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Comparative Study on the Main Chemical Composition of Button Mushroom's (*Agaricus bisporus*) Cap and Stipe

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ABSTRACT: Using agricultural waste is one of the best ways to reduce the costs and the environmental pollution. Button mushroom´s stipe is a cheap by-product that is rich in nutrients for human nutrition. The purpose of this study is to compare the nutritional value of cap and stipe of button mushroom (Agaricus bisporus). The caps were separated from the stipes after harvesting and parameters such as moisture, protein, carbohydrates, fat, fiber, ash, minerals (potassium phosphorus, calcium, iron and selenium) and the fatty acid compositions were determined. Atomic absorption was employed to determine Iron, potassium and calcium and hydride generation atomic absorption spectrophotometry and gas chromatography were used to determine selenium and fatty acid composition of the product respectively. The result indicated that the caps on average contained 90.76% moisture and total solid content consisted of 33.65% protein, 20.59% carbohydrate, 2.48% fat, 33.11% fiber and 10.17% ash while the stipes contained 90.01% moisture where the solid content consisted of 19.01% protein, 31.41% carbohydrate, 2.00% fat, 38.08% fiber and 9.5% ash. The analysis of the extracted lipid revealed that the major unsaturated fatty acid was linoleic acid, while the predominant saturated fatty acid was Palmitic acid in both cap and stipe. According to statistical analysis, significant differences ($p<0.05$) were obtained between the chemical composition of caps and stipes. The results also indicated that the amount of calcium content in the stipe is twice higher than cap (2.08 g/kg) and the amount of iron and linoleic acid in the stipe is significantly higher than cap ($p<0.05$). The cap of the mushroom has significantly higher concentration of protein ($p<0.05$) than the stipes. From statistical point of view, button mushrooms stipe, contains higher quantities of fiber and carbohydrate in comparison with cap ($p<0.05$), that could have useful health promotion effects. Therefore, this valuable product that is often considered as an agricultural waste might be employed as a rich source of nutrients in food industries.

Keywords: *Agricultural Waste, Button Mushroom, Cap, Chemical Compositions, Nutritional Value, Stipe.*

Introduction

By the increasing rate of population, supplying foodstuff specially protein foods have become one of the important issues that has attracted the attention of the governments, universities and research centers to carry out researches concerned with the application of alternative protein sources.

Edible mushrooms are one of the most valuable and least expensive source of protein that is of great importance in the world (Chang and Quimio, 1997). More than 2000 species of mushrooms exist in the nature; however, less than 25 species are widely accepted as foods. (Barros *et al*., 2007); Among the various mushrooms, button mushroom "Agaricus Bisporus" is the most common and is cultivated worldwide

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and totally accounts for 38% of the world edible mushrooms. The greatest producer of mushroom is China that produces more than one million tons a year (Hofrichter, 2010). The high nutritional value of button mushroom, along with good flavor, has increased the demand of this product. Mushrooms are categorized as healthy and valuable foodstuffs that contain combinations of protein, carbohydrates, minerals and vitamins (Olfati, 2009). Edible mushrooms contain fibers and some nutrients that have medicinal aspects; also they are poor source of carbohydrates and for this reason they can be included in the diet of people with diabetic disorder (Chang, 2004). In terms of morphology, edible mushroom has a stipe that holds the wide cap named pileus (Kalac, 2009). According to the findings, the stipe of button mushroom contains protein, fiber and high chitin (Vetter, 2007) and its calcium content is also considerable in comparison to the cap. At the present, most of the stipe of button mushroom is among the waste or it is consumed by animals.

Chang (1980) introduced the edible mushrooms as a healthy food for human. During researches about the different species of edible mushrooms, he concluded that the protein content in mushrooms is higher than fruits and vegetables. In most of researches the chemical compounds and nutritional value in the caps of the edible mushrooms have been evaluated (Mattila and Konko, 2001; Barros *et al*., 2007; Ribeiro *et al*., 2008; Tsai *et al*., 2007; Kalac, 2009; Manzi *et al*., 2001).

