

PROXIMATE AND NUTRIENT COMPOSITION OF THREE TYPES OF INDIGENOUS EDIBLE WILD MUSHROOMS GROWN IN TANZANIA AND THEIR UTILIZATION PROSPECTS

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ABSTRACT

In Tanzania wild edible mushrooms collected during the rainy season have broad cultural acceptance and constitute a traditionally very important nutritious food. However, their assessment as food, which is based on their chemical analysis, has not been adequately studied and documented. The objective of the study was to determine the proximate nutritive potential of three indigenous edible wild mushrooms namely *Coprinus cinereus*, (Schaeff) S. Gray s.lat., *Pleurotus flabellatus*, (Berk and Br.) Sacc. and *Volvariella volvaceae* (Bull.ex.Fr) Singer, grown on composted solid sisal decortication residues. Standard procedures were used to determine the proximate chemical composition of dried samples of domesticated indigenous edible wild mushrooms. Atomic absorption spectrophotometry was used to determine the mineral element composition. The results were compared using an analysis of variance test. There were significant differences in the proximate nutritive values of the three edible mushrooms ($p>0.05$). Despite differences in the chemical composition of the three indigenous edible mushroom species, the overall nutritional potential of the three mushroom species was quite good. Furthermore, the overall results indicated that the fruit bodies of the three native mushrooms studied have nutrient qualities similar to other cultivated exotic edible mushrooms, and a higher protein content than many cereals and vegetables. The results on a dry weight basis demonstrated significant amounts of protein, vitamin C and minerals, ranging from 17-28 %, 33-55 mg/100g and 5.2-3232 mg/100g, respectively. Furthermore crude fibre ranged between 6.6-11 % and carbohydrate, at 50-62 %, both of which were found to be relatively high. All three species were low in fat content, with a range of 1 to 3.3 %, and energy value (calculated), 302-313 kcal/100g. These results indicated that the studied mushrooms have good nutritive value for human beings. The fact that the domesticated mushrooms were grown using locally adapted biotechnology increases the likelihood of their incorporation in the diet as a food item contributing protein, vitamin C and mineral nutrients. The high crude fibre and low fat content are also important from a nutritional perspective. The researchers believe that it would be appropriate to popularise the utilization of the three mushrooms as unconventional protein rich food sources to supplement the traditional cereal Tanzanian based diet, aimed at combating the problem of protein malnutrition in Tanzania in particular and in developing counties in general.

Key words: Proximate composition, Wild edible mushrooms

INTRODUCTION

Mushrooms represent one of the world's greatest untapped resources of nutritious food. Cultivation of saprophytic edible mushrooms may be the only currently economical biotechnology for lignocellulose organic waste recycling that combines the production of protein rich food with the reduction of environmental pollution [1]. Mushrooms are rich in protein, minerals, and vitamins, and they contain an abundance of essential amino acids [2]. Therefore, mushrooms can be a good supplement to cereals [3]. However, many people are apprehensive about mushrooms as a food source. Ignorance has led many to become sceptical about whether food of fungal origin can hold any great nutritional promise. It seems much education is needed before full advantage can be taken of this readily available, nutritionally rich food source [4, 5].

There is a very high incidence of malnutrition, especially of protein deficiency in developing countries. The situation is especially severe in sub-Saharan Africa, which is the region with the highest prevalence of under nourishment with one in three people deprived of access to sufficient food [6]. The problem of protein shortage in developing countries including Tanzania is an existing reality and will continue for the foreseeable future. Protein malnutrition will become even more acute since the supply of protein for the diet has not kept pace with population growth [7]. In order to meet the deficit most developing countries tend to import essential protein sources of food from abroad, spending large sums of their meagre foreign exchange earnings. Such a situation has forced planners and nutritionists to think about unconventional alternative sources of protein such as mushrooms [4].

