Contents lists available at UGC-CARE

International Journal of Pharmaceutical Sciences and Drug Research

[ISSN: 0975-248X; CODEN (USA): IJPSPP]

Available online at www.ijpsdronline.com

Review Article

Immune-stimulants and Adaptogenic Properties of Selected Wild Edible Mushrooms Collected from the Western Ghats, India

Shahina NK*[1], Madhusudhanan K[2], Angel Mathew[3]

[1]*Department of Botany, Bharata Mata College, Thrikkakara Ernakulam, Kerala, India*
[2]*Department of Botany and Research Centre, St. Albert's College (Autonomous) Ernakulam, Kerala, India*
[3]*Department of Statistics, Maharaja's College, Ernakulam, Kerala, India*

ARTICLE INFO

Article history:
Received: 03 June, 2022
Revised: 18 August, 2022
Accepted: 23 August, 2022
Published: 30 September, 2022

Keywords:
Adaptogenic properties, Antioxidant, Antiviral, Covid - 19, Immune-Stimulants, Wild Edible Mushrooms

DOI:
10.25004/IJPSDR.2022.140519

ABSTRACT

Virus outbreaks such as the COVID-19 virus demand nutrition interventions among people all over the world. Consumption of foods with immune-modulating and nutraceutical characteristics is an effective strategy to avoid or lessen the severity of viral attacks and side effects. Immune stimulants function by enhancing macrophage activity and killing pathogens and diseased cells, while adaptogens work by supporting and regulating the endocrine system. This paper foreshadows the use of mushrooms as a functional food for the prevention and treatment of COVID – 19 by citing peer-reviewed papers from Google Scholar, PubMed, the WHO database, Science direct, and the author's own research. *Pleurotus ostreatus, Termitomyces heimii, T. microcarpus, T. clypiatus, Auricularia auricula, Phlebopus portentos, Ganoderma lucidum, Coprinus micaceus, Cantharellus cibarius, C. minor*, and *Lentinus bambusinus* were among the ethnomedicinal mushrooms studied. Immuno-modulating effects were found in polysaccharides, fungal immune-modulatory proteins (FIPs), terpenes, and terpenoids from wild mushrooms, as well as activation of immune effector cells such as lymphocytes, macrophages, and natural killer cells. They also cause the production of cytokines such as IFN-, IL-2, IL-4, IL-10, and TNF-. Similarly, mushrooms have been shown to have probiotic properties that can help to flatten the curve.

Introduction

Coronavirus 2 (SARS-CoV-2)-caused COVID-19 viral respiratory illnesses are spreading rapidly. SARS-CoV-2 enters the body through inhalation or contact with an infected person's respiratory droplets. The infection progresses in three stages: (1) asymptomatic phase (lasts about 1–2 days), the virus multiplies in the upper respiratory tract; (2) non-severe symptomatic phase (lasts 2–14 days), with common symptoms such as fever, dry cough, pharyngitis, shortness of breath, joint pain, and tiredness, increases the risk of community spread; (3) severe respiratory symptomatic phase, virus moves to lower airways, triggers a strong innate immune response, develops acute respiratory disease/multi--organ failure and death in worst scenario.[1]

Besides the progress of antiviral drugs, preventative public health practices such as lifestyle and appropriate nutrition are limiting the spread of infections during stage-2 and counteracting the SARS-CoV-2 infection during stage-1.[2] Recent studies highlight the potential roles of micronutrients, trace elements, dietary components antioxidants and probiotics in the development and maintenance of an effective immune system and reducing chronic inflammations during COVID 19,[3,4] also noticed that high energy diet and diabetes increase the risk factor of Coronavirus attack and subsequent spreading.[5] This postulates the necessity of a balanced food with low calories and adequate immune-supportive functions.
Mushrooms are a type of 'functional food,' meaning they have a high nutritional value as well as health advantages.

