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Nutritional Properties of Some Edible Wild Mushrooms in Sabah

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Abstract: Ten edible wild mushrooms that were commonly consumed by the native of Sabah were identified as *Lentinellus omphallodes*, *Lentinus cilliatus*, *Pleurotus* sp1, *Pleurotus* sp2, *Schizophyllum commune*, *Hygrocybe* sp., *Volvariella* sp., *Auricularia auricula*, *Trametes* sp. The nutritive value of these wild mushrooms was determined. The protein content of the mushrooms ranged from 5-15% of dry weight, whereas most of the wild species were found to have low fat content (1-5%). Potassium is the most abundant mineral, followed by magnesium and calcium. The sodium concentration was relatively low in all wild mushrooms. However, the calcium content in *Pleurotus* sp1 is 10 times higher than the cultivated mushrooms. Overall, the trace element concentrations across all wild mushrooms were in the order Fe>Zn>Mn>Cu>Cr. The high protein and low fat characteristic of these wild mushrooms indicating the need to further determine their amino acid and fatty acid profiles.

Key word: Wild mushrooms, macronutrient and micronutrient

INTRODUCTION

The acceptance of cultivated mushrooms such as shiitake (*Lentinus edodes*), oyster mushroom (*Pleurotus ostreatus*) and button mushroom (*Agaricus bisporus)* as a delicacy were well-established worldwide. These mushrooms have been used as food and food flavouring material in soups for centuries, due to their unique and subtle flavour. They are highly appreciated for their rich aroma particularly prized for cooking throughout the world. However, wild edible mushrooms have only been traditionally eaten by a specific group of people (local people, enthusiasts and gourmets) seasonally (Diez and Alvarez, 2001).

The consumption of wild mushrooms is increasing even in the developed world due to the good nutritional value of these wild species especially as a source of proteins and trace minerals (Thimmel and Kluthe, 1998). The mineral content in edible wild mushrooms is generally higher than cultivated mushrooms and plants (Aletor, 1995; Mattilla *et al*., 2001; Rudawska and Leski, 2005). The qualities of protein are good, which is constituted mainly as essential amino acids such as leusine, methionine, tryptophan and valine. (Longvah and Deosthale, 1998; Diez and Alvarez, 2001; Agrahar-Murugkar and Suggulakshmi, 2004). Whereas, their fat fraction is mainly composed of unsaturated fatty acids (Yilmaz *et al*., 2006; Pedneault *et al*., 2006; Barros *et al*., 2007). Dietery fibre is also richly found in edible wild mushrooms and had been widely known for their functional properties (Manzi and Pizzoferrato, 2000).

Borneo Island is a high rainfall area and boasts one of the most diversified rain forests in this region. The high humidity level during the monsoon season provides ideal atmospheric conditions for growth of many wild mushrooms. Mushrooms constitute a traditionally very important vegetable relish, which is passionately enjoyed by many rural village communities in Sabah. Among the indigenous people, they know which mushrooms are fit for human consumption and which should not be touched. They also know which species are medicinally potent and which are fatally poisonous, especially through their experiences and traditional practices. Edible wild mushrooms are collected from the forest for consumption and sale in the various rural and traditional markets for cash income. These mushrooms are consumed fresh and incorporated into the local cuisine. Some of these wild species such as *Schizophyllum commune* and *Trametes* sp. are used in fresh as well as in the dry forms during off-season. They are also used by traditional healers in curing ailments such as headache and cold.

Although many studies have be done on the cultivated and wild edible mushrooms in the northern hemisphere (Aletor, 1995; Demirbas, 2000; Manzi *et al*., 2001), little information is available about the nutritional values of the wild edible tropical fungi from Sabah, east

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Malaysia. Therefore, the study aimed to examine the proximate and mineral composition of the wild mushrooms. The provision of such information would display the potential of these wild mushrooms to serve as a source of micronutrients for the indigenous people.

MATERIALS AND METHODS

Sample collection: Edible wild mushrooms were obtained from different outskirt traditional markets. The mushrooms were identified based on their morphology, habitats and spore print by the experts. They were washed thoroughly to remove mud, ferns and other extraneous material before oven dried at 45°C. The fruiting bodies were ground into fine powder and stored in tightly stoppered bottles prior to further analysis.

