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EFFECT OF DOMESTIC PROCESSING ON THE NUTRITIONAL QUALITY AND ANTIOXIDATIVE PROPERTIES OF SELECTED CULINARY MUSHROOMS

NGIAM KIAH KHIM

THESIS SUBMITTED IN FULFILLMENT FOR THE BACHELOR DEGREE OF FOOD SCIENCE WITH HONOURS IN FOOD SCIENCE AND NUTRITION

SCHOOL OF FOOD SCIENCE AND NUTRITION
UNIVERSITI MALAYSIA SABAH

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DECLARATION

I hereby declare that the material in this thesis is my own except quotations, except, equations, summaries and references, which have been duly acknowledged.

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'My Special Sense of Appreciation'

Ngiam Kiah Khim
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ABSTRACT

EFFECT OF DOMESTIC PROCESSING ON THE NUTRITIONAL QUALITY AND ANTIOXIDATIVE PROPERTIES OF SELECTED CULINARY MUSHROOMS

Effect of domestic processing (blanching, pan-frying and steaming) on the nutritional quality and the antioxidant activity of *Pleurotus* species (*Pleurotus sajor-caju, Pleurotus florida)* were investigated. The samples were analyzed for proximate composition (moisture, fat, protein, fibre, carbohydrate, and ash) and minerals contents after being subjected to various cooking methods. The antioxidant activities were determined by several bioassays namely 1,1-diphenyl-2-picrylhydrazyl (*DPPH*) Radicals scavenging activity, inhibition of β-carotene bleaching, ABTS Trolox equivalent assay and FRAP ion reducing assay. For *P. sajor-caju,* steaming shown a reduction in ash (5.50-4.84 g/100 g), and protein content (19.12-16.79 g/100 g), but increasing in fibre (8.38-10.05 g/100 g) and fat content (1.03-1.41 g/100 g) from 5 min to 15 min. Meanwhile, *P. florida* shown increasing in protein (20.87-22.26 g/100 g) and fibre content (10.37-16.43 g/100 g), decreasing in ash (6.83-4.05 g/100 g) and fat content (1.43-1.14 g/100 g). As for frying methods, ash (5.50-6.80 g/100 g for *P. sajor-caju,* 6.67-7.33 g/100 g for *P. florida*), fat (1.12-1.20 g/100 g and 1.38-2.78 g/100 g for *P. sajor-caju* and *P. florida* respectively) and fibre content (9.16-10.83 g/100 g and 10.26-10.89 g/100 g for respective *P. sajor-caju* and *P. florida*) were shown increasing but the protein content (21.63-18.34 g/100 g and 20.73-19.27 g/100 g for respective *P. sajor-caju* and *P. florida*) was shown decreasing from 3 min to 9 min. The results were much more affected by the cooking methods, rather than the types of two mushrooms species. Although minerals reduced after being subjected to various cooking methods, it found that steaming seemed better in retaining the minerals. Methanol exhibited the highest extraction ability for DPPH radical scavenging activity (93.52% for *P. sajor-caju* and 94.39% for *P. florida*), and β-carotene bleaching inhibition (91.48% and 91.35% for respective *P. sajor-caju* and *P.florida*). Cooking treatments were found to have little effect in terms of antioxidant capacity for the studied samples. Blanching showed the highest influence on DPPH and β-carotene bleaching inhibition. Overall, steaming showed lesser effect on nutritional values and antioxidant activities.

