
REVIEW

Nutritional value of edible mushrooms

ADITI CHATTERJEE^{1*} AND N. SAMAJPATI²

¹*Department of Botany, Vijaygarh Jyotish Ray College, Kolkata-700032*

²*IMS, CAS in Botany, University of Calcutta, Kolkata- 700019*

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The nutritional value of edible mushrooms is due to their high protein, fibres, vitamins and minerals content and low fat levels. They are very good as vegetarian foods because they contain all the essential amino acids required for adult and contain higher amount of proteins than most vegetables. They contain a high percentage of moisture which ranges from 80-95g / 100g approximately. They are good source of protein, 200-250g / kg of dry matter and leucine, valine, glutamine, glutamic acid and aspartic acids are found in large proportions. They contain low amount of fat, 20-30g /kg of dry matter and linoleic (C18:2), oleic (C 18:1) and palmitic (C 16:0) are the main fatty acids. They contain high amount of ash, 80-120g /kg of dry matter and contain mainly potassium, phosphorus, magnesium, calcium, copper, iron and zinc. Edible mushrooms contain high proportions of carbohydrates including chitin, glycogen, trehalose and mannitol and contain fibre, β -glucans, hemicellulose and pectic substances. Besides they contain abundant sugar but fructose and sucrose are available in low content. They are also good source of vitamins with high levels of riboflavin (vitamin B₂), niacin, folate and traces of vitamin C, B₁, B₁₂, D and E.

Key words: Mushrooms, nutritional value, protein, fat, carbohydrate, vitamins, minerals

INTRODUCTION

The basidiocarps of higher fungi have been known as a source of nutritious food for thousands of years (Mattila *et al*, 2001). The mushrooms are popular for their delicacy and flavour though it is true that they are excellent sources of protein, the digestibility of protein being 72-83%. These are edible fungi and assume considerable importance in human diet as good source of non-starchy carbohydrates, dietary fibres, minerals, vitamins and essential amino acids (Kalaè, 2013). Mushrooms have poor shelf-life and dehydration appears to be good method of preservation and easy to transport for Indian conditions (Chandra and Samsher, 2002). *Agaricus bisporus* (White button mushroom), *Lentinus edodes* (Shiitake mushroom), *Pleurotus ostreatus*, *P. flabellatus*, *P. sajor-caju* etc. (Dhingari mushroom), *Volvariella volvacea* (Paddy straw mushroom), *Flamulina velutipe* (Winter mushroom), *Auricularia polytricha*

(Jew's ear mushroom) are generally commercially cultivated throughout the world.

In India, White button, Oyster or Dhingari and Paddy straw mushrooms are generally commercially cultivated. The production of mushrooms is gradually increasing from 4000 tonnes in 1985-86 to 50,000 tonnes/ annum in 2005-06 (Chandra and Samsher, 2006).

People generally consume mushrooms for their delicacies, palatability, flavour and nutritional values. Therefore it can be a way to combat the protein malnutrition problem prevalent in most of the developing and underdeveloped countries of the world. Nutritional value of edible mushrooms are given in Table 1, 2, 3 and 4 and comparison with other food items are given in Table 5 and 6 (Chandra and Samsher, 2006).

CARBOHYDRATE, CRUDE FIBRE AND ASH

It is reported that carbohydrate contents ranged from 46.6 to 81.8%, and the crude fibre content

*Correspondence: suvraditi@gmail.com

Table 1: Approximate analysis of edible mushrooms fresh weight basis

Mushrooms	Moisture (%)	Protein (%)	Fat (%)	Crude fibre (%)	Ash (%)
<i>Agaricus bisporus</i>	89.5	3.94	0.19	1.09	1.25
<i>Lepiota</i> spp.	91	3.3	0.18	0.86	1.09
<i>Pleurotus</i> spp.	90	2.78	0.65	1.08	0.97
<i>Termitomyces</i> spp.	91.3	4.1	0.22	1.14	0.81
<i>Volvariella diplasia</i>	90.4	3.9	0.25	1.67	1.1
<i>Volvariella volvacea</i>	88.4	4.98	0.74	1.38	1.48

