Chemical Compositions and Nutritional Value of Three Edible Mushrooms Widely Consumed in Cyprus

Ahmad Mohamad Al-Momany * and Gücel, Salih2.

ABSTRACT

Three mushrooms frequently consumed in Cyprus were purchased from local markets in spring 2008. Samples were studied through measurements for morphological structures of the cap, stem, gills color, shape and dimensions, as well as smell and taste. These mushrooms were identified as Agaricus macrosporus (Moller & Schaeff), Pleurotus ostreatus (Jacq. Ex. Fr.) Kummer and Tricholoma saponaceum var. squamosum (Cke.) Rea.

Nitrogen as well as mineral contents of Ca, Na, K, Zn, Mn, Cu, Fe and Mg were determined in the three mushrooms. The highest protein value (30.7%) was found in the cultivated mushroom Agaricus macrosporus, while Pleurotus ostreatus contained the lowest protein content (16.6%). Some mushroom species accumulated trace elements at high ratio as Pleurotus ostreatus for Na, Ca, and Fe, Tricholoma saponaceum var. squamosum for K, Mn, Mg and Zn, and Agaricus macrosporus for Copper.

Keywords: Mushroom, Pleurotus, Tricholoma, Protein, Minerals. Agaricus.

INTRODUCTION

More than 2000 species of mushrooms exist in nature but only approximately 25 species are intensively cultivated for commercial purposes, on ground or wood and utilising particular environmental and nutritional conditions (Lindequist et al., 2005). Mushrooms are well recognized for their flavor and nutritional values. Fungi are known as a good source of phytosterols (Mattila et al., 2002). The nutritional interest in phytosterols derives from the fact that they reduce cholesterol absorption, thereby having the capacity to reduce plasma cholesterol with no side-effects (Shin, et al., 2003). The most abundant phytosterol in mushrooms is ergosterol (Mattila et al., 2002). The consumption of wild edible mushrooms is increasing due to a good content of proteins, dietary fibre and trace elements (Thimmel and Kluthe, 1998). Both wild and cultivated mushrooms are good sources of vitamins and proteins. The crude protein content of Agaricus bisporus has been reported to be 19-38 % on a dry weight basis, but the real protein content of the mushrooms examined was at most 0.5 % on fresh weight basis and 7 % on dry weight basis which is four times lower than usually reported due to N-acetyl glucosamine solubilized from the fungal cell wall (Braaksma and Schaap, 1996). Chanterelles and king bolete have been reported to contain significant amounts of natural vitamin D2 compared with cultivated mushrooms that had a low content. Canned samples of Agaricus bisporus were slightly lower in ergosterol and vitamin D2 compared to fresh samples (Teichmann et al., 2007). Several factors may affect the accumulation and concentration of trace elements and heavy metals in...
mushrooms. Accumulation of specific heavy metals could be species dependent but substrate composition is also considered to be an important factor (Stijve et al., 2004; Cocchi et al., 2006). Spawn type and strain influenced the yield of Agaricus bisporus produced on non-composted and spent mushroom compost (Mamiro and Royse, 2008). The cultivated mushroom has received the attention of several investigators mainly for extending its shelf life and quality (Brennan et al., 2000; Aguirre et al., 2008). The lack of information about nutritional value and chemical compositions of Cyprus mushrooms lead us to this investigation. The objectives of this research were to extend knowledge on nutritional quality and chemical composition of three edible mushrooms widely consumed in Cyprus.

