ELSEVIER

0308-8146(95)00044-5

Food Chemistry **54** (1995) 265–268

0308-8146/95/$9.50

Compositional studies on edible tropical species of mushrooms

Valentine A. Aletor

Unit of Nutritional Biochemistry, Department of Animal Production & Health, The Federal University of Technology, PMB 704, Akure, Nigeria

(Received 31 August 1994; revised version received and accepted 14 February 1995)

The nutritive potential of some edible tropical species of mushrooms such as *Termitomyces robustus, Termitomyces microcarpus, Psathyrella antroumbonata, Lentinus subnudus, Auricularia auricula, Calvatia cyathiformis*, 'Peperu' and *Schzophyllum commune* were evaluated with respect to their proximate composition, energy values, mineral (trace and major) content, phytin, phytin-phosphorus and oxalate constituents. On average they contained 22·1 g/100 g DM crude protein with a range of 8·9 g/100 g DM in *A. auricula* to 33·8 g/100 g DM in *T. robustus*. The crude fibre ranged from 2·1 to 8·0 g/100 g DM while the ash ranged from 2·1 to 13·9 g/100 g DM. All the varieties had low levels of ether extract ranging from 0·1 g/100 g DM in *C. cyathiformis* to 0·2 g/100 g DM in *L. subnudus*. The gross energy ranged from 2·5 kcal/g in *P. atroumbonata* to 3·02 kcal/g in *T. robustus*. Potassium was the most abundant mineral while magnesium was the least. There were high interspecies differences in the components analysed as indicated by the high coefficients of variation (CV). Phytic acid content varied from 160 mg/100 g in *T. robustus* to 360 mg/100 g in *C. cyathiformis* with a CV of 28·4% while oxalate content varied from 80 mg/100 g in *T. robustus* to 220 mg/100 g in *A. auricula* with a CV of 3·8%. Based on the results, measures were suggested for harnessing mushroom nutritional potentials.

INTRODUCTION

Although the nutritional and medicinal values of mushrooms have long been recognised (Lucas *et al.*, 1957; Suzuki & Oshima, 1976), their consumption has mainly been confined to rural Nigeria. In recent times, however, mushrooms have assumed greater importance in the diets of both rural and urban dwellers. For example, they are being marketed along major highways and urban centres where the trade now booms. It is conceivable that the increased demand for mushrooms is contingent upon the phenomenal rise in the unit costs of the conventional sources of meat (e.g. beef, pork, chicken, etc). The nutritional potential or implications of this gradual replacement of meat with mushroom requires careful examination which involves detailed chemical and biological studies.

While most studies on edible species of Nigerian mushrooms have centred mainly on their botany and physiology (Oso, 1981; Fasidi & Kari, 1990), similar studies on their nutrient and antinutrient constituents are scanty. It is hoped that the provision of such analytical information would: (i) show the relative nutritive qualities of these species; (ii) serve as a basis for harnessing such potentials to the fullest; and (iii) enable or encourage people to embark on husbandry of the more nutritious species of mushrooms.

MATERIALS AND METHODS

Materials

Fully mature mushroom species were either harvested in the wild or purchased from local sellers in fresh conditions from Ogun, Oyo, Ondo and Edo States of Nigeria. All the States lie within the Tropical rainforest zone. They were all harvested in June corresponding to the rainy season and were subsequently identified at the Department of Botany (University of Ibadan, Ibadan, Nigeria) as *Termitomyces robustus* (Beeli) Heim; *Termitomyces microcarpus* (Berk), *Psathyrella atroumbonata, Lentinus subnudus* (Berk); *Auricularia auricula* (Hoom); *Calvatia cyathiformis* (Bosc) Morgan and *Schizophyllum commune* Fr. One of the species, although popularly consumed, could only be identified by its local name, 'Peperu'. Most mushrooms in Nigeria are harvested for consumption without division

into the pileus and stipe. Consequently, all samples were analysed whole (i.e. pileus + stipe). About 500 g each of the air-dried samples (previously rinsed with distilled water) were ground using a laboratory mill fitted with 1 mm mesh sieve prior to analysis.

