CHAPTER 24

# NUTRITIONAL IMPORTANCE OF MUSHROOMS

H.S. Garcha, P.K. Khanna and G.L. Soni

Department of Microbiology, Punjab Agricultural University, Ludhiana, India.

## 1. INTRODUCTION

The use of mushrooms as a food item is probably as old as civilization. They were preferred only for their culinary characteristics while the nutritive value of mushrooms was recognized much later (Crisan & Sands, 1978; Chang, 1980; Khanna & Garcha, 1981). In India, information about the food value of mushrooms has been provided by many workers (Samajpati, 1978; Jandaik & Kapoor, 1976; Bano *et al.*, 1981; Khanna & Garcha, 1986; Bisaria *et al.*, 1987a, b; Hira *et al.*, 1990). However, the results reported by most workers are different. These differences have been attributed to variations in the species / strain used, method of composting, composition of compost, age or maturity of fruiting body etc. Moreover, mushrooms have been evaluated for their nutritional status mainly on the basis of their chemical composition. It has now been well established that cultivated mushrooms contain reasonable amounts of proteins, carbohydrates, minerals and vitamins, and nutritionally they rank between low grade vegetables and high grade meats. Although adequate nutrition is furnished by animal products such as fish, meat, eggs or milk, in India these articles are not within the means of the common man. Moreover, animal products are not always acceptable because of many cultural and religious beliefs. Most of the population lives on grains, tubers and small quantities of pulses and vegetables. Vegetables provide hardly any dietary proteins, and proteins from cereals, the staple food, are generally deficient in essential amino acids especially lysine and sulphur-containing amino acids. Pulses, on the other hand, are deficient in other essential amino acids like tryptophan. Mushrooms, which are good protein sources, may be an additional dietary supplement to make up for the protein deficiency of the Indian population in addition to their statiety factor.

Although mushrooms cannot substitute for meat, fish or eggs as far as protein nutrition is concerned, they can serve as a good substitute in preventing protein malnutrition in the Indian dietary pattern. Being rich in minerals, their usefulness becomes still more important.

Mushrooms are rich in proteins and certain essential amino acids (Khanna & Garcha, 1984) but *in vivo* bioavailability of these components is not well established. Although edible mushrooms are apparently innocuous, accumulative side effects caused by constant consumption have not been completely ruled out (Wright, 1978). It often becomes meaningless to compare the results obtained by different workers with the same mushroom species, since the composition of a given species is affected by its diversity, genetic makeup leading to strain differences, and by environmental factors such as the nature of substrate, method of cultivation, along with relative inaccuracies arising out of the method of analysis. Many workers have reported different mushrooms under a common heading with little or no regard to variety. Being living organisms, they continue to undergo metabolic changes in the post harvest life. This adds to the changes in composition relative to the stage of development, harvest and nature of post harvest storage (Crisan & Sands, 1978).

## 2. COMPARATIVE NUTRITIONAL ANALYSIS OF *AGARICUS BISPORUS* AND *PLEUROTUS* SPP.

In the northern parts of our country, the most commonly accepted mushroom species are *Agaricus bisporus* and *Pleurotus* (*P.sajor-caju, P.florida* and *P.ostreatus*). So, in our laboratory, work on these mushrooms has been carried out extensively.

In our laboratory, nutritional evaluation of *A.bisporus* and *P.florida* has been done in detail. The results of our studies on *A.bisporus* reveal that its chemical composition is affected by both the stage of maturity and the substrate. The protein content was maximum at the immature primordial stage and slightly decreased on further development of the caps. However, the total lipids and crude fibre contents showed an opposite trend. Mineral content of the sporophores also increased with maturity (Table 1). The results indicate that the protein content continues to be good up to the picking stage.

The composition of *A.bisporus* was also affected when grown on different substrates. Protein content was maximum with compost prepared from wheat straw as the substrate, was lower with compost prepared from a 1:1 mixture of wheat straw and paddy straw, and decreased further if paddy straw alone was used to prepare the compost (Table 2). Mineral content and total carbohydrates were higher with wheat straw as the substrate whereas *A.bisporus* failed to draw nutrients from the compost prepared from paddy straw. Paddy straw did not even yield a reasonable number of fruiting bodies.

