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Original article

Macronutrients analysis of fresh and canned *Agaricus bisporus* and *Pleurotus ostreatus* mushroom species sold in Alexandria markets, Egypt

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Summary. *Background and aim:* There is a great demand for edible mushroom for its flavor and nutrient content. Mushroom became a new and alternative demand for poultry and animal protein and can be considered as a suitable solution to protein shortage all over the world especially in developing countries. The aim of this study was to analyze the macronutrient contents of fresh and canned *Agaricus bisporus* and *Pleurotus ostreatus* mushroom. *Materials and Methods:* Sixty fresh mushroom samples (30 of each of *Agaricus bisporus* (Button mushroom) and *Pleurotus ostreatus* (Oyster mushroom), in addition to 35 canned mushrooms (30 of *Agaricus bisporus* and five *Pleurotus ostreatus)* were analyzed for their moisture, ash, fiber, protein, fat and carbohydrate contents. *Results:* Fresh Agaricus mushrooms had significantly higher ash, protein and fat contents (8.7, 32.1 and 3.1 g/100g dry wt; respectively) than fresh Pleurotus (7.7, 20.0 and 2.5 g/100g dry wt) despite their lower carbohydrate contents (47.2 g/100g compared 61.1 g/100g). Fresh *Pleurotus* mushroom was higher in its macronutrients contents than canned *Pleurotus* except for fiber and carbohydrate where canned *Pleurotus* showed higher contents (8.4 and 66.0 g/100g; respectively for canned *Pleurotus* compared to 7.9 and 61.1 g/100g for fresh *Pleurotus)* with significant variations (P <0.05) only in case of carbohydrate contents. *Conclusion:* Macronutrients analysis of canned and fresh *Agaricus* and *Pleurotus* mushrooms revealed their high protein and fiber contents with a low-fat content making them healthy foods and alternatives for animal protein.

Key words: *Agaricus bisporus*, *Pleurotus ostreatus*, macronutrients

Introduction

Mushroom cultivation and consumption is increasing in this modern world. There is a great demand for edible mushroom for its flavor and nutrient content. Mushroom became a new and alternative demand for poultry and animal protein (1, 2). All over the world and especially in developing countries, there is a problem of shortage of protein. Producing cultured mushrooms can be one suitable solution to this problem; with immediately supply of additional protein to the human diet. Mushrooms are relatively fast-growing organisms. Some tropical mushrooms can be harvested and consumed within 10 days after spawning. It is possible to provide additional income to people living in the rural areas particularly working on wheat and rice agriculture (3, 4). More than 2000 species exist in nature (wild mushroom) but only about 22 species are extensively cultivated for commercial purposes (cultivated mushroom) and only a few mushroom species have been extensively cultivated on a commercial basis (1). In Egypt, only a minute proportion of fruit bodies sold in the markets and they are always either *Pleurotus* or *Agaricus* mushroom (5). Compared with vegetables, mushrooms are high in the quality of protein and have a good balance of vitamins and minerals. They contain little fat, making them suitable for low calories diets (3). Button mushroom has recently

gained attention as a "functional food" because of its unique nutrient profile and potential to confer functional properties. Mushrooms have been used for traditional foods and medicines in Asia. Generally, mushrooms are rich in dietary fiber, minerals, vitamins, and low in fat(6). Characteristically mushroom contains many different of bioactive compounds which have various degrees of immunomodulatory, lipid-lowering, anticancer and antiviral activity and other beneficial or therapeutic health effects without any significant toxicity, slowly down aging and promote the gonad function (7, 8). They prevent, inhibit obesity and regulate blood pressure and also enhance facial beauty, moisten the skin to postpone the appearance of age pigment; increase appetite, promote growth, build up immunity, and improve memory (9). Fresh mushrooms are known as a very perishable commodity, with a short shelf life, of 3-4 days (10). Being highly perishable in nature, the fresh mushrooms need to be processed to extend the off-season availability (11). Among the various methods employed for preservation, canning is the most frequently adopted method in commercial scale (12, 13). The aim of the present study was to analyze the macronutrient contents of fresh and canned *Agaricusbisporus* and *Pleurotusostreatus* mushroom species sold in Alexandria markets, Egypt.

