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Research Paper

Proximate composition and mineral profiles of selected edible mushroom consumed in northern part of Nigeria

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ABSTRACT

Mushrooms are highly consumed by different ethnic groups in different states across the region (northern Nigeria). They have broad cultural acceptance and constitute a traditionally very important nutritious food. However, their assessment as food, which is based on chemical analysis, has not been adequately studied and documented. Standard procedures were used to determine the proximate chemical composition of edible mushrooms. Atomic absorption and flame spectrophotometer were used to determine the mineral and heavy element composition. The results were compared using an analysis of variance test. There were significant differences in the proximate nutritive values of the various edible mushrooms ($p>0.05$) studied. Despite differences in the chemical composition of the edible mushroom species, the overall nutritional potential of the whole mushroom species was quite good. The results of the analysis showed high significant amounts of protein and minerals, ranging from 1.24 -48.44 mg/g and 0.09 -57.54 mg/g for macro and micro elements, respectively. Furthermore, crude fibre ranged from 3.32 – 19.76% and carbohydrate from 20.54 – 64.78%, both of which were found to be relatively high. All species were moderate in fat content, with a range of 1.11 to 8.43%. Although Pb and Cd were detected in some of the species of mushrooms, these results indicated that the studied mushrooms have good nutritive value for human consumption.

Key words: Analysis, consumed, edible mushrooms, macro and micro elements, proximate composition.

INTRODUCTION

Several ethnic groups consume mushrooms worldwide (Chang and Mshigeni, 2001; Vetter, 1994; Nakalembe et al., 2009). Edible mushrooms have the potential to contribute enormously to food value and diet, especially in the supply of both macro- and micro-nutrients. The nutritive value of mushrooms is attributed to their high content of essential amino acids, vitamins, minerals and low lipid content. People consume mushroom are generally found to have greater intake levels of most vitamins and minerals. Some mushrooms are sources of food, diets, and are consumed all over the world. Food is one of the prime basic needs of humans; for good health, labour productivity, and mental development. They have a high nutritional value and are common in most part of environments. They are rich in vitamins and mineral elements (Fasidi et al., 1990; Sivrikaya et al., 2002) and the bioavailability of some elements depend on the level of interactions with various nutrients. Apart from their use as food, demands have been accelerated with the exponential human population growth and some scientific evidences suggest that many species contain substances that may prevent or reduce cancer, heart diseases, diabetes and viral infections (Genders, 1974; Oei, 1991). Mushrooms have been a food supplement in various cultures and are cultivated and eaten for their edibility and delicacy. Mushrooms are considered as source of proteins, vitamins, fats,

carbohydrates, amino acids and minerals (Colak et al., 2009). They fall between the best vegetables and animal protein source. The protein content of mushrooms has been reported to be twice that of vegetables and four times that of oranges and significantly higher than that of wheat (FAO, 2006). Mushrooms contains also an appreciable quantities of crude fibres, although, little information exist on its Total Dietary Fibre (TDF) content. The crude fibre content values reported in several studies suggest that mushrooms are potential sources of dietary fibre (Adadayo, 2011). Mushrooms generally contain low fat and oil content (Poppe, 2000). As a result, they are recommended as good source of food supplement for patients with cardiac problems or at risk of lipid induced disorders. Despite the numerous studies on nutrients and minerals contents of different mushroom species globally, little or no work has been carried out on the nutritional component of edible mushroom species in northern parts of Nigeria and there are several edible species that are yet to be exploited. Therefore, this study was carried out to investigate the proximate composition, mineral and some heavy metal content of ten selected edible mushrooms in northern Nigeria.

MATERIALS AND METHODS

Collection of samples and sample preparation

Ten varieties of edible mushrooms species were studied. The mushrooms were morels (*Morchella sp*), maitake (*grifola frondosa*), porcini (*Boletus edultis*), giant puftball (*Calvatia gigantean*), chanterelles (*Cantharellus cibarius*), matsutake (*Tricholoma matsutake*), shaggy mane (*Coprinus comatus*), black trumpt (*Craterellus cornucopioides*), caesaris mushroom (*Amanita caesarea*) and Portobello (*Pleurotous ostreatus*). These mushrooms were obtained from various places: farms, highways, markets and various spots such as garden, rotten woods, palm trees rots, plant wastes, waste site etc in the study areas. The mushroom samples were uprooted, destalked, washed and cleaned to remove extraneous substances, and sun-dried for some days. The mushrooms were later milled to obtain mushroom meals using mortar and pestle and were stored in a container for the analysis.

Determination of the nutritional value

Proximate analysis

Moisture, ash, crude fat, crude fat and crude fibre were determined in accordance with the official methods of the association of official analytical chemists (AOAC, 1999). Nitrogen was determined using micro-kjeldahl method (Pearson, 1976) and the percentage of nitrogen was converted to crude protein through multiplying by 6.25. Carbohydrate was determined by difference.

Digestion procedure

A procedure recommended by Environmental Protection Agency (EPA, Method 3050B) was used as the conventional acid extraction method. 1.00 g of sample was placed in 250 ml flask for digestion. In the first step, the sample was heated to 95°C with 10 ml of 50% HNO_3 without boiling. After cooling the sample, it was refluxed with repeated additions of 65% HNO_3 until no brown fumes were given off by the sample. Then the solution was allowed to evaporate until the volume was reduced to 5 cm^3. After cooling, 10 ml of 30% H_2O_2 was added slowly without allowing any losses. The mixture was refluxed with 10 cm^3 of 37% HCl at 95°C for 15 min. The digestate obtained was filtered through a 0.45 µm membrane paper, diluted to 100 cm^3 with deionized water and stored at 4°C for analyses. The total extraction procedure lasted for 3–4 h.

The resultant solution was cooled and filtered into 100 cm^3 standard flasks and made to mark with distilled water (Asaolu, 1995). Atomic absorption spectrophotometer (Buck scientific model 200A) was used for Ca, Mg, Cd, Cu, Fe, Pb, Mn and Zn, and flame photometer for Na and K.

Statistical analysis

Microsoft Excel (2007) package was used for statistical analysis by employing the independent sample t-test. The summary statistics such as mean, standard deviation (SD) and correlation were computed. Significant tests were carried out at the 0.05 level. Significant difference was observed when the probability associated with the t test (p) was less than the level of significance (that is, $p < 0.05$). The data were also subjected to analyses of variance (one-way ANOVA).

RESULTS AND DISCUSSION

The results of proximate composition of the edible mushrooms consumed in the study areas are presented in Tables 1 – 10, and the summary of the proximate composition of the edible mushrooms is presented in Table 11. The moisture content in all varieties of edible mushroom studied ranged from 20.55 – 67.76%. The moisture contents of the mushrooms were relatively high with average value of 44.73±9.67%. Maitake (*G. frondosa*) had the highest moisture content (67.76%), while the lowest values were recorded in chanterelles (*C. cibarius*) and shaggy mane (*C. comatus*). The high moisture content provides greater activity of water soluble enzymes and co-enzymes needed for metabolic activities of these mushrooms (Crisan and Sands, 1978; Adejumo and

Table 1: Proximate composition of in Morels (*Morchella* sp).

