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On the Chemical Composition and Nutritional Value of *Pleurotus* Taxa Growing on Umbelliferous Plants (Apiaceae)

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Unpublished data on the chemical composition and nutritional value of *Pleurotus* mushrooms, growing on Umbelliferous plants (*Apiaceae*), are here reported. Cultivated basidiomata of four different *Pleurotus* taxa were analyzed in order to evaluate the composition in lipids, sugars, nitrogen, water, vitamins, ashes, and energetic values. The results showed that *Pleurotus* mushrooms are suitable in every type of diet thanks to their low caloric content, gastronomic value, vitamins, and mineral salt contents. The presence of a high content of vitamin B_{12} and riboflavin in *Pleurotus nebrodensis* is noteworthy.

KEYWORDS: Chemical composition; *Pleurotus*; *Apiaceae*

INTRODUCTION

The genus *Pleurotus* (Fr.) P. Kummer includes edible mushrooms of valuable organoleptic properties, some of them cultivated on a wide number of lignocellulosic wastes. In Sicily (southern Italy), a special group of *Pleurotus* taxa, growing as saprobes on Umbelliferous plants (*Apiaceae*) root residues, was recently studied by Venturella et al. (*1*, *2*). In the frame of a research project, coordinated by one of the authors (G.V.), different isolates from spontaneous basidiomata of *Pleurotus eryngii* (DC.: Fr.) Quélet var. *eryngii*, *P. eryngii* var. *elaeoselini* (*1*), *P. eryngii* var. *thapsiae* (*2*), and *Pleurotus nebrodensis* (Inzenga) Quélet were cultivated *ex situ* in order to evaluate the productivity and the nutritional value of their basidiomata (*3*, *4*).

The high percentage of linoleic and linolenic acids in *Pleurotus* basidiomata and the nutritional value of cultivated *P. nebrodensis* from Central Italy was reported by Coli et al. (*5*), but the mentioned authors erroneously analyzed as *P. nebrodensis* some samples of mushrooms belonging to a different taxon, morphologically similar to *P. nebrodensis*, recently described as *P. eryngii* var. *elaeoselini* by Venturella et al. (*1*). *P. nebrodensis* is clearly separated from all of the taxa belonging to the so-named "*P. eryngii* species complex" in consideration of its morphological, ecological, and genetic features.

Palazzolo and Venturella (*6*) analyzed the chemical composition of wild and cultivated basidiomata of *P. nebrodensis* from Sicily in comparison with other wild and cultivated mushrooms. The authors demonstrated that *P. nebrodensis* keeps the same chemical composition in the wild and cultivated basidiomata. This paper is devoted to the evaluation of the chemical composition and nutritional value of cultivated *Pleurotus* mushrooms, the wild relatives of which grow on Umbelliferous plants (*Apiaceae*) in Sicily.

MATERIALS AND METHODS

The basidiomata of different *Pleurotus* species were cultivated in some localities of Sicily. The growth substrate was prepared with wheat straw and residues of sugar beet processing, pasteurized in thermoresistant polypropylene sacks with a capacity of 4 kg, inoculated with spawn, and then incubated at 25 °C. At the end of the incubation period, the sacks were placed in rows in ridges dug in the ground (dimensions: 3 m × 1 m × 0.2 m). After opening, the sacks were covered with 2−3 cm of soil, and the beds were covered with a black shading net fitted on metal arches. Periodically, beds were lightly irrigated to maintain the right degree of humidity. Eight to 10 days after planting, under optimal climatic conditions, the mushrooms began to appear in the beds, and the first harvest started after 18−20 days. After approximately a week, other mushrooms sprouted, which were ready to harvest in about 10 days. Mushroom production happened in two periods, the first of which represented approximately 70−80% of total production. Under optimal conditions, production levels were on a par with approximately 28−30% of the weight of the compost. Production was approximately 15−18 kg of mushrooms per square meter and varied from 0.5 to 1.5 kg per bag of compost. The production cycle exhausted itself after about 45 days.

