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An Inter-Species Comparative Study on the Distribution of Nutrients in Selected Edible Mushrooms in Ekiti State, Nigeria

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Original Research Article

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Abstract: The present investigation was carried out to determine and compare the nutritional values of some selected edible mushrooms collected in Ekiti State, Nigeria such as *Pleurotus sajor-caju*, *Termitomyces robustus*, *Lentinus squarosullus*, *Termitomyces microcarpous*, *Termitomyces clypeatus*, *Lentinus tuber-regium* and *Polyporus* sp. Proximate composition, mineral composition as well as vitamins A and C contents of the mushrooms were determined using standard methods. Results revealed significant differences in the nutritional composition of the mushrooms though some had similar compositions. The overall nutritional composition of the mushrooms was quite good suggesting that they have potentials to address the nutrient deficiency prevalent in the state, particularly among the low income earners. The values (%) ranged from 6.61-9.75 for moisture content, 1.07-3.89 for fat, 1.61-10.60 for total ash content, 1.61-10.81 for crude fibre, 8.67-37.31 for protein and 49.90-75.35 for carbohydrates. The mineral composition (mg/100g) ranged between 24.96-126.66 (Na), 478.30-789.64 (K), 33.06-153.43 (Mg), 38.17-440.20 (Ca), 1.23- 14.03 (Mn), 12.84-151.14 (Fe), 3.58-14.55 (Zn) and 0.92-4.03 (Cu). Vitamin A content (mg/g) was very low ranging from 0.01-0.12 while vitamin C content ranged from 94.22-326.51. The present study contributes to the elaboration of the nutritional database of commonly consumed mushrooms in Ekiti State, Nigeria.
Keywords: edible mushrooms, nutritional composition, proximate composition, mineral composition, vitamins A and C.

INTRODUCTION

Edible mushrooms are nutritionally endowed fungi (mostly Basidiomycetes) that grow naturally on the trunks, leaves and roots of trees as well as decaying woody materials [1]. They can also be cultivated. Mushrooms have been used as food since time immemorial [2]. They are documented as being rich in proteins, minerals, vitamins while they are low in lipids [3]. The protein value of mushrooms is twice as that of asparagus and potatoes, four times as that of tomatoes and carrots and six times as that of oranges [3]. They contain an abundance of essential amino acids [4]. Therefore, they can be a good supplement to cereals [5]. Edible mushrooms also provide a nutritionally significant content of vitamins (B1, B2, B12, C, D and E) [6]. Mushrooms have long been appreciated for their excellent sensory characteristics, flavour and texture. They are now recognized as a nutritious food as well as an important valuable source of biologically active compounds [7]. They could be a source of many different nutraceuticals such as uncaptured fatty acids, phenolic compounds, tocopherols, ascorbic acid and carotenoids. Thus, they might be used directly in diet and health promoting programmes, taking advantage of the additive and synergistic effects of all the bioactive compounds present [8]. Mushrooms, one of the highest protein producers per unit area fit in well with feasible strategies to fight malnutrition [9]. Mushrooms have potential in addressing the current food crisis problems in Africa as well as future problems resulting from population explosions. Today, it has been realized that many species of mushrooms are very effective in boosting the body's immune system. This is of crucial importance in Africa, considering the prevalence of the HIV/AIDS on the continent [10]. Although in many African societies and elsewhere in the world, mushrooms 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 [11]. The contribution of mushrooms to the overall nutritive value of the diet becomes speculative in the dearth of scientific data. 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. Fundamental knowledge of the nutritive composition of these mushrooms is necessary to encourage effective popularisation of mushroom cultivation, processing, marketing and consumption at the grass roots level to enable people to break away from the prevalence of poverty trap and malnutrition in most developing countries particularly Nigeria.

The aim of this study is to determine and compare the chemical compositions of different species of edible mushrooms (wild and exotic) with particular reference to various components of nutritional and interests.