**MATERIALS AND METHODS**

Three mature fresh mushroom samples were purchased from local markets in spring 2008. Each fresh sample was five kilograms in weight, carefully cleaned from soil and organic remains with a stainless steel knife, washed with distilled water, drained and thinly sliced to have a representative sample. Mushroom samples were dried in electrical radiant heat oven (Imperial II-Lab-line Instruments, Inc. USA) at 50 °C for 24 h and then ground to pass through a 1 mm mesh sieve. They were mixed thoroughly and kept in plastic bags and stored in a freezer at −4 °C until used for mineral investigations (Mshandete and Cuff 2007). The specimens were examined in the laboratory and identified according to Benjamin (1995), Gerhardt (2008) and Phillips (1985). Each sample was studied in the laboratory by taking measurements on the morphological structures of the cap, stem, and recording gills color, shape and dimensions. Also smell and taste for each fruiting structure were taken in consideration. Spore print for each fresh mature sample was also defined by laying the fruiting body over glass sheath and covered it overnight with a glass beaker to avoid drying (Phillips 1985). Spores of each mushroom were microscopically tested by recording the shape, colour and size of more than twenty arbitrary chosen spores.

One gram of each sample was digested with 6 ml of concentrated HNO₃ and 2 ml of concentrated H₂O₂ in Milestone ETHOS PLUS 900 model microwave digestion system and diluted to 10 ml with double deionized water. Mineral contents of Ca, Na, K, Zn, Mn, Cu, Fe and Mg were determined by using an atomic absorption spectrophotometer with deuterium background corrector (Perkin-Elmer 5300 DV model ICP-OES). For each mushroom species, the whole nutritional analysis was replicated for two times. Nitrogen content was determined by Kjeldahl method according to AOAC procedure (1995) and Mshandete and Cuff (2007) and protein content (%) was calculated by multiplying nitrogen content with the factor 4.38 according to Crisan and Sands (1978). In the fruit body of edible mushrooms a large amount of nitrogen is actually present in non-protein compounds; due to urea, ninhydrin positive compounds and a high proportion of N-containing chitin; hence the conversion factor of total nitrogen into crude protein is 3.45 - 4.38 (Braaksma and Schaap 1996; Shah et al., 1997). Normally crude protein correlation factor adopted for mushrooms in food composition tables was calculated using the conversion factor of (N x 4.38).

**Statistical Analysis**

Statistical analysis of the data on nitrogen composition and mineral contents were performed using SAS package at the Computer Center of the University of Jordan. The data were reported as means ± SD for six determinations (two sets of triplicate samples per species per parameter).
RESULTS AND DISCUSSION

Identification of Mushrooms:

*Agaricus macrosporus* (Moller & Schaeff) was identified according to the following characteristics: Cap 8-25 cm across, convex, whitish and the margins becoming toothed with age. Stem 50-100X25-35 mm with a fusiform rooting base; ring thick and scaly on the underside. Gills are whitish grey at first, finally dark brown. Taste mushoomy and smell faint of crushed almonds when young. Spore print brown in color with ellipsoid spores varied from 8-12 X 5.5- 6.5 µ.

*Tricholoma saponaceum var. squamosum* (Cke.) Rea. has a cap with 5-10 cm across, convex at first then expanded with a broad umbo and grey brown in color. Stem 50-100X10-30 mm white with reddish tints and dark brown to almost black scales covering the stem. Flesh taste mushroomy, smell of soap. Spore print white with elliptical spores measuring 7.5-11X 3-4µ.

*Pleurotus ostreatus* (Jacq. Ex. Fr.) Kummer has a cap with 6-14 cm across, shell shaped, variable in color from brown to grey-brown. Stem 20-30 X 10-20 cm, excentric to lateral or absent with a woolly base. Flesh white in color and smell pleasant. Spore print lilac with subcylindric spores measuring 5-6X3.5-4µ.

