NUTRITIONAL COMPOSITION OF SOME EDIBLE WILD MUSHROOMS

SOON JAN MEI

A THESIS SUBMITTED TO THE SCHOOL OF FOOD SCIENCE AND NUTRITION IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF BACHELOR OF FOOD SCIENCE WITH HONOURS IN FOOD SCIENCE AND NUTRITION

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28 FEBRUARY 2005

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SOON JAN MEI
FEBRUARY 2005
KOMPOSISI PEMAKANAN BEBERAPA CENDAWAN LIAR YANG BOLEH DIMAKAN

Kajian ini bertujuan menentukan komposisi pemakanan beberapa cendawan liar di Sabah seperti Amauroderma perplexum, Coltricia cinnamonomea, Ganoderma applanatum, Pleurotus sp. 1 (kulat bulu), Pleurotus sp. 2 (kulat putih) dan kulat tanaman, Lentinus edodes. Penentuan komposisi proksimat termasuk kandungan air, abu, lemak kasar, serabut kasar, protein kasar dan kandungan karbohidrat. Analisis zat mineral dijalankan untuk mineral makro seperti natrium, potasium, kalsium dan magnesium. Mineral mikro termasuklah zat besi, kuprum, zink dan mangan. Penentuan dilakukan dengan menggunakan alat spektrofotometer serapan atom. Vitamin larut-air seperti thiamin dan vitamin C cendawan-cendawan liar tersebut juga dijalankan. Selain itu, jumlah kandungan fenolik, yang menggunakan unit mg gallic acid equivalent/g cendawan yang kering diekstrak dengan menggunakan tiga jenis pelarut iaitu metanol, etanol dan etil acetat. Penyaringan aktiviti antioksidan cendawan-cendawan liar yang boleh dimakan diukur dengan menjalankan ujian aktiviti antioksidan terhadap radikal 2,2-diphenyl-1-picrylhydrazil dan keupayaan menghalangi perangkaan pada β-karoten. Kulat putih menyumbang sebagai salah satu kulat liar yang memberi nilai tenaga yang tertinggi. Kulat putih adalah yang paling tinggi secara signifikan (p <0.05) dalam kandungan karbohidrat berbanding cendawan-cendawan liar yang lain. Potasium merupakan zat mineral yang paling tinggi di antara kesemua cendawan liar tersebut, manakala kandungan natrium merupakan yang terendah. Kulat putih didapati mengandungi kandungan potasium yang tertinggi pada 1467.92 ± 98.90 mg/100g. Di samping itu, kandungan zat muti dan kuprum yang masing-masing merupakan zat mineral mikro yang paling tinggi dan terendah dalam kulat liar. Kulat bulu adalah paling kaya dengan zat besi dengan kandungan min 4146.91 ± 853.02 mg/kg. Kandungan kuprum adalah dari julat di bawah tahap pengesan dilakukan untuk kedua-dua A. perplexum dan Pleurotus sp. 2 ke 157.45 ± 34.20 mg kuprum /kg pada Pleurotus sp. 1. Kandungan thiamin adalah dari 0.06-1.46 mg/g dan vitamin C pula dari 0.09-2.22 mg/g. Jumlah kandungan fenolik kulat-kulat liar yang diekstrak dengan menggunakan pelarut metanol berada dalam lingkungan 0.04-0.18 mg GAEs/g kulat yang kering. Manakala kedua-dua ekstrak etanol dan etil acetat mengandungi 0.09-0.22 mg GAE/g kulat yang kering dan 0.02-0.21 mg GAE/g kulat yang kering. Kulat putih menunjukkan aktiviti antioksidan yang terbaik memandangkan ia berupaya mengatasi radikal bebas 2,2-difenil-1-pikrylhidrazil dan menghalangi penyadaran pada β-karoten secara berkesan. Kajian ini menunjukkan beberapa spesies cendawan liar Sabah yang mempunyai potensi khasiat yang tinggi dan bernilai. Maka usaha yang giat boleh dilakukan untuk melanjutkan kajian dalam cendawan-cendawan liar di Sabah.
The objectives of this study were to determine the nutritional value of some edible wild mushrooms of Sabah such as Amauroderma perplexum, Coltricia cinnamomea, Ganoderma applanatum, Pleurotus sp. 1 (kulat bulu), Pleurotus sp. 2 (kulat putih) and cultivated mushroom, Lentinus edodes. The determination of the proximate composition includes moisture, ash, crude fat, crude fiber, crude protein, and carbohydrate contents. Minerals analysis were carried out for macrominerals such as sodium, potassium, calcium and magnesium contents while the trace elements like ferum, copper, zinc and manganese were analysed as well using atomic absorption spectrophotometer. Water-soluble vitamins such as thiamine and vitamin C content of the edible wild mushrooms were measured as well. In addition, the total phenolic contents, expressed as mg gallic acid equivalent/g of dry mushroom were extracted using three solvents which includes methanol, ethanol and ethyl acetate. Screening of the