Genccelep *et al*. (2009), evaluated the minerals of 30 edible mushroom species. According to the reported results, among the minerals, potassium has the highest concentration in all species of edible mushrooms. Barros *et al*. (2007), studied the nutritional value of 5 species of edible fungus used in northern Portugal and the results showed that the protein and carbohydrate content in these kinds of mushrooms are very high while the amount of fat is very low. Vetter in 2007, measured and compared the chitin content in cap and stipe of cultivated mushrooms. The chitin levels of cap and stipe on dried weight were 6.68% and 7.25% respectively. The available information showed that the chitin content in *Agaricus Bisporus* was more than *pleurotus*; it seems that chitin factor depends on the kind and type of mushroom. In general, the chitin content in cap is more than stipe and this difference is in *Agaricus* and no significant difference in *pleurotus* was observed. In the research that was carried out by Olfati *et al*. (2009), the mineral content in some species of native mushrooms were investigated in northern area of Iran. The mineral contents in cap and stipe were measured separately and showed that the most amount of phosphorous and potassium are in the cap and calcium and magnesium in the stipe of mushrooms. Maeda et al., (1993) did some experiments to determine the nutritional value of the button mushroom stipe *(Agaricus Bisporus)* to provide animal feed. Based on the reported results the crude protein content, fat and minerals were 25%, 1% and 18% respectively (on the basis of dry matter). According to their findings, the amount of phosphorous in the stipe was more than the cap, and its calcium content was 15 times higher than the cap.

Oboh *et al*. (2009) compared some nutrients in cap and stipe of three species of edible mushrooms that were available in Nigeria. According to the findings the amount of protein, fat and ash in cap were significantly more than stipe ($p<0.05$), while the fiber and carbohydrate contents in the stipe were significantly higher than the cap ($p<0.05$).

Considerable work concerned with the nutritional value of the button mushrooms have been carried out but no survey is performed about the nutritional value of the

mushroom's stipe as a least expensive and valuable by-product (OECD, 2007). Therefore, due to the limitation of food in general, the importance of efficient usage of different sources and also the reduction of wastes is quite evident. For this reason, the study of chemical and the nutritional aspects of the stipe of button mushroom is quite essential.

Materials and Methods

- *Preparation of the sample*

The samples of button mushrooms were obtained from Malard Agro-Industry (Karaj-Iran). After cleaning, the caps were separated from the stipes. The samples were dried in vacuum oven at 70°c for 12 hours and then were ready to be evaluated nutritionally and chemically.

- *Chemical analysis of the samples and measurements of the mineral components*

All the chemical analyses were performed in triplicate order and the employed chemicals were the analytical quality grade of the Merck Company, Germany.

Samples of the mushrooms were analysed for chemical composition (moisture, protein, fat, carbohydrates and ash) using AOAC procedures (2005). The crude protein contents (N ×4.38) of the samples were evaluated by the Macro Kjeldahl method. The crude fat was determined by extracting a known weight of powdered dried mushroom with petroleum ether, using the Soxhlet apparatus. The ash content was determined by incineration at 550 ± 15 ˚C. Total carbohydrates were calculated according to the Codex standard (1999) number 234 and the existing methods (chang & Quimio, 1997; Manzi & Pizzoferrato, 2001; Tsai & Wu, 2007).

- *Phosphorous content*

The phosphorous content of samples was determined by colorimetric method and by using the spectrophotometry device in 470 nm according to AOAC standard method number 986.24.

- *Iron, calcium and potassium contents*

These minerals were determined according to AOAC standard method number 975.03, by using Flame Atomic Absorption spectrophotometer in 248.3, 422.7 and 404.4 nm respectively.

- *Selenium content*

Hydride Generation Atomic Absorption spectrophotometer was employed to measure selenium in 196 nm according to AOAC standard method number 986.15.

- *Determination of fatty acid composition*

Fatty acids were analysed by gas chromatography equipped with Flame Ionization Detector and capillary column based on the ISO 5509 (2000) trans-esterification method using hydrogen as the carrier gas. The results are expressed in relative percentage of each fatty acid, calculated by internal normalization of the chromatographic peak area.

- *Statistical analysis*

The completely Randomize Design (CRD) model was used in this research. The investigated samples were the caps and stipes of button mushrooms and the analysis were carried out in triplicate order. Minitab and SPSS 17 softwares were used for statistical analysis of the results. The results of the chemical tests were analysed by one-way ANOVA and $p<0.05$ was considered the significant difference between the treatments.

