Nutritional and antioxidant properties of wild edible macrofungi from North-Eastern Uttar Pradesh, India

Pratima Vishwakarma, Pooja Singh* & N N Tripathi
Bacteriology and Natural Pesticide Laboratory, Department of Botany, DDU Gorakhpur University, Gorakhpur 273009, India
E-mail: pooja.ddu@gmail.com

Received 24 July 2014, revised 29 July 2015

Eastern part of Uttar Pradesh, India is home to diverse forms of macrofungi some of which are excellently edible and commonly used by local peoples as food and medicine. The nutritional composition and antioxidant activity of four wild edible macrofungi, viz. *Calocybe gambosa*, *Calocybe indica*, *Macrolepia procera* and *Tuber aestivum* collected from different areas of Gorakhpur were evaluated. The total phenol content of each species along with some bioactive compounds was analysed. The nutrient composition of these macrofungi showed that they are rich source of protein and carbohydrate. Protein, carbohydrate, lipid, fibre, moisture and ash ranged from 31.40-49.05%, 41.25-65.00%, 0.27-1.08%, 6.41-17.97%, 54.75-76.97%, 2.64-10.34%, respectively on dry weight basis. Total phenol contents (major antioxidants components) ranged from 23.89-38.37GAEmg/gm in different macrofungi. Current study confirms that macrofungi are healthy source of food and medicine can also be use as alternative source of protein in human diet.

**Keywords:** Edible mushroom, Antioxidant, Bioactive compounds, DPPH, Tharu, Bhar, Kewat, Bhuj tribes

**IPC Int. Cl.**: A01G 1/04, C09K 15/00, C07G, C01, C07

Traditional medicine or Ethnomedicine is a healthcare practice that has been transmitted orally from generation to generation through traditional healers with an aim to cure different ailments, and is strongly associated to religious beliefs and practices of the indigenous people\(^1\). Since the beginning of human civilization man has been using many herbs and herbal extracts as medicine. The classical Indian texts *Rig-Veda*, *Atharvaveda*, *Charak samhita* and *Sushruta samhita* are the evidence of the use of plants by our ancestors. It indicates that the herbal medicines have been derived from rich traditions of ancient civilization and scientific heritage. Among the ancient civilizations, India has been known to be rich storehouse of medicinal plants and macrofungi. The forests in India are the principal repository of large number of medicinal macrofungi, which are largely collected as raw materials for manufacture of drugs\(^2\). The local tribes are largely self contained, ritually sanctioned way of life where they practice utilization plants and macrofungi for curing many diseases\(^3\). Traditionally the tribes lived in and subsisted on the forests, but with increasing loss of forest areas, integration into mainstream society and urbanization, they are rapidly losing their traditional knowledge and culture\(^4\). Mushrooms have a long association with mankind and provide profound biological and economical benefit. The wild mushrooms have been traditionally consumed by man with delicacy probably, for their taste and pleasing flavour. They have rich nutritional value with high content of proteins, vitamins, minerals, fibres, trace elements and low calories and cholesterol.

In order to assess the consumption of traditionally important and indigenous medicinal macrofungi survey was carried out during January to December (2011-2014) in the different areas of Gorakhpur district and its adjoining areas. These medicinal macrofungi were used by *Bhar, Kewat, Bhuj, Tharu* and local villagers of this region. The ethanobotanical information was gathered through several visits, questionnaire, group discussion with various groups and local peoples.

**Methodology**

**Sample collection, identification and processing**

Samples of four wild edible macrofungi, viz. *Calocybe gambosa*, *Calocybe indica*, *Macrolepia procera* and *Tuber aestivum*...
procera and Tuber aestivum were collected from forest regions of Gorakhpur during the months of July to August in 2012-13. The macrofungal samples were identified on the basis of their macro and microscopic characteristic and following several authors and was also confirmed by Prof. Kamal (Retired Prof. Dept. of Botany, DDU Gorakhpur University). Collected samples were cleaned for dust and foreign materials, dried in shadow at room temperature for 14 days. Samples were then made into fine powder with help of grinder (0.5 mm sieve) for their biochemical assessment.

