NUTRITIONAL COMPOSITION OF SOME EDIBLE WILD MUSHROOMS

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ABSTRAK

KOMPOSISI PEMAKANAN BEBERAPA CENDAWAN LIAR YANG BOLEH DIMAKAN

Kajian ini bertujuan menentukan komposisi pemakanan beberapa cendawan liar di Sabah seperti Amauroderma perplexum, Coltricia cinnamomea, 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, potassium, 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 antioksida cendawan-cendawan liar yang boleh dimakan diukur dengan menjalankan ujian aktiviti antioksida terhadap radikal 2,2-diphenyl-1-picrylhydrazyl dan keupayaan menghalang penyahwarnaan pada β-karoten. Kulat putih menyumbang sebagai salah satu kulat liar yang memberi nilai tenaga yang tertinggi. Kulat putih adalah lebih tinggi secara signifikan ($p < 0.05$) dalam kandungan karbohidrat berbanding cendawan-cendawan liar yang lain. Potassium merupakan zat mineral yang paling tinggi di antara kesemua cendawan liar tersebut, manakala kandungan natrium merupakan yang terendah. Kulat putih didapati mengandungi kandungan potassium yang tertinggi pada 1467.92 $\pm$ 98.90 mg/100g. Di samping itu, kandungan zat besi dan kuprum masing-masing merupakan zat mineral mikro yang tertinggi dan terendah dalam kulat liar. Kulat bulu adalah paling kaya dengan zat besi dengan kandungan min 4146.91 $\pm$ 853.02 mg/kg. Kandungan kuprum adalah dari julat di bawah tahap pengesanan mesin untu kedua-dua *A. perplexum* dan *Pleurotus* sp. 2 ke 157.45 $\pm$ 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 antioksida yang terbaik memandangkan ia berupaya mengatasi radikal bebas 2,2-difenil-1-pikryhidrazil dan menghalang pennyahwarnaan 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.

ABSTRACT

NUTRITIONAL COMPOSITION OF SOME EDIBLE WILD MUSHROOMS

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 $\pm$ 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 $\pm$ 853.02 mg/kg. Copper ranged from below detection limits for both A. perplexum and Pleurotus sp. 2 to 157.45 $\pm$ 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.

SYMBOLS/ABBREVIATIONS LIST

%	percentage
α	alpha
β	beta
AA	antioxidant activity
AA	Ascorbic acid
Ca	Calcium
Cu	Copper
DHAA	Dehydoascorbic acid
DPPH	2,2-diphenyl-1-picrylhydrazyl
Fe	Ferum
GAE	Gallic Acid Equivalent
K	Potassium
Mg	Magnesium
Mn	Manganese
Na	Sodium
NPN	Nonprotein nitrogen
TBHQ	Tert-butylated-hydrozyquinone
Zn	Zinc
M	million
Mg	miligram
Nm	nanometer
>	larger quantity
µg	microgram
µl	microlitre

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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 ot 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 biforquis*, *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

Item	Year				
	1986	**1990**	**1994**	**1997**	**2001***
World production (tonnes)	2,183 000	3,763 000	4,909 000	6,202 000	7,500 000
Value (US$ billion)	NA	7.50	16.00	NA	22.50
A. bisporus (%)	56.00	38.00	38.00	32.00	NA
L. edodes (%)	14.00	10.00	17.00	25.00	NA
Pleurotus spp. (%)	8.00	24.00	16.00	14.00	NA

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

*Auricularia auricula (*ear fungus)	*Lyophyllum ulmarium*
Auricularia polytricha	*Pholiota nameko* (enokitake)
Auricularia fuscosuccinea	*Pleurotus sajor-caju*
Dictyophora indusiata	*Pleurotus cystidiosus*
Dictyophora duplicata	*Pleurotus cornucopiae*
Gloeostereum incarnatum	*Pleurotus florida*
Grifola frondosa (maitake)	*Stropharia rugoso-annulata*
Hericium erinaceus (lion's mane)	*Tremella fuciformis* (white-jelly leaf)
Hypsizygus marmoreus	

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

Abdalla, A. E. & Roozen, J. P. 1999. Effect of plant extracts on the oxidative stability of sunflower oil and emulsion. *Food Chem.* **64**: 323-329.

Agrahar-Murugkar, D. & Subbulakshmi, G. 2005. Nutritional value of edible wild mushrooms collected from the Khasi hills of Meghalaya. *Food Chem.* **50**: 114-120.

Ahmed Ashour Ahmed, Mostafa A. Mohamed & Hami, M. A. 1981. Libyan truffles *Terfeiza boudieri* Chatin: Chemical composition and toxicity. *J. Food Sci.* **46**: 927-929.

Akindaunsi, A. A. & Oboh, G. 1999. Effect of some post-harvested treatments on the bioavailability of zinc of some vegetables. *Rivista Italiana delle Sostanze-Grasse.* **76**: 285–287.

Aletor, V.A., 1995. Compositional studies on edible tropical species of mushrooms. *Food Chem.* **54**: 265–268.

Alexiadas, M. N. (ed.). 1996. *Selected guidelines for ethnobotanical research: a field manual.* New York: New York Botanical Garden.

Alexopoulos, C. J., Mims, C. W. & Blackwell, M. 1996. *Introductory Mycology.* New York: John Wiley.

Allen, L. 1998. Calcium. Sadler, M. J., Strain, J. J. & Caballero, B. (eds.). *Encyclopedia of Human Nutrition.* Vol. **1**. London: Academic Press.

Alofe, F. V., Odeyemi, O. & Oke, O. L. 1996. Three edible wild mushroom from Nigeria: Their proximate and mineral composition. *Plant Foods Human Nutr.* **49**: 63-75.

Alonso, J., Garcia, M. A., Pérez-López, M. & Melgar, M. J. 2003. The concentrations and bioconcentration of copper and zinc in edible mushrooms. *Arch. Environ. Contam. Toxicol.* **44**: 180-188.

Amin, I., Zamaliah, W. M. & Chin, W. F. 2004. Total antioxidant and phenolic content in selected vegetables. *Food Chem.* **87**: 581-586.

Anderson, J. W., Smith, B. M. & Gustafson, N. J. 1994. Health benefits and practical aspects of high-fiber diets. *J. Am. Diet. Assoc.* **97**: 1157-1159.

Antanasopoulos, N. *Flame Methods Manual for Atomic Absorption.* 1995. Australia: GBC Scientific Equipment Pty. Ltd.

Antolovich, M., Prenxler, P., Robards, K. & Ryan, D. 2000. Sample preparation in the determination of phenolic compounds in fruits. *Analyst.* **125**: 989-1009.

AOAC. 1990. *Official Methods of Analysis of the Association of Official Analytical Chemists*. 15th edition. Washington: AOAC.

AOAC. 2002. *Official Methods of Analysis of the Association of Official Analytical Chemists*. 15th edition. Washington: AOAC.

Arella, F., Lahély, S., Bourguignon, J. B. and Hasselmann, C. 1996. Liquid chromatographic determination of vitamins B_1 and B_2 in foods. A collaborative study. *Food Chem.* **56**: 81-86.

Arora, D. 1985. *Mushrooms demystified*. Berkeley: Ten Speed Press.

Azizah, H., Nik Ruslawati, N. M. & Tee, S. T. 1999. Extraction and characterization of antioxidant from cocoa by-products. *Food Chem.* **64**: 199–202.

Baigen, M. & Leong, S. A. 1994. *Metal Ions in Fungi*. Winkelmann, G. & Winge, D. R. (eds.). New York: Marcel Dekker, Inc.

Bano, Z. & Rajarathnam, S. 1988. *Pleurotus mushroom as a nutritious food*. Hong Kong: China University Press.

Banuelos, G. S. & Meeks, D. W. 1990. Accumulation of selenium in plants grown on selenium-treated soil. *J. Environ. Qual.* **19**: 772-777.