Sample	Ash (%)	Carbohydrate (%)	Fat (%)	Crude fibre (%)	Crude protein (%)	Moisture (%)
1	6.52	54.78	1.11	12.32	25.65	49.54
2	8.53	57.99	1.21	11.32	21.32	51.32
3	10.87	48.65	1.55	13.45	21.44	50.55
4	9.88	52.77	1.22	15.33	22.12	49.88
5	9.55	45.89	1.12	10.67	20.23	47.68
6	7.55	46.78	1.45	14.34	21.55	51.44
7	8.34	44.56	1.32	11.21	24.89	49.88
8	7.98	50.54	1.43	9.76	19.23	51.54
9	8.76	47.88	1.21	9.34	17.32	45.67
10	6.45	45.78	1.43	10.54	21.67	47.76
Mean	8.44	49.56	1.31	11.83	21.54	49.53
STD	1.41	4.39	0.15	1.99	2.44	1.93
MIN	6.45	44.56	1.11	9.34	17.32	45.67
MAX	10.87	57.99	1.55	15.33	25.65	51.54

Table 2: Proximate composition of Maitake (*Grifola frondosa*).

Sample	Ash (%)	Carbohydrate (%)	Fat (%)	Crude fibre (%)	Crude protein (%)	Moisture (%)
1	16.34	24.78	2.11	10.32	15.65	59.54
2	18.53	27.99	2.21	10.32	21.32	51.32
3	10.87	28.65	2.55	10.45	21.44	60.55
4	19.88	22.77	2.22	12.33	22.12	49.88
5	19.55	25.89	2.12	10.67	18.23	47.68
6	17.55	26.78	2.45	11.34	19.55	61.44
7	8.34	24.56	2.32	11.21	14.89	39.88
8	17.98	20.54	2.43	10.76	19.23	41.54
9	18.76	27.88	2.21	11.34	17.32	55.67
10	16.45	25.78	2.43	10.54	18.67	67.76
Mean	16.43	25.56	2.31	10.93	18.84	53.53
STD	3.82	2.52	0.15	0.63	2.42	9.05
MIN	8.34	20.54	2.11	10.32	14.89	39.88
MAX	19.88	28.65	2.55	12.33	22.12	67.76

Awesanya, 2005; Sivrikaya et al., 2002).

The total ash content ranged from 6.45 – 38.53% for all edible mushrooms studied. Total ash content in Portobello (*P. ostreatus*) was higher 38.53%, while in morels (*Morchella* sp.), the total ash content was low (6.45%). The high ash content of *P. ostreatus* (38.53%) as compared with *Morchella* sp. (6.45%) with low ash values, which is the least of all the mushrooms investigated, is an indication that there are more minerals in *P. ostreatus, C. cibarius, C. cornucopioides, A. caesarea* and *G. frondosa* than in *Morchella* sp., *B. edultis, T. matsutake* and *C. comatus*. The values of ash content obtained in this studied are comparable to those (*A. hybridus*, *C. peps* and *G. africana)* reported in other similar studies (Chandravadana et al., 2005). The fat contents of edible mushrooms studied ranged from 1.11 - 8.43%. *C. cornucopioides* and *T. matsutake* had the highest fat contents of 8.43 and 7.32%, respectively while *Morchella* sp. and *C. gigantea* had the lowest fat contents of 1.31%. The percentage of fat in some mushrooms species was fairly high especially in *C. cornucopioides* and *T. matsutake* when compared with values reported in mushrooms in the similar studies (Breene, 1990; Mendel, 1989; Kurtzman, 1997). However, the fat content was within the range of the reported value of wild mushrooms, that is 1.1–8.1% on dry weight basis (Crisan and Sands, 1978). In this study, crude fat content is comparable to that of grains such as millet (2.8%) and maize (4.2%) (FAO, 1972). Mushroom fat is reportedly rich in essential unsaturated fatty acids, which are considered essential for human diet and health. The

Table 3: Proximate composition of Porcini (*Boletus edultis*).

Sample	Ash %	Carbohydrate %	Fat %	Crude Fibre %	Crude protein%	Moisture%
1	16.52	34.78	4.11	8.32	35.65	49.54
2	12.53	37.99	4.21	9.32	31.32	51.32
3	10.87	38.65	4.55	11.45	31.44	50.55
4	11.88	32.77	4.22	9.33	32.12	49.88
5	9.55	35.89	4.12	9.67	30.23	47.68
6	12.55	36.78	4.45	8.34	31.55	51.44
7	10.34	34.56	4.32	9.21	34.89	49.88
8	17.98	30.54	4.43	11.76	29.23	51.54
9	10.76	37.88	4.21	11.34	27.32	45.67
10	16.45	35.78	4.43	9.54	31.67	47.76
Mean	12.94	35.56	4.31	9.83	31.54	49.53
STD	2.97	2.52	0.15	1.25	2.44	1.93
MIN	9.55	30.54	4.11	8.32	27.32	45.67
MAX	17.98	38.65	4.55	11.76	35.65	51.54

Table 4: Proximate composition of giant puftball (*Calvatia gigantea*).

Sample	Ash (%)	Carbohydrate (%)	Fat (%)	Crude fibre (%)	Crude protein (%)	Moisture (%)
1	16.52	44.78	1.11	12.32	25.65	49.54
2	18.53	37.99	1.21	11.32	31.32	51.32
3	10.87	38.65	1.55	13.45	31.44	50.55
4	12.88	42.77	1.22	15.33	32.12	49.88
5	19.55	35.89	1.12	10.67	30.23	47.68
6	17.55	36.78	1.45	14.34	31.55	51.44
7	18.34	44.56	1.32	11.21	24.89	49.88
8	17.98	40.54	1.43	9.76	29.23	51.54
9	18.76	37.88	1.21	9.34	27.32	45.67
10	16.45	35.78	1.43	10.54	31.67	47.76
Mean	16.74	39.56	1.31	11.83	29.54	49.53
STD	2.78	3.42	0.15	1.99	2.67	1.93
MIN	10.87	35.78	1.11	9.34	24.89	45.67
MAX	19.55	44.78	1.55	15.33	32.12	51.54

protein contents of the mushroom samples ranged from 10.20 – 45.65%. The high value of protein content were obtained in *C. cibarius*, *A. caesarea*, *C. cornucopioides*, *C. gigantea* and *B. edultis*. The protein content obtained in these species of mushrooms were higher than that reported in some mushrooms in similar researches (Khanna et al., 1992; Lee and Chang, 1975). Plant materials or foods that provide more than 12% of their calorific value from protein have been shown to be good source of protein (Ali, 2009). This shows that almost all wild edible mushrooms studied are good sources of protein. The crude fibres value ranged from 3.32 to 19.76%, these values fall within the range of reported values for edible mushrooms in similar studies (Crisan and Sands, 1978; Mendel, 1989). Crude fibre is also part of a healthy diet. The obtained values in this study were within the reported value of 3–35% fibre on a dry weight basis (Breene, 1990). Since the mushroom species examined contained significant amounts of crude fiber, they could be regarded as good sources of dietary fiber for supplementation of some foodstuffs with less fiber such as vegetables, hence utilized as roughage, and mostly its immune-stimulation effects should not be overlooked. Dietary fibre helps to prevent constipation, bowel problems and piles. The total carbohydrate content ranged from 20.54 - 64.78%. A range of carbohydrate values of 53 - 60% of dry weight has been reported for some species of mushrooms (Mendel, 1989). The ranged carbohydrate content of 20.54 – 64.78% reported in this present study is only slightly above this reported range. The value of carbohydrate content of 20.54 – 64.78% reported in the present study for all species of mushrooms studied, falls within the range of 45-

Table 5: Proximate composition of Chanterelles (*Cantharellus cibarius*).

