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Compositional and nutritional studies on edible wild mushroom from northeast India

T. Longvah* & Y. G. Deosthale

National Institute of Nutrition, Indian Council of Medical Research, Jamai Osmania PO, Hyderabad, 500 007 A.P., India

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Two species of mushrooms *Schizophyllum commune* and *Lentinus edodes* from Northeast India were assessed for their nutritive value. Protein contents of *S. commune* (16%) and *L. edodes* (23%) were high, but fat content was low (2%) in both the mushrooms. Oleic and linoleic acids accounted for 72–77% of the total fat in both the mushrooms. Essential amino acid contents of *S. commune* and *L. edodes* were 34% and 39%, respectively. The chemical scores of *S. commune* (28) and *L. edodes* (29) were low compared to whole egg protein. Methionine was the limiting amino acid in both the mushrooms. Protein quality evaluation by NPR (net protein ratio), NPU (net protein utilization) and TDP (true digestibility of protein), showed that the mushrooms were comparatively much lower then casein in all the parameters examined. Animals on *L. edodes* showed significantly ($p < 0.05$) higher NPR, RNPR, and NPU than animals on the *S. commune* diet. True protein digestibility of the *L. edodes* diet was also significantly ($p < 0.05$) higher than the *S. commune* diet. © 1998 Elsevier Science Ltd. All rights reserved.

INTRODUCTION

Numerous types of mushrooms exist in nature; however, less than 25 species are widely accepted as food and only a few have attained the level of an item of commerce (Smith, 1972). Mushrooms are reported to be a good source of protein and minerals (Ogundana and Fagade, 1982; Zakhary *et al.*, 1983; Senatore, 1990; Adewusi *et al.*, 1993; Aletor, 1995), and some investigators have even contended that the amino acid compositions of mushrooms are comparable to animal proteins (Fink and Hoppenhaus, 1958; Rafalski *et al.*, 1968; Suzuki and Oshima, 1976; Gruen and Wong, 1982).

Mushrooms are one of the many foods from the wild which are found in the diet of the various Naga tribes in Northeast India. Normally mushrooms are consumed fresh but the use of dried mushrooms during the off-season is not uncommon. Of the varieties of mushrooms from the wild that are used by the Nagas as food source, two species *Schizophyllum commune* and *Lentinus edodes* are used fresh as well as in the dry forms during off-seasons. Different biological (anticarcinogenic, anti-cholesterol, immunostimulating) effects of *Lentinus edodes* are known but little is known about its nutritive values (Vetter, 1995). Moreover, there appear to be no data in the literature concerning the food values of wild mushrooms from Northeast India. Hence, the present study was undertaken to determine the chemical composition and protein quality of the two dried mushroom species, *S. commune* and *L. edodes*, from Northeast India.

*To whom correspondence should be addressed. Fax: 0091 40 7019074; e-mail: icmrnin@ren.nic.in

MATERIALS AND METHODS

Sample collection, transportation and processing

The dried mushrooms, *S. commune* and *L. edodes*, were purchased from the local market in Ukhrul, Manipur and transported by air to Hyderabad. Upon arrival at the laboratory the mushrooms were cleaned. Most mushrooms in Northeast India are harvested for consumption without division into the pileus and stipe. Therefore the whole mushrooms (i.e. pileus + stipe) were powdered to pass through a 40 mesh sieve and stored until analysis.

Chemical analysis

Proximate analysis, including moisture, crude fat, crude protein (N ×6.25) and ash, were performed according to AOAC (1990) procedure. Total carbohydrates, including fibre, were calculated by difference. Minerals were determined by atomic absorption spectrophotometer (Varian Techtron Model AAS 1000, Varian Associates, Palo Alto, CA) after dry-ashing the samples (AOAC,

1990). Phosphorus was determined using the molybdovanadate method (AOAC, 1990). Extracted fat was methylated according to the standard method (Lowenstein *et al.*, 1975). The analysis of methyl esters were performed with a gas-liquid chromatograph (Varian 3700) equipped with hydrogen flame ionization detector using a 12 ft × $^1/_8$ inch stainless steel column packed with 10% Silar 10C on chromosorb W.AW 80/100 mesh as described earlier (Longvah and Deosthale, 1991).

