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Nutritional and Pharmacological Significance of *Boletus edulis*: The King Bolete

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Abstract:
Boletus edulis is a widely consumed and highly valued edible mushroom, known for its unique flavor, nutritional benefits, and medicinal properties. Indigenous to the temperate regions of the Northern Hemisphere, including Europe and North America, it has also been introduced to regions like New Zealand.
The mushroom is often collected both commercially and recreationally, offering culinary value due to its rich flavor, low caloric content, and use in a variety of dishes.
The nutritional composition of *B. edulis* includes a high protein content, essential amino acids, low fat, free sugars, and dietary fibers, making it a nutritionally rich food source. Additionally, the presence of key minerals such as potassium, calcium, and iron enhances its dietary significance.
B. edulis is also recognized for its pharmacological benefits, including anti-cancer, anti-inflammatory, hepatoprotective, and antioxidant activities. Polysaccharides, lectins, and glycoproteins found in *B. edulis* play a crucial role in its medicinal effects, contributing to immune modulation, tumor suppression, and liver protection.
Due to its seasonal availability and high moisture content, drying *B. edulis* is a common method to prolong shelf life. Its bioactive compounds and health-promoting properties suggest potential applications in food supplements and functional foods, providing significant benefits for human health, including the prevention of oxidative stress, viral infections, and constipation.
Boletus edulis continues to be a significant focus of research, highlighting its nutritional value and therapeutic potential in modern diets and medicine.
Keywords: Nutritional composition, Polysaccharides, Medicines.

Introduction

Edible mushrooms are an important part of the world's culinary heritage and have long been appreciated for human consumption. 1)
Edible mushrooms have sparked considerable interest because of their distinctive flavor, texture, and low calorie content. 2)
In ancient times, mushrooms were used for their unique and delicate flavor in soups, sauces, and other culinary dishes. Recently, they have gained popularity as functional foods and as a source of health-promoting compounds, offering physiological benefits without harmful side effects. 2)
Commercial mushrooms have been found to possess medicinal properties and are used in various treatments, including immunomodulation, antiviral, and antitumor therapies. 2)
Boletus edulis is one of the most highly prized wild mushrooms. Due to its seasonal nature and short shelf life, which is affected by its high moisture content, drying is an effective method to extend its availability. 3)
Boletus edulis Bull., an edible mushroom also referred to as Fr sensu lato, is a recent addition to New Zealand's records, though it has long been popular in Europe, North America, and Asia. Fruiting occurs from late January to early April, typically under Quercus spp., Fagus sylvatica, and Betula pendula. 4)

There are several fungal species on the list that have been connected to *B. edulis.* By outlining the microscopic features of the mycorrhiza and fruiting bodies collected in Christchurch, New Zealand, the development of hymenial elements on the stem before their growth on the fruiting bodies is highlighted. 4).

Boletus edulis Bull., commonly known as the king bolete, is a tubular hymenophore and a symbiotic ectomycorrhizal species. 1)

This fungus is native to the temperate regions of the northern hemisphere, including Europe, and has also been widely reported in North America.1)*B. edulis* is a popular wild mushroom frequently harvested by both commercial and recreational mushroom hunters. In Poland, 5,212 tonnes of fresh wild mushrooms were collected for commercial use in 2014, with 795 tonnes of these being *B.dulis*. 1)

Fig. *Boletus edulis*

Chemical profiles of *Boletus edulis*:

1) Nutritional composition: Nutritional contents the macronutrient and micronutrient contents of the fruiting body of *Boletus edulis* have been the focus of most research on the plant's nutritional makeup. The morphological components of the fruiting body are the stipe and cap. *B. edulis* is often regarded as a delicacy with excellent protein and low fat and calorie content.

