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A Review

Nutritional and medicinal aspects of edible mushrooms

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ABSTRACT
The mushroom is a fleshy, space-bearing organ of non-green edible fungi. Its fleshy nature of mushroom is responsible for its main attraction to human being as a source of food. Fresh mushroom contain virtually no fat and cholesterol and hence they can be consumed by patients suffering from atherosclerosis. Mushroom and their products are engaged as delicacy and its consumption is rapidly increased as they have remarkably taste, flavour and nutritive value. Its products can serves to improve the nutritional status and helping in alleviating protein deficiency in children. Mushroom can be preserved by many methods viz., drying/dehydration, canning, blanching, osmotic dehydration, irradiation, freezing, pickling, chemical treatment, product development for long term storage. In forthcoming period, development and introduction of new products with wider acceptability and comparatively at low price will be further increase the demand and consumption of value added mushroom products due their nutritional and medicinal food values.

Key Words : Diet, Medicinal, Nutritional, Preservation and Value added products.

INTRODUCTION

Mushrooms have achieved significant importance due to their nutritive and medicinal values and as an income generating industry in the world. The mushroom is a fleshy, space-bearing organ of non-green edible fungi. Its fleshy nature of mushroom is responsible for its main attraction to human being as a source of food. Like other fruit and vegetables, mushrooms are soft textured and highly perishable in nature. Mushroom are potential sources of nutrients. They can convert nutritionally valueless substances into high fat and protein food. Mushroom proteins are comparable to muscle protein in nutritive value. Being a good source of vitamins and proteins it is considered be a distinct food. The digestibility of protein in these is 72-83%. Mushrooms are edible fungi; assume considerable importance in human diet as they are good source of non starchy carbohydrate, dietary fibre, minerals and vitamins-B and essential amino acids.

Mushrooms are popular their delicacy and flavour rather that food value. However, it is now a well-established fact that they are excellent sources of vitamins and minerals (Vijaya Khader, 1988). The vitamins in mushroom are well retained during cooking, canning, and dehydration. The White button mushrooms (*Agaricus bisporus*), Shiitake mushroom (*Lentinus edodes*), Pleurotus species (*Pleurotus osteatus, P. flabellatus, P. sajor caju etc.*), Paddy straw mushrooms (*Volvariella volvacea*), winter mushrooms (*Flammulina velutipis*), Jew's ear mushrooms (*Auricularia polytricha*) are commercially cultivated species of mushroom (Table 1). In India, mainly three species viz., white button, oyster or dhingari and paddy straw mushrooms are commercially cultivated at large scale. The production of mushrooms is increasing at a fast rate from 4000 tonnes in 1985-86 to 30,000 tonnes in 1996-97 (Rama and Jacob john, 2000). At present, it estimated to be 50,000 tonnes/annum (Tewari and Pandey, 2002).

Mushrooms are highly perishable commodities and they start deteriorating immediately after their harvest. They developed of brown discolouration on the surface of mushroom caps due to enzymatic action of poly phenol oxidase and they quickly become soft at high temperature. Mushroom have poor shelf-life and dehydration appears to be a promising cost effective method of preservation for Indian conditions as dehydrated mushroom are easy to transport as compared to canned, pickled and frozen product (Chandra and Samsher, 2002). Development of appropriate storage and post harvest technology in order to extent their marketability and availability to consumers in fresh as well as processed form is of significance. Mushroom with regard to their good medico-nutritional and high digestibility values are gaining importance in today's human diet. Even in this century of vegetarian consciousness and healthy eating, the mushroom is, in fact, providing to be an excellent meat substitute (Singh *et al.,* 1995). Vijaya khader (2001) reported that fresh mushroom contain about moisture (85-95%), protein (3.0%), carbohydrate (4.0%), fat (0.3-0.4%) and mineral/vitamins (1.0%). Development of appropriate storage and preservation technology in order to extent their marketability and availability to consumption in fresh as well processed form is of great significance.

NUTRITIONAL ASPECTS

Mushrooms are consumed for their delicacies flavour, palatability and nutritional value. Palatability can be determined by their colour, texture, flavour and taste. Hence, it can be an answer for the protein malnutrition prevalent in most of the developing and under developed countries of the world. Approximate nutritional analysis of edible mushrooms (Table 2) and comparison with other food items (Table 3) are discussed below.

