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Proximate, Macroelement and Vitamin Composition of the Fruit Bodies of *Pleurotus ostreatus* Var. *Florida* Eger. Grown on Different Substrates and Substrate Supplementations

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ABSTRACT

The objective of this research was to evaluate the influence of two levels of organic manures on macroelement and vitamin contents of *Pleurotus ostreatus* var. *florida* to evaluate the use of these manures for sustainable cultivation of the macro-fungus in Umudike, Abia State, Nigeria. The proximate, macroelement and vitamin composition of the fruit bodies of *P. ostreatus* var. *Florida* Eger. mushrooms as affected by substrate and additive types were examined. Amendment of the substrate did not influence the moisture content and fat and oil contents of the mushroom while the ash content varied significantly from 1% in *Andropogon* straw (AS) with 10% cow dung (CD) to 4% in AS plus 5% CD. Similarly, the crude fibre content was significantly highest in fruit bodies produced on AS + 10% poultry droppings (PD) and lowest in those produced on AS + 10% CD, but not significantly different from those produced on the un-supplemented control and *Pennisetum* straw (PS) ($P<0.05$). The unsupplemented PS produced more carbohydrates than the supplemented AS. The mineral contents of the fruit bodies from the substrates supplemented with 10% organic manure in each case were higher than those with 5% additive. A similar trend was observed in the other elements for the two levels each of poultry and turkey droppings. PS alone, which served as the control, yielded significantly fewer macroelements than other treatments. Fruit bodies harvested from AS had significantly fewer vitamins than those obtained from AS supplemented with 5 and 10% CD. Similarly, fruit bodies from the AS with 5 and 10% PD contained vitamins that were not significantly different. Niacin and riboflavin showed an increasing trend as the level of supplementation of the substrates with organic manures increased.

Keywords: ascorbic acid, calcium, crude protein, dietary fibre, mushroom

INTRODUCTION

Out of about 100,000 fleshy fungi known, about 150 species are edible, and are widely utilized as human food (Chang 1980) in many parts of the world, including Nigeria; wild edible mushrooms have been regarded as part of the human diet for a long time. In Nigeria, the rural dwellers consume mushrooms as delicacies in soups and as ingredients for seasoning or as part of the local melon cake (a local snack called 'usu' in Igbo). For instance, the sclerotia of *Pleurotus tuber-regium* is used as thickener and seasoning in soups as well as in preparing melon cake (a local snacks prepared by grinding the dry sclerotia of the mushrooms, with melon seeds and spices and boiling the resulting paste wrapped in dry banana or plantain leaves). Mushrooms are generally cooked or fried salted or spiced. A few species such as *Agaricus bisporus* (botton stage) can be eaten raw. In recent years, mushrooms have assumed greater importance in the diets of not only the rural dwellers, but also the urban dwellers (Chang 1980; Aletor 1995). The recent increased interest in human consumption of mushrooms the world over stems from their nutritional and medicinal values (Lucas *et al*. 1958; Suzuki and Oshima 1976; Rambelli and Menini 1983; Stamets 1993; Aletor 1995), and the perception that mushrooms are low in calories and rich in vegetable proteins, chitin, vitamins and minerals (Wasser and Weis 1999). As well as having a pleasant taste, mushrooms are of significant nutritional value. They have been shown to be rich in proteins, free amino acids, fibre, vitamins and minerals while having low fat and carbohydrate contents (Rambelli and Menini 1983; Martinez-Carrera 1987; Shanmugam 1995).

The present work was carried out to find out the best choice of cow dung (CD), poultry droppings (PD) and turkey droppings (TD) as organic supplements on either *Pennisetum polystachion* or *Andropogon gayanus* straw (PS and AS, respectively) or the levels of these that would be used for sustainable cultivation of the macro-fungus in Nigeria.