Bates, C. J., Prentice, A. M. & Paul, A. A. 1994. Seasonal variations in vitamins A, C, riboflavin and folate intakes and status of pregnant of lactating women in a rural Gambian community: some possible implications. *Eur. J. Clin. Nutr.* **48**: 660-668.

Bellisle, F. Diplock, A. T., Hornstra, G., Koletzko, B., Roberfroid, M., Salminen, S. & Saris, W. H. M. 1998. Scientific concepts of functional foods in Europe consesus document. *Br. J. Nutr.* **80**(1): S1-S193.

Bonilla, F., Mayen, M., Merida, J. & Medina, M. 1999. Extraction of phenolic compounds from red grape marc for use as food lipid antioxidants. *Food Chem.* **66**: 209-215.

Botterweck, A. A. M., Verhagen, H., Goldbohm, R. A., Kleinjans, J. & Brandt, P. A. V. D., 2000. Intake of butylated hydroxyanisole and butylated hydroxytoluene and stomach cancer risk: results from analyses in the Netherlands cohort study. *Food Chem. Toxicol.* **38**: 599–605.

Bowman, B. J., Borgeson, C. E. & Bowman, E. J. 1987. Composition of *Neurospora crassa* vacuolar membranes and comparison to endoplasmic reticulum, plasmalemmas and mitochondrial membranes. *Experimental Mycol.* **11**: 197-205.

Bondet, V., Brand-Williams, W. & Berset, C. 1997. Kinetics and mechanisms of antioxidant using the DPPH free radical method. *Lebensm. Wiss. Technol.* **30**: 609-615.

Boyle, D. 1998. Nutritional factors limiting the growth of Lentinus edodes and other white-rot fungi in wood. *Soil Biol Biochem.* **30**(6): 817-823.

Braaksma, A. & Schaap, D. J. 1996. Protein analysis of the common mushroom *Agaricus bisporus*. *Postharvest Bio. Technol.* **7**: 119-127.

Bravo, L. 1998. Polyphenols chemistry, dietary sources, metabolism and nutrition significance. *Nutr. Rev.* **56**: 217-333.

Breene, W. M. 1990. Nutritional and medicinal value of specialty mushrooms. *J. Food Prot.* **53**: 883-894.

Brody, T. 1991. *Nutritional biochemistry*. Boston: Academic Press.

Bronner, F. 1997. Calcium. O' Dell, B. C. & Surde, R. A. (eds.). *Handbook of nutritionally essential mineral elements*. New York: Marcel Dekker.

Brune, M., Rossander, L. & Hallberg, L. 1989a. Iron absorption: Intestinal adaptation to a high phytate diet. *Am. J. Clin. Nutr.* **49**: 542-545.

Brune, M., Rossander, L. & Hallberg, L. 1989b. Iron absorption and phenolic compounds: importances of different phenolic structures. *Eur. J. Clin. Nutr.* **43**: 547.

Bruneton, J. 1999. *Pharmacognosy and Phytochemistry of Medicinal Plants*. Paris: Lavoisier Publishing.

Burkhill, I.H. 1935. *A dictionary of the economics products of the Malay Peninsula*. London: Crown Agents for the Colonies.

Buswell, J. A. & Chang, S. T. 1993. *Edible Mushrooms: Attributes and Applications in Genetic and Breeding of edible mushroom*. Washington: Gordon & Breach Science Publishers.

Butler, L. G. 1989. Effects of condensed tannin on animal nutrition. Hemingway, R. W. & Karchesy, J. J. (eds.). *Chemistry and Significance of Condensed Tannins*. New York: Plenum Press.

Cai, Y., Luo, Q., Sun, M. & Corke, H. 2004. Antioxidant and phenolic compounds of 112 traditional Chinese medicinal plants associated with anticancer. *Life Sciences*. **74**(17): 2167-2184.

Camarero, S., Bockle, B., Martinez, M. J. & Martinez, A. T. 1996. Manganese mediated lignin degradation by *Pleurotus pulmonaris*. *Applied Environ. Microbiol.* **62**: 1000-1072.

Campbell, N. A. & Reece, J. B. 2002. *Biology*. 6th ed. San Francisco: Pearson Education.

Cataldo, C. B., DeBruyne, L. K. & Whitney, E. N. 1999. *Nutrition and Diet Therapy*. New York: Wadsworth Publishing

Chang, R. 1996. Functional properties of edible mushrooms. *Nutr. Rev.* **54**(1): 91-93.

Chang, S. T. & Buswell, J. A. 1996. Mushrooms Nutriceuticals. *World J. Microbiol. Biotechnol.* **12**: 473-476.

Chang, S. T. 1980. Mushrooms as human food. *Bioscience.* **30**: 399-401.

Chang, S. T. 1990. Mushroom as food. *Food Laboratory News.* **21**: 7-8.

Chang, S. T. 1991. Mushroom biology and mushroom production. *Mushroom J. Tropics.* **11**: 45-52.

Chang, S. T. 1999. Global impact of edible and medicinal mushrooms on human welfare in the 21st century: non-green revolution. *Int. J. Med. Mushroom.* **1**: 1-8.

Chang, S. T. & Miles, P. G. 1984. A new look and cultivated mushrooms. *Biosci.* **34**: 358-362.

Chang, S. T. & Miles, P. G. 1991. Recent trends in world production of cultivated edible mushrooms. *Mushroom Journal.* **504**: 15-18.

Cheung, C. K. 1996. Dietary fiber content and composition of some cultivated edible mushroom fruiting bodies and mycelia. *J. Agric. Food Chem.* **44**: 468-471.

Cheung, C. K. 1997. Dietary fibre content and composition of some edible fungi determined by two methods of analysis. *J. Agric. Food Chem.* **73**: 255-260.

Cheung, L. M., Cheung, Peter, C. K. & Ooi, Vincent, E. C. 2003. Antioxidant activity and total phenolics of edible mushroom extracts. *Food Chem.* **81**: 249-255.

Cheung, P. C. K. 1996. The hypocholesterolemic effect of two edible mushrooms: *Auricularia auricula* (tree-ear) and *Tremella fuciformis* (white jelly-leaf) in hypercholesterolemic rats. *Nutr. Res.* **16**: 1721-1725.

Cheung, P. C. K. & Lee, M. Y. 1998. Comparative chemical analysis of fiber material prepared by enzymatic and chemical methods from two mushroom (*Pleurotus sajor-caju* and *Pleurotus tuber-regium*). *J. Agric. Food Chem.* **46**: 4854-4857.

Chihara,G. 1984. Antioxidants. *Rev. Immunol. Immunofarmacol.* **4**: 85-100.

Chihara, G., Maeda, Y., Hamuro, J., Sasaki, T. & Fukuoka, F. 1969. Inhibition of mouse sarcoma 180 by polysaccharides from *Lentinus edodes. Nature.* **222**: 687-388.

Chin, F. H. 1988. Edible and poisonous fungi from the forests of Sarawak. Part 1. *The Sarawak Museum Journal.* **29**: 211-225.

Chin, F. H. 1998. Edible and poisonous fungi from the forests of Sarawak. Part 2. *The Sarawak Museum Journal.* **39**:195-201.

Chiu, S. W., Chan, Y. H., Law, S. C., Cheung, K. T. & Moore, D. 1998. Cadmium and manganese in contrast to can reduce yield and nutrition values of the edible mushroom *Pleurotus pulmonaris. Mycol. Res.* **102**: 449-458.

Cho, S. M., Lee, J. H., Han, S. B. & Kim, B. K. 1999. Chemical features and purification of immunostimulating polysaccharides from the fruit bodies of *Agaricus blazei*. *Int. J. Med. Mushrooms.* **27**: 170-174.

Coskuner, Y. & Ozdemir, Y. 1997. Effects of canning processes on the elements content of cultivated mushrooms (*Agaricus bisporus*). *Food Chem.* **60**: 559-56.

Cowan, M. M. 1999. Plant products as antimicrobial agents. *Clin. Microbiol. Rev.* **12**: 564-582.