A detailed account of the compositional analyses of cultivated and wild species of edible mushrooms has been reported elsewhere [5]. Mushrooms have been used as human food for centuries, being valued particularly for the variety of flavours and textures they can provide [2]. However, they also have nutritional value and can be useful food supplements, although species vary in their nutritional value [5]. Protein tends to be present in an easily digested form and on a dry weight basis mushroom normally range between 20 and 40% protein which is better than many legume sources like soybeans and peanuts, and protein-yielding vegetable foods [3, 4]. Moreover, mushroom proteins contain all the essential amino acids needed in the human diet and are especially rich in lysine and leucine which are lacking in most staple cereal foods [2, 3]. Mushrooms are low in total fat content and have a high proportion of polyunsaturated fatty acids (72 to 85%) relative to total fat content, mainly due to linoleic acid. The high content of linoleic acids is one of the reasons why mushrooms are considered a health food [2, 4]. Furthermore, they contain significant amounts of carbohydrates and fibres as well as vitamins, especially B complex vitamins and some vitamin C, and they appear to be rich in inorganic mineral nutrients [3, 5]. Mushrooms, unlike many other supplements such as single cell protein algae, have been used as a food and food supplement throughout the world. Their broad cultural acceptance is an asset. In Africa's rural village communities mushrooms are highly treasured and appreciated as a delicacy. Most people in Tanzania include mushrooms in their diet and collect them during the rainy season [8]. Their seasonal supply and limited distribution make them highly valued and therefore very valuable [4, 8]. Producing cultured mushrooms would overcome their seasonal dependence. However, most villagers in Africa are not aware that mushrooms can be

cultivated on agricultural residues, making them available year round. Mushrooms, one of the highest protein producers per unit area and time from agro-residues, fit in well with feasible strategies to fight malnutrition [9]. Additionally, it is increasingly being realized that many species of mushrooms are very effective in boosting the body's immune system. This is of crucial importance in Africa, given the magnitude of the HIV/AIDS pandemic prevailing on the continent [4]. Mushrooms have potential in addressing current food crisis problems in Africa as well as future problems resulting from population explosions. Unfortunately, mushrooms biota of Africa are very poorly researched and documented, yet their biodiversity is extremely high [4]. Furthermore, Africa's indigenous mushrooms have hardly been preserved in mushroom "seed" banks (culture) collections which could in the future provide sources of edible products, traditional medicinal substances, and high-value pharmaceutical products [4]. Although in many African societies, and elsewhere in the world mushrooms collected during the rainy season have broad cultural acceptance and constitute a traditionally very important nutritious food, their assessment as food which is based on their chemical analysis has not been adequately studied, explored and documented [10]. In absence of any scientific data the contribution of mushrooms to the overall nutritive value of the diet is speculative. In recent times, mushrooms have assumed greater importance in the diet of both rural and urban dwellers, unlike previously when consumption was confined to rural Tanzanians. The assessment of mushrooms as food based upon its chemical analysis and the relevance of such information to traditional eating habits is therefore of interest.

Literature concerning the proximate composition of edible mushrooms from Tanzania has only recently been reported and is mostly concentrated on the nutritive value of edible wild mushrooms harvested in natural sites [8, 11]. To the best of our knowledge so far no nutritive quality data have appeared in the literature on saprophytic edible wild mushrooms cultivated on composted solid sisal decortication residues. Therefore fundamental knowledge of the nutritive composition of these mushrooms is needed to facilitate effective popularisation of mushroom cultivation, processing, marketing and consumption at the grass roots level to enable people to break away from the poverty trap and malnutrition, which is prevalent in most developing countries. The aim of this study was to determine the chemical composition and nutritional value of dried fruiting bodies of three native wild edible mushrooms namely, *Coprinus cinereus*, (Schaeff) S. Gray s.lat. *Pleurotus flabellatus*, (Berk and Br.) Sacc, and *Volvariella volvacea* (Bull.ex.Fr) Singer, grown on composted solid sisal decortications residues in Tanzania.

MATERIALS AND METHODS

Materials

Three varieties of wild edible mushrooms were included in this study: *Coprinus cinereus* (Schaeff) S.Gray s.lat, *Pleurotus flabellatus* (Berk and Br.) Sacc and *Volvariella volvacea* (Bull.ex.Fr) Singer. For simplicity, each will be referred to by the species name only for the remainder of the paper. Samples used for proximate and nutritive value analysis were cultivated on composted solid sisal decortications residues as a substrate under natural ambient conditions using locally adapted mushroom biotechnology at the University of Dar es Salaam, Mlimani main campus.