Results and Discussion

The comparison of the chemical composition of the caps and stipes of the samples are presented in table 1. According to the statistical analyzes, significant differences were not observed in moisture contents of the caps and stipes of button mushroom ($p<0.05$). Tsai *et al*. in 2007 analysed the chemical compounds of button

mushroom in different stages of their growth. According to their results the moisture of this kind of mushroom ranged between 89.3-92.3%. Caglarirmak in 2007 evaluated the nutritional value of a few types of the edible mushrooms and concluded that the moisture factor is almost stable and is about 90-92%.

As shown in table 1, the protein content in the cap was significantly more than the stipe ($p<0.05$) and according to the researches, the amount of protein in edible mushrooms is often variable and this difference depends on many factors namely the species of mushrooms, texture, the duration of time between sample preparation and the experiments, humidity, the part of the mushroom from which the sample is taken, harvesting time and other conditions (Crison, 1978; Barros *et al*., 2007).

According to Tsai's results in 2007 the protein content was reported 21.3-27% on the dry matter basis that differs a little from the results of this experiment. According to the findings of Maeda *et al*. in 1993, the amount of the protein in stipe was about 24.6% of the dried weight. Oboh *et al*. in 2009 reported that the amount of protein in cap is higher than the stipe.

According to table 1, the fat content in cap and stipe were 2.48% and 2.00% respectively based on dried weight. Barros (2007) has announced the amount of measured fat to be 2.74% on the basis of dried weight and no significant differences were observed ($p>0.05$) that agrees with our results. He also pointed out that the edible mushrooms were rich source of protein and poor source of fat that introduces this product an ideal and suitable snack. Oboh (2009) pointed out that the fat in cap is considerably more that the stipe and Maeda in 1993 indicated the presence of 1.1% total fat in dried weight which is less than our results.

According to the statistical results, carbohydrate and fiber contents in the stipes were found significantly higher than caps ($p<0.05$). The carbohydrate content was 20.59% in the cap and 31.41% in the stipe on the basis of dried weight. Barros in 2007 reported the amount of carbohydrates of cap 37.45%, but Tsai (2007) reported the amount of carbohydrate 38.3-48.9% depending on the state of growing phases. Oboh (2009), reported the average concentration of carbohydrate in the caps of three mushroom species from 23.6% to 36.0% while in the stipes the range was from 31.7% to 45.1%. He pointed out that the amount of carbohydrate in cap was less than in stipe that is in accordance with the results of current research. The fiber content in stipe and cap were 38.08% and 31.11% respectively. Polysaccharides are the major part of the cellular wall of the mushrooms and accounted for 80-90% of their dried weight. Fibers apart from lignin are regarded as polysaccharides and the most important fiber in edible mushrooms is lignin (Vetter, 2007).

According to the investigation that was carried out by Tsai (2007) the range of measured fiber is between 17.7-23.3%, that is less than our findings. According to Oboh (2009), the fiber content in stipe was significantly higher than the cap ($p<0.05$). These results are in agreements with the results of this research. Maeda (1993) reported high concentration of fiber in stipe that accounted about 44.5% based on dry weight.

Table 1 presents the ash content of stipe and cap and indicates that there were significant differences between the results ($p<0.05$). The amount of ash is reported about 17.5-31.7% in cap and 12.3-19.6% in stipe on dry matter (Oboh, 2009).

The mineral contents of cap and stipe of button mushroom are presented in table 2. According to this table, there are significant differences between all the studied minerals in cap and stipe ($p<0.05$).

Table 1. Chemical composition of cap and stipe

Chemical Composition**	Moisture (%)	Protein (%db)	Fat (%db)	Carbohydrates (%db)	Fiber (%db)	Ash (%db)
Cap	90.76±0.34[a*]	33.65±0.15[b]	2.48±0.20[a]	20.59±0.27[a]	33.11±0.11[a]	10.17±0.20[b]
Stipe	90.01±0.27[a]	19.01±0.24[a]	2.00±0.24[a]	31.41±0.42[b]	38.08±0.18[b]	9.5±0.22[a]

* Data explain analysis of triplicates ± standard deviation and the mean difference is significant at the ($P < 0.05$) level.