The whole basidiomata of cultivated *P. eryngii* var. *eryngii*, *P. eryngii* var. *elaeoselini*, *P. eryngii* var. *thapsiae*, and *P. nebrodensis*, corresponding to approximately 2 kg per samples, was collected and analyzed by NEOTRON concern (Modena, Italy) in order to evaluate, according to their standard methodology of analysis, the composition in lipids, sugars, nitrogen, water, vitamins, ashes, and energetic values of mushrooms. In particular, the vitamin A content was determined by direct saponification of the sample and then extraction of the unsaponificable part with petroleum ether and hexane. A liquid chroma-

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tography detection (HPLC) with UV detector on inverse phase column was carried out (*7*−*10*). The energetic value was obtained after determination of lipids, proteins, and carbohydrates, by computation expressed in kcal or kJ per 100 g of mushroom. The Kjeldahl method was used for proteins determination. In particular, a sample rate was submitted to acid-catalyzed mineralization to turn the organic nitrogen into ammoniacal nitrogen. The ammoniacal nitrogen was distilled at alkaline pH. The ammonia formed during distillation was collected in a boric acid solution and determined through titrimetric dosage. The value of ammoniacal nitrogen was multiplied by 6.25 [internal method, NEOT-DIR/002/07(S51); sensible limit, 0.1 g/100 g], accredited procedure Sistema Nazionale per l'Accreditamento dei Laboratori di Prova (SINAL). The fats content was obtained by acid hydrolysis with a 1:4 HCl solution on sample followed by filtration and drying in heater (70 °C). Extraction in Soxhlet with petroleum ether and, after solvent evaporation, determination by gravimetric method of residual fat were also carried out [internal method, NEOT-DIR/002/07(S52), report ISTISAN 96/34, limit of quantification = 0.1 g/100 g (accredited procedure SINAL)]. The carbohydrates content was obtained subtracting 100 to mushrooms water, ashes, fats, proteins, and dietary fiber contents [internal method, NEOT-DIR/002/07(S56); limit of quantification = 0.1 g/100 g (accredited procedure SINAL)]. As regards the water content, the sample was exsiccated, in the presence of sand, in a heater at 105 °C for 6−8 h. The water content was obtained by a ponderable way [internal method, NEOT-DIR/002/07(S49), limit of quantification = 0.1 g/100 g (accredited procedure SINAL)]. The ashes content was determined through a 5 g sample rate. The sample was weighed in a capsule of porcelain, calibrated at 600 °C, and heated at 150 °C for 6−8 h. Afterward, the sample was burned on flame and then in a muffle at 600 °C for 6−8 h. The ashes content was obtained by quantitative determination of the residual product [internal method, NEOT-DIR/002/07(S48), limit of quantification = 0.1 g/100 g (accredited procedure SINAL)]. The determination of biotin was carried out by extraction of the sample rate with a phosphate-buffered saline (PBS) buffer (pH 7.2). The ascorbic acid was removed before the measurement by incubation for 15 min with a special "spatula ascorbate−oxidase". The amount of biotin was determined on the extract filtrate by immunoenzymatic assay (ELISA) [(Kit Ridascreen Biotin−r-biopharm); Limit of quantification = 0.012 μg/100 g (1 g of sample in 10 g)]. As regards vitamin B_{12}, a sample rate was extracted in water warmed up at 100 °C for 5 min. The dosage of vitamin B_{12} was made by immunoenzymatic assay (ELISA) on the filtrate extract and conveniently diluted with PBS buffer. The exceeding vitamin C content (more than 10 μg/g or μg/mL) was removed before the dosage by incubation for 15 min with a special spatula ascorbate−oxidase (Kit Ridascreenfast Vitamin B12, r-biopharm, limit of quantification = 0.5 μg/100 g). An enzymatic method was used for L-ascorbic acid determination. In particular, a sample rate was extracted by metaphosphoric acid (15% p/v) and subsequent correction at pH 3.5−4. The dosage of L-ascorbic acid was carried out on filtrate extract by enzymatic way. At pH 3.5 and in the presence of PMS (5-methylphenazonium methylsulfate), the L-ascorbic acid was able to reduce the tetrazolium salt [3-(4,5-dimethyl-2-thiazolyl)-2,5-diphenyltetrazolium bromide, MTT] at MTT-formazan. Simultaneously, in a standard test, the L-ascorbic acid was removed by oxidation with ascorbate−oxidase in the presence of oxygen. The difference of absorbance between the sample and the standard, measured at 578 nm, is proportional to the amount of l-ascorbic acid of the sample and the produced amount of MTT-formazan (Kit L-ascorbic acid, Boehringer Mannheim, limit of quantification = 15 mg/kg). A sample was hydrolyzed with lipase in acidic pH and extracted with pentane in basic pH in order to obtain the vitamin K_1. Besides, after purification in HPLC, the vitamin K_1 was identified in HPLC with a diode array detection (DAD) detector (*11*). The determination of pantotenic acid was carried out by formation of pantolactone by boiling with 25% HCl. After extraction with dichloromethane, the compound was purified on silica gel column and determined by mass gas chromatography (*12*). The thiamine content was obtained by extraction in 0.1 N HCl and oxidation by thiochromium and analysis in HPLC with fluorometric detection (*13*, *14*) [accredited procedure, NEOT-DIR/002/07(S43)]. The riboflavin was extracted in an autoclave with a solution of diluted H_2SO_4. After enzymatic treatment, the riboflavin was determined by HPLC (for fluorescence spectra) (*15*) [accredited procedure, NEOT-DIR/002/07(S44)]. As regards vitamin D_3, the sample was hydrolyzed with KOH and the vitamin D_3 content in the unsaponificable was extracted by petroleum ether. The vitamin D_3, after purification on alumina and in HPLC, was determined in HPLC with a DAD detector on an inverse phase column (*7*, *8*, *10*, *16*−*20*) [accredited procedure, NEOT-DIR/002/07(S58)]. The niacin was extracted from the sample in acidic solution at 121 °C for 30 min and measured out by a microbiological method. The titrator strain was *Lactobacillus plantarum* ATCC 8014. The test was carried out in a liquid cultur medium with all of the indispensable factors for the growth of *L. plantarum* with the exclusion of the examined vitamin. The presence of niacin in the sample caused a proportional increase of growth of *L. plantarum* after 24 h of incubation at 37 °C. The growth is evaluated by turbidimeter and compared with the values of standard curve prepared in parallel to the test (unit, mg/100 g or mg/100 mL; limit of quantification, 0.05 mg/100 g, internal method, NEOTRON). As regards vitamin E, the sample was hydrolyzed with KOH refluxed for 45 min. The α-tocopherol in the unsaponificable was extracted with petroleum ether and determined in HPLC on an inverse phase column (for fluorescence spectra) (*16*, *18*−*22*) [accredited procedure, NEOT-DIR/002/07(S45)].

