AASCIT Journal of Bioscience
2015; 1(2): 20-25
Published online April 30, 2015 (http://www.aascit.org/journal/bioscience)

Keywords
Mushrooms,
Protein Content,
Amino Acids,
Abakaliki

Received: March 30, 2015
Revised: April 18, 2015
Accepted: April 19, 2015

Characterization of the Proximate and Amino Acid Composition of Edible Wild Mushroom Species in Abakaliki, Nigeria

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Citation
Celestine A. Afiukwa, Emmanuel C. Ebem, David O. Igwe. Characterization of the Proximate and Amino Acid Composition of Edible Wild Mushroom Species in Abakaliki, Nigeria. *AASCIT Journal of Bioscience*. Vol. 1, No. 2, 2015, pp. 20-25.

Abstract
Mushrooms are important food resources valued for its high quality protein content, health promoting properties and potential to enhance food palatability. There is little or no information in the literature particularly on the amino acid composition of mushrooms in the study area. Hence, the objective of this study was to evaluate and compare the basic nutritive constituents as well as amino acids composition of four wild edible mushroom species in Abakaliki, Nigeria. The mushroom species investigated are *Auricularia auricula-judae* (wood ear mushroom), *Pleurotus ostreatus* (oyster mushroom), *Lentinus connatus* and *Lentinus sajor-caju*. Carbohydrate was the predominant nutrient (34.71 – 57.03%) followed by protein (8.36 – 24.62%), while the least occurring nutrient was crude fats (2.29 – 4.12%). All essential amino acids (EAA) in man were found in all the mushrooms and comprised 33.04%, 30.96%, 29.49% and 29.88% of the total protein in *Auricularia auricula-judae*, *Lentinus connatus, Lentinus sajor-caju* and *Pleurotus ostreatus* respectively. The most abundant amino acid across the mushroom species was glutamic acid (5.53 – 11.10 g) followed by arginine (3.37 – 6.39 g), while cysteine (0.30 – 0.43 g) and proline (0.20 – 0.46g) were the least in abundance per 100g of protein. *Lentinus connatus* appeared to be the richest of the mushroom species in terms of protein and amino acid contents, while *Auricularia auricula- judae* was the poorest. Therefore, commercial cultivation of *Lentinus conatus* in particular and popularization of its consumption would contribute meaningfully to ameliorating the problem of protein malnutrition in the region.

1. Introduction

The high nutritional and attractive medicinal values of the fruiting body of macro-fungi (mushrooms), have been variously reported in literature. The reports show that mushrooms are especially rich in dietary protein and contain appreciable amounts of carbohydrate, fats, vitamins, fibre and minerals (Ahmed *et al*., 2013; Manjunathan *et al*., 2011; Oyetayo. 2011; Wani *et al*., 2010; Bernaś *et al*., 2006; Alofe *et al*., 1996). Chang and Miles (1989) ranked some mushrooms below animal meats, but well above most other foods including milk, on the basis of protein content. It was also noted that mushrooms are not only high in protein content, but the protein contains all the essential amino acids required by adult man (Bernaś *et al.,* 2006; Hayes and Haddad, 1976). Considering that animal protein is not easily affordable to the rural poor in most developing countries, mushrooms are and have been playing the role of good

supplements. In recognition of this fact, the Food and Agricultural Organization (FAO) had earlier recommended mushrooms for reduction of protein malnutrition in underdeveloped countries (Sohi, 1988; Pedneault *et al*., 2006). Mushrooms are generally low in fats but its fats is predominantly composed of polyunsaturated fatty acids (Bernaś *et al.,* 2006). Mushrooms also contribute some unique colour, taste, aroma, and texture, which improve palatability of foods. There are also numerous literature reports on the health promoting and medicinal properties of mushrooms. Wani, (2010) reported that mushrooms have been used in health care for treating common diseases as well as complex and pandemic disease like AIDS. Reports on the antifungal, antibacterial, antioxidant, antiviral, antihypertensive, antidiabetic, antitumor and anticancer activities of mushrooms abound in literature (Nanba, 1993; King, 1993, Wani *et al*., 2010; Manjunathan *et al*., 2011; Anderson, 1992; Mau *et al*., 2004). A lot of studies have been done in this respect to the extent that many medicinal components of mushrooms are now available in tablet and capsule forms, which are marketed as mushroom nutriceuticals and used as food supplements (Wasser, 2005; Yang *et al*., 1993).

