J. Mycopathol. Res. **59(4)** : 419-423, 2021; (ISSN 0971-3719)

Biochemical composition of four ethno-mycologically important macrofungi of Assam- a comparative study

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Received : 30.06.2021 Accepted : 15.10.2021 Published : 27.12.2021

In the present study the biochemical content of four ethno-mycologically important macrofungi of Assam *viz. Auricularia auricula-judae* (Bull.) J. Schröt, *Pleurotus ostreatus* (Jacq. ex Fr.) P. Kumm., *P. tuber-regium* (Rumph. ex Fr.) and *Schizophyllum commune* Fries were analyzed. These macrofungi are important from ethno-mycological point of view because of the fact that many of them are utilized by various ethnic groups of Assam as food and hold great significance in their culinary practices. The range of various biochemical parameters analyzed were found to be as follows: carbohydrate content (34.15% - 50.78% dw), protein content (32.19% -38.90% dw), fat content (1.76% -3.59% dw), moisture content (56.12% -71.24% fw), crude fibre content (3.62% - 5.73% dw), ash content (4.64% - 7.01% dw), total energy content (300.91kcal- 365.23 kcal/100g). Thus this study shows that the four ethno-mycologically important macrofungi are of great nutritional value and can serve as a healthy food option.

Key words: Macrofungi, ethno-mycology, biochemical analysis, mushroom, carbohydrate, protein, fat, crude fibre, moisture.

INTRODUCTION

Macrofungi or mushrooms have always been of great interest to man and are known as an excellent source of nutrients including macronutrients and bioactive compounds (Srikram and Supapvanich, 2016). Wild edible mushrooms in particular are widely collected and eaten by various people, especially the ethnic tribes. More than 2000 species of mushrooms exist in nature but only 22 species (approx.) are cultivated intensively, for commercial purposes (Manzi *et al*., 2001).

Mycophilic people of the North Eastern region of India have been collecting wild macrofungi and also growing them in significant amount on various substrates such as wood logs, paddy straw, rice husks etc. Edible macrofungi can be a very rich source of protein which otherwise is lacking in the food obtained from plant sources. The edible mushroom is usually substituted for animal protein and it is called meat for the poor (Kinge *et al.,* 2017). Mushrooms contain significant amount of protein and low amount of fat which can be highly useful for the sufferers of diabetes, artherosclerosis, obesity and high blood pressure (Rana, 2016). Though the use of macrofungi is not much popular in India, they are used quite extensively in the Oriental region. Chinese civilization has been one of the earliest to have been using macrofungi for culinary and medicinal purposes. In addition to them the Early Greek, Egyptian, Roman and Mexican civilizations also have records of use of mushrooms. In the present day various countries such as United States, Italy, The Netherlands and Poland are some of the largest producers and consumers of macrofungi (Ma *et al.,* 2018). Although nutritional analysis of mushrooms have been carried out in different parts of the world and India, analysis of wild local mushrooms popular among the various ethnic groups of Assam have hardly been carried out. This field of study is particularly important as nutritional composition is affected by various factors such as differences among strains, substrate, climatic and edaphic conditions etc. This research work was carried out with an aim to evaluate the nutritional potential of four important wild edible mushrooms of Assam which are consumed by the

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local ethnic people of this region. These four species were selected on the basis of their uses, edibility and popularity among the various ethnic tribes in culinary and medicinal aspects.

MATERIALS AND METHODS

Sample collection and Identification

Four species of macrofungi *viz. Auricularia auricula-judae* (Bull.) J. Schröt, *Pleurotus ostreatus* (Jacq. ex Fr.) P. Kumm., *P. tuber-regium* (Rumph. ex Fr.) and *Schizophyllum commune* Fries were selected for carrying out their biochemical and mineral content analyses. The samples were collected from the fields in wild condition and properly cleaned to ensure that no dirt or soil residue was present in the sample. They were brought to the laboratory in sealed plastic bags. The samples were then surface sterilized with alcohol, cut into pieces and oven dried at 30^0- 50^0C. Proper identification of the collected samples was done on the basis of their micro-morphological and macro-morphologicalcharacters. The dried samples were powdered and stored in sealed containers for further analysis. Specimens of the macrofungi were deposited at the herbarium of Gauhati University and accession numbers were obtained for the samples *viz.Auricularia auricula-judae* (Bull.) J. Schröt (GUBH-M-104), *Pleurotus ostreatus* (Jacq.exFr.) P. Kumm (GUBH-M-152), *P. tuber-regium* (Rumph. ex Fr.) (GUBH-M-156) and *Schizophyllum commune* Fries (GUBH-M-122).