Biochemical assay

Moisture content was determined by direct oven drying method. The loss in weight after oven drying 2 gm of the sample at 110°C to constant weight was expressed as percent moisture content. Protein content of macrofungal samples were determined by the method of Adedayo & Rachel. Carbohydrate was estimated by Anthrone method. Crude fibre content was evaluated following Alam et al. while lipid was estimated by the method of Gbolagade et al. Ash of the sample was estimated by the method of Gang et al.

Antioxidant activity

DPPH (2, 2'- diphenyl-1-picrylhydazyl) and reducing power of macrofungi was calculated according to the method adopted by Barros et al.

Total bioactive compounds

β- Carotene and lycopene was determined by the process described by Loganathan et al. Contents of β-Carotene and lycopene were calculated according to the following equations:

Lycopene (mg/100mL) =
0.0458 A663 + 0.372 A505 - 0.0806 A453

β- Carotene (mg/100mL) =
0.216 A663 - 0.304 A505 + 0.452 A453.

The ascorbic acid content was determined titrimetrically using 2, 6 Dichlorophenol Indophenol methods. The amount of ascorbic acid in each extract was calculated from the equation:

mg of ascorbic acid per 100gm =
titre x Dye factor x volume made x 100
Alilot of extract x weight.

Total phenolic compounds in the ethanol extracts were determined using Folin–Ciocalteu method. The contents of the phenolic compound were expressed as mg Gallic acid equivalent/gm dry weight.

Statistical analysis

Experimental values are given as mean ± standard deviation (SD). Statistical significance was determined by one way variance analysis (ANOVA). Difference at p<0.05 were considered to be significant.

Results

Table 1 clearly indicate the morphological characteristics, date and place of collection of macrofungi and voucher number of each macrofungi. It is very much clear from table that two macrofungi, viz. Calocybe gambosa and Tuber aestivum was mycorrhizal in nature while Calocybe indica and Macrolepiota procera was saprobic (Fig. 1 (a-d). Table 2 represents various uses of collected macrofungi. Each macrofungi collected had its own important medicinal property. These macrofungi were used by different tribes and many villagers for food as well as to cure various ailments, like C. gambosa used by Kewat and Tharu tribes to increase immunity, C.indica by Kewat tribes to relief from stomach pain, M. procera by Bhuj and Bhar to cure diabetes and also to relief from blood pressure and T. aestivum by Bhar, Kewat, Bhuj, Tharu and local villagers for proper healthcare.

In present study some species of mushrooms such as C. gambosa, C. indica, M. procera and T. aestivum were investigated for different nutrient content. Comparative nutritional value of all collected macrofungi is listed in Table 3. Protein content showed great variation in all tested mushroom.
Protein content ranged from 31.40-49.05%, lowest in *C. indica* while highest in *M. procera*. In present work carbohydrate content ranges from 41.25-65.00% on dry weight basis. Highest carbohydrate content was found in *M. procera* while lowest in *T. aestivum*. Tested samples contain low lipid content. In present study lipid content ranged from 0.27-1.08%. Fibre content also ranged from 6.41 (*M. procera*)-17.97 (*T. aestivum*) % while ash was in range of 2.64% (*T. aestivum*) - 10.34% (*C. indica*). Moisture content of sample ranged from 54.75-76.19%. *M. procera* shows highest moisture content (76.19%) as compared with other species.

The amount of ascorbic acid, total phenol and total carotenoids expressed as β-carotene and lycopene were considerably different among three studied samples (Table 4). The Ascorbic acid was found to be more in *M. procera* (0.098 mg/gm) followed by *C. indica* (0.056 mg/gm), *T. aestivum* (0.042 mg/gm) and *C. gambosa* (0.014 mg/gm). Phenolic compounds are found to be major bioactive compound found in food products which ranged from 23.89 to 38.379 GAE/mg. *C. indica* extracts showed the highest phenolic content (38.379 GAE/gm), while *M. procera* showed lowest phenol content (23.89 GAE/gm). β carotene and lycopene were found in very small amount.