However, mushrooms are generally scares, expensive and seasonal in Nigeria as the people rely mainly on wild and natural sources. With increasing deforestation and climate change, most indigenous mushroom species are rapidly going into extinction. There is therefore a need to develop methods for sustainable cultivation of these important food resources as is the case in most developed countries where some individuals grow their own mushrooms at home for personal use, while others produce at commercial scale.

The objective of this study was to compare four common edible mushroom species in Abakaliki area of Nigeria for nutritional quality especially in terms of protein and amino acid composition to guide our choice of species to focus artificial cultivation technology development efforts on. The mushroom species analyzed were wood ear mushroom (*Auricularia auricula-judae*), Oyster mushroom (*Pleurotus ostreatus*), (*Lentinus connatus*) and *Lentinus sajor-caju* and they were selected based on availability at the period of this study. There is little or no information documented in literature on these important food resources in the study area, especially on their amino acid composition.

2. Materials and Methods

The four fully mature mushroom species used in the study were harvested fresh from Ishielu area of Abakaliki, South-east Nigeria. The samples were analyzed for food composition using the procedure of the Association of Official Analytical Chemists (AOAC, 1995). The components determined include crude protein, crude fat, ash, crude fiber, moisture content and the percentage of all the fractions (crude protein, crude fat, ash and moisture) were summed together and subtracted from 100 to obtain the percentage carbohydrate, while crude protein was calculated as total nitrogen x 4.38 (Braaksma and Shaap, 1996).

The concentrations of amino acids in the mushroom samples was determined using the Technicon Sequential Multi-Sample Amino Acid Analyzer (TSM) method (Benitez, 1989).The dry samples were defatted and hydrolyzed in 6M HCl for 24 h at 110^{o}C. After cooling, the hydrolysate was evaporated in a vacuum evaporator, the dry residue was dissolved in a buffer and analyzed with amino acid analyzer. The concentrations of the amino acids (in g/100g protein) were calculated from external standards for the different amino acids.

3. Results and Discussion

3.1. Proximate Composition

The mushroom species differed significantly in all the proximate components ($p<0.05$).The crude protein content varied widely from 8.36% in *Auricularia auricula-judae* to 24.62% in *Lentinus connatus* on dry weigh basis. This indicates that *Lentinus connatus* followed by *Pleurotus ostreatus* is richer in protein and would be the species of choice for a commercial cultivation programme for mitigating protein malnutrition in the region, while *Auricularia auricula-judae* is a poor source of protein, containing about three times lower protein than *Lentinus connatus* and *Pleurotus ostreatus*. The highest mean protein value observed in this study (24.62%) is lower than 28.0 – 31.80% reported for strains of *Pleurotus ostreatus* by Ahmed *et al* (2013) in Bangladesh and much lower than 37% reported for *Auricularia polytricha* species by Manjunathan (2011) in India. The mean protein values of the rich species, *Lentinus connatus* (24.62%) and *Pleurotus ostreatus* (21.82%), compared very well with the range (17-28%) reported for three wild edible species in Tanzania (Mshandete and Cuff, 2007). These species also compared well with cowpea varieties (21.70 – 30.32%), a well-recognized vegetable protein source (Aluko and Yada, 1995; Chan and Phillips, 1994; Mwasaru *et al*., 1999 and Afiukwa *et al*., 2011), and are much richer than rice (7.3%), wheat (12.7%) and corn (9.4%) (Chang, and Miles, 1989; Crisan and Sands, 1978).