Biochemical Analysis

Proximate composition analyses of the macrofungi were carried out and their total energy content was also determined. The total carbohydrate content was determined using Anthrone method (Thimmiah, 1999) and the total protein content was determined using Bradford method (Bradford, 1976) with slight modification (The modification involved dissolving 100 mg of the powdered sample in 10ml PBS and centrifuging it for 15 minutes at 12000 rpm and taking 100µL of the supernatant from it for quantification of the protein content). The fat content of the macrofungi was determined using Soxhlet Apparatus following the procedure described by Masamba and Kazombo-Mwale (2010). The moisture content was determined by oven drying method described by Alam *et al.* (2008). The crude fibre content was determined using the method mentioned by Sadasivam and Manickam (2005) while the ash content was determined by followingthe method asdescribed by Alam *et al.* (2008) and the total energy values of the macrofungi were determined by the method described by Manzi*et al.* (2001).

Statistical Analysis

The results were expressed in terms of mean ± standard deviation. All data are presented in the form

Table 1: Proximate composition of the macrofungi (% dw)

Name of the species	Proximate Composition						Total Food Energy
	Carbohydrate content (% dw)	Protein content (% dw)	Fat content (% dw)	Moisture content (% fw)	Crude Fibre content (% dw)	Ash content (% dw)	kcal/ 100g
Auricularia auricula-judae (Bull.) J. Schröt	34.15± 0.14^d	38.90± 0.36^a	3.59± 0.83^a	71.24± 0.22^a	3.62± 0.25^c	5.61±0.52^b	325.95± 5.26^c
Pleurotus ostreatus (Jacq.exFr.) P. Kumm	47.32± 0.11^b	32.36± 0.18^c	2.27± 0.60^b	67.91± 0.80^b	5.17± 0.16^a	4.64±0.13^c	339.22± 4.90^b
Pleurotus tuber-regium (Rumph. ex Fr.)	39.07± 0.85^c	32.19± 0.55^c	1.76± 0.18^b	64.34± 0.54^c	4.28± 0.31^b	6.63±0.17^a	300.91± 4.90^d
Schizophyllum commune Fries	50.78± 0.38^a	35.14± 0.40^b	2.39± 0.52^b	56.12± 0.12^d	5.73± 0.50^a	7.01±0.13^a	365.23± 5.47^a

dw= Dry weight, fw= Fresh weight. Data presented as mean ± SD; three independent determinations at 5% level of significance. Data was analysed using Analysis of Variance (ANOVA) followed by Fisher's LSD post hoc test. Mean values in a column superscripted by same letters are not significantly different at *P*, 0.05.

Table 2: Pearson's correlation coefficient among proximate composition and Total food energy values of the ethno-mycologically important macrofungi

	Carbohydrate content	Protein content	Fat content	Moisture content	Crude Fibre content	Ash content	Total Food Energy
Carbohydrate Content	1						
Protein Content	-0.4757	1					
Fat Content	-0.4866	0.9486	1				
Moisture Content	-0.7381	0.2797	0.5031	1			
Crude Fibre Content	0.9978	-0.4684	0.5031	-0.7810	1		
Ash Content	0.1209	0.0399	-0.2779	-0.7589	0.1862	1	
Total Food energy	0.7632	0.1999	0.1779	-0.5567	0.7604	0.0769	1

Levels of significance: **P< 0.01 level (2-tailed); * P< 0.05 level (2-tailed)

of mean values of triplicate measurements (n= 3) obtained from three separate readings. Statistical analyses were performed by One-way analysis of variance (ANOVA) followed by Fisher's Least Significant Difference (LSD) test using Microsoft Office Excel 2010 to analyze the differences among mean values of different assays. Significance of the differences was measured statistically at $P < 0.05$. Pearson's Correlation Coefficient was worked out among the different parameters at $^{**}P< 0.01$ level (2-tailed); $^{*} P< 0.05$ level (2-tailed) levels of significance.

RESULTS AND DISCUSSION

The carbohydrate content, protein content, fat content, moisture content, crude fibre content, ash content and total food energy content of the samples are shown in Table 1.

A. auricula-judae was found to contain the highest quantity of protein(38.90% dw), fat (3.59% dw) and moisture content (71.24% fw) while *Schizophyllum commune* contained the highest carbohydrate (50.78% dw), crude fibre(5.73% dw) and ash content(7.01% dw), moreover *S. commune* was also found to be the richest in total energy content(365.23 kcal/100g).

Pearson's correlation coefficients among the proximate components and the total food energy of the ethno-mycologically important macrofungi are listed in Table 2.

Carbohydrate content was found tobe positively correlated with crude fibre content, ash content and total food energy content while it was negatively correlated with protein, fat and moisture content. Protein content showed positive correlation with fat content, moisture content, ash content and total food energy content while it was found to be negatively correlated with carbohydrate content and crude fibre content. Fat content was found to be positively correlated with protein content, moisture content and total food energy content and it showed negative correlation with carbohydrate content, crude fibre content and ash content. Moisture content showed positive correlation with protein content and fat content and negative correlation with crude fibre content, ash content and total food energy content. Crude fibre content was positively correlated with carbohydrate content, ash content and total food energy content and was negatively correlated with protein content, fat content and moisture content. Ash content showed positive correlation with carbohydrate content, protein content, crude fibre content and moisture content while it was negatively correlated with fat content and moisture content. Total food energy content was found to be positively correlated with all the parameters except moisture content.