Table 1: Various species of edible Mushrooms grown in India

S.No	Common variety of edible mushrooms	Scientific name
1.	Button, European/Temperate	Agaricus bisporus
2.	Button/Edulis/Hot weather mushroom	A. bitorqius
3.	Oyster mushroom	Pleurotus species
4.	Paddy straw / Chinese / Tropical mushroom	Valvariella volvacea, V. diplosia.
5.	Black ear mushroom	Auricularia polytricha
6.	White milky mushroom	Colocybe indica
7.	Brown cap/Giant mushroom	Stropharia ruguso annulata
8.	Shiitake mushroom	Lentinus edodes

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Table 2 : Approximate analysis of edible mushrooms fresh weight basis

S.No.	Mushroom	Moisture%	Protein%	Fat %	Crude fibre %	Ash, %
1.	Agaricus bisporus	89.5	3.94	0.19	1.09	1.25
2.	Lepiota sps.	91.0	3.30	0.18	0.86	1.09
3.	Pleurotus sps.	90.0	2.78	0.65	1.08	0.97
4.	Termitomyces sps.	91.3	4.10	0.22	1.14	0.81
5.	Volvarilla diplasia	90.4	3.90	0.25	1.67	1.10
6.	Volvariella volvacea	88.4	4.98	0.74	1.38	1.46

Table 3 : Composition of cultivated mushroom and some common vegetables per 100 g of produce

Name	Calories	Moisture, %	Fat, %	Carbohydrate, %	Protein (%) (Dry wt basis)
Mushrooms	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

Carbohydrate and Crude fibre:

Mc Connell and Essenlen (1947) reported that fresh mushroom contain mannitol (0.95%), reducing sugars (0.28%), glycogen (0.59%) and hemi cellulose (0.91%). Rajarathnam (1981) repoted that mannitol helps to maintain the osmotic concentration in the fruit body cell, which is necessary to maintain water content as high as 90%. Crisian and Sands (1978) analyzed pentoses, hexoses, methyl pentose as well as disaccharides, amino sugars, sugar alcohols and sugar acids are constituents of mushrooms carbohydrate. Rajarathanam (1982) noticed that Pleurotus species contain carbohydrate range 46.6 to 81.8% against 60 % in Agaricus bisporus on a dry weight basis. The fibre content varied from 7.4-27.6% in Pleurotus species against to 10.4% in A. bisporus and 4-20% in Volvariella volvacea. The absence of starch in mushrooms makes it an ideal food for diabetic patients and for persons who wish to shed excess fat from their bodies. Fibre is an important ingredient in human balanced and healthily diet. Andersson and Wards (1979) reported that feeding diabetic patients will high fibre diets reduces their daily insulin requirement and stabilizes their blood glucose profile, possibly by decreasing the rate of glucose absorption and/or delaying gastric emptying.

Protein:

In general, mushrooms contain about 20-40% protein on dry basis and thus surpass many foods, in terms of protein content. Quality of mushroom protein is superior to that of vegetable protein and is as good as animal protein, which is easily digestible. The use of these may contribute significantly in overcoming protein deficiency in the unacceptable for religion beliefs. On a dry weight basis, mushroom normally contains 19-35% protein as compared to 7.3 % in rice, 13.2 % in wheat, 39.1 % in soybean and 25.2% in milk. Even the available vegetable protein upto 70-90% in fresh mushrooms can be digested. Mushroom protein, like other fungal protein, is intermediate in quality between vegetable and animal protein. The supplementary value of mushroom protein in vegetarian diet is, therefore, of considerable significance.

Essential Amino Acids:

Since, mushroom proteins contain about 20 amino acids in varying amount. These are the essential amino acids (lysine, methionine, valine, Tryptophane, theonine, leucine, isoleucine, histidine and phenylanine). Tryptophane and lysine are present in high concentration as compared to cystein and methionine. These amino acids are absent in vegetable proteins. Animal food products always give a better balanced and higher quality protein than do plant foods, which often some of the important amino acid; e.g., cereals grains have to little of the essential amino acids lysine, which legume usually lack of the amino acids methionine and Tryptophane.