Chemical composition: The proximate composition was determined according to the AOAC method (1990). The protein content of the samples was estimated by the Kjeldhal method (section 954.01) and a conversion factor of 4.38 was used to quantify the nitrogen percentage of the crude protein Fat was determined by Soxhlet extraction with diethyl ether in place of petroleum ether (modified method, section 920.39). Fibre content was analyzed by the ceramic fibre filter method (section 962.09), while the ash content was determined by combusting the plant material in silica crucibles and put into a muffle furnace at 550°C for overnight (modified method, section 942.05).

Mineral determination: The samples were analyzed after wet ashing by method described in AOAC (1990). Two gram of dried and ground samples was accurately weighed into a 250ml Pyrex conical flask and 10 ml of HNO_3 were added and soaked for overnight in 3 ml of 60% $HClO_4$. Samples were heated on hot plate slowly until frothing ceases. Each flask was left to cool and the contents were filtered into a 100 mL volumetric flask through a 0.45 μm cellulose membrane filter (Whatman). In the case of magnesium and calcium, 10 mL of 5% lantahum chloride was added. The solution was then transferred into polyethylene plastic bottles, which were left at room temperature before the mineral determination.

The minerals (K, Ca, Mg, Na, Fe, Zn, Cu, Mn and Cr) were determined by flame atomic absorption spectrophotometry, except Cr, which were analyzed by graphite furnace system. Analyses were performed with a GBC Avanta atomic absorption spectrophotometer equipped with a GF3000 automated graphite system,standard air-acetylene flame and single element hollow cathode lamps.

Statistical analysis: Data obtained were evaluated statistically by Statistical Package for the Social Science (SPSS) version 14.01. Analysis of variance (ANOVA) and Tukey's mean homogeneity test were used to indicate the significant differences between the mean values ($p<0.05$). Each value was the average with standard deviation of three replicates.

RESULTS AND DISCUSSION

All the wild edible mushrooms obtained in the study are categorized as saprobic (growing on dead organic matter) in nature, except *Trametes* sp which can be both saprobic and weakly parasitic. The edible mushrooms collected in this study can be sub-divided into two groups; the first six mushrooms in Table 1 are mushrooms with pileus and stipe whereas *Schizophyllum commune*, *Galiella rufa*, *Auricularia auricular* and *Trametes* sp are mushrooms without both features. *Hybrocybe* sp can only be obtained during the monsoon season of the year unlike other non-seasonal species. *Volvariela* sp are rare, either growing on tall tree-trunk or form mycorrhizal with host tree for survival, thus valued at higher prices as compared to other wild mushrooms. *Schizophyllum commune* and *Trametes* sp are known by the locals for their medicinal properties to heal some common illness. Indeed, several antitumor compounds and anticarcinorgenic polysacharrides have been extracted for commercial purposes in Japan (Wasser, 2002).

Volvariella sp. has the highest content of ash (10.69%), followed by *Lentinellus Omphallodes* and *Hygrocybe* sp. with mean value of 7.11% and 6.56% respectively (Table 2). It is noticeable that mushrooms with pileus and stipe had higher level of ash as compared with those without. This result is agreeable with data collected from the previous study (Latiff *et al*., 1995; Alofe *et al*., 1996),

The protein level ranged from 3.77% in *Trametes* sp to 15.58% in *Volvariella* sp. This concentration is generally lower as compared to than the study by Chang and Buswell (1996), who concluded that cultivated mushrooms normally contain 19-35% protein. However, it is known that the protein contents of mushrooms are affected by a number of factors, namely the type of mushrooms, the stage of development, the part sampled and location (Flegg and Maw, 1997). A great variability can also be observed among the same species of mushrooms in the protein contents, due to the use of 4.38 as the conversion factor (Braaksma and Schaap, 1996). It is known that mushrooms contain a significant amount of non-protein nitrogen, generally in the form of chitin, thus if 6.25 were used as conversion factor, it must minus off

Table 1: Different species of wild edible fungi and their morphological characteristic used in identification

Local name	Scientific name	Function	Features
Kulat putih	*Lentinellus omphallodes*	Food	Grown on dried twigs, white funnel shape cap, most commonly found in Sabah.
Kulat bulu	*Lentinus ciliatus*	Food	Shaggy cap surface, brown in colour.
Kulat putih keras	*Pleurotus* sp.1	Food	Grown on dead log. White colour and has a nice smell.
Kulat rumpungat	*Pleurotus* sp.2	Food	Big, fleshy pileus. Brown or black in colour.
Kulat tiu	*Hygrocybe* sp	Food	Richly found in Papar forest. Fibrillose stem with adnate and decurrent gills.
Kopo Mano	*Volvariella* sp.	Food	Velvety, brownish black cap, volva at the stem base.
Kulat pokok getah	*Schizophyllum commune*	Food medicinal	Stemless, covered with grey-white felt. Appear in often crowded tiers.
Kulat mata kerbau	*Galiella Rufa*	Food	Cup shape fruiting body with thick and gelatinous inner flesh.
Kulat telinga	*Auricularia auricula*	Food	A jelly-like fungus with semi-translucent fruiting bodies; grows on wood and is rubbery in texture.
Kulat pokok	Trametes sp.	Edible medicinal	Thin, layer zone of brackets attached to the substrate, widely fan-shaped.