Table 3 compares the proximate composition of three species of *Pleurotus* namely, *P.florida, P.sajor-caju* and *P.ostreatus* commonly accepted with the agroclimatic conditions of the state in the months of October to March. The protein contents of *P.florida* and *P.sajor-caju* were comparable

TABLE 1. Percent composition of *A.bisporus* at different stages of growth on wheat straw compost.

| Component | Stages | | |
|---|---|---|---|
| | Immature (Primordia) | Mature (Unopened) | Fully mature (Opened) |
| Moisture | 89.1 | 90.2 | 88.9 |
| Protein (N x 4.38) | 27.1 | 26.7 | 25.8 |
| Lipids | 3.6 | 3.8 | 4.1 |
| Crude fibre | 6.7 | 8.0 | 8.6 |
| Minerals (ash) | 9.3 | 10.5 | 11.8 |
| Total Carbohydrates | 49.2 | 46.4 | 45.6 |
| Energy (K cals/100g) | 272.2 | 270.4 | 260.7 |



TABLE 2. Percent composition of *A.bisporus* on compost prepared from different substrates.

| Component | Stages | | |
|---|---|---|---|
| | Wheat Straw | Wheat Straw + Paddy Straw (1:1, v/v) | Paddy Straw |
| Moisture | 90.4 | 88.1 | 88.8 |
| Protein (N x 4.38) | 26.8 | 25.3 | 23.7 |
| Lipids | 3.9 | 4.2 | 4.0 |
| Crude fibre | 8.2 | 7.3 | 6.6 |
| Minerals (ash) | 10.9 | 9.8 | 7.5 |
| Total Carbohydrates | 46.8 | 43.2 | 41.5 |
| Energy (K cals/100g) | 265.6 | 251.8 | 240.0 |

whereas the protein content of *P.ostreatus* was relatively low. *P.florida* had the highest lipid content. On the other hand, the highest crude fibre content was found in *P.ostreatus*.

Carbohydrate content was comparable in all three species. Energy calculations revealed *P.florida* to be the species of choice. Since *P.florida* appeared nutritionally superior, detailed work has therefore been carried out on this species.

## 3. NUTRITIONAL ANALYSIS OF *PLEUROTUS FLORIDA*

The chemical composition of *P.florida* was affected to a considerable extent with respect to the substrate used (Table 4). Wheat straw not only supported better growth and yields of *P.florida* compared to the other substrates used but also yielded fruit bodies with higher protein content. The protein content of *P.florida* grown on the other substrates was relatively lower. Fibre and mineral contents were affected only marginally. Crude fibre was higher with paddy straw and millet (bajra). Carbohydrates and calorific values were similar for all the growth substrates when calculated according to Crisan & Sands (1978).

The chemical composition of *P. florida* at two different stages of development is shown in Table 5. Moisture content decreased with the maturity of *Pleurotus*. The protein content was also

TABLE 3. Percent composition of *Pleurotus* spp. grown on unfermented wheat straw.

| Component | *P.florida* | *P.sajor-caju* | *P.ostreatus* |
|---|---|---|---|
| Moisture | 91.5 | 88.7 | 89.2 |
| Protein (N x 4.38) | 19.1 | 18.9 | 15.7 |
| Lipids | 5.8 | 4.8 | 4.2 |
| Crude fibre | 9.5 | 10.3 | 12.0 |
| Minerals (ash) | 9.2 | 8.7 | 7.9 |
| Total Carbohydrates | 53.3 | 52.4 | 54.4 |
| Energy (K cals/100g) | 284.1 | 272.0 | 265.5 |

TABLE 4. Percent composition of *Pleurotus* spp. grown on different substrates.

| Component | Substrates | | | |
|---|---|---|---|---|
| | Wheat straw | Paddy stalks | Maize stalks | Millet |
| Moisture | 90.8 | 88.4 | 91.6 | 90.4 |
| Protein (N x 4.38) | 19.2 | 16.0 | 17.0 | 16.5 |
| Lipids | 4.9 | 4.6 | 4.3 | 5.1 |
| Crude fibre | 9.8 | 10.2 | 9.7 | 11.1 |
| Minerals (ash) | 9.0 | 10.3 | 8.2 | 8.6 |
| Total Carbohydrates | 52.6 | 54.6 | 54.2 | 53.4 |
| Energy (K cals/100g) | 274.4 | 270.4 | 269.2 | 271.8 |

lower in the fully mature fruit body compared to the immature stage. The lipid content was higher in immature fruiting bodies compared to mature ones. However, minerals and total carbohydrate levels were higher in mature fruit bodies. Total calories were similar in fruit bodies at both stages of development. Sun drying of this mushroom did not cause any substantial loss of nutrients. Carbohydrates and lipids were marginally lower, whereas minerals and crude fibre were marginally higher, compared to the mature or immature *Pleurotus*. This could be due to the loss of other nutrients.