The results were compared with data on edible mushrooms reported by Coli et al. (*5*), Souci et al. (*23*), and Carnovale and Marletta (*24*). Besides, each vitamin content (in a 250 g helping of mushroom) was compared with the recommended dietary allowances (RDA) fixed by the Italian Society of Human Nutrition (*25*) for the Italian population. The herbarium specimens of the investigated *Pleurotus taxa* are kept in the *Herbarium Mediterraneum* (PAL).

RESULTS AND DISCUSSION

Because of the genetic origin of isolates, the environmental factors (i.e., type of substratum, climate, etc.), and the methodology of cultivation, the references on the chemical composition and nutritional value of fungi are currently scarce or extremely discrepant. Besides, cultivated mushrooms shows metabolic activities also in the postharvesting phase (*26*).

In comparison with vascular plants, fungi are considered a good source of mineral salts and vitamins such as B_1, B_2, B_6, B_{12}, D, H, niacin, and pantothenic acid (*27*). Nevertheless, information on nutritional value of fungi is mainly available for "champignons" (*Agaricus bisporus*) and "oyster mushroom" (*Pleurotus ostreatus*) (*28*).

The evaluation of mushrooms nutritional value is related to the analysis of their composition. The comparison between the composition of *Pleurotus* growing on Umbelliferous plant (**Table 1**) and the data reported in the literature, referred to other edible fungi (**Tables 2**−**4**), showed very interesting nutritional characters in the former group. The comparison between vitamin contents in a helping of mushrooms and the corresponding RDA for the Italian population showed that the investigated *Pleurotus taxa* are a very good source of vitamins (**Table 5**).

The mushroom's water content is related to cultivation and postharvesting techniques, and as shown in **Table 2**, it varies from 75.5 to 92.9% (*5*, *23*, *24*). The water contents in *P. eryngii* var. *elaeoselini* and *P. eryngii* var. *thapsiae* are 93.3 and 95.6 g per 100 g, respectively (**Table 1**). The latter value is higher than the value reported by Bano and Rajarathnam (*28*) for *Pleurotus* mushrooms.