The solid sisal decortication residues were obtained from Alavi sisal estate, Coast Region, Tanzania. The sisal decortication residue was sun-dried for five days and composted under natural environmental conditions and was ready within three weeks. The main chemical constituents of the sun-dried solid sisal decortication residues prior to composting were as follows: total fibre 83%, total nitrogen 1.75%, total carbon 52%, with a C:N ratio of 30:1. The chemical constituents of the compost at maturity were, total fibre 54%, total nitrogen 1.0% , total carbon 22 %, with a C:N ratio of 22:1. The composting process showed that the major chemical components of solid sisal decortication residues are biodegradable as illustrated by the narrowing of the C:N ratio. Therefore the composted sisal was used as a substrate for cultivation of the three varieties of wild edible mushrooms.

A detailed account of taxonomy and cultivation of the three edible wild mushroom species will be reported separately elsewhere. Sample preparation was done as follows: the entire fruiting body was harvested, *Coprinus cinereus* were harvested when fruit bodies were hard, egg shaped with white gills (i.e. when young or immature), *Pleurotus flabellatus* were harvested when the cap was curved downwards before shedding spores and *Volvariella volvacea* were harvested when in the egg and elongation developmental stages. Fruit bodies were cleaned by gentle wiping with a cloth to remove any debris. Except for moisture determination, which was performed immediately after harvesting, dried samples were used.

In order to have reasonable, representative proximate and nutrient composition, three sets of samples from each species were randomly selected (9 samples per species per parameter), thinly cut by a sharp knife, weighed fresh, spread on a metal tray and then dried to a constant weight in a Gallenkamp (Sanyo OMT oven, UK) drying oven at 45°C to a constant weight, to yield a combined total weight of 200 g dried product of each species. Dried samples were ground using a laboratory mill to pass through 1 mm sieve (Model 4, Thomas Wiley; Arthur K Thomas, Philadelphia, PA, USA). All ground samples were transferred to airtight plastic bottles with well fitting caps, labelled and then sealed in polythene bags to prevent any water intake and were stored in a refrigerator at 4°C until required for analysis. The cold stored samples were allowed to attain room temperature and mixed thoroughly with a spatula before withdrawing samples for further proximate constituent analysis. Proximate analysis was done on ground samples in triplicate for each of three sets in each species to yield results from which mean compositions were computed. All weight measurements were done using an Adventurer TM balance (Ohaus Corp. Pine Brook, NJ, USA).

Analytical methods

Standard procedures of AOAC were used to determine the moisture content, crude fibre, crude fat, total nitrogen (Kjeldahl method) and ash [12]. In the fruit body of edible mushrooms a large amount of nitrogen is actually contained in non-protein compounds; hence the conversion factor of total nitrogen into crude protein is 3.45-4.38 [13, 14]. In this study crude protein was calculated using the conversion factor of (N x 4.38), a correlation factor adopted for mushrooms in food composition tables [5]. The content of ascorbic acid was determined by a titration method using the 2, 6 dichlorophenolindophenol Tillmans reagent (Tillman's method) [12]. The results were expressed in mg of ascorbic acid per 100 g of

sample. Mineral constituents (calcium, phosphorous, sodium, potassium, magnesium, iron, copper, manganese, zinc and cobalt) were determined by atomic absorption spectrophotometry [12]. The percentage of crude protein, crude fat, minerals and ash were combined and subtracted from 100 to obtain the total carbohydrate percentage for each sample, while the nitrogen-free extract (NFE) was calculated as a percentage of the total carbohydrates and crude fibre [15]. Energy value was calculated using Crisan and Sands' conversion factors [5].

Statistical analysis

The data on nutritive content determined for the three edible wild mushrooms species cultivated on solid sisal decortication residues were subjected to analyses of variance (one-way ANOVA) significance was accepted at the 5% probability level using the Statistical Package for Social Sciences (SPSS) Program 10.1 version [16]. Data for proximate nutrient composition were reported as the mean \pm SD for nine determinations (three sets of triplicate samples per species per parameter), while three determinations per sample were carried out for mineral constituents. The results are given as mean \pm SD.