antioxidative activity across the edible wild mushrooms were carried out using the scavenging effects against 2,2-diphenyl-1-picrylhydrazyl radicals method and the β-carotene bleaching method. Kulat putih contributes as one of the highest source of energy compared to the rest of the edible wild mushrooms. In fact, kulat putih was significantly (p <0.05) higher in carbohydrates content compared to the rest of the mushrooms. Potassium were the most abundant mineral among the mushrooms while sodium content ranked the lowest among the mushrooms. In addition, kulat putih was found out to be the richest source of potassium with a concentration of 1467.92 ± 98.90 mg potassium/100g. Meanwhile, both the ferum and copper content of the edible wild mushrooms were determined as the most abundant and the least trace mineral among the mushrooms respectively. Kulat bulu was the richest source of ferum with an average amount of 4146.91 ± 853.02 mg/kg. Copper ranged from below detection limits for both A. perplexum and Pleurotus sp. 2 to 157.45 ± 34.20 mg copper/kg in Pleurotus sp. 1. Thiamine ranged from 0.06–1.46 mg/g while vitamin C were from 0.09-2.22 mg/g in the local mushrooms. The total phenolic contents of these mushrooms ranged from 0.04-0.18 mg gallic acid equivalent/g of dry mushroom in the methanolic mushroom extracts. While both the ethanolic and ethyl acetate extracts contained 0.09-0.21 mg GAEs/g and 0.02-0.22 mg GAEs/g of dry mushroom. Kulat putih exhibited the best antioxidative activity since it was able to scavenge the most DPPH radical and inhibits the bleaching rate of the β-carotene effectively. This research revealed that some of the edible wild mushrooms in Sabah had nutritional potential value and intense efforts could be geared towards further investigation.
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<thead>
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<td>%</td>
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<td>β</td>
<td>beta</td>
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<td>AA</td>
<td>antioxidant activity</td>
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<td>AA</td>
<td>Ascorbic acid</td>
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<td>Ca</td>
<td>Calcium</td>
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<tr>
<td>Cu</td>
<td>Copper</td>
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<td>DHAA</td>
<td>Dehydoascorbic acid</td>
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<tr>
<td>DPPH</td>
<td>2,2-diphenyl-1-picrylhydrazyl</td>
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<tr>
<td>Fe</td>
<td>Ferum</td>
</tr>
<tr>
<td>GAE</td>
<td>Gallic Acid Equivalent</td>
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<td>K</td>
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<td>NPN</td>
<td>Nonprotein nitrogen</td>
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<td>TBHQ</td>
<td>Tert-butylated-hydroxyquinone</td>
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<td>Zn</td>
<td>Zinc</td>
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<tr>
<td>M</td>
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<td>Mg</td>
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<td>Nm</td>
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<td>&gt;</td>
<td>larger quantity</td>
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<tr>
<td>μg</td>
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<td>microlitre</td>
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CHAPTER 1

INTRODUCTION

1.1 Introduction

The study of mushrooms and fungi generally, are known as mycology where the term was derived from the Greek word *mykes*, which means fungus. The Fungi were actually regarded as members of the Plant Kingdom but are now recognized as a very distinct and separate group of organisms. Fungi are eukaryotes which have a well defined membrane-bond nuclei with a number of definite chromosomes and therefore, are clearly distinguishable from bacteria. They are heterotrophic, and hence requires organic carbon compounds of varying degrees of complexity. This characteristic distinguishes them from plants which manufacture their own organic food by photosynthesis (Philips, 1994; Miles & Chang, 1997).