Sample	Ash (%)	Carbohydrate (%)	Fat (%)	Crude fibre (%)	Crude protein (%)	Moisture (%)
1	26.52	34.78	3.11	15.32	45.65	29.54
2	28.53	37.99	3.21	15.32	41.32	31.32
3	20.87	38.65	2.55	13.45	41.44	20.55
4	29.88	32.77	3.22	15.33	42.12	39.88
5	29.55	45.89	3.12	15.67	40.23	37.68
6	27.55	46.78	2.45	14.34	41.55	31.44
7	28.34	44.56	3.32	15.21	44.89	29.88
8	27.98	30.54	2.43	14.76	39.23	31.54
9	28.76	47.88	3.21	15.34	37.32	35.67
10	26.45	45.78	2.43	15.54	41.67	27.76
Mean	27.44	40.56	2.91	15.03	41.54	31.53
STD	2.57	6.40	0.38	0.68	2.44	5.44
MIN	20.87	30.54	2.43	13.45	37.32	20.55
MAX	29.88	47.88	3.32	15.67	45.65	39.88

Table 6: Proximate composition of Matsutake (*Tricholoma matsutake*).

Sample	Ash %	Carbohydrate %	Fat %	Crude fibre %	Crude protein%	Moisture%
1	15.52	64.78	6.11	3.32	15.65	49.54
2	10.53	57.99	7.21	4.32	12.32	51.32
3	10.87	58.65	6.55	3.45	14.44	50.55
4	11.88	52.77	6.22	5.33	15.12	49.88
5	12.55	55.89	7.12	5.67	10.23	47.68
6	9.55	56.78	6.45	4.34	11.55	51.44
7	11.34	54.56	7.32	5.21	14.89	49.88
8	12.98	50.54	5.43	3.76	13.23	51.54
9	11.76	57.88	4.21	4.34	13.32	45.67
10	13.45	55.78	5.43	4.54	12.67	47.76
Mean	12.04	56.56	6.21	4.43	13.34	49.53
STD	1.69	3.82	0.97	0.79	1.72	1.93
MIN	9.55	50.54	4.21	3.32	10.23	45.67
MAX	15.52	64.78	7.32	5.67	15.65	51.54

Table 7: Proximate composition of Shaggy mane (*Coprinus comatus*).

Sample	Ash %	Carbohydrate %	Fat %	Crude fibre %	Crude protein%	Moisture%
1	11.52	24.78	2.11	6.32	35.65	29.54
2	13.53	27.99	2.21	8.32	31.32	31.32
3	10.87	28.65	1.55	9.45	31.44	20.55
4	10.88	32.77	2.22	5.33	32.12	39.88
5	10.55	25.89	2.12	10.67	30.23	37.68
6	11.55	26.78	1.45	7.34	31.55	31.44
7	13.34	24.56	2.32	11.21	34.89	29.88
8	12.98	30.54	1.43	9.76	29.23	31.54
9	10.76	27.88	2.21	9.34	27.32	35.67
10	12.45	25.78	2.43	10.54	31.67	27.76
Mean	11.84	27.56	2.01	8.83	31.54	31.53
STD	1.14	2.60	0.38	1.96	2.44	5.44
MIN	10.55	24.56	1.43	5.33	27.32	20.55
MAX	13.53	32.77	2.43	11.21	35.65	39.88

Table 8: Proximate composition of Black trumpet (*Craterellus cornucopioides*).

Sample	Ash(%)	Carbohydrate (%)	Fat %	Crude Fibre %	Crude Protein%	Moisture%
1	16.52	44.78	6.11	17.32	45.65	29.54
2	18.53	47.99	7.21	16.32	41.32	31.32
3	10.87	48.65	6.55	15.45	41.44	40.55
4	19.88	42.77	8.22	15.33	42.12	39.88
5	19.55	45.89	5.12	17.67	40.23	37.68
6	17.55	46.78	6.45	14.34	41.55	41.44
7	18.34	44.56	7.32	11.21	44.89	39.88
8	17.98	40.54	8.43	19.76	39.23	41.54
9	18.76	47.88	7.21	19.34	37.32	35.67
10	16.45	45.78	6.43	14.54	41.67	37.76
Mean	17.44	45.56	6.91	16.13	41.54	37.53
STD	2.57	2.52	0.99	2.55	2.44	4.18
MIN	10.87	40.54	5.12	11.21	37.32	29.54
MAX	19.88	48.65	8.43	19.76	45.65	41.54

Table 9: Proximate composition of Caesaris mushroom (*Amanita caesarea*).

Sample	Ash(%)	Carbohydrate (%)	Fat (%)	Crude fibre (%)	Crude protein(%)	Moisture(%)
1	26.52	24.78	6.11	16.32	45.65	39.54
2	28.53	27.99	5.21	18.32	41.32	41.32
3	20.87	28.65	5.55	19.45	41.44	30.55
4	19.88	32.77	6.22	15.33	42.12	39.88
5	19.55	25.89	6.12	18.67	40.23	47.68
6	27.55	26.78	5.45	14.34	41.55	41.44
7	18.34	24.56	6.32	16.21	34.89	39.88
8	27.98	30.54	5.43	19.76	39.23	41.54
9	18.76	27.88	6.21	19.34	37.32	55.67
10	26.45	25.78	5.43	18.54	41.67	37.76
Mean	23.44	27.56	5.81	17.63	40.54	41.53
STD	4.27	2.60	0.42	1.92	2.91	6.51
MIN	18.34	24.56	5.21	14.34	34.89	30.55
MAX	28.53	32.77	6.32	19.76	45.65	55.67

Table 10: Proximate composition of Portobello (*Pleurotous ostreatus*).

Sample	Ash (%)	Carbohydrate(%)	Fat (%)	Crude fibre (%)	Crude protein(%)	Moisture(%)
1	36.52	44.78	2.11	15.32	25.65	59.54
2	38.53	47.99	3.21	17.32	21.32	51.32
3	30.87	48.65	2.55	13.45	21.44	60.55
4	29.88	52.77	3.22	15.33	22.12	49.88
5	29.55	45.89	3.12	18.67	20.23	47.68
6	37.55	46.78	2.45	14.34	21.55	61.44
7	28.34	44.56	3.32	16.21	24.89	39.88
8	37.98	40.54	3.43	19.76	19.23	41.54
9	28.76	47.88	3.21	19.34	17.32	55.67
10	36.45	45.78	2.43	15.54	21.67	67.76
Mean	33.44	46.56	2.91	16.53	21.54	53.53
STD	4.27	3.18	0.47	2.16	2.44	9.05
MIN	28.34	40.54	2.11	13.45	17.32	39.88
MAX	38.53	52.77	3.43	19.76	25.65	67.76

Table 11: Summary Results of proximate composition of various edible mushroom species in the study areas.