MATERIALS AND METHODS

Collection and identification of samples

Fresh and matured samples of seven edible mushrooms were used in this study. They included six wild (*Termitomyces robustus*, *Lentinus squarosullus*, *Termitomyces microcarpous*, *Termitomyces clypeatus*, *Lentinus tuber-regium* and *Polyporus* sp) and one exotic (*P. sajor-caju*) edible mushroom. The wild edible mushrooms fruit bodies were collected from their natural habitats in different towns in Ekiti State, Nigeria while that of the exotic species was collected from Afe Babalola University, Ado Ekiti where it is being cultivated. The mushrooms were identified at the herbarium of the Department of Plant Science and Biotechnology, Ekiti State University, Ado Ekiti, Nigeria.

Preparation of samples for analyses

Particles of soil and unwanted wastes were removed from the samples by rinsing with distilled water. They were then sundried until they became brittle to touch and then ground to powder using a blender. All ground samples were transferred to airtight plastic bottles with well-fitting caps, labelled accordingly and then sealed in polythene bags to prevent any water intake until required for analysis. They were thereafter analysed for proximate, minerals, and vitamins A and C composition.

ANALYTICAL METHODS

Determination of proximate composition

Standard procedures of AOAC were used to determine the moisture content, crude fibre, crude fat, total nitrogen (Kjeldahl method) and ash [12]. All the chemicals used were of analytical grade. The percentage of crude protein, crude fat, 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 [13].

Determination of mineral composition

Mineral constituents (sodium, potassium, magnesium, calcium, manganese, iron, zinc and copper) were determined by atomic absorption spectrophotometry [12].

Determination of vitamins A and C composition

The content of ascorbic acid was determined by a titration method using the 2, 6 dichlorophenolindophenol Tillmans reagent (Tillman's method) while vitamin A was determined as β – carotene using AOAC Official Method of Spectrophotometric method [12]. The results were expressed in mg per g of sample.

STATISTICAL ANALYSIS

The data obtained were subjected to analyses of variance (one- way ANOVA). Significance was accepted at 5% probability level using the Statistical Package for Social Sciences (SPSS) Program 10.1 version [14].

RESULTS AND DISCUSSION

The results of the proximate composition (%) obtained for the studied edible mushrooms are shown in Table 1. Moisture content ranged between 6.61 in *P. sajor-caju* and 9.75 in *T. robustus.* This range is comparable to that (7.12-12.36%) reported by Adejumo *et al.* [15] in some wild edible mushrooms collected in Ondo State, Nigeria. Mushrooms have been reported to have high moisture contents, indicating that they are highly perishable and susceptible to microbial growth, rapid deterioration and enzyme activity [13]. The protein content of *L. squarosullus* and *T. robustus* were close to those reported by Aletor [16] in which the author obtained 33.8% for *T. robustus* and 32.8% for *Psathyrella atroumbonata*. The protein values of *P. sajor-caju, T. microcarpous, T. clypeatus* and *Polyporus* sp. were close to the value (15.4%) reported by Ijioma *et al*. [17]. However, among the studied mushrooms, *L. squarosullus* had the highest protein content (37.31%) while the least was obtained in *L. tuber-regium* (8.67%). *P. sajor-caju* and *T. clypeatus* had similar protein contents. Mushrooms are reported to be a good source of protein and some researchers have even opined that the amino acid composition of mushrooms compares favourably with that of animal proteins [18, 19]. Fat content of the mushrooms ranged between 1.07 in *P. sajor-caju* and 3.89 in *T. clypeatus*. The low fat contents of the mushrooms in the present study agreed with the previous report of Jiskani [3]. These low fat contents suggest that these mushrooms can function effectively in the management of cardiovascular diseases and obesity [20]. The fat contents presently reported for *T. microcarpous* and *L. tuber-regium* were similar. The fat values reported in the present study were higher than the values (1.0 and 1.3%) reported for *Coprinus cinereus* and *Pleurotus flabellatus* respectively by Mshandete and Cuff [21] except that of *P. sajor-caju* (1.07%) which fell within the range. However, these values were lower than the range of 3.6-7.8% previously reported for mushrooms by Ijioma *et al.* [17] except *T. clypeatus* whose value (3.89%) fell within the range. Kurtzman [22] reported that fats represent a small portion of mushrooms. Despite this, mushrooms have been reported to contain essential unsaturated fatty acids which are considered essential for human health and diet. The crude fibre content (10.8%) of *Polyporus* sp. was significantly higher than that of the other mushrooms. *L. squarosullus* and *T. microcarpous* had similar fibre contents (2.63%). The crude fibre contents observed in this study were lower than values reported for *Russula* sp. and *P. tuber-regium* by Ijioma *et al.* [17] but that of *T. robustus* and *T. clypeatus* were close to the value (5%) reported for *Termitomyces* sp. by the same authors. The fibre contents in the present study were higher than the values reported by Adejumo and Awosanya [13]. Since the studied mushrooms contained a significant amount of crude fibre, they could be regarded as a good source of dietary fibre with potential health benefits. The ash contents of the examined mushroom species ranged between 1.61 and 10.60 in *Polyporus* sp. Źródlowisk [23] and Manzi *et al.* [24] noted that ash contents as high as 20% have been reported for some species; however 10% or less is common. The ash contents obtained in the present study fall within the ranges of the reported data. Carbohydrate content of *T. clypeatus* (75.35%) was significantly higher than that of the other mushroom species; the least was however obtained in *T. robustus* (40.90%). The high carbohydrate content of the examined mushrooms may explain why they are mostly used locally as binder, bulking agent or thickeners in soup in ground forms. The range of carbohydrate values reported in the present study is comparable to reported ranges such as [5] and Khannan *et al.* [26]. Humans find it difficult to utilize a large percentage of carbohydrate in mushrooms as nutrients nevertheless; it could function as roughage [21]. Similarities were observed in the moisture content of *T. robustus* and *L. tuber-regium;* fat content of *T. microcarpous* and *L. tuber-regium*; ash content of *P.sajor-caju* and *L. squarosullus*; carbohydrate and crude fibre contents of *L. squarosullus* and *T. microcarpous* as well as protein content of *P. sajor-caju* and *T. clypeatus*. These results agree with the work of Guar *et al.* [27].