## 4. NUTRITIONAL EVALUATION OF *A. BISPORUS* AND *P. FLORIDA*

Since fats and carbohydrates are rarely deficient in the diet, they are not generally considered in the nutritional evaluation of a food class. Protein,of course, is the most critical component contributing to the nutritional value of food. Not only the quantity of protein, but its quality is also important. The quality of a protein is judged by the amino acid composition of the protein. The closer the amino acid composition of the protein is to that of hen's egg protein, the better the quality. Determination of essential amino acid compositions and digestibility of the proteins of mushrooms can give a fair approximation of their protein quality, but the real test would involve actual feeding

TABLE 5. Percent composition of *P.florida* at different stages of maturity.

| Component | Stages | | |
|---|---|---|---|
| | Immature | Mature (unopened) | Sun dried |
| Moisture | 91.1 | 87.5 | 3.2 |
| Protein (N x 4.38) | 20.7 | 17.0 | 18.4 |
| Lipids | 5.2 | 3.6 | 3.2 |
| Crude fibre | 9.2 | 10.6 | 11.5 |
| Minerals (ash) | 8.8 | 9.3 | 11.2 |
| Total Carbohydrates | 52.5 | 55.6 | 48.4 |
| Energy (K cals/100g) | 280.4 | 268.2 | 243.3 |



TABLE 6. Contents of essential amino acid (g/100g Protein) of *A.bisporus* and *P.florida*.

| Amino acid | Hen's egg | *A.bisporus* | *P.florida* |
|---|---|---|---|
| Cysteine | 2.4 | 0.86(0.36) | 0.55(0.23) |
| Methionine | 3.1 | 0.98(0.32) | 1.84(0.59) |
| Lysine | 6.4 | 3.57(0.56) | 3.20(0.50) |
| Tryptophan | 1.6 | 1.87(1.17) | 1.08(0.67) |

Values in parentheses are amino acid scores.

experiments. Work on the nutritional evaluation of the two mushrooms varieties namely, *A. bisporus* and *P. florida*, was therefore extended.

Table 6 compares the essential amino acids which are normally limiting in the Indian dietary pattern. Most cereals are deficient in sulphur-containing amino acids and lysine whereas pulses which are included in the diet compensate for lysine but do not provide balanced amounts of tryptophan. Therefore, emphasis has been placed on sulphur-containing amino acids, lysine and tryptophan.

The amino acid score and Essential Amino Acid (EAA) index, and Biological Value (BV), were calculated as per Oser (1951, 1959). The BV's or nutritional indices, of these mushrooms are reasonably good. The BV and EAA index of *A.bisporus* was better than that of *P.florida*, However, nutritional indices of the two varieties were comparable (Table 7).

## 5. COMPARISON OF THE DIGESTIBILITY OF *A. BISPORUS* AND *PLEUROTUS* SPP.

Good quantity and a good EAA index or a calculated BV, are not the true predictors of the

TABLE 7. Essential Amino Acid (EAA) index and Biological Value (BV) of *A.bisporus* and *P.florida*.

| | *A.bisporus* | *P.florida* |
|---|---|---|
| EAA | 51.10 | 46.30 |
| BV | 45.09 | 38.77 |
| Nutritional Index | 13.69 | 12.59 |

$$EAA = \sqrt[4]{\frac{Cys_p \times Lys_p \times Meth_p \times Trp_p}{Cys_s \times Lys_s \times Meth_s \times Trp_s}}$$

$$BV = 1.09\ (\text{EAA Index}) - 11.7$$

$$\text{Nutritional Index} = \frac{(\text{EAA Index} \times \%\ \text{protein})}{100}$$

TABLE 8. Protein digestibility, relative nutritive value and protein efficiency ratio of sporophores of mushrooms.

| Species | Digestiblity (%) | | | |
|---|---|---|---|---|
| | Pepsin | Pepsin+Trypsin | RNV | PER |
| *P.sajor-caju* | 73.82 ± 2.03 | 81.38 ± 3.01 | 86.90 | 2.29 |
| *P.florida* | 71.32 ± 1.19 | 79.07 ± 1.04 | 97.62 | 2.43 |
| *P.ostreatus* | 70.09 ± 1.79 | 77.62 ± 1.84 | 91.67 | 2.30 |
| *A.bisporus* | 68.51 ± 2.48 | 76.43 ± 4.26 | ND | ND |
| Casein | - | - | 100.00 | 2.50 |

ND - Not determined

$$RNV = \frac{\textit{Tetrahymena} \text{ count with sample protein}}{\textit{Tetrahymena} \text{ count with casein}} \times 100$$

Calculated PER = 0.286 + 0.022 (RNV)

nutritive value of a protein. Digestibility is another limiting factor. A good quality protein based on amino acid composition can only be good if it is easily digestible and its amino acids are available for utilization. Thus, the *in vitro* digestibility of *Agaricus* and *Pleurotus* spp. was also determined.