***Corresponding Author:** Ms. Shahina NK

Address: Department of Botany, Bharata Mata College, Thrikkakara Ernakulam, Kerala, India

Email ✉**:** drshahinank@gmail.com

Tel.: +919446763771

Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

According to our earlier research on the "ethnomedicinal applications and ecology of wild mushrooms among selected tribal societies of the Western Ghats"[6], tribes are well-versed in the concept of "mushroom as food with specific health purposes." Aside from taste, tribes consume/use mushrooms for a variety of therapeutic purposes, including respiratory ailments, including cough, cold, and asthma symptoms. Patients with SARS-CoV-2 infection experience similar symptoms, which is why the study was conducted. The immunomodulatory, anti-inflammatory, antioxidant, antiviral, and probiotic activity of ethnomedicinal mushrooms may contribute to COVID-19 preventive effectiveness, according to this hypothesis.

Ethnomedicinal Knowledge of Wild Edible Mushrooms from Kerala's the Western Ghats'

The mushrooms chosen (Fig. 1) are based on our prior study, 'ethnomedicinal knowledge of wild edible mushrooms from Kerala's the Western Ghats', which have long been used for immunity and to treat respiratory difficulties. Disease classification was based on data collected from each community during the ethnomycological survey and reliability testing using Informant Consensus Factors (ICF).[6]

Retrieval of Evidence for the Potential use of Selected Wild Mushrooms

Using the phrases "mushroom name" AND antiviral/ respiratory support/antioxidant/immune potential/ relaxant/probiotic, etc., We conducted a bibliographic search in Google Scholar, PubMed, Web of Science, WHO database, and Science Direct. These mushrooms were also investigated for possible nutritional and health-promoting properties. The year of publication (between 2010 and 2021) and the dependability of research (*in-vitro/in-vivo/* case studies) were utilised to narrow the scope of the investigation.

Immune Stimulatory Activity of Mushrooms

The immune response during COVID-19 is a double-edged sword: it maintains immunity, but the excessive and incorrect generation of inflammatory cytokines can cause cytokine storm syndrome, which can lead to organ immuno-pathology, complications, and mortality.[7] Two therapeutic approaches are currently in use: the first involves the use of immune suppressors to reduce the hyper inflammation caused by a viral infection, and the second involves the use of immune potentiators, which can eradicate the virus by stimulating the host's innate and adaptive immune responses.

Medicinal mushrooms are natural immune modulators because they stimulate both innate and adaptive immune systems and include a variety of immune-regulatory substances such as polysaccharides, and fungal immunomodulatory proteins (FIPs), terpenes, and terpenoids. Activation of immunological effector cells such as lymphocytes, macrophages, and natural killer cells are examples of immune-modulating effects. They also cause the production of cytokines such as IFN-, IL-2, IL-4, IL-10, and TNF- (Table 1).

Fig. 1: Ethnomedicinal mushrooms from the Western Ghats of Kerala.

Pleurotus ostreatus,[8-10] *Ganoderma lucidum*,[15] and *Auricularia auricula* polysaccharides enhance natural killer (NK) cell count, neutrophils, and macrophages, as well as induce cytokine expression and release.[16-17] PS-G (polysaccharide produced from *Ganoderma lucidum*) has the ability to modulate immunological responses by activating and maturing immature dendritic cells (DCs).[14] Schizophyllan (Polysaccharide from *Schizophyllum commune*) promotes the expression of genes coding for proteins in the nuclear factor (NF)–kB pathway and modulates immune system functions, according to a study by Yelithao and coworkers.[16]

Antioxidants and Anti-inflammatory Activity of Wild Mushrooms

Antioxidant supplementation has been shown in clinical trials to improve immune responses. Mushrooms, as an antioxidant source, may help maintain oxidative equilibrium.[19] Mushroom antioxidants provide protection throughout their life cycle through a variety of ways (Table 2).

Table 1: Immunomodulatory activity of mushrooms.

Mushroom	*Extract/compound*	*Pattern of effect*	*Reference*
P. ostreatus	β-(1,3/1,6) glucan	Increase natural killer (NK) cell count, neutrophils, macrophages, stimulate cytokines expression and secretion	[8-10]
G. lucidum	Fungal Immunomodulatory Protein FIP-SN15	Stimulate immune cells to produce a variety of cytokines	[11,12]
G. luidum	Mycelial extract	(NF)-κB activation	[13]
G. lucidum	Ganoderma derived Polysaccharide(PSG)	Activate immature dendritic cells (DCs), induce a significant proliferation of T-cells	[14]
G lucidum	Polysaccharide	Increase natural killer (NK) cell count, neutrophils, macrophages, stimulate cytokines expression and secretion	[15]
S. commune	Polysaccharide(Glycomannans)	Activate of nuclear factor-kappa (NF-κB) and mitogen-activated protein kinase (MAPK) stimulate immune cells to produce a variety of cytokines	[16]
S. commune	β(1–3) and β(1–6) D-glucan		[17]
A. auricula	Polysaccharide AAP	Stimulate IFN-γ, IL-2, IL-4, IL-10, and TNF-α levels in the serum	[18]

Table 2: Ethnomedicinal mushrooms' anti-inflammatory and antioxidant properties.

