ISMM

INTERNATIONAL SOCIETY FOR MEDICINAL MUSHROOMS

国际药用菌学会

International Society for Medicinal Mushrooms （ISMM）was founded in Vancouver, Canada. As a global non-profit organization, ISMM promotes the development of research, education, production, transportation, marketing and cultivation of medicinal mushrooms to have people to work towards common aspirations and goals. The integration will increase the impact of the international medicinal mushroom industry and benefit the health of people in the world.

Honorable President: Prof. S.T.Chang, Prof.S.P. Wasser
President: Academician Li Yu
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国际药用菌学会（International Society for Medicinal Mushrooms），简称ISMM，在加拿大温哥华注册成立，由从事药用菌产业的科研、教学、生产、流通、市场、文化及相关产业链的单位、团体和个人自愿组成的为实现共同意愿的非营利性国际组织。本学会致力于促进国际药用菌产业各个领域的融合与发展，以提升药用菌行业在全球的影响力，造福人类健康。

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Call for Papers

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News Reports

Five Amazing Facts about Mushrooms You may not have Known

Throughout history mushrooms have served many purposes, from benefiting diets, to being used as medicine. In this podcast episode, we dig deeper in to their uses with Long Litt Woon from Norway, who shares her experience about how they helped her overcome her grief. An inspiring journey of mushrooming and mourning.

Whilst there's still so much more for science to discover about the fascinating members of the fungi family we do know the following facts about one of the kingdom's most recognisable members: the mushroom.

Listen here to learn more about the restorative power of fungi, and for more awe-inspiring stories about the natural world.

Animals (including humans) are more closely related to mushrooms than plants.

It's estimated that fungi split from animals approximately 1.5 billion years ago. © Baac3nes | Getty

Mushrooms are part of the fungi family, which is an entire kingdom of its own, separate from plants. The fungi kingdom consists of mushrooms, lichen, yeast, plant rusts, moulds, and smut. Mushrooms are the fruit body of fungi, living a short life-span to produce spores so that the fungus can spread.

According to scientists, fungi cells are surprisingly similar to human cells. It's estimated that fungi split from animals about 1.538 billion years ago - 9 million years later than plants did. And unlike plants, which can photosynthesise, animals and fungi are both reliant on external food sources for energy.

Fungi also contain a substance called chitin in their cell walls, which also occurs in the external skeletons of insects, spiders and other arthropods.

Mycelial networks allow plants and fungi to not only exchange goods between each other, but also help different plants in the forest to communicate. © Richard Tullis | EyeEm | Getty

Mushrooms are one small part of a network that allows trees to communicate

Underneath an individual mushroom is a vast network that can spread for acres. It consists of thin threads known as mycelium which connect different plants in a forest.

They have a mutually beneficial relationship with fungi, as plants provide fungi with carbon-rich sugars, and in return fungi provide plants with nutrients taken from the soil.

These mycelial networks allow plants and fungi to not only exchange goods between each other, but also help different plants in the forest to communicate. Older and larger trees use the network to nurture seedlings by transferring carbon to them and helping them survive.

But it's not all altruistic: the network can also be used by trees to sabotage their neighbours by "stealing"' carbon, or releasing harmful chemicals to their rivals.

Ghost mushrooms (Omphalotus nidiformis) are just one of species of fungi with bioluminescent properties.

© Petar Belobrajdic | Getty

Some mushrooms glow in the dark

About 80 fungal species are known to be bioluminescent. Scientists studying two of these mushroom species - the *Neonothopanus gardneri* in Brazil and the *Neonothopanus nambi* in southern Vietnam - discovered that the mushrooms contained a compound called luciferin and the oxidative enzyme, luciferase. When these two mix with oxygen, it triggers a chemical reaction that emits light.

Mushrooms have been used for medicinal purposes for thousands of years. © Souldivina | Getty

Mushrooms have been used as medicine for thousands of years, and we're still discovering potential benefits now

Around 4500 BCE, the Greek physician Hippocrates classified the Amadou mushroom as a potent anti-inflammatory. And the first peoples of North America used – and still use - puffball mushrooms to heal their wounds.

Whilst there is little scientific evidence to support the medicinal benefits of mushrooms, they've featured in traditional Chinese medicine for centuries.

There are lots of different types of mushrooms, including edible ones – obviously – as well as hallucinogenic and poisonous ones. It's estimated that poisonous mushrooms cause more than 100 deaths per year globally, with thousands in need of medical assistance.

Meanwhile, of the estimated 10,000 species of mushroom, 216 species of fungi are thought to be hallucinogenic, and there has been much talk about how 'magic mushrooms' may be an effective treatment for certain mental health issues.

Magic mushrooms naturally contain a psychoactive compound called psilocybin. In a trial by researchers at Imperial College London on patients with treatment-resistant depression, patient-reported benefits apparently lasted up to five weeks after treatment.

Researchers believe the psychedelic compound found in magic mushrooms may be effective by resetting the "circuits" in the brain that are thought to play a role in depression.

However, much more research and testing is needed to establish the longer term effects and efficacy of using magic mushrooms as a treatment for conditions such as severe depression.

Aspergillus tubingensis which looks similar to this, secretes enzymes that help to degrade plastic.

© David Hannah | Getty

They could help break down plastic waste

Plastic generally takes years to degrade, but a fungus called *Aspergillus tubingensis* could break down plastic in just a few weeks.

The fungus was first discovered in 2017 growing in a landfill in Pakistan. Researchers from Quaid-i-Azam University found that it could break down polyurethane, which can be found in materials such as synthetic leather.

According to the researchers, the fungus secretes enzymes that help degrade the plastic, and in return they absorb organic matter back into their cells.

Featured image © Nastco | Getty

Source: https://www.bbcearth.com/

The First Yellow River Old Riverway Ancient Mulberry Garden Sanghuang Congress and the First Golden Ear (Linqing) Industry Conference in China

Sanghuang is a perennial large wood rot fungus, parasitizes on plants of the mulberry genus, with a bright yellow color, include *Sanghuang porusvaninii and Inonotus hispidus.* It is used as a traditional medicine in China with good medicinal effect on promoting blood circulation, stop bleeding, treating gynecological diseases, liver diseases and cancer.

Sanghuang

On July 30-31, 2024, the First Yellow River Old Riverway Ancient Mulberry Garden Sanghuang Congress and the First Golden Ear (Linqing) Industry Conference were held in Linqing City, Shandong Province, China. Nearly 500 attendees including experts and scholars engaged in the research of edible and medicinal mushroom, as well as representatives of enterprises engaged in the cultivation of Sanghuang and Golden Ear (*Naematelia aurantialba*) participated.

This event was hosted by the People's Government of Liaocheng City, Shandong Province, China, co-organized by China Chamber of Commerce of 1/E of Foodstuffs, Native Produce and Animal By-products (CFNA), Engineering Research Center for Edible and Medicinal Fungi of the Ministry of Education, Mycology Society of China, Shanghai Academy of Agricultural Sciences, Office of Talent Work Leading Group of Liaocheng Municipal Committee, Liaocheng Agriculture and Rural Bureau, Linqing Municipal People's Government, Zhongzhou Qingyuan (Linqing) Agricultural Technology Co., Ltd., and Linqing Qingyuan Original Biomedical Technology Co., Ltd. It provides new ideas and solutions for the development of the global Sanghuang and golden ear industries.

The opening ceremony was presided over by Mr. Liu Ziqiang, Secretary General of Edible Fungi Chamber of the CFNA, Mr. Lei Qijun, Deputy Secretary of the Linqing Municipal Party Committee, Mr. Xu Xiaohu, Vice President of CFNA, Mr. Zhang Jianjun, Vice Mayor of Liaocheng Municipal People's Government, Professor Tan Qi, president of the World Society for Mushroom Biology and Mushroom Products, Chief Scientist of the National Edible Fungus Industry Technology System, Mr. Zhang Boli, Academician of the CAE Member, and Mr. Qi Zhala, Standing Committee Member of the National Committee of the Chinese People's Political Consultative Conference, gave addresses in the opening ceremony. The awarding ceremony of Linqing Sanghuang Research Institute, academician and expert of the Yellow River Old Course in Shandong Province, China, the awarding ceremony of the Science and Technology Service Station of the Mycology Society of China, the unveiling ceremony of the seventh batch of important agricultural cultural heritage in China, and the launching ceremony of the application for the global important agricultural cultural heritage of Sanghuang in the sandy land of the Yellow River Old Course were held. The "2024 Golden Ear Popular Dish Index List" was released at the end of the opening ceremony.

After the opening ceremony, Professor Li Yu, the president of the International Society of Medicinal Mushroom and academician of the Chinese Academy of Engineering, gave a keynote speech entitled "The Big Industry of *Auricularia auricula* -40 Years of China's Edible Mushroom Industry". He reviewed the development and transformation of China's edible mushroom industry in the past 40 years, proposed to take *Auricularia auricula* and the big industry as typical examples, promote the development of the entire industry chain of edible mushroom breeding, cultivation and processing, achieve comprehensive development of social, political and ecological benefits, as well as looked forward to the future development of the industry. Professor Guo Liangdong, president of the Mycology Society of China and researcher of the Institute of Microbiology of the Chinese Academy of Sciences, made a keynote speech on the development status and prospects of the Sanghuang industry in China. He analyzed the opportunities and challenges of the mulberry yellow industry at this stage, discussed its development direction, and called for the establishment of a series of industry standards to escort the healthy and sustainable development of the industry.

Professor Li Yu and Professor Guo Liangdong gave keynote speeches.

At the sessions of the Sanghuang researches, the Golden Ear Industry and the Sanghuang industry application, more than 20 experts, scholars and enterprise leaders in the edible and medicinal mushroom industry shared their achievements and discussed the future development of the Sanghuang and Golden Ear industries, focusing on their current status, scientific research progress and industrial chain innovation.

During the peak dialogue session, renowned experts and business representatives discussed the difficulties and solutions in the current development of China's Sanghuang and golden ear industries, expressing their own opinions.

Speeches during the conference.

Peak dialogue session.

After the conference, industry tour was conducted, the attendees visited Linqing Qingyuan Original Biomedical Technology Co., Ltd., Sanghuang Industrial Park, the ancient mulberry tree group of the Yellow River Old Course (Shandong Province Yellow River Old Course Academician and Expert Linqing Sanghuang Research Institute), and the Triplet Integration of Animal, Plant and Fungi Project in Shangdian Town.

Industry tour after the conference.

A Sustainable Project Aims to Repurpose Encroacher Bush to Create Building Blocks to Solve Namibia's Housing Crisis

By Ester Mbathera

People think the house would smell because the blocks are made of all-natural products, but it doesn't smell," says Kristine Haukongo. "Sometimes, there is a small touch of wood, but otherwise it's completely odourless."

Haukongo is the senior cultivator at the research group MycoHab and her job is pretty unusual. She grows oyster mushrooms on chopped-down invasive weeds before the waste is turned into large, solid brown slabs – mycoblocks – that will be used, it's hoped, to build Namibian homes.

"We wanted a new, better way to curtail the housing crisis and a sustainable way to curb the negative effects of the encroacher bush on our environment," said Magreth Mengo, the head of brand and marketing at Namibia's Standard Bank. The bank worked with MycoHab – when it was affiliated with the Massachusetts Institute of Technology, the architecture firm Redhouse Studio and the Shack Dwellers Federation of Namibia (SDFN) – to find a sustainable way to deal with several issues. "This project is a first of its kind and is still very much in the experimental phase but shows a lot of promise," said Mengo.

Namibia, with a population of about 2.7 million, urgently needs at least half a million new homes to address its severe housing shortage. Nearly 90% of households earn less than N$2,700 ($144.69) a month, according to 2016 figures, and can't afford a home. One in five people live in makeshift homes made out of waste materials or zinc sheets.

The remnants of the oyster mushrooms grown on weeds of encroacher bush will be used to create building blocks. Photograph: Ester Mbathera

The woody, wiry encroacher bushes occupy 45m hectares (111m acres) of Namibia's land – pushing out grass and other vegetation. The plants are slowly creeping into Namibia's agricultural regions and affect groundwater recharge in a country where rainfall is precious.

The Namibian government plans to burn 300m tonnes of encroacher bush every 15 years to mitigate its environmental impacts and produce charcoal for profit, but this is increasing the country's carbon dioxide emissions.

"Traditionally encroacher bushes in Namibia are harvested and used for charcoal and wood production, hence there is a huge release of carbon emissions," said Tulimo Uushona, an environmentalist.

The MycoHab project decided to take a different approach. Rather than burning the bushes, MycoHab grinds them up and uses them as a substrate on which to grow gourmet oyster mushrooms. When fully grown, the mushrooms are sold to local retailers and the leftover waste is compressed and baked into building materials called mycoblocks, with each slab being made from about 10kg of bush.

"If this technology becomes widespread, we could mitigate much of the more than 300m tonnes of bush the government of Namibia wants to thin," said Haukongo. "In a normal mushroom farm, the substrate is thrown out or used as compost, but here we turn them into mycoblocks."

The first-ever mycelium-based home at MycoHab's base in Namibia. Photograph: Ester Mbathera

Concrete is believed to be responsible for 4 to 8% of the world's CO_2, emitting almost 1kg of CO_2 equivalent per 1kg. MycoHab estimates that mycelium blocks store 0.8kg of CO_2 equivalent per 1kg of materials produced. And because these slabs come from waste resources, the homes built using mycoblocks are "more cost-effective" and would require "less labour", said Haukongo.