RESULTS

The proximate analysis of the three domesticated native edible wild mushrooms is presented in Table 1. Significant differences ($P < 0.05$) were observed in moisture, crude fibre, crude fat, total nitrogen, crude protein, ash, total carbohydrate and nitrogen free extract, energy values and ascorbic acid (vitamin C) among the three mushroom species, *Coprinus cinereus*, *Pleurotus flabellatus* and *Volvariella volvacea*, which were cultivated on composted solid sisal decortication residues. Crude protein and crude fat were higher in *Volvariella volvacea* and lower in *Pleurotus flabellatus* and *Coprinus cinereus*. Total carbohydrate, ash, nitrogen free extract, ascorbic acid and energy content were higher in *Coprinus cinereus* and lower in *Pleurotus flabellatus* and *Volvariella volvacea*. Understandably, the differences in nutrient compositions among the three mushroom species could be attributed to their species variation.

Mushrooms probably contain every mineral present in their growth substrate. The mineral constituents of both major and trace mineral contained in mushrooms are given in Tables 2 and 3. There was a highly significant difference ($P < 0.05$) in calcium, phosphorous, sodium, potassium, magnesium, iron, copper, manganese and zinc among the three domesticated wild mushrooms. Among the major minerals, the quantities of potassium and phosphorus were highest followed by sodium in all three mushroom species studied. On the other hand, among the micro minerals contained in three species of mushroom, the quantities of iron and zinc were highest and copper and manganese were the lowest. Cobalt was not detected in any of the three species. An overview of the results showed that *Coprinus cinereus* was high in potassium, *Pleurotus flabellatus* was high in sodium, and *Volvariella volvacea* contained relatively high amounts of calcium, phosphorus and magnesium.

DISCUSSION

Because mushrooms are living organisms, their composition is in a state of flux during growth and after harvest. The chemical composition of edible mushrooms determines their nutritional value and sensory properties. It differs according to species but also depends on the substrate, atmospheric conditions, age or particular stage of development and part of the fruiting body as well as on various conditions of storage after harvest [15, 17, 18]. The results summarised in Tables 1, 2 and 3 show the nutrient and mineral composition of the three edible wild mushrooms species cultivated on composted solid sisal decortications residues in Tanzania. The nutritional composition varied significantly among these domesticated indigenous mushroom species tested. It is often impossible to compare the results obtained by different investigators working with the same species of mushrooms since the composition of a given species is affected by many variables. The use of different techniques for analysing nutrients also limits the comparison of results from different studies. However, data generated by other investigators can be used to generate estimates of probable nutritive value of given mushrooms [19].

The dry matter of the three mushroom species examined ranged between 7-9% (Table 1). It is important to consider moisture content, since all of the nutrients are contained in the dry matter of food. Dry matter levels as high as 20% have been reported for some species, however 10% or less is common [20,21]. The content of dry matter in the three domesticated edible wild mushrooms falls within ranges of reported data. The average moisture content recorded was highest for *Pleurotus flabellatus* (93%) followed by *Coprinus cinereus* (92%) and *Volvariella volvacea* (91%). These values are consistent with moisture content values reported previously for similar mushroom species [22, 23]. The high moisture content of the three mushroom species indicates that they are highly perishable. High moisture content has been reported to promote susceptibility to microbial growth and enzyme activity which accelerates spoilage [5, 15].

In terms of energy values the results indicated that the three domesticated native mushrooms species are low in calorie content and their energy value varied according to species (Table 1). The mean caloric value was highest for *Coprinus cinereus* (313 Kcal/100 g dry matter), followed by *Volvariella volvacea* (305 Kcal/100g dry matter) while *Pleurotus flabellatus* recorded the lowest (302 Kcal/100 g dry matter). The caloric values obtained in this study are consistent with published reports of 317 to 346 Kcal/100g dry matter for *Coprinus* species, 321.29 Kcal/100g dry matter for *Volvariella volvacea* and a range of 272 to 389 Kcal/100g dry matter for *Pleurotus* species [24, 25]. Owing to their high content of water and low caloric value mushrooms could be considered as a dietetic food, suitable for low-calorie diets [18, 21].

