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The Edible Mushroom *Pleurotus* spp.: I. Biodiversity and Nutritional Values

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Abstract: Mushrooms are macrofungi with numerous varieties and widely known as food and medicine in many ancient cultures. They are considered as potential source of many essential nutrients as well as therapeutic bioactive compounds and thus became one of the main components in Traditional Chinese Medicine (TCM) and in Japanese herbal medicine since more than two thousand years. The genus *Pleurotus* (widely known as oyster mushroom) is fast growing fungus belongs to basidiomycota group and considered as one of the famous species with many health benefits. Nowadays, seventy species of this genus has been discovered, but solely a few of them such as *P. florida, P. sajor-caju and P. ostreatus* are available in the market. The rich nutrients such as proteins, fibers, carbohydrates, minerals, vitamins, and lipids present this mushroom as famous healthy food. Furthermore, Bioactive compounds such as polysaccharides, proteins and nucleic acid are extracted from various species of *Pleurotus* tends the researcher to investigate more on this beneficial genus. This work is focused on reviewing the recent work published in the biodiversity and nutritional content of *Pleurotus* spp.

Keywords: *Pleurotus* spp., biodiversity, proximate analysis, nutritional values.

1. INTRODUCTION

Since centuries, mushrooms have been used as nourishment throughout the world due to its rich nutrients such as proteins, carbohydrates, lipids, minerals (phosphorous and potassium), and vitamins [1]. Mushroom nowadays considered as one of the most important functional food with many well-known therapeutic applications [2-6]. Based on historical point of view, the Chinese people introduced mushroom as a significant and well-being diet or in other words the "elixir of life". In addition, Mushroom has been prescribed as a remedial for hallucinogens purpose in spiritual ceremony within witchcrafts by Mexican Indians. The Greeks people were thought that mushrooms provided strength for the soldier or fighter in war. In the world, many species of mushroom have received a remarkable amount of interest, as they are substantial source of appetizing food with high dietary properties as well as medicinal values. Furthermore, both mushroom extract and metabolites are currently major concerns of related industries such as food additives manufactory, fermented beverages, antibiotics, pigments, pharmaceuticals [7], biofuel, industrial enzymes, vitamins, organic and fatty acids and sterols [8, 9]. For many years mushroom cultivation is usually carried out using green house. However, nowadays beside solid state cultivation system using lignocellulosic biomass residues, cultivations were also successfully carried out in full submerged cultivation system under controlled sterile conditions to reduce the production time, increase in both volumetric and specific bioactive metabolites production, and to reduce the risk of contamination during mushroom cultivation [10, 11].

In this category, the genus *Pleurotus* (oyster mushroom) is an organoleptic fast growing fungus, which belongs to basidiomycota group. Although seventy species are discovered for this genus [12-14], only few of them are available in market such as *P. florida, P. sajor-caju* and *P. ostreatus* [15-17]. The biodiversity of *Pleurotus* is main concern of numerous researchers [18, 19]. Most of research studies were conducted with the aim of clarifying more about this genus and its identification in terms of morphological appearances. Recent molecular and biochemical techniques contribute a lot in this area. Needs for the pure and well-identified strains in order to breed, preserve the gene variability, and identify new species bring more emphasis on the importance of phylogenetic studies [20-22]. Most of pharmaceutical companies in south-east Asia especially China name medicinal mushrooms as a rich source of innovative bioactive molecules [1]. These products are extracted from fruiting body, mycelia and culture broth mainly as

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polysaccharides and proteins. Thus, in this review, the biodivertsity of the genus *Pleurotus* and the nutritional value of this important mushroom were discussed in details.

2. BIODIVERSITY

In the family of *Pleurotaceae*, species of the genus *Pleurotus* are second most important commercial mushroom [20, 23]. It is mainly due to their high nutritional, which can be applied as human diet and medicals. *Pleurotus* species can be grown in wild range of temperate and tropical areas as wild mushrooms of this genus distributes worldwide [12]. Table **1** presents widespread distribution of most studied *Pleurotus* species, their habitat and distinctive features. Although around 70 species of *Pleurotus* is recoded until now, but only few of them cultivated in industrial scale. Both techniques of solid state and submerged culture is already applied for cultivation of this mushroom in industry [12]. *P. sajor-caju*, *P. citrinopileatus* and *P. florida* are other extensive available *Pleurotus* mushrooms. Mushrooms commonly utilized by human

Table 1: Habitat, Geographical Distribution and Distinctive Features of most known *Pleurotus* spp. [26, 35]

Species	Habitat	Geographical Distribution	Similar morphological species	Distinctive Features
P. calyptratus	*Populus* spp.	central and eastern Europe, Asia	*P. dyinus*	The absence of stipe and chlamydospores and the formation of a pellicular veil
P. cornucopiae	*Quercus, Alnus, Fagus, Fraxinus, Acer, Prunus,* more usually *Ulmus* trees	Europe, Asia	*P. citrinopileatus*	the convex to infundibuliform whitish to yellow pilei, the fistulose-dichotomic subcentral stipe, the dimitic hyphal system and the distinctive purple spore-print colour
P. cystidiosus	*Ficw carica*-broad-leaved trees.	Europe, Asia, north America, south Africa	*P. abalones* *P. smithii* *P. purpureo-olivaceus*	asexual synnematoid anamorphs (assigned to *Anfromycopsis);* oblongelliptical basidiospores, the abundance of clavate pileocystidia and cheilocystidia,
P. dryinus	*Picea, Iuglans, Malus, Alnus, Fagus* and *Ulmus*	Europe, Asia, north America- North Africa		light beige to light brown pilei, chlamydospores in culture, has a distinct veil and dimitic hyphal system
P. eyngii	Umbelliferae, Compositae	Europe, Asia, Africa		White to brown pileus colors scattered with numerous beige squamules, the well-developed central to subcentral stipe, the relatively large basidiospores
P. opuntiae	*Opuntia, Agave, Yucca* and *Phy tolacca* plants	Mediterranean Europe, South America, Africa, Asia		
P. ostreatus	*Abies, Fagw, Populus, Quercus, Betula, Picea, Ulmus, Salix,alnw , Iuglans,*	Widespread around the world		Cup shaped typical bivalve structure. Known also as grey oyster mushroom, tree oyster, and king oyster mushroom.
P. columbinus	*Abies, Picea, Fagus, Acer* and *Ulmw*		*P. ostreatus* var. *columbinus*	Dark grey-brown imbricate pilei, dense anastomizing lamellae, Monomitic hyphal system and can grow at low temperatures on different substrates. Known also as blue oyster.
P. djamor		Tropical region, Indonesia, Malaysia, Japan, Mexico	*Agaricus djamor*	Known as Pink flamingo oyster mushroom, Salmon mushroom, Strawberry mushroom.
P. pulmonarius	Angiosperm wood belonging to *Fagus, Populus, Sorbus, Aesculus, Fraxinus, Betuh, Quercus*	In warm and tropical region, Asia	*P. ostreatus* *P. populinus*	Small, paler caps compare to *P. ostreatus*. Also known as lung oyster, phoenix oyster, Indian oyster.

for their nutrition content as well as their immunomodulatory effects [15-17].