"While these blocks are heavier when compared to standard bricks, they can be erected faster, resulting in lower construction costs. To build a small house for one family, over 12 tonnes of bush would be needed," she said.

This is not the first time fungi has been used as a building material. In 2014 an experimental building called the Hy-Fy in Queens, New York, was made out of crop waste and mycelium and architects and researchers have been investigating the possibilities of this material ever since.

In February this year, MycoHab opened its first mycelium-based home to the public, but the startup is struggling with scaling its operations to cover housing needs in Namibia. "We would love to see MycoHab inspire the architecture and building industries to develop more regenerative design," said Haukongo. "MycoHab helps regenerate Namibia's grasslands, mitigates greenhouse gas emissions, and provides food and housing – all from waste materials."

Heinrich Amushila, the co-director of the SDFN, loves the blocks but said cost would be an issue. "The bricks are fireproof and environmentally friendly, but the initiative is still working on buy-ins from aspiring homeowners to further fund the venture. This can pose a challenge, as prices would be relatively similar to concrete homes, because, although cheaper to make, transporting Mycoblocks to the housing location is still expensive."

Amushila said his organisation helps subsidise the elevated prices by involving candidates in the process of brickmaking as well as in the construction of the houses.

The blocks are heavier than standard bricks, but can be erected more quickly, resulting in lower construction costs overall. Photograph: Ester Mbathera

Romeo Muyunda, a spokesperson for the Namibian ministry of environment, forestry and tourism, welcomed the efforts aimed at preserving the environment.

"We are happy that such initiatives are being made by Namibians," he said. "This being a private initiative, however, I must encourage them to make sure they are compliant with the Environmental Management Act."

This article is published in collaboration with Egab.

Source: https://www.theguardian.com/

Residual Waste from Mushroom Cultivation Removes Pollutants from Water

Water can be purified using mushroom substrate: the mixture of fungal filaments and horse manure that remains after harvesting mushrooms. The substrate effectively decreases concentrations of pesticides and drugs in contaminated water. Utrecht University researchers Brigit van Brenk, Han Wösten, and colleagues demonstrate this in a paper in the scientific journal Applied Microbiology and Biotechnology. The results show the potential of the substrate as a promising alternative to current water purification methods.

White button mushrooms (*Agaricus bisporus*) are grown on composted, sterilized horse manure. Grains containing the fungus are mixed into the compost, from which fungal filaments grow that fill the compost. Fruiting bodies of the fungus, mushrooms, eventually develop from this network of filaments.

But what to do with the substrate after the mushrooms are harvested? In the Netherlands, not much is done with the leftover waste: instead, large quantities are sent to Germany to be used as fertilizer. But couldn't the substrate be put to better use?

Enzymes

Van Brenk and her colleagues suspected that there might be a better way to use the substrate. Fungi that live off dead plant material, such as white button mushrooms, make enzymes to break down lignin. However, these enzymes are not highly specific, and it has been shown that they also break down substances other than lignin.

The researchers therefore decided to investigate the potential of using the leftover waste from mushroom cultivation to purify contaminated water. After all, concentrations of drug residues, pesticides and other harmful substances in surface water and groundwater are increasing, posing a threat to aquatic life forms. Moreover, existing methods of purifying water of such substances are expensive.

Van Brenk: "When we take a medicine, a portion of it is excreted through our urine, eventually finding its way into sewage water. The biggest problem is that these substances are not properly removed from the water before it is discharged into rivers. And natural processes cannot break down these substances as rapidly as we introduce them, resulting in their accumulation in the water."

Brigit van Brenk

DEET and caffeine

To test the efficiency of the mushroom substrate, the researchers first added eight substances to water, including DEET (an insect repellent), caffeine and carbamazepine, a drug used to treat epilepsy. Subsequently, the contaminated water was combined with fragments of the substrate.

"*It is a relatively straightforward, cost-effective, and sustainable way to purify water.*" Brigit van Brenk.

After two to seven days, the researchers examined whether the concentrations of the substances had changed. It was found that, depending on the substance, between 10 and 90 percent had been removed from the water. Van Brenk: "Existing, comparable methods for purifying water often target only one or two specific substances. Although the effectiveness of the substrate varies among different substances, these findings demonstrate its capability to remove a broad spectrum of substances from water. Other methods that offer such a wide range are usually quite expensive."

Fungal tea

The researchers also prepared a tea-like solution from the substrate by soaking it in water for a period and subsequently removing the pieces of substrate. They then combined this tea with the contaminated water to assess its efficiency in removing pollutants. It turned out that the tea was significantly less effective than the substrate itself.

According to Van Brenk, this finding sheds light on how the substrate eliminates substances from the water: "Initially, we believed that the primary mechanism for removing harmful substances was through the enzymes secreted by the fungus. Since these enzymes would be present in the tea, we expected the tea to be as effective as the substrate itself. This was not the case, indicating that there was a significant part of the substrate's action that remained unexplained."

Tested dyes

However, the researchers had some hypotheses regarding possible explanations. Subsequent testing revealed that either enzymes present within the fungal threads that are not excreted, or bacteria that remain attached to the substrate, may play a role. Additionally, it appears that a chemical reaction occurring within the substrate significantly contributes to the removal of the substances.

Next steps

Through other experiments, Van Brenk also demonstrated that mushroom substrate can purify water from dyes and PFAS. These findings are slated for publication later this year. Recently, she and Han Wösten were awarded an Innovation Voucher from Utrecht Holdings, enabling them to advance their research. Their next steps involve testing for the absence of toxic byproducts during purification, and scaling up the purification process.

Van Brenk believes in the potential of the technology. What is more, with water regulations becoming stricter in the Netherlands and Europe, she anticipates that companies will be required to do more to dispose cleaner wastewater in the future. Therefore, Van Brenk aims to establish a company with the purifying substrate as its main product. "It is a relatively straightforward, cost-effective, and sustainable way to purify water. But mind you, there is still a way to go."

Publication: Enzymatic and non-enzymatic removal of organic micropollutants with spent mushroom substrate of *Agaricus bisporus*

Brigit van Brenk, Fleur E.L. Kleijburg, Antoine J.B. Kemperman, Walter G.J. van der Meer en Han A.B. Wösten

Applied Microbiology and Biotechnology, 19 April 2024. DOI: https://doi.org/10.1007/s00253-024-13132-3

Source: https://www.uu.nl

Up-coming Events

Final Program of the 12th International Medicinal Mushrooms Conference (IMMC12)

DATE AND VENUE

The conference will take place in Bari, Italy, 24-27 September 2024 at the **The Nicolaus Hotel Bari - HO Collection**. The conference will be organized in parallel sessions and poster exhibitions. The official language of the conference is English.

THEME OF THE CONFERENCE:

MEDICINAL MUSHROOMS: THE BET FOR THE FUTURE OF HUMANITY

ORGANIZED BY:

University of Bari, Department of Soil, Plant, and Food Sciences (Di.S.S.P.A.)

Italian Society for Medicinal Mushrooms (SIFM)

Conference Programme

Continuous coffee breaks
Morning*:* available from 10:00 am to 12:00 am
Afternoon*:* available from 04:00 pm to 6:00 pm (excluding 26 September 2024)

Monday, 23 September 2024

16:00-20:00 Conference Registration

18:30-20:00 Sponsor tables set-up

Tuesday, 24 September 2024

08:30-18:00 CONFERENCE REGISTRATION OPEN

09:00-09:45 IMMC12 Opening Ceremony

09:45-12:00 KEYNOTE SPEECHES

Chairperson: Ulrike Lindequist (Germany)

Congress Hall 1

09:45-10:30 Psychedelic mushrooms as medicine: challenges and opportunities
Anthony Adili (Canada), O. S. Isikhuemhen

10:30-11:15 The phenomenology of psilocybin´s experience mediates subsequent persistent psychological effects independently of sex, previous experience or setting
Tomáš Páleníček (Czech Republic)

11:15-12.00 Basidiomycete fruiting body development: an exciting morphogenetic process and source of bioactive compounds
László Nagy (Hungary)

12:00-12:45 Presence and The Future of Medicinal Mushroom Process Engineering
Marin Berovič (*Slovenia*)

12:45 Group Photo

13:00-14:00 **Lunch, CASSIOPEA HALL**

14:00-15:40 **Congress Hall 1**

PARALLEL SESSION: DIVERSITY, EVOLUTION AND MORPHOGENESIS IN MEDICINAL MUSHROOMS

Chairperson: Georgios I. Zervakis (Greece)

14:00-14:20 Mining 100 Agarikon genomes: an ongoing optimization of chemical constituents and bioefficacy
Zolton J. Bair (USA), Case M. Beathard, Paul Stamets

14:20-14:40 Distribution of *Inonotus obliquus*, abundance of conks and peculiarities of basidiospore dispersal in Estonia
Karin Kütt (Estonia)

14:40-15:00 On the ecological role of medicinal mushroom *Marasmius oreades*: a study case of fairy rings in the gardens of the Royal Palace of Caserta
Maurizio Zotti (Italy)

15:00-15:20 The epidemiology of wild mushroom poisoning in Israel
Dalia Lewinsohn (Israel)

15:20-15:40 Remembering Tom Volk: A mycological Maestro in our hearts and minds
Ayman Daba (Egypt/USA)

14:00-18:45 **Congress Hall 2**

PARALLEL SESSION: MEDICINAL MUSHROOMS CULTURE COLLECTIONS, CULTIVATION TECHNOLOGY AND CIRCULAR ECONOMY IN RURAL AND MARGINAL AREAS

Chairpersons: Arend F. Van Peer (The Netherlands) and Carmenza Jaramillo Lopez (Colombia)

14:00-19:00 Effects of *A. bisporus* on the immune system, use of collections and can we improve by breeding?
Arend F. Van Peer (The Netherlands), J J.P. Baars, A. Schots

14:45-15:05 Advances in the biodegradability measurement of a hybrid material, product of the transformation of plastic and organic waste using macromycetes
Carmenza Jaramillo-López (Colombia), M.F. Ocampo-Barrero, I.F. Macías-Quiroga, C. Giraldo-Loaiza, E.U. Landazury-Rosero, N.R. Sanabria-González

15:05-15:25 Reclassification and biotechnological potential of mushrooms strains belonging to the collection of the Department of Food, Environmental and Nutritional Sciences (DeFENS) - University of Milan (Italy)
Manuela Rollini (Italy), C. Alamprese, G. Bearzi, C. Cappa, A. Marti, S. Grassi, C. Picozzi, D. Erba, M.C. Casiraghi, G. Ricci, S. Buratti, L. Goppa, E. Savino, G. Consonni, N. Negrini, G. Castorina

15:25-15:45 Fungi's Midas touch: production of medicinal mushroom mycoprotein using agroindustrial by-products
Davide Ferrero (Italy), F. Spina, C. Forliano, S. Galliano, V. T. Glicerina, R. Pera, C. M. Bertea, P, De Bernardi, G. Zeppa, C. Barolo, L. Gasco, G. C. Varese

15:45-16:05 Boosting cordycepin production in *Cordyceps militaris* via the influence of edible insects and medicinal plants
Ayman Turk (Korea), B.S. Kim, M.K. Lee

16:05-16:25 Micosylvicultural actions towards the conservation and sustainable cultivation of unique species (MicoAction)
Jaime Carrasco (Spain), M.V. García-Rubio

16:25-16:45 Bio-recycling hazelnut shells to enrich *Lentinus tigrinus* with bioactive components
Anthea Desiderio (Italy), S.A. Heleno, M. Carocho, M.C. Pedrosa, D. Bobrowski Rodrigues, I. Soffientini, L. Goppa, P. Rossi, E. Savino

16:45-17:05 Controlled cultivation of the medicinal mushroom *Hericium erinaceus* for the enrichment and extraction of functional health promoting metabolites, focusing on ergothioneine content, anti-oxidative potential and bioactivity in neuronal cells
E. Kostanda, N. Ezov, S. Doron, H. Ben Zeev, S. Khatib, Idan Pereman (Israel)

17:05-17:25 Breeding and selection for high-temperature tolerance in *Pleurotus ostreatus*
Joel Kwon (USA), N. Holt, O. S. Isikhuemhen

17:25-17:45 A novel high-temperature tolerant *Pleurotus* sp.: domestication, mating behaviour and interspecies compatibility
Nathan Holt (USA), N. S. Udombang, J. O. Enemudo, M. Mensah-Bonsu, F. N. Anike, O. S. Isikhuemhen

17:45-18:05 Impact of locally available lignocellulosic residues on the cultivation parameters and nutritional composition of the tropical milky white mushroom *Calocybe indica*
Georgios Koutrotsios (Greece), D. Tagkouli, K. Tsiantas, N. Kalogeropoulos, P. Zoumboulakis, G.I. Zervakis

18:05-18:25 Microwave-assisted extraction of *Pleurotus* mushrooms cultivated on wine pomace and antioxydant activity evaluation
Gaetano Balenzano (Italy), Giovanni Lentini, Maria Maddalena Cavalluzzi, Valeria Ferraro, Roberto Balducchi, Anna Spagnoletta, Fortunato Cirlincione, Maria Letizia Gargano

18:25-18:45 Transcriptome combined with enzyme activity analysis unveiled the key genes and pattern of lignocellulose degradation under the cultivation by corncob in *Auricularia heimuer*
Ming Fang (China), X. Sun, F. Yao, L. Lu, X. Ma, K. Shao