Mushrooms are considered to be a good source of digestible proteins. The protein content of edible mushrooms besides being species/strain specific could also vary with the growth substrate. The content of protein varied between 17-28 % on a dry weight basis among the three mushrooms species studied (Table 1). The highest content of protein was obtained from *Volvariella volvacea* while the lowest was obtained from *Coprinus cinereus*. It is well

established that more than half of the total nitrogen in mushrooms is contained in the protein fraction. The actual protein content depends among other things on the composition of the substrate, size of the pileus, harvest time and mushroom species [26]. The crude protein value obtained for *Coprinus cinereus* was close to the range of 20-25% reported previously for *Coprinus atramentarius* and *Coprinus comatus* [24]. The levels of crude protein obtained for *Pleurotus flabellatus* and *Volvariella volvacea* was similar to the reported value of 22% for *Pleurotus flabellatus* and was within the range of 21-29.5% reported for *Volvariella volvacea* [22, 27, 28]. The average protein content of cultivated edible mushrooms ranges from 3.5-4% of their fresh weight. Comparing the protein content of these mushrooms with the protein content of some common vegetables and fruits, the protein content of edible mushrooms in general is about twice of that of onion (1.4%), cabbage (1.4%) and potatoes (1.6%), and four to six times that of oranges (1.0%) and apples (0.3%). On a dry weight basis mushrooms normally contain 19-35% crude protein as compared to 7.3% in rice, 12.7% in wheat and 9.4% in corn (maize). Therefore, in terms of the relative amount of crude protein, mushrooms rank above the aforementioned vegetables and cereal foods [5, 27, 29]. Furthermore mushrooms contain all the essential amino acids for human nutrition. However, the level of some of them is below the FAO/WHO protein standard. The content of lysine is fairly high in mushrooms while cereal protein contains low levels of lysine [30]. Consuming mushrooms with cereal products has been recommended for balancing the level of essential amino acids in the diet [14]. Thus the three indigenous wild edible domesticated mushroom species examined in this study should be regarded as a good source of protein for humans.

The total fat content found in the commonly cultivated mushrooms generally has been reported to be low, varying between 0.6 and 3.1% of dry weight, and varies further depending upon the cooking method. The fat content in the three mushroom species analysed in this study were also low, ranging from 1% of dry weight for *Coprinus cinereus* to 3.3% for *Volvariella volvacea* (Table 1). The crude fat content presently reported for *Coprinus cinereus* was lower than the values of 3.1-3.3% previously reported for *Coprinus atramentarius* and *Coprinus comatus* [24]. The values obtained for the other two species compared favourably with the values of 1.4% and 3.9% reported earlier for cultivated *Pleurotus* and *Volvariella* mushroom species, respectively [5, 25]. Fat analysis has been variable in mushrooms and factors that might influence fat content have not yet been completely elucidated. However, it appears that fat represents a small part of the mushroom [31]. Although mushrooms are low in fat, they do contain essential unsaturated fatty acids, considered essential and significant for human diet and health.

Fibre is also part of a healthy diet. In modern society, some foodstuffs are refined and thus contain less fibre. For the three mushroom species examined, *Volvariella volvacea* contained 11%, *Pleurotus flabellatus* contained 9.8% and *Coprinus cinereus* contained 6.6% fibre on dry weight (Table 1). This is comparable to previously reported fibre analysis values of 7.3-9.3% for *Coprinus*, 7.5- 16.3% for *Pleurotus* and 5.5-17.4% for *Volvariella* species [5, 24, 25]. Since the three mushroom species examined all contained a significant amount of crude fibre, they could be regarded as a good source dietary fibre with potential health benefits.

Carbohydrates were found in the greatest amounts constituting 50-62% of the dry matter constituents of the three mushrooms (Table 1). The highest and lowest total carbohydrate

contents of the dry matter were recorded for *Coprinus cinereus* and *Volvariella volvacea*, respectively. A range of carbohydrate values of 53 and 60% of dry weight has been reported earlier for *Coprinus* species [24]. The total carbohydrate content of 62% reported in the present study is only slightly above this reported range. The total carbohydrate content of 60% reported in the present study for *Pleurotus flabellatus*, falls within the range of 45-77% reported by others for cultivated *Pleurotus* mushroom species [5, 22, 25]. For *Volvariella volvacea* species a total carbohydrate content between 40 and 50% dry weight which increases from button to egg to elongation stages has been previously reported [25, 32]. The content of total carbohydrate (50%), for *Volvariella volvacea* presently reported was within this range. Although, it is suspected that humans cannot utilise a large percentage of the carbohydrate in mushrooms as nutrients, it could function as roughage.