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ABSTRAK

KESAN PEMPROSESAN MEMASAK KE ATAS KUALITI NUTRISI DAN AKTIVITI ANTIOKSIDA PADA KULAT KULINER YANG DIPILIH

Kesan pemprosesan (penceluran, penggorengan, dan pengukusan) ke atas kualiti nutrisi untuk spesies Pleurotus (Pleurotus sajor-caju, dan Pleurotus forida) yang diselidikan. Sampel tersebut dianalisis untuk komposisi prosimat (kadar air, lemak, protein, abu, karbohidrat dan pelawat) dan juga kandungan mineral selepas proses pemprosesan. Aktiviti antioksida yang dianalisiskan dengan beberapa ujian: kaedah penurunan radikal DPPH, kaedah perintang mengelantangan β-carotene, kaedah tahap penyamaan ABTS dan kaedah penurunan ion FRAP. Pengukusan pada P. sajor-caju menunjukkan penurunan dalam kandungan abu (5.50-4.84 g/100 g), dan kandungan protein (19.12-16.79 g/100 g), tetapi meningkat pula dalam kandungan pelawat (8.38-10.05 g/100 g) dan juga kandungan lemak (1.03-1.41 g/100 g) daripada masa 5 min kepada 15 min. Makakala, P. florida didapati meningkat dalam kandungan protein (20.87-22.26 g/100 g) dan kandungan pelawat (10.37-16.43 g/100 g), menurun dalam kandungan abu (6.83-4.05 g/100 g) dan kandungan lemak (1.431.14 g/100 g). Bagi cara menggoreng pula, kandungan abu (5.50-6.80 g/100 g untuk P. sajor-caju, 6.67-7.33 g/100 g untuk P. florida), kandungan lemak (1.12-1.20 g/100 g dan 1.38-2.78 g/100 g untuk P. sajor-caju dan P. florida masing-masing) dan kandungan pelawat (9.16-10.83 g/100 g dan 10.26-10.89 g/100 g untuk P. sajor-caju dan P. florida masing-masing) menunjukkan peningkatan tetapi kandngan protein (21.63-18.34 g/100 g dan 20.73-19.27 g/100 g untuk P. sajor-caju dan P. florida masing-masing) pula menunjukkan penurunan daripada masa 3 min kepada 9 min menggoreng. Keputusan adalah lebih dipengaruhi oleh cara memasak, berbanding dengan jenis kulat yang diggunakan untuk kajian. Bagaimanapun minerals mengurang selepas diproseskan dengan beberapa jenis pemasakkan, tetapi didapati pengukusan tudak menunjukkan perbezaan yang signifikasi. Metanol menunjukkan pengekstrakkan yang tertinggi untuk aktiviti penurunan radikal DPPH (93.52% untuk P. sajor-caju dan 94.39% untuk P. florida), dan perintang mengelantangan β-carotene (91.48% dan 91.35% untuk P. sajor-caju dan P. florida masing-masing). Didapati kaedah pemasakkan tidak mempengaruhi kapasiti anti oksida. Namun demikian, penceluran sangat mengaruhi keputusan aktiviti penurunan radikal DPPH dan perintang mengelantangan β-carotene. Kesimpulannya, pengukusan menunjukkan sedikit perbezaan kesannya dalam nilai nutrisi dan aktiviti anti oksida.

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LIST OF ABBREVIATIONS

ANOVA	-	Analysis of Variance
BHT	-	Butylated hydrotoluene
ET	-	Electron Ion Transfer
EC_{50}	-	Half Maximal Effective Concentration
FRAP	-	Ferric ion reducing antioxidant power
HAT	-	Hydrogen Atom Transfer
SPSS	-	Statistical Package for Social Sciences
TEAC	-	Trolox equivalence antioxidant capacity
TLC	-	Thin Layer Chromatography
UV	-	Ultraviolet

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LIST OF SYMBOLS

%	-	Percentage
°C	-	Degree Celsius
<	-	Less than
>	-	More than
±	-	Plus minus
cm	-	Centimetre
dw	-	Dried weight
g	-	Gram
h	-	Hour
kg	-	Kilogram
mg	-	Milligram
min	-	Minutes
ml	-	Millilitre
mmol	-	Milimolar
nm	-	Nanometre
pH	-	Power of hydrogen
rpm	-	Round per minute
s	-	Seconds
t	-	Tons
µg	-	Microgram
µl	-	Microlitre
µm	-	Micrometre