Craig, C. D., Gull, K. & Wood, D. A. 1977. Stipe elongation in *Agaricus bisporus*. *J. Gen. Microbiol.* **102**: 337-347.

Crisan, E. V. & Sands, A. 1978. Nutritional value. Chang, S. T. & Hayes, W. A. (eds.). *The biology and cultivation of edible fungi.* New York: Academic Press.

Cuvelier, M. E., Richard, H. & Berset, C. 1996. Antioxidative activity and phenolic composition of pilot-plant and commercial extracts of sage and rosemary. *J. Am. Oil Chem. Soc.* **73**: 645–652.

Czop, J. K. & Kay, J. 1991. Isolation and characterization of beta-glucan receptors on human mononuclear phagocytes. *J. Exp. Med.* **173**: 1511–1520.

DaDamio, P. A. & Thompson, D. B. 1992. Mushroom (*Agaricus bisporus*), its polyphenoloxidase, and polyphenolics affect *in vitro* iron availability. *J. Food Sci.* **57**(2): 458-461.

Danell, E. & Eaker, D. 1992. Amino acid and total protein content of the edible mushroom *Cantharellus cibarius*. *J. Sci. Food Agric.* **60**: 333-337.

Demirbas, A. 2000. Accumulation of heavy metals in some edible mushrooms from Turkey. *Food Chem.* **68**: 415-419.

Demirbas, A. 2001. Concentration of 21 metals in 18 species of mushrooms growing in the East Black Sea region. *Food Chem.* **75**: 453-457.

Diez, V.A. & Alvarez, A. 2001. Compositional and nutritional studies on two wild mushrooms from Northwest Spain. *Food Chem.* **75**: 417-422.

Diplock, A. T. & Charleux, J-L. 1998. Functional food science and defence against reactive oxidative species. *Br. J. Nutr.* **80**: 577-612.

Dix, N. J. & Webster, J. 1995. *Fungal Ecology.* London: Chapman & Hall.

Drissner, J., Bürmann, W., Enslin, F., Heider, R., Klemt, E. & Miller, R. 1998. Availability of caesium radionuclides to plants – classification of soils and role of mycorrhiza. *J. Environ. Radioact.* **41**: 19-32.

Donnelly, J. K. & Robinson, D. S. 1990. Oxygen radicals in living systems and in food. *BNF Nutrition Bulletin.* **15**: 114-129.

Ducousso, M., Ba, A. M. & Thoen, D. 2002. Ectomycorrhizal fungi associated with native and planted tree species in West Africa: A potential source of edible

mushrooms. Hall, I. R., Wang, Y, Zambonelli, A. & Danell, E. (eds.). *Edible ectomycorrhizal mushrooms and their cultivation.* Christchurch: New Zealand Institute for Crop and Food Research.

Dziezak, J. D. 1986. Preservatives: antioxidants. *Food Technol.* **9**: 94-102.

Eitenmiller, R. R., Landen, W. O. & Augustin, Jr. Jörg. 1998. Vitamin analysis. Nielsen, S. S. (ed.). *Food Analysis.* Maryland: Aspen Publication.

Elless, M. P., Michael, J. B., Huang, J. & Gussman, C. D. 2004. Plants as a natural source of concentrated mineral nutritional supplements. *Food Chem.* **17**: 181-188.

Eloff, J. N. 1998. Which extractant should be used for the screenig and isolation of antimicrobial components from plants? *J. Ethnopharmacol.* **60** (1): 1-8.

Erbas, M., Certel, M. & Uslu, M. K. 2005. Some chemical properties of white lupin seeds (*Lupinus albus* L.). *Food Chem.* **89**: 341-345.

Evans, P. & Halliwell, B. 2001. Micronutrients: oxidant/antioxidant status. *J. Nutr.* **85**: S67-S74.

Falandyzs, L., Bona, H. & Danisleviez, D. 1994. Silver uptake by *Agaricus bisporus* from an artificially enriched substrate. *Z. Lebensen. Unters-Forsch.* **199**: 225-228.

Faller, L. D., Baroudy, B. M., Johnson, A. M. & Ewall, R. X. 1977. Magnesium requirements for yeast enolase activity. *Biochem.* **16**: 3864-3869.

Fasidi, I. O. & Olorunmaiye, K. S. 1994. Studies on the requirements for vegetative growth of *Pleurotus tuberregium* (fr) Singer, a Nigerian mushroom. *Food Chem.* **50**: 397-401.

Fennema, O. 1977. Loss of vitamins in fresh and frozen foods. *Food Technol.* **31**(12): 32-38.

Franken. E. N. 1996. Antioxidants in lipid foods and their impact on food quality. *Food Chem.* **57**: 51-55.

Furue, H. 1987. *Drugs of Today.* Washington: Gordon & Breach Science Publishers.

Gadd, G. M. 1988. Accumulation of metals in microorganisms and algae. Rehm, H. J. & Reeds, G. (eds.). *Biotechnology – A Comprehensive Treatise.* Weinheim: VCH Verlagsgesellschaft.

Gaetke, Lisa, M. & Ching, K. C. 2003. Copper toxicity, oxidative strass, and antioxidant nutrients. *Toxicol.* **189**(1-2): 147-163.

Garraway, O. M. & Evans, C. R. 1984. *Fungal nutrition and physiology.* New York: John Wiley.

Gast, C. H., Jansen, E., Bierling & Haanstra, L. 1988. Heavy metals in mushroom and their relationship with soil characteristics. *Chemosphere*. **17**:239-245.

Gibson, R. S. & Ferguson, E. L. 1999. *An interactive 24-h recall for assessing the adequacy of iron and zinc intakes in developing countries*. Washington: ILSI Press.

Gibson, R. S. & Ferguson, E. L., Thompson, L. U., Ounpu, O. & Berry, M. 1988. Phytate, zinc and calcium contents of 30 East African foods and their calculated phytate: Zinc and calcium concentration, phytate concentration and zinc concentration molar ratios. *J. Food Compos. Anal.* **1**: 316-325.

Gordon, D. T. & Williford, C. B. 1983. Chitin and chitosan: Influence on element absorption in rats. Furda, I. (ed.). *Unconventional Sources of Dietary Fiber*. Washington DC: American Chemical Society.

Graham, K. M. & Fauzi, D. 1991. Edible wild mushrooms of Malaysia, Singapore and Thailand. *Malaysia Applied Biology*. **20**(2): 223-226.

Griffin, D. H. 1994. *Fungal Physiology*. New York: Wiley-Liss, Inc.

Guerra, N. B., Melo, E. A. & Filho, J. M. 2005. Antioxidants compounds from coriander (*Coriandum sativum* L.) etheric extract. *J. Food Compos. Anal.* **18**: 193-199.

Gülçin, U. I., Gimgor, S. I., Beydemir, S., Elmastas, M. & Küfrevioglu, O. 2004. Comparison of antioxidant of clove (*Eugenia Caryophylata* Thumb) buds and lavender (*Lavandula staechas* L.). *Food Chem.* **87**: 393-400.

Gunde-Cimerman, N. 1999. Medicinal value of the genus *Pleurotus* (Fr.) P. Karst. (*Agaricales* S. R., *Basidiomycetes*). *Int. J. Med Mushrooms*. **1**: 69-80.

Guo, J-T., L, H-L., Chiang, S-H., Lin, F-I. & Chang, C-Y. 2001. Antioxidant properties of the extracts from different parts of broccoli in Taiwan. *J. Food Drug Anal.* **9**(2): 96-101.

Hagerman, A. E., Riedl, K. M., Jones, G. A., Sovik, K. N., Ritchard, N. T., Hartzfeld, P.W. & Riechel, T. L. 1998. High molecular weight plant polyphenolics (tannins) as biological antioxidants. *J. Agric. Food Chem.* **46**: 1887–1892.

Halliwell, B. 1987. Free radicals and metal ions in health and disease. *Proc. Nutr. Soc.* **46**: 13-26.