Most of the fungi have well-defined cell walls through which all their nutrients must pass in a soluble form and, from this point, they differ from animal cells which lack defined cell walls. Since fungi are separated from plants and form a kingdom itself, it includes three phyla, namely, *Ascomycota* (cup fungi), *Basidiomycota* (mushrooms) and *Zygomycota* (Pin-moulds) (Pegler, 1997). Most fungi exist as microscopic filaments or hyphae which extend the tip, branching to form a complex mycelium. When mycelial networks increase in size, they become visually apparent,
CHAPTER 2

LITERATURE REVIEW

2.1 Mushrooms

Mankind has always savoured the desirable flavours of mushrooms and recognized its medicinal and tonic properties. Mushrooms were regarded by the early civilizations of Egypt and Rome as a special delicacy and were even perceived by the Romans as “Food of the Gods” because they thought that mushrooms were resulted from the lightning thrown to earth by Jupiter during storms (Buswell & Chang, 1993; Manzi et al., 1999). The medicinal properties of mushrooms had long been appreciated by the Chinese in which the scientific bases are only just beginning to understand. It was recorded that Chinese emperors consumed Lentinus edodes in large quantities for longevity while the ancient Japanese valued the mushroom for its aphrodisiac properties (Buswell & Chang, 1993).

Edible mushrooms can be saprophytes, symbiotes and parasites of different plants and soil as long as organic matter is available for growth (Manzi et al., 1999). The majority of wild edible mushrooms are symbiotic and form mycorrhizas with trees. Saprotrophic edible mushrooms are also collected from the wild but usually are used in its cultivated forms (Prance, 1984). These mushrooms secrete enzymes for digestion and obtain their nourishment from organic matter (Manzi et al., 1999). Termitomyces are also important wild edible mushrooms and grows in association
and began to form larger structures or fruit bodies known colloquially as mushrooms (Spoerke, 2001).

For thousand of years, mushrooms have been a part of the normal human diet (Mattila et al., 2001). Through trial and error, humans have learned to avoid poisonous mushrooms and identified the edible ones. Only about 10% of the approximately 100,000 known species in the world, are thought to be edible (Mattila et al., 2000). There are fewer than 25 mushroom species which are widely used as foods and even fewer are considered as items of commerce (Chang & Buswell, 1996). About 2000 species from more than 30 genera are regarded as edible mushrooms but only 80 of them are grown experimentally, 40 cultivated economically and around 22 species cultivated commercially. There are only 5-6 species which are produced on an industrial scale (Chang, 1999). The world’s most widely cultivated mushroom is the button mushroom, *Agaricus bisporus* which takes up 56% of the total world mushrooms production, while the next most important species is the shiitake mushroom (*Lentinus edodes*) accounts for 14% (Breene, 1990). The paddy straw mushrooms (*Volvariella* spp.), oyster mushroom (*Pleurotus* spp.) and Enoki-take mushroom (*Flammulina velutipes*) are cultivated world wide too (Pegler, 1997).

Truffles and mushrooms are healthy foods which are low in calories and fat but rich in vegetable proteins. Their protein content is higher than that of most vegetables and their amino acids content are comparable to that of animal proteins (Danell & Eaker, 1992). Traditionally, mushrooms had been associated with meat and sometimes are even regarded as a meat substitute (Trinci, 1992). The proteins of most mushrooms contain all the essential amino acids and are rich in lysine and
leucine which tends to be lacking in most staple food (Chang, 1980). According to Bano & Rajarathnam (1988), the *Pleurotus* species were even considered as high grade protein vegetables.

Edible mushrooms, besides being highly nutritious, they have important medicinal attributes and contains hypolipidemic activities (Chang & Buswell, 1996). Besides, mushrooms are the only non-animal based food containing vitamin D. Thus, they are the only natural source of vitamin D for vegetarians (Murcia et al., 2002). The intake of vitamin D from food is especially important in the northern or southern latitudes. Some population groups especially vegetarians are at risk of receiving insufficient levels of this vitamin from their diet. Vitamin D deficiency is linked to rickets and osteomalacia while milder insufficiency can lead to osteoporosis (Mattila et al., 2002).