Species of the genus *Pleurotus* perform a wide variety of morphological characters in different climates and environment [12, 21, 24]. Earlier, morphological classification was applied for species identification of this genus. However it is not a preferred method in higher fungi as environment conditions, habitat and climate strongly influence the morphology of basidiomata. This morphological classification leads to confusing taxonomy of *Pleurotus* and misidentification of some species. As a result no unique conclusion will be given regarding taxonomy studies [20, 21, 25, 26]. White basidomata is a case in point. It is a distinctive feature of *P. eryngii var. nebrodensis* but recently it is also reports in some isolate of variety ferulae [24]. Besides incorrect naming of commercial strains make it more confusing [27]. The ambiguous taxonomy of *Pleurotus* species highlighted the importance of studies on genetic diversity, clarifying the misidentified species and strains in the literatures. [20]. Also, precise identified biological material is required for breeding programs and high quality production of mushroom [21, 22]. Besides, identification and preserving wild types of *Pleurotus* species from drastic diversity loss is critical as they are important biological sources for improving the characteristic of commercial cultivate mushrooms. Wild *Pleurotus* mushrooms are in danger of loss of genetic variability as a consequence of man's selection [28].

Phylogenetically based species is an appropriate alternative for developing species concepts in mushrooms [29]. In recent decades, various biochemical and molecular techniques applied for investigation of phylogenetic relationship and strain identification of *Pleurotus* population. Isozyme electrophoresis [21], sequence analysis of ribosomal DNA [30], internal transcribed spacer region (ITS) [22, 31], random amplified polymorphic DNA (RAPD)[31-33], amplified fragment length polymorphism (AFLP)[28], restriction fragment length polymorphism (RFLP) [28] and mating compatibility test [27, 29, 33, 34] are among these techniques. Although extensive research conducted to clarify the obscure taxonomy of genus *Pleurotus*, still many questions is not fully addressed in the literature.

2.1. Biological Species Concept

One of the approaches to elucidate the delimitation of morphological species is to determine biological species and its complex structure [25, 27]. The biological species concept assist in clarifying systematic relationships among different taxa and speciation processes [26]. In contrast, there is a debate on the contribution of biological species to demonstrate evolutionary relationships with the strong basis of phylogenetic, which is almost in concordant with molecular phylogeny. Evaluating genetic divergence of *Pleurotus* taxa through integration of precise molecular techniques with biological species concept and geographical distribution lead to an explicit evolutionary mechanism identification [29].

Pleurotus population is subjected to many mating compatibility tests in which two intercompatible species are categorized as one biological species and intersterility groups [26, 27, 29, 34, 36, 37]. Mating behavior studies significantly contribute to phylogenetic studies, as the compatibility status between two known taxa represent the degree of gene flow between them [26]. Population of genus *Pleurotus* possesses tetrapolar (bifactorial) mating systems in their haplo-dikaryotic life cycle [12, 20, 22, 26, 34]. A haploid dikayotic mycelium only occurs once two compatible monokaryotic hyphae fuse together [20, 34]. In fact the two diverse genetic loci named as A and B control the mating-type of homo basidiomycetes such as *Pleurotus* species and two monokaryons are compatible only when the alleles at both loci differ [26, 33, 34]. Mainly model species of *Schizophyllum commune* and *Coprinopsis cinerae* are studied to figure out the mating compatibility control of tetrapolar fungi regarding the genetic basis. However, positional cloning and degenerate PCR of *P. djamor* indicate similar genetic basis for it [34].

Vilgalys and Sun collected strains of *Pleurotus* with various geographic origins around the world and assessed the mating compatibility of the strains. As a result, eight different intersterility groups is reported [29]. In another study thirteen European *Pleurotus* species subjected to mating analysis through homokaryotes isolation of around 100 *Pleurotus* dikaryons by Zervakis and Bali [26]. Eight different intersterility groups were detected considering mating compatibility along with morphological, physiological and ecological characteristics of strains [26]. In other study, twelve biological species were defined among 25 *Pleurotus* morphological species mainly collected from Asia. Table **2** shows the biological species identified by these authors [27]. A simple comparison between the results of above-mentioned studies reveals few discrepancies in biological classification.

Table 2: The Intersterility Groups in the *Pleurotus* Taxa Based on Mating Compatibility Tests

References	**[27]**		**[26]**		**[29]**	
Species	Synonyms-sub species taxa	IG*	Synonyms-sub species taxa	IG	Synonyms-sub species taxa	IG
P. ostreatus	*P. ostreatus var. columbinus* *P. djamor* *P. flabellatus*	I	*P. columbinus* *P. florida* *P. salignus* *P. spodoleucus*	I		I
P. pulmonarius	*P. eugrammus* *P. eugrammus var. brevisporus* *P. sajor-caju* *P. sapidus* *P. sp. florida* *P. opuntiae*	II	*P. sajor-caju* *P. sapidus*	II		II
P. populinus	—	—		III		III
P. calyptratus		III		VIII		
P. cornucopiae	*P. cornucopiae var. citrinopileatus*	IV	*P. citrinopileatus*	IV	*P. citrinopileatus*	IV
P. corticatus		V	—	—	—	—
P. cystidiosus	*P. abalonus*	VI	*P. abalonus*	VII	*P. abalonus* *P. smithii*	VII
P. djamor	—	—	*P. flabellatus* *P. ostreatoroseus* *P. salmoneostramineus P. euosmus*	V	*P. flabellatus* *P. salmoneostramineus* *P. salmonicolor*	V
P. dryinus		VII		IX		VIII
P. eryngii		VIII	*P. ferulae* *P. nebrodensis* *P. hadamardii,* *P. fossulatus*	VI	*P. fossulatus*	VI
P. nebrodensis		IX	—	—	—	—
P. purpureo-oliuacerrs	—	—		X	—	—
P. salmoneostramineus	*P. rhodophyllus* *P. ostreatoroseus*	X	—	—	—	—
P. smithii		XI	—	—	—	—
P. tuberregium	—	—		XI	—	—
P. ulmarius		XII	—	—	—	—

*IG stands for intersterility groups.