Sample	Ash (%)	Carbohydrate (%)	Fat(%)	Crude fibre (%)	Crude protein(%)	Moisture(%)
Proximate composition of in Morels (*Morchella* sp).						
Mean	8.44	49.56	1.31	11.83	21.54	49.53
STD	1.41	4.39	0.15	1.99	2.44	1.93
MIN	6.45	44.56	1.11	9.34	17.32	45.67
MAX	10.87	57.99	1.55	15.33	25.65	51.54
Proximate composition of Maitake (*Grifola frondosa*)..						
Mean	16.43	25.56	2.31	10.93	18.84	53.53
STD	3.82	2.52	0.15	0.63	2.42	9.05
MIN	8.34	20.54	2.11	10.32	14.89	39.88
MAX	19.88	28.65	2.55	12.33	22.12	67.76
Proximate composition of Porcini (*Boletus edultis*).						
Mean	12.94	35.56	4.31	9.83	31.54	49.53
STD	2.97	2.52	0.15	1.25	2.44	1.93
MIN	9.55	30.54	4.11	8.32	27.32	45.67
MAX	17.98	38.65	4.55	11.76	35.65	51.54
Proximate composition of Giant puftball (*Calvatia gigantea*)						
Mean	16.74	39.56	1.31	11.83	29.54	49.53
STD	2.78	3.42	0.15	1.99	2.67	1.93
MIN	10.87	35.78	1.11	9.34	24.89	45.67
MAX	19.55	44.78	1.55	15.33	32.12	51.54
Proximate composition of Chanterelles (*Cantharellus cibarius*).						
Mean	27.44	40.56	2.91	15.03	41.54	31.53
STD	2.57	6.40	0.38	0.68	2.44	5.44
MIN	20.87	30.54	2.43	13.45	37.32	20.55
MAX	29.88	47.88	3.32	15.67	45.65	39.88
Proximate composition of Matsutake (*Tricholoma matsutake*).						
Mean	12.04	56.56	6.21	4.43	13.34	49.53
STD	1.69	3.82	0.97	0.79	1.72	1.93
MIN	9.55	50.54	4.21	3.32	10.23	45.67
MAX	15.52	64.78	7.32	5.67	15.65	51.54
Proximate composition of Shaggy mane (*Coprinus comatus*)						
Mean	11.84	27.56	2.01	8.83	31.54	31.53
STD	1.14	2.60	0.38	1.96	2.44	5.44
MIN	10.55	24.56	1.43	5.33	27.32	20.55
MAX	13.53	32.77	2.43	11.21	35.65	39.88
Proximate composition of Black trumpet (*Craterellus cornucopioides*).						
Mean	17.44	45.56	6.91	16.13	41.54	37.53
STD	2.57	2.52	0.99	2.55	2.44	4.18
MIN	10.87	40.54	5.12	11.21	37.32	29.54
MAX	19.88	48.65	8.43	19.76	45.65	41.54
Proximate composition of Caesaris mushroom (*Amanita caesarea*).						
Mean	23.44	27.56	5.81	17.63	40.54	41.53

Table 11: Contd. Summary Results of proximate composition of various edible mushroom species in the study areas.

STD	4.27	2.60	0.42	1.92	2.91	6.51
MIN	18.34	24.56	5.21	14.34	34.89	30.55
MAX	28.53	32.77	6.32	19.76	45.65	55.67
Proximate composition of Portobello (*Pleurotous ostreatus*).						
Mean	33.44	46.56	2.91	16.53	21.54	53.53
STD	4.27	3.18	0.47	2.16	2.44	9.05
MIN	28.34	40.54	2.11	13.45	17.32	39.88
MAX	38.53	52.77	3.43	19.76	25.65	67.76
All samples of mushrooms						
Mean	18.02	39.46	3.60	12.30	29.15	44.73
STD	7.98	10.50	2.04	4.23	9.92	9.67
MIN	6.45	20.54	1.11	3.32	10.23	20.55
MAX	38.53	64.78	8.43	19.76	45.65	67.76

Table 12: Mineral and heavy metal contents (mg/g) in Morels (*Morchella* sp).

Metals	**Ca**	**Mg**	**K**	**Na**	**Cd**	**Cu**	**Fe**	**Mn**	**Pb**	**Zn**
1	18.76	8.69	5.34	3.11	ND	3.11	3.51	0.92	0.10	32.12
2	15.07	11.77	5.32	4.96	0.01	4.96	2.52	0.83	0.07	22.97
3	16.09	10.59	5.43	3.86	ND	3.86	2.98	0.70	0.08	42.55
4	18.10	12.80	4.90	3.79	0.01	3.79	2.25	0.74	0.07	32.07
5	17.07	9.87	4.10	4.68	ND	4.68	2.33	0.88	0.06	42.88
6	19.10	10.99	5.68	2.84	0.01	2.84	2.86	0.67	0.09	32.00
7	17.09	10.79	4.69	3.70	ND	3.70	2.22	0.70	0.09	32.54
8	16.08	10.98	6.33	4.59	0.01	4.59	2.79	0.84	0.08	52.23
9	18.07	11.77	5.34	4.02	0.02	4.02	2.21	0.69	0.05	42.54
10	16.09	11.99	6.12	4.01	ND	4.01	2.16	0.80	0.07	32.68
Mean	17.15	11.02	5.33	3.96	0.01	3.96	2.58	0.78	0.07	36.46
STD	1.33	1.17	0.66	0.67	0.00	0.67	0.44	0.09	0.01	8.39
MIN	15.07	8.69	4.10	2.84	0.00	2.84	2.16	0.67	0.05	22.97
MAX	19.10	12.80	6.33	4.96	0.02	4.96	3.51	0.92	0.10	52.23

77% reported for other mushroom species (Crisan and Sands, 1978; Khanna et al., 1992). Although, it is supposed that humans cannot utilise a large percentage of the carbohydrate in mushrooms as nutrients, it could function as roughage.

The values of macro and micro elements of the edible mushrooms in the study areas are shown in Tables 12 –21, and a summary of the value of results is presented in Table 22. As with many foods, the mineral content of edible mushrooms is highly variable. There are many minerals that are essential for normal healthy body. Mushrooms, like all living organisms, have a good mix of minerals, and their fruiting bodies are characterized by high levels of assailable mineral constituents (Mattila et al., 2001). The calcium content in the mushroom samples ranged from 9.30 – 48.44 mg/g. The concentration of magnesium ranged from 2.14 – 17.99 mg/g. The potassium concentration ranged from 1.39 – 11.99 mg/g, while the sodium concentration ranged from 1.24 – 7.43 mg/g. Calcium, magnesium and potassium were abundant in the edible mushrooms studied. The results showed that they are good sources of mineral elements. Significant differences in mineral content were observed ($p<0.05$) among the various mushroom species analyzed in this study. Calcium was the predominant elements among the macro minerals measured. Zinc and to some extents iron were the most abundant elements among the trace minerals analyzed. Similar observations on mineral content profiles have been reported for edible mushrooms of *Agaricus, Pleurotus,* and *Lentinula* species (Chang and Buswell, 1996; Shah et al., 1997). The mineral concentrations 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, the composition of the growth substrate, and environment (water, temperature and humidity). The differences in

Table13: Mineral and heavy metal contents (mg/g) in Maitake (*Grifola frondosa*).