For amino acid analysis, defatted mushroom samples were hydrolysed at 110°C for 22 h with 6 N constant boiling hydrochloric acid in evacuated sealed ampoules. After hydrolysis, the excess acid was removed by flash evaporation under reduced pressure. Amino acid analysis was carried out by ion-exchange chromatography in an automatic amino acid analyzer (Beckman 119-C, Beckman Instruments, Fullerton, CA) (Moore *et al.*, 1958).

Biological evaluation of mushrooms

The powdered mushrooms were used directly for protein quality evaluation as the fat contents in the samples were low. Diets were formulated according to the procedure of Campbell (1963). The compositions of the diets are given in Table 1.

Male weanling NIN Wistar rats (21–23 days) were fed 10% casein diet for 2 days for acclimatization. The rats were randomly divided into 4 groups of 6 animals each on the basis of equal mean body weights. The room temperature was maintained at 22 ± 1°C, relative humidity 65 ± 5% and a 12 h light and dark cycle. Animals were allotted to the different diets as shown in Table 1. Animals were housed individually in metal cages with facilities for faecal as well as spilled food collection. Food and water were given *ad libitum*. Daily food intake and weekly body weight changes of individual rats were recorded. From the data on the food intake and weight changes, net protein ratio (NPR) and relative net protein ratio (RNPR) were calculated (Sarwar *et al.*, 1984). During the last four days of the experimental period (days 11–14), faeces of individual rats were collected and nitrogen content was estimated.

Table 1. Diet composition for protein quality evaluation (g 100 g^{-1})

Diet components	Group I	Group II	Group III	Group IV
	Casein	Protein-free	*S. Commune*	*L. Edodes*
Salt mixture	4.0	4.0	4.0	4.0
Vitamin mixture	1.0	1.0	1.0	1.0
Choline chloride	0.2	0.2	0.2	0.2
Cellulose	1.5	1.5	1.5	1.5
Groundnut oil	10.0	10.0	10.0	10.0
Casein	12.3	—	—	—
Schizophyllum commune	—	—	62.9	—
Lentinus edodes	—	—	—	43.9
Corn starch	71.0	83.3	20.4	39.4

Table 2. Proximate and mineral composition of mushrooms from northeast India (per 100 g sample)

Mushroom		*Schizophyllum commune*	*Lentinus edodes*
Moisture	(g)	5.3	4.7
Protein	(g)	15.9	22.8
Fat	(g)	2.0	2.1
Ash	(g)	8.0	6.0
Carbohydrates and Fiber	(g)	68.0	64.4
Energy Kcal		399	411
Phosphorus	(mg)	408	493
Magnesium	(mg)	227	200
Calcium	(mg)	188	127
Iron	(mg)	12.3	20.1
Zinc	(mg)	5.7	4.3
Magnesium	(mg)	8.8	5.1
Copper	(mg)	0.9	0.9
Chromium	(μg)	133	140

Values are expressed on dry weight basis.

From the data, apparent protein digestibility (ADP) and true protein digestibility (TDP) were calculated (Sarwar and Peace, 1986). After 14 days, all the rats were sacrificed by exposure to ether atmosphere. The rat carcasses were hydrolysed in 6 N hydrochloric acid by autoclaving at 15 lbs pressure for 2 h. Nitrogen contents of the hydrolysates were determined by the Kjeldahl method (AOAC, 1990). From the protein intake and carcass nitrogen content of individual animals, net protein utilization (NPU) was calculated (Hegsted and Chang, 1965).

Data were analysed using analysis of variance and means were separated using the least significant difference (lsd) test procedures (Ott, 1988).