The mushrooms were also found to be good sources of other nutritive constituents such as lipids, crude fibre, minerals (ash) and carbohydrate. The lipid contents are generally low and is the least nutritive constituents in all the mushroom species. This is in line with previous findings (Patil, 2010; Mshandete and Cuff, 2007; Manzi *et al.*, 2001; Bernaś, 2006). It varied between 2.29% in *Auricularia auricula- judae* to 4.12% in *Pleurotus ostreatus* (Fig. 1).These values are within 3.3% previously reported by Mshandete and Cuff (2007) for *Volvariella volvacea* species and also close to 3.28% and 3.36% recorded for *Agaricus bisporus* and *Pleurotus ostreatus* respectively by Jaworska and Bernaś, 2011, but well above 1.8% and 2.0% reported by

Shah *et al*. (1997) for *Lentinus sajor-caju* and *Pleurotus ostreatus*. However, over 70% of the fatty acid constituents of the fats would be unsaturated according to Bernaś *et al.* (2006) and is a very healthy attribute of mushroom fats. The four mushroom species examined are high in dietary fibre, also an important part of a healthy diet. The values spanned from 12.21% in *Auricularia auricula- judae* to 21.00% in *Lentinus sajor- caju* (Fig. 1). These values are higher than those recorded for *Pleurotus* species (7.5- 16.3%) and *Volvariella* species (5.5-17.4%) (Obodai, 1992), but lower than 21.80 – 27.4% reported for *Pleurotus* strains by Ahmed *et al.* (2013), although significant overlap exists between the range of values observed and some of the values published in literature.

The mushrooms evaluated have reasonable amounts of ash content, an indication of rich mineral constituent. The ash value varied from 4.30% in wood ear mushroom (*Auricularia auricula-judae*) to 10.14% in *Lentinus connatus*. These values are comparable to 8.6 – 12.80% recorded for *Pleurotus* species in Bangladesh by Ahmed *et al.* (2013) and 5.14 – 15.73% reported for four mushroom species in India by Manjunathan *et al*. (2011). *Auricularia auricula-judae* had the highest amount of moisture (15.82%) while *Lentinus connatus* had the least value of 10.80%. The moisture contents indicate that the mushrooms are generally highly perishable. Carbohydrate is the most abundant nutritive constituents of the mushroom species. This is consistent with previous reports (Mshandete and Cuff, 2007; Manjunathan *et al*., 2011; Wani *et al*., 2010). *Auricularia auricula-judae* had the highest value of 57.03% while *Lentinus connatus* had the least value of 34.71% (Fig. 1).These values are lower than the range of values (50 -62%) recorded for *Pleurotus* species by Mshandete and Cuff (2007) in Tanzanian and 50.50 – 56.20% for *Pleurotus* strains grown on different lignocellulosic substrates by Ahmed *et al.* (2010) in India, but higher than 29.20 – 35.40% reported for *Pleurotus* species in Bangladesh (Ahmed *et al.,* 2013) and highly comparable to 38.38 – 60.0% recorded for four different species in India by Manjunathan *et al*. (2011).

Although none of the mushroom species consistently contained the highest amounts of all the proximate constituents evaluated, wood ear mushroom (*Auricularia auricula-judae*) appeared to be the least in amounts of the constituents with the exception of carbohydrate and moisture. The observed variability among the mushroom species in proximate composition may be attributed to species differences, the effect of growth substrate, harvest stage and environmental conditions (Alofe *et al.,* 1996; Mshandete and Cuff, 2007; Patil, *et al.*, 2010).