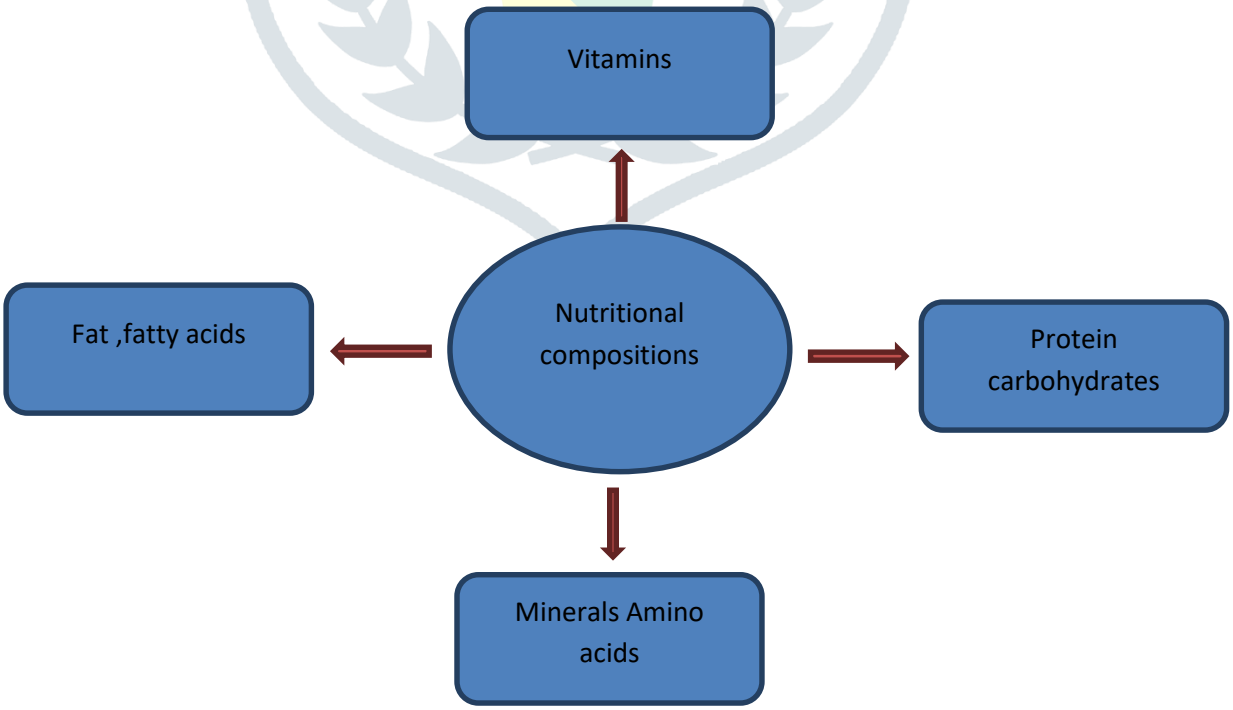

Figure 1

2) Proximate compositions: When evaluating the nutritional status of mushrooms, the dry matter/moisture content is the most crucial factor to consider, as it directly influences their nutritional value.