Mushroom	*Extract/compound*	*Pattern of effect*	*Reference*
P. ostreatus	Pleuran	Prevent TNF-α mediated inflammation	
P. ostreatus	Mushroom concentrate	Inhibit proliferation and secretion of interferon-γ (IFN-γ), IL-2, and IL-6 in mice	[20]
G. lucidum	Mushroom extract	Suppress growth and proliferation of tumors by Jak-STAT signaling pathway, T cell receptor signaling pathway and PI3K-Akt signaling pathway in mouse	[9]
C. cibarius	Polysaccharide (CC-1)	Proliferation effect on B cells	[21]
C. cibarius	Mushroom extract	Lower expression of cyclooxygenase-2 in rats	[22]
S. commune	Homogeneous protein bound heteropolysaccharide	*In-vitro* antioxidant activity. inhibits the production of nitric oxide (NO), induce nitric oxide synthase (iNOS), and 5- lipoxygenase (5-LOX) from macrophages in RAW 264.7 murine macrophages	[23]
Phlebopus portentosus	Pulvinic acid derivatives	Cytotoxic activity against human mammalian cell lines	[24]
A. auricula	Fruit body extract	Reduced expressions of inflammatory cytokines (IL-6, TNF-α and IL-1β)	[25]
Coprinellus species	Ergothioneine	*In-vitro* antioxidant activity Diminish ROS and NO	[26]
Termitomyces heimii	β-glucan	*In-vitro* antioxidant activity: Diminish ROS and NO	[27]
T.microcarpus	Polyphenol	*In-vitro* antioxidant activity: Diminish ROS and NO	[28]
A. auricula	polysaccharides	Anti-oxidant up-regulate stress-resistance-related enzymes including superoxide dismutase (SOD)	[29]
T. microcarpus	Crude extract	DPPH radical scavenging activity	[30]

They are involved in chain breaking, free radical scavenging, lipid hydroperoxide inhibition or breakdown, primary antioxidant renewal, and singlet oxygen (1O2) quenching. Antioxidants can serve as inducers, causing changes in gene expression and the activation of enzymes that remove reactive oxygen species (ROS) in the body. With different polysaccharides and polyphenols, alterations in the redox state lead to anti-inflammatory effects.

Probiotic Activity of Wild Mushrooms

The review here addresses the key areas in mushrooms that govern gut microbiota in the health of the host. Probiotics have been shown in studies to flatten the curve

Table 3: Antiviral activity of mushrooms

Mushroom	*Extract/compound*	*Pattern of effect*	*Virus strains*	*Reference*
P. ostreatus	β-glucan pleuran	Increase proinflammatory cytokines (IL-1β, IL-6, and TNF-α	HSV-1 and HSV-2	[34]
A. auricula	Mycelial extract	Inhibit influenza virus type H1N1 and herpes simplex virus type 2 (HSV-2),	H1N1 and herpes simplex virus type 2 (HSV-2),	[35]
G. lucidum	Proteoglycan	Inhibit herpes simplex virus	herpes simplex virus 1 HSV1, HSV 2	[36]
Ganoderma	Triterpenoids	Inhibitors of Dengue virus DENV NS2B-NS3 protease,	Dengue virus DENV	[37]
S. commune	Extract	By interfering with the initial stage of DENV-2 infection,	DENV-2	[38]
P ostreatus	Lectin	Hepatitis B virus tolerance via TLR6 signaling	Hepatitis B virus	[39]