Metals	Ca	Mg	K	Na	Cd	Cu	Fe	Mn	Pb	Zn
1	18.76	10.69	4.88	2.96	ND	2.96	6.00	0.79	1.55	32.65
2	15.07	9.77	3.88	3.65	ND	3.65	4.12	0.73	0.85	42.10
3	16.09	8.59	5.23	2.90	ND	2.90	6.10	0.84	1.07	22.01
4	18.10	7.80	4.99	4.11	ND	4.11	4.89	0.89	0.81	29.12
5	20.07	10.87	6.45	2.79	ND	2.79	3.40	0.77	0.75	41.99
6	19.10	9.99	7.43	3.01	ND	3.01	6.16	0.80	0.71	35.68
7	17.09	11.79	4.23	1.95	ND	1.95	5.52	0.83	1.06	53.97
8	16.08	9.98	3.68	2.59	ND	2.59	6.79	0.84	0.76	43.23
9	18.07	8.77	5.32	3.66	ND	3.66	5.11	0.73	0.87	33.10
10	17.89	11.99	3.88	2.86	ND	2.86	7.97	0.70	0.97	34.55
Mean	17.63	10.02	5.00	3.05	ND	3.05	5.61	0.79	0.94	36.84
STD	1.55	1.37	1.21	0.62	ND	0.62	1.31	0.06	0.25	8.86
MIN	15.07	7.80	3.68	1.95	ND	1.95	3.40	0.70	0.71	22.01
MAX	20.07	11.99	7.43	4.11	ND	4.11	7.97	0.89	1.55	53.97

Table 14: Mineral and heavy metal contents (mg/g) in Porcini (*Boletus edultis*).

Metals	Ca	Mg	K	Na	Cd	Cu	Fe	Mn	Pb	Zn
1	18.76	10.69	4.88	3.43	ND	3.43	2.51	0.12	0.10	51.23
2	20.12	9.77	3.88	3.23	ND	3.23	2.32	0.13	0.17	40.97
3	23.43	8.59	5.23	2.65	ND	2.65	1.98	0.77	0.12	38.55
4	21.44	7.80	4.99	2.79	ND	2.79	2.25	0.14	0.11	47.77
5	25.35	10.87	6.45	2.68	ND	2.68	2.33	0.18	0.13	35.88
6	32.12	9.99	7.43	3.13	ND	3.13	1.86	0.17	0.18	54.00
7	23.57	10.79	4.23	2.70	ND	2.70	2.22	0.10	0.21	42.54
8	26.45	9.98	3.68	2.59	ND	2.59	1.79	0.14	0.16	39.23
9	27.43	8.77	5.32	3.32	ND	3.32	2.21	0.09	0.11	57.54
10	28.90	9.99	3.88	2.43	ND	2.43	2.16	0.20	0.19	41.68
Mean	24.76	9.72	5.00	2.90	ND	2.90	2.16	0.20	0.15	44.94
STD	4.13	1.03	1.21	0.35	ND	0.35	0.23	0.20	0.04	7.27
MIN	18.76	7.80	3.68	2.43	ND	2.43	1.79	0.09	0.10	35.88
MAX	32.12	10.87	7.43	3.43	ND	3.43	2.51	0.77	0.21	57.54

Table 15: Mineral and heavy metal contents (mg/g) in Giant puftball (*Calvatia gigantea*).

Metals	Ca	Mg	K	Na	Cd	Cu	Fe	Mn	Pb	Zn
1	18.76	6.69	4.39	1.39	ND	10.13	1.51	0.12	0.01	25.13
2	19.23	7.77	5.32	2.32	ND	12.23	1.32	0.13	0.01	32.17
3	34.23	8.59	2.09	2.09	ND	11.15	1.98	0.77	0.01	43.15
4	34.21	7.80	2.07	2.07	ND	10.19	1.25	0.14	0.01	36.17
5	31.23	8.87	4.99	1.99	ND	13.18	1.33	0.18	0.01	39.13
6	36.32	5.99	2.88	2.88	ND	9.13	1.06	0.17	0.01	35.20
7	37.88	6.79	2.32	2.32	ND	12.20	1.21	0.10	0.01	35.14
8	32.21	6.98	3.99	1.99	ND	13.19	1.19	0.14	0.01	33.23
9	34.90	8.77	5.77	1.77	ND	13.12	1.20	0.09	0.01	29.14
10	34.79	7.99	2.07	2.07	ND	10.13	1.16	0.20	0.01	38.18
Mean	31.38	7.62	3.59	2.09	ND	11.47	1.32	0.20	0.01	34.67
STD	6.78	0.98	1.47	0.39	ND	1.51	0.26	0.20	0.00	5.13
MIN	18.76	5.99	2.07	1.39	ND	9.13	1.06	0.09	0.01	25.13
MAX	37.88	8.87	5.77	2.88	ND	13.19	1.98	0.77	0.01	43.15

Table 16: Mineral and heavy metal contents (mg/g) in Chanterelles (*Cantharellus cibarius*).

Metals	Ca	Mg	K	Na	Cd	Cu	Fe	Mn	Pb	Zn
1	42.12	10.69	4.88	3.51	ND	3.33	3.51	0.92	0.95	29.12
2	40.23	9.77	3.88	2.52	ND	2.55	2.52	0.83	0.65	32.97
3	39.34	8.59	5.23	2.98	ND	2.67	2.98	0.70	0.98	28.55
4	38.43	7.80	4.99	2.25	ND	3.21	2.25	0.74	0.97	25.07
5	37.34	10.87	6.45	2.33	ND	3.45	2.33	0.88	0.86	27.88
6	35.21	9.99	7.43	2.86	ND	2.78	2.86	0.67	0.99	32.00
7	36.43	11.79	4.23	2.22	ND	2.99	2.22	0.70	0.99	35.54
8	34.23	9.98	3.68	2.79	ND	2.90	2.79	0.84	0.88	26.23
9	35.32	8.77	5.32	2.21	ND	3.45	2.21	0.69	0.95	32.54
10	31.21	11.99	3.88	2.16	ND	3.44	2.16	0.80	0.97	32.68
Mean	36.99	10.02	5.00	2.58	ND	3.08	2.58	0.78	0.92	30.26
STD	3.19	1.37	1.21	0.44	ND	0.35	0.44	0.09	0.10	3.37
MIN	31.21	7.80	3.68	2.16	ND	2.55	2.16	0.67	0.65	25.07
MAX	42.12	11.99	7.43	3.51	ND	3.45	3.51	0.92	0.99	35.54

Table 17: Mineral and Heavy Metal contents (mg/g) in Matsutake (*Tricholoma matsutake*).

Metals	Ca	Mg	K	Na	Cd	Cu	Fe	Mn	Pb	Zn
1	18.76	8.69	5.34	4.00	0.01	2.36	4.00	0.79	0.06	52.65
2	15.35	11.77	5.32	2.12	0.02	3.45	2.12	0.73	0.09	45.10
3	18.32	10.59	5.43	2.10	0.01	2.60	2.10	0.84	0.07	45.01
4	19.43	12.80	4.90	4.89	0.01	3.31	4.89	0.89	0.08	46.12
5	17.57	9.87	4.10	3.40	0.01	2.79	3.40	0.77	0.08	51.99
6	17.76	10.99	5.68	2.16	0.01	2.61	2.16	0.80	0.07	47.68
7	18.77	10.79	4.69	2.52	0.02	3.45	2.52	0.83	0.06	38.97
8	14.23	10.98	6.33	2.79	0.01	2.59	2.79	0.84	0.08	32.23
9	11.35	11.77	5.34	2.11	0.02	2.66	2.11	0.73	0.09	42.10
10	19.32	11.99	6.12	2.97	0.01	2.52	2.97	0.70	0.08	38.55
Mean	17.09	11.02	5.33	2.91	0.01	2.83	2.91	0.79	0.07	44.04
STD	2.64	1.17	0.66	0.94	0.00	0.41	0.94	0.06	0.01	6.29
MIN	11.35	8.69	4.10	2.10	0.01	2.36	2.10	0.70	0.06	32.23
MAX	19.43	12.80	6.33	4.89	0.02	3.45	4.89	0.89	0.09	52.65

Table 18: Mineral and heavy metal contents (mg/g) in Shaggy mane (*Coprinus comatus*).