MATERIALS AND METHODS

The investigation was carried out in the Mushroom house/laboratory, Department of Biological Sciences, Michael Okpara University of Agriculture Umudike Nigeria in 2005. The investigation was conducted in a completely randomized design with three replications. In this work, two substrate types (AS and PS), were used. These straws were collected in piles from a freshly cleared farm, near Ehimiri housing Estate in Umuahia, Abia State, Nigreria. The straw heaps were taken to the Mushroom house of Michael Okpara University of Agriculture, Umudike, and dried under the sun for one week. The dried straws were then chopped into pieces of ~2 cm long using a sharp machete. They were then soaked in fresh water over night, packed in evenly perforated plastic pail of equal sizes before pasteurizing in gas-heated drum at 80°C for 2 h. AS was supplemented with two levels (5 or 10%, w/w) of CD, PD and TD. The organic manures (amendments) were collected from the university (animal) farm. CD was from about 12 year-old Muturu cows, while PD and TD were from eight weeks white broilers and local turkeys, respectively. The droppings were colleted from a deep litter system of poultry management and dried under natural conditions for six weeks before use.

AS and PS were chopped into about 10 cm average length, and known quantities of the substrates were filled into each of the

Received: 14 July, 2008. Accepted: 19 September, 2008.

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28, 16 × 17 cm plastic buckets and soaked in clean cold tap water overnight. Excess water was squeezed out of the soaked substrates which were rated moisture-adequate when no more drops of water oozed out from the perforated buckets. The soaked substrates were then mixed with fermented organic animal wastes at the rate of 5 or 10% CD, PD and TD (substrate plus organic amendments = 1 kg). Each treatment was replicated three times. Three buckets of the substrate were not mixed with any organic manure and served as the control experiment. The buckets of amended substrates were pasteurized for 2 h at 80°C in a gas heated-drum. After cooling, the substrates were inoculated with a uniform amount of grain spawn (30 g per bucket). Spawn was prepared by inoculating sterilized sorghum grains in heat-resistance bottles, with a uniform amount of mycelial mat of the mushroom. The inoculated grains were left to be ramified by the mycelium. The original culture used for the investigation was supplied by Dr. I. A. Okwujiako, a mushroom scientist in the Department of Biological Sciences, Michael Okpara University of Agriculture, Umudike. The mushroom culture was sub-cultured and maintained on pH 6.0 Malt Extract Agar (MEA; 20 g agar powder + 20 g malt extract broth + 2 g yeast powder + 1 g peptone in 1 L distilled water) in sterile Petri dishes. The culture used for the inoculation of the grains was incubated at 25°C after having dispensed the mixture into two 250 ml conical flasks which were then plugged with cotton wool and sterilized in an autoclave and autoclaved at 0.1 MPa for 15 min.

The buckets inoculated with the grain spawn were covered with their lids and placed in wooden racks in the cropping room where they produced fruit bodies. The first harvest started 14-15 days after inoculation. The mushroom fruit bodies were harvested in flushes (i.e. regular intervals) for analysis.

Evaluation of the proximate composition of *P. ostreatus* var. *florida* fruit bodies grown on different substrates

Fruit bodies were harvested from the various substrates, and after measurements were made of the fresh weight, pileus and stipe sizes, they were stored in perforated polyethylene bags in the refrigerator at 12°C until use (Fasidi 1996).

Preparation of samples for analysis

For the determination of the proximate composition of the fruit bodies of mushrooms harvested from different substrates, mushrooms were oven-dried at 104°C for 4 h following the method of Latiff *et al*. (1996). About 500 g of each of the dry samples were broken into sizeable pieces (about 2 cm) and then finely ground into powder of particle size of less than 0.5 mm using a Thomas Willey milling machine (Okwulehie and Odunze 2004a). The resulting powder was stored in dry, air-tight bottles until needed for analysis.

Moisture content determination

To obtain the moisture content value of the mushroom fruit bodies, 20 g of the powdered dry samples was placed into clean dry glass Petri dishes of known weight. These were placed in an electric oven at 15°C and allowed to dry for 6-8 h (la Guardia *et al*. 2005; Konuk *et al*. 2006). The oven-dried samples were weighed and placed back in the oven to further dry for 1 hr. The weighing and drying was repeated until the weight became constant.

The percentage moisture content was calculated as follows:

$$\frac{\text{Weight of moisture}}{\text{Weight of sample}} \times \frac{100}{1}$$

Ash content of the fruit bodies

To obtain the ash content value of the fruit bodies, 5 g of the ground dry sample was used. This value was obtained by weighing the sample before and after burning it at 500°C overnight (Mattila *et al*. 2002).

