Functional Properties of Edible Mushrooms

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INTRODUCTION

Wild mushrooms have a worldwide distribution. It is not known how many mushroom species exist; some experts estimate that they number in the tens of thousands. It has been claimed that <10% of mushroom species are edible and a roughly equal proportion of them is considered to be poisonous. 1 Through trial and error, humans have learned to avoid the poisonous mushrooms. Today, because of the progress in developing innovative cultivation techniques, huge quantities of various cultivated mushrooms are produced and sold throughout the year. The two most popular cultivated mushrooms in the world are the button mushroom (Agaricus bisporus) and shiitake (Lentinus edodes). The first is popular in the West and the latter in the Far East; however, shiitake is also increasing in popularity in the West. 2

Since ancient times mushrooms have been consumed by humans not only as a part of the normal diet but also as a delicacy...
because they have a highly desirable taste and aroma. In addition, the nutritional, tonic, and medicinal properties of mushrooms have been recognized for a long time. Certain ancient religious scriptures such as the Vedas have mentioned their medicinal importance; Romans considered mushrooms to be the Foods of the Gods and the Chinese declared them to be the Elixir of life.3

Mushrooms are quite high in protein (19–35%, including all the essential amino acids) and low in fat. Mushrooms also contain relatively large amounts of carbohydrate and fiber, ranging from 51 to 88% and from 4 to 20% (dry weight), respectively, for the major cultivated species. In addition, mushrooms contain significant amounts of vitamins, namely thiamin, riboflavin, ascorbic acid, and vitamin D2, as well as minerals.2,4 In addition to their nutritional value, some mushrooms popular in the Far East may also have a medicinal value; antitumor, antiviral, and hypolipidemic effects have been reported.2–4 The present paper deals with the last-mentioned of these properties, as well as the vitamin D contents of mushrooms, focusing especially on the shiitake, the most popular mushroom reported to have medicinal properties.

**VITAMIN D AND MUSHROOMS**

Although humans can synthesize vitamin D in the skin through the action of sunlight, the dietary intake of vitamin D compounds is important, especially in northern latitudes. In addition to being efficient in preventing rickets and osteomalacia, vitamin D may also be effective in preventing and treating postmenopausal osteoporosis. Unfortunately, few foodstuffs naturally contain significant levels of vitamin D. Mushrooms are the only non-animal–based food containing vitamin D, and hence they are the only natural vitamin D source for vegetarians. Vitamin D in freeze-dried mushrooms was shown to be available for uptake in humans, which strengthened interest in them as a natural vitamin D source.5

Vitamin D2 contents are considerable in many wild mushroom species. For example, according to Mattila et al.,6 Chantarelles tubaeformis contained vitamin D2 at a concentration of 29.8 μg/100 g fresh weight. As compared to the recommended daily intake for adults7 (5 μg/day), eating 100 g of these mushrooms would fulfill nearly 1 wk’s vitamin D requirement. C. cibarius was also found to contain high concentrations of vitamin D2 (12.8 μg/100 g), whereas other wild mushrooms studied contained 2.9–5.8 μg/100 g. Unfortunately, only trace amounts of vitamin D2 were found in the most popular cultivated mushroom, A. bisporus.6 On the other hand, reasonably high contents have been found in cultivated shiitake (22–110 μg/100 g dry matter).8

Mushrooms cultivated indoors contain lower levels of vitamin D than those cultivated outdoors because the metabolic route from ergosterol to ergocalciferol (vitamin D2) requires sunlight or artificial ultraviolet (UV) light. According to Mau et al.9 and Ono et al.,10 common cultivated mushrooms could be remarkably enriched with vitamin D2 by UV-B irradiation after harvest. This easy way to improve the nutritional value of common mushrooms and make them more functional as a source of Vitamin D is worth noting.

**ANTITUMOR/ANTICANCER ACTIVITY**

The medicinal property for which mushrooms have been most extensively investigated is their antitumor activity. Most of this research has been conducted in Japan. Whole mushrooms of several species and/or extracts from them have been reported to have an antitumor effect: Among these species are A. bisporus, Auricularia auricula, Collybia confluens, Coriolus versicolor, Flammulina velutipes, Ganoderma applanatum, G. lucidum, L. edodes, Pholita nameko, Pleurotus ostreatus, Schizophyllum commune, Tremella fuciformis, Tricholoma matsutake, and Volvariella volvacea.2–4

Ikekawa et al.11 found that intraperitoneal injection of aqueous extracts of six of seven edible mushrooms species tested greatly inhibited the growth of tumors (72–92% versus controls) arising from sarcoma-180 cells implanted in Swiss albino mice. Based on chemical analysis the active antitumor agent in shiitake was suggested to be a polysaccharide. It was later called lentinan and its chemical structure was characterized as β-1,3 glucan, having branching of the 1,6 bonds. In addition, lentinan was proven to exhibit prominent antitumor activity not only in allogeneic hosts, such as sarcoma 180, but also in syngeneic and autochthonous hosts with no noticeable side effects. Furthermore, it can prevent chemical and viral carcinogenesis and cancer metastases. Its effect results from the activation of the host’s immune system.12,13