P. smithii and *P. nebrodensis* considered as independent interincompatible species [27] while they were categorized as *P*. cystidiosus and *P. eryngii* subspecies respectively [29]. Moreover, *P. salmoneostramineus* was recorded as a subspecies of *P. djamor* in both reports in 1994 and 1994, separated as single intersterility groups [27]. Instead, *P. djamor* and one of its subspecies named *P. flbellatus*, identified as subspecies of *P. ostreatus*. The biological identification of *P. florida* is another disagreement between different categorizations. It has been reported as a member of *P. pulmonarius* species complex [27] whereas it has been found as subspecies of *P. ostreatus* complex too [26]. Existence of current speciation process could be give rise to this minute disagreement. A phylogenic study on *P.eryngii* species complex suggests current specification process of this taxon [24, 26].

2.2. Molecular and Biochemical Studies

Despite precious information obtain form inter-fertility tests, but the need for more accurate comprehension of phylogenic relationship among species and specification mechanism of this genus increase the importance of precise means of species identification, especially for the strain which their geographical locations are in ambiguity [21]. Therefore, various molecular and biochemical techniques applied for this reason [27, 31]. One of the approaches is enzymes electrophoresis, which is subjected to 11 *Pleurotus* species [18], as eleven enzymatic activities were investigated regarding the number of genes and alleles involved in their production. Also a interspecies and intra species relationship is visualized through dendrogram was generated by neighbor-joining clustering method [21]. It demonstrates nine distinct clusters, which six clusters composed of one discrete species (*P. dryinus*, *P. flabellatus*, *P. abalones*, *P. cystidiosus*, *P. eryngii, P. columbines and P. cornucopiae*) while *P. cystidiosus* is splitting up to two clusters. The strains with different geographical location of Greece and U.S.A constitute these two clusters. These suggest the effect of geographical location on the gene flow and specification of *Pleurotus* species, which is supported by other authors too [26, 29]. In addition, the remained cluster composed two main subclusters. One includes *P. ostreatus* strains and the other one consist of *P. pulmonarius*, *P. sajor-caju* and *P. sapidus*. It should be note that all of later species were categorized as one biological species [26, 27, 29]. This may contribute to the justification of low genetic diversity among them. In general, the phylogeny study of these 11 species demonstrates an obvious delimitation of *P. dryinus*, *P. flabellatus*, *P. eryngii* and *P. cornucopiae* from other taxa. Moreover, The highest intraspecies diversity reported in *P. cystidiosus* and *P. eryngii* species respectively [21]. Different geographical origins of *P. cystidiosus* explain its high genetic diversity. Special host plant system of *P. eryngii* lead to high variation of isoenzyme pattern and set boundaries for spreading through conforming ecological niche [21].

2.3. Pleurotus Species

Systematic studies of mushroom through molecular studies along with biological species concept and geographical distribution proposed ancient history of some species. The importance of molecular phylogenetic studies is recognized when not noticeable data on the dispersal and origin of related taxa is attainable from fossil records of fungi [29]. They were also proposed an ancient evolving of *P. cystidiosus, P. djamor, P. dryinus, and P. cornucopiae* intersterility groups through sequence analysis of 5' portion of the nuclear encoded large subunit (LSU) rDNA. These species complexes are distributed widespread around the word. Moreover, they believed tight branching of *P. ostreatus*, *P. pulmonarius* also, *P. populinus*, *P. eryngii* species complex in related phylogram reveal their recent lineage in the Northern Hemisphere. Furthermore, phylogenetically based pattern of genetic divergence of rDNA internal transcribed spacer (ITS) region supports allopatric speciation in *Pleurotus* taxa with in the Northern Hemisphere. The high isoenzyme pattern variation of *P. cystidousus* suggests allopatric speciation of some *Pleurotus* species. It indicates the significant of biogeography in accordance to molecular speciation studies. The ephemeral fruiting pattern is one of the boundaries of understanding the distribution of mushrooms species. Previously, other mushroom groups indicated that geographical isolations with genetic divergence still have compatibility attitude. The contribution of geographical isolation to *Pleurotus* speciation is supported by high level of bootstraps for distinct geographical populations. It should be noted that polymorphic analysis of ITS possess adequate variation for elucidating phylogenetic relationship among geographically isolates as it's substitution rate was seven times higher than in the LSU sequences [29].

The geographical pattern of specification stem from dispersal and vicariance events on the basis of molecular studies and historical biogeography distribution. *P. cystidiosus, P. djamor, P. dryinus,* and *P. cornucopiae,* which are broadly distribute across both Hemispheres are regarded as ancient origin, while *P. ostreatus*, *P. pulmonarius*, *P. populinus*, *P. eryngii* species viewed evolved more recently in this speciation pattern. Later, it is mentioned species seems to be distributed solely within the Northern Hemisphere. Two historical hypotheses were proposed to address this distribution. One of these theories dated back the origin of higher taxa to Cambrian or earlier bases on continental drift theory. This theory believed the existence of ancient species before the Pangean continent break up around 200 million years ago. Moreover, some recent species are result of Laurasia breakup in events occurring in the Northern Hemisphere. It is expected to observe similar gross vicariance pattern across the Northern and Southern in this scenario. Another hypothesis, regular and intermittent dispersal of species are responsible for the geographical speciation pattern. Therefore in this theory older species is distributed across wider geographical areas than more recently one [29].

3. NUTRITIONAL VALUE

Consumers ate mushrooms for their palatability, nutritional value and medicinal value. Palatability can be elaborate as color, texture, flavor and taste. Higher Basidiomycetes mushrooms possess certain natural benefits in terms of dietary supremacy when compared with vegetarian diet. These include high protein content, essential amino acids enabling it to be as substitute for meat diet), a chitin rich wall acts as a source of dietary fiber, vitamin content (B1, B2, B12, C, D, and E), micro and macro-elements, carbohydrates, low fat content, and almost zero cholesterol content [38, 39]. The scientific works involves the analysis of the proximate analysis and also study the diversity of amino acids, fatty acids, vitamins, minerals, and nucleic acid present in this mushroom. Due to high amount value of proteins, mushrooms contribution can used to bridge the protein malnutrition gap and low of starch and cholesterol content, this mushroom suitable for diabetic and heart disease patients. Therefore, the bioaccumulation potential of nutrients by fungi enriched with essential elements for human health has been investigated [40].