Table 2: Proximate composition (% dry weight) of edible wild mushrooms

Scientific name	Moisture[1]	Ash	Protein	Fat	Fibre	Carbohydrate
Lentinellus omphalodes	83.82±3.21[bcd]	7.11±0.07[b]	14.01±1.48[a]	1.50±0.50[d]	14.75±3.25[bc]	61.28±3.55[d]
Lentinus ciliatus	75.35±8.90[de]	4.74±0.54[de]	10.38±0.53[b]	2.48±0.02[cd]	17.21±4.51[abc]	63.83±4.18[cd]
Pleurotus sp.1	85.22±1.69[abcd]	6.10±0.36[bc]	6.56±0.18[cd]	3.45±0.05[bc]	13.07±1.50[bc]	69.93±1.07[bc]
Pleurotus sp.2	81.89±0.45[bcde]	4.17±0.54[def]	5.30±0.87[de]	4.43±1.10[ab]	23.50±1.32[a]	61.24±1.87[d]
Hygrocybe sp.	90.31±1.98[abc]	6.56±0.26[b]	13.35±0.12[a]	1.10±0.08[d]	14.25±0.35[BC]	63.41±0.05[d]
Volvariella sp.	91.58±1.22[ab]	10.69±0.15[a]	15.58±1.94[a]	5.60±0.36[a]	12.67±0.76[c]	54.06±1.08[e]
Schizophyllum Commune	71.87±3.12[ab]	3.10±0.07[f]	3.10±0.07[f]	1.34±0.34[d]	4.20±0.25[d]	84.48±0.50[a]
Galiella rufa	94.13±0.64[a]	3.73±0.41[ef]	10.11±0.49[b]	4.90±0.65[ab]	14.33±0.80[bc]	65.60±1.50[cd]
Auricularia auricular-judea	90.29±0.58[abc]	5.26±0.09[cd]	5.52±0.13[de]	3.50±1.00[bc]	11.67±3.51[c]	72.74±2.36[b]
Trametes	64.12±4.32[f]	4.32±0.87[de]	3.77±0.27[e]	5.00±0.50[ab]	19.08±1.77[ab]	66.55±2.41[bcd]
Lentinus edades (cultivated)	80.63±1.76[cde]	4.75±0.15[de]	8.32±0.42[bc]	1.92±0.01[d]	11.52±0.24[c]	72.53±0.71[b]

[1]Values are expressed as fresh weight basis, [2]The mean values with different letters within the same column indicate significant different ($p<0.05$)

the non-protein nitrogen (Diez and Alvarez, 2001). A constant factor of 4.38 was preferred as a conversion factor for the determination of protein content in mushrooms to reduce the influence of non-protein based nitrogen source.

The fat content of the wild mushrooms ranged from 1-5%, with the lowest found in *Hygrocybe sp.* due to it dry and fibrillose nature. The fat contents of the local wild mushrooms are agreeable with the study by Alofe *et al.* (1995) on edible wild fungi found in Nigeria with the average range of 4.9%. The low fat content of the wild species indicating that the food is suitable to be incorporated as/into a healthy and low fat diet especially for those who are on weight management program.

Table 2 shows the fibre content of *Pleurotus* sp2 was generally higher than the other wild mushrooms reported elsewhere by many authors (Aletor, 1995; Sanmee *et al.*, 2003). In addition, *Pleurotus* sp2 was found to have two times higher fibre as compared to the selected cultivated mushrooms (*Lentinus edodes*) used in the current study. Other *Pleurotus* species were also reported to be high in dietary fibre (Manzi *et al.*, 2001; Manzi *et al.*, 2004). Carbohydrate content (by subtraction) ranged from 50% to 70%, relatively higher than the ectomycorrhizal fungi reported by Sanmee *et al.* (2003).