Materials and methods

A total of 95 samples, 30 of each fresh *Agaricus* and *Pleurotus* mushrooms were purchased from various markets in Alexandria in addition to 35 of canned samples (30 samples from *Agaricus* obtained from different commercial brands of different countries of origin in addition to five samples from *Pleurotus* obtained from the only available commercial brand). Only five samples were collected from the canned *Pleurotus* since only one commercial brand was available in the market.

Determination of moisture content

It was carried out according to (Association of Official Analytical Chemists, 1999) (14) where five grams of the homogenized samples were weighed in moisture dishes and dried at temperature of 70 °C for 16-18 hours. This process was repeated until two successive constant weights were obtained and the moisture percentage was calculated.

Determination of ash content

It was carried out according to (Association of Official Analytical Chemists, 1999) (14) where two grams of the dried samples were weighed into porcelain crucible and ignited in a muffle furnace at 550°C until white ash was obtained. The crucible was transferred to a desiccator and left to cool and weighed. This process was repeated until two successive constant weights were obtained and the ash percentage was calculated.

Determination of crude fiber content

It was carried out as described by (Association of Official Analytical Chemists, 1990) (15) where two grams of the dried samples were digested by adding 200 ml of sulfuric acid (1.25%) and heated for 30 minutes after which the sample was filtered using Buchner funnel. The residues on the filter paper were washed several times by distilled water and transferred into a flask where they were digested by adding 200 ml sodium hydroxide (1.25%) and heated for 30 minutes and then filtered again. The remained residues on the filter paper was transferred to a dry and clean crucible that was placed in an oven and then dried for 2 hours at 105°C after which it was removed from the oven and placed in a desiccator, cooled for about 30 minutes and then weighed. The Crucible and its contents were ignited in a muffle furnace at 550-600°C until white ash was obtained. The crucible was transferred to a desiccator, allowed to cool and weighed. The process was repeated until two successive constant weights were obtained. The fiber percentage was calculated.

Determination of protein content

It was carried out using micro kjeldahl, according to (Association of Official Analytical Chemists, 1984) (16) where half gram of the dried samples was transferred into 250 ml kjeldahl digestion flask then 20 ml of the concentrated sulfuric acid and five grams digestion mixture (320 gm of potassium sulphate and 80 gm of copper sulphate) were added. The kjeldahl contents were heated for three hours and the flask was

allowed to cool. The content was transferred quantitatively using distilled water to 100 ml volumetric flask then 10 ml were used for distillation with 10 ml of 40% sodium hydroxide. The liberated ammonia was received in 25 ml of boric acid (2%) then titrated with (0.02 N) HCL using screened methyl red as indicator (0.016 gm methyl red dissolved with 0.083 gm bromocresol green in 100 ml alcohol). When the end point was reached as indicated by the appearance of the pink color, the volume of hydrochloric cid was recorded and the nitrogen percentage was calculated.

Determination of fat

It was carried out according to [Pearson, 1981] (17) where five grams of the dried samples were weighed in to a thimble that was introduced into the Soxhlet apparatus. The fat was extracted by using petroleum ether (40-60°C) for about 16-18 hours. After that the petroleum ether was evaporated from the extract and dried in an oven, cooled in a desiccator and then weighed. The fat percentage was calculated.

Determination of carbohydrate contents

Carbohydrate content was estimated by difference according to [Pearson, 1981] (17).

Carbohydrate% = 100 – [Moisture% + Ash% + Fat% + Protein% + Fiber%].

Statistical analysis (18)

Data was analyzed statistically using SPSS version 11.5 computer software. The cut off point for statistical significance was P value <0.05 and all tests were two-sided. Data were tabulated and presented in the form of arithmetic mean and standard deviation. Mann-Whitney test was used to compare the mean chemical composition between fresh and/or canned Agaricus and Pleurotus as well as between their two forms.

