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Schizophyllum commune: A comprehensive review of its nutritional value, phytochemistry, and pharmacological activities

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Abstract
Schizophyllum commune is a widely distributed edible basidiomycete mushroom recognized for its nutritional, medicinal, and therapeutic potential. It is commonly found on hardwood and bamboo substrates and is traditionally consumed in several Asian and African regions. Rich in proteins, carbohydrates, dietary fiber, vitamins, and essential minerals, *S. commune* serves as an important dietary supplement, especially in developing countries. Phytochemical investigations reveal the presence of bioactive compounds such as alkaloids, flavonoids, phenolics, saponins, tannins, terpenoids, and polysaccharides, which contribute to its diverse biological activities. Numerous studies have demonstrated its antioxidant, antimicrobial, antifungal, antiviral, antitumor, anticancer, anti-inflammatory, antidiabetic, hepatoprotective, neuroprotective, and immunomodulatory properties. Schizophyllan, a major polysaccharide component, plays a crucial role in immune modulation and anticancer activity. Additionally, *S. commune* exhibits acetylcholinesterase inhibitory effects, highlighting its potential in managing neurodegenerative disorders. Traditional uses, combined with modern scientific evidence, emphasize its significance in functional food and pharmaceutical applications. This review compiles information on taxonomy, morphology, phytochemistry, nutritional composition, and pharmacological activities of *S. commune*, aiming to support further research and promote its utilization as a natural source of therapeutic agents and nutraceutical products.

Keywords: Schizophyllum commune, phytochemical constituents, nutritional value, medicinal mushroom, bioactive compounds, pharmacological activities

Introduction

Mushrooms are fleshy, spore-producing fruiting bodies of basidiomycete fungi, usually growing above the ground on soil or on their food source. The FAO recommends edible mushrooms as a valuable food option to help meet the protein needs of developing countries, where many populations rely heavily on cereals as their main diet. Generally, edible mushrooms are low in fat and calories and are rich in vitamins such as B, D, and K, and in some cases, vitamins A and C [1]. They contain more protein than most other plant-based foods and are also an excellent source of essential mineral nutrients [2]. Fungi usually grow abundantly during the rainy season and are often found on dead wood [3].It is also known as the split gill mushroom and typically grows on hardwood logs or bamboo surfaces, either scattered or in clusters. It produces unique enzymes that can degrade lignocellulosic biomass. The genome has been reported to contain 240 genes that encode glycoside hydrolases. Distribution records indicate that it occurs on every continent except Antarctica, where the absence of wood prevents it from growing [4]. The mushroom has been reported to be consumed in Mexico, parts of Nigeria, and several Asian countries. In India, its edibility has been documented mainly in the northeastern states, including Manipur, Mizoram, and Tripura [5]. Affordable alternatives to costly healthy diets should be explored across different regions, cultures, and traditions worldwide to identify potential solutions to food insecurity [6]. The delicacy prepared from *S. commune* is regarded as a specialty and is deeply embedded in the culture and traditions of the community in Manipur. Details regarding its method of preparation, nutritional value, and the secondary metabolites identified are presented here [7]. Within this fungal genus, 15 species have been described in the Index Fungorum database, including *S. album* Rick, *S. amplum* (Lév.) Nakasone, *S. commune* Fr., *S. brasiliense* W.B. Cooke, *S. brevilamellatum* Linder, *S. fasciatum* Pat., *S. leprieurii* Linder, *S. murrayi* Massee, *S. palmatum* Jungh. ex W.B. Cooke, *S. umbrinum* Berk., *S. radiatum* Fr., *S. variabile* Sorokin, *S. lobatum* Went, *S. mexicanum* Pat., and *S. miia* (Scop.) Fr. According to MycoBank, the genus *Schizophyllum* comprises 21 species. However, ex-type strains are unavailable for many of the described species, and only a limited number of expert-recognized strains—such as *S. commune*, *S. fasciatum*, *S. radiatum*, and *S. umbrinum*—have been deposited in public culture collections.

