PharmaNutrition 5 (2017) 35–46

Contents lists available at ScienceDirect

PharmaNutrition

journal homepage: www.elsevier.com/locate/phanu

Mushroom nutraceuticals for improved nutrition and better human health: A review

Himanshi Rathore*, Shalinee Prasad, Satyawati Sharma

Centre for Rural Development & Technology, Indian Institute of Technology Delhi (IIT Delhi), Hauz Khas 110016, India

ARTICLE INFO

Article history:
Received 13 January 2017
Accepted 1 February 2017
Available online 9 February 2017

Keywords:
Mushrooms
Antioxidants
Nutraceuticals
Bioactive molecules
Nutritional and therapeutic role

ABSTRACT

Mushrooms have always been treasured and appreciated due to their immense role in curing various degenerative diseases. Also their unique taste and flavour make them a demanding food for every man's plate. Information on their chemical composition, nutritional value and therapeutic properties has expanded dynamically during the last few years. Mushrooms contain 50 to 65% total carbohydrate, 19 to 35% proteins (with various biological and medicinal activities such as lectins) and 2 to 6% fat content of their dry matter. In mushrooms unsaturated fatty acids are found to be predominant over saturated fatty acids especially palmitic acid, oleic acid and linoleic acid, while the proportion of linolenic fatty acids is very limited. Mushrooms rich in fat soluble vitamins along with ergosterol content are thought to be the only vegetarian source for vitamin D. Data on fibre content and composition is limited but polysaccharides like β-glucans boost up the nutritional value of mushrooms. It has been observed and established that mushrooms are wonderful food with their immense nutraceutical properties. And for this one of the reasons is the presence of bioactive molecules i.e. β-glucans, triterpenoids, antioxidants etc. These molecules are not only therapeutically strong but also immune-modulators. In this paper all the bioactive molecules in mushrooms along with their possible mechanisms have been discussed and highlighted so that these can be better harnessed for the mankind.

Contents

* Corresponding author.
E-mail addresses: heemansi24@yahoo.com (H. Rathore), shalinee013@gmail.com (S. Prasad), satyawatis@hotmail.com (S. Sharma).

http://dx.doi.org/10.1016/j.phanu.2017.02.001
2213-4344/

1. Introduction

Human relationship with mushrooms is fascinating since they have been used both as a food and medicine for last few decades. The studies on Cultural Revolution reveal that mushrooms were an integral part of the human diet since the time when they were food gatherer and hunters [1]. But now the usage of mushrooms has expanded up to a wider extent not only as food but also in the area of pharmaceuticals, nutraceuticals and cosmeceuticals for the mankind. According to current estimates, mushrooms constitute at least 12,000 species worldwide and out of that 2000 species are reported as edible. About 35 edible mushroom species are commercially cultivated whereas nearly 200 wild species used for medicinal purposes [2]. *Agaricus bisporus* is the most cultivated mushroom worldwide followed by *Lentinus edodes* and *Pleurotus* spp. [3].

Many researchers have documented that edible mushrooms are source of variety of nutraceutical compounds such as polysaccharides (β-glucans), dietary fibres, terpenes, peptides, glycoproteins, alcohols, mineral elements, unsaturated fatty acids, antioxidants like phenolic compounds, tocopherols, ascorbic acid etc [4]. Also the presence of specific bioactive compounds makes these mushrooms therapeutically valuable right from strengthening the immune system till the cure and prevention of life threatening diseases like heart diseases, hypertension, cerebral stroke and cancers. Mushrooms are also known to exhibit antifungal, anti inflammatory, antitumor, antiviral, antibacterial, hepatoprotective, anti diabetic, hypolipedemic, antithrombotic and hypotensive activities [5]. The therapeutic and neutraceutical exploration of mushrooms gives the impression that they are the next generation food, not only in providing quality protein but also in curing deadly diseases like cancers, tumors and nervous disorders. There is a huge challenge to better exploit this wonderful gift of nature and bring it forward from the farm to fork level.