Table 5 shows the result of DPPH scavenging activity of different edible mushrooms tested. Result revealed that *C. indica* extract showed the highest DPPH radical scavenging activity (lowest EC_{50} value), followed by *C. gambosa*, *M. procera* and *T. aestivum*, respectively, β carotene bleaching activity of different mushroom species are presented in Table 5. *C. indica*
showed strong reducing power activity. *C. gambosa*, *T. aestivum* and *M. procera* extract showed weak reducing power (EC$_{50}$= 2.590, 3.395, 3.516, respectively) with high EC$_{50}$ value as in comparison with *C. indica*.

**Discussion**

Macrofungi are used by peoples from time immoral as food and medicine to cure various diseases.\(^{18}\) Now a days with increasing modernization and industrialization lots of new synthetic drugs are available in markets for various disease but they shows many adverse effects. Natural products being highly effective in treating various ailments shows no side effects hence these natural products must be use for the extraction of compounds for the synthesis of drugs or they can be directly use as whole for rehabilitation\(^{19,20,21}\). It was concluded from the present study that protein, carbohydrate, lipid, fibre, moisture and ash showed variation in all the evaluated samples. The result of the nutritional analysis of the macrofungi (Table 3) shows great variation in nutrient content. Edible macrofungi are highly valued as good source of carbohydrate. Carbohydrate content of *C. gambosa* (55.00%) was found to be more than amount reported by Barros et al.\(^{22}\). *C. indica* contain 52.13% of carbohydrate which is same as data obtained by Alam et al.\(^ {12}\) for dried sample. Edible macrofungi are highly valued for its high protein content. In present study, protein contents of four mushrooms show a great variation. Similar results were also reported by Akyüz & Kirbağ\(^ {23}\). In present study tested samples contain low lipid. These results were similar with those obtained by Barros et al.\(^ {22}\) for few species of macrofungi like *Agaricus*, *Boletus*, *Calocybe*, *Cantharellus*, *Craterellus* and *Marasmius*. Low amount of lipid clearly indicate its high medicinal importance that it can be included in daily human diet and also it can also referred to heart patients. Fresh macrofungi contain high amount of fibre which may be responsible for its relatively high amount of ash. Biochemical analysis of few macrofungi, viz. *M. procera* and *T. aestivum* have been carried out for the first time. The relative high protein and carbohydrate content recorded in the samples is proof of its being highly nutritious and fit for human consumption. Nutritional value of mushrooms is generally very high due to its high protein and other nutrient content. Nutritional value of mushrooms depends largely on the chemical composition of the compost on which it is growing. Present studies reveal that these macrofungi are good sources of protein and carbohydrate and low in fat hence can be recommended for good health diet.

Antioxidant property of mushrooms largely depends upon the amount of bioactive compounds present in the samples.\(^ {24,25}\) β carotene, lycopene, phenol and ascorbic acid are important bioactive compounds which imparts significant role in antioxidant property. Especially phenol content, larger the amount of phenol larger its antioxidant property.\(^ {26,27}\) The antioxidant activity of macrofungi increased with the increased in the concentration of samples, higher the antioxidant property lower the EC$_{50}$ values. A lower EC$_{50}$ value means better radical scavenging activity. DPPH is a stable free radical of deep purple colour which absorption maximum at 570 nm. When, antioxidant is present in the sample purple colour of DPPH fades.\(^ {28}\) Hence, absorbance of sample decrease due to the quenching effect of DPPH free radical which result in the release of electron. Table 5 shows the antioxidant activity of the