Previously, *S. commune* and *S. radiatum* were considered conspecific because of their morphological similarities and ITS rDNA sequence resemblance. Nevertheless, multigene analyses have confirmed that although they are closely related and similar in appearance, they represent distinct and independent taxa.

Schizophyllum commune has been reported to exhibit a wide range of biological activities, including antidiabetic, anti-inflammatory, antimicrobial, antioxidant, antitumor, anti-tyrosinase, immunomodulatory, neuroprotective, cytotoxic, genotoxic, antibacterial, antifungal, antiviral (including anti-dengue), hypoglycemic, immunostimulant, and anticancer properties [8]. Mushrooms are rich sources of bioactive compounds, including polyphenols, flavonoids, alkaloids, saponins, tannins, and trehalose. Owing to these therapeutic

properties, they have long been used in traditional medicine [9]. The term *Schizophyllum* originates from the Latin words "schizo," meaning split, and "phyllum," meaning lamella or membrane [10]. The species was named *commune* because of its widespread growth, and its spores can disperse over long distances, resulting in considerable genetic variation both within and between populations due to genetic drift [11].

Synonyms [12]

Synonyms of *Schizophyllum commune* include:

- *S. fasciatum*
- *S. umbrinum*
- *S. leprieurii*
- *S. brasiliense*
- *S. lobatum*
- *S. variabile*
- *S. Palmatum*

Common names [13]

Language	Names
Manipuri	Kanglayen
Mizoram	Pasi
Arunachal Pradesh	Hubsi
Indonesia	Tanggidi
Bengali	Pakha chhatu
Kannada	Birukulli anabe
Urdu	Kulat Kodop

Taxonomy: *Taxonomic classification of* S. commune [11, 14].

Kingdom	***Fungi***
Phylum	*Basidiomycota*
Order	*Agaricales*
Class	*Agaricomycetes*
Sub-class	*Agaricomycetideae*
Family	*Schizophyllaceae*
Genus	Schizophyllum
Species	commune

Origin and distribution [11, 15]

Schizophyllum commune has a wide geographic distribution, occurring in several Asian countries, including Thailand, Taiwan, Malaysia, Vietnam, and southern regions of China, as well as in Mexico. Within Indonesia, it is found on Sumatra Island, and in southern Thailand. In India, the species occurs mainly in the northeastern states, including Manipur, and in West Bengal.

Plant Morphology

The fruiting bodies shrink during dry weather, displaying colors ranging from light grey to brown, with the hymenophore located only on the underside. The marginal growth is clearly noticeable. This fungus belongs to the Basidiomycetes and is commonly referred to as "split-gilled fungi" or "split fungi [16]. The gills serve as the site for basidiospore production. During the dry season, the splits in the gill regions close, protecting the fertile areas as the fruiting body shrivels, and reopen when favorable environmental conditions return. This reopening exposes the spore-producing structures, allowing spores to be released [17, 18].

Phytochemical constituents [19, 20]

Most studies investigating the specific bioactivities of *S. commune* focus on the effects of its extracts while identifying the compounds responsible for these activities. Analysis of ethanolic (EtOH) extracts of *S. commune* has revealed the presence of saponins, tannins, alkaloids, flavonoids, terpenoids, proteins, and carbohydrates.

Bioactive compound (mg/100 g)	
Alkaloids	4.26
Flavonoids	4.67
Phenolics	10.8
Saponins	23.83
Tannins	1.24

Nutritive properties [21]

Protein	**18.83**
Fat	3.45
Carbohydrates	66.06
Fibre	(0.044%)