Halliwell, B. 1990. How to characterize a biological antioxidant. *Free Radical Res. Comm.* **9**: 1-32.

Halliwell, B. & Gutteridge, J. M. C. 1989. *Free radicals Biol Med*. Oxford: Clarendon Press.

Hamano, H. 1997. Functional properties of sugar alcohols as low calorie sugar substitutes. *Food Ind. Nutr.* **2**: 1-6.

Han, S. B., Lee, C. W., Jeon, Y. J., Hong, N. D., Yoo, I. D., Yang, K. H. & Kim, H. M. 1999. The inhibitory effects of polysaccharides from *Phellinus linteus* on tumor growth and metastasis. *Immunopharmacol.* **41**: 157-164.

Härkönen, M. 1998. Uses of mushrooms by Finns and Karelians. *Int. J. Circumpolar Health.* **40**: 40-55.

Härkönen, M. 2002. Mushroom collecting in Tanzania and Hunan (Southern China): inherited wisdom and folklore of two different cultures. Watling, R., Frankland, J. C., Ainsworth, A. M., Isaac, S. & Robinson, C. H. (eds.). *Tropical Mycol.* Vol. 1. 149-165.

Härkönen, M. & Järvinen, I. 1993. Evaluation of sources for mushroom advisors in Finland. *Aquilo Ser. Botanica.* **31**: 93-97.

Hendricks, D. G. 1998. Mineral analysis. Nielsen, S. S. (ed.). *Food Analysis.* Maryland: Aspen Publication.

Herodež, S. S., Hadolin, H., Skerget, M. & Knez, Z. 2003. Solvent extraction study of antioxidants from balm (*Melissa offecinalis* L.) leaves. *Food Chem.* **80**: 275-282.

Hewitt, E. J. & Smith, T. A. 1975. *Plant Mineral Nutrition.* London: English Universities Press.

Hipkins, M. F. 1983. *Metals and Micronutirents, Uptake and Utilization by Plants.* London: Academic Press.

Hobbs, C. 1995. *Medicinal mushrooms.* Santa Cruz: Botanica Press.

Holaso, M., Fiedlerova, V., Smrcinova, H., Orsak, M., Lachman, J. & Vavreinova, S. 2002. Buckwheat – the source of antioxidant in functional foods. *Food Res. Int.* **35**:207-211.

Hopia A. I., Kahkonen, M. I., Vuorela, H. J., Ravha, J., Pihlaja, K., Heinonen, T. S.. 1999. Antioxidant activity of plant extracts containing phenolic compounds. *J. Agric. Food Chem.* **47**: 3954-3962.

Howard, L. R. Smith, R. T., Wagner, A. B., Villalon, B. & Burns, E. E. 1994. Provitamin A and ascorbic acid content of fresh pepper cultivars (*Capsicum annum)* and processed jalapenos. *J. Food Sci.* **59**: 362-365.

Hsu, T-H., Shino, L-H., Hsieh, C. & Chang, D. M. 2002. A comparison of the chemical composition and bioactive ingredients of the Chinese medicinal mushroom DongChongXiaCao, its counterfeit and mimic, and fermented mycelium of *Cordyceps sinensis. Food Chem.* **78**: 463-469.

Huang, D., Ou, B. & Prior, R. L. 2005. The chemistry behind antioxidant capacity assays. *J. Agric. Food Chem.* **53**: 1841-1856.

Huang, L.-C. 2000. Antioxidant properties and polysaccharide composition analysis of *Antrodia camphorata* and *Agaricus blazei.* Taichung: National Chung-Hsing University.

ICZM. 1998. Sabah Coastal Zone Profile Task Force 4. Danish Cooperation for Environment and Development (DANCED). Kota Kinabalu: Integrated Coastal Zone Management Unit, Town and Regional Planning Department.

Ikekawa, T., Urehara, N. Maeda, Y., Nakanishi, M. & Fukuoka, F. 1969. Antitumor activity of aqueous extracts of edible mushrooms. *Cancer Res.* **28**: 734-735.

Insel, P., Turner, R. E. & Ross, D. 2004. *Nutrition*. Sudbury: Jones and Bartlett Publishers, Inc.

Ishikawa, Y. Morimoto, K. & Hamasaki, T. 1984. Flavoglaucin, a metabolite of *Eurotium chevalieri*, its antioxidant and synergism with tocopherol. *J. Am. Oil Chem. Soc.* **61**: 1864-1868.

Ismail, A., Marjan, Z. M. & Chin W. F. 2004. Total antioxidant activity and phenolic content on selected vegetables. *Food Chem.* **87**: 581-586.

Jonathan, S. G. & Fasidi, I. O. 2001. Studies on phytohormones, vitamins and mineral element requirements of *Lentinus subnudus* (Berk) and *Schizophyllum commune* (Fr. Ex. Fr) from Nigeria. *Food Chem.* **75**: 303-307.

Jonathan, S. G. & Fasidi, I. O. 2003. Studies on *Psathyrella atoum bonata* (Pegler) a Nigerian edible fungus. *Food Chem.* **81**: 481-484.

Jonathan, S. G., Fasidi, I. O. & Ajayi, E. J. 2004. Physico-chemical studies on *Volvariella esculenta* (Mass) singer, a Nigerian edible fungus. *Food Chem.* **85**: 339-342.

Jones, E. B. G., Whalley, A. J. S. & Hywel-Jones, N. L. 1994. A fungus foray to Chiang Mai market in Northern Thailand. *Mycologist.* **8**(2): 87-90.

Jones, G., Seamark, D. A., Trafford, D. J. H. & Makin, H. C. J. 1985. *Vitamin D: Cholecalciferaol, ergocalciferol and hydroxylated metabolites*. Basel: Marcel Dekker Inc.

Jones, K. 1998. Maitake: a potent medicinal food. *Alternat. Comparat. Ther.* **12**: 420-423.

Joung, H., Nam, G., Yoon, S., Lee, J., Shim, J. & Paik, H. Y. 2004. Bioavailable zinc intake of Korean adults in relation to the phytase content of Korean foods. *J. Food Compos. Anal.* **17**: 713-724.

Kader, A. A. 1988. Influence of preharvest and postharvest environment on nutritional composition of fruits and vegetables. Quebedeaux, B. & Bliss, F. A. (eds.). *Horticulture and Human Health: Contributions of Fruits and Vegetables*. Proceedings of the 1st International Symposium on Horticulture and Human Health. New Jersey: Prentice-Hall.

Kalác, P., Niżonanskä, N., Bevilaqua, D., Śtaśková, I. 1996. Concentrations of mercury and copper in mushrooms in the vicinity of lead smelter. *Sci. Total Environ.* **105**: 109-119.

Kalác, P. & Svoboda, L. 2000. A review of trace element concentrations in edible mushrooms. *Food Chem.* **69**:273-287.

Kalác, P. & Svoboda, L. & Havlíčková, B. 2004. Contents of detrimental metals mercury, cadmium and lead in wild growing edible mushrooms: A review. *Energy Edu. Sci. Technol.* **13**(1): 31-38.

Kalác, P. & Svoboda, L. & Zimmermannová, K. 2000. Concentrations of mercury, cadmium, lead and copper in fruiting bodies of edible mushrooms in an emission area of a caopper smelter and a mercury smelter. *Sci. Total Environ.* **246**: 61-67.

Kamchan, A., Puwastien, P., Sirichakwal, P. & Kongkachuichai, R. 2004. *In vitro* calcium bioavailability of vegetables, legumes and seeds. *J. Food Compos. Anal.* **17**: 311-320.

Kanner, J., Frankel, E., Granit, R., German, B. & Kinsella, A. 1994. Natural antioxidants in grapes and wines. *J. Agric. Food Chem.* **42**: 64-69.

Kasuga, A., Aoyagi, Y. and Sugahara, T. 1995. Antioxidant activity of fungus *Suillus bovinus*. *J. Food Sci.* **60**: 1113-1115.