Vitamin content is an important factor in the overall nutritional value of food. Because of its antioxidant and therapeutic properties ascorbic acid (vitamin C) is a valuable food component [26]. The locally grown wild mushroom species included in the present study contained a relatively high amount of ascorbic acid (vitamin C) which varied from 33 to 55 mg/100g dry weight (Table 1). The highest and lowest ascorbic acid (vitamin C) levels were obtained from *Coprinus cinereus* and *Pleurotus flabellatus*, respectively. The value of ascorbic acid (vitamin C) for *Pleurotus flabellatus*, was much below the range of 93 and 113 mg /100g dry weight reported for cultivated *Pleurotus* species [25]. Species or growth substrate differences might account for the differences observed. The ascorbic acid content of *Volvariella volvacea* in this study were within the range of 20-62 mg/100g dry weight obtained in previous studies of cultivated *Volvariella* species [25, 27]. In the literature no data were obtained on ascorbic acid compositions of *Coprinus* species, so comparisons with published data are not possible. Although ascorbic acid contents varied among the three types of wild edible mushrooms analysed, these mushrooms could serve as a source of vitamin C in the diet.

There are many minerals that are essential for a normal healthy body. As with many foods, the mineral content of mushrooms is highly variable. Mushrooms like all living organisms have a good mix of minerals, and their fruiting bodies are characterized by high levels of assimilable mineral constituents [33]. The macro and micro mineral contents of the three domesticated edible wild mushrooms are listed in Tables 2 and 3, respectively. Significant differences in mineral content were observed among the three species analyzed in this study. Potassium and phosphorous were the predominant elements among the macro minerals measured. Iron and zinc were the most abundant elements among the trace minerals analyzed. Similar observations on mineral content profiles have been reported for cultivated mushrooms of *Agaricus*, *Pleurotus*, and *Lentinula* species [3, 14, 33]. The mineral concentration of mushrooms can be influenced by a number of factors including mushroom species and strain types, age of the mushroom, part of the mushroom used (stipe or pileus), pileus diameter, the composition of the growth substrate and the environment (water, temperature and humidity). The differences in mineral contents of the three edible wild mushrooms used in the present study and those reported in the literature are thought to be due to the above mentioned factors [15, 26, 33]. The current analysis shows that the three edible wild mushroom species ranged between 36 and 3232 mg/100g dry weight for major minerals and between 5.2 and 426 mg/100g on a dry weight basis for trace minerals. The quantitative mineral compositions observed falls within earlier report of analysis of some cultivated

mushrooms like *Pleurotus* and *Volvariella* species [5, 25, 33]. However, no mineral concentration data were available in the literature for *Coprinus* species. From the mineral analysis reported in this study, it seems that the three edible wild domesticated mushrooms can provide a useful source of phosphorus, potassium, iron, calcium, zinc, magnesium, manganese and copper. Much of the rural poor of Tanzania as well as the rest of Africa can only afford a diet based primarily on staple crops, which are generally low in micronutrients, particularly iron and zinc resulting in effects of micronutrient malnutrition particularly among women and children [34]. Thus, the inclusion of these domesticated edible mushrooms in the diet could be one of the strategies for combating iron, zinc and other micronutrient deficiencies.

CONCLUSION

Based on the data presented in this study, it appears that the three domesticated edible wild species analyzed are highly nutritious and compare favourably with other foreign edible species. From these analyses it can be concluded that these three edible mushrooms hold tremendous promise in addressing the protein and minerals deficits prevalent in the diets in Tanzania and in other developing countries particularly among the low income families. For the full potential of mushrooms as a nutritional supplement to be realized, intensive efforts should be geared toward their cultivation using mushroom biotechnology adapted locally. A detailed analysis of the amino acid content of the three domesticated mushrooms is suggested to permit more direct comparisons with more popular food sources. Further research is needed on species like *Pleurotus* and *Volvariella* that have the greatest market potential and efforts should be made to highlight their nutritional properties and advantages.