Table 8 compares the *in vitro* digestibility of sporophores of *Pleurotus* spp. and *A. bisporus*. The data revealed that the digestibility of *Pleurotus* spp. is better than that of *A. bisporus* when pepsin or a pepsin-trypsin combination was used.

Furthermore, when hydrolysates of protein from *Pleurotus* spp. were evaluated using a test

TABLE 9. Fatty acid composition (per cent) of *A.bisporus* and *P.florida*.

| Fatty Acid | *A.bisporus* | *P.florida* |
|---|---|---|
| Capric acid (10:0) | 2.38 | - |
| Lauric acid (12:0) | 0.84 | Traces |
| Myristic acid (14:0) | 0.25 | 11.80 |
| Palmitic acid (16:0) | 28.12 | 11.12 |
| Palmitoleic acid (16:1) | 4.20 | 0.36 |
| Stearic acid (18:0) | 7.48 | - |
| Oleic acid (18:1) | 12.65 | 13.91 |
| Linoleic acid (18:2) | 35.13 | 72.81 |
| Linolenic acid (18:3) | 4.90 | - |
| Arachidonic acid (20:0) | Traces | - |
| Saturated fatty acids | 43.07 | 12.92 |
| Unsaturated fatty acids | 56.83 | 87.08 |



involving the growth of the protozoan *Tetrahymena*, their nutritive value appeared to be quite close to that of high quality casein.

## 6. FATTY ACID COMPOSITION OF *A. BISPORUS* AND *P. FLORIDA*

Fats are not only important as energy yielding substances, but the dietary unsaturated fatty acids add to the hypocholesterolemic/hypolipidemic activity of the food item and, thus, may be of potential biomedical importance. Table 9 compares the fatty acid composition of *A. bisporus* and *P. florida*. *A. bisporus* has most of the common fatty acids with linoleic acid as the main fatty acid followed by palmitic acid and oleic acid. *Agaricus* contained about 57% unsaturated fatty acids. On the other hand, *P. florida* also had linoleic acid as the main fatty acid followed by oleic acid. These represented nearly 87% of the total unsaturated fatty acids. Since unsaturated fatty acids are known to have a hypocholesterolemic effect, a high degree of unsaturation in the lipids of mushrooms, particularly of *P. florida*, is worth mentioning. Although these mushrooms have only small amounts of lipids, they are important as the lipids are rich in unsaturated fatty acids.

## 7. FEEDING EXPERIMENTS

In order to achieve a real nutritional evaluation of the mushrooms, feeding experiments were also conducted. Both *A. bisporus* and *P. florida* were incorporated in the diet of growing albino rats at 5% or 10% levels. Rats were divided into 5 groups of six animals and were housed individually. Rats of group A were given the basal diet while rats of group B and C were given the basal diet to which 5% or 10% of mushroom on a dry weight basis had been incorporated. Animals of group D and E were given the basal diet containing 5% or 10% *P. florida*, respectively. Inclusion of mushroom increased the food intake substantially. The increase in food intake was more with *Pleurotus* compared to *Agaricus* indicating that these mushrooms add to the palatability of the diet. Therefore, their inclusion in the food formulation may be useful in preventing the protein calorie malnutrition amongst children whose intake is poor because of non-acceptability of the usual diet within the Indian

TABLE 10. Effect of feeding *A.bisporus* or *P.florida* on food intake, gain in body weight, food efficiency and protein efficiency values.

| Group | Food intake | Gain in body wt.(g) | FER | PER |
|---|---|---|---|---|
| A | 164.2±4.30 | 40.66±2.62 | 0.229±0.025 | 2.50±0.27 |
| B | 183.3±8.51 | 45.33±3.24 | 0.236±0.018 | 2.47±0.34 |
| C | 186.2±7.62 | 43.33±4.55 | 0.232±0.016 | 2.31±0.41 |
| D | 192.4±8.72 | 45.24±3.72 | 0.235±0.026 | 2.42±0.31 |
| E | 212.5±7.36 | 47.12±4.56 | 0.221±0.023 | 2.20±0.25 |