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CHAPTER 1

INTRODUCTION

Edible fungi, like mushrooms, have been widely consumed as food in ceremonies that are well known and documented in Europe, China and Japan since ancient times. However, such information is scanty and poorly known in Malaysia. This dearth of information is probably due to the lack of a traditional "mushroom culture" in Malaysia as well as a shortage of trained mycologists or fugal taxonomists. Cultivated mushrooms, such as oyster mushrooms (*Pleurotus* spp.), shitake (*Lentinula* edodes), Jew's ear fungus (locally called monkey's ear fungus) (*Auricularia* spp.) and paddy straw mushroom (*Volvariella* volvacea) have long been utilized in Malaysia for food by the Malays, Chinese and Indians. They are intensively cultivated, for commercial purposes, on ground or wood and utilizing particular environmental and nutritional conditions (Chang, 1999). Mushroom mycelia (vegetative phase) are important in the ecosystem because they are able to biodegrade the substratum as part of natural agricultural wastes. The oyster mushroom *Pleurotus* spp., in particular *P. sajor*-caju, is edible, easy to grow and cultivation has now been commercialized in Malaysia by utilizing agro-industrial waste.

Mushrooms are excellently edible and highly perishable commodities due to their high content in nutrients. They are appreciated not only for their texture, pleasant flavours, and aroma but also for their nutritional (Manzi *et al.*, 1999; Breene, 1990; Crisan and Sands, 1978), chemical (Manzi *et al.*, 1999b) and pharmacological (Bobek *et al.*, 1999, 1995, 1991) properties (Manzi *et al.*, 1999). For nutritional point of view, mushrooms are low in calories, rich in carbohydrates and proteins with most essential amino acids, high in dietary fibre, vitamins, as well as minerals (Ouzouni *et al.*, 2007; Ouzouni & Riganakos, 2007; Mendil *et al.*,

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2004; Ouzouni, 2004; Racz *et al.,* 1996). In terms of essential amino acids, for instance, leusine, methionine, tryptophan and valine, are constituted to be good qualities of protein (Agrahar-Murugkar & Sunggulakshmi, 2004; Diez & Alvarez, 2001; Longvah & Deosthale, 1998). Moreover, they do have significant level of vitamins, such as thiamine, riboflavin, ascorbic acid, and vitamin D2 (Mattila *et al.*, 2000).

Edible mushrooms are used extensively in cooking. It is common that many mushrooms are cooked by a simple boiling or microwave process. These cooking processes would certainly bring about a number of changes in physical characteristics and chemical composition of mushrooms (Sukhwant *et al.*, 1992). Khachik *et al.* (1992) reported that various cooking methods, such as boiling, frying, blanching and pressure cooking, affected the carotenoid content of mushrooms. However, the content of total carotenoids remained unchanged in the steaming and microwave cooking. Moreover, Price *et al.* (1998) pointed out the cooking affected the phenolic content of mushrooms. Total phenolics declined continuously during cooking because of phenolics were largely leached into the cooking water.

Apart from nutritional quality, some medicinal mushrooms, namely *Ganoderma lucidum, Ganoderma tsugae,* and *Coriolus versicolor* are commonly used for pharmaceutical purposes and as health foods. These medicinal mushrooms have been reported as therapeutic foods, which are useful in preventing diseases such as hypertension (Bobek *et al.,* 1999), hypercholesterolemia and cancer (Bobek *et al.,* 1995). Besides, they were found to be medically active in several therapeutic effects, such as antitumor, immunomodulating, and chronic bronchitis (Wasser and Weis, 1999), anticarcinogenic, anti-inflammatory, and immunosuppressing effects (Longnah and Deosthale, 1998). These functional characteristic are mainly due to their chemical composition (Manzi *et al.*, 2001).

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Nutraceutical can be defined as a substance that may be considered foods or parts of food and provide medical or health benefits, such as the prevention and treatment of disease. Mushrooms are rich sources of neutraceuticals (Caglarirmak, 2007; Elmastas *et al.*, 2007; Ribeiro *et al.*, 2007) which responsible for their antioxidant (Barros *et al.*, 2007a; Lo & Cheung, 2005; Mau *et al.*, 2002), antitumor (Wasser & Weis, 1999), and antimicrobial properties (Barros *et al.*, 2007; Turkoglu *et al.*, 2007; Hatvani, 2001; Hirasawa *et al.*, 1999; Smania *et al.*, 1995). Besides, nutraceuticals may range from isolated nutrients and dietary supplements to genetically engineered "designer" foods, herbal products and processed products such as cereals, soups and beverages. For example of nutritive nutraceuticals or "functional food ingredients" are dietary fibre, polyunsaturated fatty acids (PUFA, fish oil), proteins, peptides, amino acids, keto acids, minerals, antioxidative vitamins and other antioxidants (glutathione, selenium, etc.) (Kruger and Mann, 2003; Andlauer and Furst, 2002)