Until the 1980s, most evidence of the antitumor activity of mushrooms was from studies in which the preparations were administered by injection into test animals. Lentinan and many other polysaccharides extracted from shiitake and other mushrooms were shown to be ineffective when administered orally. Some of the most recent studies on anticarcinogenicity have involved oral administration of powdered, dried mushroom fruiting bodies into mice, and promising results have been obtained.14–16

The antitumor studies conducted with mushrooms thus far are very interesting and do show a potential for providing therapeutic control of cancer. It is, however, difficult to say whether mushrooms, particularly shiitake, could have preventive effects against cancer when consumed as part of the diet. Further epidemiologic and biological research is needed to clarify the role of mushrooms as preventive and curative agents.

**ANTIVIRAL ACTIVITY**

Shiitake mushrooms have been believed to cure the common cold for hundreds of years. More recently, some scientific evidence has been obtained to support this belief. Cochran et al.17 examined extracts of different parts of many different plants and fungi for activity against the influenza virus in vitro and in mice. About 70 species, including apples, beans, and spinach, showed no antiviral activity. Of the mushrooms tested shiitake showed an activity (expressed as the percentage decrease in lung lesion score compared with the control) of 46%, which was of the same magnitude as for amantadine hydrochloride, a common drug against influenza (40%). A watery extract from shiitake was also reported to prevent the multiplication of polio virus.13

According to Chihara,13 lentinan enhanced host resistance against infections with bacteria as well as with fungi, parasites, and viruses, including the agents of AIDS. Lentinan reduced the toxicity of AZT (a drug commonly used for treating HIV carriers and AIDS patients). Prevention of the onset of AIDS symptoms through potentiation of host defense is now being actively investigated both experimentally and clinically.12

In addition to lentinan, other substances from shiitake and other mushrooms have also been shown to have antiviral activity. The mechanism of their effect is in most cases via induction of interferons.2,4,18

In Asia, people have regularly consumed mushrooms, among many other purposes, for preventing and curing colds. However, whether there are benefits to one’s general feeling of well-being is a highly subjective matter. Moreover, the antiviral studies have been performed using various extracts rather than whole mushrooms and there is currently no convincing scientific evidence that consuming mushrooms as a part of the diet could prevent or cure influenza or other viral diseases.

**HYPOLIPIDEMIC ACTIVITY**

Initial research on the cholesterol-lowering effects of mushrooms was performed in Japan and coworkers. Kaneda and coworkers. Kaneda and Tokuda19 demonstrated that when rats were fed a diet supplemented with 5% (dry weight) of shiitake fruiting bodies for 10 wk,
the plasma cholesterol levels of the animals decreased significantly. In addition to shiitake, *A. bisporus* was also effective. The active hypocholesterolemic substance in shiitake was isolated and identified as an adenosine derivative. In addition to animal tests, the effectiveness of shiitake in lowering blood serum cholesterol was also tested in human subjects. Suzuki and Oshima11 found that a daily intake of 90 g of fresh shiitake, 9 g of dried shiitake, and 9 g of UV-irradiated dried shiitake for 7 d lowered the mean serum cholesterol levels in young women by 12%, 7%, and 6%, respectively. All three diets decreased serum cholesterol levels of older persons (>60 y of age) by 9% over 7 d. However, the authors did not provide information on the composition of the whole diets of their subjects.

The relationship between high levels of cholesterol in the blood and cardiovascular diseases is well known. Hence, the cholesterol-lowering effect of eritadenine and shiitake is very interesting, especially as it has been found both in animal tests and in human studies. Furthermore, no enrichment of the active fraction or component is required to achieve the effect, but consuming shiitake mushrooms as part of the normal diet appears to achieve the lowering effect.

**CONCLUSIONS**

It is clear that mushrooms contain some interesting compounds that have been shown in clinical studies to be effective in treating several serious diseases common in developed countries. Unfortunately, results from previous studies have been published mainly in Japanese, which restricts their availability for researchers in Western countries. A common feature of clinical studies published in Western journals is their short duration. To improve understanding of the different facets of edible mushrooms’ medicinal effects, longer studies—lasting the entire life of the test animals—should be conducted.

Mushrooms can be considered to have potential as a functional food. According to studies conducted thus far, mushrooms may strengthen the immune system of both healthy and sick individuals. Furthermore, cholesterol-lowering effects of some mushrooms have been reported in both animal and human studies, and several mushrooms contain significant levels of vitamin D₂. However, published studies on mushrooms are quite limited. Furthermore, in addition to the good compounds many of them also contain bad compounds. Hence, more research is needed to be able to exploit the functional properties of mushrooms.

**REFERENCES**