Methods

Proximate chemical composition of the samples was determined by the method of the AOAC (1980) and the nitrogen-free extract estimated by difference. Phosphorus was determined by the phosphovanado molybdate method (1980) while the other minerals were determined after wet digestion with a mixture of nitric, sulphuric and perchloric acids, using an atomic absorption spectrophotometer (AAS; Model SP 9). Extraction and precipitation of phytate were done by the method of Wheeler and Ferrel (1971). Iron in the precipitate was determined by the method of Makower (1970) and phytin was determined by multiplying phytin phosphorus by 3·55 as described by Young and Greaves (1940). Oxalate content of the samples was determined by the titrimetric method of Moir (1953) as modified by Ranjhan and Krishna (1980) while the gross energy was determined, after pelleting, using a Gallenkamp ballistic bomb calorimeter (Model CBB-330-010L).

RESULTS

The proximate composition and gross energy values of the mushrooms are presented in Table 1. The crude protein (CP) ranged from 8·9 g/100 g DM in *A. auriculata* to 33·8 g/100 g DM in *T. robustus* with a coefficient of variation (CV) of 44·8%. Generally, all the mushroom varieties had low ether extract (EE) which ranged from 0·1 g/100 g DM in *C. cyathiformis* to 0·2 g/100 g DM *L. subnudus* with a CV of 27·3%. There were marked variabilities in the ash and silica-free ash values as indicated by the high CV values. The energy values ranged from 2·49 kcal/g in *T. atroumbonata* to 3·02 kcal/g in *T. robustus*. The energy values showed no marked variations.

Table 3 shows the phytin, phytin-P and oxalate constituents of the mushrooms. Phytic acid varied from 160 mg/100 g in *T. robustus* to 360 mg/100 g in *C. cyathiformis* with a CV of 28·44. The phytin-P content of the samples varied widely ranging from 50 mg/100 g in *Termitomyces* species to 100 mg/100 g in

Table 1. Proximate composition (g/100 g DM) and gross energy (kcal/g) values of some edible tropical mushrooms[a]

Botanical names	Local names	Moisture	DM	CP	CF	EE	Ash	SFA	NFE	GE
1. *Termitomyces robustus* (Beeli)	EWE	8·3	91·7	33·8	3·7	0·1	13·9	6·3	40·2	3·02
2. *Termitomyces microcarpus* (Berk)	Oron	9·6	90·4	30·2	4·9	0·1	7·8	1·8	47·4	2·82
3. *Psathyrella atroumbonata*	Wowo	5·9	94·0	32·8	7·9	0·1	16·6	6·4	36·5	2·49
4. *Lentinus subnudus*	Patiro	2·3	97·7	16·4	6·5	0·2	2·1	0·4	72·5	2·77
5. *Auricularia auricula* (Hook)	Etiologbo	4·0	96·0	8·9	3·5	0·1	3·2	0·7	30·3	2·88
6. *Calvatia cyathiformis* (Bosc)	Isoaparo	5·3	94·7	13·2	7·2	0·1	10·1	1·9	64·2	3·07
7. —	Peperu	6·4	93·6	14·4	2·0	0·1	5·6	1·2	71·6	2·76
8. *Schizophylum commune* Fr.	Eseadie	7·2	92·7	27·1	7·4	0·1	10·8	0·1	47·3	2·99
	Mean	6·1	93·9	22·1	5·4	6·1	8·8	2·4	57·5	2·85
	SD	2·3	2·3	9·9	2·2	0·1	5·2	2·6	16·6	1·18
	CV (%)	38·0	2·5	44·8	40·8	27·3	57·8	108·5	28·9	6·32

[a]Means are for duplicate determinations. DM, dry matter; CP, crude protein; CF, crude fibre, EE, ether extract; SFE, silica-free ash; NFE, nitrogen-free ash; GE, gross energy; CV, coefficient of variation.

Table 2. Mineral constituents of some edible tropical mushrooms[a]

Botanical names	Local names	Na	K	P	Ca	Mg	Fe	Cu	Mn
		(g/100 g DM)			(ppm)				
1. *Termitomyces robustus* (Beeli)	Ewe	0·1	4·0	0·2	16	7	742	27	136
2. *Termitomyces microcarpus* (Berk)	Oron	0·2	4·8	0·2	37	10	392	25	6
3. *Psathyrella atroumbonata*	Wowo	0·6	8·2	0·2	6	4	1230	56	120
4. *Lentinus subnudus*	Patiro	0·1	1·6	0·2	236	81	145	11	45
5. *Auricularia auricula* (Hook)	Etiologbo	0·4	2·2	0·1	235	14	396	4	44
6. *Calvatia cyathiformis* (Bosc)	Isoaparo	0·3	4·4	0·2	31	11	1134	8	52
7. —	Peperu	0·2	2·7	0·2	36	10	1930	6	41
8. *Schizophyllum commune* Fr.	Eseadie	0·1	5·16	0·1	43	14	497	21	53
	Mean	0·3	4·1	0·2	80	18·9	808	19·8	62·1
	SD	0·18	2·18	0·04	90	25·3	589	17·1	43·4
	CV (%)	69·2	50·4	23·5	112·5	134·2	72·8	86·6	69·9

[a]Means are for duplicate determinations.