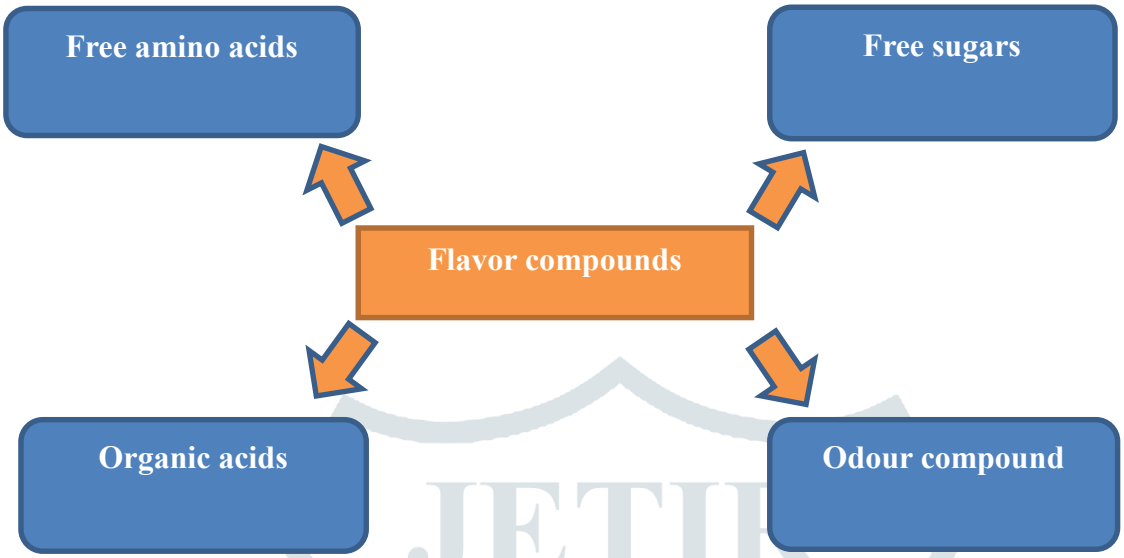

Figure 2

3) Free sugars and fibers: The free sugar content of *B. edulis* varies significantly, ranging from 14.4 g/100 g in Poland to 59.9 g/100 g in Croatia. While arabitol, fructose, mannose, and myo-inositol were detected in only one region, mannitol and trehalose were the only primary sugars present in all samples from the four regions. Overall, the sugar levels of *B. edulis* remained consistent, except for samples from Croatia, which showed an additional 36.2 g/100 g of mannose.

4) Amino acids: The highest total amino acid content was found in *B. edulis* from Finland (26.6 mg/g DM), Yunnan, China (21.5 mg/g DM), Taiwan, China (9.0 mg/g DM), and Croatia out of the four sites. In mushrooms from Yunnan, China; Croatia; and Finland, nine essential amino acids (EAA) were found: histidine, isoleucine, leucine, methionine, phenylalanine, tryptophan, valine, threonine, and lysine.

5) Minerals: The most abundant minerals in *B. edulis* are potassium (K), calcium (Ca), sodium (Na), and iron (Fe). The potassium concentrations in samples from Shanxi, China (26.2 g/kg DM) and Sweden (28.0 g/kg DM) were significantly higher compared to those found in *B. edulis* grown in Tibet, China.