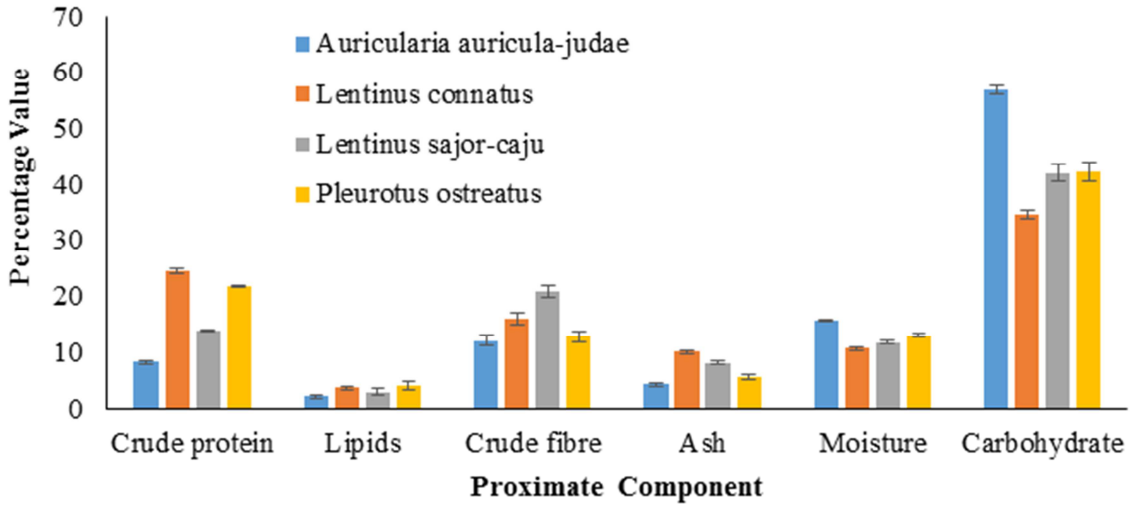

Fig. 1. *Proximate Composition of Four Mushrooms Species in Abakaliki, Nigeria.*

3.2. Amino Acid Profile

The relative concentration of the twenty constituent amino acids in protein is an index of quality of a protein. Seventeen (17) of the twenty biologically active amino acids in humans were assayed for in these mushrooms. It includes lysine, histidine, arginine, aspartic acid, threonine, serine, glutamic acid, proline, glycine, alanine, cysteine, valine, methionine, isoleucine, leucine, tyrosine and phenylalanine. Table 1 shows the amino acid profile of the four mushroom species in mg/100g protein. *Lentinus connatus* recorded the highest amounts of seven of the amino acids namely; lysine, histidine, aspartic acid, serine, glutamic acids and tyrosine. Our results showed that *Auricularia auricula- judae* has the least amounts of all but three amino acids (cysteine, isoleucine and leucine) which did not differ significantly across the four mushroom species. *Pleurotus ostreatus* (Oyster mushroom) was significantly higher than *Lentinus connatus* only in two amino acids (glycine and proline), and higher than *Lentinus sajor-caju* only in lysine and aspartic acid contents. Based on the outcome of this study, the four mushroom species could be ranked in a decreasing order of preference as *Lentinus connatus>Pleurotus ostreatus >Lentinus sajor-caju>Auricularia auricula- judae* in terms of protein and amino acid contents. The study also revealed glutamic acid as the most abundant amino acid in all the mushroom species followed by arginine and aspartic acid,

whereas the least occurring amino acid was cysteine, followed by proline and methionine. The value of glutamic acid varied from 5.53g/100g in *Auricularia auricula-judae* to 11.10 g/100g in *Lentinus connatus*, while cysteine ranged in value from 0.30 g/100g in *Auricularia auricula-judae* to 0.43 g/100g in *Lentinus connatus*. Glutamic acid accounted for 24.22% of the total amino acid in *L. sajor-caju,* 24.04% in *P. ostreatus*, 23.90% in *L. connatus* and 18.55% in *A. auricula-judae*. These values are higher than 18% reported for *Agaricus bisporus* and much higher than 12% recorded for *P. ostreatus* by Jaworska and Bernaś (2011), but much lower than 45% reported for *A. bisporus* by Tsai *et al*.(2008).These authors also detected glutamic acid as the most abundant amino acid in the mushrooms. However, Guo *et al*. (2007) reported aspartic acid as the most abundant endogenous amino acid in *Pleurotus djamor* mushrooms, comprising 19% of total endogenous amino acids. The predominance of glutamic acid and the least abundance of cysteine in mushroom species observed in this study is also in accordance with previous reports (Ahmed *et al.*, 2010; Kim *et al.,* 2009), but the values of amino acids obtained in the present study are generally higher when compared to the values reported by these authors. Ahmed *et al.* (2010) reported a range of 55 – 64 mg for glutamic acid and 5.6–6 mg for cysteine in *Pleurotus* species, while Kim *et al.* (2009) recorded a lower values (18-36 mg) per 100g protein. Bernaś and Jaworska (2010) reported values of amino acids generally higher than the values obtained in this study. However, the amount of glutamic acid observed in the present study (11.10 g/100g) is highly comparable to that reported by Bernaś and Jaworska (2010) for *Pleurotus* and *Agaricus* species (11.82 g/100g).