Table 2: Amino acid composition of different mushrooms (g/100g protein)

Amino acid	<i>A.bisporus</i>	<i>P. flabellatus</i>	<i>P. sajor-caju</i>	<i>V. volvacea</i>
Alanine	9.1	10.3	10.5	8.4
Arginine	4.9	4.3	3.5	3.6
Aspartic acid	8.9	10.8	14.1	10.7
Cystine	1	0.5	-	-
Glutamic acid	11.2	10.4	12.8	12.2
Glycine	10.3	10.3	7.3	9
Histidine	3.1	0.9	2.2	4
Isoleucine	5.5	5.1	3.9	4.4
Leucine	7.5	8.1	6.7	7.8
Lysine	6.6	5.4	4.5	7.2
Methionine	1.4	1.9	1.3	1.4
Phenylalanine	1.7	3.1	10.8	2.6
Proline	8.4	5.5	5.7	6.1
Serine	6.4	8.4	7.3	7
Threonine	6.9	6.4	7.1	6.3
Tyrosine	1.1	1.5	1.6	1.7
Valine	5.4	6.3	0.1	6.6
Total essential amino acids	35	36.3	34.4	36.3

varied from 7.4-27.6%. The ash content of mushrooms varied from 0.81-1.46%.

PROTEIN

Mushrooms contain about 19-35% protein on dry weight basis and the quality of easily digestible proteins of mushrooms is superior to that of all vegetable proteins. On a dry weight basis mushrooms generally contain 19-35% protein as compared to 7.3% in rice, 13.25% in wheat, 39.1% in soybean and 25.25% in milk. It is also reported that protein up to 70-90% in fresh mushrooms can be digested (Table 1).

ESSENTIAL AMINO ACIDS

The proteins of mushrooms contain about 20 amino acids in varying amounts. These are the essential

amino acids like lysine, methionine, valine, tryptophan, leucine, threonine, isoleucine, histidine and phenylalanine. Tryptophan and lysine are found in high amount as compared to sulphur amino acids, cysteine and methionine. The sulphur amino acids are absent or present in trace amount in mushroom and vegetable protein (Table 2).

FAT CONTENT

It is reported that the fat content in different species of mushrooms is 1.1 to 8.3% on a dry weight basis with an average content of 4.0%. In mushroom at least 72% of the total fatty acids are found to be unsaturated. The high content of unsaturated fatty acids is due to the presence of essential linoleic acid of the total fatty acids, which accounts for 76%

in *Lentinus edodes*, 70% in *Volvariella volvacea* and 69% in *Agaricus bisporus*.

VITAMINS

It is reported by several scientists that edible mushrooms are good source of different essential vitamins such as thiamine, riboflavin, niacin, biotin and vitamin C. The thiamine content (mg/100g dry wt.) range from 1.1 in *Agaricus bisporus*, 1.2 in *Volvariella volvacea*, 4.8 in *Pleurotus ostreatus* and 7.8 in *Lentinus edodes* (Table 3). The niacin content (mg/100g dry wt.) is found to be 54.9 mg in *L. edodes*, 55.7 mg in *A. bisporus*, 91.9 mg in *V. volvacea* and 108.7 mg in *P.ostreatus* (Table 3). Mushrooms are reported to be an excellent source of riboflavin and niacin. The value of vitamin C or ascorbic acid is found to be 81.9 mg in *A. bisporus* and 20.2 mg in *V. volvacea* as mg/100g dry wt. basis (Table 3).

Table 3: Vitamin content of some edible mushroom (mg/100g dry wt.)