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Table 1. Proximate nutrient compositions of the three domesticated edible wild mushrooms

Nutrient	<i>Coprinus cinereus</i>	<i>Pleurotus flabellatus</i>	<i>Volvariella volvaceae</i>
Moisture (% wet weight)	92±0.84	93±1.93	91± 0.64
Dry matter (%)	8±0.16	7± 1.07	9±0.36
Total nitrogen (% dry weight)	4.0±0.06	4.8±0.29	6.5±0.04
Crude Protein (% d. wt)	17±0.25	21±0.09	28±0.16
Crude fat (% d. wt)	1.0±0.03	1.3±0.53	3.3±0.01
Crude fibre (% d. wt.)	6.6±0.32	11±0.89	9.8±0.41
Ash (%(% d. wt)	13±0.62	6.1±0.27	10±0.12
Total carbohydrate (% d. wt.)	62±0.58	60±0.25	50±3.15
NFE (% d. wt.)	56±0.85	49±1.12	41±2.9
Energy (K cal)	313±4.34	302±8.65	305±12.58
Ascorbic acid (mg/100 g d. wt.)	55± 1.91	33±1.19	48±1.55

Values are mean ± SD for nine determinations

Table 2. Major mineral content of the three domesticated edible wild mushrooms

Mineral (mg/100 g dry matter)	<i>Coprinus cinereus</i>	<i>Pleurotus flabellatus</i>	<i>Volvariella volvaceae</i>
Sodium (Na)	338± 2.3	686±3.0	258± 2.2
Potassium (K)	3232± 2.6	1537±2.4	1324± 2.5
Phosphorus (P)	1142±3.0	1616±2.97	1699± 2.57
Magnesium (Mg)	36± 2.1	40±1.9	57±2.3
Calcium (Ca)	214±2.6	120±2.5	446±19

Values are means ± SD of three analyses.

Table 3. Trace mineral content of the three domesticated edible wild mushrooms

Mineral (mg/100 g dry matter)	<i>Coprinus cinereus</i>	<i>Pleurotus flabellatus</i>	<i>Volvariella volvaceae</i>
Zinc (Zn)	141± 3.4	145± 2.3	68 ± 2.2
Iron (Fe)	248± 2.2	209± 2.5	426± 2.4
Manganese (Mn)	14± 3.1	10± 1.8	5.2± 1.7
Copper (Cu)	23±0.1	22± 0.2	16± 0.42
Cobalt (Co)	Not detected	Not detected	Not detected

Values are means ± SD of three analyses.

REFERENCES

1. **Obodai M, Cleland-Okine J and KA Vowotor** Comparative study on the growth and yield of *Pleurotus ostreatus* mushroom on different lignocellulosic by-products. J. Ind. Microbiol. Biotechnol. 2003; **30**: 146–149.
2. **Sadler M** Nutritional properties of edible fungi. British Nutrition Foundation Nutrition Bulletin. 2003; **28**: 305–308.
3. **Chang ST and JA Buswell** Mushroom nutraceuticals. World J. Microb. Biotechnol. 1996; **12**: 473-476.
4. **Chang ST and KE Mshigeni** Mushroom and their human health: their growing significance as potent dietary supplements. The University of Namibia, Windhoek, 2001:1-79.
5. **Crisan EV and A Sands** Nutritional value. In: ST Chang and WA Hayes (Eds). The Biology and Cultivation of Edible Mushrooms. London, Academic Press Inc, 1978:137-165.
6. **FAO**. Food and Agriculture Organization. The state of food insecurity in the world. A FAO. org. Report. FAO, Rome, Italy. 2006.
7. **FAO**. Food and Agriculture Organization. The Sixth World Food Survey. Food and Agriculture Organization of the United Nations, Rome. 1996.
8. **Härkönen M, Niemelä T and L Mwasumbi** Tanzanian Mushrooms. Edible, harmful and other fungi. Botanical Museum, Finish Museum of Natural History, Helsinki. 2003.
9. **Poppe JA** Use of agricultural waste materials in the cultivation of mushrooms. Mush. Sci. 2000; **15**: 3-23.
10. **Breen WM** Nutritional and medicinal value of specialty mushrooms. J. Food Protect. 1990; **53**: 883-894.
11. **Mdachi SJ, Nkunya MH, Nyigo VA and IT Urasa** Amino acid composition of some Tanzanian wild mushrooms. Food Chem. 2004; **86**: 179-182.
12. **AOAC**. Official Methods of Analysis -17th ed. Association of Official Analytical Chemist, Maryland. 2002.
13. **Braaksman A and DJ Schaap** Protein analysis of the common mushrooms *Agaricus bisporus*. Post. Harv. Biol. Technol. 1996; **7**: 119-127.
14. **Shah H, Khalil IA and S Jabeen** Nutritional composition and protein quality of *Pleurotus* mushroom. Sarhad J. Agric. 1997; **13**: 621-627.

