INTRODUCTION

Mushrooms have been recognized for their nutritional and nutraceutically properties because of their inherent composition. They are rich in essential nutrients including carbohydrates, proteins, vitamins, minerals, antioxidants and variety of bioactive components [1-4]. Because of the nutritional and medically important components, mushrooms are considered as functional foods worldwide [3] and can be compared favourably with the food value of milk, egg, meat and commonly consumed vegetables [5-9]. A number of Indian workers [6, 10-19] evaluated a variety of cultivated and wild edible mushrooms for their nutritional and nutraceutically profile including amino acids which are monomeric units of proteins and serve as antioxidant, energy metabolites and precursors of many biologically important nitrogen containing compounds [4, 20-21].

*Lentinus sajor-caju* (Fr.) Fr. is one such mushroom which is widely consumed in India [22, 23] and abroad [24, 25]. It is a basidiomycetous mushroom which grows in great abundance on dead and fallen branches, tree trunks and even on buried roots [26]. It is of common occurrence in the foot hills of North-West India and is being collected locally for consumption. So as to look into its culinary credentials amino acid profiling was done from the dried sporophores of the mushroom obtained in the laboratory through cultivation.

MATERIALS AND METHODS

The materials

The culture of *Lentinus sajor-caju* (Fr.) Fr. mushroom was raised through tissue culture from the sporophores collected from the wild. Subsequently, cultivation studies were undertaken under laboratory conditions so as to raise the sporophores. The mature sporophores were harvested and dried in a hot air drier at 40±1 °C [27] which was subsequently used for amino acid profiling.

Reagents and chemicals

All reagents and chemicals were of analytical grade. Amino acid standards, ninhydrin, hydridinantin, dimethyl sulfoxide were purchased from SIGMA-Aldrich; phenol, acetic acid, trisodium citrate dihydrate, sodium hydroxide, lithium hydroxide, lithium acetate dihydrate from FLUKA and HCl 30% from MERCK.
mushroom sample was filtered through 0.22 µm cellulose acetate membrane filter units before injection.

**Instrumentation**

The amino acid composition of the mushroom sample was determined with ion-chromatograph equipped with metrohm 881 compact IC pro anion, metrohm 882 compact IC plus cation, metrohm 886 professional thermostat reactor, metrohm 887 professional auto sampler and metrohm 887 professional uv-vis detector. The amino acids in the standards and in the mushroom sample were separated in the column containing the elution buffers at a temperature of 60 °C with 20-50 µl injection volume at a flow rate of 0.4 ml/min. Finally, products were sent to the detector and detection was achieved with a uv-vis detector at 570 nm.

**Expression of data**

Each amino acid was expressed as g/100g dry weight basis and essential amino acid (EAA-geometric mean of the ratios of the essential amino acids in a protein relative to their respective amounts in reference protein/whole egg) index and biological value (BV) were calculated by using the following formulas [29].

\[
\text{EAA Index} = \frac{\text{Lys} \times (\text{Phe + Tyr})_p \times \text{Leu}_s \times \text{His}_p \times \text{Ile}_p \times \text{Val}_p \times (\text{Met + Cys})_p}{\sqrt{\text{Lys} \times (\text{Phe + Tyr})_s \times \text{Leu}_s \times \text{His}_s \times \text{Ile}_s \times \text{Val}_s \times (\text{Met + Cys})_s}}
\]

Where subscript \( p \) refers to the food protein; \( s \) the standard protein and \( n \) the number of amino acids (counting pairs such as methionine and cysteine as one).

**Biological Value** = 1.09 (EAA Index)-11.73

**RESULTS**

From the dried sample of *Lentinus sajor-caju* in all 15 amino acids were quantified following standard biochemical procedure [28]. The estimated amino acid amounts (g/100g) are summarized in table 1, 2 and 3 while fig. 1 and 2 depicts the chromatogram of amino acid standards and amino acid content in mushroom sample respectively.