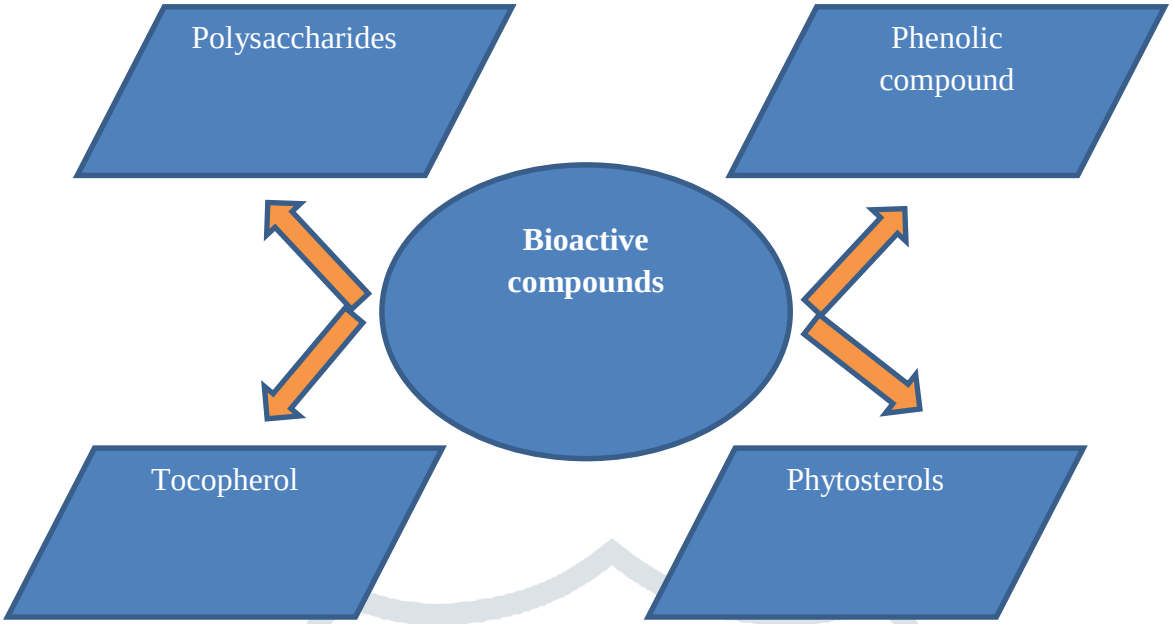

Figure 3

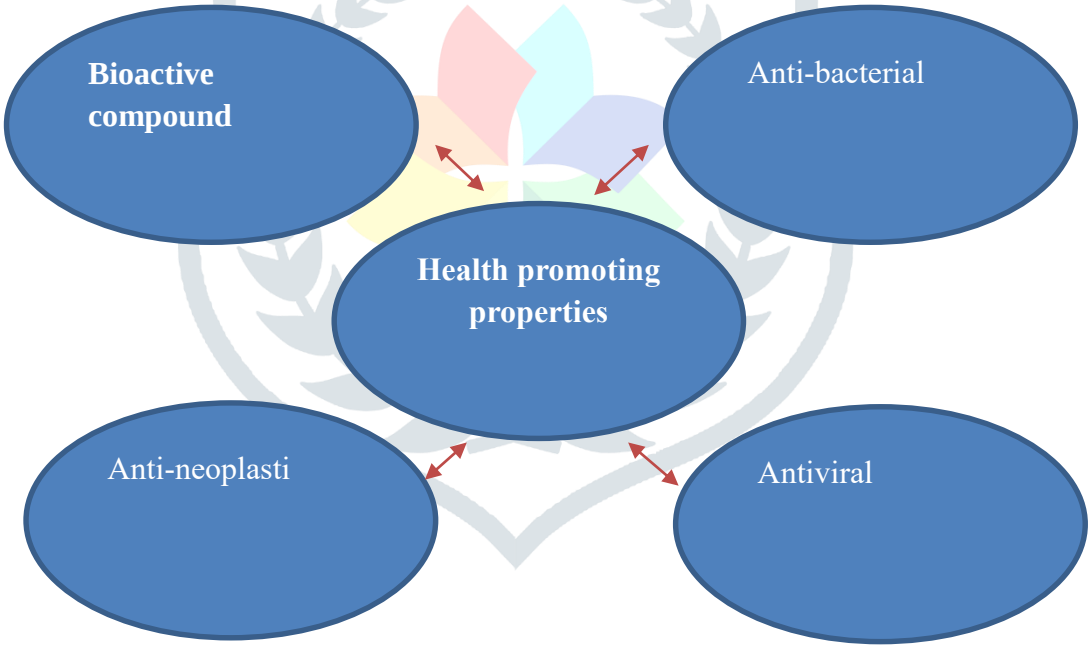

Figure 4

Pharmacological profile of *boletus edulis*:

1) Anti-neoplastic activity:

The fruiting body of *B. edulis* contains various bioactive compounds with anticancer properties, including polysaccharides, lectin, biopolymers (such as polysaccharides and glycoproteins), and unique proteins.