Mushrooms are also well-known as a source of physiologically beneficial and nontoxic medicines. They are used in different cultures in the pharmaceutical industry for their medicinal and tonic properties throughout the world (Gunde-Cimermen, 1999). These medicinal mushrooms produce substances that have potential medical properties, such as immune-modulatory, cardiovascular, liver protective, anti-fibrotic, anti-inflammotory, anti-diabetic, anti-viral and anti-microbial activities (Ooi, 2000; Gunde-Cimerman, 1999; Ooi & Liu, 1999; Wasser & Weis, 1999a, 1999b). These antioxidants include carotenoids, vitamins, flavonoids, other phenolic compounds, dietary glutathione, and endogenous metabolites (Larson, 1988). Mushrooms are good sources of natural antioxidants for the human diet, containing many different antioxidant components which provide protection against harmful free radicals and have been strongly associated with reduced risk of chronic diseases, such as cardiovascular disease, cancer, diabetes, Alzheimer's disease, cataracts and age-related functional decline in addition to other health benefits (Knekt *et al.*, 2002; Sweeney *et al.*, 2002; Cohen *et al.*, 2000; Liu *et al.*, 2000; Velioglu *et al.*, 1998; Cao *et al.*, 1996; Wang *et al.*, 1996).

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Mushrooms are becoming more important in our diet due to their nutritional value. However, there are limited scientific data and studies on the influence of cooking methods (Barros *et al.*, 2007d) on some nutritional properties and antioxidative activity (Barros *et al.*, 2007b) of cultivated mushrooms. Therefore, this research is to evaluate the effect on nutrients composition included the determination of proteins, fats, ash, crude fibre, and minerals and antioxidative properties which was screened by using several bioassays tests systems of cultivated mushrooms after treatments.

The specific objectives of the current study were:

1. To evaluate the effect of different cooking methods on the nutritive value of *Pleurotus sajor-caju* and *Pleurotus florida*;
2. To determine the antioxidant property of *Pleurotus sajor-caju* and *Pleurotus florida* with different solvent extracts;
3. To evaluate the changes of different cooking treatments onto the antioxidant properties of *Pleurotus sajor-caju* and *Pleurotus florida*.

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CHAPTER 2

LITERATURE REVIEW

2.1 Edible Mushrooms

Edible mushrooms commonly defined as higher fungi or macrofungi with distinctive and visible fruiting bodies, which may be grow above ground (epigeous) or below ground (hypogeous) (Miles & Chang, 1997). A macrofungus has a fruiting body with visible structure of sufficient size to be seen by naked eyes and to be picked up by hands. These fungi mostly belong to class Basidiomycetes (fungi producing basidiospores) and some fungi of class Ascomycetes (fungi producing ascospores). In fact, the fruiting body of the fungus is the structure, which is called mushroom (Fig. 2.1), while mycelium is the vegetative part comprising a system of branching threads and cordlike stands, which could produce the fruiting body under favorourable conditions (Chang, 2008). Mushrooms are saprophytic, growing on dead organic matter of vegetative origin. They can utilize almost all agricultural wastes as substrates (Miles & Chang, 1997). Many species of mushrooms are edible; examples being *Pleurotus* sp., *Agaricus bisporus* and *Volvariella volvacea*. Some are medicinal like *Auricularia* sp. And *Tremella fusiformis* for treating haemorrhoids and maintain healthy lung tissue, respectively, while others are poisonous like *Pholiota squarrasa* and *Amanita vaginata* (Chang & Buswell, 1996).