The nutritional values of mushrooms are directly related to moisture and environmental conditions (Colak *et al.,* 2009a,b; Kalac, 2009; Ao and Deb, 2019) and is also affected by the composition of growth substrate, the method of cultivation, stage of harvesting and specific portion of the fruiting bodies used for analysis (Alam*et al*., 2008). In the present study, the carbohydrate content of the four experimental macrofungal species viz. *Auricularia auricula-judae* (Bull.) J. Schröt., *Pleurotus ostreatus*

(Jacq. ex Fr.) P. Kumm, *P. tuber- regium* (Rumph ex Fr.) Singer and *Schizophyllum commune* Fries was found to be between 34.15% and 50.78% which is similar to the findings of Pushpa and Purushothama (2010). The carbohydrate content of *Auricularia auricula- judae* was found to be 34.15% which shows similarity with the results obtained by Johnsy *et al.* (2011). The carbohydrate content of *Pleurotus ostreatus* was found to be 47.32% which again is similar to that reported by Johnsy *et al.* (2011) but less in comparison to the results reported by Chirinang and Intarapichet (2009). The carbohydrate content of *P. tuber regium* (39.87%) was found to be quite lower than that reported by Akindahunsi and Oyetayo (2006) while that of *S. commune* (50.78%) was found to be lower than the results reported earlier by some authors, but higher than that reported by Herawati *et al.* (2016). The protein content of the experimental macrofungi were found to be between 32.19% and 38.90% which is in agreement with the findings of various authors (Akyüz and Kirbac, 2010; Pushpa and Purushothama, 2010; Johnsy *et al.,* 2011; Ahmed *et al*., 2013). The protein content of *A.auricula-judae* was found to be 38.90% which is similar to the result obtained by Johnsy *et al.*(2011) and that of *P. ostreatus* was found to be 32.36% which is slightly lower than that reported by Johnsy *et al.* (2011) and Akyüz and Kirbac (2010) while it was comparatively higher than the results reported by Chirinang and Intarapichet (2009). *P. tuber-regium* showed a protein content of 32.19% in the present study which is higher than earlier report by Akindahunsi and Oyetayo (2006) while *S. commune* showed a protein content of 35.14% which is also higher than the results reported earlier (Herawati *et al*. 2016). Mushrooms are a very good source of protein, in fact the protein content of some mushrooms are equal to muscle protein in nutritive value. In this study the protein content of the mushrooms were found to be much higher than that of rice (7.3%), wheat (12.7%) and corn (9.4%) (Afiukwa *et al.,* 2015). The fat content of mushrooms is generally low but they contribute towards their palatability (Akata, 2012). In the present study the fat content of the experimental macrofungi were found to be between 1.76% and 3.59% which is in concordance with earlier reports (Shin *et al.,* 2007; Pushpa and Purushothama, 2010; Manjun-athanand Kaviyarasan, 2011; Woldegiorgis*et al.,* 2015). The amount of fat in mushrooms usually ranges from 0.2-0.8% of fresh weight or between 2-8% of the dry weight (Woldegiorgis *et al.,* 2015). The moisture content of the experimental macrofungi have been found to range between 56.12% and 71.24% which is slightly lower than some previously reported results (Shin *et al.,* 2007, Johnsy *et al*., 2011) but higher than the results obtained by two other authors (Akata *et al*., 2012; Akyüz and Kirbac, 2010). Mushrooms are a rich source of some novel dietary fibres that have various beneficial health effects to humans and in comparison to other conventional sources of dietary fibres such as cereals, legumes, fruits and vegetables mushrooms are underutilized (Cheung, 2013). The present study reveals the fibre content of the experimental macrofungi to be in the range between 3.62% and 5.73% which lies within the crude fibre content range obtained by earlier workers (Egwim *et al.,* 2011; Gbolagade *et al.,* 2006). Ash content of mushroom is usually 5-12% of dry matter (Kalac, 2009). In the present study the ash content of the experimental macrofungi were found to range between 4.64% and 7.01% which is in agreement with the results obtained by previous workers (Mau *et al.,* 2001). The total food energy content of the experimental macrofungi was found to be between 300.91 kcal/100g and 365.23 kcal/100g which is similar to the range reported by previous workers (Colak *et al.,* 2009b) who reported the food energy values of mushrooms to be in the range from 367.9 kcal/100 g-450.2 kcal/100 g. The energy values are similar to that of cereals (millet 341 kcal and maize 349 kcal).The present study thus reveals that the four species of ethno-mycologically important macrofungi are rich in nutrients. The carbohydrate and protein content is quite high in addition to satisfactory amount of fibre while the fat content is quite low which indicates that these four ethno-mycologially important mushrooms are a very good and cheap source of nutrients and can become a very important part of balanced diet.

ACKNOWLEDGEMENTS

The authors are grateful to Head of the Department of Botany, Gauhati University, Guwahati, Assam for providing the laboratory facilities. The first author gratefully acknowledges the financial assistance received from Department of Biotechnology (DBT), Govt. of India.

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