RESULTS AND DISCUSSION

Table 2 shows the proximate and mineral composition of the two mushrooms, *S. commune* and *L. edodes*. The crude protein content of *L. edodes* (23%) was higher than that of *S. commune* (16%). Protein content of *S. commune* from Nigeria has been reported to be 27% (Aletor, 1995). However, it is known that the protein contents of mushrooms are affected by a number of factors, namely the type of mushrooms, the stage of development, the part sampled, level of nitrogen available and the location (Kurkela, 1972; Motskus, 1973; Flegg and Maw, 1977). Ash content of *L. edodes* (6%) was relatively low compared to mushrooms of Agaricus sp (10.1–10.9%) (Zakhary *et al.*, 1983). The crude protein and ash contents of the mushrooms analysed in the present study compared favourably with other mushrooms such as *Lentinus subnudus* (Aletor, 1995). The contents of magnesium, calcium, zinc and manganese in *S. commune* were higher than those of *L. edodes*. On the whole, both mushrooms analysed in the present study appear to be rich in minerals.

Table 3. Fatty acid composition of mushrooms from northeast India (values are per cent of total fat)

Fatty acids	*Schizophyllum commune*	*Lentinus edodes*
C16:0 Palmitic	20.8	19.2
C18:0 Stearic	2.5	2.7
C20:0 Arachidic	0.2	0.4
C18:1 Oleic	10.4	8.3
C18:2 Linoleic	61.3	68.8
C18:3 Linolenic	4.8	0.6
Total Saturates	23.5	22.3
Total Unsaturates	76.5	77.7

Values are means of duplicate determinations.

Table 4. Amino acid composition of mushrooms from northeast India compared to FAO whole egg protein (g 16 g N)

Amino acids	*Schizophyllum commune*	*Lentinus edodes*	FAO whole egg
Threonine	3.3	3.2	5.1
Valine	5.7	6.7	6.9
Cysteine	1.1	1.4	5.9
Methionine	0.6	0.8	3.3
Isoleucine	3.7	4.9	6.3
Leucine	6.5	7.3	8.8
Tyrosine	3.2	3.3	4.2
Phenylalanine	4.8	4.2	5.7
Lysine	4.3	6.4	7.0
Histidine	0.2	2.3	2.4
Arginine	13.9	8.0	6.1
Aspartate	9.5	9.9	9.6
Serine	5.9	5.3	7.6
Glutamate	20.3	12.6	12.7
Proline	3.9	8.0	4.2
Glycine	4.2	5.1	3.3
Alanine	5.6	7.8	5.9
Total essential amino acid	33.2	38.2	
Total amino acid	96.7	97.2	
% Essential amino acid	34	39	
Chemical score	28	29	

The crude fat content (2%) in the two mushroom samples were similar. Fatty acid analysis of the mushroom in the present study showed that the unsaturated fatty acids were higher than the saturated ones (Table 3). This is consistent with the observations that, in mushrooms, unsaturated fatty acids predominate over the saturated (Senatore *et al.*, 1988). Palmitic, Oleic and Linoleic acids accounted for almost the whole of the fatty acids determined. Similar observations have been made in other mushrooms (Senatore *et al.*, 1988; Senatore, 1990). Other fatty acids detected were found only in minor amounts. Amino acid compositions of *S. commune* and *L. edodes* are given in Table 4. The essential amino acid content of *S. commune* and *L. edodes* are 34% and 39%, respectively. Compared to whole egg protein (FAO, 1970), the chemical scores of *S. commune* and *L. edodes* were 28 and 29, respectively. Methionine was the limiting amino acid in both cases. Normally mushrooms are deficient in sulphur-containing amino acids (Senatore *et al.*, 1988; Senatore, 1990). Our present study is in agreement with this observation.

