NEWSLETTER OF THE INTERNATIONAL SOCIETY FOR MEDICINAL MUSHROOMS

Volume 1, Issue 23

Date-released: August 28, 2023

Issue Editor- Mr. Ziqiang Liu
lzqynkm@vip.163.com
Department of Edible Mushrooms, CFNA,
4/F, Talent International Building
No. 80 Guangqumennei Street,
Dongcheng District, Beijing 10062, China

News Reports

Dutch Mushroom Days A Great Success Again!

By Roel Dreve, Mushroom Business

The 36th edition of the Dutch Mushroom Days in The Netherlands proved to be on of the best editions ever! With 110 exhibitors from18 different countries and 4555 visitors from 83 countries, the event (10-12 May) in the city of Den Bosch was a spectacular success.

Even before the fair started on May 10th, industry suppliers like Hooymans Substrates, Christiaens Group, Legro, Kekkilä-BVB and GTL Europe received many international guests to join seminars, company visits and farm tours.

Team of compost supplier CNC, celebrating its 70 year jubilee this year in their stand.

The ambiance in The Brabanthallen was very friendly from the start, with many old friends glad to meet again, sometimes after several years. But at the same time, all exhibitors agreed that most talks were substantive, and, after four years, there were many new innovations and (automated cultivation) systems on display. Stands looked great, food was good (and free for visitors) the new organisers did a great job, and the change to a more informal, festive 'welcome program' with live music by 'The Big Swingers' on the first evening worked out fine.

The Ambassador of the Industry Awards ceremony on the same night produced four new winners; Bert Rademakers (Mycelium Materials), Peter Christiaens (Fungivital), both from The Netherlands, Greg Seymour (President of ISMS) from Australia and Karel Sterckx (Sterckx compost) from Belgium received the coveted Award for their important mushroom work in and beyond the call of duty.

Peter Christiaens (to the left), Karel Sterckx (center) and Bert Rademakers (right) hold their Ambassador winner certificate. In the back, Ko Hooijmans holds the certificate of Greg Seymour, who was present via a live connection with Australia.

On the second day, the new European promotional campaign 'European Mushrooms – the hidden gem' was launched. Representatives of the GEPC, the promotional campaign team and communication agency SOPEXA gave insight into the highlights and goals of the battle plan, to about 40 players from the sector.

Turn key supplier Christiaens Group always has one of the biggest stands at the fair, with tilting shelves and their drawer system in the back, attracting a lot of attention. Director Mart Christiaens front left.

In the evenings, many companies had their own private parties in the lively and hospitable city of Den Bosch, which was, for one week in 2023, the very center of the international mushroom industry again.

Source: mushroombusiness.com
Pictures copyright Mushroom Business magazine / Global Roel Media BV.

Finc and OCM Invest in US Growing Facility

On July 1st 2023, Shanghai Finc Biotech Co. Ltd announced its subsidiary Finc (Singapore) Bio-tech and OCM Globe Inc jointly invest 60 million US dollar to build a modern and smart growing facility, Finc (America) Biotech, in Houston, Texas.

As the mother company, Shanghai Finc Biotech is the largest Shimeji mushroom producer with a production capacity of 260 tons per day in China. OCM Globe Inc., headquartered in Los Angeles, is the leading Chinese brand operator in Asian food markets through different distribution systems in North America.

The cooperation agreement signing ceremony was held in JW Marriott Shanghai Fengxian on July 1, 2023. There were around 60 representatives from governments, associations, media and business partners present. Dr. Tan Qi, Chairman of WSMBMP, delivered an opening presentation on the outlook of the specialty mushrooms (enoki and shimeji) market. Ms. Zhang Wenhong, CEO of Shanghai Finc Biotech and Mr. Wang Gang, President of OCM Globe Inc. reviewed their own strengths and advantages to assure a good start of the cooperation.

Mr. Wang Nan, the managing director of Finc (America) Biotech, stated the new state-of-the-art facility will supply 50 tons enoki mushroom per day within the bottle system in 2024. It will be the first commercial enoki mushroom growing farm in the US, offering 100 job opportunities, and changing the situation that the US had to import enoki mushroom from Asian countries in the past.

Mr. Cao Derong, President of CFNA, and Mr. Ted Shibita, Deputy Director of the Agricultural Trade Office at the US Consulate General in Shanghai both thought highly of the mutual investment between China and the United States and congratulated the participants in this project.

