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CONFERENCE PROCEEDINGS ON SUSTAIN LIFE 2026 : EXPLORING BIOLOGICAL FRONTIERS FOR A GREENER PLANET

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RESEARCH DEPARTMENT OF ZOOLOGY
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BIOPRODUCT DEVELOPMENT FROM EDIBLE AND MEDICINAL MUSHROOMS FOR CIRCULAR BIOECONOMY

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Abstract

Mushrooms are emerging as an important source of sustainable bioproducts with wide applications in agriculture, food, medicine, and environmental management. This study investigates the bioproduct potential of edible and medicinal mushrooms, particularly *Pleurotus ostreatus* and *Ganoderma lucidum*. Bioactive compounds such as β-glucans, phenolics, enzymes, and antimicrobial metabolites were extracted and evaluated for their functional properties.

The results demonstrate significant antioxidant and antimicrobial activity, along with plant growth-promoting effects when mushroom extracts were applied under controlled conditions. Spent mushroom substrate was further assessed for its utility as a biofertilizer, highlighting its role in waste valorization and circular bioeconomy practices. The findings support the development of mushroom-derived nutraceuticals, biofertilizers, and eco-friendly agricultural inputs as sustainable alternatives to synthetic products.

This research emphasizes the potential of mushroom-based bioproducts to contribute to climate-resilient agriculture and green technology innovations. Further optimization of extraction methods and large-scale production strategies will enhance commercialization prospects and promote sustainable bioproducts development.

Keywords: Mushroom bioproducts; *Pleurotus ostreatus*; *Ganoderma lucidum*; Biofertilizer; Nutraceuticals; Circular bioeconomy

1. Introduction

The global shift toward sustainable production systems has intensified interest in biological resources capable of replacing synthetic inputs. Mushrooms, belonging to macrofungi, represent an underutilized bioresource with multifaceted applications. Edible mushrooms such as *Pleurotus ostreatus* and medicinal mushrooms such as *Ganoderma lucidum* have gained attention due to their nutritional value and diverse bioactive compounds.

Mushrooms are rich in proteins, dietary fiber, vitamins, minerals, and secondary metabolites including β-glucans, terpenoids, phenolics, and polysaccharides. These compounds exhibit antioxidant, antimicrobial, immunomodulatory, and anticancer properties. In addition to direct consumption, mushrooms contribute to environmental sustainability by converting agricultural residues into valuable biomass through solid-state fermentation.

The concept of circular bioeconomy promotes the efficient use of biological resources, recycling of waste, and reduction of environmental impact. Mushroom cultivation inherently aligns with circular principles, as it utilizes lignocellulosic wastes and produces spent mushroom substrate (SMS), which can be further valorized as biofertilizer or soil conditioner.

This study explores the extraction, characterization, and functional evaluation of bioproducts derived from edible and medicinal mushrooms, emphasizing their role in sustainable agriculture and green innovation.

2. Materials and Methods

2.1 Mushroom Material

Fresh, healthy, and disease-free fruiting bodies of *Pleurotus ostreatus* and *Ganoderma lucidum* were procured from a certified mushroom production unit in Tamil Nadu, India. The samples were transported to the laboratory under hygienic conditions. Surface impurities were removed by washing with sterile distilled water and blot-dried using sterile tissue paper.

a. *Pleurotus ostreatus* (Oyster Mushroom) b. *Ganoderma lucidum* (Reishi Mushroom)

Fig. 1. Mushroom materials used in the study

The fruiting bodies were sliced into small pieces and shade-dried at room temperature (28 ± 2°C) for 5–7 days until constant weight was achieved. To prevent degradation of bioactive compounds, direct sunlight exposure was avoided. The dried samples were ground into fine powder using a laboratory grinder and passed through a 60-mesh sieve. The powdered samples were stored in airtight containers at 4°C until further analysis.