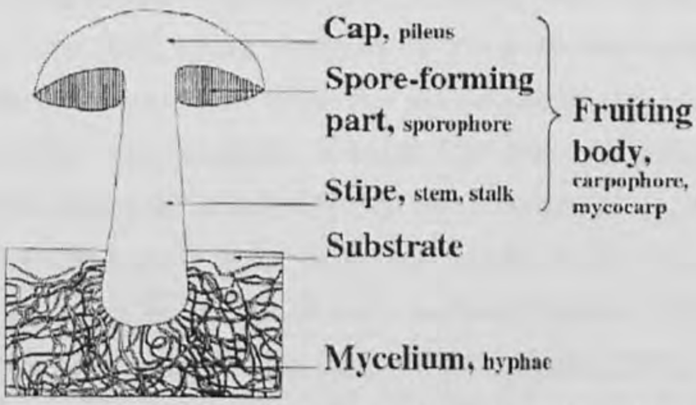

Figure 2.1: Sketch of a mushroom and used mycological terms.
Source: Kalac, 2009

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Mushroom is the spore-producing fruit body of a Basidiomycete, and may be compared to the flower of a plant. The "plant" of the Basidiomycete is the network of the hyphae or mycelium) which spreads through the substratum upon which the fungus grows. Nevertheless, mushrooms are finicky about its food source. Hence, they are different from green plants, in which do not contain chlorophyll to absorb light energy for photosynthesis. Mushrooms, on the other hands, rely on the substrate for their food. The spores are produced on a specialized, cylindrical cell unit, called an ascus. The spores usually eight in number are finally forcibly ejected through the ascus apex (Pelger, 1997). As spores released from the gills, they germinate and then develop into spacious underground mycelia (hyphae), eventually forming a fruiting bodies by the process of fructification. Meanwhile, the life time of fruiting bodies is only 10-14 days. Hyphae are the main mode of vegetative growth in fungi that symbiosis with tree.

The fruiting body of edible mushroom is usually the material, collected and consumed as food. Several types of products from fruiting bodies and mycelia are commercialized as dietary supplements by their potential therapeutic effects, and/or consumed in the form of capsules, tablets or extracts (Wasser *et al.*, 2000). These fungi have been considered to have a potential market as a functional food. At the same time, some species are greatly appreciated for an extremely high value in gourmet cooking (Chang & Miles, 1989).

2.2 Nutritional Values of Mushroom

Fruiting bodies mushrooms are becoming essential as part of our diet for their good nutritive values. Analyses of the proximate composition of the commonly cultivated mushroom reveal that edible mushrooms are rich in crude protein and carbohydrates, moderate in crude fiber and ash, and low in fat content (Sadler, 2003; Chang & Buswell' 1996; Crison & Sands' 1978). The energy values are low. Mushrooms are a good source of essential amino acids, some unsaturated fatty acids, vitamins, as well as the minerals. Potassium and phosphorus are the two dominant elements in the mineral portion (Park, 2001). The mushrooms contain a substantial amount of thiamine, riboflavin, niacin, and provitamin D_2. The edible

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mushrooms contain high moisture percentage (81.8-94.8%) whose variability in content depends on the substrate, atmospheric conditions, age or particular stage of development and part of the fruiting body on various conditions of storage after harvest (Adejumo and Awesanya, 2005; Manzi *et al.*, 2001; Vetter, 1994).

Mushrooms are susceptible to microbial growth and enzyme activity that accelerates spoilage owing to the high water content, at around 90% (Adejumo and Awesanya, 2005; Crisan and Sands, 1978). Three mushrooms species, such as *Pleurotus flabellatus* (oyster mushroom with pink caps), *Coprinus cinereus* and *Volvariella volvacea* (paddy straw mushroom) grown in Tanzania, are highly perishable for the highest moisture content recorded as 93%, 92%and 91% respectively (Khanna *et al.*, 1992; Stamets and Chilton, 1983). Fresh edible mushroom has a short shelf life, being the consumption of wild edible mushroom not possible throughout the year unless an appropriate storage processing is performed (Mattilda *et al.*, 2001). The food industry provides a wide range of different protections system to extend the storage period and preserving the nutritional as well as the organoleptic value of the raw material. Drying, marinate, sterilization and freezing are the most frequently treatments used on mushroom preservation, to prolonged their shelf-life and preserve their nutrients as well (Barros *et al.*, 2007; Bernas *et al.*, 2006; Manzi *et al.*, 2004; Czapski, 2003; Czapski & Szudyga, 2000; Vivar-Quintana *et al.*, 1999).