Dietary fibre

The total dietary fibre of the fruit bodies of *P. ostreatus* var. *florida* was determined by the Weende Method (AOAC 1980). Two g of the sample was placed into a 250-ml beaker and hydrolyzed by adding 20 ml of 25% sulphuric acid and boiled under control for about 30 min on a hot plate. The mixture was filtered through a piece of clean white cloth then rinsed with hot distilled water. The residue was again boiled with 50 ml of 2.5% sodium hydroxide (NaOH) for 30 min, then filtered and rinsed with distilled water. The residue was finally collected and transferred into a crucible, dried in the oven to a constant weight. The sample was finally ashed in a muffle furnace for 30 min. The weight of the fibre was calculated and expressed as a percentage of crude fibre as follows:

$$\text{Crude fibre} = \frac{\text{weight of fibre}}{\text{weight of sample}} \times \frac{100}{1}$$

Crude protein

Crude protein content of the samples was determined by the use of the macro-Kjeldahl method. In this method, nitrogen (N) contents were determined first and the value was multiplied by 6.25 coefficients (la Guardia *et al*. 2005). To determine the N content, 2 g of the dry powdered sample was digested with 5 ml of concentrated sulphuric acid (H_2SO_4), i.e. tetra-oxo-sulphate (vii) acid, to which a tablet of selenium catalyst was added in a fume cupboard. The digest was made up to the mark in a 250-ml volumetric flask. Ten ml of the digest was distilled and titrated with 0.2 N H_2SO_4. The crude protein therefore equalled the total N multiplied by 6.26.

Determination of fats and oil

The fat and oil contents of the sample were determined following the Twisselman method using diethyl-ether as solvent (AOAC 1980). Two g of the dry mushroom sample was introduced into an ether-extracting thimble and placed on a Soxhlet reflux flask connected to a round-bottomed flask of known weight. This was placed on a heating mantle filled with about 250 ml of petroleum ether. The oil was extracted by a reflux system. After a series of refluxes, a clear solution was obtained in the flask, the sample was removed. Further heating separated the ether from the extraction oil. The round-bottomed flask containing the oil was finally dried in an oven at 70°C. Determination by gravimetric method was done and expressed as a percentage of the sample used, thus:

$$\% \text{ Fats and oil} = \frac{\text{weight of oil}}{\text{Weight of sample}} \times \frac{100}{1}$$

Calculation of carbohydrate content of the sample

The carbohydrate content of the dry samples was calculated as follows:

CHO (% dry weight) = 100 – CP + FO + Ash, + M + DF (in g/100 g DW) (la Guardia 2005) where: CHO = carbohydrate, CP = crude protein, FO = fats and oil, MC = moisture content and DF = dietary fibre.

Food energy value calculation

The food energy value of the samples was estimated using the following factors.

Protein, 4.0 Kcal/g; fats and oil, 8.37 Kcal/g and carbohydrates, 3.48 Kcal/g (Crisan and Sands 1978) and the formula used was:

FEV = (% CP × 4.0) + (% FO × 8.37) + (% CHO × 3.48), all in Kcal/g.

where FEV = food energy value, CP = crude protein, FO = fats and oil and CHO = carbohydrates.

Determination of macroelement composition

The mushroom harvested from different substrates, were oven dried at 104°C for 4 h following the method of Latiff *et al.* (1996). The macroelements Ca, K, Mg, Na, P, and N contents of the dry samples of the mushroom fruit bodies were determined by the

Table 1 The proximate composition of *Pleurotus ostreatus* var *florida* fruit bodies, grown on *Andropogon* and *Pennisetum* straws with different levels of organic manure.