Katz, S. A. & Salem, H. 1993. The toxicology of chromium with respect to its chemical speciation: A review. *J. Applied Toxicol.* **13**: 217-224.

Keen, C. L., Ensunsa, J. L. & Zidenberg-Cherr, S. 1998. Manganese. Sadler, M. J., Strain, J. J. & Caballero, B. (eds.). *Encyclopedia of Human Nutrition.* Vol. **2**. London: Academic Press.

Khan, M. R. & Shahidi, R. 2001. Effects of natural and synthetic antioxidants on the oxidative stability of borage and evening primrose triacylglycerols. *Food Chem.* **75**: 431-437.

Kim, D.-O., Jeong, S. W. & Lee, C.Y. 2003. Antioxidant capacity of phenolic phytochemicals from various cultivars of plums. *Food Chem.* **81**(3):321-326.

Kim, H. M., Han, S. B., Oh, G. T., Kim, Y. Hong, N. H. & Yoo, I. D. 1996. Stimulation of tumoral and cell mediated immunity by polysaccharide from mushroom *Phellinus linteus*. *Int. J. Immunopharmacol.* **18**: 295–303.

Koide, R. T., Shumway, D. C. & Stevens, C. M. 2000. Soluble carbohydrates of red pine (*Pinus resinosa*) mycorrhizas and mycorrhizal fungi. *Mycol. Res.* **104**(7): 834-840.

Krantz-Rülcker, C., Allard, B. & Schnürer, J. 1996. Adsorption of IIB metals by three common soil fungi. Comparison and assessment of importance for metal distribution in natural soil systems. *Soil Biol. Biochem.* **28**(7): 967-975.

Kurkela, R., Koivurinta, J. & Kuusinen, R. 1980. Non-protein nitrogen compounds in the higher fungi – A review. *Food Chem.* **5**(2): 109-130.

Lattif, A. G., Omar, I. M., Said, I. M. & Kadri, A. 1984. A multi-variate approach to the study of medicinal plants in Malaysia. *J. Singapore Natural Academy Sci.* **13**: 101–105.

Lebeau, J., Furman, C., Bernier, J.-L., Duriez, P., Teissier, E. & Cotelle, N. 2000. Antioxidant properties of di-*tert*-butylhydroxylated flavonoids. *Free Radical Biol. Med.* **29**: 900–912.

Lee, S. K. & Kader, A. A. 2000. Preharvest and postharvest factors influencing vitamin C content of horticultural crops. *Postharvest Biol. Technol.* **20**: 207-220.

Lehtinen, P. & Laakso, S. 1998. Effect of extraction conditions on the recovery and potency of antioxidants in oat fiber. *J. Agric. Food Chem.* **46**: 4842–4845.

Léon-Guzmán, M. F., Silva, I. & López, M. G. 1997. Proximate chemical composition, free amino acids contents and free fatty acid contents of some wild edible mushrooms from Querétaro, México. *J. Agric. Food Chem.* **45**: 4329-4332.

Leonard, R. T. 1983. *Metals and Micronutrients, Uptake and Utilization by Plants.* London: Academic Press.

Lepsova, A. & Majstrik, V. 1998. Accumulation of trace elements in fruiting bodies of macrofungi in the Krusne Hory Mountains, Czechoslavakia. *Sci. Total Environ.* **76**: 117-178.

Levensor, D. L. & Bockman, R. S. 1994. A review of calcium preparations. *Nutr. Rev.* **52**: 221-232.

Lien, E. J., Ren, S. J., Bui, H. Y. H. & Wang, R. B. 1999. Quantitative structure activity relationship analysis of phenolic antioxidants. *Free Radical Biol. Med.* **26**: 285–294.

Lin, C. C. & Huang, P. C. 2002. Antioxidant and hepatoprotective effects of *Acathopanax senticosus*. *Phytotherapy Res.* **14**: 489–494.

Lincoff, G. 2002. There only a dozen basic groups. *Mushroom, J. Wild Mushrooming.* **20**: 9-15.

Lisiewska, Z. & Kmiecik, W. 1996. Effectof level of nitrogen fertilizer, processing conditions and period of storage for frozen broccoli and cauliflower on vitamin C retention. *Food Chem.* **57**: 267-270.

Löliger, J. 1991. The use of antioxidants in foods. *Free Radicals Food Add* London: Taylor and Francis.

Lowore, J. & Boa, E. 2001. Bowa markets: local practices and indigenous knowledge of wild edible fungi. Egham: CABI Bioscience.

Lowy, B. 1974. *Amanita muscaria* and the Thunderbolt legend in Guatemala and Mexico. *Mycologia.* **66**: 189-191.

Malkönen, E., Derone, J., Fritze, H., Helmisaar, H-S., Kukkola, M. & Kytö, M. 1999. Compensatory fertilization of Scots pine stands polluted by heavy metals. *Nutr. Cycl. Agroecosyst.* **55**: 239-268.

Manzi, P., Gambelli, L., Marconi, S., Vivanti, V. & Pizzoferrato, L. 1999. Nutrients in edible mushrooms: an inter-species comparative study. *Food Chem.* **65**: 477-482.

Manzi, P. & Pizzoferrato, L. 2000. Beta-glucans in edible mushrooms. *Food Chem.* **68**: 315-318.

Marangoni, A. G. 2000. Phenolics and antioxidants special issue. *Food Res. Int.* **33**: 407.

Marger, Sheldon (ed.). 2002. *Wellness of Foods A to Z.* New York: Rebus.

Marinova, E. M. & Yanishlieva, N. 1997. Antioxidative activity of extracts from selected species of the family *Lamiaceae* in sunflower oil. *Food Chem.* **58**: 245–248.

Mathlouti, M., 2001. Water content, water activity, water structure and the stability of food stuffs. *Food Control*. **12**: 409–417.

Mattila, P. H., Lampi, A. M., Ronkainen, R., Toivo, J. & Piironen, V. 2002. Sterol and vitamin D_2 contents in some wild and cultivated mushrooms. *Food Chem.* **76**: 293-298.

Mattila, P. H., Piironen, V. I., Uusi-Rauva, E. J & Koivistoinen, P. E. 1994. Vitamin D contents in edible mushrooms. *J. Agric. Food Chem.* **42**: 2449-2453.

Mattila, P. H., Suonpää, K. & Piironen, V. 2000. Functional properties of mushrooms. *Nutr.* **16**: 694-696.

Mattila, P. H., Suonpää, K. & Piironen, V. 2001. Contents of vitamins, mineral elements and some phenolic compounds in cultivated mushrooms. *J. Agric. Food Chem.* **49**: 2343-2348.

Mau, J-L., Chang, C.-N., Huang, S.-J. & Chen, C.-C. 2004. Antioxidant properties of methanolic extracts from *Grifola frondosa*, *Morchella esculenta* and *Termitomyces albuminosa* mycelia. *Food Chem.* **89**(1): 111-118.

Mau, J-L., Lin, H. C. & Chen, C. C. 2001. Non-volatile components of several medicinal mushrooms. *Food Res. Int.* **34**: 521-526.

Mau, J-L., Lin, H. S. and Song, S. F. 2002. Antioxidant property of several specialty mushrooms. *Food Res. Int.* **35:** 97-104.

Mau, J-L., Tsai, S-Y., Tsang, Y-H. & Huang, S-J. 2005. Antioxidant properties of methanolic extracts from *Ganoderma tsugae*. *Food Chem.* **93**: 641-649.

Mclarty, J. W. 1997. Antioxidants and cancer: the epidemiologic evidence. Garewal, H. S. (ed.). *Antioxidants and Disease Prevention.* New York: CRC Press.

Mdachi, S. J. M., Nkunya, M. H. H., Nyigo, V. A. & Urasa, I. T. 2004. Amino acid composition of some Tanzanian wild mushroom. *Food Chem.* **86**: 179-182.