Table 3. Phytin, phytin-P and oxalate content (mg/100 g) and some edible tropical species of mushrooms

Botanical names	Phytic acid	Phytin-P	Oxalate
1. *Termitomyces robustus*	160	50	80
2. *Termitomyces microcarpus* (Berk)	100	50	140
3. *Psathyrella atroumbonata*	190	50	100
4. *Lentinus subnudus*	200	600	110
5. *Auricularia auricula*	270	70	220
6. *Calvatia cyathiformis* (Bosc)	360	100	190
7. 'Peperu'	300	80	160
8. *Schizophyllum commune* Fr.	270	70	100
Mean	241	66·4	138
SD	68·4	17·7	49·2
CV%	28·4	26·7	35·8

[a]Means are for duplicate determinations.

C. cyathiformis. Oxalate content varied from 80 mg/100 g in *T. robustus* to 220 mg/100 g in *A. auricula* with a CV of 35·8%.

DISCUSSION

Results on the proximate, mineral and energy values of the edible species of mushrooms clearly indicate the potentials for their use as sources of good quality food. For example, the crude protein, ash and crude fibre values of most of the mushrooms compared favourably with, and, in some instances, surpassed those reported for most legumes (except groundnut and soya beans) grown in West Africa (FAO, 1970; Ologhobo, 1980; Aletor & Aladetimi, 1989). The mineral levels (mainly K, P, Na and Fe) in these mushrooms were higher than those reported for several cowpea varieties (Aletor & Aladetim, 1989) but lower than those reported for fish, snails and broiler meat by Imevbore (1992) (Table 2). Using these proximate, mineral and energy analytical values as approximate indices of nutritional quality, it would appear that some of these mushrooms (mainly *T. robustus, T. microcarpus, P. atroumbonata* and *S. commune*) fall between most legumes and meat. Indeed, earlier studies (Suzuki & Oshima, 1976; Gruen & Wong, 1982; Zakhary *et al.*, 1983) indicate that edible mushrooms are highly nutritious and compare favourably with meat egg and milk. Additionally, a number of them are known to possess anti-tumorigenic and hypocholesterolaemic agents, which implies that mushrooms could hold special attraction for, and indeed may be recommended for people with cholesterol-related ailments. From the analytical data, it would appear that mushroom contents of phytin and phytin-P are generally no higher than those reported for cowpeas and soya beans by Ologhobo (1980). The anti nutritional nature of phytic acid lies in its ability to chelate certain mineral elements, especially calcium, magnesium, iron and zinc (Nelson *et al.*, 1968; Reddy *et al.*, 1982; Forbes & Erdman, 1983) which often renders the elements metabolically unavailable, thus inducing deficiencies. It is documented that phytic acid interferes with basic residues of proteins, in a way that inhibits the activities of certain digestive enzymes such as α-amylase, pepsin and pancreatin (Huisman, 1991). Phytic acid has been implicated for the rachitogenic properties of certain cereals while magnesium deficiency has been observed in rat and man when fed diets high in sodium phytate. While reviews by Fasset (1966) indicate very little danger associated with the ingestion of oxalate-containing plants, studies by Oke (1969) suggest contrary views, especially with respect to magnesium, the metabolism of which is reported to be impaired by oxalic acid. However, the oxalate values in these mushrooms were quite low (80–220 mg/100 g) compared with values of 5·8–2·3 g/100 g reported earlier (Aletor, 1990) for some varieties of guinea corn.

From the present analytical information, it is conceivable that a number of these edible mushrooms hold tremendous promise in narrowing the protein and mineral supply deficits prevalent in several developing countries of Africa. To date, virtually all of these mushrooms are harvested in the wild, with no efforts at their husbandry. Consequently, for their full nutritional potentials to be realised, intensive efforts must be geared towards the husbandry and popularization of the more nutritious species such as *T. robustus, T. microcarpus, P. atroumbonata* and *S. commune*. Additionally, detailed amino acid analysis of these species is suggested to permit a more direct comparison with other more popular food sources.