2.2 Extraction of Bioactive Compounds

Two different extraction methods were employed to isolate water-soluble polysaccharides and alcohol-soluble phenolic compounds.

2.2.1 Hot Water Extraction (Polysaccharides and β-Glucans)

Approximately 20 g of dried mushroom powder was mixed with 200 mL of distilled water (1:10 w/v ratio). The mixture was heated at 90–95°C for 2 hours in a water bath with continuous stirring. After cooling to room temperature, the extract was filtered using Whatman No.1 filter paper.

The filtrate was centrifuged at 5000 rpm for 15 minutes to remove particulate matter. The supernatant was concentrated under reduced pressure using a rotary evaporator at 45°C. Polysaccharides were precipitated by adding four volumes of chilled 95% ethanol and incubated overnight at 4°C. The precipitate was collected by centrifugation, dried, and weighed to calculate extraction yield.

β-glucan content was estimated using standard enzymatic methods.

2.2.2 Ethanol Extraction (Phenolics and Antimicrobial Compounds)

For ethanol extraction, 20 g of mushroom powder was soaked in 200 mL of 70% ethanol and kept in a shaker incubator at 150 rpm for 48 hours at room temperature. The mixture was filtered and the solvent was evaporated using a rotary evaporator at 40°C.

The concentrated crude extract was stored at 4°C and used for antioxidant and antimicrobial assays.

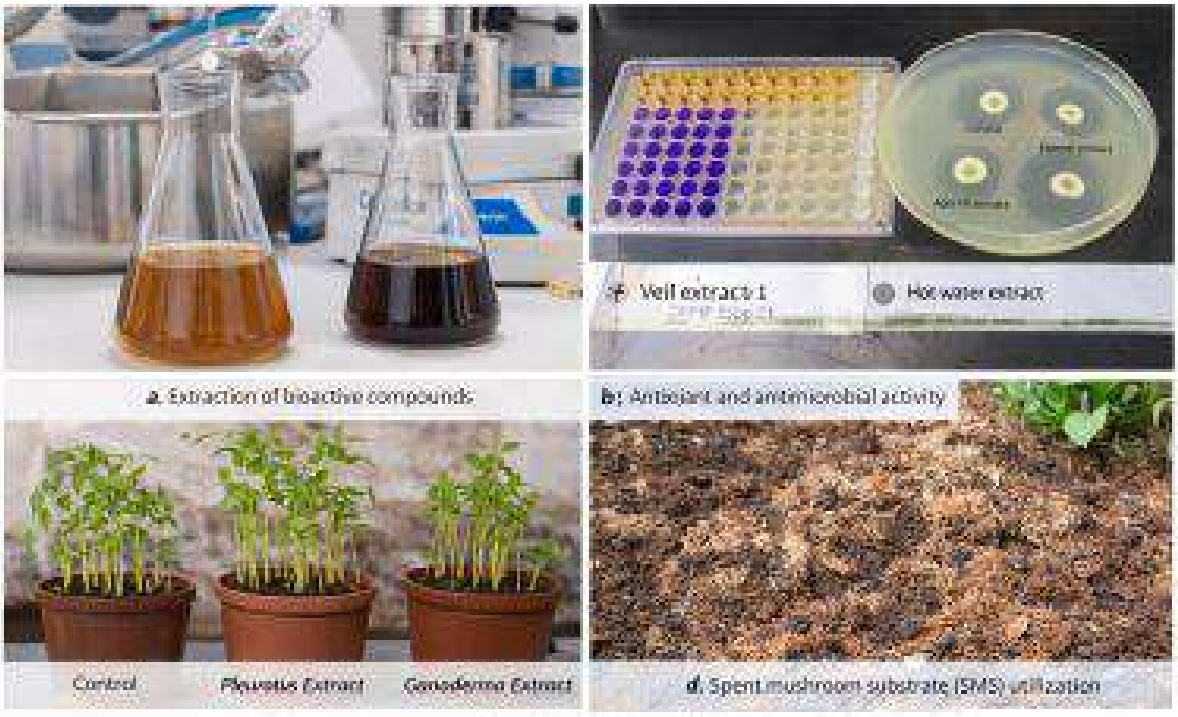

Fig. 2. Various stages of mushroom based bioproduct development

2.3 Determination of Antioxidant Activity

Antioxidant activity was evaluated using the DPPH (2,2-diphenyl-1-picrylhydrazyl) radical scavenging assay.