It is obvious that Potassium (K) and Magnesium (Mg) are the main constituents in the ash content as shown in Table 3. The levels of K in all mushroom samples were found to be higher in comparison to Sodium (Na). The present findings seem to be consistent with other researches, which found the similar trend (Manzi *et al.*, 1999; Sanmee *et al.*, 2003; Agrahar-Murugkar *et al.*, 2004). These mushrooms are expected to meet the desires of hypertension and heart diseases patients as a special food for daily consumption.

Calcium was present significantly higher in the wild mushrooms analyzed especially *Trametes* sp (1,308.77 mg kg^{-1}) and *Pleurotus* sp1 (1,691.9 mg kg^{-1}) which were found 10 times higher than the calcium content in *Lentinus edodes* (141 mg kg^{-1}), the cultivated mushroom. The calcium level in wild mushrooms was higher or equivalent to some leafy greens such as Chinese cabbage, cabbage and cauliflower (Kawashima and Valente Soares, 2003; Ekholm *et al.*, 2007). Mg contents of the mushrooms in the current study ranged between 500-2000 mg kg^{-1}. A relatively higher ($p<0.05$) Mg was observed as compared to the previous published report on *Calvatia gigantean*, *Cantharellus cibarius*, *Russula integra*, *Gomphus floccosus* and *Lactarius quieticolor* in India (Agrahar-Murugkar and Subbulakshimi, 2004). *Auricularia auricular* seems to have the highest Mg (2,014 mg kg^{-1}) among the wild mushrooms analyzed, much higher ($p<0.05$) than the cultivated counterpart. Nevertheless, the mineral content in the mushrooms are mainly affected by acidic and organic matter content of their ecosystem and soil (Gast *et al.*, 1988).

The mean micro-mineral concentrations in the wild mushrooms across all fungi were in order Fe >Zn>Mn>Cu>Cr. *L. Omphallodes* has the highest content of ferum (390 mg kg^{-1}), follow by *Trametes* (251 mg kg^{-1})

Table 3: Mineral cintents (mg kg^{-1} dry weight) of edible wild mushrooms

Mushrooms	K	Na	Mg	Ca
Lentinellus omphalodes	978.35±6.72^{e}	155.57±22.18^{c}	900.83±133.45^{bcd}	435.35±60.17^{de}
Lentinus ciliatus	1019.98±0.93^{de}	153.95±19.28^{c}	1130.82±22.80^{bc}	172.73±11.60^{e}
Pleurotus sp1	1007.62±10.24^{e}	106.85±17.27^{cde}	860.83±171.63^{bcd}	1691.90±135.74^{a}
Pleurotus sp2	1026.78±17.05^{de}	59.32±15.40^{e}	514.32±51.81^{de}	811.12±83.67^{cd}
Hygrocybe sp.	985.88±24.86^{e}	521.28±24.10^{a}	995.93±190.93^{bc}	46.43±7.29^{e}
Volvariella sp	997.08±13.95^{e}	221.18±30.50^{b}	749.93±153.27^{cd}	184.33±22.46^{e}
Schizophyllum commune	1171.03±4.63^{bc}	129.75±10.60^{cd}	901.55±52.59^{bcd}	125.70±1.18^{e}
Galiella rufa	1101.42±49.16^{cd}	250.17±8.12^{b}	860.97±145.36^{bcd}	825.50±70.27^{c}
Auricularia auricula	1101.67±26.74^{cd}	135.33±11.26^{cd}	2014.33±222.35^{a}	412.85±7.29^{e}
Trametes sp.	1194.62±10.55^{b}	94.47±25.81^{de}	1202.92±217.64^{b}	1308.77±196.31^{b}
Lenitnus edodes (cultivated)	1534.12±22.44^{a}	130.45±17.84^{cd}	1320.84±245.67^{e}	140.87±8.97^{e}