It is well known that the composition or ingredients of *Pleurotus* species is affected by the diversity of its genetic framework or makeup, which leads to variety strain differences and environmental conditions. The edible mushroom *Pleurotus* species are nutritious foods, low in calories and in fat, luxuriant in protein, chitin, vitamins and minerals [41, 42].

3.1. Proximate Compositions of *Pleurotus*

Proximate study of certain compound would encompass the analysis content of moisture, crude protein, crude fat, crude fiber, ash and energy. Generally, fresh *Pleurotus* mushroom contain 85-95% moisture [43]. Proximate composition of *Pleurotus* species is highly varied according to its species and substrate. Table **3** shows the proximate composition within different species while Table **4** showed the nutritional compositions of *P. ostreatus* when using different substrates. Soybean straw showed maximum protein, fat, and ash with the values 24.66%, 2.82% and 6.70% respectively. The fat content on dry weight basis ranged between 2.56% to 2.82% and for the moisture ranged between 88.51% - 89.88% of *P. ostreatus*. Rice straw was given maximum percentage of about 7.70% for crude fiber followed by soybean and the minimum was found when using soybean straw (7.15%) alone during cultivation. A research done by Chye *et al.* (2008) suggested that the general ash content of edible wild *Pleurotus* sp. was found to be around 5.64% [44]. Another kind of strain which is *P. eryngii* are known rich in carbohydrate, fiber, and protein and low in ash and fat, which was in agreement with the previous study [45]. The fruiting body of *P. ostreatus* contains approximately 100 of different bioactive compounds, which mainly considered as a potential new source of dietary fiber [5].

3.2. Protein Content

It was reported that the protein contents of mushrooms are affected by a number of factors namely: the type of mushroom, the stage of maturation, the part mushroom body, availability of nitrogen content in the medium and the harvest location [65]. Table **3** shows the protein content of different *Pleurotus* species. *Pleurotus* was known as a good source of protein especially for vegetarian because this edible mushroom contains some essential amino acid for human intakes [53]. The digestibility of edible mushroom *Pleurotus* species proteins is as same as that of plants (90%) and comparable with meat (99%) [53]. According to Patil (2012), the protein content stated as a percentage of a dry weight in mushrooms in general in range between 10 and 40%, and varied extensively among and within the species. However, the average of protein content of *Pleurotus* is most common between 20 and 25% [64].

3.3. Amino Acid Content

Edible mushroom, *Pleurotus* contains 40% of the essential amino acids required for human intake and thus it considered as potential diet for people suffering from malnutrition problem [66]. Moreover, mushroom proteins contain all the essential amino acids needed in the human diet and rich with lysine and leucine which are absent in most staple cereal foods [67].

A total of 18 amino acids were recorded in *Pleurotus* species (Table **5**). Generally, the amino acid constituents were comparable in all species as they belong to the same family of *Pleurotus.* Tryptophan was discovered to be the minimum abundant essential amino acids in the *Pleurotus* species [42]**.** Table **6** shows the amino acid profile of *P. ostreatus* when

Table 3: Proximate Composition of *Pleurotus* Species

Pleurotus Species	Moisture (fresh weight) [%]	Crude Protein [%]	Crude fat [%]	Carbohydrate (Total) [%]	Crude fiber [%]	Ash [%]	References
P. eous	92.2	25.0	1.1	59.2	12.0	9.1	[46]
P. florida	91.5	27.0	1.6	58.0	11.5	9.3	[46]
P. ostreatus	90.8	30.4	2.2	48.9	8.7	9.8	[47]
P. ostreatus	-	19.59	0.62	50.03	18.52	3.66	[48]
P. ostreatus	73.7-90.8	10.5-30.4	1.6-2.2	57.6-81.8	7.5-8.7	6.1-9.8	[49]
P. ostreatus	4.46	20.82	0.56	68.35	45.50	5.81	[50]
P. sajor-caju	90.1	26.6	2.0	50.7	13.3	6.5	[51]
P. sajor-caju	-	21.22	0.25	51.19	16.68	3.09	[48]
P. sajor-caju	5.32	21.30	0.29	65.14	42.50	7.95	[50]
P. sajor-caju	90.9	26.6	2.0	50.7	13.3	6.5	[47]
P. djamor	82.21	15.6	1.65	59.9	17.2	5.83	[52]
P. ferulae	91.11	30.3	5.71	47.8	11.2	4.96	[52]
P. nebrodensis	87.74	27.7	7.35	46.2	15.7	3.84	[52]
P. sapidus	90.53	20.4	4.85	57.1	12.3	5.32	[52]
P. flabellatus	90.95	2.75	0.103	-	1.084	0.974	[53]

Note:a: Water and dry matter contents are presented based on fresh weight, others are presented based on dry weight.

Table 3: Proximate Composition of *Pleurotus* Species (Cont.)

Pleurotus* *Species	Moisture [%]	Protein [%]	Fiber [%]	Ash [%]	Fat [%]	Carbohydrate [%]	Energy kcal/100g	Reference
P. ostreatus	-	24.90	-	7.62	2.08	61.9	-	[54]
P. ostreatus	85-87	17-42	24-31	-	0.5-5	37-48	-	[43]
P. ostreatus	84.3	14.7	-	5.69	1.53	78.1	385	[55]
P. eryngii	93.09	19.11	19.79	6.77	2.62	51.71	-	[56]
P. sajor-caju	-	39.25	5.5	16.2	5.8	33.25	-	[57]
P. ostreatus	-	23.52	22.44	7	4.1	43.134	-	[58]
P. ostreatus	-	27.13	20.36	20.55	4.89	32.50	-	[59]
P. ostreatus	8.2	33.5		7.1	2.3	48.9	350	[60]
P. ostreatus	-	7.02	10.83	5.72	1.4	85.86	416	[61]
P. eryngii	-	11	11	6.18	1.45	81.37	421	[61]
P. sajor-caju	-	37.4	10	6.3	1	55.3	-	[62]
P. ostreatus	90.0	28.4	27.4	11.4	3.8	29.6		[63]

cultivated on diverse agricultural substrates. According to Table **7**, amino acid in edible *Pleurotus* species were divided into several groups regarding taste characteristic [68, 69]**.** Palatable taste (aspartic and glutamic) is belong to group 1, group two involve sweet taste amino acids (alanine, glycine, serine, threonine), for bitter taste amino acid was classification as group 3 including arginine, histidine, isoleucine, leucine, methionine, phenylalanine, tryptophan and valine.