Referring to the dry weight, Bano and Rajarathnam (*28*) reported a protein content of 8.9% in *Pleurotus opuntiae* and 38.7% in *Pleurotus limpidus* and an average value of 19.8%. As regards *P. nebrodensis*, Coli et al. (*5*) reported a protein content of 1.2−1.28 g per 100 g of fresh matter corresponding to 11.5−12.2% of dry weight. Because the substratum used for mushrooms cultivation shows a significant influence on *Pleurotus* protein contents and, usually, the absolute amount of

Table 1. Composition of *Pleurotus* Taxa from Sicily

taxa	amount per 100 g	taxa	amount per 100 g
	water (g)		
P. eryngii var. *thapsiae*	95.6	*P. eryngii* var. *eryngii*	93.5
P. eryngii var. *elaeoselini*	93.3	*P. nebrodensis*	93.8
	proteins (g)		
P. eryngii var. *thapsiae*	1.92	*P. eryngii* var. *eryngii*	1.73
P. eryngii var. *elaeoselini*	1.59	*P. nebrodensis*	1.58
	lipids (g)		
P. eryngii var. *thapsiae*	0.43	*P. eryngii* var. *eryngii*	0.56
P. eryngii var. *elaeoselini*	0.30	*P. nebrodensis*	0.39
	carbohydrates (including dietary fiber) (g)		
P. eryngii var. *thapsiae*	1.28	*P. eryngii* var. *eryngii*	3.34
P. eryngii var. *elaeoselini*	4.23	*P. nebrodensis*	3.22
	ashes		
P. eryngii var. *thapsiae*	0.77	*P. eryngii* var. *eryngii*	0.87
P. eryngii var. *elaeoselini*	0.58	*P. nebrodensis*	1.01
	vitamin D_3 (μg)		
P. eryngii var. *thapsiae*	0.33	*P. eryngii* var. *eryngii*	0.30
P. eryngii var. *elaeoselini*	0.49	*P. nebrodensis*	0.26
	thiamine (mg)		
P. eryngii var. *thapsiae*		*P. eryngii* var. *eryngii*	
P. eryngii var. *elaeoselini*		*P. nebrodensis*	0.027
	riboflavin (mg)		
P. eryngii var. *thapsiae*	0.15	*P. eryngii* var. *eryngii*	0.199
P. eryngii var. *elaeoselini*	0.146	*P. nebrodensis*	0.29
	niacin (mg)		
P. eryngii var. *thapsiae*	4.7	*P. eryngii* var. *eryngii*	5.9
P. eryngii var. *elaeoselini*	4	*P. nebrodensis*	5
	pantotenic acid (mg)		
P. eryngii var. *thapsiae*	0.887	*P. eryngii* var. *eryngii*	0.532
P. eryngii var. *elaeoselini*	0.393	*P. nebrodensis*	0.519
	pyridoxin (μg)		
P. eryngii var. *thapsiae*	48	*P. eryngii* var. *eryngii*	45
P. eryngii var. *elaeoselini*	38	*P. nebrodensis*	44
	biotin (μg)		
P. eryngii var. *thapsiae*	8.4	*P. eryngii* var. *eryngii*	7.45
P. eryngii var. *elaeoselini*	5.1	*P. nebrodensis*	18.3
	vitamin B_{12} (μg)		
P. eryngii var. *thapsiae*	0.44	*P. eryngii* var. *eryngii*	1.7
P. eryngii var. *elaeoselini*	0.43	*P. nebrodensis*	1.93

proteins in fungal species is not relevant, we considered enough, according to Fidanza and Liguori (*29*), to assess the protein contents of *Pleurotus* growing on Umbelliferous plants (**Table 1**) multiplying the total nitrogen content for 6.25.

The protein content of *P. eryngii* var. *thapsiae* (**Table 1**) corresponds to 1.92 g per 100 g (i.e., 43.6% of dry weight), while lower values are shown by *P. eryngii* var. *eryngii* (1.73 g, i.e., 26.6% of dry weight). The protein contents of *P. eryngii* var. *elaeoselini* (1.59 g, i.e., 23.7% of dry weight) and *P. nebrodensis* (1.58 g, i.e., 25.5% of dry weight) are almost identical and very close to data reported for other edible mushrooms (**Table 2**) by Souci et al. (*23*) and Carnovale and Marletta (*24*).