Of the twenty standard amino acids in protein, histidine, isoleucine, leucine, lysine, methionine, threonine, phenylalanine, cysteine, valine and (tryptophan not determined), are considered essential because they cannot be synthesized *in vivo* and must therefore be obtained through food. They are also described as exogenous amino acids (Bernaś and Jaworska, 2010). Their presence and relative abundance in a protein is a major determinant of quality of the protein. Interestingly, all the mushroom species evaluated in this study showed the presence of all the essential amino acids. This is in agreement with the reports of Bernaś *et al.* (2006) and Hayes and Haddad (1976) that mushrooms contain all the essential amino acids required by an adult man. The proportion of essential amino acids (EAA) in the mushrooms were 33.04%, 30.96%, 29.49% and 29.88% in *Auricularia auricula-judae*, *Lentinus connatus, Lentinus sajor-caju* and *Pleurotus ostreatus* respectively. The most abundant essential amino acid in *L. connatus* and *P. ostreatus* was threonine, accounting for 18.36% and 20.17% of the total essential amino acids respectively, whereas in *L. sajor-caju* and *A. auricular-judae,* it was leucine and comprised about 18.37% and 19.70% of the total essential amino acids respectively. On the contrary, Bernaś and Jaworska (2010) reported leucine as the predominant essential amino acid in *P. ostreatus* and *A. bisporus.*

4. Conclusion

This study presents the mushroom species as good sources of carbohydrate, protein, fiber, minerals (ash) and amino acids, but low in fats. However, all the amino acids essential in man are present in the mushrooms. The study also revealed the nutritive values of *Lentinus connatus* and *Pleurotus ostreatus* to be more attractive than *Auricularia auricula-judae* and *Lentinus sajor-caju*, especially in terms of protein and amino acid contents.

Table 1. *Concentration of Amino Acids in Four Mushrooms found in Abakaliki.*

Amino Acid	*Auricularia auricula-judae*	*Lentinus connatus*	*Lentinus sajor-caju*	*Pleurotus ostreatus*
Lysine*	1.22±0.035^{d}	2.15±0.057^{a}	1.51±0.113^{c}	1.72±0.064^{b}
Histidine*	0.96±0.071^{c}	1.45±0.085^{a}	1.25±0.021^{b}	1.20±0.092^{b}
Arginine	3.37±0.120^{b}	6.39±0.247^{a}	6.22±0.120^{a}	6.09±0.304^{a}
Aspartic acid	3.00±0.021^{d}	5.00±0.134^{a}	4.31±0.042^{b}	3.97±0.085^{c}
Threonine*	1.74±0.113^{b}	2.64±0.064^{a}	2.20±0.212^{ab}	2.62±0.198^{a}
Serine	2.07±0.078^{c}	2.54±0.092^{a}	2.23±0.078^{bc}	2.34±0.085^{ab}
Glutamic acid	5.53±0.106^{c}	11.10±0.163^{a}	10.15±0.212^{b}	10.45±0.212^{b}
Proline	0.20±0.000^{b}	0.31±0.148^{ab}	0.41±0.000^{a}	0.46±0.071^{a}
Glycine	1.32±0.099^{c}	1.55±0.156^{b}	1.55±0.049^{b}	2.14±0.170^{a}
Alanine	3.44±0.078^{ab}	3.74±0.354^{a}	3.65±0.163^{a}	3.84±0.049^{a}
Cysteine*	0.30±0.049^{a}	0.43±0.042^{a}	0.37±0.049^{a}	0.33±0.099^{a}
Valine*	1.25±0.120^{b}	1.62±0.085^{a}	1.51±0.205^{ab}	1.48±0.042^{ab}
Methionine*	0.35±0.014^{b}	0.55±0.071^{a}	0.59±0.021^{a}	0.56±0.014^{a}
Isoleucine*	1.03±0.071^{a}	1.35±0.156^{a}	1.22±0.071^{a}	1.30±0.141^{a}
Leucine*	1.94±0.078^{a}	2.29±0.156^{a}	2.27±0.120^{a}	2.17±0.099^{a}
Tyrosine	1.03±0.113^{b}	1.43±0.226^{a}	1.03±0.113^{b}	1.19±0.113^{ab}
Phenylalanine*	1.06±0.064^{b}	1.90±0.057^{a}	1.44±0.12^{ab}	1.61±0.12^{a}

All values are means ± SD of three determinations (in g/100g protein). Means with the same letter across a row are not significantly different at 0.05 probability level. *Essential amino acids.