**All ingredients except the moisture, were calculated based on dry weight.

The potassium content in cap was more than in stipe and about 43.95 g/kg. Genccelep *et al.* (2009) studied the amount of minerals in 30 species of edible mushrooms and reported the amount of potassium 12.6-29.1 g/kg.

According to their Statements, among all the minerals, potassium had the highest concentration. Olfati *et al.* (2009) studied the amount of potassium in cap (34 g/kg) and in the stipe of edible mushrooms (23.4-29.3 g/kg) and the results are in agreement with the acquired results. Mattila & Konko in 2001 surveyed the amount of minerals in a few types of edible mushroom and reported that the amount of potassium is about 47.3 mg/kg.

According to table 2, the amount of the phosphorous in the cap was more than that of the stipe. The phosphorous content was measured by Genccelep *et al.* 2009, this was about 0.64-4.49% that is considerably less than the results of this experiment. This difference is due to different species of edible mushrooms. The phosphorous content reported by Maeda (1993) was about 7.6 g/kg in stipe. According to the researches of Olfati (2009) the amount of the phosphorous in the stipe of the edible mushrooms was about 3.7-8.9 g/kg that is in accordance with our findings. In respect of the statistical analyses, the amount of calcium in stipe and cap is significantly different ($p<0.05$). Table 2 shows the calcium content of stipe that is about two times more than that of the cap. The measured amount of calcium was about 3.2 g/kg in the stipe that was measured by Meade *et al*. in 1993. In 2009 Olfati *et al*. reported the amount of calcium in button mushroom *Agaricus Bisporus* and reported the concentration of 0.3 g/kg.

As presented in table 2, the Iron content in the cap (55 mg/kg) was less than the stipe (78 mg/kg). Among other microelements Iron has the highest concentration. Mattila and Konko (2001), reported the Iron content of button mushroom, that was 48 mg/kg.

The selenium content in cap was found also significantly more than stipe ($p<0.05$). Mattila & Konko (2001), reported the amount of selenium in button mushroom (1.4 mg/kg) that is in agreement with the results of this research.

Table 2. Minerals of cap and stipe of the button mushroom

Treatment	Potassium g/kg	Phosphorous g/kg	Calcium g/kg	Iron mg/kg	Selenium mg/kg
Cap	43.958±0.00[b*]	12.856±0.00[b]	1.472±0.13[a]	55±0.07[a]	1.9±0.07[b]
Stipe	37.723±0.25[a]	8.529±0.00[a]	2.592±0.23[b]	78±0.01[b]	1±0.09[a]

* Data explain analyses of triplicates ± standard deviation and the mean difference is significant at the ($P< 0.05$) level.

Table 3. Fatty acid composition of oil extracted from cap and stipe of the button mushroom

Fatty acids	Cap	Stipe
C16:0	18.46±0.08[a*]	18.5±0.03[a]
C16:1	0.61±0.01[b]	0.21±0.01[a]
C17:0	0.61±0.01[a]	0.35±0.04[a]
C17:1	0.55±0.04[a]	0.54±0.03[a]
C18:0	11.5±0.02[b]	7.78±0.03[a]
C18:1	24.65±0.01[b]	11.34±0.04[a]
C18:2	38.63±0.11[a]	56.10±0.03[b]
C18:3	2.06±0.05[b]	0.69±0.04[a]
C20:0	2.06±0.05[b]	1.88±0.1[a]
C20:1	0.25±0.01[a]	0.27±0.01[a]
C22:0	0.70±0.01[a]	1.21±0.01[b]
C24:0	1.49±0.04[b]	0.13±0.07[a]

*Data explain analyses of triplicates ± standard deviation and the mean difference is significant at the ($P < 0.05$) level.

Table 3 presents the fatty acid composition of the oil extracted from the cap and stipe of button mushroom. Gas chromatography analysis indicates that linoleic acid is the predominant unsaturated fatty acid while palmitic acid is the predominant saturated fatty acids present. Statistical results indicate significant differences in fatty acid composition of cap and stipe ($p<0.05$). However, there were not significant differences concerning the results of palmitic, margaric, heptadsenoic, arachidic and Icosenoic acids of the cap and stipe ($p>0.05$). The amount of the linoleic acid of the stipe was significantly more than the cap.