In studies involving tumor-bearing mice, polysaccharides extracted from *B. edulis* enhanced the immune response, indirectly indicating a strong antitumor effect. (1)

Furthermore, research has shown that a newly discovered acidic polysaccharide from *B. edulis* exhibits significant anticancer activity by inhibiting the growth of breast cancer cells and inducing cell death through reactive oxygen species (ROS)-mediated pathways. (1)

2) Anti-inflammatory activity:

Polysaccharides from *B. edulis* alleviated inflammation in female BaLB/c mice with ovalbumin-induced asthma. (1)

These polysaccharides decreased immune marker levels, alleviated symptoms of asthma (such as airway resistance), and improved histological findings (including the thickening of the alveolar wall, damage to lung bronchial epithelial cells, and peribronchial inflammatory cell infiltration). (1)

Additionally, the administration of polysaccharides increased the levels of IL-4 and IFN-γ (both protein and mRNA) in lung tissue and Broncho alveolar lavage fluid, enhancing anti-inflammatory effects. (1)

3) Hepato-protective effect:

The hepatoprotective effects of *B. edulis* polysaccharides were investigated in a rat model subjected to a high-fat and high-sugar diet as well as streptozocin-induced type 2 diabetes mellitus (T2DM). (1)

The results showed that the polysaccharides significantly inhibited the rise in fasting blood glucose, triglycerides, alanine aminotransferase (ALT), and aspartate aminotransferase (AST) levels in the serum associated with T2DM. (1)

Additionally, these polysaccharides markedly increased the levels of glutathione (GSH) and the activities of catalase (CAT), superoxide dismutase (SOD), and glutathione peroxidase (GSH-Px) in the liver while reducing malondialdehyde (MDA) levels. This suggests that their protective effects on the liver may be linked to their antioxidant properties. (1)

4) Anti- bacterial and antiviral activity:

There have been reports of several *B. edulis* formulations having useful antiviral and antibacterial qualities. (1)

B. edulis aqueous extract has shown strong antibacterial activity against Escherichia coli, Pseudomonas aeruginosa, Klebsiella pneumoniae, and Acinetobacter baumannii. (1)

Petroleum ether, ethyl acetate, n-butyl alcohol, and aqueous solvent extracts of *B. edulis* were further tested for their antibacterial properties utilising the broth microdilution method and agar diffusion procedures.

Proteus vulgaris, P. aeruginosa, and E. coli were all shown to be inhibited in growth to differing degrees by these solvent extracts. (1)

5) Intervention of constipation:

Edible mushrooms, particularly due to their high polysaccharide content, especially dietary fibre, may serve as both a preventive and therapeutic food for constipation. (1)

In mice with induced constipation, soluble dietary fibres extracted from *B. edulis* enhanced the propulsion rate of the small intestine in a dose-dependent manner. (1)

The effects observed in the high-dose group (400 mg/kg) were comparable to those of the positive control group treated with lactulose at 200 mg/kg. (1)

These findings confirm the efficacy of *B. edulis* dietary fiber in relieving constipation. (1)

6) Antioxidant activity:

Bioactive compounds extracted from *B. edulis* enhanced antioxidant levels in rats and protected cells from oxidative damage. (1)

The polysaccharides derived from *B. edulis* increased the activity of superoxide dismutase (SOD) in erythrocytes and improved superoxide radical scavenging in vivo. (1)

Additionally, *B. edulis* polysaccharides lowered malondialdehyde (MDA) levels and prevented liver damage in mice by boosting glutathione activity, glutathione peroxidase, and liver SOD levels, which significantly reduced hepatic lipid peroxidation. (1)

Conclusion:

Boletus edulis, commonly known as the king bolete, is a prized edible mushroom with a rich gastronomic heritage. Native to temperate regions of Europe and North America, and recently recorded in New Zealand, it is valued for its unique flavor, texture, and low calorie content. Besides its culinary uses, *B. edulis* is notable for its nutritional composition, containing proteins, amino acids, minerals, and sugars that vary by region. It also possesses significant bioactive compounds, contributing to its pharmacological potential.

The mushroom exhibits various health-promoting properties, including anticancer, anti-inflammatory, hepatoprotective, antibacterial, antiviral, and antioxidant effects. Its polysaccharides, in particular, play a critical role in boosting immune responses, combating oxidative stress, and protecting against liver damage. Additionally, *B. edulis* dietary fibers have demonstrated therapeutic potential in alleviating constipation**.**

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