18:45-19:05 Innovative multifunctional production system in marginal areas
Matteo Spagnuolo (Italy)

18:45-19:00 18:45-19:00 Ex situ conservation, enhancement and sustainable use of *Pleurotus nebrodensis*, a rare species, endemic to Sicily (southern Italy)

Giuseppe Venturella (Italy), M.L. Gargano

19:30-21:00 **WELCOME RECEPTION (CASSIOPEA HALL)**

Wednesday, 25 September 2024

08:30-18:00 CONFERENCE REGISTRATION OPEN

09:00-19:00 **Congress Hall 1**

SESSION Biochemistry, biotechnology and pharmacology of medicinal mushrooms

Chairpersons: Marin Berovič (Slovenia) and Angel Trigos (Mexico)

09:00-09:30 Medicinal mushrooms as multicomponent mixtures (MOCS) - Demonstrated with the example *Lentinula edodes*
Ulrike Lindequist (Germany)

09:30-10:00 Impact of medicinal mushroom extracts on ribosomal biogenesis, translation, and metabolic pathways in colorectal cancer: a proteomic study
Boris Jakopovic (Croatia), A. Horvatić, J. Baranasic, I. Car, N. Oršolić, I. Jakopovich, S. Kraljević Pavelić

10:00-10:30 Ergosterol, a versatile metabolite of mushrooms
Ángel Trigos (Mexico), I. Lagunes, R. Hernández-Chacón, K. Manzano

10:30-11:00 Medicinal marvels of mushrooms: unlocking their potential for health and wellness
Ayman Daba (Egypt/USA)

11:00-11:20 Unveiling environmental influence on high molecular weight polysaccharides in *Ganoderma lucidum* submerged fermentation for industry
Jie Feng (China), J. Guo, Y.F. Liu, J.S. Zhang

11:20-11:40 Study on active compounds of protecting nerve cells in *Ganoderma lucidum* based on spectrum-effect relationship method
Jingsong Zhang (China), W. Wang, Y. Yang, Z. Yu, N. Feng, C. Tang, Q. Tang, J. Feng, Y. Liu, S. Zhou, M. Yan

11:40-12:00 Neuroprotective activity of polyamines and phenolic compounds derived from three *Fomes fomentarius* strains in the Balkan Region (Serbia, Croatia, Bosnia and Herzegovina)
M. Rašeta, Eleonora Čapelja (Serbia), J. Mišković, D. Pintać Šarac, S. Berežni, Á.E. Kulmány, I. Zupkó, S. Jovanović-Šanta, M. Kebert, M. Karaman

12:00-12:20 Mycelium of medicinal mushrooms for production of mycelium-based bio-composites and its physical and mechanical properties
Štěpán Hýsek (Austria), M. Jozífek, M. Němec, J. Hradecký, R. Wimmer

12.20-12:40 Hypoglycemic properties of *Leccinum scabrum* - An in vitro study on α-glucosidase and α-amylase inhibition activity
Valeria Ferraro (Italy), M.M. Cavalluzzi, G. Lentini, N.P. Rotondo, A. De Palma, D.V. Miniero, G. Venturella, M.L. Gargano

12:40-13:00 Physicochemical characteristics and anti-breast cancer properties of medium molecular weight sulfated polysaccharides from *Laetiporus sulphureus*
Chia I. Jen (Taiwan), L.T. Ng

13:00-14:30 **Lunch, CASSIOPEA HALL**

Chairpersons: Ayman Daba (Egypt/USA) and Boris Jakopovic (Croatia)

15:00-15:20 Chemical and functional characterization of *Leccinum scabrum* and *Leccinum versipelle*
Francesca Medri (Italy), C. Terenzi, Giuseppe Venturella, Maria Letizia Gargano, G. A. Bermúdez-León, S. Montanari, V. Andrisano

15:20-15:40 Mycochemical profile and antioxidant activity of two cultivated *Pleurotus* species: *P. ostreatus* (Jacq.) P. Kumm. 1871 and *P. eryngii* (DC.) Quél. 1872
Vesna Šolaja (Serbia), M. Rašeta, M. Nocić, J. Mišković, M. Rakić, E. Čapelja, M. Karaman

15:40-16:00 Composition and antimicrobial activity of hydroalcoholic extracts of *Pleurotus eryngii* var. *ferulae* and *P. eryngii* var. *elaeoselini*
Flavio Polito (Italy), L. De Martino, G. Mirabile, G. Venturella, M. L. Gargano, V. De Feo, H. Elshafie, I. Camele

16:00-16:20 Potential of submerged exo - and intra-polysaccharides from two *Schizophyllum commune* Fr. 1815 strains in biopriming of pea (*Pisum sativum* L.) seed
J. Mišković, Maja Karaman (Serbia), G. Tamindžić, M. Borišev, M. Rašeta, G. Gojgić-Cvijović

16:20-16:40 Phamacological activities and standard compounds of *Cordyceps pruinosa* mycelial extracts
Seong Hwan Kim (South Korea), I.H. Lee

16:40-17:00 Antioxidant properties, total phenolic and flavonoid content of different extracts of the medicinal mushrooms *Pleurotus eryngii*, *Leccinum scabrum*, *Leccinum versipelle* and *Pisolithus tinctorius*
Giulia Mirabile (Italy), M.L. Gargano, G. Venturella, M. Asatiani

17:00-17:20 Advances in the use of medicinal mushrooms in animal production
Omon S. Isikhuemhen (USA/Nigeria), L. K. Olagunju, S.A. Suberu, U.Y. Anele

17:20-17:40 Means from *Fomes fomentarius* for adding to the feed of domestic animals in order to improve the quality of milk and meat products
Olga Seniuk (Ukraine), A. Zaitseva, N. Hryshchenko

17:40-18:00 Biological screening of some wild mushrooms of Berti Raj Forest, Buner, KP, Pakistan
Muhammad Hanif (Pakistan), F. Suleman

18:00-18:20 Pleurotus ostreatus as a new antimicrobial agent against bovine mastitis.
Ewa Zapora (Poland), A. Kalinska

18:20-18:40 Evaluation of the drought tolerance and study on the drought tolerance mechanism of *Auricularia heimuer*
Fang-jie Yao (China), J. Sun, L.-x. Lu, M. Fang

18:40-19:00 Velvet family members regulate pigment synthesis of the fruiting bodies of *Auricularia cornea*
Li-xin Lu (China), X.-x. Ma, F.-j. Yao, M. Fang

Thursday, **26 September 2024**

08:30-13:00 CONFERENCE REGISTRATION OPEN

08:30-13:00 **Congress Hall 1**

Parallel Session Medicinal mushrooms in human studies: from healthy aging to different diseases

Chairpersons: Paola Rossi (Italy) and Liudmila Kalitukha (Germany)

08:30-09:15 Clinical experiences from the use of medicinal mushrooms in outpatient hospital settings in Germany
Christoph Keßler (Germany)

09:15-09:30 Benefits of *Fomes fomentarius* fibres (Good Feeling Power®) in the treatment of Addison's disease. Case study
Liudmila Kalitukha (Germany)

09:30-09:45 The potential benefits of AndoSanTM in subjects with colorectal cancer-related fatigue. rational for its use, preliminary results and safety profile
Ralf Schmidt (Norway), B. L. Fiebich, H. Fjos

09:45-10:00 Nanoemulsified fungal compounds emerge as natural immunoadjuvants for cancer prevention and treatment in ongoing clinical trials
E. Sinde, A. Rodríguez-Blanco, Iván Simon, N. Sinde, Catalina Fernandez de Ana Portela (Spain)

10:00-10:15 Chitin-glucan-melanin complex from *Fomes fomentarius* as a means to stop bleeding and treat lacerations and burns in combat conditions
Olga Seniuk, N. Kurochko (Ukraine)

10:15-10:30 Electrophysiological Insights into *Hericium erinaceus*: Unveiling its Neuroprotective Potential
Federico Brandalise (Italy), D. Ratto, L. Goppa, M.T. Venuti, A. Desiderio, E. Roda, E. Savino, P. Rossi

10:30-10:45 Preclinical Studies of a fibrinolytic pharmaceutical formulation containing a protease complex derived from the fungus *Sarocladium strictum* 203
Anna Shestakova (Russia), S.N. Rizatdinova, E.I. Kornienko, A.A. Osmolovskiy

10:45-11:00 Mushroom versus rare diseases: activity against the Leishmania parasite
Segula Masaphy (Israel), L. Zabar, A. Peretz

11:00-11:15 *Pisolithus arhizus*: a bio-factory of terpenoids and pigments with health-promoting activity
Valentina Parisi (Italy), R. Nocera, G. Donadio, E. Rosa, S. Francheschelli, V. Santoro, A. L. Piccinelli, L. Rastrelli, N. De Tommasi

11:15-11:30 *Ganoderma pfeifferi* Bres. 1889 and *G. resinaceum* Boud. 1889 as potential therapeutic agents: A comparative study on antioxidant, antiproliferative and lipid-lowering properties in alloxan-induced diabetic rats
Maja Karaman (*Serbia*), M. Kebert, S. Kaišarević, N. Stilinović, S. Vukmirović, S. Kostić, J. Mišković, M. Rašeta

11:30-11:45 Extracts from King Oyster mushrooms (*Pleurotus eryngii*), and their major bioactive compounds, reduce inflammatory stress signals in HAPI microglia cells
Isabelle Hininger-Favier (France), D. R. Fisher, A. Boumendjel, B. Shukitt-Hale

11:45-12:00 Administration of *Coriolus* mrl resulted in a significant reduction in PSA levels among prostate cancer patients
Eneribholo Eno-Edobor (Nigeria), T. N. Ogbonna, G. A. Aka , O. S. Isikhuemhen

12:00-12:15 Biological role of ricin B-type lectins from the entomopathogenic fungi, *Cordyceps militaris*
Jili Zhang (Japan), Ono Akiko, Chihiro Sato, Rina Matsuda, Yuki Tanaka, Tomohiro Suzuki

12:15-12:30 The improved effect of bone health in animal models of osteoporosis administered ethanolic extracts of *Wolfiporia hoelen*
Youngki Park (Korea), Rhim Ryoo, Jong-Beom Seo, Kyoung Tae Lee

12:30-12:45 Genome and transcriptomic analysis of biologically active angel-wing mushroom *Pleurocybella porrigens* that cause acute encephalopathy.
Nozomu Watanabe (Japan), K. Mitsukuni, T.Sato, A. Ono, T. Suzuki

12:45-13:00 Function evaluation and mechanism study of Sanghuangporus vaninii in inhibiting cervical cancer and lowering uric acid
Yan Yang (China), D. Wu, T. Li, W.Ch. Chen, P. Liu, Z. Zhang, W. Li

08:30-13:30 **Congress Hall 2**
Parallel Session Medicinal mushrooms as a source of novel functional food and health benefits
Chairpersons: Lilian Barros (Portugal) and Alessandro Colletti (Italy)

08:30-09:00 Full spectrum mycoproducts explained
John Holliday (*USA*)

09:00-09:15 Medicinal mushrooms, regulatory aspects and quality: let's open the pandora box
Marzia Pellizzato (*Italy*)

09:15-09:30 Safety and efficacy of medicinal mushroom supplements: is a "significant history of consumption" enough?
Alessandro Colletti (*Italy*)

09:30-09:45 Medicinal mushrooms: not only β-glucans for clinical practice
Valentina Citi (*Italy*)

09:45-10:00 Recent Advances in Biotechnological and Biomedical Research of Macrofungi
Susanna Badalyan (Armenia), S. Rapior, A. Zambonelli

10:00-10:15 Degradation of β-D-glucan from *Ganoderma lucidum* to produce oligosaccharides and the separation, structural and immunoregulatory property investigation
Yanfang Liu (China), X. Qin, G. Ma, L. Liu, J. Feng, J. Zhang

10:15-10:30 Completeness of Spagyric multiextraction from medicinal mushrooms and their relative structures of crystallizations
David Casulli (Italy)

10:30-10:45 Production of new bioactive metabolites from *Hericium erinaceus* by the regulation of cultivation conditions
Mi Kyeong Lee (Korea), S. H. Ryu, A. Turk, B. S. Kim

10:45-11:00 *Hericium erinaceus* supplementation as a prebiotic fibre impacting microbiome composition and neuroactive targeted metabolomics
Julie Daoust (USA), S. Andrasko, J. Schmaltz, J. Ghyselinck, P. Gamorow

11:00-11:15 Application of design of experiment and multivariate analysis in the process of *Ganoderma lucidum* basidiocarps extraction
Ivana Sofrenić (Serbia), L. Popović, K. Simić, S. Ivanović, J. Ljujić, V. Tešević, B. Anđelković

11:15-11:30 Gluten free plant-based functional cookies: an interesting food for celiac consumers
Fortunato Cirlincione (Italy), M.L. Gargano, G. Balenzano, R.V.C. Cardoso, D. Almeida, T.C. Finimundy, B. Melgar, L. Barros

11:30-11:45 Application of FTIR spectroscopy in monitoring of *Fomitopsis betulina* fruiting bodies chemical composition
Boban Anđelković (Serbia), I. Sofrenić, D. Gođevac, A. Knežević, V. Tešević, I. Đorđević, S. Milosavljević