Mendil, D., Uluözlu, Ö. D., Hasdemir, F. & Cağlar, A. 2004. Determination of trace elements on some wild edible mushrooms samples from Kastamonu, Turkey. *Food Chem.* **88**(2): 281-285.

Michelot, D., Siobud, E., Dore, J. C., Viel, C. & Poirier, F. 1998. Update of metal content profiles in mushrooms – toxicological implications and tentative approach to the mechanisms of bioaccumulation. *Toxicon.* **36**: 1997-2012.

Miles, P. G. & Chang, S-T. 1997. *Mushroom biology: concise basics and current development.* Singapore: World Scientific.

Miliauskas, G., Venskutonis, P. R. & van Beek. 2005. Screening of radical scavenging activity of some medicinal and aromatic plant extracts. *Food Chem.* **85**: 231-273.

Miller, D. D., Schricke, B. R., Rasmussen, R.R. & Camper, D. V. 1981. An in vitro method for estimation of iron availability from meals. *Am. J. Clin. Nutr.* **34**: 2248-2256.

Mizuno, T. 1999. A development of antitumor polysaccharides from mushroom fungi. *Food Ingred. J. (Japan).* **167**: 69-85.

Mizuno, T. 2002. Medicinal properties and clinical effects of *Agaricus blazei. Int. J. Med. Mushrooms.* **4**:167-169.

Mizuno, T., Sakai, T., Chihara, G. 1995. Health foods and medicinal usage of mushrooms. *Food Rev. Int.* **11**: 69-81.

Molyneux, P. 2004. The use of the stable free radical diphenylpicrylhydrazyl (DPPH) for estimating antioxidant activity. *Songklanakarin J. Sci. Tecnol.* **26**(2): 211-219.

Mondon, P., Leclreq, L., Lintner, K. 1999. Evaluation of free-radical scavenger effects of *Helianthus annuus* extracts using new *ex vivo* stripping methods. *Cosmetics, Aerosols and Toiletries in Australia.* **12**(4): 87-95.

Monks, N. M., Bordignon, S. A. L., Ferraz, A., Machado, K. R., Faria, D. H., Lopes, R. M., Mondin, C. A., de Souza, I. C. C., Lima, M. F. S., da Rocha, A. B. & Schwartsmann, G. 2002. Anti-tumor screening of Brazilian plants. *Pharmaceutical Biol.* **40**: 603-616.

Moore, D. 1998. Mushrooms upright, side ways and inside out. *Mycol. Res.* **102**: 641-657.

Moore-Landacker, E. 1996. *Fundamentals of the Fungi.* New Jersey: Prentice Hall.

Moreno-Rojas, R., Díaz-Valverde, A., Arroyo, B. M., González, T. J. & Capote, C. J. B. 2004. Mineral content of gurumelo (*Amanita ponderosa*). *Food Chem.* **85**: 325-330.

Moretti, C. L., Sargent, S. A., Huber, D., Calbo, A. G. & Puschmann, R. 1998. Chemical composition and physical properties of pericarp, locule and placental tissues of tomatoes with internal bruising. *J. Am. Hortic. Sci.* **123**: 656-660.

Moure, A., Cruz, J. M., Fraco, D., Domínguez, J. M., Sineiro, J., Domínguez, H., Núñez, M.J. & Parajó, J.C. 2001. Natural antioxidants from residual waste sources. *Food Chem.* **72**: 146-171.

Moure, A., Franco, D., Sineiro, J., Domínguez, H., Núñez, M. J. & Lema, J. M. 2000. Evaluation of extracts from *Gevuina avellana* hulls as antioxidants. *J. Agric. Food Chem.* **48**: 3890–3897.

Mozafar, A. 1993. Nitrogen fertilizers and the amount of vitamins in plants: A review. *J. Plant. Nutr.* **16**: 2479-2506.

Munzuroglu, O., Karatas, F. & Geckil, H. 2003. The vitamin and selenium contents of apricot fuit of different varieties cultivated in different geographical regions. *Food Chem.* **83**: 205-212.

Murcia, Antonia, M., Martínez-Tomé, M., Jiménez A. M., Vera, A. M., Honrubia, M. & Parras, P. 2002. Antioxidant activity of edible fungi (truffles and mushrooms): Losses during industrial processing. *J. Food Prot.* **65**: 1614-1622.

Mustafa, Yilmaz & Merdivan, 2001. Concentration of trace elements in wild edible mushroom. *Food Chem.* **73**:169-175.

Nagy, S. 1980. Vitamin C contents of citrus fruits and their products: a review. *J. Agric. Food Chem.* **28**: 8-18.

Naurato, N., Wong, P., Lu, Y., Wroblewski, K. & Bennick, A. 1999. Interaction of tannin with human salivary histatins. *J. Agric. Food Chem.* **47**: 2229-2234.

Navarro, N. P. & Vaquero, M. P. 1998. Potassium. Adler, M. J., Strain, J. J. & Caballero, B. (eds.). *Encyclopedia of Human Nutrition.* Vol. **3**. London: Academic Press.

Nepote V., Grosso, N. R. & Guzman, C. A. 2002. Extraction of antioxidant components from peanut skins. *Grasas Y Aceites.* **54**(4): 391–395.

Ndaw, S., Bergaentzlé, M., Aoudé-Werner, D. & Hasselmann, C. 2000. Extraction procedures for the liquid chromatographic determinations of thiamin, riboflavin and vitamin B_6 in foodstuffs. *Food Chem.* **71**: 129-138.

Nitisewono, P. 1988. *Prinsip Analisis Makanan.* Bangi: UKM.

Noble, R. & Gaze, R. H. 1994. Controlled environment composting for mushroom cultivation substrates based on wheat and barley straw and deep litter poultry manure. *J. Agric. Sci.* **123**: 71-79.

Novellino, D. 1999. *The ominous switch: from indigenous forest management to conservation-the case of the Batak on Palawan Island, Philippines.* Copenhagen: IWGIA.

Oso, B. A. 1977. Mushrooms in Yoruba mythology and medicinal purposes. *Econ. Botany.* **31**(3): 367-377.

Outila, T. A., Mattila, P. H., Piironen, V. I. & Lambert-Allardt, C. J. E. 1999. Bioavailability of vitamins D from wild edible mushroom (*Cantharellus tubaeformis*) as measured with a human bioassay. *Am. J. Clin. Nutr.* **69**: 95-98.

Pamplona-Rogers, G. D. 2001. *Encyclopedia of Foods and their Healing Power.* Vol. **2**. Madrid: Editorial Safeliz.

Parejo,I., Francesc V., Bastida, J., Rosas-Romero, A., Saavedra, G., Murcia, M., Jiménez, A. & Codina, C. 2003. Investigation of Bolivian plant extracts for their radical scavenging activity and antioxidant activity. *Life Sciences.* ***73***: 1667-1681.

Parrish, D. B. 1979. Determination of vitmain D in foods: A review. *Crit. Rev Food Sci. Nutr.* **12**: 29-57.

Parvianen, M. T. & N yyssonen, K. 1992. Ascorbic acid. Leenhen, A. P. D., Lambert, W. E. & Nelis, H. (eds.). *Modern Chromatographic Analysis of Vitamins.* New York: Marcel Dekker.

Pegler, David, N. 1997. *The Larger Fungi of Borneo.* Kota Kinabalu: Natural History Publications.

Pegler, David, N. & Vanhaecke, M. 1994. Termitomyces of southeast Asia. *Kew Bulletin.* **49**: 717-736.

Pellati, F., Stefania, B., Magro, L., Melegari, M. & Soragni, F. 2004. Analysis of phenolic compounds and radical scavenging activity of *Echinacea* spp. *J. Pharm. Biomed. Anal.* **35**: 289-301.

Perry, E. K., Pickering, A. T., Wamg, W. W., Houghton, P. J. & Perru, N. S. 1999. Medicinal plants and Alzheimer's disease: from ethnobotany to phytotherapy. *J. Pharm. Pharmacol.* **51**: 527-534.