References

[1] Afiukwa, C. A., Kunert, K. J., Vorster, J., Cullis, C. A. and Ubi, B. E. (2011). Microsatellite association with seed protein content and flowering time in Nigerian cowpea cultivars. *African Journal of Biotechnology* 10 (79):18057-18064.

[2] Ahmed, M., Abdullah, N., Ahmed, K. U. and Borhannuddin-Bhuyan, M. H. M. (2013). Yield and nutritional composition of oyster mushroom strains newly introduced in Bangladesh. *Pesquisa Agropecuária Brasileria,* 48(2):197-202.

[3] Alofe, F. V., Odeyemi, O. and Oke, O. L. (1996). Three edible wild mushrooms from Nigeria: Their proximate and mineral composition. *Plant Foods for Human Nutrition,* 49(1):63-73.

[4] Aluko, R.E. and Yada, R.Y. (1995). Structure-function relationships of cowpea (*Vigna unguiculata*) globulin isolate: influence of pH and NaCl on physicochemical and functional properties. *Food Chemistry* 53: 259 – 265.

[5] Anderson, J. B. and Stasovski, E. (1992). Molecular phylogeny of Northern Hemisphere species of *Armillaria*. *Mycologia,* 84:505–516.

[6] AOAC (1995). Official Methods of Analysis. Association of Official Analytical Chemists. 16th Ed., Arlington. VA.

[7] Benitez, L. V. (1989). Amino acid and fatty acid profiles in aquaculture nutrition studies. *In*: S. S. De Silva (ed.) Fish nutrition research in Asian fish. Asian Fishery Society, Manila, Philippines, pp 23 – 35.

[8] Bernaś, E. and Jaworska, G. (2010). Comparison of amino acid content in frozen *P. ostreatus* and *A. bisporus* mushrooms. *Acta Scientiarum Polonorum, Technologia Alimentaria*, 9(3): 295-303.

[9] Bernaś, E., Jaworska, G. and Lisiewska, Z. (2006). Edible mushroom as a source of valuable nutritive constituents. *Acta Scientiarum Polonorum, Technologia Alimentaria,* 5(1):5-20.

[10] Braaksma, A. and Schaap, D. J. (1996). Protein analysis of the common mushroom *Agaricus bisporus*. *Postharvest Biology and Technology,* 7: 119-127.

[11] Chan, C.W. and Phillips, R.D. (1994). Amino acid composition and subunit constitution of protein fractions from cowpea (*Vigna unguiculata* L. Walp) seeds. *Journal of Agriculture and Food Chemistry* 42: 1857 – 1860.

[12] Chang, S.T. and Miles, P.G. (1989). Edible mushrooms and their cultivation. Florida, CRS Press, Inc. 27-38.

[13] Crisan, E. V. and Sands, A. (1978). Nutritional value. *In*: S.T. Chang and W.A. Hayes (Eds). The Biology and Cultivation of Edible Mushrooms. London, Academic Press Inc, 137-165.

[14] Guo, L.Q., Lin, J.Y. and Lin, J.F. (2007). Non-volatile components of several novel species of edible fungi in China. *Food Chemistry,* 100, 643-649.

[15] Hayes, W. A. and Haddad, N. (1976). The food value of the cultivated mushrooms and its importance in industry. *Mushroom Journal*, 40: 104-110.

[16] Jaworska, G. and Bernaś, E. (2011). Comparison of amino acid content in canned *Pleurotus ostreatus* and *Agaricus bisporus* mushrooms. *Vegetable Crops Research Bulletin* 74:107-115

[17] Kim, M. Y., Chung, M. I., Lee, S. J., Ahn, J. K., Kim, E. H., Kim, M. J., Kim, S. L., Moon, H. I., Ro, H. M., Kang, E. Y., Seo, S. H., and Song, H. K. (2009). Comparison of free amino acid, carbohydrate concentrations in Korean edible and medicinal mushrooms. *Food Chemistry*, 113: 386 – 393.