Referring to the essential amino acids contents (**Table 3**) reported in the literature, it is worthy of note that, because of their lack of essential amino acids, the protein content of mushrooms is scarce.

In many mushrooms, fat contents vary from 1.08 to 9.4% of dry weight, and oleic acid (79.4%) prevails over stearic acid (24%), palmitic acid (14.3%), and linoleic acid (6.3%).

Prakash et al. (*27*) reported the presence of ergosterolsqualene (free and esterificated) and ubiquinone 7, while Souci et al. (*23*), Carnovale and Marletta (*24*), and Coli et al. (*5*) pointed out a

Table 2. Composition in Proteins, Carbohydrates, Fats, Dietary Fiber (g/100 g of Edible Part), and Energy Value of Some Species of Mushrooms

	water	proteins	fats	carbohydrates	dietary fiber	calories
Agaricus bisporus[a]	90.7	2.7	0.2	0.7	1.9	15.4
Armillaria mellea[a]	89.0	1.6	0.7	0.1	7.6	13.1
Boletus edulis[a]	88.6	2.8	0.4	0.5	6.9	16.8
Cantharellus cibarius[a]	91.5	1.5	0.5	0.2	5.6	11.3
Lactarius deliciosus[a]	89.8	1.9	0.7	0.1	6.9	14.3
Leccinum aurantiacum[a]	92.3	1.4	0.8		4.7	12.8
Leccinum scabrum[a]	88.5	2.5	0.6		7.3	15.4
Morchella esculenta[a]	90.0	1.7	0.3		7.0	9.5
Suillus luteus[a]	91.1	1.7	0.4	0.3	5.9	11.6
Tuber melanosporum[a]	75.5	5.5	0.5		16.5	26.5
Pleurotus ostreatus[b]	88.4	2.2	0.3	4.5	0.7	28
Amanita caesarea[b]	92.9	2.0	0.3			
Boletus edulis[b]	92.0	3.9	0.7	1.0	2.5	26
Agaricus campestris[b]	90.4	3.7	0.2	0.8	2.3	20
Tuber melanosporum[b]	75.8	6.0	0.5	0.7	8.4	31
Pleurotus eryngii (three stocks average)[c]	89.3	1.3	0.7	3.7	3.8	29.7
P. eryngii var. *elaeoselini*[c] (erroneously reported in the literature as *P. nebrodensis*)	89.5	1.6	0.7	3.4	3.0	29.9
Pleurotus ostreatus (two stocks average)[c]	88.7	1.8	0.4	2.6	4.5	26.6
Pleurotus nebrodensis (two stocks average)[c]	89.9	1.2	0.7	3.3	3.2	26.0

[a] From ref *23*. [b] From ref *24*. [c] From ref *5*.

Table 3. Essential Amino Acids Content (mg/g of Protein)[a] of Some Mushrooms and Comparison with Essential Amino Acids Content of the Reference Protein (Refs *35* and *36*)

	Lys	His	Thre	Val	Cys + Meth	Ileu	Leu	Tyr + Phe	Trp
ref protein	58	19	34	35	25	28	66	63	11
Leccinum scabrum[b]	16.5	6.5	32.7	19.8	22.6	12.1	39.9	52.0	7.3
Agaricus bisporus[b]	62.0	20.8	31.8	32.8	13.5	40.1	43.8	51.1	8.8
Cantharellus cibarius[b]	25.7	19.7	85.5	40.8	84.2	25.7	72.4	114.5	31.6
Leccinum aurantiacum[b]	67.6	31.7	40.7	37.2	68.3	20.7	75.9	82.8	19.3
Pleurotus ostreatus[c]	60.0	22.7	52.7	52.3	23.6	40.5	78.2	79.1	23.2
Boletus edulis[c]	39.5	20.0	46.4	36.7	27.9	27.9	53.1	46.9	9.7
Pleurotus eryngii (three stocks average)[d]	35.7	8.2	23.5	31.9	12.0	22.6	36.0	35.4	10.6
P. eryngii var. *elaeoselini*[d] (reported in the literature as *P. nebrodensis*)	54.9	14.0	37.2	48.3	13.5	36.0	59.0	58.6	13.1
Pleurotus ostreatus (two stocks average)[d]	48.1	11.8	26.1	35.7	13.7	27.5	45.0	43.7	13.3
Pleurotus nebrodensis (two stocks average)[d]	35.3	10.1	19.7	27.4	13.4	21.2	28.3	31.2	9.3

