these mushrooms is unusually high, making it an excellent dietary item for fighting malnutrition.

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