In the picture (from left to right): Ms. Zhang Hongyu (Trade attache at the US Consulate General), Mr. Ted Shibata (US Consulate), Mr. Cao Derong (CFNA), Mr. Wang Gang (OCM), Mr. Wang Nan (Finc) and Ms. Zhang Wenhong (Finc).

Source: mushroombusiness.com

China Tongjiang Tremella Industry Development Conferenceand & The Fourth China Tongjiang Tremella Days

The "China Tongjiang Tremella Industry Development Conference & The Fourth China Tongjiang Tremella Days" organized by the China Chamber of Commerce for Import and Export of Foodstuffs, Native Produce and Animal By-Products was held from August 9th-10th in Tongjiang, Sichuan Province, China. The theme of this conference was "Innovation Driven, Revitalization and Development". During the event, 8 major activities were held, including the opening ceremony, exhibition, industry tour, the "Tongjiang Flower Moonlight" night tour, tremella tasting, summit forum, press conference, and business negotiations. It was aim to promote the culture and publicity brand of Tongjiang Tremella, collaborate on the revitalization and development of the Tremella industry, and accelerate the construction of a billion level industrial cluster.

China renowned experts and scholars, government officials, department heads, and entrepreneurs attended the opening ceremony. Academician Li Yu, chairman of the International Society for Medicinal Mushrooms, attended the conference and delivered a speech. Academician Li Tianlai, a doctoral supervisor of Shenyang Agricultural University delivered a keynote speech. Greg Seymour, President of the International Society for Mushroom Science, delivered a speech via video. Xu Xiaohu (Vice President of the China Chamber of Commerce for Import and Export of Foodstuffs, Native Produce and Animal By-Products), Tan Qi (Vice President of the Shanghai Academy of Agricultural Sciences, Chief of the National Edible Fungus Industrial Technology System, Chairman of the World Society for Mushroom Biology and Mushroom Products), Guo Liangdong (Chairman of the Mycological Society of China, and Researcher of the Institute of Microbiology of the Chinese Academy of Sciences), and Li Yufu (Secretary of the CPC Tongjiang County Committee), delivered speeches respectively on the opening ceremony.

The conference organized the "Integration of Three Substances and Linkage of Three Industries" Tongjiang Tremella Industry High Quality Development Summit Forum, which focused on the current situation of the Tremella industry, cultivation technology, brand building, innovation drive, and many other sustainable development issues of the Tongjiang Tremella industry, covered twelve academic speeches.

During the event, attendees visited Tongjiang Tremella Museum, Science and Technology Innovation Center, Chenhe Ecological Planting Core Area, Yude Tremella Plantation Base, Muzigang Original Ecological Wild Tremella Base, Tremella Primary Processing Factory and Tremella Factory Plantation Industrial Park, and so on. During the tour, participators gained a detailed understanding of Tongjiang Tremella culture, science and technology innovation, germplasm resource development and utilization, resource cultivation, and base construction, as well as the situation of deep processing and marketing.

As a supporting activity of the conference, Tongjiang Tremella Industry Upgrading and Supporting Exhibition including an exhibition area for edible mushroom manufacturing equipment, a comprehensive exhibition area for the "Tongjiang Tremella" image, and a high-quality exhibition area for Tongjiang edible mushroom brands. Among them, the edible mushroom manufacturing equipment exhibition area has 40 booths, showing the design of edible mushroom production and processing technology, raw materials, specialized equipment for environmental simulation, packaging, and modern food processing, etc. The suppliers of equipment and technology required for various production stages of mushroom were selected. It was the first large-scale introduction of equipment and technology enterprises to Tongjiang, to promote the technological and development of Tongjiang edible mushroom industry, and move towards the track of modern agricultural industry development, providing industry chain support for the development of Tongjiang mushroom industry.

The comprehensive exhibition area of the image of "Tongjiang Tremella" showcased the historical origins, modern development, production, and brand honors of Tongjiang County and Tongjiang Tremella. It focused on presenting Tongjiang's advantages of environmental, industrial and investment, with external and internal connections. With Tongjiang Tremella as the starting point, it would promote the Tongjiang rural revitalization strategy. The exhibition area of Tongjiang Edible Mushroom Brand has 22 booths, including Tongjiang edible mushroom quality brand and some special agricultural products. Except dried and fresh tremella products, the exhibits also include tremella soup product, tremella wine, tremella noodles and other processed foods. The exhibition attracted nearly 500 visitors. It was a concentrated appearance of Tongjiang brand enterprises. With the brand as the road, it would lead Tongjiang brand products to the world.