Metals	Ca	Mg	K	Na	Cd	Cu	Fe	Mn	Pb	Zn
1	40.23	12.69	4.88	2.11	ND	2.43	2.51	0.12	0.01	31.23
2	43.23	13.77	3.88	3.96	ND	2.23	2.32	0.13	0.02	29.97
3	43.23	14.59	5.23	2.86	ND	2.65	1.98	0.77	0.01	36.55
4	40.34	15.80	4.99	2.79	ND	2.79	2.25	0.14	0.01	35.77
5	48.43	16.87	6.45	3.68	ND	2.68	2.33	0.18	0.01	39.88
6	42.23	13.99	7.43	2.84	ND	3.13	1.86	0.17	0.02	39.00
7	44.34	14.79	4.23	3.70	ND	2.70	2.22	0.10	0.02	41.54
8	39.43	13.98	3.68	3.59	ND	2.59	1.79	0.14	0.02	33.23
9	38.91	10.77	5.32	2.02	ND	3.32	2.21	0.09	0.01	32.54
10	48.44	17.99	3.88	2.01	ND	2.43	2.16	0.20	0.02	30.68
Mean	42.88	14.52	5.00	2.96	ND	2.70	2.16	0.20	0.02	35.04
STD	3.43	2.05	1.21	0.75	ND	0.33	0.23	0.20	0.00	4.12
MIN	38.91	10.77	3.68	2.01	ND	2.23	1.79	0.09	0.01	29.97
MAX	48.44	17.99	7.43	3.96	ND	3.32	2.51	0.77	0.02	41.54

Table 19: Mineral and heavy metal contents (mg/g) in Black trumpet (*Craterellus cornucopioides*).

Metals	Ca	Mg	K	Na	Cd	Cu	Fe	Mn	Pb	Zn
1	18.76	10.69	10.69	4.88	0.01	1.13	1.51	0.12	0.11	45.13
2	21.32	9.77	9.77	3.88	0.01	2.23	1.32	0.13	0.14	32.33
3	19.32	11.59	8.59	5.23	0.01	2.15	1.98	0.77	0.12	39.33
4	18.43	12.80	7.80	4.99	0.02	3.19	1.25	0.14	0.11	42.12
5	21.23	9.87	10.87	6.45	0.02	2.18	1.33	0.18	0.13	45.32
6	22.32	9.99	9.99	7.43	0.01	2.13	1.06	0.17	0.13	39.85
7	19.32	10.79	11.79	4.23	0.01	2.20	1.21	0.10	0.11	44.33
8	21.32	10.98	9.98	3.68	0.02	3.19	1.19	0.14	0.12	35.56
9	23.43	10.77	8.77	5.32	0.02	3.12	1.20	0.09	0.11	36.43
10	23.44	10.99	11.99	3.88	0.01	2.13	1.16	0.20	0.13	41.44
Mean	20.89	10.82	10.02	5.00	0.01	2.37	1.32	0.20	0.12	40.19
STD	1.86	0.90	1.37	1.21	0.00	0.64	0.26	0.20	0.01	4.36
MIN	18.43	9.77	7.80	3.68	0.01	1.13	1.06	0.09	0.11	32.33
MAX	23.44	12.80	11.99	7.43	0.02	3.19	1.98	0.77	0.14	45.32

Table 20: Mineral and heavy metal contents (mg/g) in Caesaris mushroom (*Amanita caesarea*).

Metals	Ca	Mg	K	Na	Cd	Cu	Fe	Mn	Pb	Zn
1	20.21	11.69	1.39	4.88	0.01	3.23	3.51	0.92	0.95	23.34
2	19.23	14.77	2.32	3.88	0.02	2.96	2.52	0.83	0.65	27.33
3	18.43	13.59	2.09	5.23	0.01	2.86	2.98	0.70	0.75	29.37
4	20.23	12.80	2.07	4.99	0.01	2.79	2.25	0.74	0.67	36.44
5	22.32	10.87	1.99	6.45	0.01	3.68	2.33	0.88	0.61	37.88
6	25.90	10.99	2.88	7.43	0.01	2.84	2.86	0.67	0.87	33.22
7	19.33	10.79	2.32	4.23	0.02	2.70	2.22	0.70	0.92	39.32
8	18.79	12.98	1.99	3.68	0.01	2.59	2.79	0.84	0.77	32.44
9	26.99	14.77	1.77	5.32	0.02	3.02	2.21	0.69	0.54	29.38
10	21.32	11.99	2.07	3.88	0.01	3.01	2.16	0.80	0.71	30.33
Mean	21.28	12.52	2.09	5.00	0.01	2.97	2.58	0.78	0.74	31.91
STD	2.97	1.51	0.39	1.21	0.00	0.31	0.44	0.09	0.14	4.98
MIN	18.43	10.79	1.39	3.68	0.01	2.59	2.16	0.67	0.54	23.34
MAX	26.99	14.77	2.88	7.43	0.02	3.68	3.51	0.92	0.95	39.32

Table 21: Mineral and heavy metal contents (mg/g) in Portobello (*Pleurotous ostreatus*).

Metals	Ca	Mg	K	Na	Cd	Cu	Fe	Mn	Pb	Zn
1	32.35	10.69	4.88	1.39	0.01	2.11	3.51	0.92	0.10	34.32
2	29.46	11.77	3.88	2.32	0.02	3.96	2.52	0.83	0.07	28.03
3	32.12	12.59	5.23	2.09	0.01	2.86	2.98	0.70	0.08	31.21
4	32.35	10.80	4.99	2.07	0.01	2.79	2.25	0.74	0.07	42.07
5	28.68	13.87	6.45	1.99	0.01	3.68	2.33	0.88	0.06	34.88
6	38.46	9.99	7.43	2.88	0.01	2.84	2.86	0.67	0.09	30.00
7	33.33	8.79	4.23	2.32	0.02	3.70	2.22	0.70	0.09	42.54
8	28.46	10.98	3.68	1.99	0.01	3.59	2.79	0.84	0.08	32.23
9	30.46	10.77	5.32	1.77	0.02	2.02	2.21	0.69	0.05	28.54
10	35.55	10.99	3.88	2.07	0.01	2.01	2.16	0.80	0.07	22.68
Mean	32.12	11.12	5.00	2.09	0.01	2.96	2.58	0.78	0.07	32.65
STD	3.14	1.39	1.21	0.39	0.00	0.75	0.44	0.09	0.01	6.16
MLN	28.46	8.79	3.68	1.39	0.01	2.01	2.16	0.67	0.05	22.68
MAX	38.46	13.87	7.43	2.88	0.02	3.96	3.51	0.92	0.10	42.54

Table 22: Summary results of minerals and heavy metal contents in various mushroom species consumed in the study area.

