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Review Article

Mushroom Meal Supplementation as Prebiotic Sources in Poultry Nutrition: A Review

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Abstract

Mushrooms are fleshy, spore-bearing fungi grown above ground. Mushrooms have a cap (pileups), stem (stipe), and lower cap gills (lamellae) or pores. The mushroom fungus produces millions of small spores under its top instead of seeds. Among common edible mushroom Shiitake (*Lentinula edodes*), the second most grown edible mushroom, accounts for 25% of production. Shiitake is a complete nutritional diet since it has all nutritional components protein, lipids, carbohydrate (CHO), polyunsaturated fatty acid (PUFA) content, vitamins minerals and fibers. Shiitake mushrooms have gained widespread recognition for their diverse bioactivity, which includes antifungal, antibacterial, antparasitic, antiviral, antioxidant, anti-inflammatory, anti-proliferative, cytotoxic, anticancer, antitumor, hepatoprotective, hypocholesterolemic, antidiabetic, and anticoagulant effects. The use of growth promoter drugs in chicken feed has raised concerns about the emergence of antibiotic-resistant bacteria, which has put both human and animal health at risk. Consequently, issues with animal performance, feed conversion ratio, agitation, and an increase in the prevalence of specific animal diseases have resulted from the withdrawal of antibiotics as growth promoters.

Keywords

Immune Responses, Mushroom Meal, Prebiotic Sources

1. Introduction

The word "mousseron" refers to a group of both edible and hazardous species. The fleshy fruiting body of a fungus that bears spores developed above ground is called a mushroom. A mushroom usually consists of gills (lamellae) or pores on the underside of the cap, a stem (stipe), and a cap (pileups). The mushroom fungus produces millions of microscopic spores under the mushroom's crown rather than seeds. The spawn, or mushroom seed, is made in a laboratory, while the fruiting culture of the mushroom can be mostly collected from other areas and cultured on substrates such as plant wastes (cereal straw or sugarcane bagasse), salts (urea, superphosphate, or gypsum), supplements (rice bran or wheat bran), and water at the proper temperature and humidity is utilized to create the compost substrate that will be used to grow mushrooms [1].

Shiitake makes over 25% of the world's edible mushroom production, making it the second most popular kind [2]. The high percentage of polyunsaturated fatty acids (PUFAs), low lipid content, high protein content, vitamins, minerals like potassium, and fibers that promote gut health and aid in digestion make shiitake a complete nutritional food type [3]. The polysaccharides and β-glucans found in shiitake mushrooms (Lentinula edodes) strengthen poultry's immune sys-

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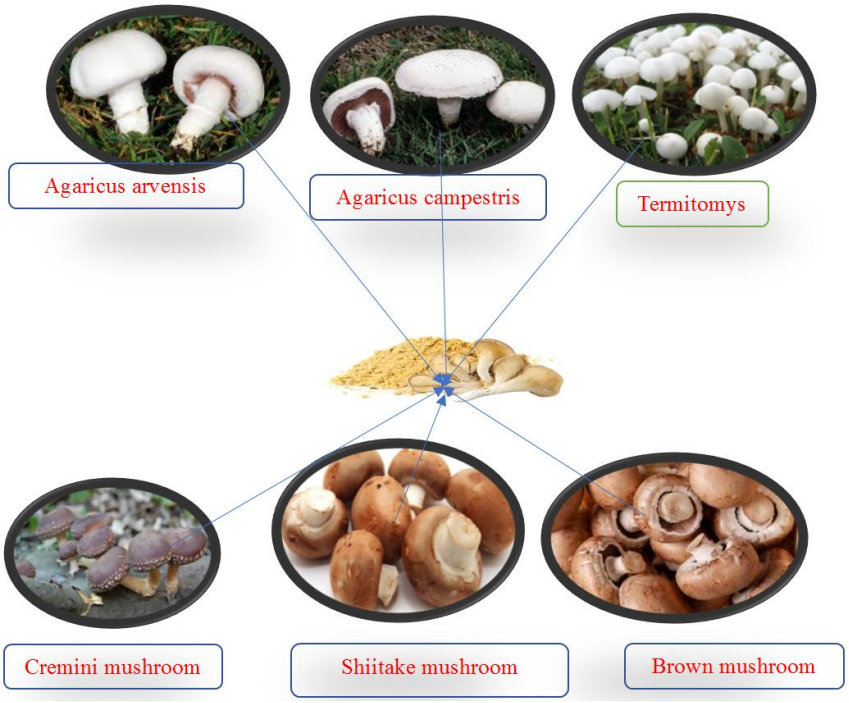
tems. Lentinan may have indirect anticancer and antimicrobial effects because it has been shown to activate T lymphocytes, macrophages, and other immune effector cells that regulate cytokine release [4]. Antifungal, antibacterial, antparasitic, antiviral, antioxidant, anti-inflammatory, anti-proliferative, cytotoxic, anticancer, antitumor, hepatoprotective, hypocholesterolemic, antidiabetic, and anticoagulant properties are some of the bioactivity properties that have made shiitake mushrooms well-known [5].