Protein quality evaluation

The results of the feeding trials are presented in Table 5. Protein intakes of animals on the casein control diet and the mushroom diets were not significantly different. However, animals on the casein diet gained body weight rapidly and had significantly ($p < 0.05$) higher NPR (4.4 ± 0.3) than the animals on mushroom diets. Rats on the *S. commune* diet showed a meagre gain in body weight ($1.6 + 1.0$ g) and low NPR (0.9 ± 0.2) showing that this mushroom could provide enough protein for maintenance only. In contrast, animals on the *L. edodes* diet showed significantly higher body weight gain (13.6 ± 1.4 g) and NPR (1.7 ± 0.3) than animals on the *S. commune* diet. Adewusi *et al.* (1993) reported a NPR of 0.8 ± 0.4 for *Termitomyces robustus*, similar to that of *S. commune* in our present study. RNPR of animals on the *S. commune* diet (20.5 ± 1.4 g) and *L. edodes* diet (38.4 ± 7.2 g) were low, reflecting their inferior protein quality. True digestibility of the *S. commune* diet (53.2 ± 10.2) or *L. edodes* diet (76.3 ± 5.4) was significantly lower than the casein control diet (91.2 ± 2.3). Like NPR and TDP, animals on the *L. edodes* diet showed a significantly higher NPU than the *S. commune* diet. However, all the parameters studied were significantly lower for both the mushroom diets than the casein diet. The low chemical score and deficiency of sulphur-containing amino acids in both the mushrooms may be responsible for the poor performance of animals on the mushroom diets. Normally these mushrooms are smoke-dried, and polyphenols and antinutritional factors such as tannins may be present in these mushrooms, thereby affecting the digestion and/or absorption of nutrients (Bressani *et al.*, 1982; Huisman, 1991). Based on the *in vivo* biological values examined, the protein quality of *L. edodes* appears to be better than *S. commune*. This may be due to the higher lysine and total essential amino acid content in *L. edodes*.

Table 5. NPR, RNPR, NPU and TDP of mushrooms from northeast India

Group	Protein intake g/2 weeks	Gain in body weight g/2 weeks	NPR	RNPR	NPU	ADP	TDP
Casein	$1.3.5 \pm 2.3^a$	51.7 ± 10.3^a	4.4 ± 0.3^a	100 ± 5.91^a	77.6 ± 4.6^a	87.1 ± 3.3^a	91.2 ± 2.3^a
S. commune	10.3 ± 1.2^b	1.6 ± 1.0^b	0.9 ± 0.2^b	20.5 ± 5.3^b	23.7 ± 3.7^b	47.9 ± 10.7^b	53.2 ± 10.2^b
L. edodes	12.7 ± 2.3^b	13.6 ± 1.40^c	1.7 ± 0.3^c	38.4 ± 7.2^c	45.8 ± 6.5^c	72.1 ± 6.1^c	76.3 ± 5.4^c

Values are means of 6 animals in each group.
Values with different superscripts are significantly different at $p < 0.05$.

However, protein quality of *L. edodes* is inferior even to grain legumes unlike some other mushrooms which are considered to be comparable to animals proteins (Fink and Hoppenhaus, 1958; Rafalski *et al.*, 1968; Suzuki and Oshima, 1976; Gruen and Wong, 1982; Zakhary *et al.*, 1983).

To date, all the mushrooms used by the Nagas have been harvested in the wild with no effort at their husbandry. Mushrooms like *L. edodes* may be a valuable protein supplement for human diets although they are eaten more for their flavour and taste. A careful study and popularization of the more nutritious species of wild mushrooms from Northeast India is necessary to realise their full nutritional potentials as food supplements.

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REFERENCES

Adewusi, S. R. A., Alofe, F. V., Odeyemi, O., Afolabi, O. A. and Oke, O. L. (1993) Studies on some edible wild mushrooms from Nigeria: 1, Nutritional, teratogenic and toxic consideration. *Plant Food Human Nutrition* **43**, 115–121.

AOAC (1990) *Official Methods of Analysis*. 15th edition. Association of Official Analytical Chemists, Washington, DC, USA.

Aletor, V. A. (1995) Compositonal studies on edible tropical species of mushrooms. *Food Chemistry* **54**, 265–268.

Bressani, R., Elias, L. G. and Braham, J. G. (1982) Reduction in digestibility of legume proteins by tannins. *Journal of Plant Foods* **4**, 43–55.

Campbell, J. A. (1963) In *Evaluation of Protein Quality*. NAS/NRC Publication 110, Washington, DC.

FAO (1970) *Amino Acid Contents of Food and Biological Data on Protein*. FAO Nutritional studies No. 24. Food and Agriculture Organization of the United Nations FAO, Rome.

Fink, H. and Hoppenhaus, K. W. (1958) Peculiar observations in the estimation of biological quality of the proteins of edible boletus (*Boletus edulis*) and mushroom (*Psalliato biospora*) with reference to dietetics and therapeutics. *Nutrition Abstracts Review 28*: Abs. 4886.