Results

The present study revealed that fresh Agaricus mushrooms had significantly higher ash, protein and fat contents (8.7, 32.1 and 3.1 g/100g dry wt; respectively) than fresh Pleurotus (7.7, 20.0 and 2.5 g/100g dry wt) despite their lower carbohydrate contents (47.2 g/100g compared 61.1 g/100g) (P<0.05). Also, although the variations in moisture and fiber contents were insignificant, fresh Agaricus had higher fiber contents. Concerning the canned mushrooms, *Agaricus* species were higher in their macronutrient contents except for their carbohydrate contents where canned cut *Pleurotus* showed significantly higher contents (P<0.05), in addition to similar fat contents (2.1 g/100g for each) (Table 1). Fresh *Agaricus* showed lower moisture, ash, and fiber contents, similar protein contents but higher fat and carbohydrate contents (88.4, 8.7, 8.9, 32.1, 3.1 and 47.2 g/100g; respectively) compared to the canned varieties (89.7, 14.3, 10.0, 31.5, 2.2, and 42.0 g/100g) with significant variations (P<0.05) between them only in their ash and carbohydrate contents. Fresh *Pleurotus* mushroom was higher in its macronutrients contents than canned *Pleurotus* except for fiber and carbohydrate where canned *Pleurotus* showed higher contents (8.4 and 66.0 g/100g; respectively for canned *Pleurotus* compared to 7.9 and 61.1 g/100g for fresh *Pleurotus)* with significant variations (P <0.05) only in case of

Table 1. Macronutrients content (mean ±SD) of different types and forms fresh Pleurotus and Agaricus mushroom

Types	Species	Form	NO. of samples	Moisture	Ash	Fiber	Protein	Fat	Carbohydrate
				(g/100g wet wt)	(g/100g dry wt)				
Fresh	***Pleurotus***		30	90.4 ± 1.5	7.7 ± 1.6^{a}	7.9 ± 2.1	20.0 ± 3.1^{ad}	2.5 ± 0.7^{a}	61.1 ± 4.2^{af}
	Agaricus		30	88.4 ± 4.4	8.7 ± 1.8^{adef}	8.9 ± 2.0	32.1 ± 3.6^{a}	3.1 ± 0.6^{adef}	47.2 ± 4.7^{ade}
Canned	***Pleurotus***	Cut	5	88.8 ± 10.2	6.2 ± 1.3^{bc}	8.4 ± 1.7	17.3 ± 2.3^{bcd}	2.1 ± 0.7	66.0 ± 3.6^{bcf}
	Agaricus	Cut	15	89.2 ± 3.8	13.4 ± 4.8^{bd}	10.0 ± 4.0	31.0 ± 6.5^{b}	2.3 ± 0.6^{d}	43.2 ± 8.9^{b}
		Whole	15	90.2 ± 3.0	15.2 ± 4.5^{ce}	10.0 ± 2.8	32.0 ± 3.8^{c}	2.1 ± 0.6^{c}	40.8 ± 7.0^{cd}
		ALL	**30**	**89.7 ± 3.4**	**14.3 ± 4.7** ^{f}	**10.0 ± 3.4**	**31.5 ± 5.2**	**2.2 ± 0.6**^{f}	**42.0 ± 8.0**^{e}

Cells with similar superscripts in the same column are significant (P <0.05)

carbohydrate contents. Egyptian canned cut *Pleurotus* had lower macronutrients contents than both Chinese and French cut and whole canned *Agaricus* except in its carbohydrate contents that were higher and fat contents that were more or less similar with significant variations (P<0.05) in case of ash, fiber, protein and carbohydrate contents (table 2).

Discussion

Moisture content

Edible mushrooms tend to be high in moisture indicating that they are highly perishable (19). Lower humidity levels during culture of mushroom promote moisture loss leading loss of weight and loss of thus economic value, mushroom senescence and undesirable textural changes but do not significantly reduce bacterial growth. High humidity levels favor microbial growth and enzyme activity which accelerates spoilage (20). The present study revealed that moisture contents of the two studied fresh mushroom species were insignificantly more or less similar ranging from 88.4% in *Agaricus bisporus* to 90.4% in *Pleurotus ostreatus* (P>0.05). There were insignificant variations (P>0.05). in the moisture contents between fresh and canned varieties of the same mushroom species and this may be attributed to whether the mushrooms were blanched during their canning or not as the highest losses take place when the mushroom was not blanched during canning process. Also, the longer storage of the canned mushrooms, the slightly higher will be their moisture contents (21). Other studies reported higher moisture contents in fresh *Agaricus bisporus* 90.2% (22), 92.3% (23), and 92.8 % (1) and in fresh *Pleurotus ostreatus* 94.7% (24) while lower moisture contents were reported by other studies, 82.8% (25) and 84.7% (26) for fresh *Agaricus bisporus* and *Pleurotus ostreatus*; respectively. Another study reported higher moisture contents in canned *Agaricus* (from 93.7 to 94.7% vs 89.2 and 90.2 in canned cut and whole canned *Agaricus*; respectively in the present study) but more or less similar moisture contents in canned *Pleurotus (*from 88.5 to 89.6% vs 88.8% in the present study) (27).