Mushrooms	Thiamin	Riboflavin	Niacin	Ascorbic acid
<i>Agaricus bisporus</i>	1.1	5	55.7	81.9
<i>Lentinus edodes</i>	7.8	4.9	54.9	0
<i>Pleurotus ostreatus</i>	4.8	4.7	108.7	0
<i>Volvariella volvacea</i>	1.2	3.3	91.9	20.2

MINERALS

Mushrooms are found to contain a high amount of calcium, phosphorus, sodium and potassium and low amount of available form of iron and magnesium (Table 4). *A. bisporus* contains high amount of calcium, phosphorus and potassium. *L.edodes* and *V. volvacea* contain high amount of calcium, phosphorus, iron, sodium and potassium. *P.ostreatus* contains high amount of calcium, phosphorus, iron, sodium but no potassium (Table 4).

Table 4: Mineral composition of some of edible mushroom (mg/100g dry wt.)

Mushrooms	Ca	P	Fe	Na	K
<i>Agaricus bisporus</i>	23	1429	0.2	-	4762
<i>Lentinus edodes</i>	33	1348	15.2	837	3793
<i>Pleurotus ostreatus</i>	98	476	8.5	61	-
<i>Volvariella volvacea</i>	71	677	17.1	374	3455

It has been found that the composition of cultivated mushroom when compared with other common

vegetables reveals that the mushroom has 36.9% protein on dry wt. basis which is much higher than that of other vegetables (Table 5). The data in Table 6 reveal that the protein content of mushroom is better than that of fresh and dried apples, peas, cabbage, carrot, cauliflower, potato, tomato, apricot, banana, dried date and dried raisin (Table 6).

The data in Table 7 reveal that mushrooms contain about 80-90% of water, 8-10% of fibre and are excellent source of vitamins and minerals. These are good source of folic acid, thiamine, riboflavin and niacin. These are found to contain minerals such as potassium, sodium and phosphorus in higher amount and also contain Cu, Zn, and Mg in traces but deficient in iron and calcium.

The data in Table 8 reveal that mushrooms have good nutritional value as they are rich source of protein with a good amount of essential amino acids, fibre and low fat but with excellent important fatty acids. Edible mushrooms contain a nutritionally significant amount of vitamins B1, B2, B12, C, D and E.

The data in Table 9 reveal that some specific polysaccharides with their properties being quantified in different mushrooms viz. rhamnose, xylose, fucose, arabinose, fructose, glucose, mannose, mannitol, sucrose, maltose and trehalose.

The data in Table 10 reveal that palmitic and linoleic acids are present in appreciable amount in all the test fungi. Oleic acid is present in *P. ostreatus* and *P. eryngii* as 12.3 (g/100g fresh wt.) but linoleic acid is present in negligible amount.

Chittaragiet *al* (2014) have determined the nutritive value of four wild mushrooms viz. *Lycoperdon umbrinum*, *Ganoderma sinense*, *Hygrocybe cantharallus* and *Calocera viscosa*, which are collected from the Shimoga forest regions of Karnataka. They have found that these wild mushrooms contain the moisture in the range of 83.6-90.26%, lipids 1.4-2.79%, carbohydrates 23.73-47.5%, crude protein 5.4-33.5%, crude fibre 8.4-13.2%, ash 1.92-9.2% and nutritive value 88.44-125.84 Cal/100g. Among the macronutrients these mushrooms contain Ca (46.85-73.62%), followed by Na (1.01-1.91%), K (0.51-0.81%), P (0.33-0.51%), and Mg (0.10-0.22%) only and

Table 5 : Composition of cultivated mushroom and some common vegetables per 100 g of produce

Name	Calories (%)	Moisture (%)	Fat (%)	Carbohydrate (%)	Protein (%) dry wt. basis
Mushroom	16	91.1	0.3	4.4	36.9
Beet root	42	87.6	0.1	9.6	12.9
Brinjal	24	92.7	0.2	5.5	15.1
Cabbage	24	92.4	0.2	5.3	18.4
Cauliflower	25	91.7	0.2	4.9	28.8
Celery	18	93.4	0.2	3.7	20.6
Green peas	98	74.3	0.4	17.7	26.1
Green beans	35	88.9	0.2	7.7	21.6

Table 6: Comparison of the protein content of the mushroom (*Agaricus bisporus*) with that of various foods.