### Table 4—Bioactive compound analysis of collected macrofungi

<table>
<thead>
<tr>
<th>Sample</th>
<th>β carotene µg/mg</th>
<th>Lycopene µg/mg</th>
<th>Phenol GAE mg/gm</th>
<th>Ascorbic acid mg/gm</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>C. gambosa</em></td>
<td>1.279±0.32</td>
<td>0.088±0.13</td>
<td>36.282±0.28</td>
<td>0.014±0.88</td>
</tr>
<tr>
<td><em>C. indica</em></td>
<td>1.939±0.44</td>
<td>0.098±0.43</td>
<td>38.379±0.65</td>
<td>0.056±0.92</td>
</tr>
<tr>
<td><em>M. procera</em></td>
<td>0.025±0.61</td>
<td>0.650±0.58</td>
<td>23.890±0.81</td>
<td>0.098±0.98</td>
</tr>
<tr>
<td><em>T. aestivum</em></td>
<td>0.093±0.48</td>
<td>0.160±0.60</td>
<td>30.861±0.94</td>
<td>0.042±0.59</td>
</tr>
</tbody>
</table>

Values are means ± SEM for groups of 3 observations with their standard errors.

### Table 5—EC50 of collected macrofungi for their antioxidant activity

<table>
<thead>
<tr>
<th>Sample</th>
<th>DPPH (mg/ml)</th>
<th>EC$_{50}$</th>
<th>Reducing power (mg/ml)</th>
<th>EC$_{50}$</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>C. gambosa</em></td>
<td>1.883±0.17</td>
<td>2.590±0.95</td>
<td>1.939±0.54</td>
<td></td>
</tr>
<tr>
<td><em>C. indica</em></td>
<td>0.741±0.45</td>
<td>3.516±0.43</td>
<td>3.916±0.60</td>
<td></td>
</tr>
<tr>
<td><em>M. procera</em></td>
<td>2.523±0.90</td>
<td>3.160±0.43</td>
<td>3.916±0.60</td>
<td></td>
</tr>
<tr>
<td><em>T. aestivum</em></td>
<td>3.916±0.60</td>
<td>3.395±0.73</td>
<td>0.052±0.41</td>
<td></td>
</tr>
<tr>
<td>BHT</td>
<td>0.052±0.41</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
</tbody>
</table>

Values are means ± SEM for groups of 3 observations with their standard errors.
mushroom extracts as measured by the bleaching of β-carotene. The absorbance of sample decreased rapidly in absence of antioxidant. When antioxidant is present in the sample it retains its colour and thus gives absorbance for longer time. When concentration of sample increases antioxidant property of it also increases. C. indica revealed better antioxidant properties (lower EC50 values) than other samples tested and agreed with the statement of higher content of phenols present in it. Synthetic antioxidants such as BHT, BHA, TBHQ at higher level shows many toxic effect hence natural antioxidants from plants and macrofungi have been receiving greater attention for future use. All the tested samples in present study also contain significant amount of antioxidant activity with higher amount of phenol in them. It proves its correlation between the amount of phenol and its antioxidant property. Higher the amount of phenol higher its antioxidant property.

Conclusion
Now a day mushrooms are also taking important position with plants in treating many ailments. The present study shows that mushrooms can be use as medicine to prevent various diseases. This type of knowledge can open new field for researchers to work out and find new type of drug to prevent various ailments. In Gorakhpur many macrofungi are widely used as food during the rainy season by local peoples and plays vital role in socio economic life of the tribal peoples. Beside their use as food it is highly used as folk medicine. Some of the macrofungi are even locally marketed at high rate. Present study clearly showed that all the tested mushroom species contained considerable amount of protein which can be used as good nutrient supplement for human being. The production of protein rich food is required to meet the demand for protein and overcome malnutrition in the developing countries hence macrofungi are highly recommended as alternative food source for providing adequate nutrition to the world’s increasing population.

Acknowledgement
The authors wish to thank Head, Department of Botany DDU Gorakhpur University, Gorakhpur for providing necessary Lab. Facilities

References
4 Khongsai M, Salikia SP & Kayang H, Ethnomedicinal plants used by different tribes of Arunachal Pradesh, Indian J Tradit Knowle, 10(3) (2011) 541-546.