Fat Content:

The fat content in several species of mushrooms are range from 1.1 to 8.3% on a dry weight basis, with an average content of 4.0%. The crude fat of mushrooms is representative of free fatty acids, mono-glycerides, di-glycerides, try-glycerides, sterols, sterol esters and phospholipids. At least 72% of the total fatty acids are found to be unsaturated in each of these mushrooms. The high content of unsaturated fatty acids in mainly due to linoleic acids, which, of the total fatty acids, accounts for in Lentinus edodes (76%), Volvariella volvacea (70%), Agaricus bisporus (69%). Unsaturated fatty acids are essential in our diet (Holman, 1976); whereas, saturated fatty acids, which are present in high amounts in animal's fats, may be dangerous to human health. Hughes (1962) reported that mushrooms are rich in linoleic acid, which is an essential fatty acid. These are some evidence that the cream varieties contain more fat that of other varieties. The finding of a high proportion of unsaturated fatty acids and a high percentage of linoleic acid in these mushrooms is a significant factor in regarding mushroom as health foods.

Vitamins:

It has been examined that edible mushrooms are a good source of several essential vitamins like thiamine, riboflavin, niacin, biotin and vitamin-C (Crisian and Sands, 1978). Vitamin of B-complex and vitamin C are present in significant quantities. Folic acid and vitamin B_{12}, which are normally absent in vegetative foods, are present in mushrooms. The thiamine content ranges 0.35 mg, 1.114 mg and 1.16 to 4.8 mg in V. volvacea, A. bisporus and Pleurotus species, respectively. Andersson and Feller (1942) reported that A. bisporus does not contain vitamin A, D or E. They found ascorbic acid (8.6 mg), nicotinic acid (5.82 mg), panthothenic acid (2.38 mg), thiamine (0.12 mg), riboflavin

Table 4: Comparison of the Protein content of the mushroom (Agaricus bisporus) with that of various foods.

S. No.	Food products		Protein,%	Food Product	Protein,%
1	Mushroom				
	A. bisporus (Fresh)	3.7			
	(Dried)	5.0			
2.	Vegetable, etc.				
	Kidney beans, dried		21.3	Fresh podded peas	2.6
	Broad beans, dried		24.0	Cabbage	1.5
	Lentils, dried		24.7	Carrot	1.1
	Frozen green peas		5.4	Cauliflower	2.7
	Dried peas		24.2	Potato, raw	2.3
	Brussels sprout		4.7	Tomato	1.1
3.	Fruits, nuts				
	Dried apricot		5.0	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		3.0		
4.	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
5.	Dairy product				
	Raw egg, whole		12.8	Cow milk	3.2
	Cheddar		12.0	Buffalo milk	3.8
6.	Meat			Fish	
	Beef		19.5-21.5	Mackerel	19.0
	Liver		19.7	Haddock	18.3
	Rabbit		20.4	Cod	17.5
	Chicken		19.0-20.6	Perch, trout	18.4-19.2
	Lamb		18.0	Lobster, Crab	16.9-17.4
	Pork		14.6-18.6		

Table 5 : Amino acid composition of different mushrooms (g/100g protein)

Amino acid	A. bisporus	P. flabellatus	P. sajor caju	V. volvacea
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	0.5	-	-
Glutamic acid	11.2	10.4	12.8	12.2
Glycine	10.3	10.3	7.3	9.0
Histidine	3.1	0.9	2.2	4.0
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	7.0
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	35.0	36.3	34.4	36.3

(0.52 mg) and biotin (0.018 mg) per 100g fresh weight. The niacin content was found in L. edodes (54.9 mg), A. bisporus (55.7mg), V. volvacea (64.88 mg) and Pleurotus species (46.0 - 108.7 mg) per 100g dry weight of mushroom. Mushroom is reported to be an excellent source of riboflavin and nicotinic acid (niacin) and a good source of panthothenic acid. The value of vitamin C was found in P. sajor caju (7.4 mg), A. bisporus (1.8 mg), V. volvacea (1.4 mg) as mg/100g dry weight of edible mushroom.

Table 6 : Vitamin content of some edible mushroom (mg/100 g dry wt)

S.No	Mushrooms	Thiamin	Riboflavin	Niacin	Ascorbic acid
1.	Agaricus bisporus	1.1	5.0	55.7	81.9
2.	Lentinus edodes	7.8	4.9	54.9	0.0
3.	Pleurotus ostereatus	4.8	4.7	108.7	0.0
4.	Volvariella volvacea	1.2	3.3	91.9	20.2

Minerals:

Mushrooms also contain a high amount of calcium, phosphorus, sodium and potassium and low but available form of iron and magnesium (Table 7). Andersson and Sands (1942) that A. bisporus contain high amount of potassium, phosphorus, copper and iron but the calcium percentage is quite low through ash analysis. Mushrooms with regard to their good nutritional and high digestibility values are gaining importance in today's human diet. *Agaricus bisporus, L. edodes, V. volvacea* and Pleurotus species are richest source of potassium and phosphorus (Chang and Hayes, 1978).