![Fig. 1: Ion-exchange chromatograph of 15 standard amino acids](image1)

![Fig. 2: Ion-exchange chromatograph amino acid profile of Lentinus sajor-caju](image2)
The composition of analyzed amino acids revealed the presence of essential and non-essential free amino acids in varying quantity ranging from 6.66 g/100g to 0.16 g/100g in the cultivated mushroom. The total amino acid content has been evaluated at 18.82 g/100g. Lysine, alanine, cysteine, phenylalanine, leucine and histidine were present in large amounts while isoleucine, tyrosine, glycine, valine and methionine in reduced amount. Glutamic acid, aspartic acid, threonine and serine were not detected during estimation.

The present work revealed that lysine (6.66 g/100g) was the preponderant essential amino acid in this mushroom. Non-essential amino acid alanine (3.40 g/100g) was found to be the second and cysteine (1.99 g/100g) third most abundant amino acid. Amongst the essential and non-essential amino acids, methionine (0.16 g/100g) was observed as the least abundant amino acid. Amongst the 7 essential amino acids detected in the presently evaluated mushroom sample, lysine (6.66 g/100g), phenylalanine (1.63 g/100g), leucine (1.39 g/100g) and histidine (1.28 g/100g) were detected in substantial amount in comparison to isoleucine (0.76 g/100g), valine (0.43 g/100g) and methionine (0.16 g/100g). Amino acid threonine was not detected at all.

In the presently evaluated sample lysine (6.66 g/100g) was found to be in higher concentration in comparison to its required value (5.20 g/100g) in the human diet as prescribed pattern by [30] of the amino acid requirement for 3-10 y old individual. Also in the presently evaluated mushroom sample the concentration (2.25 g/100g) of aromatic amino acids (phenylalanine+tyrosine), histidine (1.28 g/100g) and concentration (2.15 g/100g) of Sulphur amino acids (methionine+cysteine) were found to be very close to the value of reference protein recommended for human nutrition [30].

### Table 1: Amino acid composition of *Lentinus sajor-caju* (g/100g dry weight)

| S. No. | Amino acid | g/100g | Essential Amino Acids |
|--------|------------|--------|-----------------------|
| 1      | Lysine (K) | 6.66   |                       |
| 2      | Phenylalanine (F) | 1.63 |                       |
| 3      | Leucine (L) | 1.39  |                       |
| 4      | Histidine (H) | 1.28 |                       |
| 5      | Isoleucine (I) | 0.76 |                       |
| 6      | Valine (V) | 0.43   |                       |
| 7      | Methionine (M) | 0.16  |                       |
| 8      | Threonine (T) | ND   |                       |

**Non-Essential Amino Acids**

| S. No. | Amino acid | g/100g | Essential Amino Acids |
|--------|------------|--------|-----------------------|
| 9      | Alanine (A) | 3.40   |                       |
| 10     | Cysteine (C) | 1.99  |                       |
| 11     | Tyrosine (Y) | 0.62  |                       |
| 12     | Glycine (G) | 0.50   |                       |
| 13     | Glutamic acid (E) | ND |                       |
| 14     | Aspartic acid (D) | ND |                       |
| 15     | Serine (S) | ND     |                       |

**Total Amino Acid Content**

18.82 g/100g

ND = not detected

### Table 2: Amino acid composition in *L. sajor-caju* compared to pattern by [30] of amino acid requirements for 3-10 y old individual

| S. No. | Essential amino acid | g/100g dry weight | FAO 2013 |
|--------|----------------------|-------------------|----------|
| 1      | Lysine               | 6.66              | 4.8      |
| 2      | Phenylalanine+Tyrosine | 1.63+0.62 = 2.25 | 4.1      |
| 3      | Leucine              | 1.39              | 6.1      |
| 4      | Histidine            | 1.28              | 1.6      |
| 5      | Isoleucine           | 0.76              | 3.0      |
| 6      | Valine               | 0.43              | 4.0      |
| 7      | Methionine+Cysteine  | 0.16+1.99 = 2.15  | 2.3      |

### Table 3: Nutritional quality evaluation

| S. No. | Nutritional quality | Results |
|--------|---------------------|---------|
| 1      | Total Amino Acid (TAA) | 18.82 g/100g |
| 2      | Total Essential Amino Acid/Total Non-Essential Amino Acid | 1.89 g/100g/1.99 g/100g |
| 3      | Total Sulphur Amino Acid (TSAA=Meth+Cys) | 2.15 g/100g |
| 4      | Total Aromatic Essential Amino Acid (TArEAA=Phe+Tyr) | 2.25 g/100g |
| 5      | Total Essential Amino Acids (%) | 65.41% |
| 6      | Essential Amino Acid (EAA) Index (%) | 44.64% |
| 7      | Total Non-Essential Amino Acid (TNEAA)/Total Amino Acid (TAA) % | 34.59% |
| 8      | Biological Value (BV %) | 36.93% |
DISCUSSION