[a] In refs *23* and *24*, each amino acid content is formulated in mg (or g) per 100 g of food (edible part). To formulate them in mg per g of protein, we divided their value by the amount of protein (in g) of the corresponding food indicated in the same bibliographic reference. In ref *5*, each amino acid content is formulated in g/16 g of nitrogen, i.e., applying the conversion factor 6.25, g/100 g of proteins. To formulate them in mg per g of protein, we multiplied their values per 10. [b] From ref *23*. [c] From ref *24*. [d] From ref *5*.

lipid content lower than 1 g per 100 g in different mushrooms including *Pleurotus taxa* (**Table 2**).

As regards *Pleurotus* on Umbelliferous plants (**Table 1**), the lipid content is low and varies from 0.3 g per 100 g (i.e., 4.5% of dry weight) in *P. eryngii* var. *elaeoselini* to 0.56 g per 100 g (i.e., 8.4% of dry weight) in *P. eryngii* var. *eryngii*.

In *Pleurotus* mushrooms, carbohydrates are represented by sugars utilizable by human organisms as energy sources, and chitin and emicellulose (mainly hexosanes). The latter belongs to the "dietary fiber" that increase the intestinal motility and

Table 4. Mineral Content (in 100 g of Edible Part) of Some Species of Mushrooms

	mg								μg			
	Na	K	Fe	Ca	P	Mg	Zn	Cu	Se	Mn	Ni	Cr
Agaricus bisporus (*Champignon*)[a]	8	422	1.3	8	123	13	0.39	0.40	7	110	2	7
Armillaria mellea[a]		440	0.9	7		12.5				160		
Boletus edulis[a]	6	486	1.0	23	115	12	0.70	0.23	100	170	10	5
Cantharellus cibarius[a]	3	507	6.5	8	44	14	0.65		0.4	180	10	4
Lactarius deliciosus[a]	6	310	1.3	6	74	8				300		
Leccinum aurantiacum[a]		314		30		9						
Leccinum scabrum[a]	2	346	1.6		115					740		
Morchella esculenta[a]	2	390	1.2	11	162	11				450		
Suillus luteus[a]		190	1.3	25		6				62		
Tuber melanosporum[a]	77	526	3.5	24	62	23.8						
Pleurotus ostreatus[b]			0.9		97							
Amanita caesarea[b]			1.1	17	89							
Boletus edulis[b]	52	235	1.2	22	142							
Agaricus campestris[b]	5	320	0.8	6	100	13	1.46	0.27	7.5			
Pleurotus eryngii (three stocks average)[c]	143	70	0.9	8	53	17.6	0.74	0.66				
P. eryngii var. *elaeoselini*[c] (erroneously reported in the literature as *P. nebrodensis*)	136	51	1.7	3	58	14.8	0.75	0.70				
Pleurotus ostreatus (two stocks average)[c]	163	201	2.0	5	99	15.9	0.95	1.15				
Pleurotus nebrodensis (two stocks average)[c]	179	46	1.3	5	51	16.9	0.61	0.60				
Pleurotus nebrodensis (wild basidiomata)[d]	100	104	5.0	5	95	13.5						
Pleurotus nebrodensis (cultivated basidiomata)[d]	57	57	3.2	4	51	6.6						

[a] From ref *23*. [b] From ref *24*. [c] From ref *5*. [d] From ref *6*.

satiety and modulate the absorption of many nourishing elements. According to Bano (*30*), the carbohydrate content in *Pleurotus* species varies from 46.6 to 81.8% (60% in *Agaricus bisporus*) of dry weight. These data were also confirmed by Coli et al. (*5*).