Pharmacological activities of *Schizophyllum commune*

1. Antioxidant Properties [9]

Free radicals are highly unstable molecules that can damage cells and tissues by oxidizing biomolecules, potentially leading to cell death. Excessive free radicals are linked to several degenerative conditions, including aging, cancer, cardiovascular disease, Alzheimer's disease, and other chronic illnesses. Antioxidants help control oxidative stress in the body and protect against these diseases.Recent studies have investigated the antioxidant potential of *S. commune* extracts using different assays. The ethanolic extract showed the strongest overall antioxidant activity. According to Chandrawanshi *et al*., the ethanolic extract exhibited the highest DPPH radical scavenging activity (IC50 = 18.56 µg/µl), followed by hot water and methanol extracts. The hot water extract showed notable scavenging activity (IC50 = 20.00 µg/µl), and the aqueous extract demonstrated the highest reducing power at a concentration of 10 mg/ml. The ethanolic extract also had the strongest H2O2 scavenging activity (IC50 = 19.24 µg/µl).Phenolic compounds, including flavonoids (29.80 ± 0.27 mg QE/g) and phenolic acids, are key dietary components that help neutralize free radicals, prevent vascular diseases and certain cancers, and reduce oxidative stress that can damage DNA, proteins, and cell membranes. Studies reported that the aqueous extract of *S. commune* had the highest total phenolic content (81.97%), followed by the methanol extract (75.11%), while the ethanol extract had the lowest (47.08%).

2. Antimicrobial properties [9]

Schizophyllum commune, being rich in bioactive compounds such as saponins, tannins, alkaloids, flavonoids, terpenoids, and proteins, exhibits significant biological activity and contributes to the antimicrobial properties of its extracts. Its antibacterial activity is generally more effective against Gram-positive bacteria, including *Bacillus cereus*, *B. subtilis*, *Enterococcus faecalis*, and *Streptococcus sanguis*, than against Gram-negative bacteria such as *Escherichia coli*, *Salmonella* sp., *S. typhi*, *Shigella* sp., *Proteus vulgaris*, and *Pseudomonas aeruginosa*.

Various extracts of *S. commune*, including methanol, ethyl acetate, dichloromethane, and aqueous extracts, were compared for their zones of inhibition. Among them, the dichloromethane extract was the most active, showing a 12 ± 1 mm inhibition zone against *Streptococcus sanguis* at a concentration of 2.0 mg/ml, while ethyl acetate and

methanolic extracts exhibited moderate antimicrobial activity.

In a study by Jayakumar *et al*., the antimicrobial activity of oxidized schizophyllan (scleraldehyde) was evaluated against both Gram-positive and Gram-negative bacteria using disc diffusion, minimum inhibitory concentration (MIC), and minimum bactericidal concentration (MBC) assays. The MIC and MBC values ranged from 3.0 to 8.0 mg/ml, confirming that scleraldehyde possesses notable antimicrobial properties.

Antitumor Activity [22, 23]

Because of the wide variation in their physicochemical properties and the complexity of their antitumor mechanisms, the anticancer effectiveness of natural polysaccharide–protein hybrids (PSHs) is difficult to directly compare with that of synthetic drugs. Different fungal PSHs exhibited varying levels of antitumor activity, which generally correlated with the immunomodulatory effects of the compounds they contained [22]. Studies conducted before 2017 analyzed the antitumor activity of *S. commune*, but no recent research during the period covered in this paper specifically examined this activity. Lopez-Legarda *et al*. focused on the submerged cultivation, extraction, and antitumor activity of PSHs from *S. radiatum*. Various cancer cell lines, including EL-4, MDA-MB-231, RAW 264.7, and U937, were tested for antitumor and immunostimulatory effects. The results suggest that these PSHs can inhibit tumor growth both directly and indirectly by activating immune cells such as macrophages. The SIPS extract exhibited the highest antitumor activity, while the SEPS extract showed the strongest immunostimulatory effects. The researchers concluded that although the PSHs from *S. commune* did not demonstrate a strong direct antitumor effect comparable to conventional anticancer drugs, they significantly activated macrophages *in vitro*. It is likely that the *in vivo* antitumor activity of SIPS and SEPS could be enhanced through interactions with the immune system and gut microbiota [23].