11:45-12:00 Integrative Omics analysis of *Hericium erinaceus*: comparative insights from proteomics and NMR metabolomics
Lorenzo Goppa (Italy), M. Spano, E. Ferrari, C. Santambrogio, S. Brocca, L. Mannina, P. Rossi, E. Savino

12:00-12:15 Extraction of antioxidant and anti-inflammatory fractions from *Sparassis crispa* using pressurized fluids
Paula García-Ponsoda (Spain), C. Soler-Rivas, A. Ruiz-Rodríguez, L. Jaime, M. Trinidad Herrero, S. Santoyo

12:15-12:30 Industrial cultivation of medicinal mushrooms: unlocking functional food potential
William Goss (USA)

12:30-12:45 Mycolife liquid extracts, the new generation of medicinal mushroom preparations. Innovative know-how procedure and what is behind it
Kolos Kiss (Italy), N. Szabó, A. Gubó

12:45-13:00 Mushroom bio-residues as a source of dietary fibre
Eliana Pereira (Portugal), L.G.F. Ferri, R. Cardoso, D. Almeida, D.C. Lenhard, I.C.F.R. Ferreira, L. Barros, Â. Fernandes

13:00-13:15 Biopreparation Mikosan from *F. fomentarius* for plant protection
Olga Seniuk (Ukraine), *G. Leontij*

13:15-13:30 Implementation of the MIRRI-SAAF catalogue of culture collections: an example of data management and resources sharing
Rosa Guarcello (Italy)

13:30-14:30 **Lunch, CASSIOPEA HALL**

17:00 **Visit to the city of Altamura**

20:00 **Congress Dinner I LUOGHI DI PITTI – MASSERIA SAN GIOVANNI (Altamura)**

Friday, **27 Sept 2024**

08:30-15:00 CONFERENCE REGISTRATION OPEN

09:00-12:55 **Congress Hall 1**

Session *Therapeutic potential of psychedelic mushrooms*

(simultaneous translation provided)

Chairpersons: Tania Re (Italy), John Holliday (USA), Omoanghe S. Isikhuemhen (USA)

09:00- 09:45 Psilocybin mushrooms: history, use and identification
<u>*Paul Stamets*</u> (USA)

09:45-10:15 *Psychedelic-assisted psychotherapy - How to catalyze the mechanisms of psychotherapeutic action*
<u>*Daniele Zullino*</u> (Switzerland)

10:15-10:35 Ethnomycology and the therapeutic potential of psychedelic mushrooms: Policy and advocacy perspectives
<u>*William Goss*</u> (USA)

10:35-11:55 End of life: a new training approach
<u>*Tania Re*</u> (Italy)

10:55-11:15 The use of phenomenology to understand the psychedelic experience induced by psilocybin. New potential applications in research and clinical practice
<u>*Antonio Metastasio*</u> *(Italy), E. Prevete, A. Garofalo, S. Venturini, N. De Pisapia, O. Corazza*

11:15-11:35 Neurophenomenology in Tibetan mediation and in psychedelics
<u>*Filippo Bosco*</u> *(Italy), B. Neri, T. S. Re, A. Chiolerio*

11.35-11:55 Correlation and complexity of fungal electrome
<u>*Alessandro Chiolerio*</u> (*Italy*)

11:55-12:15 Heavenly prospects: Psilocybin-induced death and god encounters compared
<u>*Lucas Pawlik*</u> (*Austria*)

12:15-12:35 Exploring the therapeutic potential of psilocybin in neurology
<u>*Evan Cole Lewis*</u> (*Canada*)

12:35-12:55 De novo implementation of publicly-funded Psilocybin-Assisted Therapy for cancer patients in a palliative care outpatient practice: A Montreal story
<u>*Houman Farzin*</u> (*Canada*)

13:00-14:30 **Lunch, CASSIOPEA HALL**

15:00-17:00 **Congress Hall 1**

ROUND TABLE: Psychedelics between the right to science and national laws

co-organized with Associazione Luca Coscioni **(simultaneous translation provided)**

Moderators: Tania Re and Marco Perduca (Italy)

SPEAKERS

Psilocybin fungi: bridge between life and death
<u>*Piero Cipriano*</u> (*Italy*)

The right to science and substances under international control
Giulia Perrone (*Italy*)

The clinical experiences that do not exist
Mauro D'Alonzo (*Italy*)

Compassionate therapies at the end of life
Claudia Moretti (*Italy*)

MAPS in Italy – First Italian conference on psychedelics
Michelle Barocchi (*Italy*)

Great treatment with psilocybin and Ayahuaca: preliminary results
Alessio Faggioli (*Italy*)

Conclusions: *Marco Cappato*, (*Italy*) Associazione Luca Coscioni

17:00 Congress Hall 1
IMMC12 Closing Ceremony

e-Posters

(available for the duration of the Conference on the appropriate screens)

eP_01 Therapeutic potential of *Ganoderma* species: Traditional medicine and evidence of effectiveness
S.M. Badalyan, S. Morel, S. Rapior, F. Fons

eP_02 Fungal mycelium: Innovations in 3D bioprinting and yeast cell immobilization
S. Brunet, M. Odanović, S. Birgermajer, U. Miljić, J. Kojić, N. Jaćimović, Lj. Janjušević

eP_03 Tara Mountain (Serbia) - a valuable habitat for medicinal mushrooms
E. Čapelja, M. Karaman, M. Marković, I. Dudaš, M. Rakić

eP_04 Verification of the regenerative potential of *Laetiporus sulphureus* extracts for topical applications
H. Car, A. Sadowska, D. Sawicka, B. Skonieczna, E. Zapora

eP_05 The correlation of antimicrobial potential and bioactive compounds between extracts of cultivated and wild edible mushrooms of *Agaricus*
A.D. Ćirić, M.D. Soković, L.A. Barros, F.S. Reis, J.M. Glamočlija

eP_06 Sustainable cultivation of medicinal mushrooms: mycoagroecology and Iside farm case study
C. Di Giovambattista , M.Giordano, E.Gobbi

eP_07 Comparative chemical analysis and bioactive properties of aqueous and glucan-rich extract *Cyclocybe aegerita* (V. Brig.) Vizzini
J.M. Glamočlija, J.D. Petrović, D.S. Stojković, D.D. Milinčić, M.B. Pešić

eP_08 Chemical composition analysis of *Fomitopsis betulina* fruiting bodies by HRMAS NMR spectroscopy
D. Gođevac, I. Sofrenić, B. Anđelković, P. Shestakova, Y. Mitrev, V. Tešević, S. Milosavljević

eP_09 Comparative study of chitin nanofibers extraction from fruiting bodies, stems and mycelium of cultivated mushrooms
V. Grifoll, P. Bravo, M. Pérez Clavijo

eP_10 Potential of NMR multi-suppression experiment in quality control analysis of natural deep eutectic solvent extracts of *Ganoderma resinaceum* fruiting bodies
S. Ivanović, K. Simić, I. Sofrenić, B. Anđelković, J. Ljujić, D. Gođevac

eP_11 Cultivation of Birch Bracket mushroom Fomitopsis betulina (Agaricomycetes) on alternative substrates
A. Knežević, I. Djokić, B. Anđelković, I. Sofrenić

eP_12 Assessment of the chemical and biomedicinal characteristics of the acetonic extract of the edible mushroom *Armillaria cepistipes* (Agaricomycetes)
M. Kosanić, T. Tosti, I. Srbljak, A. Đurić, N. Petrović

eP_13 Mushroom chitosan-clay composite as antioxidant and mycotoxin adsorbent
M. Kozarski, M. Pantić, V. Lazć, M. Nikšić, N. Todorović, D. Smiljanić, A. Daković

eP_14 Adsorption parameters and cadmium removal from water solutions by *Ganoderma lucidum* heteropolysaccharides
T. Kralj, G. Marolt, M. Slapničar, A. Gregori

eP_15 Enhancing the bioactive components in *Psilocybe cubensis* mycelium: The influence of submerged fermentation conditions
E. Kurzbaum, S. Azerrad, A. Rosenberg, D. Lewinsohn, Y. Dekel

eP_16 Supplementation of substrates to cultivate edible mushrooms with algae clumps from Mar Menor lagoon improved levels of bioactive compounds in the obtained fruiting bodies
R. Lavega, S. Figueredo, M. Pérez, A. Gomez-Arribas, F. R. Marín, A. Ruiz-Rodriguez, C. Soler-Rivas

eP_17 Biological activity of supercritical water extracts derived from the mushroom *Inonotus obliquus*
V. Lazić, J. Vunduk, M. Kozarski, A. Doroški, A. Klaus

eP_18 Extracts from *Ophiocordyceps sinensis* and *Ganoderma lucidum* and their complexation with silver ions
L. Maľučká-Ugvarská, A. Uhrínová, M. Pavlík

eP_19 Ecology of the smoky polypore *Bjerkandera adusta* from Serbia
V. Oro, B. Pisinov, R. Stanisavljevic, M. Tabakovic, Z. Sekulic

eP_20 Chitosan from *Lentinus edodes* fruiting bodies: Extractiona, antioxidative and antibacterial activity
M. Pantić, M. Kozarski, V. Lazić, J. Todorov, N. Todorović, M. Nikšić, A. Daković

eP_21 Bioactive secondary metabolites from *Hirschioporus fuscoviolaceus* (Hymenochaetales, Basidiomycota), a white-rot fungus of coniferous forests
V. Papp, S. Suratno, B. Várnai, C. A. Felegyi-Tóth, I. Boldizsár, T. Gáti, A. Móricz, S. Béni, A. Ványolós

eP_22 Inhibitory activity of *Sparassis latifolia* on the lipid accumulation through suppressing adipogenesis and activating lipolysis, lipophagy, and thermogenesis in 3T3-L1 Cells
Y. Park, R. Ryoo, K. T. Lee, J. Beom Seo, J. B. Jeong

eP_23 Evaluation of chemical and bioactive properties of the methanolic extract of *Armillaria gallica* (Agaricomycetes) from Serbia
N. Petrovic, T. Tosti, I. Srbljak, A. Đurić, M. Kosanic

eP_24 Higher bioaccessibility of triterpenes in *G. lucidum* sporocarp external skin in contrast to the inner flesh highlights it as a valuable source for the intake of bioactive compounds
D.B. Rodrigues, N. J. Murrube, R. Cardoso, P. Petros, E. Puro, L. Barros

eP_25 Triterpenic and phenolic composition of *Ganoderma lucidum* extracts as affected by the sporocarp part and extraction technique
D.B. Rodrigues, N. J. Murrube, R. Cardoso, P. Petros, E. Puro, L. Barros

eP_26 A safety assessment of *Heterobasidion annosum* extract in the treatment of colorectal cancer
A. Sadowska, D. Sawicka, B. Skonieczna, E. Zapora, H. Car

eP_27 Green approach in extraction of bioactive metabolites from *Ganoderma resinaceum* fruiting bodies
K. Simić, S. Ivanović, I. Sofrenić, B. Anđelković, J. Ljujić, D. Gođevac

eP_28 Cultivated *Hericium erinaceus* (Bull.) Pers. 1797 and *Lentinula edodes* (Berk.) Pegler 1976 hot water and polysaccharide extracts are sources of anti-stress compounds
V. Šolaja, M. Rašeta, V. Živaljevic, J. Mišković, M. Rakić, E. Čapelja, M. Karaman

eP_29 Isolation and characterisation of secondary metabolites from weeping bolete (*Suillus granulatus*)
A. Ványolós, D. Krafcsik, S. Suratno, I. Boldizsár, S. Béni

eP_30 Chemical composition, antimicrobial efficacy, and sensory characteristics of Kombucha beverages from *Lentinus edodes* and Coriolus versicolor medicinal mushrooms
A. Sknepnek, D. Miletić, D. Matijašević, S. Lević, V. Nedović, M. Nikšić, M. Pantić

India Mushroom Days

4th, 5th, 6th October the India Mushroom Days will be organized for the first time in New Delhi, India

WHY ATTEND?

Networking Opportunities

Whether you're looking to expand your business, share knowledge, or simply build valuable relationships, this event provides an unparalleled opportunity to network with like-minded individuals. Engage in discussions, exchange ideas, and forge partnerships that can drive your mushroom-related ventures to new heights.

Stay at the Forefront of Industry Trends

Stay at the forefront of the mushroom industry in the event. Engage with the latest trends, technologies, and market dynamics. Connect with peers, gain valuable insights and unlock new opportunities for success. Elevate your business and stay ahead of the curve in this dynamic and growing sector.

WHAT TO EXPECT?

Get a glimpse of the exciting lineup of workshops, seminars, networking opportunities, and more that await you at India Mushroom Days.

EXHIBITOR REGISTRATION

Exhibition booths are offered in multiples of 12 square meters at the India Mushroom Day'24. Minimum size for a booth is 12 square meters. Each booth will be equipped with prefabricated standard panels, lighting, a front table, a round table, four chairs, and a brochure display shelf. One complimentary conference registration and food coupons for one person.

CONFERENCE REGISTRATION

Registration Information:

Conference registration provides delegates access to all three days of the IMD'24 event. The registration fee is for one participant & includes the registration kit, refreshments (morning tea, evening tea, lunch and entry to NETWORK DINNER) entry to the Exhibition Hall. This registration and fee does not include cost of stay in Delhi during the event days.