Substrate + supplement	Crude protein (%)	Moisture content (%)	Ash content (%)	Fats and oils (%)	Dietary fibre (%)	CHO (%)
As + 5% CD	15.37 ± 1.00 b	7.00 ± 0.87 a	4.00 ± 0.50 a	0.30 ± 0.05 a	0.70 ± 0.26 a	69.63
As + 10%CD	20.00 ± 0.87 a	8.00 ± 0.50 a	1.00 ± 00 b	0.30 ± 0.00 a	0.70 ± 0.17 b	70.00
As + 5% PD	17.50 ± 1.00 b	8.00 ± 0.00 a	4.00 ± 0.00 a	0.35 ± 0.90 a	3.65 ± 1.25 a	66.50
As + 10% PD	18.00 ± 5.00 ab	8.50 ± 0.50 a	4.50 ± 0.50 a	0.35 ± 0.00 a	4.15 ± 0.68 a	64.00
As + 5 TD	18.50 ± 1.00 ab	8.50 ± 5.00 a	3.50 ± 0.50 a	0.35 ± 0.05 a	3.15 ± 0.13 a	66.00
As + 10% TD	20.00 ± 0.50 a	20.00 ± 0.50 a	9.00 ± 1.00 a	4.00 ± 0.50 a	0.35 ± 0.00 a	64.00
Control	10.33 ± 0.76 c	7.33 ± 0.76 a	3.50 ± 0.50 a	0.35 ± 0.09 a	3.20 ± 0.05 a	75.29
Pennisetum alone	15.00 ± 0.50 b	7.50 ± 0.87 a	3.50 ± 0.50 a	0.35 ± 0.50 a	0.35 ± 0.05 a	70.50
CV	4.74	8.81	12.37	18.14	16.39	39.55

Values are means of 3 replicates and values with the same superscript are not significantly the same
As = *Andropogon* straw, CD = Cow dung, PD = poultry droppings, TD = turkey droppings CHO = carbohydrate and CV = co-efficient of variation

multiple nutrients wet acid digestion methods (AOAC 1980). The tests were carried out at the central laboratory of the National Root Crop Research Institute, Umudike. To prepare the digest for the determination of the various mineral elements, 0.2 g each, was placed into a 100 ml conical flask, and 3 ml of sulphuric acid – selenium salicylic acid mixture was added to each and allowed to stand overnight. The samples were heated on a hot plate for 2 h at 30°C and digested further using 5 ml of perchloric acid ($HClO_4$) which was gradually added to each as the heating continued until digestion is completed. After cooling, the solutions were filtered into a 50 ml volumetric flask and finally made up to mark with distilled water. This digest was then used to determine Ca and Mg contents by the versenate ethyldiamine-tetra acetic acid (EDTA) complexometric titration method using 10 ml of the digest each, K and Na by the flame photometric method; P content was determined by the vanado-molybdate yellow spectrophotometric method while the N content was determined by Kjeldhal method.

Vitamin contents

About 500 g of each of the dry samples were broken into sizeable pieces (about 2 cm) and then finely ground into powder of particle size of less than 0.5 mm using a Thomas Willey milling machine (Okwulehie and Odunze 2004a). The resulting powder was stored in dry air-tight bottles until needed for analysis.

The ascorbic acid (Vit. C) content of the mushroom fruit bodies was determined by the EDTA/TCA (tricyclic antidepressant) extraction methods (AOAC 1975). Niacin content was determined by Konig's spectrophotometric method, riboflavin content by spectrophotometric method, (with 5 g of the dry powdered sample) and thiamin by spectrophotometric method (AOAC 1975).

RESULTS AND DISCUSSION

Proximate composition of *P. ostreatus* fruit bodies

The proximate composition of the fruit bodies of *P. ostreatus* var. *florida* produced on different substrates and substrate supplementations is shown in **Table 1**. All the substrates and substrates supplementations produced fruit bodies with appreciable quantities of proteins, ash, fats and oils, crude fibre moisture and carbohydrates. This result confirms the nutritional richness of *Pleurotus* mushrooms, as reported by Manu-Tawial and Martin (1980), and Yildiz *et al*. (1998) on *P. tuber-regium*, Kadiri and Fasidi (1990), Fasidi and Ekuere (1993) and Okwulehie and Odunze (2004a) on *P. squarrosulus*, and Yildiz and Saya (1992) and Okwulehie and Odunze (2004a) on *P. florida*.