Lipids containing polyunsaturated fatty acids undergo oxidation, producing ROS such hydroxyl radicals. According to Cintia *et al.* [6], shiitake's antioxidant components can lessen the damage that reactive oxygen species (ROS) cause to tissue. The use of growth promoter drugs in chicken feed has raised concerns about the emergence of antibiotic-resistant bacteria, which has put both human and animal health at risk. According to Hossan *et al.* [7], the elimination of antibiotics as growth promoters has consequently resulted in issues with animal performance, feed conversion ratio, agitation, and an increase in the prevalence of specific animal diseases.

2. Taxonomical Classification of Mushrooms

According to modern classification, which is based on R-DNA sequences, the kingdom Fungi is divided into four phyla: Zygomycota, Chytridiomycota, Basidiomycota, and Ascomycota [8]. Mushroom can be studied by biological called mycology belonging to a separate kingdom, being neither plants, nor animals. They are being classified in the kingdom of fungi [9].



Sources: Boushra et al. [10]

Figure 1. *Common Edible Types of Mushroom.*

2.1. Nutritional Value of Shiitake Mushroom

The term "fruiting body" is now used to describe the above-ground portion of fungus that is edible [11]. A mushroom is a fungus's fleshy, spore-bearing fruiting body that is normally produced above ground. Typically, a mushroom has a cap (pileups), a stem (stipe), and gills (lamellae) or pores on the lower side of the cap. It is a wood-decaying white-rot fungus that naturally inhabits the dead wood of many hardwood tree species under various climatic conditions. Shiitake can be cultivated using sawdust-based substrates; maize straw and sawdust as a most popular basal ingredient used in the production of shiitake [12].

There are thousands of species of mushrooms in the world; however, only about 25 varieties are cultivated with culinary characteristics and medicinal properties [13].

Among those varieties, is the Lentinula edodes (popularly known as shiitake). Shiitake is the second most cultivated edible mushroom in the world, accounting for 25% of the production [2].

Shiitake is a complete nutritional food type because it has low lipid content, high protein content, high percentage of poly-unsaturated fatty acids (PUFAs), vitamins (B1, B2, and

B3), vitamin D), minerals such as potassium, selenium, and phosphorus and fibers which enhances gut health and supports digestion [3].

Table 1. *Proximate Analysis of edible Mushroom (SM).*

Edible mushroom	Protein	CHO	Lipid (fat)	Fiber	Ash (Mineral)	References
Shiitake mushroom (Lenticular edodes)	18.5-35	50-65	2-6	9-10	4-5	Sara *et al.* [3].
Horse mushroom (Agaricus arvensis)	20-38	33-48	1-6	2-18	2.3-14	Boushra *et al*. [10]
Termite mushroom (Termitomys)	25.5-30	46.44	2.3	10-11	9.56	Soumitra *et al*. [14]
Brown mushroom (Cremini)	22.6-36	60-61	3-7	7.9	4-10	Nwagu. [15]
Buttom mushroom	25.1	52.7	1.4	2.9	9.3	Maria et at. [16]

2.2. Immunomodulatory Effects of Mushroom

Shiitake mushrooms (SM) (Lentinula edodes) have long popularity as a traditional drug and health food in East Asian countries. SM has good contents of polysaccharide medicines such as Lentinan and eritadenine. These compounds are well-known as a type of immunostimulant that possesses antitumor and antiviral properties [17]. Shiitake Mushrooms (*Lentinula edodes)* contain β-Glucans and polysaccharides that enhance the immune system of poultry. The compound Lentinan has been found to activate macrophages, T lymphocytes and other immune effector cells that modulate the release of cytokines, which may in turn account for its indirect antitumor and antimicrobial properties [4].