Mushrooms	Fe	Zn	Mn	Cu	Cr
Lentinellus omphalodes	390.83±20.27^{a}	55.05±3.65^{abc}	31.40±4.89^{bc}	7.97±0.70^{d}	0.72±0.18^{b}
Lentinus ciliatus	130.88±28.46^{cd}	58.82±3.97^{ab}	14.92±2.67^{cd}	9.40±1.3^{d}	0.49±0.08^{b}
Pleurotus sp1	151.20±23.30^{c}	42.57±2.97^{bcd}	12.68±2.21^{d}	12.48±2.33^{d}	0.30±0.06^{b}
Pleurotus sp2	65.70±12.08^{ef}	34.12±2.50^{cd}	12.55±0.3^{d}	9.55±1.56^{d}	0.65±0.14^{b}
Hygrocybe sp.	119.03±25.79	34.83±1.17^{cd}	7.70±1.13^{d}	36.35±5.86^{c}	4.13±0.27^{a}
Volvariella sp	135.30±14.95^{cd}	55.37±6.43^{abc}	10.62±1.13^{d}	70.97±11.97^{a}	3.57±0.18^{a}
Schizophyllum commune	68.23±3.26^{ef}	61.58±6.83^{ab}	17.50±9.30^{cd}	3.75±0.21^{d}	0.57±0.03^{b}
Galiella rufa	212.53±4.74^{b}	55.25±21.29^{abc}	16.63±1.87^{cd}	12.48±1.13^{d}	3.60±0.54^{a}
Auricularia auricula	83.02±13.10^{ef}	28.28±4.97^{d}	44.77±2.67^{b}	3.45±0.2^{d}	0.75±0.15^{b}
Trametes sp.	251.77±31.29^{b}	25.55±3.73^{d}	114.40±6.62^{a}	8.55±1.21^{d}	0.83±0.05^{b}
Lenitnus edodes (cultivated)	17.24±6.67^{f}	76.61±3.47^{a}	11.76±0.98^{d}	51.65±1.25^{b}	0.41±0.06^{b}

*The means with different letters within the same column indicate a significant different ($p<0.05$)

and *G. Rufa* (218 mg kg^{-1}) (Table 3). Since the Recommended Daily Allowances of iron (FAO/WHO) for adult women and men are 35 mg, hence, eating 100 g of dried *L. omphallodes* is equivalent to the RDA requirement. According to World Health Organization (WHO, 2007), the prevalence of iron deficiency anemia in Sabah was 17-24% for children in rural areas and 33-37% for pregnant women. This indicates that iron deficiency still a major nutritional problem in the country and good nutritional advices on dietary intake based on the locally available food sources play important role in the eradication of nutrient deficiency. Most fresh and cooked lean meat contains 20-30 mg kg^{-1} of ferum (Tee *et al*., 1997). However, due to the cholesterol and portion size, human can normally consumed only 200-300g of meat per serving. Thus, *Lentinellus omphallodes* can be a substitution of meat for their iron source especially for those hardcore poor in the rural area of Sabah, where meat intake are almost impossible.

The mushrooms investigated in the current study were also quite good sources of Zn, Mn and Cu as compared to the cultivated mushroom. Zinc concentrations ranged from 25.5 mg kg^{-1} in *Trametes* to 61.58 mg kg^{-1} in *S. commune*, which was in paralleled with the results reported previously elsewhere (Mattila *et al*., 2001; Longvah and Deosthale, 1998). The highest Mn content was found in *Trametes* sp (114.4 mg kg^{-1}), while *Volvariella* sp. has the highest Cu content. (70.97 mg kg^{-1}). The findings of the current study are in agreement with those of Işıloğlu *et al*. (2001) on *Volvariella speciosa* found in Turkey. The extreme difference between Mn, ranged from 7.7 to 114.4 mg kg^{-1} is not rare as it was also previously reported by Mendil *et al*. (2005) on various wild mushrooms collected from the forest of Turkey, which ranged from 21.2 to 103 mg kg^{-1}.

Hygrocybe (4.13 mg kg^{-1}), *Volvariella* (3.57 mg kg^{-1}) and *Galiella rufa* (3.60 mg kg^{-1}) were relatively high in Cr contents compared to the cultivated species (0.41 mg kg^{-1}). Chromium contents of mushroom samples have been reported in the range of 0.34-1.05 mg kg^{-1} (Soylak *et al*., 2005) and 1.1-4.4 mg kg^{-1} (Mendil *et al*., 2005). Nevertheless, the concentrations of the elements in fruiting bodies of mushrooms are generally species-dependent. Substrate composition is also an important factor besides the great differences exist in uptake of individual trace elements by the fruiting body of mushrooms (Nikkarinen and Mertanen, 2004; Kalac and Svoboda, 2000).

CONCLUSION

The edible wild mushrooms found in Sabah are of high nutritional quality, comparable to the commercially cultivated mushroom in particular their protein, fibre and mineral contents. Therefore, further study on the amino acids and anti-nutritional factors should be carried out to establish a complete nutritional database on these unique species, which could be used in the nutrition intervention program.

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