[18] King, T.A. (1993). Mushrooms, the ultimate health food but little research in U. S to prove it. *Mushroom News*, 41: 29-46.

[19] Manjunathan, J., Subbulakshmi, N., Shanmugapriya, R. and Kaviyarasan, V. (2011). Proximate and mineral composition of four edible mushroom species from South India. *International Journal of Biodiversity and Conservation,* 3(8):386-388.

[20] Manzi, P. A., Agguzzi, A. and Pizzoferrato, L. (2001). Nutritional mushrooms widely consumed in Italy. *Food Chem*istry, 73: 321-325.

[21] Mau, J. L., Chang, C. N., Huang, S. J. and Chen, C. C. (2004). Antioxidant properties of methanolic extracts from *Grifola frondosa, Morchella esculenta* and *Termitomyces albuminosus* mycelia. *Food Chemistry*, 87:111–118.

[22] Mshandete, A. M. and Cuff J. (2007). Proximate and nutrient composition of three types of indigenous edible wild mushrooms grown in Tanzania and their utilization prospects. *African Journal of Food, Agriculture, Nutrition and Development*, 7(6): 1684-5374.

[23] Mwasaru, M. A., Muhammad, K., Bakar, J. and Cheman, Y. B. (1999). Effect of isolation technique and conditions on the extractability, physiochemical and functional properties of pigeon pea (*Cajanus cajan*) and cowpea (*Vigna unguiculata*) protein isolates. *Journal of Food Chemistry* 67: 445–452.

[24] Nanba, H. (1993). Maitake mushroom: the king mushroom. *Mushroom News*, 41: 22-25.

[25] Obodai, M. (1992). Comparative studies on the utilization of agricultural waste by some mushrooms (*Pleurotus* and *Volvariella* species). M.Phil., The University of Ghana, Legon.

[26] Oyetayo. O. V. (2011). Medicinal uses of mushrooms in Nigeria: Towards full and sustainable exploitation. *African Journal of Traditional, Complementary and Alternative Medicines,* 8(3): 267–274.

[27] Patil, S.S., Ahmed, S.A., Telang, S.M. and Baig, M.M.V. (2010). The nutritional value of *Pleurotus ostreatus* (Jacq. Fr) Kumm cultivated on different lignocellulosic agro‐wastes. *Innovative Romanian Food Biotechnology*, 7:66‐76.

[28] Pedneault, K. P., Gosselia, A. and Tweddell, R. J. (2006). Fatty acid composition of lipids from mushrooms belonging to the family *Boletaceae*. *Mycology Research*, 110: 1179-1183.

[29] Shah, H., Khalil, I. A. and Jabeen, S. (1997). Nutritional composition and protein quality of *Pleurotus* mushroom. *Sarhad Journal of Agriculture,* 13: 621- 626.

[30] Sohi, H. S. (1988). Mushroom culture in India: Recent research findings. *Indian Phytopathology*, 41: 313-326.

[31] Tsai, S.Y., Tsai, H.L. and Mau, J.L. (2008). Non-volatile taste components of *Agaricus blazei*, *Agrocybe cylindracea* and *Boletus edulis*. *Food Chemistry* 107: 977-983.

[32] Wani, B. A., Bodha, R. H. and Wani, A. H. (2010). Nutritional and medicinal importance of mushrooms. *Journal of Medicinal Plants Research*, 4(24): 2598-2604.

[33] Wasser, S. P. (2005). Reishi or Lingzhi (*Ganoderma lucidum*). Encyclopedia of Dietary Supplements, Marcel Dekker, Germany, pp. 603-622.

[34] Yang, Q. Y., Hu, Y. J., Li, X. Y., Yang, S. X., Liu, J. X., Liu, T. F., Xu, G. M. and Liao, L. M. (1993). A new biological response modifier - PSP. *In*: Chang, S. T., Buswell, J. A. and Chiu, S. W. (eds.) Mushroom biology and mushroom products. The Chinese University Press, Hong Kong, pp. 247-259.