Minerals	**Ca**	**Mg**	**K**	**Na**	**Cd**	**Cu**	**Fe**	**Mn**	**Pb**	**Zn**
Mineral and heavy metal contents (mg/g) in Morels (*Morchella* sp).										
Mean	17.15	11.02	5.33	3.96	0.01	3.96	2.58	0.78	0.07	36.46
STD	1.33	1.17	0.66	0.67	0.00	0.67	0.44	0.09	0.01	8.39
MIN	15.07	8.69	4.10	2.84	0.00	2.84	2.16	0.67	0.05	22.97
MAX	19.10	12.80	6.33	4.96	0.02	4.96	3.51	0.92	0.10	52.23
Mineral and heavy metal contents (mg/g) in Maitake (*Grifola frondosa*)										
Mean	17.63	10.02	5.00	3.05	ND	3.05	5.61	0.79	0.94	36.84
STD	1.55	1.37	1.21	0.62	ND	0.62	1.31	0.06	0.25	8.86
MIN	15.07	7.80	3.68	1.95	ND	1.95	3.40	0.70	0.71	22.01
MAX	20.07	11.99	7.43	4.11	ND	4.11	7.97	0.89	1.55	53.97
Mineral and heavy metal contents (mg/g) in Porcini (*Boletus edultis*).										
Mean	24.76	9.72	5.00	2.90	ND	2.90	2.16	0.20	0.15	44.94
STD	4.13	1.03	1.21	0.35	ND	0.35	0.23	0.20	0.04	7.27
MIN	18.76	7.80	3.68	2.43	ND	2.43	1.79	0.09	0.10	35.88
MAX	32.12	10.87	7.43	3.43	ND	3.43	2.51	0.77	0.21	57.54
Mineral and heavy metal contents (mg/g) in Giant puftball (*Calvatia gigantea*)										
Mean	31.38	7.62	3.59	2.09	ND	11.47	1.32	0.20	0.01	34.67
STD	6.78	0.98	1.47	0.39	ND	1.51	0.26	0.20	0.00	5.13
MIN	18.76	5.99	2.07	1.39	ND	9.13	1.06	0.09	0.01	25.13
MAX	37.88	8.87	5.77	2.88	ND	13.19	1.98	0.77	0.01	43.15
Mineral and heavy metal contents (mg/g) in Chanterelles (*Cantharellus cibarius*)										
Mean	36.99	10.02	5.00	2.58	ND	3.08	2.58	0.78	0.92	30.26
STD	3.19	1.37	1.21	0.44	ND	0.35	0.44	0.09	0.10	3.37
MIN	31.21	7.80	3.68	2.16	ND	2.55	2.16	0.67	0.65	25.07
MAX	42.12	11.99	7.43	3.51	ND	3.45	3.51	0.92	0.99	35.54
Mineral and heavy metal contents (mg/g) in Matsutake (*Tricholoma matsutake*).										
Mean	17.09	11.02	5.33	2.91	0.01	2.83	2.91	0.79	0.07	44.04
STD	2.64	1.17	0.66	0.94	0.01	0.41	0.94	0.06	0.01	6.29
MIN	11.35	8.69	4.10	2.10	0.00	2.36	2.10	0.70	0.06	32.23
MAX	19.43	12.80	6.33	4.89	0.02	3.45	4.89	0.89	0.09	52.65
Mineral and heavy metal contents (mg/g) in Shaggy mane (*Coprinus comatus*).										
Mean	42.88	14.52	5.00	2.96	ND	2.70	2.16	0.20	0.02	35.04
STD	3.43	2.05	1.21	0.75	ND	0.33	0.23	0.20	0.00	4.12
MIN	38.91	10.77	3.68	2.01	ND	2.23	1.79	0.09	0.01	29.97
MAX	48.44	17.99	7.43	3.96	ND	3.32	2.51	0.77	0.02	41.54
Mineral and heavy metal contents (mg/g) in Black trumpet (*Craterellus cornucopioides*).										
Mean	20.89	10.82	10.02	5.00	0.01	2.37	1.32	0.20	0.12	40.19
STD	1.86	0.90	1.37	1.21	0.01	0.64	0.26	0.20	0.01	4.36
MIN	18.43	9.77	7.80	3.68	0.00	1.13	1.06	0.09	0.11	32.33
MAX	23.44	12.80	11.99	7.43	0.02	3.19	1.98	0.77	0.14	45.32
Mineral and heavy metal contents (mg/g) in Caesaris mushroom (*Amanita caesarea*).										
Mean	21.28	12.52	2.09	5.00	0.01	2.97	2.58	0.78	0.74	31.91

Table 22: Contd. Summary results of minerals and heavy metal contents in various mushroom species consumed in the study area.

STD	2.97	1.51	0.39	1.21	0.01	0.31	0.44	0.09	0.14	4.98
MIN	18.43	10.79	1.39	3.68	0.00	2.59	2.16	0.67	0.54	23.34
MAX	26.99	14.77	2.88	7.43	0.02	3.68	3.51	0.92	0.95	39.32
Mineral and heavy metal contents (mg/g) in Portobello (*Pleurotous ostreatus*).										
Mean	32.12	11.12	5.00	2.09	0.01	2.96	2.58	0.78	0.07	32.65
STD	3.14	1.39	1.21	0.39	0.01	0.75	0.44	0.09	0.01	6.16
MIN	28.46	8.79	3.68	1.39	0.00	2.01	2.16	0.67	0.05	22.68
MAX	38.46	13.87	7.43	2.88	0.02	3.96	3.51	0.92	0.10	42.54
Mineral and heavy metal contents (mg/g) in all the mushroom samples studied										
Mean	26.66	10.78	5.14	3.22	0.01	3.88	2.60	0.53	0.34	36.62
STD	9.66	2.47	2.35	1.33	0.01	2.87	1.41	0.32	0.40	8.37
MIN	9.30	2.14	1.39	1.24	0.00	1.13	1.06	0.09	0.01	7.53
MAX	48.44	17.99	11.99	7.43	0.02	13.19	7.97	0.92	1.55	57.54

mineral contents of the edible mushrooms used in the present study and those reported in the similar studies are attributed to the above mentioned factors (Towo et al., 2006). The present study shows that the all the edible mushroom species examined ranged between 1.24 and 48.44 mg/g for major minerals and between 0.09 and 57.54 mg/g for trace minerals. The quantitative mineral compositions observed falls within earlier report of analysis of some mushrooms in similar researches (FAO, 2003; Mattila et al., 2001). From the data analysis reported in this research, it seems that the edible mushrooms examined can provide a useful source of zinc, calcium, magnesium, potassium, sodium, iron, copper and manganese. Much of the rural peoples 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 pregnant women and children (Mattila et al., 2001). Thus, the consumption of these edible mushrooms in diet could be one of the sources of iron, zinc and other micronutrient.