2. Nutritional components of mushrooms

The total carbohydrate content in the fruiting bodies of mushrooms accounts for 50 to 65% on dry weight basis. It comprises of sugars which are monosaccharides, their derivatives and oligosaccharides. The carbohydrates contain some amount of alcoholic sugar, such as mannitol and trehalose. Trehalose is known to synthesize stress-responsive factors in human cells when exposed to environmental stresses like heat, cold, oxidation, desiccation etc by retaining cellular integrity. The possible mechanism behind this is the prevention from protein denaturation which usually degrades under stress conditions [6]. Mushrooms rich in proteins contain all the essential amino acids and of these the rich ones are glutamic acid, aspartic acid and arginine. Besides these, the two unusual amino acids γ-amino butyric acid (GABA) a non essential amino acid and ornithine which are known for their peculiar physiological activities have also been found [7].

Mushrooms contain unsaturated fatty acids with total lipid (crude fat) content 20–30 g kg^{-1} DM. They are found to be rich in linoleic and oleic acids [8]. Linoleic acid has been reported to exhibit anti-carcinogenic effects on almost all stages of tumorigenesis in animal models of breast, prostate, and colon cancers and also in reducing the tumor cell growth by altering the 5-lipoxygenase metabolite, 5-hydroxyeicosatetraenoic acid (5-HETE) and expressing the five-lipoxygenase activating protein (FLAP) [9]. Linoleic acid is also a precursor of 1-octen-3-ol (an alcoholic group of mushrooms) which is the key aromatic compound contributing to mushroom flavour [10]. The lipid fraction of mushrooms contains tocopherol an important antioxidant component. Mushrooms are good reservoir of vitamins specially vit. B complex and vit. D. Interestingly mushrooms are the only non animal based food that contains vit. D [11–13]. Recent studies have indicated that mushrooms when exposed to UV light under certain conditions produces vit. D_2 in amounts greatly higher than that that of daily requirements of vitamin D [14–16]. The process of vit D_2 formation takes place through a higher than that of daily requirements photochemical reaction in which fungal sterol, ergosterol, is converted to vitamin D_2 through a series of photochemical and thermal reaction catalyzed by ultraviolet (UV) radiation coming from sunlight [17].

Mushrooms are rich in potassium, calcium, phosphorus and magnesium. Sodium is relatively less in mushrooms and hence they are thought to be a good option amongst other vegetables for the hypertensive people [18]. Fresh mushrooms with soluble and non- soluble fibers are proved to lower the total cholesterol levels and thereby good in managing cardiovascular diseases [19]. The presence of dietary fiber (DF) with non dietary carbohydrates (NDCs) including β - glucans, polysaccharides-protein Complexes (PSPC), chitin, hemicelluloses, mannans, xylans and galactose provides a wide range of health benefits to the humans. Mushrooms also contains large number volatile compounds which are inbuilt with some enzyme system that are capable of catabolising aromatic substrates, the major one's are 3-octone, 3-octanol, 1-octen 3-ol, benzaldehyde, octanol, and 2-octen-1-ol (Table 1).

2.1. Bioavailability of nutrients

Certain diseased conditions require specific nutrient management. Bioavailability refers to the nutrient absorption and utilization in the body and is affected by many factors. Mushrooms are excellent functional foods and contain selenium, vitamin D_2, ergothioneine, Vitamin B_1 and Iron etc. It is interesting to mention that the bioavailability of any nutrient depends on the mushroom variety [28]. Mushroom contains 0.4–2.0 mg/g (dry weight) of ergothioneine (sulfur containing amino acid) [29]. Various researchers have reported good bio availability of ergothioneine

Table 1
The comparative information about the proximate composition (g/Kg) and energy value (kcal/Kg) of some edible mushrooms.

Species	Dry matter	Crude protein	Ash	Lipid	Carbohydrates	Energy	References
Agaricus bisporus(white)	87.3	140.8	97.4	21.8	740.0	325	Kalac [20]
Agaricus bisporus (brown)	83.6	154.3	113.6	16.7	715.4	303	Kalac [20]
Pleurotus eryngii	110.0	110.0	61.8	14.5	813.7	421	Kalac [20]
P. ostreatus	106.0	284.0	86.0	47	354.0	–	Ahmadetal. [21]
Lentinus Edodes	202.2	228	60	21	644	411	Bisen et al. [22]
Volvariella volvaceae	90.3	280	10	33	503	305	Mashandete & Cuff [23]
Auricularia auricular	94	360	52	43.7	285	–	Usha & Sugune [24]
Flammulina velutipes	121.3	176.0	74.3	28.9	731	378	Reis et al. [25]
Calocybe gambosa	90.8	154.6	138.9	83	698.2	317	Vaz et al. [26]
Calocybe indica		214	131	49.5	485	320	Alam et al. [27]