Among essential amino acids, lysine, leucine, phenylalanine and threonine were present in high

Table 4: Effects of Different Substrates on Proximate Compositions of *Pleurotus ostreatus* [64]

Substrate	Moisture [%]	Protein [%]	Fat [%]	Crude Fiber [%]	Total carbohydrate [%]	Ash [%]
Soybean straw	88.54	24.66	2.82	7.15	53.20	6.70
Rice straw	88.59	23.40	2.80	7.70	55.33	6.30
Wheat straw	88.51	21.00	2.60	7.35	55.20	6.35
Soybean and paddy straw	89.37	23.00	2.70	7.68	50.50	6.42
Soybean and wheat straw	89.34	21.10	2.56	7.40	52.00	6.15
Wheat straw and paddy straw	89.88	20.33	2.58	7.50	56.20	5.90

amounts; valine, isoleucine, histidine and arginine in moderate concentrations and methionine and tryptophan in low amounts. On the other hand, non-essential amino acids such as glutamic acid, aspartic acid, serine, glycine and alanine were found in high amount whereas proline, histidine, and tyrosine content were low [57].

The most abundant amino acids in *P. eryngii* were Asp and Glu and furthermore, the low content amino acids were Cys, Met and His. Even though mushrooms content are rich source of with proteins, several of these proteins have not been identified and even fewer characterized. Some researchers mentioned the protein contents in *P. ostreatus* are varied according to strains, physical and chemical differences in growing medium composition of the substrate, size of the pileus, and harvest time [5]. However, Proteins of *Pleurotus* sp. mushroom still have superior quality because some of the members of this genus contain complete proteins with the well distribution of essential amino acids, as well as non-essential amino acids [5].

3.4. Carbohydrate and Fiber

Carbohydrates contribute around 50-60% of mushroom dry weight basis, which consists of various compounds: sugars (monosaccharides, disaccharide and oligosaccharides) and directly associated in synthesis process of polysaccharides (glycans) [5, 70]. Carbohydrates are mainly deposit in *P. ostreatus* as polysaccharides are represented by glycogen, indigestible fiber (cellulose, dietary fibers, chitin, α- and β- glucans) and other hemicelluloses (mannans, xylans and galactans) [71].

Table **3** shows the proximate analysis of fresh *Pleurotus*. *P. ostretaus* has very high carbohydrate content with 57% and 14% fiber. However, the fibers of plants and mushroom are different. Major sources of fiber are cellulose and other un-digestible cell wall polymers. Although fiber is un-digestible, it has substantial nutritional role in human physiological processes. The crude fiber content of *P. sajor caju* in biomass was found to be 5.5±0.48% [57]. Carbohydrates generally constitute cell wall of mushroom. Glucan and mannan are the two main polysaccharides of the cell wall. Glucan as food has beneficial effect for lowering the serum cholesterol, a risk for cardio-vascular disease [72], while mannan has radio-protective effect [73]. *P. ostreatus* characterized by the production of special type of intracellular and extracellular immunomodulatory β-glucan polysaccharides named pleuran [74, 75]. However, it is also quite interesting that mushrooms contain glycogen and even chitin, which is a group of polysaccharides occurring in animals instead of starch and cellulose, typically in plants. Glycogen is a kind of reserved polysaccharide by mushrooms. Limited literature data report the contents of 50–100 g kg^{-1} dry mass. The nutritional importance for humans is limited due to its content in meat and producible particularly in human liver [70]. Chitin is a water insoluble, structural N-containing polysaccharide which is characterized by β-(1,4)-branched N-acetylglucosamine units. Through partially deacetylation process of chitin, yields chitosan.

3.5. Mineral Content

In general all edible mushrooms also are a good source of minerals (Table **8**). Like all living organisms, *Pleurotus* mushrooms have a mix of minerals and their fruiting bodies are characterized by high level of mineral constituents. It contain minerals such as K, P, Na, Ca, Mg are the majority mineral elements in mushrooms and others constituents including Cu, Zn, Fe, Mo, Cd are the minor components [46]. One of the highest mineral in all higher species of *Pleurotus* is Cu content varied from 12.2 to 21.9 ppm. Content of Ca and Pb varied from 0.3- 0.5 ppm and from 1.5- 3.2 ppm, respectively in all *Pleurotus* species [46]. Table **9** shows that the mineral content of *P. ostreatus* is varied according to the substrate composition. From this table, it can be concluded that Ca (330mg/100g) will be the

Table 5: Essential Amino Acids of Different Edible *Pleurotus* Species Compared to Egg

Amino acids	*P. ostreatus*	*P florida*	*P. cystidiosus*	*P. abalanos (mg/g fruit body)*	*P sajor-caju*	*P. djamor (mg/g dry weight)*	*P. ferulae (mg/g dry weight)*	*P. nebrodensis (mg/g dry weight)*	*P. Sapidus (mg/g dry weight)*	Egg
Leucine	Nd	7.5	Nd	0.43	7.0	4.14	12.9	5.66	7.85	8.84
Isoleucine	0.19	5.2	0.23	0.27	4.4	4.3	12.6	10.1	8.23	6.64
Valine	0.02	6.9	0.09	0.44	5.3	5.57	21.1	11.8	12.4	7.25
Tryptophan	0.02	1.1	0.14	1.11	1.2	3.16	2.51	0.53	0.73	1.60
Lysine	0.19	9.9	0.32	0.75	5.7	3.65	32.5	22.2	21.2	6.64
Thereonine	Nd	6.1	0.42	0.60	5.0	3.73	9.53	5.62	5.59	5.07
Phenyalanine	0.19	3.5	0.28	0.45	5.0	2.69	4.47	3.19	3.29	5.84
Methionine	0.16	3.0	Nd	1.81	1.8	1.23	11.38	5.76	5.56	3.15
Histidine	0.12	2.8	Nd	0.82	2.2	1.84	22.3	8.96	9.58	2.38
Cysteine	0.13		0.05	4.48	37.6	5.86	12.96	6.75	7.81	47.22
Aspartic acid	Nd		0.51	0.56		8.64	3.62	2.61	6.24	
Serine	0.71		1.16	0.54		6.01	8.68	4.54	5.57	
Glutamic acid	0.12		0.14	2.49		7.11	5.66	7.06	2.46	
Proline	2.13		3.94	12.50		4.66	8.61	4.56	6.63	
Glycine	0.08		Nd	0.66		5.53	8.06	4.65	6.23	
Alanine	0.02		0.05	27.91		5.50	3.29	2.47	3.62	
Arginine	4.08		7.33			7.36	11.8	6.82	6.49	
Tyrosine						3.35	192	113	119	
Total A. acid						84.4				
References	[77]	[78]	[77]	[79]	[78]	[52]	[52]	[52]	[52]	[47]