Anticancer properties [24, 25, 26, 27]

Schizophyllan, a polysaccharide present in *S. commune*, has been shown to possess antitumor properties. It promotes the production of acute-phase proteins and cerebrospinal fluid, stimulating the proliferation of macrophages, peripheral blood mononuclear cells, and lymphocytes, while also activating the complement system [24]. Bioactive compounds such as alkaloids, terpenoids, and flavonoids extracted from this mushroom also contribute to its anticancer properties. These compounds can induce apoptosis in cancer cells, inhibiting their growth with an IC50 of 5.44 µg/ml [25]. A study investigated the antiproliferative effects of *S. commune* on human cholangiocarcinoma (KKU-M213) using MTT and wound healing assays. It was reported that 200 µg/ml of the crude ethanol extract inhibited the proliferation of KKU-M213 cells and suppressed their migration [26]. MTT cytotoxicity assays demonstrated that EA-SPG-NP and EA-Ch-NP inhibited the growth of breast cancer cell lines, with IC50 values of 60 µg/ml and 115 µg/ml, respectively [27].

Anti-Acetylcholinesterase Activity [28]

An imbalance between free-radical production and scavenging can lead to various diseases, including neurodegenerative disorders such as Alzheimer's disease. Since there is currently no cure or way to halt or reverse its progression, acetylcholinesterase (AChE) inhibitors have attracted significant research interest. Consequently, a range of organisms, including fungi, have been investigated as potential sources of physiologically active compounds that could serve as effective AChE inhibitors.

To date, the anti-acetylcholinesterase activity of *S. commune* has been explored in only one study conducted in 2021. Mišković *et al*. demonstrated that PSH extracts of *S. commune* exhibited notable neuroprotective effects, establishing the species as a promising source of AChE inhibitors. In their study, the highest AChE inhibition was observed with the M28 SRB PSH extract (IC90 = 79.73 ± 26.34 µg/mL), while the IT extract showed greater activity in the F14 ethanol extracts (IC50 = 0.8 ± 0.6 µg/mL). Notably, the activity of the M28 SRB PSH extract was comparable to that of the commercially approved Alzheimer's drug donepezil (IC90 = 87.92 µg/mL).

The anti-AChE activity has been associated with phenolic compounds and flavonoids, and evidence from previous studies suggests a possible synergistic effect between primary metabolites (such as the polysaccharide fraction, likely SPG) and secondary metabolites (phenolics).

Anti fungal activity [29]

The filamentous fungus *S. commune* produces metabolites with antifungal activity (Teoh *et al*., 2012). In this study, the concentration of *S. commune* extract tested was 5 µg/µL, which is comparable to commercial levels. Antifungal activity was evaluated using the minimum inhibitory concentration (MIC) assay, where MIC is defined as the lowest concentration of fungal mycelial extract that prevents the growth of wood-decaying fungi after the incubation period (Das *et al*., 2010). The MIC values indicate the minimum amount of active compounds from *S. commune* required to suppress the growth of these fungi, as presented in the Table. Additionally, the food poisoning technique was employed to further assess antifungal activity, with the percentage inhibition of mycelial growth recorded and reported in the Table.

In the present study, the crude extracts of *S. commune* showed antifungal activity against selected wood-decaying fungi, with MIC values ranging from 0.16 to 5.00 µg/µL (Table). These results align with findings by Jayakumar *et al*. (2010), who reported antibacterial activity in the range of 3.00 to 8.00 µg/µL using methods such as disc diffusion, MIC, and minimum bactericidal concentration assays. Among the fungi tested, *P. sanguineus* exhibited the lowest susceptibility to both water and ethanol extracts of *S. commune*, with MIC values exceeding 5.00 µg/µL. However, the methanolic extract effectively inhibited the growth of *P. sanguineus* with an MIC of 5.00 µg/µL (Table), indicating that methanol extracts provided stronger antifungal activity compared to water and ethanol extracts.

Methanol is a strong solvent and the smallest alcohol molecule, which allows it to achieve more complete extraction of less polar compounds compared to water (Margaritis & Jajuee, 2007). Additionally, methanol extraction may produce saponins (Masoko & Eloff, 2006; Teoh *et al*., 2012), which can exhibit higher toxicity against fungi and contribute to the enhanced antifungal activity observed.