Mushrooms are rich sources of proteins as well as amino acids. Because of the variety of substrates used in the cultivation of edible mushrooms and their genetic profile, there is substantial variation in their amino acid content [31]. Amongst the cultivated species, the total amino acid content reported in Pleurotus ostreatus grown on different substrates have been reported to range from 35.97 g/100g-42.30 g/100g [32]. As compared only 18.82 g/100g total amino acid content was evaluated presently from the dried sporophores of Lentinus sajor-caju raised on the mixture of wheat straw, padd straw, saw dust and wooden flakes substrate, which is much less in comparison to the range of total amino acids documented in oyster mushroom [32].

Pleurotus citrinopileatus worked by [33] and documented eight essential amino acids, namely leucine, valine, threonine, lysine, phenylalanine, isoleucine, methionine and tryptophan in their decreasing order of abundance. All the essential amino acids reported in adequate quantity in Lentinus polychrous. However, in the case of Lentinus sajor-caju the order of their abundance starts with lysine followed by phenylalanine, leucine, histidine, isoleucine, valine and methionine. Threonine which has been reported to be present in an abundant amount in P. citrinopileatus was found to be altogether absent in L. sajor-caju during the present investigation. The total essential amino acid percentage (65.41%) documented in the cultivated sample of L. sajor-caju is substantially low in comparison to the average range of essential amino acid percentage reported for cultivated (42.91%-43.67%) and wild mushrooms (42.90%-43.73%). It is even less than the total essential amino acid percentage (34.65%) documented for Tricholoma matsutake [36].

However amongst the essential amino acids documented in the presently investigated species, lysine (6.66 g/100g) which is vital for hormone production and bone growth [37] is present in substantial amount in comparison to its amount in Lentinus connatus (2.15 g/100g) as documented by [38], Lentinus polychrous (1.74 g/100g) as documented by [39], Agaricus bisporus (3.57 g/100g) and Pleurotus floridus (3.20 g/100g) as documented by [39]. Even it is much higher than reported for Pleurotus species (5 g/100g) by [40] and Agaricus bohusii (1.5%) by [41]. However higher percentage of lysine [42] in Agaricus species (6.26%) and Pleurotus sajor-caju (6.33%) which is comparable to the net amount of lysine (6.66 g/100g) evaluated in L. sajor-caju during the present investigations.

The deficiency of this amino acid has been reported to result in anemia and chronic fatigue syndrome [37]. Histidine, which has been reported to serve as a precursor of tyrosine, which in turn is the precursor of neurotransmitters and is a powerful antioxidant [37].

Phenylalanine (1.63 g/100g) was found to be the second most abundant exogenous amino acid in L. sajor-caju. This amount is slightly less than the amount of this amino acid documented in Pleurotus ostreatus (2 g/100g) by [40], in Lentinus connatus (1.90 g/100g) by [38], in Agaricus abruptibulbus (1.92 g/100g) by [43] and on the higher side in comparison to its range (1.27 g/100g-1.44 g/100) documented by [32] in Pleurotus ostreatus. While working with Agaricus species, much higher amount of this amino acid (6.67%) was documented by [42] while much less percentage (0.65%) of this amino acid was also documented by [33] in Pleurotus citrinopileatus. Higher amount of phenylalanine (3.28 g/100g) was reported by [34] in Lentinus polychrous while [41] documented its much less percentage (0.6%) in Agaricus bohusii. This amino acid has been reported to serve as a precursor of tyrosine, which in turn is the precursor of neurotransmitters and is a powerful antidepressant [37].

Different workers have been reported the variable amount of leucine in different edible mushrooms which is a potent stimulator of insulin [37]. The amount of this amino acid evaluated during the present investigations in L. sajor-caju (1.39 g/100g) is almost comparable to its percentage documented in Pleurotus citrinopileatus (1.07%) by [33]. However, comparatively much lower amount of leucine has been reported in P. sajor-caju (0.46%) by [42].