15. **Adejumo TO and OB Awesanya** Proximate and mineral composition of four edible mushroom species from South Western Nigeria. *Afri. J. Biotechnol.* 2005; **4**: 1084-1088.
16. **SPSS.** Statistical package for Social Sciences. Computer Program, MS for Windows. SPSS 10 for Windows, Chicago, Illinois, USA. 1999.
17. **Vetter J** Mineral elements in the important cultivated mushrooms. *Agaricus bisporus* and *Pleurotus ostreatus*. *Food Chem.* 1994; **50**:277-279.
18. **Manzi I, Aguzzi A and L Pizzoferrato** Nutritional value of mushrooms widely consumed in Italy. *Food Chem.* 2001; **73**:321-325.
19. **Degreef J, Malaisse F, Rammeloo J and E Baudart** Edible mushrooms of the Zambezi woodland area: a nutritional and ecological approach. *Biotechnologie Agronomie Societe et Environnement* 1997; **1**: 221-231.
20. **Żródlowisk Z** The effect of washing and peeling of mushrooms *Agaricus bisporus* on the level of heavy metal contamination. *Pol. J. Food.Nutr. Sci.* 1995; **4/45**:26-33.
21. **Manzi I, Gambelli L, Mariconi S, Vivanti V and L Pizzoferrato** Nutrients in edible mushrooms: an interspecies comparative study. *Food Chem.* 1999; **65**:477-482.
22. **Khanna PK, Bhandari GL, Soni GL and HS Garcha** Evaluation of *Pleurotus* spp for Growth, Nutritive Value and Antifungal Activity. *Indian.J.Microbiol.* 1992; **32**:197-200.
23. **Stamets P and JS Chilton** *The Mushroom Cultivator. A practical guide to growing mushrooms at home.* Washington, Agarikon Press. 1983.
24. **Mendel LB** The chemical composition and nutritive value of some edible American fungi. *Am.J.Physiol.* 1898; **1**:225 - 238.
25. **Obodai M** Comparative studies on the utilization of agricultural waste by some mushrooms (*Pleurotus* and *Volvariella* species). M.Phil., The University of Ghana, Legon. 1992.
26. **Bernaś E, Jawarska G and Z Lisiewska** Edible mushrooms as a source of valuable nutritive constituents. *Acta Sci. Pol. Technol. Aliment.* 2006; **5**:5-20.
27. **FAO.** Food and Agriculture Organization. Food composition Table for use in East Asia. Food Policy Food and Nutri. Div. Food Agric. Organ. U. N, Rome. 1972.
28. **Lee TF and ST Chang** Nutritional analysis of *Volvariella volvacea*. *J.Chin.Soc.Hortic.Sci.* 1975; **21**:13-20.

29. **Chang ST and PG Miles** Edible mushrooms and their cultivation. Florida, CRS Press, Inc. 1989:27-38.
30. **FAO/WHO.** Protein quality evaluation. Report of a joint FAO/WHO expert consultation. Food and Nutrition Paper 51. FAO, Rome.1991.
31. **Kurtzman RH jr.** Nutrition from mushrooms, understanding and reconciling available data. Mycoscience. 1997; **38**:247-253.
32. **Li GSF and ST Chang** Nutritive value of *Volvariella volvacea*. In: Chang ST and TH Quimio (Eds). Tropical mushrooms: The Biological Nature and Cultivation Methods. Hongkong, The Chinese University Press.1982: 199-219.
33. **Mattila P, Konko K, Eurola M, Pihlaya JM, Astola J, Vahteristo L, Hietaniemi V, Kumpulainen J, Valtonen M and V Pironen** Contents of vitamins, mineral elements, and some phenolic compounds in cultivated mushrooms. J. Agric. Food Chem. 2001;**49**:2343-2348.
34. **Towo E, Mgoba C, Ndossi GD and S Kimboka** Effect of phytate and iron-binding phenolics on the content and availability of iron and zinc in micronutrients fortified cereal flours. Afric. J. Food Agric. Nutr. and Dev.2006; **6**:1-14.