Generally, the crude protein content of the fruit bodies was high, ranging from 10.5-20.0%. This value compared favourably with that reported by Stamets (1993) – 10-30% – for *Pleurotus* mushrooms. According to Flegg and Maw (1977) and Longvah and Deosthale (1998), the protein content of mushrooms is affected by factors such as mushroom type, stage of development the part sampled, level of N available in the substrate and location, i.e. where the mushroom are obtained. This might be the reason why AS supplemented with 10% CD, PD and TD produced mushrooms with significantly higher protein contents (20, 20 and 18.0%, respectively) than AS with a lower concentration of the organic manure (5%) and substrates without any additive at all (i.e. PS). For instance, AS and PS without organic manure produced fruit bodies with less crude protein, 10.5 and 15%, respectively while substrates with 5% manure produced 15.5, 17.5 and 18.5% crude protein, respectively for CD, PD and TD. The moisture contents of the fruit bodies produced on all the substrates and substrate combinations (7-8.5%) did not vary significantly while the ash contents of the mushrooms was relatively low, varying from 1-4%, but compared favourably with that of other mushrooms, such as *Lentinus subnudus* (1.85%) (Aletor 1995), *Pleurotus squarrosulus* (1.5%) and *P. tuber-regium* (2.5%) (Okwulehie and Odunze 2004a).

The fats and oils content of the mushroom (0.3-0.35%) was also low and did not vary significantly according to the substrates or substrate supplement levels. Similarly the crude fibre content was significantly highest in the fruit bodies produced on AS with 10% PD (4.15%), and lowest in those produced on AS with 10% CD (0.7%). The unsupplemented AS and PS produced fruit bodies with 3.20 and 3.15% crude fibre, respectively ($P>0.05$). These unsupplemented straws produced mushrooms with higher carbohydrates (75.0 and 70.5%, respectively) than the supplemented substrates. This trend suggests that the straws contain more carbohydrates than proteins for the fruit bodies to absorb. This result is strengthened by the work of earlier researchers who reported that the contents of the substrates influence the nutritional status of the mushrooms. For instance, Rugunathan *et al*. (1996) reported significant variation in the nutrients, mineral and lignocellulosic contents of *Pleurotus* mushrooms as a result of the different substrates on which they were produced.

Macro-element and vitamin composition of *P. ostreatus*

Table 2 shows the macroelement contents of the fruit bodies of *P. ostreatus* grown on different substrates and substrate supplementation. Generally, mushroom fruit bodies contained all elements at appreciable amounts. This result is similar to that obtained by previous researchers (Fasidi and Kadiri 1990; Kadiri and Fasidi 1990; Fasidi and Ekuere 1993; Yildiz *et al*. 1998; Okwulehie and Odunze 2004b). The macroelement content of the fruit bodies from substrates supplemented with 10% of any of the organic manures were in most cases higher than those with 5% additive (**Table 2**) while only was the riboflavin level higher in CD and PD whereas all other vitamins were statistically identical (**Table 3**). The vitamin C and thiamine contents of fruit bodies supplemented with any organic manure were higher than controls (no CD, PD or TD added). A similar trend could be observed for Ca, Mg, P and N. All other vitamin contents and macroelements showed variable trends depending on the choice (CD, PD or TD) or level (5 or 10% w/w) of the additive. Although the mineral contents of the organic matter was not analysed, it appears that they contain a rich amount of macro-elements. Their accumulation in the mushroom fruit bodies implies that fungi have a specialized mecha-

Table 2 Vitamin constituents of the fruit bodies of *P. ostreatus* var. *florida*, produced on different substrates and additive levels.

Substrate/additive	Vitamin C (%)	Niacin (mg/100 g)	Riboflavin (mg/100 g)	Thiamin (mg/100 g)
AS + CD 5%	21.00 ± 0.87 b	0.08 ± 0.00 ab	37.25 ± 0.38 d	125.00 ± 0.00 a
AS + CD 10%	21.00 ± 0.00 b	0.09 ± 0.00 a	37.50 ± 0.66 cd	125.00 ± 5.00 a
AS + PD 5%	20.00 ± 0.00 b	0.10 ± 0.00 a	30.29 ± 0.02 f	75.00 ± 0.05 b
AS + PD 10%	21.00 ± 1.00 b	0.97 ± 0.00 a	40.50 ± 0.46 a	75.00 ± 0.00 b
AS + TD 5%	23.00 ± 0.05 a	0.08 ± 0.00 ab	38.40 ± 0.62 b	75.00 ± 1.32 b
AS + TD 10%	20.00 ± 0.00 b	0.08 ± 0.00 ab	39.30 ± 0.75 b	75.00 ± 0.87 b
Control	16.00 ± 1.00 c	0.05 ± 0.04 b	35.00 ± 0.50 b	50.00 ± 0.87 c
Pennisetum	21.00 ± 0.50 b	0.08 ± 0.00 ab	39.20 ± 1.04 b	75.00 ± 0.05 b

Values are means of three replicates and means with the same superscripts are not statistically significant (α = 0.50) according to LSD.
AS = Andropogon straw, CD = Cow dung, PD = Poultry dropping, TD = Turkey dropping

Table 3 Macro-element composition of *P. ostreatus* var. *florida* produced on different substrates and additive levels.