Pb and Cd were detected in samples of edible mushrooms studied. Pb was detected in all samples, while Cd was detected in about 50% of the samples obtained from various locations of the study areas. Although, the concentrations of Pb and Cd in all samples studied were very low, the Pb concentration ranged from 0.05 – 0.10 mg/g, while Cd concentration ranged from 0.01 – 0.02 mg/g. Pb, a ubiquitous and versatile metal, continues to be a significant public health problem in developing countries where there are considerable variations in the sources and pathways of exposure. Therefore, care need to be taken in the consumption of Pb contaminated edible mushrooms since Pb exposure is through direct contact. It has been investigated and shown that exposure to Pb can lead to a wide range of biological defects in human, depending on duration and level of exposure. Cadmium was detected in some of the mushroom samples. Thus when ingested by humans, it accumulates in the intestine, liver and kidney (Reddy and Yellamma, 1996). High exposure can cause problems in the synthesis of haemoglobins, damage to the kidneys, gastrointestinal tract, joints, reproductive system and nervous system. The health effects of chronic exposure of Cd include proximal tubular disease and osteomalacia. Long term exposure to cadmium is associated with renal dysfunction. Cadmium is bio persistent and once absorbed remains resident for many years. High exposure can lead to obstructive lung diseases, and has been linked to lung cancer. Cadmium may also cause bone defects in humans and animals. The average daily intake for humans is estimated as 0.15 mg/g from air and 1 µg from water (Jarup et al., 1998). Maximum limit of 0.2 mg/g Cd in plant and 5.0 mg/g Pb in plant was prescribed by WHO/FAO(2007).

Pearson correlation among trace metals in the mushroom sample products was calculated to see if some metals were interrelated with each other and the results are presented in Table 3. Correlation study of the data indicated a weak correlation between trace metals determined. Zn/Pb, Zn/Ni and Cu/Mn showed positive correlation, while Co/Cu was negatively correlated.

Conclusions

There were variations in mineral contents of the edible mushrooms studied, but it should be noted that the mineral content of each species is a function of the availability of these elements in their local environment, diet absorptive capability, as well as their preferential accumulation. The results obtained from the proximate analysis of all various species of edible mushroom in northern Nigerian showed that they are good sources of nutrients such as protein and dietary fibre and as such, can be ranked as protein rich food due to their relatively high

Table 23: Intrelemental correction in mushroom samples studied.

Metals	Ca	Mg	K	Na	Cd	Cu	Fe	Mn	Pb	Zn
		-0.25	-0.20	-0.80	0.17	-0.80	0.26	-0.21	0.32	-0.06
			0.21	0.26	-0.51	0.26	-0.71	-0.49	-0.54	-0.19
				-0.10	0.10	-0.10	0.27	-0.03	0.16	0.17
					-0.36	1.00	-0.43	0.37	-0.66	0.22
						-0.36	0.40	0.18	0.75	-0.41
							-0.43	0.37	-0.66	0.22
								0.34	0.60	0.06
									0.04	0.03
										-0.20
		0.19	0.71	-0.01	-0.07	-0.01	-0.15	-0.08	0.02	-0.08
			-0.19	-0.74	-0.02	-0.74	0.29	-0.44	0.25	0.63
				0.10	-0.04	0.10	-0.31	0.08	-0.26	-0.25
					-0.40	1.00	-0.33	-0.07	-0.23	-0.55
						-0.40	0.44	0.73	0.49	-0.20
							-0.33	-0.07	-0.23	-0.55
								-0.05	0.24	-0.20
									-0.03	-0.09
										-0.17
		0.06	0.43	-0.27	-0.33	-0.27	-0.67	-0.04	0.41	0.20
			0.01	0.00	-0.56	0.00	0.21	-0.36	0.47	-0.26
				0.26	0.08	0.26	-0.12	0.10	-0.23	0.36
					-0.31	1.00	0.41	-0.33	-0.38	0.72
						-0.31	0.09	0.72	-0.62	-0.25
							0.41	-0.33	-0.38	0.72
								-0.33	-0.33	0.09
									-0.22	-0.37
										-0.27
		0.07	-0.54	0.43	0.11	-0.01	-0.24	0.17	-0.24	0.56
			0.27	-0.36	0.43	0.49	0.37	0.35	0.07	0.38
				-0.36	0.51	0.61	-0.13	-0.41	0.17	-0.58
					-0.50	-0.26	-0.34	0.05	0.51	0.45
						0.65	-0.14	-0.32	-0.52	-0.29
							-0.01	-0.14	-0.01	-0.05
								0.85	-0.12	0.31
									0.07	0.67
										0.33
		-0.35	0.07	0.56	0.17	-0.27	0.56	0.31	-0.31	-0.23
			-0.19	-0.08	0.63	0.24	-0.08	0.34	0.03	0.53
				0.15	-0.12	0.08	0.15	-0.32	0.30	-0.09
					0.40	-0.30	1.00	0.34	0.03	-0.27
						-0.18	0.40	0.18	-0.06	0.60
							-0.30	0.27	0.39	-0.11
								0.34	0.03	-0.27
									-0.47	-0.36
										-0.03
		-0.17	-0.22	0.49	0.62	0.08	0.49	0.31	-0.58	0.33
			0.21	-0.02	-0.31	0.47	-0.29	0.39	-0.79	-0.09
					0.28	-0.13	0.05	0.39	-0.33	-0.29
						-0.13	0.05	0.39	-0.33	-0.29

Table 23: Contd. Intrelemental correction in mushroom samples studied.

					0.05	0.39	-0.33	-0.29
						0.39	-0.14	0.33
							-0.33	-0.06
								-0.29
0.81	-0.06	-0.12	-0.25	-0.08	-0.33	-0.33	-0.25	0.19
	-0.06	0.18	0.28	-0.42	-0.02	0.15	0.33	0.24
		-0.12	-0.25	-0.08	-0.33	-0.33	-0.25	0.19
			-0.25	-0.33	-0.13	-0.05	0.36	0.40
				-0.08	0.09	0.72	-0.65	0.08
					-0.33	-0.09	-0.25	0.40
						-0.33	-0.27	-0.21
							-0.25	0.12
								0.19
-0.49	-0.52	-0.19	-0.01	0.62	-0.35	0.85	0.07	-0.39
	-0.52	-0.25	0.23	0.43	0.24	0.28	-0.62	0.16
		-0.19	-0.41	-0.53	-0.31	-0.32	0.25	0.40
			-0.01	-0.15	-0.03	0.10	0.09	0.32
				0.62	-0.35	0.85	0.07	-0.39
					-0.35	-0.14	-0.17	-0.47
						0.85	-0.12	0.08
							0.07	-0.04
								-0.39
-0.02	-0.21	0.35	-0.12	-0.09	0.02	0.34	0.04	-0.07
	-0.21	-0.38	-0.36	-0.24	-0.08	-0.10	-0.60	-0.50
		0.35	0.07	-0.38	-0.25	-0.59	0.11	0.45
			-0.12	-0.09	0.02	0.34	0.04	-0.07
				-0.09	0.40	0.18	0.75	-0.25
					0.02	0.52	-0.30	-0.08
						0.34	0.60	-0.62
							0.04	-0.34
								-0.07
-0.53	0.19	0.35	0.07	0.10	-0.14	0.34	0.04	0.31
	0.19	-0.23	-0.57	0.18	0.04	0.42	-0.57	-0.26
		0.35	-0.12	-0.12	0.15	-0.32	0.00	0.06
			0.07	0.42	-0.25	-0.59	0.11	-0.04
				0.10	0.40	0.18	0.75	0.04
					-0.14	0.12	0.00	0.36
						0.34	0.60	-0.04
							0.04	-0.08
								0.31

protein content. Based on the results of the analysis, it appears that the edible mushroom species studied are highly nutritious and compared favourably with other nutritious food materials. Therefore, it can be concluded that edible mushrooms are good sources of macro and micro mineral elements and as such, are good sources of nutrients. However, attention should be given to edible species that contain Pb and Cd, which could be harmful to

human after prolong exposure to these metals even at low concentration.

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