Nitrogen and Protein Content

The highest protein value (30.7%) was found in the cultivated mushroom *Agaricus macrosporus*, while *Pleurotus ostreatus* contained the lowest protein content (16.6 %) as shown in Table 1. *Agaricus macrosporus* showed the highest nitrogen content in

<table>
<thead>
<tr>
<th>Mushroom Name</th>
<th>Nitrogen %</th>
<th>Protein %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1st replicate</td>
<td>2nd replicate</td>
</tr>
<tr>
<td><em>Agaricus macrosporus</em></td>
<td>6.91</td>
<td>7.11</td>
</tr>
<tr>
<td><em>Pleurotus ostreatus</em></td>
<td>3.88</td>
<td>3.71</td>
</tr>
<tr>
<td><em>Tricholoma saponaceum</em></td>
<td>var.</td>
<td>5.62</td>
</tr>
</tbody>
</table>

Values are means of 3 determinations.

Nitrogen and protein content of three cultivated Cyprus mushrooms.

both run probes. Our results were in agreements with the findings of Diez and Alvarez (2001), Braaksma and Schaap (1996) and Mashandete and Cuff (2007). There were significant differences amongst the three mushroom genera concerning protein content. According to Lintzel (1943), 72-83% of the total nitrogen would be in the form of digestible protein. This would establish that mushrooms are relatively high in digestible proteins compared with vegetable foods. The corrected amino acid scores of two *Tricholoma* species were low.
compared with those of egg white but higher than those of many vegetable proteins (Diez and Alvarez, 2001). However, it is known that the protein contents of mushrooms are affected by many factors, namely the type of mushrooms, the stage of development, the part sampled, level of nitrogen available and the location (Flegg and Maw, 1977). Wild mushrooms were rich sources of protein (close to 16% of dry weight) and had low fat contents (5.7 – 6.6%) making it an ideal snack material (Diez and Alvarez, 2001).

**Mineral Analysis**

The data on mineral analysis of the investigated mushrooms are shown in Table 2. Significant differences were observed between the three mushrooms concerning mineral contents (P=0.05). *Tricholoma saponaceum var. squamosum* contained the highest contents of K, Mg, Zn and Mn compared to other mushrooms. The highest Na, Ca, and Cu contents were found in *Pleurotus ostreatus*. Care should be taken for substrate composition to avoid any buildup of any trace metals (Cocchi *et al.*, 2006). Manganese was not detectable in *Agaricus macrosporus*. Phosphorus content was very low in all three tested mushrooms and it was not detectable in both analyzed samples. *Agaricus macrosporus* and *Tricholoma saponaceum var. squamosum* are good sources for K while *Pleurotus ostreatus* contained the lowest concentration. The explanation for the variation of mineral contents in the tested mushrooms might be due to genotypic effect (Kalac and Svoboda, 2000). Not only that but also the type of substrate used composted or non-composted, its composition and availability of its mineral contents, the absorptive capacity of the mushroom mycelia, age of the mushroom and the environment (water, temperature and humidity) have also prominent effects.

<table>
<thead>
<tr>
<th>Mushroom Name/ Element</th>
<th>First Replicate mg/g dry matter±SD</th>
<th>Second Replicate mg/g dry matter±SD</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Agaricus macrosporus</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potassium (K) 766,490*</td>
<td>21.56±0.60</td>
<td>23.64±0.44</td>
</tr>
<tr>
<td>Sodium (Na) 589,592</td>
<td>0.21±0.01</td>
<td>0.26±0.01</td>
</tr>
<tr>
<td>Calcium (Ca) 317,933</td>
<td>0.14±0.02</td>
<td>0.19±0.01</td>
</tr>
<tr>
<td>Iron (Fe) 238,204</td>
<td>0.03±0.00</td>
<td>0.03±0.00</td>
</tr>
<tr>
<td>Copper (Cu) 327,393</td>
<td>0.03±0.00</td>
<td>0.03±0.00</td>
</tr>
<tr>
<td>Manganese (Mn) 257,610</td>
<td>Below DL</td>
<td>below DL</td>
</tr>
<tr>
<td>Magnesium (Mg) 285,213</td>
<td>0.71±0.00</td>
<td>0.76±0.03</td>
</tr>
</tbody>
</table>
The iron content of the mushrooms ranged from 30 µg/g in *Agaricus macrosporus* to 70 µg/g in *Pleurotus ostreatus*. Iron values in mushroom samples have been reported in the range of 31-1190 µg/g (Sesli and Tuzen, 1999) and 30-150 µg/g (Kalac and Svoboda, 2000). Our iron values are in agreement with those reported in the literature. It is known that adequate iron in the diet is very important for decreasing the incidence of anemia. The copper levels range from 10-40 µg/g for *Tricholoma saponaceum var. squamosum* and *Pleurotus ostreatus*, respectively in this study. Copper contents found in this study ranged from 10 to 70 µg/g are in agreement with values reported in the literature (Isiloglu *et al.*, 2001; Soylak *et al.*, 2005). Copper concentrations in the accumulating mushroom species are usually 100-300 mg/kg dry matter, which is not considered a health risk (Kalac and Svoboda, 2000).