Substrate/additives	Ca (mg/100 g)	K (ppm)	Mg (mg/100 g)	Na (ppm)	P (mg/100 g)	N (%)	S (mg/100 g)
AS + CD 5%	1.600 ±0.05 b	2.00 ± 0.23 c	31.000 ± 1.50 c	2.000 ± 0.00 c	78.80 ± 0.30 d	2.400 ± 0.05 d	0.131 ± 0.00 cd
AS + CD 10%	2.000 ± 0.00 a	3.00 ± 0.05 a	32.000 ± 0.87 c	3.000 ± 0.50 b	80.30 ± 0.53 bc	3.200 ± 0.00 a	0.151 ± 0.00 a
AS + PD 5%	1.600 ± 0.00 b	2.00 ± 0.00 c	34.000 ± 1.00 b	2.000 ± 0.50 c	76.50 ± 1.32 e	2.800 ± 0.05 bc	0.124 ± 0.00 d
AS + PD 10%	2.000 ± 0.09 a	3.00 ± 0.05 a	35.000 ± 0.50 b	3.000 ± 0.00 b	82.20 ± 0.82 a	2.880 ± 0.10 b	0.131 ± 0.00 cd
AS + TD 5%	1.600 ± 0.05 b	2.50 ± 0.09 b	34.000 ± 0.00 b	3.000 ± 0.06 b	79.20 ± 0.56 cd	2.960 ± 0.03 ab	0.138 ± 0.01 bc
AS + TD 10%	1.600 ± 0.00 b	3.00 ± 0.00 a	39.000 ± 0.50 a	4.000 ± 0.00 a	81.50 ± 0.87 ab	2.533 ± 0.49 cd	0.144 ± 0.00 ab
Control	1.200 ± 0.00 c	2.00 ± 0.00 c	20.000 ± 1.00 e	2.000 ± 0.05 c	70.25 ± 0.13 g	1.680 ± 0.02 e	0.082 ± 0.01 e
Pennisetum	0.800 ± 0.01 d	2.00 ± 0.01 c	27.000 ± 0.50 d	2.000 ± 0.05 c	72.60 ± 0.10 f	2.400 ± 0.05 d	0.131 ± 0.00 cd

Values are means of three replicates, and any means with the same superscript(s) are not significantly different (α = 0.50) according to LSD.
AS = Andropogon straw, CD = Cow dung, PD = Poultry dropping, TD = Turkey dropping

nism to absorb and accumulate mineral nutrients in their fruit bodies (Rudawska and Leski 2005). Giacomini (1957) noted that mushrooms are rich in the vitamins we detected.

General nutritional considerations of mushrooms

The protein content of mushrooms is about twice that of vegetables and four times that of oranges; moreover, all amino acids essential for human nutrition are present in mushrooms (Bano 1993). The protein context in mushrooms, however, varies from species to species and from strain to strain. In addition, they vary according to the source and method of cultivation, particularly the substrate used in the cultivation (Rambelli and Menini 1983). Farms that produce *A. bisporus* have apparently succeeded in selecting strains with high protein content. In any case, the protein content of mushrooms averages 20% of the dry mass (Stamets 1995). Crisand and Sands (1978), gave the protein contents determined on the dry weight basis, as approximately varying between 4 and 9% in *Auricularia* spp. and between 24 and 44% in *Agaricus* spp. On a fresh weight basis, Bano (1993) indicated the protein content of *A. bisporus*, *Pleurotus flabellatus* and *Volvariella displansia* as 3.94, 2.98 and 3.90%, respectively. Similarly Okwulehie and Odunze (2004a) indicated that the protein content of four Nigerian mushrooms, *Auricularia auricular*, *Pleurotus squarrosulus*, *P. tuber-regium* and *Russula* sp. ranged from 15.0-24.96 g/100 g on a dry matter basis. Many other authors have investigated the protein contents of mushrooms, using the Kjeldahl method (Rambelli and Menini 1983), or other methods, but the results have consistently confirmed the high protein levels of mushrooms on a dry weight basis.