Philips, R. 1994. *Mushrooms and other fungi of Great Britain and Europe.* Milan: Interlitho S.p.A.

Pranze, G. 1984. The use of edible fungi by Amazonian Indians. *Advances in Econ Botany.* **1**: 127-139.

Prasad, A. S. 1997. The role of zinc in brain and nerve functions. Connor, A. (ed.). *Metals and oxidative damage in neurological disorders.* New York: Plenum Press.

Qian, H. & Nihorimbere, V. 2004. Antioxidant power of phytochemicals from Psidium guajava leaf. *J. Zhejiang Univ. Sci.* **5**(6): 676-683.

Reh, C., Bhat, S.N. & Berrut, S. 2003. Determination of water content in powdered milk. *Food Chem.* **86**: 457-464.

Repetto, M. G. & Llesuy, S. F. 2002. Antioxidant properties of natural compounds used in popular medicine for gastric ulcers. *Brazilian J. Med Biol. Res.* **35**: 532-534.

Reshetnikov, S. V., Wasser, S. P. & Tan, K. K. 2002. Higher basidiomycota as a source of antitumor and immunostimulating polysaccharides. A review. *Int. J. Med Mushrooms.* **3**: 361-394.

Rice-Evans, C. A., Miller, N. J. 1995. Antioxidants – the case for fruit and vegetables in the diet. *Br. Food J.* **97**(9): 35-40.

Rice-Evans, C. A., Miller, N. J. & Paganga, G. 1996. Structure-antioxidant activity relationships of flavonoids and phenolic acids. *Free Radical Biol. Med.* **20**(7): 933-956.

Royse, D. J., Bahler, B. D. & Bahler, C. C. 1990. Enhanced yield of shiitake by saccharide amendment of the synthetic substrate. *Appl. Environ. Microbiol.* **56**:479-482.

Rudawska, M. & Leski, T. 2005. Trace elements in fruiting bodies of ectomycorrhizal fungi growing in Scots pine (*Pinus sylvestris* L.) stands in Poland. *Sci. Total Environ.* **339**: 103-115.

Rühling, A. & Söderström, B. 1990. Changes in fruitbodies production of mycorrhizal and litter decomposing macromycetes in heavy metal polluted coniferous forests in North Sweden. *Water Air Soil Pollut.* **49**: 375-387.

Ryvarden, L., Piearce, G. D. & Masuka, A. 1994. *An introduction to the larger fungi of South Central Africa.* Oslo: Norway.

Sadler, Michèle, 1990. Myco-protein – A new food. *BNF Nutrition Bulletin.* **15**:123-126.

Samorini, G. 2001. New data on the ethnomycology of psychoactive mushrooms. *Int. J. of Med. Mushrooms.* **3**: 257-278.

Sánchez-Moreno, C., Larrauri, J. A. & Saura-Calixto, F. 1999. Free radical scavenging capacity and inhibition of lipid oxidation of wines , grape juices and related polyphenolic constituents. *Food Res. Int.* **32**: 407-417.

Sanmee, R. Dell, B., Lumyong, P., Izumori, K. & Lumyong, S. 2003. Nutritive value of popular wild edible mushroom from northern Thailand. *Food Chem.* **82**: 527-537.

Saris, W. H. M. & Asp, N. G. L. 1998. Functional food science and substrate metabolism. *Br. J. Nutr.* **80**: 547-575.

Sasakit, T. & Takasuka, N. 1976. Further study of the structure of lentinan, an antioxidant polysaccharide from *Lentinus edodes. Carb. Res.* **47**: 99-104.

Savage, G. P., Nilzen, V., Österberg, K. & Vanhaner, L. 2002. Soluble and insoluble oxalate content of mushrooms. *Int. J. Food Sci. Nutr.* **53**(4): 293-296.

Selvendran, R. R. & MacDougall, A. J. 1995. Cell-wall chemistry and architecture in relation to sources of dietary fiber. *Eur. J. Clin. Nutr.* **49**(3): S27-S41.

Senatore, Felice. 1991. Chemical constituents of some mushrooms. *J. Sci. Food Agric.* **58**: 499-53.

Serra, B. J. & Ventura, C. F. 1997. Evaluation of bitterness and astringency of polyphenolic compounds in cocoa powder. *J. Agric. Food Chem.* **60**: 365-370.

Sesli, E. & Tüzen, M. 1999. Levels of trace elements in the fruiting bodies of macrofungi growing in the East Black Sea region of Turkey. *Food Chem.* **69**:273-287.

Shahidi, F. & Wanasundara, P. K. J. P. D. 1992. Phenolic antioxidants. *Crit. Rev. Food Sci. Nutr.* **32**: 67-103.

Shahidi, F. & Naczk, M. 1995. *Food Phenolics: Sources, Chemistry, Effects and Applications.* Basel: Technomic Pub. Co.

Shahidi, F. & Naczk, M. 2004. *Phenolics in Food and Nutraceuticals.* CRC Press: Boca Raton.

Sharon, N. & Lis, H. 1993. Carbohydrates in cell recognition. *Sci. Am. J.* **5**: 74-87.

Sherwin, E.R. 1990. Antioxidants. Branen, A.l. Davidson, P.M. and Salmiren S. (eds.). *Food antioxidants*. New York: Marcel Dekker Inc.

Shimada, K., Fujikawa, K., Yahara, K. & Nakamura, T. 1992. Antioxidative properties of xanthan on the autoxidation of soybean oil in cyclodextrin emulsion. *J. Agric. Food Chem.* **40**: 945-948.

Shlomai, P., Margalith, P. & Mokady, S. 1991. Nutritional evaluation of the fungus *Phycomyces blakesleeanus* as a protein source. *Food Agric.* **58**: 125-128.

Shon, Y. N. &. Nam, K. S. 2001. Antimutagenicity and induction of anticancinogenic phase II enzymes by *basidiomycetes. J. Ethnopharmacol.* **77**: 103–109.

Siegenberg, D., Baynes, R. D., Bothwell, T. H., MacFarlane, B. J., Lamparelli, R. D., Car, N. G., MacPhail, P. S. U., Tal, A. & Mayet, F. 1991. Ascorbic acid prevents the dose-depemdent inhibitory effects of polyphenols and phytates on non-heme absorption . *Am. J. Clin. Nutr.* **53**: 537-541.

Siegert, E., Anke, M., Szentminalyi, S., Regius, A., Lokyey, D., Parel, J., Grun, M. & Hora, K. 1986. *Pure element-symposium.* Leipzig: Karl-Marx Universitat.

Singh, L. 1985. Vitamin D. Augustin, J., Kelin, B. P., Becker, D. A. & Venugol, P. B. (eds.). *Methods of Vitamin Assay.* Chicester: John Wiley.

Singleton, V. 1981. Naturally occurring food toxicants: phenolic substances of plant origin common in foods. *Advanced Food Research.* **27**: 149-243.

Singleton, V. L., Orthofer, R. & Lamuela-Raventos, R., M. Analysis of total phenols and other oxidation substrates and antioxidants by means of Folin-Ciocalteu Reagent. 1999. *Methods Enzymol.* **299**: 152-178.

Smith, J. E., Rowan, N. J. & Tan, K. K. 2000. Functional food: Science and their medicinal mushroom. *Int. J. Med. Mushroom.* **2**: 277-285.

Son, S. & Lewis, B. A. 2002. Free radical scavenging and antioxidant activity of caffeic acid amide and ester analogues: structure-activity relationship. *J. Agric. Food Chem.* **50**(3): 468-472.

Song, S.Y., Kim, S.H., Sa, J.H., Jin, C., Lim, C.J. & Park, E.H. 2003. Anti-angiogenic, antioxidant and xanthine oxidase inhibition activities of the musroom *Phellinus linteus. J. Ethnopharmocol.* **88**: 113-116.

Soong, Y-Y. & Barlow, P. J. 2005. Antioxidant and phenolic content of selected fruit seeds. *Food Chem.* **50**: 104-110.