Mushrooms are known as zinc accumulator and...
sporophore: substrate ratio for zinc ranges from 1 to 10 mg/kg (Isiloglu et al., 2001). The zinc content was the highest (80 µg/g) in Tricholoma saponaceum var. squamosum, whereas in Agaricus macrosporus, it was the lowest (30 µg/g). Zinc concentrations of mushroom samples in the literature have been reported in the range of 33.5-89.5 µg/g (Soylak et al., 2005) and 45-188 µg/g (Tuzen, 2003). The manganese content of the mushrooms studied in the present work ranged from 20 µg/g in Tricholoma saponaceum var. squamosum to 40 µg/g in Pleurotus ostreatus. Manganese content was not detectable in Agaricus macrosporus. The manganese values in the present study are in agreement with a range between 20 and 40 µg/g which has been reported in literature (Tuzen, 2003). Phosphorus content was very low and not detectable at all in the three tested mushrooms. Some mushroom species accumulated trace elements at high ratio as Pleurotus ostreatus for Na, Ca, and Fe, Tricholoma saponaceum var. squamosum for K, Mn, Mg and Zn, Agaricus macrosporus for Cu. Washing and peeling of Agaricus bisporus decreased concentrations of cadmium, copper and zinc by 30-40 % (Zrodlowski, 1995). During bleaching of Agaricus bisporus at 95-100°C for 15 min, losses of 45, 36, 23 and 4 % were observed for manganese, iron, zinc, and copper relatively (Coskuner and Özdemir, 1997). So it is necessary to use always fresh samples for any nutritional analysis. Mushrooms are excellent sources of vitamin B1 (thiamine), B2 (riboflavin, B3, biotin and vitamin C (ascorbic acid). Edible mushrooms are nutritionally sound and good dietary component for vegetarians (Breene, 1990) and are suitable for diabetic and heart patients (Bobek and Galbavy, 1999). Mushrooms quality is influenced by the stage of development and pre- and post-harvest conditions. Post-harvest treatment with citric acid or hydrogen peroxide extended the shelf life of fresh sliced mushrooms (Brennan et al., 2000). On average, a serving (100 g) of mushrooms guarantees from 9 to 40 % of the daily recommendation of dietary fibre (Manzi et al., 2001). Content of dietary fibre was high (approx. 45 % of dry matter) in two Tricholoma species (Diez and Alvarez, 2001). Agaricus bisporus and Pleurotus ostreatus contain low levels of the trace elements (Kalac and Svoboda, 2000), thus consumption of the accumulating species should be restricted.

In conclusion, the chemical composition and protein values of the three mushrooms clearly indicated that they provide key nutrients. Being a good source of protein and carbohydrate, they fall between most legumes and meat (FAO/WHO, 1989) and prove to be excellent foods that can be used in well- balanced diets for their low contents of fat and energy.

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Mushroom, Pleurotus, Tricholoma, \textit{Agaricus macrosporus}, \textit{Pleurotus ostreatus}, \textit{Tricholoma saponaceum}.