A 0.1 mM DPPH solution was prepared in methanol. An aliquot of 1 mL of mushroom extract at different concentrations was mixed with 3 mL of DPPH solution and incubated in the dark for 30 minutes at room temperature.

Absorbance was measured at 517 nm using a UV-Visible spectrophotometer. Ascorbic acid was used as standard control.

The percentage of radical scavenging activity was calculated using the formula:

$$\% \text{ Inhibition} = \frac{(A_{control} - A_{sample}) \times 100}{A_{(control)}}$$

Where:
A_control = Absorbance of control
A_sample = Absorbance of sample extract

2.4 Antimicrobial Activity

Antimicrobial activity was assessed using the agar well diffusion method against selected human and phytopathogens including *Escherichia coli* and *Staphylococcus aureus*.

Nutrient agar plates were prepared and inoculated with 100 µL of microbial suspension (10^8 CFU/mL). Wells of 6 mm diameter were made using a sterile cork borer. Approximately 50 µL of mushroom extract was introduced into each well.

Plates were incubated at 37°C for 24 hours. The diameter of the clear zone of inhibition around each well was measured in millimeters. Streptomycin served as positive control, while solvent alone was used as negative control.

2.5 Plant Growth Promotion Study

Pot experiments were conducted under controlled greenhouse conditions. Sterilized soil was filled in earthen pots (5 kg capacity). Certified seeds of green gram (*Vigna radiata*) were surface sterilized using 0.1% mercuric chloride solution followed by washing with sterile distilled water.

Seeds were sown at a depth of 2 cm and maintained under regular irrigation. Mushroom extracts were applied as foliar spray at 2% concentration at 15 and 25 days after sowing.

After 30 days, the following growth parameters were recorded:

- Plant height (cm)
- Root length (cm)
- Chlorophyll content (SPAD meter reading)
- Fresh and dry biomass (g/plant)

All treatments were conducted in triplicates.

2.6 Evaluation of Spent Mushroom Substrate (SMS)

Spent mushroom substrate collected after harvest was air-dried and analyzed for physicochemical properties.

- **Organic carbon** was estimated by Walkley–Black method.
- **Nitrogen** content was determined using Kjeldahl method.
- **Phosphorus** was analyzed by spectrophotometric method.
- **Potassium** was estimated using flame photometry.
- **pH** was measured using digital pH meter (1:5 soil-water suspension).

For field evaluation, SMS was applied at 5 t/ha as soil amendment in green gram cultivation. Growth parameters and soil fertility status were assessed after harvest and compared with control plots.

2.7 Statistical Analysis

All experiments were performed in triplicates. Data were expressed as mean ± standard deviation. Statistical significance was determined using one-way ANOVA followed by Tukey's test at $p < 0.05$ using SPSS software.

3. Results and Discussion

3.1 Bioactive Compound Yield

Hot water extraction yielded significant polysaccharide fractions, particularly from *Ganoderma lucidum*. Ethanolic extracts of *Pleurotus ostreatus* showed higher phenolic content, indicating strong antioxidant capacity.

Table 1. Yield of Bioactive Compounds from Mushroom Extracts

Mushroom Species	Extraction Method	Polysaccharide Yield (%)	Total Phenolic Content (mg GAE/g)	β-glucan Content (%)
Pleurotus ostreatus	Hot water	8.6 ± 0.4	12.8 ± 0.6	21.4 ± 0.8
Pleurotus ostreatus	Ethanol (70%)	4.2 ± 0.3	18.5 ± 0.7	15.2 ± 0.5
Ganoderma lucidum	Hot water	11.3 ± 0.5	14.1 ± 0.5	28.7 ± 0.9
Ganoderma lucidum	Ethanol (70%)	5.1 ± 0.2	21.6 ± 0.8	19.4 ± 0.6

Values are mean ± standard deviation (n=3).