A : Basal diet
B : Basal diet + 5% *A.bisporus*
C : Basal diet + 10% *A.bisporus*
D : Basal diet + 5% *P.florida*
E : Basal diet + 10% *P.florida*

TABLE 11. Nitrogen excretion of rats fed on diet containing *A.bisporus* or *P.florida*.

| Group* | Fecal mass (g/day) | N-Excretion | |
|---|---|---|---|
| | | mg/g fecal mass | mg/day |
| A | 1.32±0.089 | 26.24±0.82 | 34.52±1.12 |
| B | 1.26±0.214 | 26.16±0.65 | 32.90±1.94 |
| C | 1.28±0.220 | 29.98±3.61 | 37.12±2.50 |
| D | 1.45±0.270 | 30.42±2.76 | 44.11±4.32 |
| E | 1.58±0.350 | 31.68±2.84 | 50.05±4.21 |

* As in Table 10

TABLE 12. Effect of feeding *A.bisporus* or *P.florida* on organ weight indices (g/100g body weight).

| Group | Liver | Heart | Kidney | Spleen | Lung |
|---|---|---|---|---|---|
| A | 4.78±0.31 | 0.300±0.017 | 0.475±0.810 | 1.06±0.113 | 0.908±0.236 |
| B | 4.53±0.41 | 0.297±0.034 | 0.447±0.045 | 1.01±0.085 | 0.807±0.121 |
| C | 4.24±0.44 | 0.281±0.031 | 0.440±0.070 | 1.04±0.096 | 0.870±0.146 |
| D | 4.54±0.14 | 0.278±0.058 | 0.437±0.048 | 1.00±0.153 | 0.876±0.195 |
| E | 4.71±0.30 | 0.320±0.068 | 0.482±0.051 | 1.17±0.019 | 0.890±0.126 |

Groups as in Table 10.

TABLE 13. Effect of inclusion of *A.bisporus* or *P.florida* on lipid peroxidation (nM MDA/g tissue) of various tissues.

| Group | Liver | Heart | Kidney | Spleen | Lung |
|---|---|---|---|---|---|
| A | 2.64±0.53 | 2.58±0.06 | 5.51±0.98 | 6.96±0.94 | 2.58±0.46 |
| B | 2.90±0.36 | 2.81±0.65 | 5.57±0.91 | 8.51±2.13 | 6.51±1.26 |
| C | 3.22±0.26 | 3.32±0.34 | 5.22±0.46 | 7.22±1.14 | 5.70±0.83 |
| D | 2.85±0.31 | 3.04±0.44 | 5.89±0.76 | 7.34±0.89 | 4.47±0.43 |
| E | 2.78±0.56 | 2.82±0.46 | 4.64±0.63 | 6.72±0.58 | 3.75±0.43 |

Groups as in table 10.

dietary pattern. Gain in rat body weight was also higher in mushroom fed groups but was not in concordance with the food intake which resulted in slightly decreased PER and FER (Table 10).

The decrease in PER can be partly attributed to the higher food intake and partly to the decreased digestibility of the dietary proteins by the inclusion of these mushrooms. In fact, this was found to be the case as there was a relatively higher level of fecal N excretion (Table 11).

The rats were sacrificed after 4 weeks of feeding to assess any untoward reaction due to the inclusion of these edible fungi. Organ weight indices (g/100 g body weight) of rats fed on diets



TABLE 14. Effect of inclusion of *A.bisporus* or *P.florida* on the hemoglobin, packed cell volume (PCV), GOT and GPT levels.

| Group | Hb | PCV | GOT | GPT |
|---|---|---|---|---|
| A | 13.97±0.42 | 29.86±1.20 | 84.6±8.7 | 32.4±4.1 |
| B | 14.03±0.50 | 31.66±0.42 | 8.85±7.6 | 33.6±2.8 |
| C | 14.57±1.07 | 29.33±1.33 | 96.2±8.6 | 35.2±3.6 |
| D | 15.52±1.17 | 31.24±1.41 | 82.4±7.2 | 31.6±2.9 |
| E | 14.20±0.81 | 28.22±1.18 | 98.4±8.6 | 38.2±4.2 |

Groups as in table 10

containing mushrooms were not affected by either of the mushrooms at either of the levels used in the diet (Table 12).