As reported in **Table 1**, the carbohydrates (including "dietary fiber") are mainly represented in *P. eryngii* var. *elaeoselini* (4.23 g per 100 g, i.e., 63.1% of dry weight) and progressively decrease in *P. eryngii* var. *eryngii* (3.34 g per 100 g, i.e., 51.4% of dry weight), *P. nebrodensis* (3.22 g per 100 g, i.e., 51.9% of dry weight), and *P. eryngii* var. *thapsiae* (1.28 g per 100 g, i.e., 29.1% of dry weight). These values correspond to *Agaricus bisporus* and *Agaricus campestris* carbohydrate contents (i.e., carbohydrates plus dietary fiber in **Table 2**) but are lower if compared with other edible mushrooms (**Table 2**). Sometimes, according to different authors, the carbohydrate content is different within the same species (i.e., *Pleurotus ostreatus*, **Table 2**). It mainly depends on different factors such as temperature, humidity, type of soil, and type of basidiomata analyzed (spontaneous or cultivated); for this reason, we exactly assessed the content of each type of carbohydrate.

In consequence of their chemical composition (dearth of energetic compounds and low caloric content; suitable amount of dietary fiber and earlier satiety and unlikely constipation), fungi could be suggested also in diets for obese and/or diabetic people. Besides, their good taste increases the acceptance of the diets and improves the compliance in such patients.

As regards vitamins (*28*), the thiamine content reported for *Pleurotus* species varies from 1.16 to 4.80 mg per 100 g, a value not so much higher than the *A. campestris* thiamine content (*31*); the niacin content varies from 46 to 108.7 mg, while the content in ascorbic acid (from 90 to 144 mg per 100 g) is higher than the value reported in the literature for *A. campestris* (82 mg per 100 g).

Table 5. Vitamin Content in a Helping of Tested Mushrooms (250 g) and Met Rate of RDA of Each Vitamin

samples	amount in a helping	met rate of RDA[a] for an adult male
	vitamin D_3 (μg)	
P. eryngii var. *thapsiae*	0.825	5.5[b]
P. eryngii var. *elaeoselini*	1.225	8.2[b]
P. eryngii var. *eryngii*	0.75	5.0[b]
P. nebrodensis	0.65	4.3[b]
	thiamine (mg)	
P. eryngii var. *thapsiae*		
P. eryngii var. *elaeoselini*		
P. eryngii var. *eryngii*		
P. nebrodensis	0.07	5.8
	riboflavin (mg)	
P. eryngii var. *thapsiae*	0.375	20.8
P. eryngii var. *elaeoselini*	0.365	20.3
P. eryngii var. *eryngii*	0.5	27.8
P. nebrodensis	0.725	40.3
	niacin m (g)	
P. eryngii var. *thapsiae*	11.75	65.3
P. eryngii var. *elaeoselini*	10	55.6
P. eryngii var. *eryngii*	14.75	82
P. nebrodensis	12.5	69.4
	pantotenic acid (mg)	
P. eryngii var. *thapsiae*	2.22	18.5[c]
P. eryngii var. *elaeoselini*	0.98	8.2[c]
P. eryngii var. *eryngii*	1.33	11.1[c]
P. nebrodensis	1.3	10.8[c]
	piridoxin (μg)	
P. eryngii var. *thapsiae*	120	8
P. eryngii var. *elaeoselini*	90	6
P. eryngii var. *eryngii*	112.5	7.5
P. nebrodensis	110	7.3
	biotin (μg)	
P. eryngii var. *thapsiae*	21	21.0[c]
P. eryngii var. *elaeoselini*	12.75	12.7[c]
P. eryngii var. *eryngii*	18.625	18.6[c]
P. nebrodensis	45.75	45.7[c]
	vitamin B_{12} (μg)	
P. eryngii var. *thapsiae*	1.1	55.0
P. eryngii var. *elaeoselini*	1.075	53.7
P. eryngii var. *eryngii*	4.25	212.5
P. nebrodensis	4.825	241.2

[a] RDA of energy and nutrients for Italian people; revision 1996 by the Italian Society of Human Nutrition. [b] The recommended dietary intake for men with minimum endogenous synthesis has been considered. [c] In the absence of definite needs, the maximum value of security and suitability range has been considered.

Shivrina et al. (*32*) reported for *P. ostreatus* a vitamin B_{12} content corresponding to 1.4 mg per kg (dry weight). The data concerning the above-mentioned water soluble vitamins for the analyzed *Pleurotus* species are lower (**Table 1**) if compared with data reported from literature and similar to data reported by Souci et al. (*23*) and Carnovale and Marletta (*24*).