Table 7: Mineral composition of some the edible mushroom (mg/100g dry wt)

S.No.	Mushrooms	Ca	P	Fe	Na	K
1.	Agaricus bisporus	23	1429	0.2	-	4762
2.	Lentinus edodes	33	1348	15.2	837	3793
3.	Pleurotus ostereatus	98	476	8.5	61	-
4.	Volvariella volvacea	71	677	17.1	374	3455

MEDICINAL ASPECTS

Flammulina velutipis can boughtin the grocery store. Auricularia auricular has antiplatelet effects. Due to the alkaline ash, high potassium, sodium ratio and high fibre content, they are also suitable for the people with hypertension, hyper acidity, and constipation. Although mushrooms have not provided any drug for established, contemporary scientific therapy, their selective toxicity directed against organism other than man, or specifically against an undesirable condition or function in human is being exported. It has been found that various edible mushrooms (cultivated or wild) show anti-bacterial, anti-fungal, anti-protozoal and anti-viral effects. Pleurotus officinalis was used in homes as a drastic purge and applied externally to stop bleeding. It was also used for chromic catarrh diseases of the breast and lungs, as remedy for night sweating in tuberculosis, for rheumatism, gout, jaundice, dropsy and intestinal worms. It is used homeopathic doses as Boletus laricis (Agaricus albus). Jew's ear (Auricularia auricula) was frequently used as a poultica inflamed eyes and as a gargle for inflammation of the throat. They lower the blood pressure-and are also active against tumour cells. With regard to health benefits and medicinal value, edible fungi produce secondary metabolites, which are biological active. Many fungi today have been used for medicinal purpose. Lentinus edodes has been shown to contain anti-tumor, anti-viral and hypolipidemic agents (Moore *et al.*, 1985). The hypolipidemic and the hypocholesterolemic properties are due to eritadenine (2, 3-dihydroxy – 4-9-adenyl) - butyric acid (chibata *et al.,* 1969).

The anti-tumor properties are due to poly saccharides lentinans and emitanin-1 (chihara *et al.,* 1970). In addition to anti-tumor anti-cholesterol and anti-thromobic effects of mushrooms, shiitake mushrooms can help in preventing high blood pressure, diabetes, atherosclerosis, kidney ailments, cataract, neuralgia, gallstones, numbness of the hand and feet, hemorrhoids and also improves sexual powers (Mori, 1974). In the Nigyotake mushroom (polyporus confluens), the two principal components, namely, grifolin and neogrifolin are responsible for contributing to the hypocholesterolemic action (sugiyama *et al.,* 1992 a,b). More over, protein containing poly saccharides having anti-tumer activity were reported from pleurotus sajor caju (Zhaung *et al.,* 1993). Anticancerous extract of shiitake causes recession of some kinds of cancer and inhibits the growth of some viruses like influenza (Edwards, 1975). Oyster mushroom (P. ostreatus) lowers blood pressure and cholesterol. They have been reported to possess significant anti-cancer and blood cholesterol reducing properties. Shiitake mushrooms have antimicrobial effects along with lipid lowering effects. It has been shown to improve liver function in individuals with hepatitis. It is felt to lower serum cholesterol by binding it in the gut and increasing its excretion in the stool. It can lower the blood pressure of high blood pressure patient.

PRESERVATION OF EDIBLE MUSHROOMS

In the peak period of production due to gluts in the market and owing to highly perishable nature, its preservation in to more value added stable products is of great importance. Mushrooms are a freshly edible fungi and soft textured and highly perishable in natured due to 91% moisture, so has short shelf life. Development of appropriate storage and preservation technology in order to extent their marketability and availability to consumption in fresh as well processed form is of great significance. There are several techniques of the preservation of fresh mushroom in different processed form viz. dehydration, steeping in chemical solution, blanching in boiled water and chemical solution, canning, freezing, freeze drying, vacuum cooling, osmotic dehydration, pickling, dielectric heating, irradiation, micro-oven heating, low temperature storage, modified and controlled atmospheric packaging and hyperbaric storage.