ACKNOWLEDGEMENTS

This study was supported by the University Research Grant No. URG. 89-90/27 of the Federal University of Technology, Akure. Many thanks are due to Drs I. O. Kadiri and M. Fasidi. Department of Botany, University of Ibadan, Ibadan for identifying the species. The technical assistance of Philip Aigberua, Nutrition Laboratory, is also acknowledged with thanks.

REFERENCES

Aletor, V. A. (1990). Anti-nutritional factors in some Nigerian feedstuffs, herbage byproducts, crop residues and browse plants. A monograph prepared for the Presidential Task Force on Alternative Formulation of Livestock Feed: Product Development, Quality Evaluation and Health Implications. Cabinet Office, Lagos, Nigeria, Feb. 1990.

Aletor, V. A. & Aladetimi, O. O. (1989). Compositional evaluation of some cowpea varieties a some under-utilized edible legumes in Nigeria. *Die Nahrung*, **33**, 99–1007.

AOAC *Official Method of Analysis* (13th edn). Association of Official Analytical Chemists, Washington, DC, USA.

FAO (1970). *Food and Agricultural Organization* (No. 12). FAO, Rome, Italy.

Fasidi, I. O. & Kadiri, M. (1990). Changes in enzyme activities of *Termitomyces robustus* (Beeli) and *Lentinus subnudus* during sporophore development. *Food Chem.*, (In Press).

Fasset, D. W. (1966). Oxalates. In: *Toxicants Occurring Naturally in Foods*. National Academy of Sciences Research Council, Washington, DC, USA.

Forbes, R. M. & Erdman, J. W. (1983). Bioavailability of trace mineral elements. *Ann. Rev. Nutr.*, **3**, 213–31.

Gruen, E. H. & Wong, M. W. (1982). Distribution of cellular amino acids, protein and total organic nitrogen during fruitbody development in *Flammulina veluptipes. Can. J. Bol.*, **60**(8), 1330–41.

Huisman, J. (l991). Anti-nutritional factors in poultry feeds and their management. In *Proc. 8th. European Symp. Poultry Nutr.* pp. 42–61, Venezia-Mestre, Italy.

Imevbore, E. (1992). Chemical composition and nutritive value of some African giant land snails. *Nig. J. Technol. Res.*, (in press).

Lucas, E. H., Rigler, R. L. & Byrrum, R. U. & Stock, O. O. (1957). Tumor inhibitors in *Boletus edulis* and other holobasidiomycetes. *Antibiot. Chemother*, **7**, 1–4.

Makower, R. V. (1970) Extraction and determination of phytic acid in beans (*Phaseolus lunatus*). *Cereal Chem.*, **47**, 288–92.

Moir, K. W. (1953). The determination of oxalic acid in plants. *Queensland J. Agric. Sci.*, **10**(1), 1–3.

Nelson, T. S., Ferrara, L. W. & Stover, N. L. (1968). Phytate phosphorus content of feed ingredients derived from plants. *Poultry Sci.*, **47**, 1372–8.

Oke, O. L. (1969). Oxalic acid in plants in nutrition. *World Rev. Nutr. Dietetics*, **10**, 262–302.

Ologhobo, A. D. (1980). Biological and nutritional studies on cowpeas and lima beans with particular reference to some inherent anti-nutritional components. PhD thesis, University of Ibadan, Ibadan, Nigeria.

Oso, B. A. (1981). Fungi and mankind. University Inaugural Lecture, Department of Botany, University of Ibadan, Ibadan.

Ranjhan, S. R. & Krishna, G. (1980). *Laboratory Manual for Nutrition Research*, eds Ranjhan S. R. & Krishna G. Vikas Publ. Co., New Delhi, India.

Reddy, N. R., Sathe, S. K. & Salunkhe, D. K. (1982). Phytates in legumes and cereals. *Adv. Food Res.*, **28**, 1–9.

Suzuki, S. & Oshima, S. (1976). Influence of *shii-te-ke* (*Lentinus edodes*) on human serum cholesterol. *Mushroom Sci.*, **a**(1), 463–7.

Wheeler, V. E. & Ferrel, R. E. (1971). A method for phytic acid determination in wheat fractions. *Cereal Chem.*, **48**, 312–16.

Young, S. M. & Greaves, J. S. (1940). Influence of variety and treatment on phytin contents of wheat. *Food Res.*, **5**, 103–5.

Zakhary, W. J., Abu-Bakr, M. T., El-Mahoy, R. A. & El-Tabey, M. A. (1983). Chemical composition of world mushrooms collected from Alexandria, Egypt. *Food Chem.*, **11**(1), 31–41.