Table 6: Amino Acid Profile of *P. ostreatus* Cultivated on Different Agricultural Wastes [64]

Amino acids	Soybean straw	Paddy straw	Wheat straw	Soybean and paddy straw	Soybean and wheat straw	Wheat and paddy straw
Alanine	25.1	20.2	28.3	20	23.7	18.5
Arginine	29.4	22.2	23.5	32.0	28.2	20.6
Aspartic acid	45.1	38.7	32,3	39.2	36.4	29.8
Cystine	5.6	3.7	6.0	3.9	3.2	3.5
Glutamic acid	64.2	58.5	56.8	63.1	59.0	55.7
Glycine	9.2	9.5	11.8	7.0	6.9	7.2
Histidine	15.9	16.4	19.2	12.2	15.8	13.0
Lysine	33.6	36.2	18.9	24.7	20.2	28.8
Methione	4.3	5.1	3.6	4.9	3.9	3.2
Phenyl alanine	20.2	16.5	18.2	16.5	17.2	19.0
Proline	16.8	13.8	13.8	15.8	10.9	14.2
Serine	18.5	16.3	17.2	14.3	15.8	12.6
Thereonine	32.5	29.0	26.3	28.0	28.5	24.8
Tryptophan	5.2	6.9	6.5	4.7	5.3	5.6
Tyrosine	12.3	9.7	9.2	11.0	10.5	8.6
Valine	30.1	28.4	25.0	27.5	28.7	24.2
Leucine	37.0	35.2	28.6	32.9	26.5	23.8
Isoleucine	21.5	19.2	18.5	18.0	14.6	16.0
Glutamine	5.6	5.2	6.2	5.3	4.6	4.8

highest mineral content when *P. ostreatus* was cultivated on soybean and rice straw.

Some minerals are essential to a healthy diet such as calcium, phosphorous, potassium and sodium whereas others can be toxic such as lead, mercury, cadmium and aluminum. The mineral proportions are varied; depend on the species, age and also on the shape of the fruiting body. Mushrooms have a mix of minerals, and their fruiting bodies are characterized by

Table 7: Amino Acid Contribution for Taste Characteristic of Several *Pleurotus* Species

Taste characteristics	*P. djamor*	*P. ferulae*	*P. nebrodensis*	*P. sapidus*	*P. cystidiosus*	*P. ostreatus*	*P. abalonus*
Palatable	15.8	53.6	34.0	33.7	1.21	0.84	6.29
Sweet	20.8	39.1	20.5	26.3	5.01	2.25	5.16
Bitter	30.3	74.8	42.0	44.9	0.74	0.78	14.69
Tasteless	7.00	16.3	9.22	11.4	0.37	0.21	1.77
Reference	[52]				[77]		[79]

Table 8: Mineral Contents Of Different *Pleurotus* Strains (mg/g dry Weight)

Mineral element	*P. djamor*	*P. ferulae*	*P. nebrodensis*	*P. sapidus*	*P. ostreatus*	*P. ostreatus*	*P. sajor-caju*	*P. florida*
Ca	1.42	0.23	0.17	0.84	35.9	33.0	22.15	33.7
Mg	1.21	0.85	0.79	1.19	16.395	N.D	20.22	13.4
P	7.57	4.99	5.10	5.13	-	1348	-	-
K	12.3	16.2	16.3	14.3	-	3793	-	-
Fe	0.59	0.07	0.05	0.19	55.45	15.2	33.45	43.2
Zn	0.18	0.08	0.02	0.07	26.565	837	20.9	16
Mn					2.85		2.87	2.7
Se					0.011		0.025	0.013
As					0.1		0.095	0.083
Na								
References	[52]	[52]	[52]	[52]	[47, 80]	[47]	[47, 80]	[47, 80]

Table 9: Effect of Different Substrates on Mineral Content (mg/100g) of *Pleurotus ostreatus* [64]

Substrate	Ca	P	Fe	Na	K	K/Na ratio
Soybean straw	300	1000	14.35	310	2320	7.48
Rice straw	296	920	14.94	290	2260	7.79
Wheat straw	270	810	13.88	305	2100	6.88
Soybean and paddy straw	330	870	15.62	295	2100	7.l1
Soybean and wheat straw	260	910	14.20	260	2000	7.69
Wheat and paddy straw	240	790	13.13	275	1900	6.90
S.E.	4.18	8.14	0.16	4.16	8.72	-
C.D. at 5%	12.45	24.25	0.47	12.39	25.90	-

high levels of mineral constituents. In general, mushrooms contain significant amounts of phosphorus, sodium, and potassium among the macro-minerals in its content, while on the other hand, iron and zinc are the most ample elements among the trace minerals been analyzed in it. Among the micro-minerals measured, the iron and zinc are the most abundant elements among the trace minerals analyzed. Other than that, *Pleurotus* species would provide a useful source of phosphorus, potassium, iron, zinc, calcium, magnesium, manganese, and copper [43]. Therefore, the addition of *Pleurotus* species in diet could be one of the approaches for fighting iron, zinc, and other micronutrient deficiencies. Overall, the contents of ash and particularly of phosphorus and potassium are somewhat higher than if not at least comparable to that content in vegetable [70]. As shown, the *Pleurotus* species can provide a useful source of phosphorus, potassium, iron, zinc, calcium, magnesium, manganese, and copper [76]. Thus, the addition of highly nutritional mushrooms in human diet could be one of the solutions for combating iron, zinc, and other micronutrient deficiencies.

3.6. Vitamins

Wild Mushrooms are relatively good source of vitamins than cultivated mushrooms especially the fruit bodies which is rich in vitamins mainly Thiamine (B1), Riboflavin (B2), C and ergocalcoferol [58]. It has been published that all edible mushrooms are a beneficial source for several vitamins such as thiamine (Vitamin B_1), riboflavin (vitamin B_2) [76, 81, 82], niacin, biotin and vitamin C (ascorbic acid). This was further supported by Isikhuemhen *et al.* (2009) who claimed that mushrooms appear to be a good source of vitamins, including thiamine, riboflavin, niacin, biotin and ascorbic acid aside than minerals. Mattila *et al.* (2001) reported that the vitamin of group B particularly are thamine, riboflavin, pyridoxine, pantotene acid, nicotinic acid, nicotinamid, folic acid and cobalamin whilst other vitamins such as ergosterol, biotin, phytochinon and tocopherols presence are also detected [82].