Registration Fee: FOREIGN PARTICIPANTS

Early Bird Registration (Till 15 July' 2024): US$490

General Registration (from 16 July' 2024 – 31st August' 2024): US$590

Late Registration (After 1st September' 2024): US$790

Registration Fee: INDIAN PARTICIPANTS

Early Bird Registration (Till 15/07/2024): 3995/- + (18%GST)

General Registration (from 16/07/24 – 31/08/24): 5995/- + (18%GST)

Late Registration (After 1/09/2024): 9995/- + (18%GST)

Registration Fee: STUDENTS

GENERAL REGISTRATION: Rs. 2600/- (DOES NOT INCLUDE DINNERS)

** Registration is VOID if appropriate fee is not paid in prescribed deadlines.*

** This fee is refundable ONLY within Three Days of payment.*

** Fee is applicable for each participant please fill seprate form for every candidate.*

VENUE

Multipurpose Hall, Sports Complex University of Delhi, Delhi -110007 India

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https://www.cognitoforms.com/

The 11th International Conference on Mushroom Biology and Mushroom Products (ICMBMP11）

The 11th International Conference on Mushroom Biology and Mushroom Products (ICMBMP11）will be held in Ghana, 2026, the chairman of the conference is Dr. Mary Obodai. Please stay tuned for the call for papers and conference programme.

ABOUT WSMBMP

The World Society for Mushroom Biology and Mushroom Products is an international organization devoted to the enhancement and application of knowledge related to basic and applied aspects of mushroom biology and mushroom products. Activities of the Society shall be conducted with the Constitution and Bye Laws and include: publishing the Society Bulletin, and other educational and scientific literature; organizing scientific meetings, symposia, workshops and training courses; representing mushrooms-related interests internationally and other means deemed appropriate.

CONTACT US

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Research progress

Research progress of edible mushroom polysaccharide-metal trace element complexes

Yanbo Hu [a 1], Yi Cao [a 1], Yuzhu Shen [a], Yakun Shan [a], Jiaxin Liu [b], Yudi Song [a], Yue Yang [a], Jun Zhao [a]

[a]*School of Food Sciences and Engineering, Changchun University, Changchun 130024, China*

[b]*Jilin Province Product Quality Supervision and Inspection Institute, Changchun, 130012, China*

Abstract: Metal trace elements are crucial for human health, and the complexes of edible mushroom polysaccharides with metal trace elements are currently a research hotspot in the field of food science. This article reviews the preparation methods, structural characterization, and physiological activities of edible mushroom polysaccharide-metal trace element complexes, including iron, selenium, and zinc. Research has shown that iron complexes obtained through Co-thermal synthesis of the $FeCl_3$ method exhibit excellent antioxidant and anti-anemia functions; selenium complexes prepared via selenium-enriched cultivation significantly enhance immunological and anti-cancer properties; zinc complexes improve lipid-lowering, liver protection, and antioxidant capabilities. However, there is an imbalance in research among different metal elements, particularly with a high density of studies on selenium complexes. These studies provide a foundation for the future development of edible mushroom polysaccharide-metal trace element complexes.

Keywords: Edible mushroom polysaccharide-metal trace element complexes, Structural characterization, Preparation, Physiological activity

Food Chemistry: X, Available online 10 August 2024

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Mushrooms and Their Compounds with Potential Anticancer Activity: A Review

Díaz-Godínez Gerardo [a], Téllez-Téllez Maura [b]

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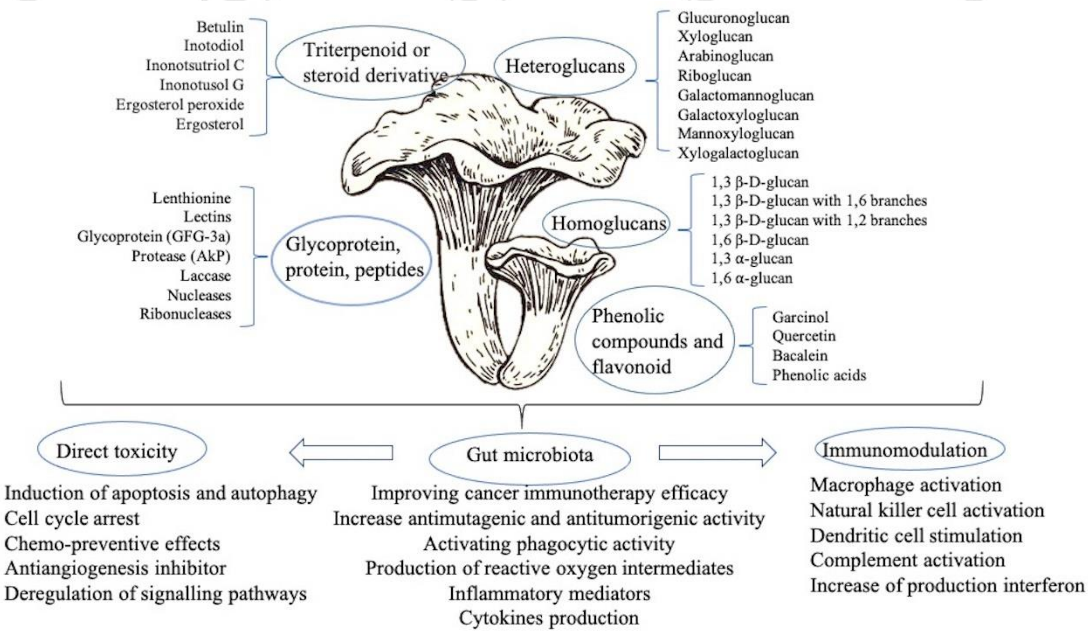
Abstract: Mushrooms produce many metabolites that show biological activity, which can be obtained from their fruiting body, mycelium or recovered from the culture broth when mushrooms are grown in submerged fermentation. Mushrooms are a source of natural pharmaceuticals; they have been reported to have potential inhibitory or preventive

activity against some diseases, including different types of cancer. Cancer represents one of the main causes of death worldwide. It is worth mentioning that despite advances in pharmacological treatments, they still present side effects in patients. In this sense, the study of the use of mushrooms in complementary treatments against cancer is of great interest. Based on studies carried out *in vitro* and, in some cases, using animal models, it has been observed that mushrooms present preventive, corrective, and therapeutic properties against different types of cancer, by stimulating the immune system, due to their antioxidant, antimutagenic, and anti-inflammatory activities, as well as the regulation of the expression of some cellular processes, cell cycle arrest, and apoptosis, etc. Based on the above, this manuscript shows a review of scientific studies that support the anticancer activity of some mushrooms and/or their bioactive compounds.



Some anticancer compounds of mushrooms and their possible function

Keywords: Ascomycetes, apoptosis, Basidiomycetes, cancer, mycopharmaceuticals, immune system, medicinal mushrooms

International Journal of Medicinal Mushrooms, Volume 26, Issue 9, 2024, pp. 1-15

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Mushroom oils: A review of their production, composition, and potential applications

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Abstract: This review delves into the world of mushroom oils, highlighting their production, composition, and versatile applications. Despite mushrooms' overall low lipid content, their fatty acid composition, rich in essential fatty acids like linoleic acid and oleic acid, proves nutritionally significant. Variations in fatty acid profiles across mushroom species and the prevalence of unsaturated fats contribute to their cardiovascular health benefits. The exploration extends to mushroom essential oils, revealing diverse volatile compounds through extraction methods like hydrodistillation and solvent-assisted flavor evaporation (SAFE). The identification of 1-octen-3-ol as a key contributor to the distinct "mushroom flavor" adds a nuanced perspective. The focus broadens to applications, encompassing culinary and industrial uses with techniques like cold pressing and supercritical fluid extraction (SFE). Mushroom oils, with their unique nutritional and flavor profiles, enhance gastronomic experiences. Non-food applications in cosmetics and biofuels underscore the oils' versatility. The nutritional composition, enriched with essential fatty acids, bioactive compositions, and trace elements, is explored for potential health benefits. Bioactive compounds such as phenolic compounds and terpenes contribute to antioxidant and anti-inflammatory properties, positioning mushroom oils as nutritional powerhouses. In short, this concise review synthesizes the intricate world of mushroom oils, emphasizing their nutritional significance, extraction methodologies, and potential health benefits. The comprehensive overview underscores mushroom oils as a promising area for further exploration and utilization. The characteristics of mushroom biomass oil for the use in various industries are influenced by the mushroom species, chemical composition, biochemical synthesis of mushroom, and downstream processes including extraction, purification and characterization. Therefore, further research and exploration need to be done to achieve a circular bioeconomy with the integration of SDGs, waste reduction, and economic stimulation, to fully utilize the benefits of mushroom, a valuable gift of nature.

Keywords: Mushroom oil, Fatty acid, Essential oil, Mushroom biomass, Fungal lipid

Heliyon, Volume 10, Issue 11, 15 June 2024, e31594

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Anti-Hyperuricemia Activity and Potential Mechanisms of Medicinal Mushroom Activity: A Review of Preclinical Studies

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Abstract: Hyperuricemia (HUA) is characterized by abnormally elevated levels of serum uric acid, the product of purine metabolism. The primary symptom of HUA is gout; however, asymptomatic HUA is associated with complications such as hypertension, kidney disease, cardiovascular disease, and metabolic syndrome. The activation of xanthine oxidase (XO), a pivotal enzyme in uric acid biosynthesis, is coupled with extensive reactive oxygen species generation, leading to inflammatory responses, and triggers the development of HUA and its complications. In clinical practice, XO inhibitors are primarily used to treat HUA; however, their prolonged use is accompanied by serious adverse effects. Mushrooms and their bioactive constituents have shown promising anti-HUA activities in both *in vitro* and *in vivo* studies, including inhibition of urate production, modulation of renal urate transporters, enhancement of intestinal uric acid excretion, and antioxidant, anti-inflammatory, and antimetabolic syndrome properties. Clinical trials are necessary to validate the beneficial effects and safety of mushrooms in preventing or alleviating HUA and attenuating the associated complications. This review presents contemporary insights into the pathogenesis of HUA, the bioactive components of mushrooms, their therapeutic potential, and the underlying mechanisms involved in ameliorating HUA.

Keywords: hyperuricemia, inflammation, medicinal mushrooms, reactive oxygen species, urate transporter, xanthine oxidase

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DOI: 10.1615/IntJMedMushrooms.2024053556

Wild edible mushrooms to achieve sustainable development goals: Novel sources for food security, health, and well-being

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Abstract: A wide range of functional foods has been developed to meet health-conscious consumer's needs, which are now an important drive worldwide to achieve sustainable development goals (SDGs) 2 and 3. The identification of a prebiotic that modifies the human gut flora and improves host health is crucial. In this regard, mushrooms have received an attention as one of the healthiest low-calorie food in promoting overall well-being. We reviewed the latest advancements and emerging trends of functional foods derived from wild edible mushrooms. Furthermore, we further reviewed the wild edible mushrooms as a significant source of prebiotics and identified their potential applications in the pharmaceutical sector as well as the food packaging industry. Polysaccharides found in mushrooms have been demonstrated to possess anti-diabetic characteristics, antibacterial activity, anti-cancer and antiviral effects, and the inclusion of these polysaccharides into diets is highly beneficial. Additionally, it is anticipated that the utilization of mushrooms in muscle foods would expand as a result of the growing demand from consumers for foods that are either more sustainable, healthier, or functional. Mushroom resources will play a vital part in the achievement of sustainable development goals because of the important potentials available in the food and pharmaceutical industries.

Food Bioscience, Volume 60, August 2024, 104277

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<u>Characterization of chitosan derived from mushroom sources: Physicochemical, morphological, thermal analysis</u>

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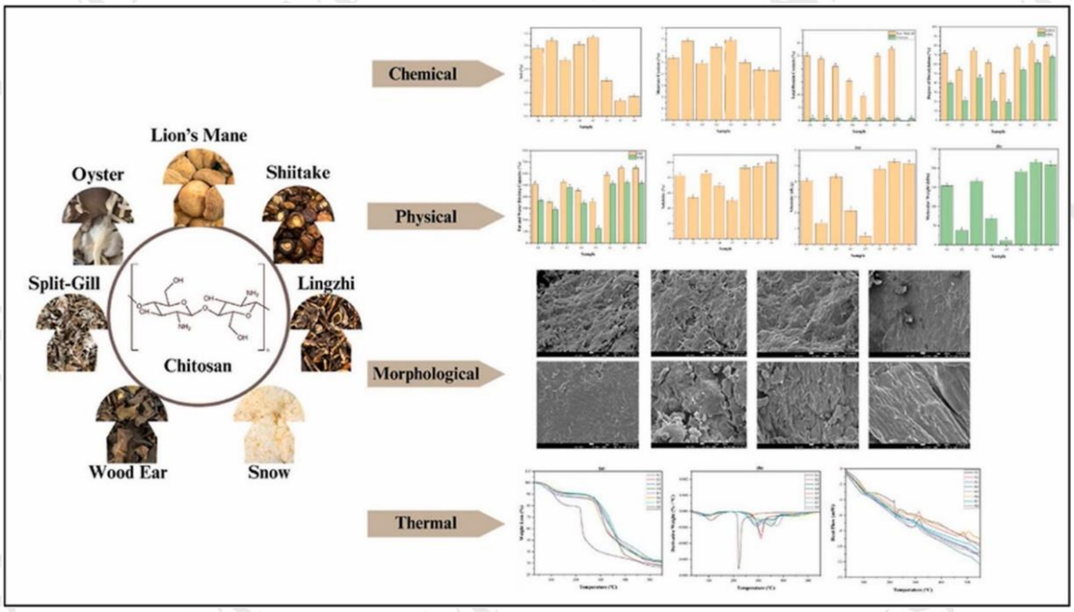
Abstract: This research explores chitosan from mushrooms actively cultivated in Malaysia, focusing on its physicochemical, morphological, and thermal properties. The extraction method involves four stages of acid-alkali treatment (HCl and NaOH) with constant conditions across all samples. Chitosan from seven mushroom species and commercially available chitosan (labelled A1 to A8) are compared due to scarce data on mushroom chitosan. Chemical composition results reveal ash (0.65%–3.33%), moisture (4.29%–6.94%), degree of deacetylation (DD%) from 19.15% to 81.94%, and functional group peaks including hydroxyl, amine and carbonyl group. Physical properties present fat binding capacity (FBC) from 354.26% to 649.91%, water binding capacity (WBC) from 124.83% to 522.42%, solubility (50.02%–100.00%), intrinsic viscosity (ηη) from 1.79 dL/g to 5.26 dL/g, average molecular weight (M_v) from 54.26 kDa to 215.26 kDa, and crystallinity index (CrI) from 49.07% to 75.67%. Structural analysis demonstrates rougher surfaces and irregular shapes for the majority of samples. The thermal analysis includes mass loss (68.07%–73.64%), decomposition temperature (220.98 °C–354.29 °C), and glass transition temperature (T_g) from 201.76 °C to 350.94 °C. Overall, mushroom chitosan could serve as an alternative source due to its superior FBC compared to animal-derived chitosan and better thermal stability than commercial chitosan, highlighting its versatility for various applications.