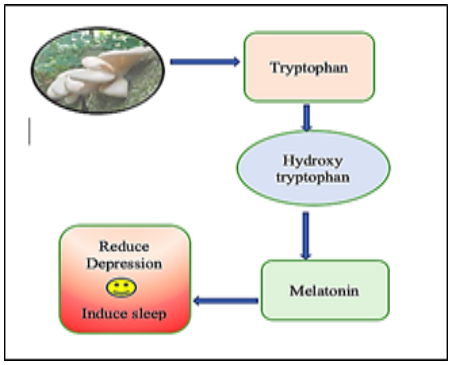

Fig. 2: Sleep inducing action of mushroom.

of the coronavirus disease COVID-19 by reducing bacterial and viral infections, including RTIs.[31] The mushrooms in this investigation are also looking for probiotic functions. Various polysaccharides found in the fruit body, mycelia, and water extract of mushrooms suppress endogenous pathogens in the GI tract, allowing the immune system to be more capable of resisting external pathogens (Table 3). *G. lucidum* is a probiotic mushroom that has a wide range of benefits. The anti-obesity polysaccharide xylan degrading bacterium bacteroides promotes by the and glucan content of this mushroom decreases obesity in mice.[13,14] The extracts of *G. lucidum* and *P. ostreatus* boost the immune system.

Antiviral Activity of Mushrooms

Mushrooms and their active chemicals have been widely recognised a rich reservoir and used as a traditional medicinal medicine for many chronic infections, including viral disorders, since ancient times.[33] Mycelia extracts and other isolated compounds have been found to have antiviral properties in mushrooms. Polysaccharides, carbohydrate-binding proteins, peptides, enzymes, polyphenols, triterpenoids, and other mushroom components help to fight viral infections. These drugs primarily target viral entrance, uncoating, replication, assembly, release, and immune cell modulation. Antiviral effects of mushrooms against herpes simplex virus types 1 and 2 (HSV-1 and 2) have been described utilising -glucan extracted from *P. ostreatus*,[34] mycelial extract of *Auricularia auricula*,[35] and *G. lucidum* Proteoglycan.[36] Dengue virus (DENV) is inhibited by *G. lucidum* triterpenoids[37] and *S. commune* extract.[38] However, the action of mushroom components is distinct. *P. ostreatus* lectin has antiviral action against the hepatitis B virus.[39] Table 3 summarizes the research on mushrooms' antiviral properties

Sleep Inducing Activity of Mushrooms

COVID-19 has negative effects on sleep, including sleep disturbances, mental diseases, and physiologic ailments, particularly during quarantine.[40] Sleep-inducing qualities include indoleamine (5-hydroxytryptophan, serotonin, and melatonin), which is produced from dietary tryptophan, as well as appropriate vitamin D levels (Fig. 2). Serotonin and its precursor, 5-hydroxytryptophan, are abundant in *C. cibarius* and *P. ostreatus.* In rats, *G. lucidum* extract (GLE) increases total sleep time and non-rapid eye movement (NREM) sleep time, implying that mushrooms may have sleep-inducing properties.[43]

Nutritional and Biochemical Components of Mushroom

Various micronutrients and dietary components have important roles in the development and maintenance of a healthy immune system that can help to reduce chronic inflammation. Except for Ganoderma and Auricularia, the nutrient profile of ethnomedicinal mushrooms from the Western Ghats has been published in our previous studies[44] which revealed the high protein, crude fibre, and low fat and salt content are relevant from a pharmacological standpoint. In addition, the antioxidant activities of *Lentinus bambusinus* and *Coprinellus micaceus* as measured by DPPH (IC_{50}) ranged from 3.38 0.10 to 9.790.14 mg/mL. These data also indicate the mushrooms' considerable immune-boosting properties.

Summary

Mushroom consumption has antiviral, immune-boosting, and cholesterol-lowering benefits, according to several pathways. The wild mushroom extracts investigated

potentially have therapeutic effects against problems including lung inflammation and consequences that typically follow COVID-19 infection. More extensive chemical and pharmacological investigations of particular substances are recommended to complete the information. *L. bambusinus, C. micaceous,* and *Termitomyces* are poorly explored wild mushroom species found in the Western Ghats