There are numbers of reports including that for Lentinus connatus (2.29 g/100g) [38], for Pleurotus species (4.4 g/100g) [40], for P. ostreatus (1.76 g/100g-2.31 g/100g) [32], for Agaricus species (14.2%) [42], for Agaricus bohusii (2.7%) [41] and for Lentinus polychrous (7.64 g/100g) [34] where the presence of much higher percentage of leucine has been reported in comparison to its amount (1.39 g/100g) in the presently evaluated sample of L. sajor-caju. Deficiency of leucine has been reported to result in chronic fatigue syndrome [37].

Histidine which has a role in the formation of RBGs and WBCs and treatment of rheumatoid arthritis [37] is present in fairly comparable amount (1.28 g/100g) in L. sajor-caju in comparison to its percentage documented in P. ostreatus (1.03 g/100g-1.10 g/100g) by [32], but it is on the lower side than documented by [40] in Pleurotus species (2.1 g/100g), Lentinus polychrous (1.82 g/100g) [34], Lentinus connatus (1.45 g/100g) [38] and almost more than double in comparison to its percentage documented in P. citrinopileatus (0.51%) [33]. Much less amount of histidine in Agaricus bohusii (0.3%) was reported by [41]. Much higher quantity of histidine (8.26 g/100g) in Agaricus abruptibulbus was documented by [43]. The concentration of histidine (1.28 g/100g) in the presently evaluated sample was found to be very close to the suggested pattern of amino acid [50].

Amongst the essential amino acids documented in L. sajor-caju in comparison to lysine (6.66 g/100g), phenylalanine (1.63 g/100g), leucine (1.39 g/100g), histidine (0.6%) has been documented in P. citrinopileatus by [33], while in P. ostreatus (1.10 g/100g) in Lentinus polychrous (1.35 g/100g) and in Agaricus bohusii (1.85%) much higher percentage of this amino acid has been documented [32,38,41] respectively. In comparison, presence of 5.8 g/100g of isoleucine was reported by [40] in unidentified species of Pleurotus, 9.46 g/100g of isoleucine in Agaricus abruptibulbus was documented by [43] and 3.61 g/100g of this amino acid was reported in Lentinus polychrous [34] which is still on the higher side in comparison to the percentage of its occurrence in all other mushrooms discussed above. Like other amino acids, isoleucine is also important for human health. It is reported to have a role in the formation of hemoglobin and regulation of blood sugar and energy level and its deficiency has been reported to result in chronic fatigue syndrome [37].

Substantially higher percentage of valine (4.65 g/100g) which has a role in tissue repair [37], has been documented in Pleurotus species [40], in P. ostreatus (1.42 g/100g) and L. sajor-caju (1.62 g/100g) [32], in P. sajor-caju (7.81%) [42], in P. citrinopileatus (0.85%) [33], in Lentinus polychrous (5.42 g/100g) [34]. In L. connatus (1.62 g/100g) [38], in Agaricus abruptibulbus (4.18 g/100g) 43 and in Agaricus bohusii (3%) [41] as compared to the percentage of its occurrence (0.43 g/100g) in L. sajor-caju.

Amongst the essential amino acids evaluated in L. sajor-caju, lowest amount was documented for methionine (0.16 g/100g), which is substantially on the lower side than documented in P. citrinopileatus (0.30%) by [33], P. ostreatus (0.42 g/100g-0.53 g/100g) by [32], P. floridus (1.84 g/100g) by [39], Agaricus bisporus (0.98 g/100g) by [39], Pleurotus species (1.26 g/100g) by [40], Agaricus abruptibulbus (1.62 g/100g) by [43], Lentinus polychrous (2.25 g/100g) by [33] and L. connatus (0.55 g/100g) by [38]. Almost comparable amount of methionine (0.1%) has been documented in Agaricus bohusii [41]. Methionine is reported to assist in the breakdown of fats and also serves as an antioxidant [37].