Sustainable Chemistry and Pharmacy, Volume 40, August 2024, 101624

https://doi.org/10.1016/j.scp.2024.101624

<u>Functional analysis of basidiomycete specific chitin synthase genes in the agaricomycete fungus *Pleurotus ostreatus*</u>

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Abstract: Chitin is an essential structural component of fungal cell walls composed of transmembrane proteins called chitin synthases (CHSs), which have a large range of reported effects in ascomycetes; however, are poorly understood in agaricomycetes. In this study, evolutionary and molecular genetic analyses of *chs* genes were conducted using genomic information from nine ascomycete and six basidiomycete species. The results support the existence of seven previously classified *chs* clades and the discovery of three novel basidiomycete-specific clades (BI–BIII). The agaricomycete fungus *Pleurotus ostreatus* was observed to have nine putative *chs* genes, four of which were

basidiomycete-specific. Three of these basidiomycete specific genes were disrupted in the *P. ostreatus* 20b strain (*ku80* disruptant) through homologous recombination and transformants were obtained (Δ*chsb2*, Δ*chsb3*, and Δ*chsb4*). Despite numerous transformations Δ*chsb1* was unobtainable, suggesting disruption of this gene causes a crucial negative effect in *P. ostreatus*. Disruption of these *chsb2–4* genes caused sparser mycelia with rougher surfaces and shorter aerial hyphae. They also caused increased sensitivity to cell wall and membrane stress, thinner cell walls, and overexpression of other chitin and glucan synthases. These genes have distinct roles in the structural formation of aerial hyphae and cell walls, which are important for understanding basidiomycete evolution in filamentous fungi.

Keywords: Chitin, Agaricomycete, Basidiomycete specific chitin synthase, Cell wall, *Pleurotus ostreatus*

Fungal Genetics and Biology, Volume 172, June 2024, 103893

https://doi.org/10.1016/j.fgb.2024.103893

The anti-fatigue and sleep-aiding effects vary significantly among different recipes containing *Ganoderma lucidum* extracts

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Abstract:

Aims

This study aims to delve into the anti-fatigue and sleep-aiding effects of various formulations containing Ganoderma lucidum extracts.

Materials and methods

PGB [incorporating Ganoderma lucidum extract (GE), broken Ganoderma lucidum spore powder (GB) and Paecilomyces *hepiali* mycelium (PH)] and GBS [composed of GE, GB, and *Ganoderma sinense* powder (GS)] were chosen as representative recipes for this study. Mice were treated with these recipes or key components of *Ganoderma lucidum* for 14 consecutive days. Subsequently, a weight-bearing swimming experiment was conducted to assess the mice's exhaustion time and evaluate the anti-fatigue properties of the recipes. Sleep-aiding effects were analyzed by measuring

the sleep latency and duration. Furthermore, levels of blood lactic acid, serum urea nitrogen, hepatic glycogen, muscle glycogen, and malondialdehyde (MDA) were measured in the livers and muscles.

Key findings

The anti-fatigue abilities of the tested mice were significantly improved after treatment with PGB and their sleep quality improved as well with GBS treatment. PGB treatment for 14 days could significantly prolong the exhaustion time in weight-bearing swimming (from 10.1 ± 0.5 min to 15.2 ± 1.3 min). Meanwhile, glycogen levels in the livers and muscles were significantly increased, while the levels of serum lactic acid, serum urea nitrogen, and MDA in the livers and muscles were significantly decreased. In contrast, mice treated with GBS for 14 days experienced significant improvements in sleep quality, with shortened sleep latency (from 6.8 ± 0.7 min to 4.2 ± 0.4 min), extended sleep duration (from 88.3 ± 1.4 min to 152.5 ± 9.3 min), and decreased muscle MDA levels. These results indicated that *Ganoderma lucidum* extracts can be used for anti-fatigue and or aid in sleeping, depending on how they are prepared and administered.

Significance

This study provides experimental evidence and theoretical basis for the development of *Ganoderma lucidum* recipes that are specifically designed to help with anti-fatigue and sleep.

Keywords: *Ganoderma lucidum* extract, anti-Fatigue activity, Sleep-aiding activity, Glycogen levels, Serum lactic acid, Serum urea nitrogen, Malondialdehyde

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Innovative application of CRISPR for eliminating Ustiloxin in *Cordyceps militaris*: Enhancing food safety and quality

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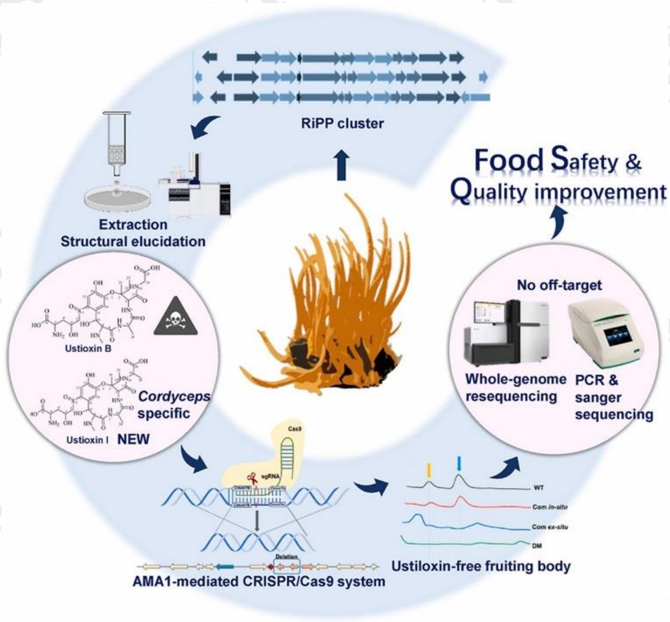
Abstract: *Cordyceps militaris* (L.) Fr. Has long been recognized as a valuable functional food consumed in numerous countries. However, biosynthetic gene clusters of this species and safety regarding mycotoxin production remain largely unexplored. In this study, a ribosomally synthesized and post-translationally modified peptide (RiPP) cluster responsible for the production of cyclopeptide mycotoxins in *Cordyceps* was unveiled via genome mining. Ustiloxin B and a novel, predominant and *Cordyceps* specific ustiloxin I were confirmed by extraction and structural analysis. The difference

between Ustiloxins I and B lied in the side chain at C19, where an additional methyl substituent in Ustiloxin I resulted in an alanine moiety substitution for glycine of Ustiloxin B. The simultaneous deletion of the two adjacent core genes, *CmustYb* and *CmustYa*, using a single guide RNA designed in the intergenic region, and subsequent *in-situ* complementation via AMA-mediated CRISPR/Cas9 system confirmed the RiPP cluster's responsibility for ustiloxin production. The cultivation of the edited strain yielded ustiloxin-free fruiting bodies without affecting agronomic characters. PCR and genome resequencing confirmed the absence of any off-target events or foreign sequence remnants. This study marks a significant advancement in utilizing CRISPR technology to control ustiloxins in food, underscoring its broader implications for food safety and quality improvement.

Graphical abstract



Keywords: *Cordyceps,* RiPP cluster, Ustiloxin, CRISPR/Cas9, Ustiloxin elimination

LWT, Volume 204, 15 July 2024, 116420

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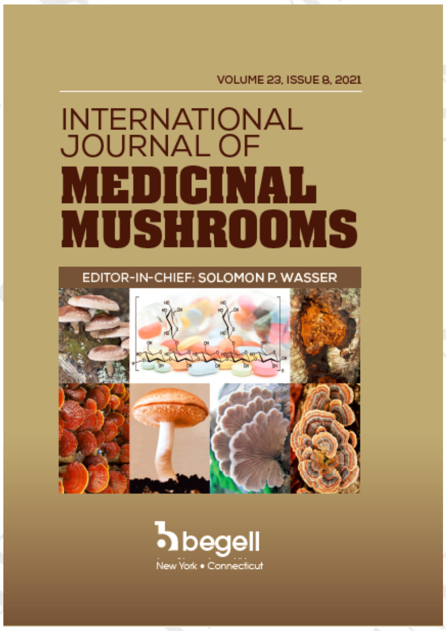
International Journal of Medicinal Mushrooms Call for Papers



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Medicinal Mushrooms

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Mushrooms and Their Compounds with Potential Anticancer Activity: A Review

Díaz-Godínez Gerardo, Téllez-Téllez Maura

Size Matters: Influence of Particle Size on Antioxidant, β-Glucan, and Anti-Inflammatory Potential in *Pleurotus floridanus* (Agaricomycetes)

Wei-Yan Wong, Siti Marjiana Ismail, Chia Wei Phan, Yee Shin Tan

Analysis of the Chemical and Medicinal Properties of *Armillaria ostoyae* (Agaricomycetes) Extracts and the Presence of Heavy Metals in Dry Basidiocarps

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Gréta Töros, Áron Béni, Ferenc Peles, Mahendra Rai, Hassan Elramady, József Prokisch

International Journal of
Medicinal Mushrooms

2024, Vol. 26, Issue no.10

Addition of Mucoadhesive Agent to Enzymatically Polymerized Caffeic Acid-Based Nasal Vaccine Formulation Attenuates Antigen-Specific Antibody Responses in Mice

Rui Tada, Hiroki Ito, Yuzuho Nagai, Yasuhiro Sakurai, Daisuke Yamanaka, Naohito Ohno, Jun Kunisawa, Yoshiyuki Adachi, Yoichi Negishi

Antifungal and Antibacterial Activities of Crude Extracts of Four *Phellinus* Species and *Coltricia fragilissima* (Agaricomycetes) from Cameroon and Democratic Republic of Congo

Blondo-Pascal Metsebing, Romuald Oba, Fabrice Tsigaing Tsigain, Thierry Youmbi Fonkui, Marthe Carine Djuidje Fotsing, Tata Charlotte Mungoh, Derek Ntantoh Ndinteh, Dominique Claude Mossebo

Evidence for Regulation of Cordycepin Biosynthesis by Transcription Factors Kräppel-Like Factor 4 and Retinoid X Receptor Alpha in Caterpillar Medicinal Mushroom *Cordyceps militaris* (Ascomycetes)

Hucheng Zhang, Lina Deng, Shuai Luo, Linying Liu, Guowei Yang, Yuning Zhang, Bo Gao, Dongqing Yang, Xiaojie Wang, Shuangshi Li, Xingjuan Li, Yaguang Jiang, Wenyan Lao, Frank Vriesekoop

Integrated Comparative Transcriptome and Weighted Gene Co-Expression Network Analysis Provide Valuable Insights into the Mechanisms of Pinhead Initiation in Chinese Caterpillar Mushroom *Ophiocordyceps sinensis* (Ascomycota)

Li He, Fan Xiao, Chen Xi Dou, Bo Zhou, Zhao He Chen, Jing Yi Wang, Cheng Gang Wang, Fang Xie

Progression Over Time of Nutritional Content and Antioxidant Activity of Grains Fermented with the Medicinal Mushrooms *Pleurotus ostreatus* and *Ganoderma sessile* (Agaricomycetes)

Antonella Mazzola, Francisco Kuhar, Alina G. Greslebin

Chitin and Its Derivative Chitosan: Distribution in Nature, Applications, and Technology Research (A Review)

Vladimir V. Perelygin, Mikhail V. Zharikov, Ivan V. Zmitrovich, Tatyana A. Nekrasova

Points and Reviews

Crude Polysaccharides from Mushrooms Elicit an Anti-Allergic Effect Against Type 1 Allergy *In Vitro*

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Orgainal Published on International Journal of Medicinal Mushrooms, 26(2):1-9(2024)

ABSTRACT: Type 1 allergic disease is a global challenge, hence the search for alternative therapies. Mushroomshave several medicinal and health benefits. However, scant data exist on the anti-allergic properties of polysaccharides from fruiting bodies (FB) and mycelia of mushrooms. We used an *in vitro* co-culture system comprising Caco-2 cells (intestinal epithelial colorectal carcinoma cell line) and RBL-2H3 cells (cell line from rat basophilic leukemia cells). Reduction in degranulation of mast cells indicated anti-allergy properties. The inhibitory effect of crude polysaccharides from different mushroom FB and mycelia on β-hexosaminidase release from RBL-2H3 cells was measured. Results showed that crude polysaccharides from the FB of *Inonotus obliquus* exhibited a significant inhibitory effect on β-hexosaminidase release and lowered it by 16%. Polysaccharides from the FB of *Lentinus squarrosulus*, and *Pleurotus ostreatus* did not exhibit a significant reduction in β-hexosaminidase. However, crude polysaccharides from their mycelia had a significant inhibitory effect, resulting in up to a 23% reduction in β-hexosaminidase activity. Among fungi showing degranulation properties, crude polysaccharides from their mycelia showed more potent action against degranulation than their corresponding FB. Polysaccharides extracted from FB and or mycelia, of selected mushrooms, possess anti-allergic properties that could be harnessed for use in alternative allergy therapies.