Food products	Protein (%)	Food products	Protein (%)
Mushrooms			
<i>A. bisporus</i> (Fresh)	3.7		
<i>A. bisporus</i> (Dried)	5		
Vegetables			
Kidney beans, dried	21.3	Fresh podded beans	2.6
Broad beans, dried	24	Cabbage	1.5
lentils, dried	24.7	Carrot	1.1
frozen gree peas	5.4	Cauliflower	2.7
Dried peas	24.2	Potato, raw	2.3
Brussels sprout	4.7	Tomato	1.1
Fruits, nuts			
Dried apricot	5	fresh apricot	0.9
Dried coconut	7.2	Banana	1.1
Roasted peanut	26.2	Dried date	2.2
Fresh apple	0.3	Dried raisin	2.5
Dried apple	3		
Yeast, bread			
Compressed yeast	12.1	Corn flour	7.8
dried yeast	38.8	Whole rice	7.5
Bread	8.7-9.1	Dry spaghetti	12.5
Wheat flour	11.7	Maize	3.5
Dairy products			
Raw egg, whole	12.8	Cow milk	3.2
Cheddar	12	Buffalo milk	3.8
Meat			
Beef	19.5-21.5	Mackerel	19
Liver	19.7	Haddock	18.3
Rabbit	20.4	Cod	17.5
Chicken	19.0-20.6	Perch, trout	18.4-19.2
Lamb	18	Lobster, crab	16.9-17.4
Pork	14.6-18.6		

among the macronutrients Fe (84.33-103.63%), Mn (32.89-83.5%), Cu (26.25-60.38%), Zn (11.45-35.0%), and Pb (13.33-16.3%) but Cd is completely absent in all the four mushrooms.

The total protein, total carbohydrate, total lipid, crude fibre and ash content of *A. bisporus* (White), *A. bisporus* (Brown), *Lentinus edodes* and *Pleurotus ostreatus* were determined by Teklit (2015) and they found the values ranged from 28.38-49.2, 1.54-4.96, 13.2-29.02, and 7.0-17.92 respectively. Singha *et al* (2017) analysed the nutrients present in *Termitomyces humii*, *Astrocus hygrometricus*, *Leucopaxilu ssp.*, *Amanita vaginata*, *Agaricus campestris*, *Russula delica*, *Schizophyllum commune*, *Pleurotus ostreatus* and *Cantharellus* sp. on dry wt. basis and have shown that these mushrooms are rich in proteins (20.4-38.3%) and carbohydrates (33.2-48.4%), while low in lipid content (0.8-6.2%). The fibre and ash content are 2.0-18.6% and 2.3-14.9% respectively.

It has been reported by Kamalebo *et al* (2018) that 73 species of wild mushrooms are used by the people of Tsopo, Congo. Women are more involved in collection of wild mushroom. It is also found that knowledge of useful mushroom differs between ethnic groups. *Pleurotus tuber-regium* is the most important species which is used as food while *Schizophyllum commune*, *Auricularia cornea*, *A. delicate*, *Marasmius buzengolo* and *Lentinus squamoculus* are highly appreciated as food. Waktola and Temesgen (2018) have reported that mushrooms have high nutritional value as these contain high amount of protein, vitamins, minerals, fibre, trace elements and low/no calories and cholesterol. Fekadu (2015) has described that the higher contents of mushrooms is water (90%), protein (2-40%), fat (2-8%), carbohydrates (1-55%), fibre (3-32%) and ash (8-10%).