Flegg, P. B. and Maw, G. (1977) Mushrooms and their possible contribution to world protein needs. *Mushroom Journal* **48**, 395–403.

Gruen, E. H. and Wong, M. W. (1982) Distribution of cellular amino acids, protein and total inorganic nitrogen during fruit body development in *Flammulina veluptipes*. *Canadian Journal of Botany* **60**(8), 1330–1341.

Hegsted, D. R. and Chang, Yet-oy (1965) Protein utilization in growing rats. Relative growth index as a bioassay procedure. *Nutrition* **85**, 159–168.

Huisman, J. (1991) Antinutritional factors in poultry feeds and their management. In *Proceedings of the 8th European Symposium of Poultry Nutrition*, pp 46–61. Venezia-Mestre, Italy.

Kurkela, R. (1972) Wild Mushrooms—challenge for our food industries and nutritional research. *Kemian Teoffisuus*, **29**, 825–829 (cf Fd Sci Tech Abst 5, 703).

Longvah, T. and Deosthale, Y. G. (1991) Chemical and nutritional studies on hanshi (*Perilla frutescens*) a traditional oilseed from Northeast India. *Journal of the American Oil Chemists Society* **68**, 781–784.

Lowenstein, J. M., Brunergraber, H. and Wadka, M. (1975) *Measurement of Rates of Lipogenesis with Saturated and Tritiated Water In Methods in Enzymology*, Vol. **35B**, pp 279–287.

Moore, S., Speckman, D. H. and Stein, W. H. (1958) Chromatography of amino acids on sulfonated polystrene resins. An improved system.. *Analytical Chemistry* **30**, 1185–1190.

Motskus, A. V. (1973) Biochemical investigations of agaricus mushrooms: Concentration of protein substance in fruit bodies of some edible mushrooms. *Lief. Ter. Moksiu. Akad. Darbai. Serc.* **2**, 185–190 (cf. Biol Abst 58, 10357).

Ogundana, S. K. and Fagade, O. E. (1982) Nutritive value of some Nigerian edible mushrooms. *Food Chemistry* **8**, 263–268.

Ott, L. (1988) *An Introduction to Statistical Method and Analysis*. 3rd edition. PWS. Kent Publishing Boston, MA.

Rafalski, H., Mlodecki, H., Lasota, W. and Kluszozynsk, Z. (1968) Biological value of the proteins of field agaric, and nutritive value of the protein of dishes made from it. *Proca Pantstowewege Zalki* **18**, 345–350.

Sarwar, G. and Peace, R. N. (1986) Comparison between true digestibility of total nitrogen and limiting amino acids in vegetable proteins fed to rats. *Journal of Nutrition* **116**, 1172–1184.

Sarwar, G., Blair, R., Friedman, M., Gumbman, M. R., Hackler, L. R., Pellet, P. L. and Smith, T. K. (1984) Inter and intra laboratory variability in rat growth assays for estimating protein quality of foods. *Journal of Association Off Analytical Chemists* **67**, 976–981.

Senatore, F. (1990) Fatty acid and free amino acid content of some mushrooms. *Journal of Science Food Agriculture* **51**, 91–96.

Senatore, F., Dini, A. and Marino, A. (1988) Chemical constituents of some Basidiomycetes. *Journal of Science Food Agriculture* **45**, 337–345.

Smith, J. (1972) Commercial mushroom production. *Process Biochemistry* **7**, 24–26.

Suzuki, S. and Oshima, S. (1976) Influence of Shii-te-ke (*Lentinus edodes*) on human serum cholesterol. *Mushroom science* **a**(1), 463–467.

Vetter, J. (1995) Mineral and amino acid contents of edible cultivated shii-take mushrooms (*Lentinus edodes*). *Z lebensm Unters Forsch (Germany)* **201**, 17–19.

Zakhary, J. W., Taiseer, M., Abo-Bakr, EL-Mhady, A. and EL-Tabey, A. M. S. (1983) Chemical composition of wild mushrooms collected from Alexandria. *Egyptian Food Chemistry* **11**, 31–41.