The macro and micro mineral content (mg/100g) observed in the different mushroom species studied is presented in Tables 2 and 3 respectively. They ranged between 24.96-126.66 (Na), 478.30-789.64 (K), 23.56-153.43 (Mg), 38.17-440.20 (Ca), 1.23-14.03 (Mn), 12.84-151.14 (Fe), 3.58-14.55 (Zn) and 0.92-4.03 (Cu). Among the species studied, maximum content of Na (126.66), Ca (440.20), Fe (151.14) and Zn (14.55) was found in *T. robustus*; K (789.64) in *L. squarosullus*; Mg (153.43), Mn (14.03) and Cu (4.03) in *L. tuber-regium*. *T. microcarpous* contained the least amount of the macro minerals except Ca. The least amount of Mn (1.23), Fe (12.84), Zn (3.58) and Cu (0.92) were found in *P. sajor-caju, T. clypeatus, Polyporus sp.* and *L. squarosullus* respectively. Na content of *P. sajor-caju* and *Polyporus* sp. as well as Cu content of *L. squarosullus* and *T. clypeatus* was similar. This result agrees with the previous work of Guar *et al.* [27]. Values of mineral content reported in the present study were higher than those reported by Okwelehie and Ogoke [28]. The result showed that the studied mushrooms contained reasonable levels of the minerals which is in consonance with the previous report of Kalac [29].

The mushrooms included in the present study contained a relatively high amount of vitamin C, ranging from 94.22 mg/g in *P. sajor-caju* to 326.51 mg/g in *L. squarosullus* while vitamin A contents were low ranging from 0.01 in *P. sajor-caju* to 0.12 in *T. microcarpous* (Table 4). The values of vitamin C obtained for *P. sajor-caju* was within the range of 93 and 113 mg/g dry weight reported for *Pleurotus* sp [30]. The values of vitamin C observed in this study were higher than values reported in mushrooms species by [31; Mshandete and Cuff [21]. The present result suggests that the studied mushrooms could serve as good sources of vitamin C but not dependable sources of vitamin A. The importance of vitamins cannot be overemphasized in the overall nutritional value of food. Bernaś *et al.* [32] reported that the antioxidant and therapeutic properties of vitamin C in particular make it a valuable food component.