According to Teichmann *et al.,* 2007, was shown that vitamin D_2 reaching the highest amount in wild mushroom than dark cultivated *A. bisporus* [83]. Edible mushrooms also comprising in small amount of vitamin C and lack of Vitamins A, Vitamins D and last but not least of Vitamin D [53]. Table **10** shows the vitamin properties in the several *Pleurotus* species from literature review after analyzed. From this table, was shown that the oyster mushroom are rich in viamins such as vitamin C, Vitamin B complex including Thiamin, Riboflavin, Niacin, Folic Acid and Vitamin B12. Niacin is very important in human diet and with the high doses at 1g to 5g everyday is very useful to help control blood cholesterol [84]. Table **11** also presented Vitamin content of *P. ostreatus* when cultivated on different lignocellulosic wastes. From this table, it is concluded that the thiamine ranges between 0.004 to 0.008 mg/100g and for the riboflavin is between 0.037 to 0.298 mg/100g. Mushroom in conserve, showed the lowest vitamins from the others mushroom.

3.7. Fatty Acids Composition

In mushrooms, the fat content is very low as compared to carbohydrates and proteins. The fats present in mushroom fruiting bodies are dominated by unsaturated fatty acids [51]. Fatty acid is very important as a source of energy yielding substances, especially for unsaturated fatty acids was used to the hypocholesterolemic or hypolipidemic activity for biomedical part. *Pleurotus* mushroom are low in fat content, but contain some essential fatty acids (Table **12**). However, mushrooms are not considered as a significant source of essential fatty acids for fulfilling the requirements of human body. Oleic acid is the major monounsaturated fatty acid while linoleic acid is the major polyunsaturated fatty acid in *P. ostreatus* [5]. Tables **12** and **13** show the fatty acid compositions of some *Pleurotus* species. It was also reported that the most common monounsaturated fatty acid present in fungi is oleic acid (C18:l) [57]. The highest levels of SFA (20.2%) with the main contribution from palmitic acid (C16:0; 11.2%), followed by pentadecanoic acid (C15:0; 2.55%) and stearic acid (C18:0; 2.53%). Among PUFA (69.1%), linoleic acid (C18:2n–6c; 68.1%) was the most common and abundant in percentage [55].

Table 10: Vitamin B_1 and B_2 Content in Edible *Pleurotus* ssp [85]

Species	Common name	B1(mg/100g)	B2 (mg/100g)
Pleurotus spp.	Mushroom in conserve	0.004	0.037
	Oyster salmon mushroom	0.037	0.107
	Oyster white mushroom	0.025	0.075

Table 11: Vitamin Content of *P. ostreatus* when Cultivated on Different Lignocellulosic Wastes [86]

Substrate	Thiamin	Riboflavin	Pyridoxin	Niacin
Millet stalk	0.14	0.12	0.25	0.07
Wheat stalk	0.15	0.19	0.21	0.20
Cotton stalk	0.23	0.23	0.21	0.21
Soybean stalk	0.93	0.67	1.43	0.59

Table 12: Fatty Acids Composition of *Pleurotus* Species

Fatty acids	**No. of carbon**	**Percentage (%`)**						
		P. sajor-caju	***P. sajor-caju***	***P. cystidiosus***	***P. pulmonarius***	***P. floridanus***	***P. sapidus***	***P. sajor-caju***
Caprylic acid	C8:0	-	0.92	-	-	-	-	-
Pelargonic acid	C9:0	-	-	0.26	0.2	0.32	0.25	0.32
Capric acid	C10:0	-	-	0.33	0.18	0.13	0.2	0.18
Lauric acid	C12:0	0.69	-	-	0.45		0.12	0.1
Myristic acid	C14:0	3.14	0.18	-	-	-	-	-
Pentadecanoic acid	C15:0	1.35		4.06	1.56	2.12	4.43	5.58
Palmitic acid	C16:0	24.16	5.34	27.04	21.69	27.82	37.02	32.3
Palmitoleic acid	C16:1	1.04	0.22	1.56	0.13	0.21	0.96	0.83
Margaric acid	C17:0	-	0.21	-	-	-	-	-
	C17:1	-	-	2.38	0.73	1.11	3.21	2.34
	C17:3	-	-	1.38	0.77	0.22	0.88	0.93
Stearic acid	C18:0	6.46	2.38	3.82	2.17	3.98	5.75	4.38
Oleic acid	C18:1	9.31	41.71	33.6	46.86	32.98	40.21	41.3
Linoleic acid	C18:2	53.5	29.54	-	-	-	-	-
Linolenic acid	C18:3	-	11.67	-	-	-	-	-
	C19:1	-	17.28	17.28	20.57	2.87	12.89	11.3
Arachidic acid	C20:0	-	0.12	-	-	-	-	-
Arachidonic acid	C22:4	-	0.22	-	-	-	-	-
Behenic acid	C22:0	-	0.25	-	-	-	-	-
Erucic acid	C22:1	-	7.09	-	-	-	-	-
Lignoceric acid	C24:0	-	0.16	-	-	-	-	-
References		[57]	[87]	[88]				

Table 13: Fatty Acid Composition of Different *Pleurotus* Strain [89]

Fatty acid compositions						
***Pleurotus* strain**	**C16:0**	**C16:1,n-9**	**C18:0**	**C18:1,n-9**	**C18:2, n-6**	**others**
P. abalones LGM 39	18.43	2.61	6.50	21.37	49.43	1.68
P. abalones PO 37	25.33	3.70	5.43	25.18	38.66	1.70
*P. calyptratus*MUCL 28909	16.05	1.23	6.69	12.27	61.26	2.51
P. columbinus CBS 37351	22.24	1.29	4.24	13.20	57.50	1.53
P. cornucopiae ATCC 38547	18.59	0.59	3.76	5.57	68.46	3.04
P. cystidiosus ATCC 28597	16.59	1.98	3.81	36.39	38.59	2.66
P. cystidiosus ATCC 28597	32.17	32.1	3.72	6.92	20.49	33.26
*P. eryngii*CBS 10082	15.17	0.21	5.15	46.87	30.84	1.76
P. eryngii LGM 850404	15.79	0.42	3.87	43.97	34.92	1.04
P.ostreatus LGM 40	22.78	0.02	8.99	23.28	42.76	2.17
P. ostreatus LGM 861008	15.01	0.52	4.25	12.76	65.48	1.98
P. pulmonarius CBS 13385	19.61	1.37	12.94	13.37	49.31	3.41
P. pulmonarius ATCC 34682	12.29	2.73	6.01	17.22	59.19	3.41
P.sajor-caju MUCL 29148	22.83	1.34	14.46	13.13	45.42	2.84
P.sajor-caju LGM 851003	25.10	1.32	11.58	12.17	46.38	3.46
P. sapidus ATCC 29986	14.91	1.44	9.63	21.40	52.62	-

Note: C 16:0 palmitic acid; C16:1 palmitoleic acid; C18:0 stearic acid; C 18.1, oleic acid; C18,2, linoleic acid.