Shiitake mushrooms are popularly known by exerting different bioactivity properties acting as antifungal, antibacterial, antparasitic, antiviral, antioxidant, anti-inflammatory, anti-proliferative, cytotoxic anticancer, antitumor, hepatoprotective, hypocholesterolemic, antidiabetic, and anticoagulant properties [5].

The beneficial properties of bioactive compounds in shiitake mushrooms show their potential as performance-enhancing natural feed additives in livestock. Reports exist on the therapeutic and biological effects of mushroom use in poultry [18].

These studies indicate that mushrooms impact birds positively as they increase growth performance, modulate the immune response, improve gut health, exert tissue antioxidant activity, influence intestinal morphology, and improve lipid profile [19].

The bioactive compounds β-Glucans and Lentinan present in the shiitake mushrooms used to modulate the immune system and used to enhance innate and adaptive immune responses and act as antioxidant and anti-inflammatory effects. These bioactive compounds improve the macrophage activity and lymphocyte proliferation in reducing oxidative stress and inflammation in tissues. These effects make Shiitake mushrooms a valuable alternative to antibiotic growth promoters (AGPs), particularly in immune-challenged flocks [20].

2.2.1. Antimicrobial and Antioxidant Properties of Mushroom

In addition to their nutritional potentials, mushrooms are also good sources of physiologically beneficial bioactive substances that promote good health. They produce a wide range of secondary metabolites with high therapeutic value. Mushrooms exhibit natural antimicrobial effects against pathogenic bacteria such as E. coli and Salmonella [21].

Their antioxidants help reduce oxidative stress, improving overall bird health and performance. The oxidation proceeds in lipids with polyunsaturated fatty acids, generating ROS such as hydroxyl radicals. Antioxidant compounds of shiitake can reduce the action of reactive oxygen species (ROS) in tissue damage [6].

2.2.2. Growth Performance and Feed Efficiency

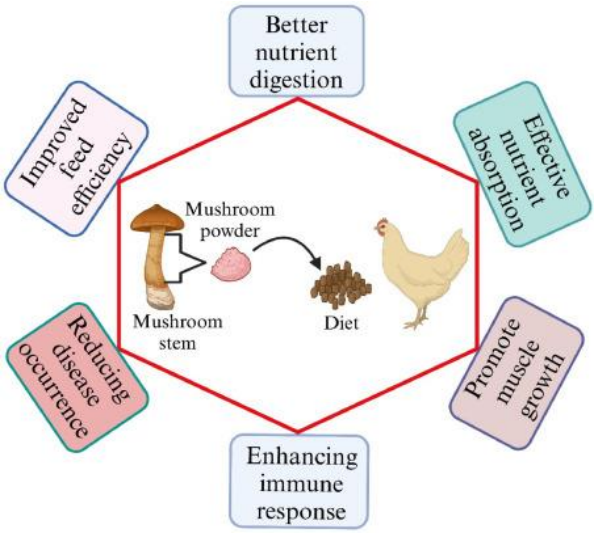
The continuous and over application of growth promoter antibiotics in poultry feed has created public and animal health hazards because of concern over the development of antibiotic resistant bacteria. Therefore the removal of antibiotics as growth promoters has then led to animal performance problems, feed conversion ratio, incensement, and a rise in the incidence of certain animal diseases [7].

Consequently, there has been a growing interest in finding viable phytogenic or plant-derived replacements of antibiotics in poultry feed for production enhancement and disease prevention and nowadays, mushrooms have been investigated as safe alternative natural products to be included in poultry diets [22]. Supplementing broiler or layer diets with mushroom powder or extracts (1-5%) has been linked with: Better weight gain, improved feed conversion ratio (FCR) and Enhanced carcass quality.

2.2.3. Gut Health and Micro Biota

Recent research mostly focused on mushroom species as alternative feed additives to promote growth in farm animals; however there is quite limited information in literature about the potential use of Shiitake mushroom in animal feeding [23].