Pleurotus mushrooms growing on Umbelliferous plants also showed vitamin A, vitamin B_1, vitamin C, vitamin E, and vitamin K_1 undetectable contents while the niacin content varies from 4.0 to 5.9 mg. In a 250 g helping of mushrooms, such a high content is sufficient to satisfy the 55−82% of nicotinic acid RDA (**Table 5**).

P. nebrodensis showed the highest content of vitamin B_{12} and riboflavin (i.e., 241 and 40% of RDA in a 250 g helping of mushrooms, respectively, **Table 5**). The pantothenic acid content varies from 0.887 mg per 100 g in *P. eryngii* var. *thapsiae* and 0.393 mg in *P. eryngii* var. *elaeoselini* while *P. eryngii* var. *thapsiae* showed the highest content of vitamin B_6.

As reported in **Table 5**, the biotin content in *P. nebrodensis* is 18.3 μg corresponding to 46% of the maximum value of security and suitability range. The vitamin D_3 content varies from 0.26 μg per 100 g in *P. nebrodensis* to 0.49 μg per 100 g in *P. eryngii* var. *elaeoselini*. According to Ramsbotton (*33*), fungi could turn ergosterol into vitamin D under the ultraviolet radiation action. In consequence, *Pleurotus* on Umbelliferous plants showed a significant nutrition content of riboflavin, niacin, cyanocobalamin, and biotin.

The riboflavin and niacin contents are similar to those reported by Souci et al. (*23*) and Carnovale and Marletta (*24*) for other mushroom species. *P. nebrodensis* showed a very interesting content of vitamin B_{12}, a vitamin that is usually produced by fungi (*34*). Because the cyanocobalamin is absent in plant organisms, its presence in basidiomata could represent a suitable alternative in diets in which food of animal origin is less represented or, quite, the only source in the vegetarian feeding. Because a percentage of hydrosoluble vitamins is lost during cooking (*29*), it is advisable to cook mushrooms in small water using it in the preparation of dishes.

As regards the ashes content (**Table 1**), the highest value was reported for *P. nebrodensis* (1.01 g per 100 g) while lower contents are present in *P. eryngii* var. *eryngii* (0.87 g), *P. eryngii* var. *thapsiae* (0.77 g), and *P. eryngii* var. *elaeoselini* (0.58 g). In many edible mushrooms, potassium and phosporous are the main components of ashes and in *Pleurotus* species also, sodium is well-represented. Considering RDA, the contents of calcium and magnesium in many mushrooms are not significant while iron and copper are present in valuable amounts (**Table 4**, *35*, *36*).

In *Pleurotus* species, the iron content is high, particularly in spontaneous and cultivated basidiomata of *P. nebrodensis* (*6*); nevertheless, the iron available for absorption is less than one-third of total iron (*37*). In *Pleurotus* species, the copper content is also high and varies from 0.6 to 1.15 mg per 100 g of edible part (the RDA for copper is 1.2 mg per day).

Among the heavy metals, the zinc content is higher in the basidiomata than the substratum of cultivation so that, like other mushrooms (*38*), *Pleurotus* species are able to accumulate zinc in the basidiomata. As regards the mineral salts composition, the differences between *P. nebrodensis* spontaneous and cultivated basidiomata are not nutritionally relevant (*6*).

In conclusion, soon fungi could be considered as an important reserve of food for mankind and could obtain meaningful spaces in the local markets. According to data reported in this paper, *Pleurotus taxa* growing on Umbelliferous plants are suitable in every type of diet, including the hypocaloric, thanks to their low caloric content and gastronomic value. Besides, these fungi are a good source of vitamins and mineral salts.

ABBREVIATIONS USED

AOAC, International Official Methods of Analysis; DAD, diode array detector; HPLC, high-pressure liquid chromatography; MTT, 3-(4,5-dimethyl-2-thiazolyl)-2,5 diphenyltetrazolium bromide; PBS, phosphate-buffered saline; PMS, 5-methylphenazonium methylsulfate); RDA, recommended dietary allowances; SINAL, Sistema Nazionale per l'Accreditamento dei Laboratori di Prova.

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