The predominant fatty acids in the cap and the stipe of the button mushroom in decreasing order were linoleic, palmitic and Oleic acids respectively that are in agreement with the findings of Barros *et al.* in 2007.

Conclusion

According to the statistical analysis, it might be concluded that little differences might be observed between the stipe and cap concerning the food nutritional values. The results of this research also indicate that carbohydrate, fiber, calcium and iron contents in the stipe are significantly higher than that of the cap ($p<0.05$) and analysis of

the fatty acids of the extracted oil shows linoleic acid is the predominant fatty acid present.

Therefore, it can be concluded that by regarding the high nutritional value of the stipe of the button mushroom we shouldn't consider them as waste and disregard them. The comparison of the results of this study with the surveys carried out by other researchers are in agreement, but factors such as species, growing phase, harvesting time, place and conditions of cultivation and methods of analysis must be taken into account. The findings in this research indicates that we might use the stipe of the button mushroom as an inexpensive source to be used in dried form in some products such as instant soups and in producing some fabricated snacks.

References

AOAC (2005). Official methods of analysis (18th ed.). Arlington VA, USA: Association of Official Analytical Chemists.

Barros, L., Baptista P., M.Correia, D., Casal, S., Oliveira, B. & Ferreira I. (2007). Fatty acid and sugar compositions, and nutritional value of five wild edible mushrooms from Northeast Portugal. Food Chemistry 105, 140–145.

Chang, S. T. & Miles, P.G. (2004). Mushrooms, Cultivation, Nutritional value, Medicinal effect and Environmental impact. 2nd Ed. CRC press, Boca Rotan, p. 451.

Chang, S. T. & Quimio, T. H. (1997). Tropical mushrooms: Biological nature and cultivation methods. Page 94-95.

Crison, E.V. & Sands, A. (1978). Nutritional value in the biology and cultivation of edible mushroom. Chang, S-T & Hayes, W.A., Eds., Academic press, New York, 137.

Genccelep, H., Uzun, Y., Tuncturk, Y. & Demirel, K. (2009). Determination of mineral contents of wild-grown edible mushrooms. Food Chemistry, 113, 1033-1036.

Hofrichter, M. (2010). Industrial Applications. Second Ed. Springer Verlag, Berlin. P. 80-84.

ISO 5509 (2000). Animal and vegetable fats and oils – preparation of methyl esters of fatty acids.

Kalac, P. (2009). Chemical composition and nutritional value of European species of wild growing mushrooms: A review. Food Chemistry, 113, 9-16.

Meada, Y., Takenaga, H., Aso, S. & Yamanaka, Y. (1993). Utilization of heat-dried stipe of mushroom (Agaricus bisporus) for animal feed. Journal of Japanese Society of Grassland Science. V. 39(1) p. 22-27.

Manzi, P., Aguzzi, A. & Pizzoferrato, L. (2001). Nutritional value of mushrooms widely consumed in Italy. Food Chemistry, 73, 321-325.

Mattila, P. & Konko, K. (2001). Content of vitamins, mineral elements and som phenolic compounds in cultivated mushrooms. J. Agric. Food Chem, 49, 2343-2348.

Oboh, G. & Shodehinde, S. A. (2009). Distribution of nutrients, polyphenols and antioxidant activites in the pilei and stipes of some commonly consumed edible mushrooms in Nigeria. Chemical Society of Ethiopia, 23(3), 391-398.

OECD (2007). Consensus document on compositional considerations for new varieties of the cultivated mushroom Agaricus bisporus: Key food and nutrients, anti-nutrients and toxicants. Organisation for Economic Co-operation and Development, Series on the Safety of Novel Foods and Feeds, No. 15. P. 12-33.

Olfati, J. A., Peyvast, Gh. A. & Mami, Y. (2009). Identification and chemical properties of popular wild edible mushrooms from northern Iran. Journal of Horticulture and Forestry Vol. 1(3) pp. 048-051.

Tsai, S. Y., Wu, T. P., Huang, S. J. & Mau, J. L. (2007). Nonvolatile taste components of *Agaricus bisporus* harvested

at different stages of maturity. Food Chemistry, 103, 1457-1464.

Vetter, J. (2007). Chitin content of cultivated mushrooms *Agaricus bisporus*, *Pleurotus ostreatus* and *Lentinula edodes*. Food Chemistry, 102, 6-9.