3.8. Soluble Sugar

Myo-inositol was found in the highest amounts only in *P. ferulae* mushrooms (3.69 and 34.31 mg/g weight) (Table **14**). Usually, glucose, mannitol and trehalose were established in several species of *Pleurotus*. Mannitol and trehalose are the main representatives of alcoholic sugars and oligosaccharides, respectively [77]. The contents vary widely both among species and probably within individual species. This could be seen in *P. ostreatus, P. ferulae, P. sajor-caju* and *P. cystidiosus* where most of the soluble sugar presences are glucose and mannose. In mushrooms, soluble sugars controlled contributed a sweet or sugary taste. Carbohydrates constitute about one-half of mushroom dry mass. The group comprises various compounds: sugars (monosaccharides, their derivatives and oligosaccharides) and both reserve and construction polysaccharides (glycans).

3.9. Volatile Compounds

The aroma of mushrooms came from volatile compound it possessed. In the food nourishment, one of the most important consumer acceptances evaluating dishes is the flavor of the foods itself. Mushrooms contain typical volatile of aromatic compounds. The most important components are terpenes including hydrocarbons formed from isoprene unit, open chain, closed chain, cyclic, saturated and unsaturated fatty acids [91].

Table **15** presented the isolated volatile flavor compounds found in edible mushroom of *Pleurotus* species were 3-octanone, 1-octen-3-one, 3-octanol, 1-octen-3-ol, benzaldehyde, 1-octanol and 2-octen-1-ol. Benzaldehyde was recognized as the major compound in 2 type fruiting bodies of *P. eryngii*. Other studies also reported that 1-octen-3-one were the major volatile absent in *P. florida, P. ostreatus* and *P. Sajor-caju*. These compounds obtained from the mushroom species is not very important as nutritional, but only provide aroma, to gives mushrooms dishes a characteristic flavor [69, 92]. Table **16** shows the estimated main volatile compounds of *Pleurotus* species by the % Area of volatile compounds in the chromatogram. Two prominent volatile compounds in

Table 14: Soluble Sugar Composition of *Pleurotus* Species

Sugar	Content (mg/g dry weight)						
	P. djamor	*P. refulae*	*P. nebrodensis*	*P. sapidus*	*P. ostreatus*	*P. ferulae*	*P. cystidiosus*
Glucose	1.47	3.39	6.85	7.25	10.6	13.2	11.6
Mannitol	3.65	10.10	9.33	9.91	3.60	31.6	24.6
Trehalose	4.25	6.68	7.51	14.8	2.73	33.3	28.6
Myo-inositol	9.37	20.2	23.7	31.9	1.27	34.0	Nd
Arabitol					18.2	24.1	Nd
Total						125	64.9
References	[52]	[52]	[52]	[52]	[77]	[90]	[77]

Table 15: Volatile Compounds in the *Pleurotus* Species

Compound	*P. eryingii* Large fruiting body	*P. eryingii* small fruiting body	*P. ostreatus* using CCl_4 extraction
	µg/g fresh wt.	µg/g fresh wt.	µg/g fresh wt.
3-octanone	0.27A	0.29A	136
1-octen-3-one	0.20 A	0.07B	217
3-octanol	0.10B	0.14A	558
1-octen-3-ol	0.03B	0.03B	2800
benzaldehyde	26.75 A	15.61B	256
1-octanol	1.05 A	0.83A	
2-octen-1-ol	0.70 A	0.81A	
total	29.10 A	17.78B	
References	[69]	[69]	[93]

Table 16: Estimated Main Volatile Compounds of *Pleurotus* Species Obtained by Comparing GS–MS Library Catalog [94]

Volatile compound of *P. ostreatus*	a%	Volatiles compounds of *P. sajor-caju*	a%
1-Dodecanal-lauraldehyde	1.97	2,5-Dimethyloctane	12.1
1,2-Di(choloroacetoxy) octane	2.56	4-Ethyloctane	3.68
Octadecanoic acid	1.74	N-octan-3-ol	3.19
Nonadecanoic acid	26.28	2-Methoxythiozole	3.44
2-Nitrocyclooctanone	5.58	Hexadecanoic acid–palmitic acid	31.61
9,12-Octadecadien-1-ol	24.64	3,4-Dimethyldecane	4.01
Cis-Linoleic acid methyl ester	13.11	Octadecanoic acid	6.12
Akuammilan-17-ol	2.04	9-Hexadecenoic acid, 9-hexadecenyl ester	9.37
Hexadecadienoic acid, methyl ester	5.66	9-Dodecenol	4.32
		Palmitic acid, (2-tetradecyloxy)ethyl ester	14.92
		9-Octadecanoic acid–octadecyl ester	5.59

* a% Area of volatile compounds in the chromatogram.

P. ostreatus are Nonadecanoic acid and 9,12-Octadecadien-1-ol with value of 26.28% and 24.64% respectively. On the side of *P. sajor-caju,* the highest area percentage of volatile compound is hexadecanoic acid–palmitic acid of 31.61%.

CONCLUSIONS

The mushrooms belong to *Pleurotus* spp. are highly diversified group and distributed world-wide. Almost all mushrooms belong to this species are edible and used in different culture as potential source of food and medicines. They are rich of large amount of essential nutrients such as carbohydrates, proteins, vitamins, amino acids, fiber, in organic elements, lipid and volatile active compounds. Thus, they are considered as one of the richest well-balanced source for human nutrition and widely human food and nutraceutical industries. In addition they are able to grow on almost all agro-industrial waste based on their high ability to degrade lignocellulosic material. This make them more attractive component of any waste to wealth programs. In spite of many research done in identification, cultivation, and nutritional profiling of *Pleurotus* spp., studies are required to integrate the knowledge between the mushroom species, ability to degrade different types of lignocellulosic wastes, and the nutritional value of the grown mushroom. This will help for sure to increase our knowledge and awareness to improve the current application of this type of healthy food in both fresh and processed form.

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