Shiitake mushroom had low calorie and high vitamin, protein and mineral contents and had various functional characteristics such as antitumor, antimicrobial, antioxidant and hypocholesterolemic effects such attributes, Shiitake mushroom would be a possible candidate as a new and natural growth-promoter substance for poultry diets [22]. Mushroom components support beneficial gut flora and suppress harmful bacteria, leading to better nutrient absorption and growth. With the ban or reduction of antibiotics in poultry, mushrooms serve as a natural alternative for promoting growth and disease resistance [24].



Sources: Mohammad *et al.* *[5]*

Figure 2. *Nutritional Effect of Mushroom Meal.*

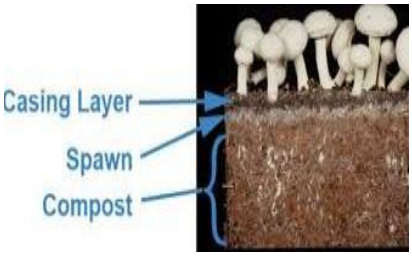
2.3. Mushroom Production and Processing

Mushroom cultivation started from preparing of good compost, reliable and productive spawn (seeds) and monitoring the right temperature and humidity during growing period [25].

Natural compost is prepared from horse dung, chicken manure, wheat or barley and maize straws. Mushroom can grow at optimum temperature of 24-25 ℃ producing white cottony mycelium spreads and permeate through the compost. It takes around 12 to 15 days for the complete spawn running. The casing soil is spread over plastic sheet and formalin will be applied and stirred frequently for a week to remove formation of gases. After casing the temperature has to be maintained at 24-25 ℃ for three days then lowered to 18 ℃ [26].

Table 2. *Steps of Mushroom Production and Processing.*

Steps	Demonstrative image	Methods
1. Compost preparation		Mixing and wetting the ingredients from horse dung, chicken manure wheat or barley and maize straw in a rectangular pile with tight sides and a loose centre. Water is sprayed

Steps	Demonstrative image	Methods
2. Finishing compost		Pasteurization is necessary to kill any insects, nematodes, pest fungi, or other pests that may be present in the compost. Removing the ammonia to a lower than 0.07%
3. Spawning		Production of microscopic spores on mushroom gills lining the underside of a mushroom cap. These spores function similar to the seeds of a higher plant.
4. Casing		Top dressing applied to the spawn-run compost with mixture of peat moss with ground limestone. Casing does not need nutrients but acts as a water reservoir and a place where rhizomorphs form.
5. Pinning		Pins continue to expand and grow larger through the button stage, and ultimately a button enlarges to a mushroom.
6. Cropping/harvesting		Picking mature mushrooms by (cutting, twisting, or pulling) depending on the mushroom type and desired stage of maturity. The harvesting time depends on factors like temperature, humidity, and mushroom cultivar

Sources: Kratika. [1]

3. Conclusion

Supplementation of Mushroom meal, in poultry nutrition gained currently promise as a prebiotic source, contributing various benefits for poultry growth, health, and productivity. Mushrooms can be utilized in different forms like powders or extracts, improving feed utilization and modulate the gut microbiome, as well as antioxidant activity leading to reduced pathogenic bacteria and increased beneficial bacteria and therefore improving egg and meat quality, making them a valuable addition to poultry diets.

Mushrooms are considered as a complete nutritional food type because mushrooms contains all complete nutritional value and acting as antimicrobial, antioxidant properties, boosting gut health and controlling and adjusting gut micro biota and promoting growth and overall enhancing performance and feed efficiency in poultry nutrition. Mushrooms constitute low lipid (fat) content, but high protein, different poly-unsaturated fatty acids (PUFAs), vitamins (B1, B2, and B3), vitamin D), minerals such as potassium, selenium, and phosphorus and fibers which enhances gut health and supports and facilitate digestion processes.

Abbreviations

AGPs	Antibiotic Growth Promoters
CHO	Carbohydrate
FCR	Feed Conversion Ratio
PUFAs	Polyunsaturated Fatty Acids
ROS	Reactive Oxygen Species

R-DNA	Recombinant– Deoxyboneuclic Acid
SM	Shiitake Mushroom

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Author Contributions

Seyoum Bekele Alemu: Methodology, Investigation, Data curation, Formal analysis, Writing − original draft, Conceptualization, Writing − review & editing.

Meseret Girma Abebe: Validation, Formal analysis, Writing − review & editing, Project administration, Funding acquisition, Conceptualization, Methodology, Supervision.

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Conflicts of Interest

The authors declare no conflicts of interest.

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