Mushrooms have been used as food supplements throughout the world because of vary in their nutritional values (Crisan and Sands, 1978). Generally, their incorporation in the diet as food item contributing 56.8% carbohydrate, 25.0% protein, 5.7% fats and 12.5% ash (Mendil *et al.*, 2004; Demirbas, 2002; Latiff *et al.*, 1996). In addition, they are good source of minerals like potassium, calcium, sodium, copper, zinc, iron, manganese and cobalt (Chang, 1980). Vitamin B, C, and D, including niacin, riboflavin, thiamine and folate are also important from a nutritional perspective.

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Table 2.1: Proximate composition of mushroom fruiting bodies (% dry matter)

Species	Crude protein	Lipids	Ash	Carbohydrates	Reference
1	80.93	0.92	9.90	8.25	Barros *et al.* (2008)
3	71.99	2.05	16.48	9.49	
4	70.47	2.43	14.93	12.18	
8	17.18	4.60	7.07	71.15	
9	47.22	1.05	8.72	43.01	
10	53.7	2.9	11.5	31.9	
11	69.45	4.88	12.22	13.44	
17	59.4	1.8	18.5	20.3	
19	17.2	0.4	32	50.4	
21	52.22	2.99	11.39	29.41	
24	39	1.4	8.8	50.8	
2	56.3	2.7	3.5	37.5	Barros *et al.* (2007)
13	29.8	2.2	5.1	62.9	
18	3.40	0.41	0.65	3.11	
25	2.35	0.09	0.29	3.38	
29	2.12	0.38	0.81	3.64	
7	5.52	3.50	5.26	72.74	Chong *et al.*, 2007
12	10.11	4.90	3.73	65.60	
14	14.0	1.50	7.11	61.28	
15	10.38	2.48	4.74	17.21	
16	8.32	1.92	4.75	72.53	
22	6.56	3.45	6.10	69.93	
23	5.30	4.43	4.17	61.24	
26	3.10	1.34	3.10	84.48	
6	31.9	27.5	10	30.6	Colak *et al.* (2007)
17	44.2	9	5.4	41.4	
6	26	72	4.6	62.2	Ouzouni and Riganakos (2007)
8	26.5	2.8	5.3	65.4	
17	19.8	3.2	6	71	
20	23.9	2.3	5.4	68.4	
27	16.5	4	5.2	74.3	
5	21.9	1.8	-	16.4	Florczak *et al.* (2004)
28	18.1	2	-	37	
29	19.6	5.8	9.9	34.6	Diez & Alvarez (2001)
30	20.1	6.6	12.1	31.1	
31	15.58	5.60	10.69	54.06	

[a] Calculated content of carbohydrates without fibre.

1= *Agaricus bisporus*; 2= *Agaricus arvensis*; 3= *Agaricus silvaticus*; 4= *Agaricus silvicola*; 5= *Amanita mellea*; 6= *Amanita rubescens*; 7= *Auricularia auricular-judea*; 8= *Boletus edulis*; 9= *Calocybe gambosa*; 10= *Cantharellus cibarius*; 11= *Craterellus carnucopioides*; 12= *Gallella rufa*; 13= *Lactarius deliciosus*; 14= *Lentinellus omphalodes*; 15= *Lentinus ciliatus*; 16= *Lentinus edodes*; 17= *Lepista nuda*; 18= *Leucopaxillus giganteus*; 19= *Lycoperdon perlatum*; 20= *Macrolepiota procera*; 21= *Marasmius oreades*; 22= *Pleurotus* sp. 1; 23= *Pleurotus* sp. 2; 24= *Ramaria botrytis*; 25= *Sarcodon imbricatus*; 26= *Schizophyllum Commune*; 27= *Suillus granulatus*; 28= *Tricholoma flavovirens*; 29= *Tricholoma portentosum*; 30= *Tricholoma terreum*; 31= *Volvarie* sp.