Conflict of interest

The authors have no conflict of interests

References

1. Cao X. COVID-19: immunopathology and its implications for therapy. Nature reviews immunology. 2020;20:269-70.-270.
2. Alkhatib A. Antiviral functional foods and exercise lifestyle prevention of coronavirus. Nutrients. 2020; 12:2633. Available from: doi.org/ 10.3390/nu12092633
3. Lange KW. Food science and COVID-19. Food Science and Human Wellness. 2021; 10:1-5. Available from: doi.org/ 10.1016/j.fshw.2020.08.005
4. Jayawardena R, Sooriyaarachchi P, Chourdakis M, Jeewandara C, Ranasinghe P. Enhancing immunity in viral infections, with special emphasis on COVID-19: A review. Diabetes and Metabolic. Syndrome:: Clinical Research Reviews. 2020; 14:367-82. Available from: doi.org/ 10.1016/j.dsx.2020.04.015
5. Chidambaram V, Tun NL, Haque WZ, Majella MG, Sivakumar RK, Kumar A, Hsu AT, Ishak IA, Nur AA, Ayeh SK, Salia EL. Factors associated with disease severity and mortality among patients with COVID-19: A systematic review and meta-analysis. PLOS ONE. 2020 18;15(11):e0241541.
6. Shahina NK. Ethnomedicinal and Ecological studies of wild edible mushrooms used by selected tribes in Kerala Palakkad and Wayanad districts. PhD Thesis, M G University; 2019 http://hdl.handle.net/10603/273416
7. Zhou Y, Fu B, Zheng X, Wang D, Zhao C, Qi Y, Sun R, Tian Z, Xu X, Wei H. Pathogenic T-cells and inflammatory monocytes incite inflammatory storms in severe COVID-19 patients. National. Science Review 2020; 7(6):998-1002.
8. Bergendiova K, Tibenska E, Majtan J. Pleuran (β-glucan from Pleurotus ostreatus) supplementation, cellular immune response and respiratory tract infections in athletes. European Journal of Applied Physiology. 2011; 111:2033-40. Available from: doi.org/ 10.1007/s00421-011-1837-z.
9. Oloke JK, Adebayo EA. Effectiveness of immunotherapies from oyster mushroom (Pleurotus species) in the management of immunocompromised patients.International immunology. 2015; 3:8.
10. Van Steenwijk HP, Bast A, de Boer A. Immunomodulating Effects of Fungal Beta-Glucans: From Traditional Use to Medicine. Nutrients. 2021;13:1333. Available from: doi.org/ 10.3390/nu13041333.
11. Li QZ, Wang XF, Bao TW, Ran L, Lin J, Zhou XW. In vitro synthesis of a recombinant fungal immunomodulatory protein from Lingzhi or Reishi medicinal mushroom, Ganoderma lucidum (W. Curt.: Fr.) P. Karst. (Aphyllophoromycetideae) an analysis of its immunomodulatory activity. International Journal of Medicinal Mushrooms. 2010; 1; 347-358
12. Cong WR, Xu H, Liu Y, Li QZ, Li W, Zhou XW. Production and functional characterization of a novel fungal immunomodulatory protein FIP-SN15 shuffled from two genes of Ganoderma species. Applied Microbiology and Biotechnology. 2014;98:5967-75. Available from: doi.org/ 10.1007/s00253-014-5539-4
13. Kuo MC, Weng CY, Ha CL, Wu MJ. Ganoderma lucidum mycelia enhance innate immunity by activating NF-κB. Journal of Ethnopharmacology. 2006;103:217-22.
14. Jan RH, Lin TY, Hsu YC, Lee SS, Lo SY, Chang M, Chen LK, Lin YL. Immuno-modulatory activity of Ganoderma lucidum-derived polysaccharide on human monocytoid dendritic cells pulsed with Der p 1 allergen. BMC immunology. 2011; 12:31. Available from: doi.org/ 10.1186/1471-2172-12-31.
15. Kuo HC, Liu YW, Lum CC, Hsu KD, Lin SP, Hsieh CW, Lin HW, Lu TY, Cheng KC. Ganoderma formosanum exopolysaccharides inhibit tumour growth via immunomodulation. International journal of molecular sciences. 2021; 22: 11251. Available from: doi.org/ 10.3390/ijms222011251.