In general, the variations in the nutritional values among the mushroom species indicate the extent of variability among mushroom species. Such variations had been reported between and within species [27]. This can be attributed to factors such as inherent biological factors [33], growth compost [24], substrate, atmospheric conditions, age or stage of development, parts of fruiting bodies as well as pre and post-harvest conditions [34, 19,35].

Table-1: Proximate composition (%) of the selected mushrooms

Species	Moisture content	Crude protein	Fat	Crude fibre	Ash	Carbohydrate
P. sajor-caju	6.61^{f}	10.10^{e}	1.07^{e}	1.61^{f}	4.18^{e}	61.68^{d}
T. robustus	9.75^{a}	32.73b	2.62^{b}	5.14^{c}	8.76^{c}	49.90^{f}
L. squarosullus	9.19^{b}	37.31^{a}	2.37^{bc}	2.63^{e}	4.26^{e}	56.35^{e}
T. microcarpous	7.49^{e}	13.44^{c}	2.14^{cd}	2.63^{e}	1.61^{f}	56.35^{e}
T. clypeatus	8.21^{d}	10.10^{e}	3.89^{a}	4.30^{d}	9.31^{b}	75.35^{a}
L. tuber-regium	9.70^{a}	8.67^{f}	2.13^{cd}	7.11^{b}	7.75^{d}	68.27^{c}
Polyporus sp.	8.57^{c}	11.73^{d}	1.83^{d}	10.81^{a}	10.60^{a}	68.71^{b}

*Means with the same letters within columns are not significantly different at P<0.05

Table-2: Macro mineral content (mg/100g) of the selected mushrooms

Species	Na	K	Mg	Ca
P. sajor-caju	45.76[c]	577.42[e]	39.83[c]	165.15[e]
T. robustus	126.66[a]	697.34[c]	35.96[d]	440.20[a]
L. squarosullus	75.84[b]	789.64[a]	36.22[e]	285.17[b]
T. microcarpous	34.80[e]	510.01[f]	23.56[g]	258.17[c]
T. clypeatus	42.73[d]	720.27[b]	33.06[f]	233.41[d]
L. tuber-regium	24.96[f]	585.60[d]	153.43[a]	38.17[g]
Polyporus sp.	46.55[c]	478.30[g]	56.52[b]	90.30[f]

*Means with the same letters within columns are not significantly different at P<0.05

Table-3: Micro mineral content (mg/100g) of the selected mushrooms

Species	Mn	Fe	Zn	Cu
P. sajor-caju	1.23[g]	13.81[f]	7.66[b]	2.42[c]
T. robustus	5.75[c]	151.[1a4]	14.55[a]	2.53[b]
L. squarosullus	4.16[d]	25.17[d]	6.39[c]	0.92[f]
T. microcarpous	3.05[f]	34.64[b]	5.02[f]	1.35[e]
T. clypeatus	3.26[e]	12.84[g]	6.06[d]	0.92f
L. tuber-regium	14.03[a]	29.63[c]	5.15[e]	4.03[a]
Polyporus sp.	6.64[b]	15.06[e]	3.58[g]	1.84[d]

*Means with the same letters within columns are not significantly different at P<0.05

Table-4: Vitamins A and C content (mg/g) of the selected mushrooms

Species	Vitamin A	Vitamin C
P. sajor-caju	0.01[c]	94.22[g]
T. robustus	0.07[b]	188.23[c]
L. squarosullus	0.10[a]	326.51[a]
T. microcarpous	0.12[a]	182.52[d]
T. clypeatus	0.02[c]	165.21[e]
L. tuber-regium	0.05[b]	134.51[f]
Polyporus sp.	0.02[c]	225.63[b]

*Means with the same letters within columns are not significantly different at P<0.05

CONCLUSION

The results of the present study revealed the presence of substantial amount of proximate, mineral and vitamin C in all the selected mushrooms. It also revealed variations in the nutritional values among the studied mushrooms though some had similar values. Thus, there is an indication that these mushrooms have the potentials to address the protein and mineral deficit prevalent in diets in Nigeria and other developing countries particularly among families with low incomes. It is hereby recommended that efforts be geared towards mushroom cultivation and domestication using locally adapted mushroom biotechnology. Toxicological and phytochemical studies on the selected mushrooms are currently on going.

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