Wood-degrading fungi	Minimum Inhibitory Concentration, MIC (µg/µL)			Mycelia Inhibition (%)		
	Water Extract	Methanol Extract	Ethanol Extract	Water Extract	Methanol Extract	Ethanol Extract
Earliella scabrosa	5.00	1.25	2.50	99.4%	100.0%	100.0%
Gloeophyllum trabeum	5.00	2.50	2.50	99.5%	100.0%	100.0%
Lentinus sp.	0.31	0.16	0.16	100.0%	100.0%	100.0%
Lentinus sajor-caju	2.50	1.25	1.25	100.0%	100.0%	100.0%
Lentinus strigosus	5.00	2.50	2.50	99.5%	100.0%	100.0%
Microporus affinis	0.61	0.31	0.31	100.0%	100.0%	100.0%
Microporus xanthopus	0.61	0.31	0.31	100.0%	100.0%	100.0%
Pycnoporus sanguineus	>5.00	5.00	>5.00	0.2%	100.0%	1.5%
Trametes versicolor	5.00	1.25	2.50	99.8%	100.0%	100.0%
Trametes feei	5.00	1.25	2.50	99.7%	100.0%	100.0%
Trametes menziezi	5.00	0.31	2.50	99.7%	100.0%	100.0

Antiviral activity [30]

A polysaccharide called sizofiran (SPG), isolated from *Schizophyllum commune*, has been shown to regulate both cellular and humoral immune responses to the nucleocapsid antigen in patients with chronic hepatitis B, enhancing antibody levels. Dengue virus (DENV) is an arbovirus primarily transmitted to humans by *Aedes aegypti* mosquitoes. Dengue fever poses a significant global public health threat, infecting 100 to 400 million people annually, with tropical and subtropical regions being the most affected. In a study, five medicinal fungi—*Lignosus rhinocerotis*, *Pleurotus giganteus*, *Hericium erinaceus*, *Schizophyllum commune*, and *Ganoderma lucidum*—were extracted sequentially using hot aqueous and ethanol methods, followed by n-hexane, ethyl acetate, and water extractions. Their anti-dengue virus activity was assessed using a plaque reduction assay. Results indicated that hot aqueous extracts and water-soluble extracts of *L. rhinocerotis*, *P. giganteus*, *H. erinaceus*, and *S. commune* exhibited minimal toxicity to Vero cells and demonstrated significant anti-DENV-2 activity. Further studies on dengue virus–induced inflammation showed that hot aqueous extracts of *G. lucidum*, *S. commune*, and *P. giganteus*, along with aqueous extracts of *L. rhinocerotis*, effectively inhibited cytokine production in dengue-infected monocytes.Additionally, human immunodeficiency virus type 1 (HIV-1), the retrovirus responsible for acquired immunodeficiency syndrome (AIDS), was shown to be inhibited by compounds isolated from *S. commune*. A 29 kDa hemolysin monomer and a 20 kDa ribonuclease purified from the fruiting bodies were found to inhibit HIV-1 reverse transcriptase, with IC50 values of 1.8 mM and 65 mM, respectively.

Hepatoprotective avtivity [31]

The hepatoprotective effects of *S. commune* extracts against H2O2-induced cytotoxicity were evaluated in HepG2 cells. While herbal medicines are widely claimed to support liver health, scientific validation is often limited. Cytotoxicity of the extracts was assessed using the MTT assay. The results showed that hexane and methanol extracts had no significant effect ($p > 0.01$ and 0.001) on HepG2 cell viability at concentrations below 200 µg/mL, whereas chloroform and ethyl acetate extracts were non-toxic ($p > 0.001$) at concentrations below 400 µg/mL. The polysaccharide extract, at 100–1000 µg/mL, and schizophyllan, the primary active compound in the polysaccharide extract, also did not affect cell viability. Extracts showing more than 80% cell viability were selected for further evaluation of their hepatoprotective effects against H2O2-induced cytotoxicity in HepG2 cells.