Ash content

The present study revealed that, fresh *Agaricus* had a significantly lower ash contents than canned varieties (8.7% and 14.3%; respectively) (P<0.05) whereas fresh *Pleurotus* contained insignificantly (P>0.05). higher ash content (7.7%) than its canned varieties (6.2%). Fresh *Pleurotus* contained significantly lower ash contents (7.7%) than fresh *Agaricus* (8.7%) (P<0.05). Also present study showed that, there was a significant difference between Chinese and France whole canned *Agaricus* (P<0.05). Ash content of fresh mushroom is affected by the substrate, as shown from the results of another study which found that *Pleurotus ostreatus* grown on rice straw with soy straw had almost the highest amount of ash (10.0%) as compared to that grown on rice straw, wheat straw or saw dust where the ash content ranged between 7.0 and 8.9% (27). Moreover, ash content of *Pleurotus ostreatus* grown on sugar waste ranged between 9 and 13% (28). Another study indicated that compared with *Agaricus bisporus*, *Pleurotus ostreatus* contained significantly lower levels of ash (29).

Table 2. Macronutrient content (mean ±SD) of different forms of canned Pleurotus and Agaricus mushroom according to their country of origin

Species	Form	Country of origin	NO. of samples	Moisture	Ash	Fiber	Protein	Fat	Carbohydrate
				(g/100g wet wt)	(g/100g dry wt)				
Pleurotus	Cut	Egypt	5	88.8 ± 10.2	6.2 ± 1.3^{ac}	8.4 ± 1.7^{a}	17.3 ± 2.3^{abcd}	2.1 ± 0.7	66.0 ± 3.6^{abcd}
Agaricus	Cut	China	10	89.3 ± 4.0	14.1 ± 5.3^{a}	8.9 ± 4.1	29.5 ± 5.3^{a}	2.2 ± 0.6	45.2 ± 8.1^{a}
		France	5	88.9 ± 3.9	12.0 ± 3.8	12.1 ± 3.0^{a}	34.2 ± 7.9^{b}	2.3 ± 0.6	39.3 ± 1.0^{b}
	Whole	China	10	89.2 ± 2.8^{a}	16.8 ± 4.0^{b}	9.9 ± 2.9	31.2 ± 3.0^{c}	2.0 ± 0.6	40.1 ± 4.7^{c}
		France	5	92.4 ± 2.0^{a}	11.9 ± 4.0^{bc}	10.3 ± 2.8	33.5 ± 5.2^{d}	2.2 ± 0.7	42.1 ± 11.0^{d}

Cells with similar superscripts in the same column are significant (P <0.05)

Fiber content

Dietary fibers play an important and healthful role in the history of human food supply. The people with low fiber diets had significantly more incidence of cancer, coronary heart disease, diabetes mellitus and obesity (30). The present study revealed that fresh *Agaricus bisporus* mushrooms had insignificantly higher fiber contents than *Pleurotus ostreatus* (8.9% and 7.9%; respectively) (P>0.05). Another study reported higher fiber contents in fresh *Pleurotus ostreatus* grown on soy straw (10.6%) and on rice straw (15.2%) (27) indicating the impact of the substrate on the fiber content of the mushroom. Other study reported various fiber contents 7.5-8.7% in fresh *Pleurotus ostreatus* (31) and 8.0-12.0% in fresh *Agaricus bisporus* (32). The present study showed that canned mushrooms varieties had insignificantly (P>0.05). higher fiber contents than fresh types (8.4% and 10.0% in canned *Pleurotus ostreatus* and *Agaricus bisporus*) with a significant difference between cut canned *Pleurotus ostreatus* and *Agaricus bisporus* from the origin Egypt and France (P<0.05). Another study reported similar results where canned *Pleurotus ostreatus* contained higher crude fiber contents (13.0%) than fresh varieties (11.9%) (26). Fiber contents of *Agaricus bisporus* increased from 10.4% in fresh to 12.4% for canned types, (33) and crude fiber of canned mushroom increased by storage (34).