Out of the non-essential amino acids, alanine (18%-45%) which is a major part of connective tissues and help to boost immune system [37] has been reported to be the main component in almost all the mushrooms [44]. Presently also in L. sajor-caju, alanine (3.40 g/100g) which has a role in the sugar metabolism and boosting the immune system [44], was found in maximum proportion in comparison to tyrosine (1.75 g/100g), tryptophan (0.35 g/100g) and glycine (0.50 g/100g). The documented amount of alanine in the presently investigated species is almost comparable to its amount in Lentinus connatus (3.74 g/100g) by [38] and Pleurotus ostreatus (3.55 g/100g) as reported by [32]. However, in comparison much less percentage of alanine (1.60%) has been documented in Agaricus.
bisorus [42] and in Agaricus bohussi [0.8%] [41]. In five wild edible species of Lentinus, namely L. sajor-caju, L. connatus, L. torulosus, L. cladosus and L. squarrosulus, the alaline content has been reported to range from 0.0%-0.15% [45]. Also amongst the five wild Pleurotus species evaluated by [46], maximum (0.19%) percentage of alanine was documented in P. platinumus, which is much less in comparison to the proportion of alaline present in L. sajor-caju (3.40 g/100g). The documented amount of alaline in the presently investigated species is much less in comparison to its amount in Agaricus abruptibus (7.15 g/100g) reported by [43] and in Lentinus polychrous (11.29 g/100g) reported by [34]. This amino acid is reported to be responsible for giving sweet taste to mushroom [4].

The second most abundant non-essential amino acid evaluated in the presently investigated mushroom is cysteine (1.99 g/100g) which is a natural detoxifier and its deficiency in the body results in food allergy [37]. In comparison, much less cysteine percentage has been documented in Agaricus bisporus (0.86%) and Pleurotus floridus (0.55%) [39]. Even in P. ostreata (0.46%-0.53%) cysteine has been documented in much less proportion [32]. Same is true for P. citrinopileatus in which substantially low percentage of cysteine (0.20%) has been evaluated [33], for L. connatus (0.43 g/100g) [38] and for Agaricus bohussi (0.1%) by [41]. However, in Lentinus polychrous almost comparable (1.92 g/100g) amount of cysteine has been documented [34]. In comparison, high cysteine quantity has been documented in Agaricus abruptibus (2.75 g/100g) by [43].

Tyrosine, which is a precursor of neurotransmitters-dopamine, nor-epinephrine, epinephrine and melanin [37], has been documented in Agaricus bisporus (0.86%) and Pleurotus floridus (0.55%) [39]. Even in P. ostreata (0.46%-0.53%) cysteine has been documented in much less proportion [32]. Same is true for P. citrinopileatus in which substantially low percentage of cysteine (0.20%) has been evaluated [33], for L. connatus (0.43 g/100g) [38] and for Agaricus bohussi (0.1%) by [41]. However, in Lentinus polychrous almost comparable (1.92 g/100g) amount of cysteine has been documented [34]. While working with five edible Lentinus species from North-West India, tyrosine content ranged from 0.16%-0.24% [45] and in five wild Pleurotus species ranged from 0.14%-0.20% [46], with maximum in P. sapidus (0.20%). As in all other edible mushrooms, the presence of tyrosine in the presently investigated mushroom adds to the nutraceutically credentials of L. sajor-caju, as the deficiency of this amino acid has been reported to result in hypothyroidism.

Glycine, although the present in substantially low (0.50 g/100g) amount in L. sajor-caju is an important structural constituent of hemoglobin and its deficiency results in hypoglycemia and anemia [37]. It is an integral part of commonly cultivated mushrooms including Agaricus bisporus (0.32%) and Pleurotus sajor-caju (11.1%) as documented by [42]. In the case of Pleurotus ostreata, glycine content ranged from 0.43 g/100g to 1.65 g/100g (1.32), which is almost comparable to the amount of glycine documented in L. sajor-caju (0.50 g/100g). Another oyster mushroom, Pleurotus citrinopileatus, also possesses glycine (0.84%) in the proportionate amount [33]. However, in Agaricus abruptibus (3.21 g/100g) much higher amount of glycine has been documented [43], in Agaricus bohussi (1.9%) [41], in Lentinus polychrous (5.55 g/100g) by [34] and in L. connatus (1.55 g/100g) by [38].