KEY WORDS: medicinal mushrooms, polysaccharides, fungal mycelia, type 1 allergy

ABBREVIATIONS: Ag, antigen; **BSA**, bovine serum albumin; **DMEM**, Dulbecco's modified Eagle's medium; **DNP**, dinitrophenyl; **EMEM**, Eagle's minimum essential medium; **FB**, fruiting body; **FBS**, fetal bovine serum; **IL**, interleukins;

NEAA, non-essential amino acids; **PBS**, phosphate-buffered saline; **SB**, Siraganian buffer; **TER**, transepithelial electrical resistance

I. INTRODUCTION

The problem of IgE-mediated hypersensitivity has continued to increase globally with no known cure yet.[1] This type of hypersensitivity reaction is also termed, type 1 allergic disease and it includes food allergy, allergic rhinitis, asthma, and atopic dermatitis.[2] It is usually triggered by allergens such as food, dust, and pollen. Many food allergens are stable to heat, acid, and proteases, making them resistant to digestion and allowing them to get in contact with the intestinal immune system. Some individuals are genetically predisposed to developing IgE-mediated hypersensitivity because they are easily sensitized by exposure to the allergen.[3] Once an individual is sensitized, and allergen-specific IgE has been produced in the body, re-exposure to the same allergen induces cross-linking of IgE receptor (FcεR1), and triggers degranulation of primed mast cells with the release of pro-inflammatory mediators, such as histamine, eicosanoids, and cytokines which results in allergic reactions within seconds or minutes.[4,5] When mast cells are stimulated, they produce significant amounts of cytokines and chemokines, among which are IL-3, IL-4, IL-5, and IL-13. These cytokines are specifically important in allergic reactions, and they mediate the infiltration of basophils and eosinophils, IgE class-switching, mucus production, and airway hyperreactivity.[5,6] Repeated exposures to allergens may lead to life-threatening chronic inflammatory responses resulting in subsequent chronic structural changes of the tissues, such as mucus cells and smooth muscle hypertrophy, fibrosis, and organ dysfunction.[3]

Mushrooms have been used for food for many centuries. Currently, intense research on the therapeutic significance of mushrooms is ongoing. Some reports have linked the medicinal properties of mushrooms to the presence of polyphenols, proteins, polysaccharides, vitamins, and steroids.[7,8] Most important is the discovery that β-glucans from mushrooms possess immuno-stimulatory properties.[9–11] Many authors have reported that β-glucans specifically bind to dectin-1, a C-type lectin-like receptor, expressed by innate immune cells, such as macrophages, dendritic cells, and neutrophils.[12] Stimulation of dectin-1 by β-glucans triggers intracellular signaling events that result in the release of immunological mediators that activate protective immune responses. Mushroom polysaccharides are becoming increasingly important for their medicinal and health-promoting activities.[13] Activities ranging from antiviral, cholesterol-lowering, antitumor, antifungal, antimicrobial, antioxidant, hepatoprotective, and antidiabetic have been reported for mushroom-containing bioactive compounds.[14–16] Advances in allergic diseases have revealed the mechanism of allergic response and how the immune system can be modulated for defense, but the problem of type 1 allergy persists. Given the immunomodulatory activities attributed to mushroom bioactive compounds, it is important to study the antiallergy potentials of their polysaccharides. In this research, we extracted crude polysaccharides from the fruit bodies and mycelia of selected mushrooms, and their anti-allergy potential was investigated using an *in vitro* co-culture model.

II. MATERIALS AND METHODS

A. Reagents

Dulbecco’s modified Eagles’ medium (DMEM, high glucose) containing 2 mM glutamine, and streptomycin were purchased from Wako Pure Chemical Industries (Osaka, Japan). Eagle’s minimum essential medium (EMEM) was purchased from Nissui Pharmaceutical (Tokyo, Japan). DNP-albumin, p-nitrophenyl-N-acetyl-β-D-glucosaminide, and anti-dinitrophenyl (DNP) IgE were purchased from Sigma (St. Louis, MO, USA). Fetal bovine serum (FBS) was purchased from Biological Industries (Beit, Israel), and the trypsin and MEM non-essential amino acids (NEAA) were purchased from Gibco BRL (Grand Island, NY, USA). MP Biomedicals (Aurora, OH, USA) supplied penicillin while luteolin was from Extrasynthese (Genay, France). Other reagents used were of standard analytical grade.

B. Mushroom Samples

A total of 10 species of mushrooms were selected and used for the study. Mushroom fruit bodies were collected from the wild or cultivated at the mushroom facility at the North Carolina A&T school farm, in Greensboro, North Carolina. Mushroom mycelia were generated through liquid-state fermentation. To produce the mycelia,100 mL of liquid medium (composed of 15 g of malt extract and 10 mL wood extract per liter) was inoculated with 1 mL of homogenized 3- to 5-d-old agar cultures of selected mushroom species. Fermentation was done at 25°C for 21 days. Mycelia were harvested at the end of the fermentation by vacuum filtration and washed 3 times with distilled deionized water. Both fruit body and mycelia were individually lyophilized, ground into powder, and used for crude polysaccharides extraction. Table 1 shows the type of mushroom samples used.

C. Crude Polysaccharide Extraction

The extraction of crude polysaccharides from lyophilized samples was according to the method of Mizuno et al.[16] with slight modifications. Ten grams (10 g) of each sample (fruit body, or mycelia) were extracted with 200 mL of deionized water at 100°C for 15 min. The extracts were allowed to cool and filtered using Whatman filter paper. Absolute ethanol was added in the ratio of 3:1 (ethanol:sample) and allowed to stand overnight at 4°C to precipitate the polysaccharides. The supernatant and precipitate were separated by centrifugation at 6,000 rpm, 4°C for 20 min. The pellets were washed twice with deionized water, and centrifuged again at 6000 rpm, 4°C for 20 min. Pellets obtained were lyophilized to obtain the dried crude polysaccharides extract used for the study. Due to possible thermal degradation of the polysaccharide during extraction at 100°C, we used a high concentration (500 µg/mL) of the polysaccharide for the study.

TABLE 1: Mushroom species and sample types used in the study

Mushroom	**Sample type**	
Lentinus squarrosulus (cultivated)	Fruit body	Mycelia
Pleurotus ostreatus (cultivated)	Fruit body	Mycelia
Laetiporus sulphureus (wild)	Fruit body	Mycelia
Grifola frondosa (wild)	Fruit body	Mycelia
Gymnopilus sp. (cultivated)	Fruit body	Mycelia
Inonotus obliquus (wild)	Fruit body	–
Tylopilus plumborio	Fruit body	–
Ganoderma sp.	–	Mycelia
Ganoderma lucidum	–	Mycelia
Agaricus sp.	–	Mycelia

D. Cell Culture

Cells were cultured according to the method reported by Yamashita et al.[17] Human intestinal epithelial cell line, also known as Caco-2 cells, were cultured in a 75 cm^3 plastic flask containing 10 mL of DMEM (high glucose) supplemented with 10% FBS, 1% MEM-NEAA, 100 µg/mL streptomycin, and 100 U/mL penicillin. Passage numbers 50 65 were used. Rat basophilic leukemia cell line, RBL-2H3 cells, were cultured in Petri dishes containing Eagle's MEM supplemented with 10% (v/v) heat-inactivated FBS (57°C, 30 min), 100 µg/mL streptomycin, 100 U/mL penicillin, and 2 mM L-glutamine. Passage numbers 20 40 were used.

Both cell cultures were incubated at 37°C in a 5% CO_2

incubator and were passaged when either cell line reached 80% confluence. Adhering cells were released from the culture dish or flask with the use of trypsin after washing with phosphate-buffered saline (PBS). The cells were re-plated in a new dish or flask. The Caco-2 and RBL-2H3 cells used for this study were originally purchased from ATCC and are routinely used in research in the laboratory of M.M.

E. Co-Culture System

The method adopted here was previously reported by Yamashita et al.[17] Caco-2 cells were seeded at the concentration of 1.5 × 10^5 cells/well onto 12-well Transwell insert plates. Cell culture medium (DMEM) was changed every three days until the cells were fully differentiated [transepithelial electrical resistance (TER) value > 300 ꞑ cm^{-2}]. RBL-2H3 cells were also seeded at 3.8 × 10^5 cells/well on a 12-well tissue culture plate in Eagle's MEM and incubated overnight with 0.25 µg/mL at a final concentration of anti-DNP (2,4-dinitrophenyl)-IgE. The media were replaced with Siraganian buffer (SB; 119 mM NaCl, 5 mM KCl, 0.4 mM $MgCl_2$, 1 mM $CaCl_2$, 40 mM NaOH, 25 mM PIPES, 5.6 mM glucose, 0.1% BSA, pH 7.2), and the trans well inserts on which Caco-2 cells had been cultured were added into the 12-well plate preloaded with RBL-2H3 cells which had been stimulated overnight with DNP-IgE, such that the Caco-2 cells are on the apical side while the RBL-2H3 cells are on the basolateral side of the trans well.

F. p-Hexosaminidase Assay

Measurement of β-hexosaminidase activity was used to evaluate the anti-allergic properties of the mushroom samples. The method reported by Yamashita et al.[17] was strictly followed; 0.5 mL of SB or test solution (500 µg/mL of crude polysaccharides) was applied to Caco-2 cells on the inserts of the transwell (apical side) co-cultured with anti-DNP-IgE-stimulated RBL-2H3 cells on the basolateral side and incubated at 37°C in a 5% CO incubator for 6 h. Cells incubated with only anti-DNP-IgE (without luteolin or polysaccharide) served as negative controls (IgE/Ag). After incubation, the RBL-2H3 cells were challenged with 10 ng/mL at a final concentration of DNP-albumin adjuvant (allergen) from the basolateral side for 10 min at 37°C. The plate was cooled in an ice bath for 10 min to stop degranulation responses. The supernatant (50 µL) from the co-cultured system was transferred to a 96-well plate and incubated with an equal volume of substrate solution (5 mM, p-nitrophenyl-N-acetyl-β-D glucosaminide in 0.2 M citrate buffer at pH 4.5) for 1 h at 37°C. Luteolin (100 µM) was used as the positive control because it had previously been reported to have an anti-allergic effect by suppressing RBL-2H3 cell degranulation.[17] After incubation, 100 µL/well of stop buffer (0.2 M Tris, pH 8.0) was added to the wells. Absorbance was measured at 405 nm using a microplate reader. The percentage of β-hexosaminidase released was calculated as a percentage of the degranulation group (IgE/Ag).

G. Statistical Analysis

All data are presented as mean ± SE. Statistical analysis was performed using the Tukey-Kramer test. Statistical significance was defined as *P* <0.05.

III. RESULTS

A. Inhibitory Effects of Crude Polysaccharides from Fruit Bodies of Mushrooms on Degranulation of RBL-2H3 Cells in a Co-Culture System

Crude polysaccharides from fruit bodies of *L. squarrosulus*, *P. ostreatus*, *L. sulphureus*, *G. frondosa*, *Gymnopilus* sp., *I. obliquus*, and *T. plumborio* were tested against degranulation of RBL-2H3 cells. Results obtained (Fig. 1) indicated that only crude polysaccharides from the fruit bodies of *I. obliquus* exhibited significant inhibitory effects against degranulation of RBL-2H3 cells when compared with the negative control group (IgE/Ag). Crude polysaccharide from *I. obliquus* inhibited degranulation by 15.82%. The range of inhibition of degranulation (3.62 9.61%) by crude polysaccharides of other mushrooms (*L. squarrosulus*, *P. ostreatus*, *L. sulphureus*, *G. frondosa*, and *Gymnopilus* sp.) was not significant. It is worthy to note that crude polysaccharide from *T. plumborio* increased degranulation of RBL-2H3 cells by 5.41%, although the increase was not significant (Fig. 1). This data suggests that among all the mushrooms studied, only *I. obliquus* possessed anti-allergic in its fruit body.