In order to confirm the innocuous nature of these edible fungi at cellular level, lipid peroxidation in various tissues was also determined (Table 13). The data revealed that these mushrooms did not affect lipid peroxidation in any of the tissues at either of the levels used thereby indicating that they do not affect the antioxygenic potential of various tissues. These observations are also supported by the lack of histopathological lesions in any of the organs.

The innocuous nature of these mushrooms has also been confirmed at the biochemical level. Hemoglobin, packed cell volume (PCV), glutamate-oxoglutarate transaminase (GOT) and glutamate-pyruvate transaminase (GPT) levels were hardly affected by these mushrooms at either of the levels used (Table 14). The innocuous nature of pellets of mushroom mass grown on liquid medium has also been shown by El-Kattan *et al.* (1991a, b).

Thus, in conclusion, these mushrooms are reasonably digestible, providing good amounts of proteins and essential amino acids, unsaturated fatty acids and minerals. They add to the palatability of the diet and do not show any untoward reaction even when consumed regularly in high amounts.

## REFERENCES


BANO, Z., BHAGYA, S. & SRINIVASAN, K.S. (1981). Essential amino acid composition and proximate analysis of the mushrooms, *Pleurotus eous* and *P.florida. Mushroom Newsletter for the Tropics* **1**, 6-10.

BISARIA, R., MADAN, N., BISERIA, V.S. & MUKHOPADHYAY, S.N. (1987a). Amino acid composition of mushroom *Pleurotus sajor-caju* cultivated on different agro residues. *Biological Wastes* **20**, 251-259.

BISARIA, R., MADAN, N. & BISERIA, V.S. (1987b). Mineral content of mushroom *Pleurotus sajor-caju* cultivated on different agro residues. *Mushroom Journal for the Tropics* **7**, 53-60.

CHANG, S.T. (1980). Mushrooms as human food. *Bioscience* **30**, 399-401.

CRISAN, E.V. & SANDS, A. (1978). Nutritional value of edible mushrooms. In *The Biology and Cultivation of Edible Mushrooms*, pp 137-168. Edited by Chang, S.T. & Hayes, W.A. New York and London: Academic Press.

EL-KATTAN, M.H., AFFIFY, A.S. & ALY, A.Z.M. (1991a). Evaluation of *Pleurotus sajor-caju*

fungal pellets as food. *Mushroom Journal for the Tropics* **11**, 13-22.
EL-KATTAN, M.H., HELMY, Z.A., EL-LEITHY, M.A.E. & ABDELKANI, K.A. (1991b). Studies on cultivation techniques and chemical composition of oyster mushrooms. *Mushroom Journal for the Tropics* **11**, 59-66.
HIRA, C.K., VADHERA, S. & MANN, A.P.S. (1990). Biochemical changes in sporophores of two mushroom species before and after opening of caps. *Annals of Biology* **6**, 95-99.
JANDAIK, C.L. & KAPOOR, J.N. (1976). Amino acid composition of *Pleurotus sajor-caju* (Fr.) Sing. *Mushroom Journal* **41**, 154-156.
KHANNA, P.K. & GARCHA, H.S. (1981). Nutritive value of mushroom *Pleurotus florida*. *Mushroom Science* **XI**, 561-572.
KHANNA, P.K. & GARCHA, H.S. (1984). *Pleurotus* mushroom - A source of food protein. *Mushroom Newsletter for the Tropics* **4**, 9-14.
KHANNA, P.K. & GARCHA, H.S. (1986). Nucleic acid content and relative nutritive value of sporophore proteins of *Pleurotus* spp. *Mushroom Newsletter for the Tropics* **6**, 17-20.
OSER, B.L. (1951). Method for integrating essential amino acid content in nutritional evaluation of proteins. *Journal of American Dietitians Association* **27**, 396-402.
OSER, B.L. (1959). An integrated essential amino acid index for predicting the biological value of protein. In *Protein and Amino Acid Nutritition*, pp 281-295. Edited by A.A. Albanese. New York: Academic Press.
SAMAJPATI, N. (1978). Nutritive value of some Indian edible mushrooms. *Mushroom Science* **10**, 695-703.
WRIGHT, A.V., NISKANEN, A., PYYSALO, H. & KORPELA, H. (1978). The toxicity of some N-methyl, N-formyl hydrazones from *Gyromietra esculenta* and related compounds in mouse and microbial tests. *Toxicology and Applied Pharmacology* **45**, 429-434.