Mushrooms were found to be good sources of thiamine, riboflavin, niacin, biotin, folates and ascorbic acid although different species vary considerably for specific vitamins (Chang & Buswell, 1993; Bano & Rajarathnam, 1988). Mushrooms are also a good source of minerals which are taken up from the substrate by the growing mycelium (Chang & Buswell, 1993). Some common edible mushrooms which are widely consumed in Asian culture were found to possess antioxidant activities (Cheung, Cheung & Ooi, 2003). Antioxidants which are present in human diets are possible to act as protective agents against free radical damages (Mau, Lin & Song, 2002).

Wild edible mushrooms have been traditionally eaten by specific group of people seasonally and are becoming more important for their nutritional, organoleptic
and pharmacological characteristics (Diez & Alvarez, 2001). Wild growing macrofungi have always been a favourite delicacy in many countries. Some people collect macrofungi to make a substantial contribution to food intake. Therefore, it is necessary to know the levels of toxic and essential elements in the edible wild mushrooms (Mustafa, Yilmaz & Merdivan, 2001). Scientific information of these wild and edible mushrooms that are scarely used but only utilized as a herbal remedy by the indigenous folks here are interesting and beneficial to find new sources of functional foods. Therefore, the aim of this study was to determine the nutritional composition of some edible wild mushrooms.

The objectives of this study were:

1) To determine the macronutrients of various edible wild mushrooms found in Sabah.

2) To determine the minerals and vitamins (thiamine and vitamin C) contents of the edible wild mushrooms.

3) To determine the phenolic contents and screening of the antioxidative activity of the edible wild mushrooms.
with termites and their nests. They are dependent on organic matter brought by the insects from their feeding (Pegler & Vanhaecke, 1994). The growth compost can influence the chemical composition and therefore, the nutritional value of the mushrooms (Tshinyangu, 1996).

2.1.1 Mushrooms and historical uses
Throughout history, many cultures have built-up a practical knowledge of which mushrooms were suitable to eat and those that were poisonous. Many cultures, especially in the Orient, identified that certain mushrooms could have profound health promoting benefits (Hobbs, 1995). However, there does exist an insidious fear of mushroom poisoning in many cultures which can even approach phobic levels. Such profound mycophobic reactions are evident in the United Kingdom, Ireland and much of North America while, in sharp contrast, fungus-loving societies can be witnessed throughout Asia, much of Europe and Russia where wild mushrooms are extensively collected or purchased for food. Catholic countries, in general, are more myophilic and it has been suggested that this may have arisen because they are not allowed to eat meat on Fridays and mushrooms could be a good alternative (Samorini, 2001).

Besides that, in some societies where gourmet mushrooms were regularly consumed at feasts and banquets, it was relatively easy to add in a few poisonous mushrooms e.g. Amanita phalloides with dire consequences. It was strongly believed that Claudius II and Pope Clement VII to have died in this way. Symptoms and death normally came many hours later which allowed the perpetrator to have ample time before the onset of the symptoms (Samorini, 2001). Another fascinating aspect of ancient mushroom usage is related to the psycho-active, hallucinogenic properties of
some mushrooms (Arora, 1985). It was demonstrated that the extensive past use of psycho-active hallucinogenic mushrooms like *Psilocybe* spp. and *Panaeolus* spp. in Meso America and *Amanita muscaria* in Northern Europe/Siberia and in the Sahara region dating back to Paleolithic times, strongly implies that the use of powerful hallucinogenic mushrooms were in primitive forms of religion purposes (Wasson, 1978).

### 2.1.2 Commercially Cultivated Mushrooms

Throughout the world, around 22 types of mushrooms are cultivated commercially with 6 species being grown on an industrial scale. The 6 species includes *Agaricus bisporus*, *Agaricus bisporus*, *Flammulina velutipes*, *Lentinus edodes*, *Pleurotus ostreatus* and *Volvariella volvacea* (Pegler, 1997). The Oriental countries; China, Japan and Korea are the main countries that grow and consume mushrooms on a huge basis. On the other hand, the western countries produced more mushrooms like *Lentinus edodes* and *Pleurotus* spp. since the 1990s (Chang, 1991).