Anti inflammatory activity [32]

Ultrasound treatment has been shown to be an effective method for producing polysaccharides from *S. commune* mycelial fermentation with a desired molecular weight, lower viscosity, and enhanced anti-inflammatory activity. A Box-Behnken response surface design combined with numerical optimization was used to optimize the process and investigate both the individual and interactive effects of key variables—initial concentration, ultrasonic power, and irradiation time—on the polysaccharide's anti-inflammatory activity.

Anti-diabetic propertie

Diabetes mellitus is a chronic hyperglycaemic disorder, characterized by disturbances in lipid and carbohydrate metabolism, as well as glucose homeostasis [33]. Hydrolysis of α-1,4-glycosidic bond which is a major pathway for producing simple sugar in humans is inhibited by *S. commune* enzymes α-glucosidase which results in delaying carbohydrate metabolism and rate of glucose absorption. Hence, decreasing postprandial plasma glucose levels and improving glucose tol-erance in diabetes patients [34]. The anti-diabetic properties of *S. commune* crude extracts were investigated through various assays and it was observed that the ethanolic extract exhibited the highest anti-diabetic rate of 23.74 ± 0.09, while the aque-ous extract showed the lowest rate of 21.49 ± 0.0. The meth-anolic extract demonstrated an anti-diabetic rate of 22.98 ± 0.06 [35].

Immunomodulating effects [9]

Schizophyllan interacts with immune cells such as polymorphonuclear cells (PMCs) and peripheral blood mononuclear (PBM) cells, stimulating the production of cytokines including interleukin-8 (IL-8). It activates macrophages, leading to systemic immunomodulatory effects. This process involves binding to two non–complement receptor 3 (non-CR3) receptors on promonocytic U937 cells, resulting in macrophage activation both *in vitro* and *in vivo*. Consequently, T-cell activity is enhanced, and the responsiveness of cytotoxic lymphokine-activated killer (LAK) cells and natural killer (NK) cells to interleukin-2 (IL-2) is increased. Additionally, the schizophyllan complex is readily phagocytosed by macrophages, promoting the production of macrophage inhibitory factor, which plays a significant role in inflammatory bowel disease.

Conclusion

Schizophyllum commune is a widely distributed basidiomycete mushroom with significant nutritional, medicinal, and biotechnological importance. As an edible

species consumed in various parts of Asia, Africa, and Latin America, it represents a valuable and affordable dietary resource, particularly in regions facing protein deficiency and food insecurity. Its rich nutritional profile—including appreciable protein content, essential minerals, carbohydrates, and bioactive compounds—supports its role as a functional food.Phytochemical investigations reveal the presence of diverse bioactive constituents such as phenolics, flavonoids, alkaloids, saponins, tannins, and terpenoids, which contribute to its broad spectrum of pharmacological activities. Experimental studies have demonstrated antioxidant, antimicrobial, antifungal, antiviral, hepatoprotective, anti-inflammatory, antidiabetic, neuroprotective, immunomodulatory, antitumor, and anticancer properties. The polysaccharide schizophyllan (SPG), one of its major bioactive components, has shown promising immunomodulatory and therapeutic potential, particularly in cancer and infectious disease research.Although substantial *in vitro* and preliminary *in vivo* evidence supports its medicinal value, further well-designed clinical studies are necessary to validate its safety, efficacy, dosage standardization, and mechanisms of action in humans. Additionally, deeper exploration of its secondary metabolites, molecular pathways, and potential synergistic interactions may facilitate the development of novel therapeutic agents.Overall, *Schizophyllum commune* holds considerable promise as a nutraceutical, functional food ingredient, and source of bioactive compounds for pharmaceutical applications. Continued research and sustainable utilization of this mushroom could contribute significantly to global health, disease management, and food security.

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Conflicts of interest
The author declares no conflicts of interest.

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