16. Yelithao K, Surayot U, Lee C, Palanisamy S, Prabhu NM, Lee J, You S. Studies on structural properties and immune-enhancing activities of glucomannans from Schizophyllum commune. Carbohydrate Polymers.2019; 218:37-45.
17. Ayeka PA. Potential of mushroom compounds as immunomodulators in cancer immunotherapy: a review. Evid. -based Complement Alternative Medicine. 2018 Available from: doi.org/ /10.1155/2018/7271509
18. Damte D, Reza MA, Lee SJ, Jo WS, Park SC. Anti-inflammatory activity of dichloromethane extract of Auricularia auricula-judae in RAW264. 7 cells. Toxicological Research. 2011; 27:11-4.
19. Sánchez C. Reactive oxygen species and antioxidant properties from mushrooms. Synthetic and Systems Biotechnology. 2017; 2:13-22.
20. Jedinak A, Dudhgaonkar S, Wu QL, Simon J, Sliva D. Anti-inflammatory activity of edible oyster mushroom is mediated through the inhibition of NF-κB and AP-1 signaling. Nutrition Journal. 2011; 10(1):1-0.
21. Zhao D, Ding X, Hou Y, Hou W, Liu L, Xu T, Yang D. Structural characterization, immune regulation and antioxidant activity of a new heteropolysaccharide from Cantharellus cibarius Fr. International Journal of Molecular Medicine. 2018; 41:2744-54.
22. Uthan ET, Senturk H, Uyanoglu M, Yamaç M. First Report on the in vivo Prebiotic, Biochemical and Histological Effects of Crude Polysaccharide Fraction of Golden Chantharelle Mushroom, Cantharellus cibarius (Agaricomycetes). International Journal of Medicinal Mushrooms. 2021; 23:67-77 . Available from: doi.org/ 10.1615/IntJMed Mushrooms.2021038233
23. Du B, Yang Y, Bian Z, Xu B. Characterization and anti-inflammatory potential of an exopolysaccharide from the submerged mycelial culture of Schizophyllum commune. Frontiers in Pharmacology. 2017; 8:252.
24. Chuankid B, Schrey H, Thongbai B, Raspé O, Arnold N, Hyde KD, Stadler M. Secondary metabolites of Phlebopus species from Northern Thailand. Mycological Progress. 2020; 19:1525-36.
25. Damte D, Reza MA, Lee SJ, Jo WS, Park SC. Anti-inflammatory activity of dichloromethane extract of Auricularia auricula-judae in RAW264. 7 cells. Toxicological Research. 2011; 27:11-4.
26. Tešanović K, Pejin B, Šibul F, Matavulj M, Rašeta M, Janjušević L, Karaman M. A comparative overview of antioxidative properties and phenolic profiles of different fungal origins: fruiting bodies and submerged cultures of Coprinus comatus and Coprinellus truncorum. Journal of Food Science and Technology. 2017; 54:430-8. Available from: doi.org/ 10.1007/s13197-016-2479-2.
27. Singha K, Hor PK, Soren JP, Mondal J, Mondal KC, Pati BR, Mohapatra PK. Exploration of bioactive prospects of a polysaccharide fraction from Termitomyces heimii against colorectal cancer and broad spectrum bacteria. Bioact. Carbohydr. Diet. Fibre .Mycological Progress. 2021; 25:100255.
28. Manna DK, Nandi AK, Pattanayak M, Maity P, Tripathy S, Mandal AK, Roy S, Tripathy SS, Gupta N, Islam SS. A water-soluble β-glucan of an edible mushroom Termitomyces heimii: Structural and biological investigation. Carbohydrate and polyers.. 2015; 134:375-84.
29. Xu S, Zhang Y, Jiang K. Antioxidant activity in vitro and in vivo of the polysaccharides from different varieties of Auricularia auricula. Food & function. 2016; 7:3868-79.
30. Mitra P, Mandal NC, Acharya K. Mycochemicals and antioxidant activity of polyphenol-rich fraction of Termitomyces microcarpus. Int Food Res J. 2016; 23(6). Available from: doi.org/ 10.1080/10496475.2016.1225621
31. Giannoni E, Baud D, Agri VD, Gibson GR, Reid G. Probiotics and COVID-19. Lancet Gastroenterology and Hepatology. 2020;5:720-721. Available from: doi.org/ 10.1016/S2468-1253(20)30195-3.