MUSHROOM PRODUCTS

The edible mushroom has attracted consumers due to their flavour palatability and nutritive value. The use of edible mushroom for human consumption is probably as old as man himself has been accepted widely as favorite food item. Mushroom foods are enjoyed as a delicacy and its consumption is rapidly increasing as they have remarkable taste, flavour and nutritive value. Mushrooms, popularly regarded as vegetarian food available in fresh, frozen, canned, pickled and dried forms. The diversification of mushrooms to various products for mass consumption is now met through the preparation of different mushrooms foods like pickles, chutney, soups, chips, mushrooms snacks, mushroom chicken, butter and various other processed foods. In the recent years, there has also been a marginal shift in the consumption of fresh mushroom by institutional users like pizza

parlours and food parks. Fresh mushroom contain virtually no fat and cholesterol and hence they can be consumed by patients suffering from atherosclerosis. It is also suitable for diabetes. As the crude fibre content is more, it can help in digestive problems such as constipation. It also provides very low energy, which can be used as a slimming diet. It supplies valuable proteins and all essential amino acids for growing children. In view of all the above reasons, consumption of mushroom foods is fast increasing. In the recent years, the gourmet appeal of mushrooms is gaining popularity and the consumer's demand for varieties has led to the processing of mushrooms to processed foods like chutneys, pickles, soups, flavours etc.

However, pre-cooking of the mushrooms under pressure was a pre requisite for the absolute microbiological safety and increased shelf-life of the product (Joshi *et. al.,* 1991). Soups have already played an important role as a delicacy and have been a part of meals in parties and celebrations. Various formulated soups have gained popularity because of their nourishing and appetizing qualities and have created their position in food habits of many countries. Since mushrooms lack in sulphur containing amino acids viz., cystine and methionine, and supplementation of mushrooms with whey protein which are rich in these amino acids, would increase the protein quality of soups in terms of protein efficiency ratio and net protein utilization. Some value added mushroom products are listed below: (1) Dehydrated mushrooms (2) Canned mushrooms (3) Ketchup (4) Pickled (5) Salad (6) Chutney (7) Curry (8) Soups (9) Dried mushroom powder (10) Pakoda (11) Candy (12) Samosa (13) Morrabba (14) Mushroom kheer (15) instant mushroom whey soup powder. The major components responsible for the mushroom flavour are its alcohol, 1-octan-3-ol and other volatiles. A mushroom flavourant has been prepared by Kibler and co-workers by oxygenating an aqueous medium of homogenized mushrooms and a water soluble salt of linolenic acid. Carob bean extract has also been used to further enhance the flavourant. Carriers and other additives may be used to protect the flavourant during spray drying (Kibler et al., 1992). Currently, in India, monosodium glutamate (MSG) is being used as a flavour enhancer in commercial preparations of mushrooms soup powders. Thus, in general, mushroom may be a part of the daily diet. Nutritionally to it was found that they contribute significant amount of nutrients and help meet the required allowance of nutrients.

FUTURE THRUST

An overview of post harvest scenario indicates that the handling and processing technologies have been standardized to some extent but a few big concerns dealing with export are employing such technologies. The cultivation of mushrooms has a great potential for the production of protein-rich quality food and for the recycling of cellulosic agro waste/residues and other wastes. It is the only industry, which contributes effectively in the disposal of the cellulosic agro-wastes. The mushroom industry is fast growing to meet the demand of the foreign nations. However, its consumption in India is very limited (Singh *et al*., 1995). Thus, in general, mushroom may be a part of the daily diet. Nutritionally to it was found that they contribute significant amount of nutrients and help meet the required allowance of nutrients. In India, mushrooms are mostly consumed in fresh condition. For storage of the produce, it is well established that low temperature technique is very important to check the post harvest losses. Introduction of refrigerated vans to collect the produce from the growers directly and delivering it to the local market and processors will boost the production and make available the quality produce to the consumers. For export of processed mushrooms, sophisticated technologies like individual quick freezing (IQF), freeze drying and vacuum drying is required. In recent years, tremendous interest has been generated amongst the entrepreneurs and many export-oriented units with modern methods of preservation and packaging are coming up. Proper infrastructure development for post harvest handling of these highly perishable commodities is more or less negligible, when compared to some advanced countries.

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