Table 7: Nutritive value of different mushrooms (dry wt basis g/100g)

Mushrooms	Carbohydrates	Fibre	Protein	Fat	Ash	Energy (k cal)
<i>A. bisporus</i>	46.17	20.9	3.48	3.1	5.7	499
<i>P. sajor-caju</i>	63.4	48.6	19.23	2.7	6.32	412
<i>L. edodes</i>	47.6	28.8	32.93	3.73	5.2	387
<i>P. ostreatus</i>	57.6	8.7	30.4	2.2	9.8	265
<i>V. volvacea</i>	54.8	5.5	37.5	2.6	1.1	305
<i>F. velutipes</i>	73.1	3.7	17.6	1.9	7.4	378
<i>A. auricula</i>	82.8	19.8	4.2	8.3	4.7	351

Table 8: Proximal composition of some edible mushroom (dry wt. basis g/100g)

Species	Protein (%)	Fat (%)	Ash (%)	Carbohydrate (%)	Energy (cal/kg)
<i>A. bisporus</i>	14.1	2.2	9.7	74	325
<i>L. edodes</i>	4.5	1.73	6.7	87.1	772
<i>P. ostreatus</i>	7	1.4	5.7	85.9	416
<i>P. eryngii</i>	11	1.5	6.2	81.4	421
<i>P.sajor-caju</i>	37.4	1	6.3	55.3	-
<i>P.gigantium</i>	17.7	4.3	-	78	364
Dry powder formulation					
<i>A.blarzei</i>	31.3	1,8	7.5	59.4	379
<i>L. edodes</i>	12.8	1	4.3	81.9	388

After Carneiro *et al* (2013),)Kalaè (2013), Phan *et al* (2012) Reis *et al* (2012)

Table 9: Compositions of sugars of some edible mushrooms (g/ 100g fresh wt.)

Species	Fructose	Mannitol	Sucrose	Trehalose	Total sugar
<i>A.bisporus</i>	0.03	5.6	nd	0.16	5.79
<i>L.edodes</i>	0.69	10.1	nd	3.38	14.03
<i>P.ostreatus</i>	0.01	0.54	nd	4.42	4.87
<i>P.eryngii</i>	0.03	0.6	0.03	8.01	8.67
Dry powder formulation					
<i>A. blazei</i>	0.27	60.89	nd	5.74	66.91
<i>L.edodes</i>	nd	2.33	nd	13.22	38.31

Nd: Not detected. ; After Carneiro *et al* (2013), Reis *et al* (2012)

Table 10: Fatty acid contents of some edible mushrooms (g/100g fresh wt.)

Species	Palmitic (C16:0)	Stearic (C18:0)	Oleic (C18:1)	Linoleic (C18:2)	Linolenic (C18:3)
<i>A. bisporus</i>	11.9	3.1	1.1	77.8	0.1
<i>L. edodes</i>	10.3	1.6	2.3	81.1	0.1
<i>P. ostreatus</i>	11.2	1.6	12.3	68.9	0.1
<i>P. eryngii</i>	12.8	1.7	12.3	68.8	0.1
Powder dry formulation					
<i>A.blazei</i>	11.38	2.8	1.85	72.42	Nd
<i>L. edodes</i>	11.78	1.09	3.28	78.59	0.59

Nd: not detected; After Carneiro *et al* (2013), Reis *et al* (2012)

The nutritional value of *V. volvacea* was also analysed by Zahid *et al* (2019) and reported that it contains moisture, fibre (chitin), vitamins (thiamine, biotin, riboflavin, and high quantity of vitamin C), protein, carbohydrates, fat, essential amino acids (glycine, arginine, alanine and serine etc.), important minerals (sodium, potassium, and phosphorus), unsaturated fatty acids and also have low calorific value. In a recent study on nutritional values of white button mushrooms, it was reported that white button mushroom is rich source of protein (3.27 ± 0.12), fibre (1.87 ± 0.08), carbohydrates (2.66 ± 0.61), fats (0.22 ± 0.05), and energy (28.50 ± 1.22 Kcal) g/100g fresh weight basis respectively. Moreover it contains highest amount of potassium (3560 ± 153.33) and sulphur (2195.59 ± 1405.60) mg/kg fresh weight basis (Sinha *et al* .2021)

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