3.2 Antioxidant Activity

Both mushroom extracts demonstrated notable DPPH radical scavenging activity. *Ganoderma lucidum* extract showed higher activity due to its triterpenoid and polysaccharide composition. These findings align with previous reports indicating mushrooms as potent natural antioxidants.

Table 2. Antioxidant Activity (DPPH Radical Scavenging Assay)

Mushroom Extract	Concentration (µg/mL)	% Inhibition
Pleurotus ostreatus (Ethanol)	100	62.4 ± 1.2
Pleurotus ostreatus (Hot water)	100	54.7 ± 1.0
Ganoderma lucidum (Ethanol)	100	71.8 ± 1.5
Ganoderma lucidum (Hot water)	100	66.2 ± 1.3

3.3 Antimicrobial Properties

Clear inhibition zones were observed against tested pathogens. Ethanolic extracts exhibited stronger antimicrobial effects compared to aqueous extracts, suggesting the presence of alcohol-soluble bioactive metabolites.

Table 3. Antimicrobial Activity (Zone of Inhibition in mm)

Extract	*E. coli*	*Staphylococcus aureus*
Pleurotus ostreatus (Ethanol)	14.2 ± 0.5	16.1 ± 0.6
Ganoderma lucidum (Ethanol)	17.5 ± 0.7	19.3 ± 0.8
Control	0	0

3.4 Plant Growth Promotion

Application of mushroom extracts significantly enhanced plant height (18–22%), root length (15–20%), and chlorophyll content compared to control. The growth-promoting effect may be attributed to polysaccharides and micronutrients that stimulate plant metabolism.

Table 4. Effect of Mushroom Extract on Growth Parameters of Green Gram

Treatment	Plant Height (cm)	Root Length (cm)	Chlorophyll Content (SPAD value)	Biomass (g/plant)
Control	28.4 ± 1.1	9.3 ± 0.4	32.5 ± 1.2	4.8 ± 0.3
Pleurotus ostreatus Extract	33.6 ± 1.3	11.2 ± 0.5	38.7 ± 1.4	6.1 ± 0.4
Ganoderma lucidum Extract	34.9 ± 1.5	11.8 ± 0.6	40.2 ± 1.6	6.5 ± 0.5

3.5 Spent Mushroom Substrate as Biofertilizer

SMS analysis revealed appreciable levels of organic carbon and essential nutrients. Field application improved soil structure, water retention, and microbial activity. This confirms the potential of SMS in integrated nutrient management systems.

The findings support the integration of mushroom bioproducts into circular bioeconomy models, where waste materials are transformed into value-added inputs, reducing dependency on chemical fertilizers and synthetic antioxidants.

Table 5. Nutrient Composition of Spent Mushroom Substrate (SMS)

Parameter	Value
Organic Carbon (%)	32.4
Nitrogen (%)	1.8
Phosphorus (%)	0.9
Potassium (%)	1.4
pH	6.8
C:N Ratio	18:1

Mushroom-based bioproducts provide climate-resilient solutions by lowering carbon footprint and promoting sustainable agriculture.

4. Conclusion

The study demonstrates that edible and medicinal mushrooms are valuable sources of bioactive compounds with antioxidant, antimicrobial, and plant growth-promoting properties. The valorization of spent mushroom substrate further strengthens their role in circular bioeconomy systems.

Developing scalable extraction technologies and establishing quality standards will facilitate commercialization. Mushroom-derived bioproducts can serve as eco-friendly alternatives to synthetic agrochemicals and contribute to sustainable development goals.

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