Soong, Y. Y. & Barlow, P. J. 2004. Antioxidant activity and phenolic content of selected fruit seeds. *Food Chem.* **5**:165-168.

Spoerke, David, G. 2001. *Foodborne Disease Handbook.* New York: Marcel Dekker, Inc.

Stamets, P. 2000. *Growing gourmet and medical mushrooms.* Berkeley: Ten Speed Press.

Stevanato, R., Fabris, S. & Momo, F. 2004. Enzymatic method for the determination of total phenolic content in tea and wine. *J. Agric. Food Chem.* **52**: 6287-6293.

Stijve, T., Goessler, W. & Dupuy, G. 2004. Influence of soil particles on concentrations aluminium, iron, cadmium and other metals in mushrooms. *Ditsch Lebensm-Rundsch.* **100**: 10-13.

Strack, D. 1997. Phenolic metabolism. Dey, P. M. and Harbourne, J. B. (eds.). *Plant Biochemistry.* San Diego: Academic Press. 387-416.

Sun, J., Chu, Y. F., Wu, X. Z. & Liu, R. H. 2002. Antioxidant and antiproliferative activities of common fruits. *J. Agric. Food Chem.* **50**(25): 7449-7454.

Tebib, K., Rouanet, J. M. & Besançon, P. A. 1994. Effect of grape seed tannins on the activity of some rat intestinal enzyme activities. *Enzyme Protein.* **48**: 51-60.

Tee, E. S., Mohd Ismail Noor, Mohd Nasir Azudin & Khatijah Idris. 1997. *Nutrition Composition of Malaysian Foods.* Kuala Lumpur: Institute for Medical Research.

Tortora, G. J., Funke, B. R. & Case, C. L. 2002. *Microbiology: An Introduction.* San Francisco: Benjamin Cummings.

Trinci, A. P. J. 1992. Myco-protein: A twenty-year overnight success story. *Mycol. Res.* **96**: 1-13.

Tsai, S.-Y. 2002. Antioxidant properties and their cytotoxic activities on tumor cells of *Ganoderma tsugae* and *Agrocybe cylindracea* and antimutagenic properties of *Agrocybe cylindracea*. National Chung-Hsing University, Taichung.

Tshinyangu, K. K. 1996. Effect of grass hay substare on nutritional value of *Pleurotus ostreatus* var. *colombinus*. *Die Nahrung*. **40**: 79-83.

Tsuda, T., Watanabe, M., Ohshima, K., Yamamoto, A., Kawakishi, S. & Osawa, T. 1994. Antioxidative components isolated from the seed of tamarind (*Tamarindus indica* L.). *J. Agric. Food Chem.* **42**: 2671–2674.

Turkekul, I., Elmastes, M., & Tüzen, M. 2004. Determination of ferum, copper, manganese, zinc, lead and cadmium in mushroom samples from Tokat, Turkey. *Food Chem.* **84**: 389-392.

Tyler, G. 1980. Metals in sporophores of basidiomycetes. *Trans. Br. Mycol. Soc.* **74**: 41-49.

Velioglu, Y. S., Mazza, G., Gao, L. & Oomah, B. D. 1998. Antioxidant activity and total phenolics in selected fruits, vegetables, and grain products. *J. Agric. Food Chem.* **46**(10): 4113-4117.

Verhagen, Hans, Schilderman, P.A., & Kleinjans, J. C. S. 1991. Butylated hydroxyanisole in perspective. *Chemico-Biological Interactions.* **80**: 109-134.

Vetter, J. 2003. Data on sodium content of common edible mushrooms. *Food Chem.* **81**(4): 589-593.

Vetter, J. 2004. Lithium content of some common edible wild-growing mushrooms. *Food Chem.* **90** (1-2): 31-37.

Viñas, P., Campillo, N., Carcía L. I. & Córdoba, H. M. 1992. Liquid chromatographic determination of fat-soluble vitamins in paprika and paprika oleoresin. *Food Chem.* **45**: 349-355.

Wader, Jr. L. G. 2003. *Organic Chemistry*. New Jersey: Pearson Education.

Wang, S. Y. & Zheng, W. 2001. Effect of plant growth temperature on antioxidant capacity in strawberry. *J. Agric. Food Chem.* **49**: 4977-4982.

Wasser, S. P. & Weis, A. L. 1999. Medicinal properties of substances occurring in higher Basidiomycetes mushrooms: current perspective (review). *Int. J. Med. Mushrooms.* **1**: 31-62.

Wasser, S. P., Nevo, E., Sokolov, D., Reshetnikov, S. & Timor-Tismenetsky, M. 2000. Dietary supplements from medicinal mushrooms: diversity of types and variety of regulations. *Int. J. Med. Mushrooms.* **2**: 1-19.

Wasson, R.G. 1978. *The wondrous mushroom: mycolatry to Mesoamerica*. New York: McGraw-Hill.

Wettasinghe, M. & Shahidi, F. 1999. Antioxidant and free radical-scavenging properties of ethanolic extracts of defatted borage (*Borago officinalis* L.) seeds. *Food Chem.* **63**: 399–414.

Whitney, E. N., Cataldo, C. B. & DeBruyne, L. E. 1999. *Nutrition and Diet Therapy.* 5th ed. Belmont: Westwadsworth.

Wildman, A. & Medeiros, H. 2000. *Advanced Human Nutrition.* London: Academic Press.

WHO. 1996. World Health Organization. *Trace elements in human nutrition and health.* Geneva: WHO.

Xiao, K., Xuan, L. J., Xu, Y. M., Bai, D. L., Zhong, D. X., Wu, H. M., Wang, Z. H. & Zhang, N. X. 2002. Dimeric stilbene glycosides from *Polygonum cuspidatum. Eur. J. Organic Chem.* **3**: 564-568.

Yanaki, T., Ito, W. & Kojima, T. 1981. Ultrasonic degradation of schizophyllan, an antitumor polysaccharide produced by *Schizophyllum commune. Fries Carbohydr. Res.* **89**: 121-135.

Yanaki, T., Ito, W. & Kojima, T. 1983. Correlation between the antitumor activity of a polysaccharides schizophyllan and its triple-helical conformation in dilute aqueous solution. *Biophys. Chem.* **17**: 337–342.

Yen, G. C. & Duh, P. D. 1994. Scavenging effect of methanolic extracts of peanut hulls on free radical and active-oxygen species. *J. Agric. Food Chem.* **42**: 629-632.

Yilmaz, F., Oder, N. & Isiloglu, M. 1997. The macrofungi of the Soma (Manisa) and Savastepe (Balikesir) districts. *Turkish Jour. Botany.* **21**(4): 221-230.

Yorou, S. N. & De Kesel, A. 2002. Plant Systematics and phytogeography for the understanding of African biodiversity. *Syst Georg. Pl.* **7**: 627-637.

Yu, L., Haley, S. Perret, J. & Harris, M. 2004. Comparison of wheat flours grown at different locations for their antioxidant properties. *Food Chem.* **86**(1): 11-16.

Zheng, W. & Wang, S. Y. 2001. Antioxidant activity and phenolic compounds in selected herbs. *J. Agric. Food Chem.* **49**: 5165-5170.

Zhou, S., Gao, Y., Chen, G., Dai, X. & Ye, J. 2001. A Phase I/II study of a *Ganoderma lucidum* extract (Ganopoly) in patients with advanced cancer. *Int. J. Med. Mushrooms.* **70**: 699-705.

Zijp, I. M., Korver, O. & Tijburg, B. M. 2000. Effect of tea and other dietary factors on iron absorption. *CRC Crit. Rev. Food Sci. Nutr.* **40**: 371-398.

Zoberi, M. H. 1972. *Tropical Macrofungi.* London: Macmillan.

Zumbé. A. 1998. Polyphenols in cocoa: are there health benefits? *Br. Nutr. Bulletin.* **23**:94-102.