32. Wang Y, Sun M, Li W, Zhang Y, Zhang H, Han CC. Antioxidant Activity and Probiotic Proliferation and Acidifying Activity of Intracellular Polysaccharides from the Shaggy Ink Cap Medicinal Mushroom, Coprinus comatus (Agaricomycetes), under Optimal Polysaccharide Synthase Activity. International Journal of Medicinal Mushrooms. 2021;23(10 Available from: doi.org//:10.1615/intjmedmushrooms.2021039970
33. Baud D, Dimopoulou Agri V, Gibson GR, Reid G, Giannoni E. Using probiotics to flatten the curve of coronavirus disease COVID-2019 pandemic. Frontiers in Public Health. 2020;8:186. Available from: doi.org/ 10.3389/fpubh.2020.00186
34. Urbancikova I, Hudackova D, Majtan J, Rennerova Z, Banovcin P, Jesenak M. Efficacy of pleura (β-glucan from Pleurotus ostreatus) in the management of herpes simplex virus type 1 infection. Evid-based Compl Altern Med.2020.
35. Sillapachaiyaporn C, Nilkhet S, Ung AT, Chuchawankul S. Anti-HIV-1 protease activity of the crude extracts and isolated compounds from Auricularia polytricha. BMC Complementary and Alternative Medicine 2019;19:1-0.
36. Cong WR, Xu H, Liu Y, Li QZ, Li W, Zhou XW. Production and functional characterization of a novel fungal immunomodulatory protein FIP-SN15 shuffled from two genes of Ganoderma species. Appl Micro Biotech. 2014;98:5967-75. Available from: doi.org/ 10.1007/s00253-014-5539-4
37. Bharadwaj S, Lee KE, Dwivedi VD, Yadava U, Panwar A, Lucas S, Pandey A, Kang SG. Discovery of Ganoderma lucidum triterpenoids as potential inhibitors against dengue virus NS2B-NS3 protease. Science Reports. 2019; 9:1-2. Available from: doi.org/ 10.1038/s41598-019-55723-5
38. Zhang W, Tao J, Yang X, Yang,Z, Zhang L. Liu H, Wu K, Wu J. Antiviral effects of two Ganoderma lucidum triterpenoids against enterovirus 71 infection. Biochemical and Biophysical Research Communication. 2014 449:307-12.
39. He M, Su D, Liu Q, Gao W, Kang Y. Mushroom lectin overcomes hepatitis B virus tolerance via TLR6 signaling. Scientific Reports. 2017;19:71-1.
40. Lin YN, Liu ZR, Li SQ, Li CX, Zhang L, Li N, Sun XW, Li HP, Zhou JP, Li QY. The burden of sleep disturbance during COVID-19 pandemic: a systematic review. Natural Sciences. 2021;13:933-966. Available from: doi.org/ 10.2147/NSS.S312037.
41. Muszyńska B, Kała K, Firlej A, Sułkowska-Ziaja K. " Cantharellus cibarius": culinary-medicinal mushroom content and biological activity. Acta Poloniae Pharmaceutica. 2016; 73(3): 589-598
42. Park YS, Jang S, Lee H, Kang S, Seo H, Yeon S, Lee D, Yun CW. Identification of the Antidepressant Function of the Edible Mushroom Pleurotus eryngii. Journal of Fungi. 2021;7:190. Available from doi.org/ 10.3390/jof7030190
43. Cui XY, Cui SY, Zhang J, Wang ZJ, Yu B, Sheng ZF, Zhang XQ, Zhang YH. Extract of Ganoderma lucidum prolongs sleep time in rats. Journal of Ethnopharmacology 2012; 139(3):796-800
44. Shahina NK. Nutritional and biochemical studies of wild edible mushrooms used by selected tribes in Palghat and Wayanad, Back to Lab Report, WSD, KSCSTE, Kerala.2018. https://ws.kscste.kerala.gov.in › blp › shahina_n_k

HOW TO CITE THIS ARTICLE: Shahina NK, Madhusudhanan K, Angel Mathew. Immune-stimulants and Adaptogenic Properties of Selected Wild Edible Mushrooms Collected from the Western Ghats, India. Int. J. Pharm. Sci. Drug Res. 2022;14(5):639-644. **DOI:** 10.25004/IJPSDR.2022.140519