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2.2.1 Carbohydrates and Polysaccharides

Mushrooms contain carbohydrates, mainly as polysaccharides or glycoproteins which range 50-90%. Most abundant mushroom polysaccharides are represented by glycogen and indigestible forms as dietary fibre, such as chitin, cellulose, hemicelluloses, β- and α-glucans, mannans, xylans and galactans (Manzi *et al.*, 2001; Manzi *et al.*, 2000; Bohn and BeMiller, 1995; Grochowski, 1990). Various linear (1,3)-β-glucans and branched (1,3)(1,6)-linked β-glucans isolated from different mushroom origins are well known (Gonzaga *et al.*, 2005; Lim *et al.*, 2005; Dada & Ezeronye, 2003; Sasaki *et al.*, 1978). These compounds are important in the proper functioning of the alimentary tract. On the genetic level, it has powerful inhibition of mutation caused by chemicals. It can be also used in the comprehensive treatment of lassitude, leukocytopenia, and reduced immunity due to chronic hepatitis and radio-chemotheraphy for malignant tumours. Besides, it has certain preventive role for AIDS (Miao *et al.*, 2004).

In recent years, mushroom polysaccharides have drawn the attention of both chemists and immunobiologists due to their multipurpose medicinal activities that include immunodulating and antitumor properties (Wong *et al.*, 2007; Carbonero *et* al., 2006; Huie & Di, 2004; Borchers *et al.*, 1999). However, of all the polysaccharides isolated from mushroom origin, β-glucans are the most important due to their potent antitumor properties and health-positive effects. Some of them are considered true heteroglycans containing glucuronic acid, xylose, galactose, mannose, arabinose or ribose, however, mostly as linear and branched glucans with different types of glycosidic linkages, which linked by β-(1-3), (1-6) glycosidic bonds and α-(1-3) glycosidic bonds (Wasser, 2002).

The main source of biologically active polysaccharides consists mainly of chitin, a non-soluble protein that precipitates bile in large intestine so it is eliminated from the body. It breaks down cholesterol as well by improving cardiac health (Manzi, 2004). Cultivated mushrooms of genus *Pleurotus* have attracted much attention in the field of functional foods because of its present of β-glucans which demonstrate great immunomodulation, antioxidant, anti-inflammatory and

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analgestic properties (Smiderle *et al.*, 2008; Bobek and Galbavy, 2001). Since chitin- and β-glucose-basedpolysaccharides cannot be digested and absorbed in the human intestine, the mushroom sclerotium obviously contains abundant cell wall and extra-cellular matrix materials that can be classified as dietary fire (Wasswe & Weis, 1999; Cheung, 1997).

Glucose, mannitol, and trehalose are as main representatives of monosaccharides, their derivatives and oligosaccharide groups respectively. They are as main sugars as well. In edible mushrooms the dominant sugar is mannitols (Wannet *et al.*, 2000; Tseng and Mau, 1999), provide support and expansion for the fruit body. Mushrooms also contain glucose, galactose, trehalose, mannose and fructose apart from manniyol. Glucose and trehalose content are low; however, mannitol is different in volume growth and firmness of fruiting bodies. Relative low amounts of trehalose were found in *P. fuerulae* and *P. ostreatus* (33.3 and 32.8 mg/g, respectively). The profile Arabitol, glucose, mannitol, myo-inositol and trehalose were similar and consistent. For *Pleurotus* mushrooms (Tsai *et al.*, 2009). The content of sugars and polyols in these two mushrooms were in the middle range as compared to other mushrooms. Hence, it can be concluded as high content of sugars and polyols give rise to moderately sweet taste perception.

2.2.2 Protein and Essential Amino Acids

Mushroom is a better source in protein in the range between 20 and 40% than legumes sources, such as soybeans and peanuts, and as well protein-yielding vegetable foods (Chang and Mshigeni, 2001; Chang and Buswell, 1996). In developing countries, the problem of protein malnutrition becoming even more acute due to the supply of protein for the population is insufficient (FAO. 2006). Hence, unconventional alternative sources of protein like mushrooms have been introduced by planners and nutritionists (Chang & Mshigeni, 2001) due to mushrooms consist of high protein quality and containability of some essential amino acids in order to meet the deficit.

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