Protein content

Estimates of the World Health Organization refer that the individual's average per capita of the animal proteins in Egypt is less than the world recommended average. The food problem in Egypt in general and lack of animal proteins in particular are considered as the greatest challenge before the Egyptian community particularly under the current economic situations (35). Protein constitutes more than half of the total nitrogen of mushrooms and their contents depend on mushrooms species, composition of the substrate, size of pileus and harvest time (36, 37). Mushrooms contain 19 to 35% protein as compared to 7.2% in rice, 13.2 % in wheat, 39.1% in soybean and 25.2% in milk on dry weight basis (35). The present study revealed that fresh *Agaricusbisporus* had significantly higher protein content than fresh *Pleurotus ostreatus* (32.1% and 20.0%; respectively) (P<0.05). Another study reported similar results where the fresh dried *Agaricus bisporus* had significantly (P<0.05) higher protein content than *Pleurotus ostreatus* (33.85% and 26.05%; respectively) (38). The present study revealed that fresh *Pleurotus ostreatus* had significantly higher protein contents than the canned varieties (20.0% and 17.3%; respectively) (P<0.05) also *Agaricus bisporus* showed the same trend (32.1% in fresh varieties compared to 31.5% in canned varieties) but without significant variation between them. Also there was a significant difference between canned *Pleurotus ostreatus* from the original of Egypt and the other forms of the other countries (P<0.05). Another study declared that the amount of protein various from 34%-44% of fresh *Agaricus bisporus*, while the amount of protein decreases gradually from 27.6% to 25.9% in its canned types (39, 40). The decrements of protein content of canned mushrooms may be attributed to its leaching out during blanching before canning process (41).

Fat content

Although mushrooms are low in fat, they contain unsaturated fatty acids that are considered essential for human health (2). Linoleic acid makes up 75% of the total fatty acids. This high content of linoleic acids is one of the reasons why mushrooms are considered a health food (37,42). The present study revealed that fat contents of fresh mushrooms species ranged from 2.5% in *Pleurotus ostreatus* to 3.1% in *Agaricus bisporus* with significant variation between them (P<0.05). Moreover, lower contents were found in canned *Pleurotus ostreatus* (2.1%) and *Agaricus bisporus* (2.2%), while there was insignificant difference between canned *Pleurotus ostreatus and Agaricus bisporus* in different origin and forms (P>0.05). Canning has slight decrement effect on fat content (27). Higher fat contents were reported by other study (5.3-7.3%) in *Pleurotus ostreatus* (28) and 6.5% in *Agaricus bisporus* (43), whereas lower fat contents (0.85%) were found in fresh *Pleurotusostreatus* grown on rice straw mixed with cotton straw reflecting the importance of the substrate on the fat content (44).

Carbohydrate content

Carbohydrate is one of the major constituents in mushrooms. Since mushrooms are devoid of starch,

the food is stored in a form of glycogen. Water soluble polysaccharides in the fruiting bodies of mushrooms have the ability to inhibit the growth of tumors (45). The present study revealed that fresh *Pleurotus ostreatus* contained significantly higher carbohydrate contents (61.1%) than fresh *Agaricus bisporus* (47.2%) ($P<0.05$) and carbohydrate content of canned *Pleurotus ostreatus* was insignificantly higher (66.0%) than fresh type (61.1%) ($P>0.05$) whereas canned *Agaricus bisporus* contained significantly lower contents (42.0%) than the fresh varieties (47.2%) ($P<0.05$) and there was a significant difference between canned *Pleurotus ostreatus* from the original of Egypt and the other forms and countries of canned *Agaricus bisporus* ($P<0.05$). Other studies reported various carbohydrate contents; 20.2% in *Agaricus bisporus* grown on wheat straw compost (43), 19.5 and 30% in fresh *Agaricus bisporus* and *Pleurotus ostreatus*; respectively (23), 41.6% in fresh *Agaricus bisporus,* (46) and between 51.94 - 61.77% in fresh *Pleurotus ostreatus* (47).

Conclusion

Macronutrients analysis of canned and fresh *Agaricus* and *Pleurotus* mushrooms revealed their high protein and fiber contents with a low-fat content making them healthy foods and alternatives for animal protein. Further researches are required to study the possibility of using mushrooms in low calories diets and in preventing diseases such as hypertension, hypercholesterolemia, diabetes, heart disease and cancer.

Author contributions

All authors have made full contribution to data acquisition, interpretation of results, drafting and revising the final manuscript. All authors read and approved the final manuscript.

Study limitations

Limited number of canned *Pleurotus ostreatus* samples were collected and analyzed due to *Pleurotus ostreatus* mushrooms are sold fresh only in Egypt.

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