CONCLUSION

Lentinus sajor-caju (Fr.) Fr. is a potential source of quality protein with a substantial proportion of exogenous and endogenous amino acids. In view of its nutritional quality parameters, amino acids composition and the presence of some such amino acids as lysine, phenylalanine, leucine, histidine amongst the exogenous amino acids and alanine, cysteine, tyrosine and glycine amongst the non-essential amino acids, this mushroom can be a good food supplement.

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CONFLICT OF INTERESTS

The authors do not have any conflict of interests.

REFERENCES

1. Prabu M, Kumathakalawali R. Antioxidant activity of oyster mushroom (Pleurotus floridus [Mont. Singar]) and milky mushroom (Calocybe indica P and C). Int J Curr Pharma Res 2016;8:48-51.
2. Nyman J. Incorporation of arginine, ornithine and phenylalanine into tropane alkaloids in suspension-cultured cells and asexual mushroom contact plants on Atropa belladonna. Exp Bot 1994;45:979-86.
3. Chang ST, Miles G. The nutritional attributes of edible mushrooms. In: Mushroom cultivation, nutritional value, medicinal effects and environmental impact. Ed 2nd. Boca Raton, London, New York Washington, D.C. 2004. p. 27-36.
4. Voet D, Voet JG. Biochemistry. Wiley, Hoboken, New Jersey; 2004.
5. Gruen EH, Wong MW. Distribution of cellular amino acids, protein and total organic nitrogen during fruit body development in Flammulina velutipes. Can J Biol 1982:6:1330-41.
6. Khanna PK, Garha HS. Pleurotus mushroom-a source of food protein. Mushroom News Trop 1984;4:9-14.
7. Breene WM. The nutritional and medicinal value of specialty mushrooms. J Food Prot 1990;53:883-94.
8. Tseng YH, Mau JL. Contents of sugars, free amino acids and free 5’nucleotides in mushrooms Agaricus bisporus during post-harvest storage. J Sci Agric Food 1999:79:1519-23.
9. Tsai SY, Wu TP, Huang SJ, Mau JL. Nonvolatile taste components of Agaricus bisporus harvested at different stages of maturity. Food Chem 2007;103:1457-64.
10. Jandaik CL, Kapoor JR. Amino acid composition of Pleurotus sajor-caju (Fr.) Fr. Eur J Mycol 1979;41:154-56.
11. Samaigati N. Nutritive value of some Indian edible mushrooms. Mushroom Sci 1978;10:695-703.
12. Bano Z, Bhagya S, Srinivasan KS. Essential amino acid composition and proximate analysis of the mushrooms, Pleurotus eous and Pleurotus floridus. Mushroom Newsl Trop 1980;11:6-10.
13. Khanna PK, Garha HS. Pleurotus mushroom-a source of food protein. Mushroom News Trop 1984:4:9-14.
14. Khanna PK, Garha HS. Nucleic acid content and relative nutritive value of sporophore proteins of Pleurotus species. Mushroom News Trop 1986;6:17-20.
15. Bisaria R, Madan N, Bisaria VS. Mineral content of mushroom Pleurotus sajor-caju cultivated on different agro residues. Mushroom J Trop 1987;7:53-60.
16. Bisaria R, Madan N, Bisaria VS, Mukhopadhyay SN. Amino acid composition of mushroom Pleurotus sajor-caju cultivated on different agro residues. Biol West 1987b;20:251-9.
17. Hira CK, Vaidhara S, Mann APS. Biochemical changes in sporophores of two mushroom species before and after the opening of caps. Ann Biol 1990;6:95-9.
18. Atri NS, Sharma SK, Joshi R, Gulati A, Gulati A. Nutritional and nutraceutical composition of five wild culinary-medicinal species of genus Pleurotus [higher basidomycetes] from north-west India. Int J Med Mushroom 2013;15:49-56.
19. Kumari Babita, Upadhyay RC, Atri NS. Evaluation of nutraceutical components and antioxidant potential of North Indian wild culinary medicinal termitephilous mushrooms. Int J Med Mushroom 2013;15:189-95.
20. Rathore MS, Gupta VB. Protective effect of amino acids on eye lenses against oxidative stress induced by hydrogen peroxide. Asian J Pharm Clin Res 2010;3:166-9.
21. Obreshkova DP, Tsvetkova DD, Ivanov KV. Simultaneous identification and determination of the total content of amino acids in food supplements-tablets by gas chromatography. Asian J Pharm Clin Res 2012;5:57-68.
22. Purkayastha RP, Chandra A. Manual of Indian Edible Mushrooms. New Delhi; 1985.
23. Verma RN, Singh BG, Singh SM. Mushroom flora of North Eastern Hills. In: Chadha KL, Sharma SR. ed. Advances in Horticulture. New Delhi, India; 1995. p. 35-62.