The data in Table 2.1 is the total amount of world production of cultivated mushrooms from 1986 to 2001. It was reported that production keeps ascending from 1986 at 2,183,000 tonnes to 2001 with a total amount of 7,500,000 tonnes (Chang & Miles, 1991; Chang, 1999). Even though the production of *Agaricus bisporus* shown in Table 2.1, were slowing down, but it still reigns ahead of *L. edodes* and *Pleurotus* spp. Furthermore, the other commercially cultivated mushrooms in the world are also shown in Table 2.2. There are a total of 17 species in Table 2.2 excluding the 6 main species aforementioned.
Table 2.1: World production of cultivated mushrooms from 1986-2001

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>World production</td>
<td>2,183</td>
<td>3,763</td>
<td>4,909</td>
<td>6,202</td>
<td>7,500</td>
</tr>
<tr>
<td>(tonnes)</td>
<td>000</td>
<td>000</td>
<td>000</td>
<td>000</td>
<td>000</td>
</tr>
<tr>
<td>Value (US$ billion)</td>
<td>NA</td>
<td>7.50</td>
<td>16.00</td>
<td>NA</td>
<td>22.50</td>
</tr>
<tr>
<td>A. bisporus (%)</td>
<td>56.00</td>
<td>38.00</td>
<td>38.00</td>
<td>32.00</td>
<td>NA</td>
</tr>
<tr>
<td>L. edodes (%)</td>
<td>14.00</td>
<td>10.00</td>
<td>17.00</td>
<td>25.00</td>
<td>NA</td>
</tr>
<tr>
<td>Pleurotus spp. (%)</td>
<td>8.00</td>
<td>24.00</td>
<td>16.00</td>
<td>14.00</td>
<td>NA</td>
</tr>
</tbody>
</table>

NA: Not Available

*:2001 figures based on estimates of 5% annual increase in volume and 5% increase in value in 1994 prices.

Source: Chang & Miles, (1991); Chang, (1999)

Table 2.2: Species of other commercially cultivated mushrooms

<table>
<thead>
<tr>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auricularia auricula (ear fungus)</td>
</tr>
<tr>
<td>Auricularia polytricha</td>
</tr>
<tr>
<td>Auricularia fuscussuccinea</td>
</tr>
<tr>
<td>Dictyophora indusiata</td>
</tr>
<tr>
<td>Dictyophora duplicata</td>
</tr>
<tr>
<td>Gloeostereum incarnatum</td>
</tr>
<tr>
<td>Grifola frondosa (maitake)</td>
</tr>
<tr>
<td>Hericium erinaceus (lion’s mane)</td>
</tr>
<tr>
<td>Hypospygus marmoreus</td>
</tr>
<tr>
<td>Lyophyllum ulmarium</td>
</tr>
<tr>
<td>Pholiota nameko (enokitake)</td>
</tr>
<tr>
<td>Pleurotus sajor-caju</td>
</tr>
<tr>
<td>Pleurotus cystidiosus</td>
</tr>
<tr>
<td>Pleurotus cornucopiae</td>
</tr>
<tr>
<td>Pleurotus florida</td>
</tr>
<tr>
<td>Stropharia rugoso-annulata</td>
</tr>
<tr>
<td>Tremella fuciformis (white-jelly leaf)</td>
</tr>
</tbody>
</table>

Adapted from Buswell & Chang, 1999

2.1.3 Edible wild mushrooms

Edible wild mushrooms provide two main benefits to people, acting as a source of food and secondly, generates income (Reshetnikov, Wasser & Tan, 2001). The local names of edible fungi were named based on shape, taste and other properties that are distinctive or important to the local people. The edible fungus (*Auricularia auricula-judae*) have a similar name in Chinese which was *Mu-er* (ear of wood). This help to identify where they grew and could be collected. However, mycologists sometimes were wary of local classification because they were based on scientifically unreliable characteristics (Härkönen, 2002). But according to Alexiades (1996), local names provide important clues to researches to learn about collecting practices and to analyse markets. The importance of wild edible fungi to people in developing
REFERENCES


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