B. Anti-Degranulation Effect of Polysaccharides from Mycelia of Mushrooms on RBL-2H3 Cells

Crude polysaccharides from mycelia of eight mushroom isolates, *L. squarrosulus*, *P. ostreatus*, *P. djamor*, *L. sulphureus*, *Agaricus* sp., *Gymnopilus* sp., *G. lucidum*, and *G. frondosa* were tested against degranulation of RBL-2H3 cells. Results (Fig.2) show that while polysaccharides from mycelia extract of some mushrooms decreased degranulation, some increased degranulation while others did not affect degranulation. The polysaccharides from mycelia of two mushrooms *L. squarrosulus* and *P. ostreatus* had highly significant inhibitory effects against the degranulation of RBL-2H3 cells in a co-culture system when compared to the degranulation group (IgE/Ag) (Fig. 2A and 2B).

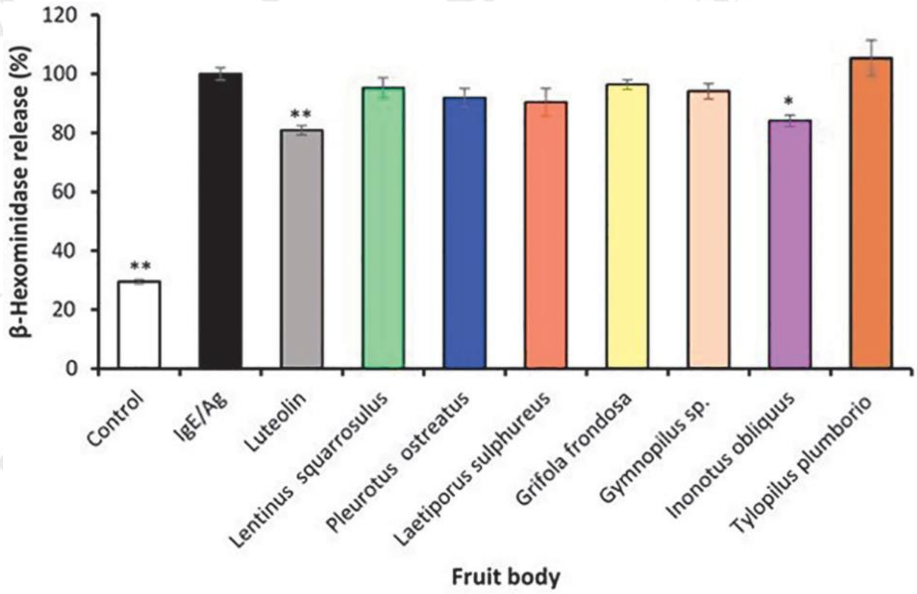

FIG. 1: Anti-allergic activities of crude polysaccharides from fruit bodies of mushrooms. Crude polysaccharides were added to the apical side of a Caco-2/RBL-2H3 cells co-culture system and incubated for 6 h at 37°C. Values are expressed as mean ± SE (*n* = 3). **P* < 0.005, ***P* < 0.01.

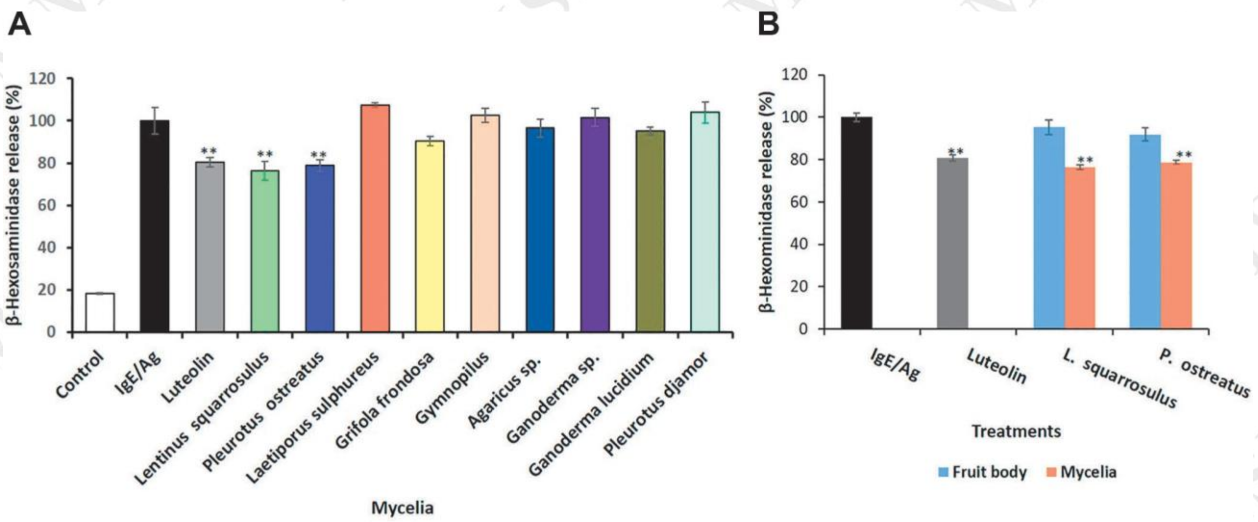

FIG. 2: Anti-allergic effects of crude polysaccharides from mushrooms mycelia. Crude polysaccharides were added to the apical side of the Caco-2/RBL-2H3 cells co-culture system, and incubated for 6 h at 37°C. (A) Polysaccharides from the mycelia of two out of nine mushrooms had an inhibitory effect on the degranulation of RBL-2H3 cells in a co-culture system. (B) Comparison of β-hexosaminidase release between fruit bodies (blue bar) and mycelia (orange bar) of *Lentinus squarrosulus* and *Pleurotus ostreatus*. IgE/Ag (black bar) = β-hexosaminidase release in the absence of mushroom extract, luteolin (grey bar) = positive control. Values represent mean ± SE (n = 3). ** $P < 0.01$.

Degranulation of RBL-2H3 cells by mycelia extracts is shown as a reduction in β-hexosaminidase activity by *L. squarrosulus* (23.53%) and *P. ostreatus* (21.24%) (Fig. 2). Polysaccharides from mycelia of three of the eight isolates tested did not show any significant reduction in degranulation of RBL-2H3 cells as listed *G. frondosa* (9.48%), *G. lucidum* (4.85%), and *Agaricus* sp. (3.46%). There was a numerical increase in degranulation of RBL-2H3 cells by the extracts from mycelia of *L. sulphureus*, *Gymnopilus* sp., and *P. djamor* by 7.23, 2.72, and 4.03% respectively. However, these increases in degranulation levels were not significant compared to control. Generally, mycelia reduced β-hexosaminidase by 6.57% higher than fruit body among the mushrooms studied. This data suggests that polysaccharides from mushrooms or mycelia of a particular species may possess different biological activities.

IV.. DISCUSSION AND CONCLUSIONS

Mushroom polysaccharides belong to a structurally diverse class of macromolecules, made up of polymers of monosaccharide residues joined together by glycosidic linkages. The polysaccharides found in mushrooms are mostly glucans, however, glycans and heteroglycans may be present.[18,19] Whereas glucans have glucose in their backbone, glycans and heteroglycans have other units other than glucose as their backbone.[18,20] A wide range of biologically active glucans and heteroglycans from mushrooms have been described based on the make-up (types of sugars), arrangement (linear versus branched) and conformations of the backbone, types of linkages (β, α, and their positions), and the position, composition, and structure of the side chain.[18,21] Mushroom polysaccharides are well-known bioactive compounds with health-promotion properties. The different activities of polysaccharide extract from different mushrooms are attributed to the variability in their structures. Several reports are available on the overall activities of mushroom polysaccharides on health parameters such as antiviral, immunomodulating, and anti-inflammatory, but few are available on their anti-allergic properties. Mushroom fruit bodies, especially the edible species can be harvested from the wild or from indoor fruiting houses, which takes a considerable amount of time to find or produce compared to mycelium. Therefore, mycelium is considered a quicker, scalable, and sustainable way to generate polysaccharides. Anti-allergic factors, when present in polysaccharides, can inhibit the degranulation of mast cells, and reduce the amount of β-hexosaminidase released.[22] We report here the activity of polysaccharide extracts from fruit bodies and mycelia of some mushrooms on the release of β-hexosaminidase allergic mediators from sensitized mast cells (RBL-2H3).

In this study, the anti-allergic effect of polysaccharides from fruit bodies of seven edible mushrooms were investigated using β-hexosaminidase assay, and the results showed that only *I. obliquus* inhibited degranulation of mast cells (Fig. 1). The presence of anti-allergic effect or the lack thereof in polysaccharide of different mushroom fruit bodies could be attributed to the type of mushroom, wild versus cultivated,[23] substrates used for cultivation,[24] fruit body processing methods (air/heat drying versus lyophilization),[25] polysaccharide extraction method (hot water or alcohol or acid).[20,26] Since the fruit bodies were processed similarly in this study, it seems logical that the type and source of mushrooms could play a role in the anti-allergic activity of polysaccharide fractions. We recognize that three of the fruit bodies (*L. sulphureus*, *G. frondosa* and *T. plumborio*) were from the wild, while three (*P. ostreatus*, *L. squarrosulus*, and *Gymnopilus* sp.) were cultivated. It is not certain if the source of the fruit body had any effect on the anti-allergic response of these polysaccharides. Since polysaccharides from other wild mushrooms such as *L. sulphureus* and *G. frondosa* did not show significant anti-allergic activity, we conclude that the type of mushroom plays a critical role in the type and activity of polysaccharides in the extract. Our result agrees with the report of Yoo et al.[27] on the inhibitory effect of chaga mushroom (*I. obliquus*) extract on 48/80-induced anaphylactic shock and IgE production in mice. Their work suggests that hot water extract from chaga mushroom can counteract type 1 hypersensitivity. Furthermore, Ellertsen and Hetland[13] have demonstrated the anti-allergic effects of an extract from a mixture containing *Agaricus blazei* and *Hypsizygus erinaceus*, and according to the authors, the extract was able to reduce anti-ovalbumin IgE in mice and reduced Th2 relative to Th1 cytokine levels.

We further extracted polysaccharides from the mycelia of nine edible mushrooms and tested their anti-allergic effects *in vitro*, and interestingly, polysaccharides from two of the fungi mycelia tested significantly suppressed degranulation and prevented the release of β-hexosaminidase (Fig. 2). Polysaccharides from fruit bodies of *L. squarrosulus* and *P. ostreatus* did not show anti-degranulation effect, but those from their mycelia significantly reduced degranulation (Fig. 2B). Another major finding of interest here is that, among tested samples, mycelia derived polysaccharides were more effective at reducing degranulation compared to fruit body derived polysaccharides (Fig. 2B). This suggests that polysaccharides extracted from fruit body and mycelia of mushrooms may possess different therapeutic potency. Our result is supported by Carvajal et al.[28] who reported the differences in the activities of hydroalcoholic extracts of fruit body and mycelia of *Agaricus brasiliensis* in DPPH, ABTS radical scavenging, iron chelation, and lipid-peroxidation tendencies. Yu et al.[29] has shown that there is a difference between the polysaccharides extracted from the fruit body and the mycelia of *Ganoderma lingzhi*. They found that mycelia contain 3.8% more polysaccharides than fruit bodies (0.59%). Furthermore, they reported that the monosaccharide composition and their molar ratio were different for fruit bodies and mycelia. They deduced that mycelia contained mostly glucose monomers, and the fruit body contained mainly glucose and galactose; also, the polysaccharide structures derived from the fruit body and mycelia were different. Hence these factors are critical components that could affect the activity of extracts and explain why extracts of fruit body and mycelia of the same mushroom may not have a similar effect on mast cell degranulation.

However, more research is needed to elucidate differences in the structure of polysaccharides from fruit bodies and mycelia of commonly used mushrooms and to determine how these differences affect activity. Knowledge gathered so far indicates that polysaccharides from mushrooms fruit bodies and mycelia possess different activities and should be used differently in health-related applications.

The role of mushroom polysaccharides on immune modulation is published mostly in animal models and little in humans.[7] Sano[30] reported that oral administration of ethanol extracts of polysaccharide of higher Basidiomycetes *Hypsizygus marmoreus* and *Flammulina velutipes* showed a significant anti-allergic effect in mice at a dose of 250 mg/kg body weight/d. Kimura et al.[31] showed that adding 0.5 1.0% of β-glucans from *A. pullulans* strain AI to diet of ovalbumin-allergic BALB/c mice considerably mitigated food allergic reactions in mice. Furthermore, finely dispersed *Lentinus edodes* β-glucan administered orally in humans allergic to Japanese cedar pollen, relieved both seasonal and perennial allergies to cedar pollen.[32] As mushrooms and their products gain global acceptance, utility, and popularity, we anticipate more research on the anti-allergic properties of medicinal mushrooms as well as understanding their mode of action in humans. This study is the first to demonstrate the anti-allergic activity of crude polysaccharides from *I. obliquus* using a co-culture system. It is also the first report on the ability of crude polysaccharides from *L. squarrosulus*, which is a tropical mushroom found in Africa and many Asian countries, including Japan, to reduce allergic response in an *in vitro* allergy model.

Our findings indicate that there could be many more mushrooms out there that have the potential to reduce allergies. Furthermore, the results of this research suggest that mushroom mycelia could be a promising source of therapeutic products, and therefore, opens the door to further research into the potential of mycelia-based mushroom polysaccharides to manage allergic diseases and other health challenges. Although these differential antiallergy effects of crude polysaccharides from mushroom mycelia and fruit bodies are reported from an *in vitro* study, which may not represent a true physiological state, a more rigorous *in vivo* study is recommended to confirm this outcome. We were unable to carry out an *in vivo* study due to the insufficient quantity of our polysaccharides at the time of the study.

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