24. Chin FH. Edible and poisonous fungi from the forest of Sarawak. Part I. Susr Mushroom J 1981;50:211-25.

25. Corner EJH. The agaric genera Lentinus, Panus and Pleurotus with particular references to Malaysian species. Nova Hedwigia Beih; 1981. p. 69-169.

26. Pegler DN. The genus Lentinus-A World Monograph. London; 1983.

27. Atri NS, Kaur Amanjeet, Kour Harwinder. Wild mushrooms—collection and identification. In: RD Rai, RC Upadhayay, SR Sharma. Ed. Frontiers in Mushroom Biotechnology. Solan, India; 2005. p. 9-26.

28. AOAC. Lysine, methionine and threonine in feed grade amino acids and premixes. Official Methods Anal AOAC 1999;999:13.

29. Oyetayo VO, Ariyo OO. Micro and macro nutrient properties of Pleurotus ostreatus (Jacq: Fries) cultivated on different wood substrates. J Biol Sci 2013;6:223-6.

30. Liu GH, Wang B, Zhou XG, Hu X. Compositional analysis and nutritional studies of Tricholoma matsutake collected from South west China. J Med Plant Res 2010;4:1222-7.

31. Diez VA, Alvarez A. Compositional and nutritional studies on two wild edible mushrooms from north-west Spain. Food Chem 2001;75:417-22.

32. Oyetayo VO, Ariyo OO. Micro and macro nutrient properties of Pleurotus ostreatus (Jacq: Fries) cultivated on different wood substrates. J Biol Sci 2013;6:223-6.

33. Musieba F, Okoth S, Mibey RK, Wanjiku S, Moraa K. Proximate composition, amino acids and vitamins profile of Pleurotus citrinopileatus singer: an indigenous mushroom in Kenya. Am J Food Technol 2013;8:200-10.

34. Ravikrishnan V, Naik P, Ganesh S, Rajasekhar M. Profile of mushroom Lentinus polychrous Lév, from Western Ghats, Southern India. Int J Plant Anim Environ Sci 2015;5:278-81.

35. How to cite this article

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36. Liu GH, Wang B, Zhou XG, Hu X. Compositional analysis and nutritional studies of Tricholoma matsutake collected from South west China. J Med Plant Res 2010;4:1222-7.

37. Afiukwa CA, Ehem EC, Igwe DO. Characterization of the proximate and amino acid composition of edible wild mushroom species in Abakaliki, Nigeria. Am Assoc Sci Technol J Biosci 2015;1:20-5.

38. Garcha HS, Khanna PK, Soni GL. Nutritional importance of mushrooms. In: Chang ST, Buswell JA, Chiu S. Ed Mushroom Biology and Mushroom Products. Chinese University, Hong Kong; 1993. p. 227-36.

39. Bano Z, Srinivasan KS, Srivastava HC. Amino acid composition of the protein from mushroom Pleurotus (species). Appl Microbiol 1963;11:184-7.

40. Wu G. Amino acids: metabolism, functions and nutrition. Amino Acids 2009;37:1-17.

41. Mdachi SJM, Nkunya MHH, Nyigo VA, Urasa IT. Amino acid composition of some tanzanian wild mushrooms. Food Chem 2004;86:179-82.

42. Naga MS, Kandikere RS. Nutritional composition of two wild mushrooms consumed by the tribals of the Western Ghats of India. Mycologia 2014;5:64-72.

43. Ribeiro B, Andrade AB, Silva BM, Baptista P, Seabra RM, Valentao P. Comparative study on free amino acid composition of wild edible mushroom species. J Agric Food Chem 2008;56:19073-9.

44. Sharma SK, Atri NS, Joshi R, Gulati A, Gulati A. Evaluation of wild edible mushrooms for amino acid composition. Acad J Plant Sci 2012;5:56-9.

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