Mushrooms contribute a wide range of free essential amino acids (Stamets 1993). The free amino acid content is remarkably variable from species to species. However, the range is very high and generally includes the rare and other similar compounds especially cysteine, lysine, threonine and tryptophan (Bano 1993). Attamura *et al*. (1967) found up to 53 nitrogen compounds in a single strain of *A. bisporus*. Leon-Guzman *et al*. (1997) also reported the presence of many free amino acids in Mexican mushrooms.

The fibre content of mushrooms varies from species to species, ranging from 3.5 to 3.78 g/100 g in *A. auricular* (Aletor 1995; Okwulehie and Odunze 2004a), 7.4 g/100 g in *Calvatia cyathifomis* (Aletor 1995); 7.0 to 8.82 g/100 g in *P. tuber-regium* (Fasidi and Ekuere 1993; Okwulehie and Odunze 2004a), and 6.08 and 3.54 g/100 g in *P. squarrosulus* and *Russula* sp., respectively (Okwulehie and Odunze 2004a).

The carbohydrate content of mushrooms is low and occurs in mushrooms in the form of xylose, ribose, rhamnose, glucose, sucrose and mannitol (Rambelli and Menini 1983). The low content of carbohydrates in mushrooms was further reported by Bano (1993), who showed that the carbohydrate value of *A. bisporus*, *Pleurotus flabellatus* and *Volvariella displansia* on a fresh weight basis as 6.28, 5.33 and 5.15%, respectively.

The fat fraction of mushrooms is also low and is mainly composed of unsaturated fatty acids, corresponding to about 4.0% on a dry weight basis (Bano 1993; Leon-Guzman *et al*. 1997). The fat and oil content of *Auricullaria auricular* is 1.08 g/100 g; *Russula* sp. 2.10 g/100 g; *P. squarrosulus*, 4.02 g/100 g and *P. tuber-regium*, 4.24 g/100 g (Okwulehie and Odunze 2004a).

The low carbohydrate and fat contents of mushrooms implies that mushrooms are a low-calorie food and hence are ideal for diabetic and heart patients (Bano 1993).

According to Bano (1993), the mineral contents of mushrooms are higher than that of meat and fish and almost twice that of vegetables. The mineral salt contents vary from species to species and according to the substratum used for their cultivation. Fasidi and Ekuere (1993) and Aletor (1995) reported the mineral elements of nine Nigerian mushrooms in parts per million (ppm) as follows: Na 0.1–2.55, K 1.6–7.88, P 0.1–1.37, Ca 0.76–236, Mg 1.03–81, Fe 0.01–1230, Cu 0.005–56 and Mn 0.002–136. Mushrooms are rich in vitamins. They provide several types of vitamins, particularly thiamine (Vitamin B_1), riboflavin (Vitamin B_2), niacin, biotin, ascorbic acid (Vitamin C), Vitamin D and Vitamin K (Giacomini 1957; Bano 1993; Stamets 1995; Okwulehie and Odunze 2004b). On a dry weight basis, *Pleurotus* species contain 30–144 mg/100 g ascorbic acid, 1.16–4.8mg/100 g of thiamine 109 mg/100 g niacin and 4.7 mg/100 g riboflavin. *Volvariella volvacea* contain 206.27 mg/100 g of ascorbic acid, while Nigerian *Auricularia auricular*, *Pleurotus squarrosulus*, *P. tuber-regium* and *Russula* species contain 5.46–9.86 mg/100 g ascorbic acid, 0.53–0.70 g/100 g biotin, 4.25–7.65 g/100 g nicin, 0.49–0.67 mg/100 g riboflavin and 0.08–0.17 mg/100 g thiamine (Okwulehie and Odunze 2004b). The vitamins in mushrooms are retained during cooking, canning, drying and freezing (Bano 1993). Mushrooms also contain a high percentage of folic acid (Bano 1993).

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