Through on-site visits, news releases, investment promotion, and enterprise signing, this conference had demonstrated the new results of Tongjiang tremella industry development in an all-round, deep and multi-angle manner, effectively promoted the propagandizing and popularizing, marketing and brand building of Tongjiang tremella industry, expanded the opening up and exchange and cooperation of Tongjiang tremella industry, and accelerated the building of Tongjiang Tremella industrial cluster of 10 billion. Comprehensively promote the development of Tongjiang tremella industry to a new level.

<u>**Can Fungi Help Save Us Again?**</u>

By Robert Beelman

One of the great advances in science and medicine was the result of the accidental discovery of a fungal contaminant in a Petri dish that eventually led to the development of the antibiotic penicillin. This fortunate observation by Sir Alexander Fleming occurred in 1928 and eventually resulted in him being awarded the Nobel Prize in 1945 and ushered in a revolution in medicine that saved countless lives from deadly bacterial infections.

In 1909 another fungal metabolite was discovered with little notice in Ergot fungus and it was appropriately named Ergothioneine (ERGO). For many years little attention was paid to ERGO until some curious investigators found that it occurred in relatively high concentration in some animal and human blood samples and traced it back to certain foods they consumed. Later it was determined that only fungi and a few other microbes can produce ERGO and that fungi were the primary source in the diet. In 2005 a major discovery was made that all mammals, including humans, produce a highly specific and efficient transporter for ERGO that rapidly moves it from food into red blood cells that distributes among body tissues where it has potent antioxidant and anti-inflammatory functions that appear to help mitigate chronic diseases of aging like Alzheimer’s and Parkinson’s Disease. This led some scientists to suggest that ERGO should be considered a longevity vitamin and spurred investigations on how ERGO in the diet might improve long-term health outcomes and increase life expectancy.

Mushrooms are by far the richest dietary source of ERGO but it has also been found in much lower amounts in numerous foods. Unfortunately, the relatively low mushroom consumption in America appears to contribute to low ERGO in our diet. A recent study estimated that we only consume about 1 mg per day while other countries consume over 4 mg per day. This led our researchers at the Center for Plant and Mushroom Foods for Health at Penn State to ponder factors that contribute to ERGO levels in our food supply. We hypothesized that ERGO must be coming from fungi in soil that pass it on to plants through their roots and that farming practices that adversely affect healthy soil-borne fungal populations could negatively impact ERGO levels in our food. We subsequently determined some of our conventional agricultural practices such as excessive tillage of the soil (deep plowing) appears to disrupt fungal networks in the soil and reduces ERGO content of crops. Fortunately, we have shown that some regenerative farming practices such as minimal disturbance of soil at planting (No-Till) can mitigate this problem allowing fungi in the soil to supply more ERGO to our food crops.

Obviously, penicillin-producing fungi once had a profound impact on our health when infectious diseases were a major cause of mortality. Now, chronic inflammatory diseases are rampant with sixty percent of Americans suffering from at least one of them. Hence, ERGO-producing fungi in our farm soils will likely have a more subtle, but perhaps an even more long-lasting, improvement in our health outcomes. Also, regenerative farming practices help to reduce soil erosion and sequester more carbon in the soil that mitigates climate change helping us live longer, healthier lives.

Source: FUNGI Volume 15:5

Up-coming Events

India Mushroom Summit' 2023

A.P. Sinde Symposium Hall, NASC Complex, New Delhi. INDIA

20 NOVEMBER, 21 NOVEMBER, 22 NOVEMBER, 2023

Organized By Growdiesel Climate Care Council, New Delhi

Looking To Stay Ahead Of The Curve In The Fast-Paced World Of Mushrooms? Then You Won't Want To Miss The International Mushroom Conference In New Delhi! This Event Brings Together Top Researchers, Cultivators, And Industry Leaders From Around The Globe To Share Their Knowledge And Expertise.

About Us

The India Mushroom Summit will bring together key players from the mushroom industry to discuss challenges, opportunities, and advancements in the sector.

Experts from various fields will share their insights and knowledge, making this a must-attend event for everyone involved in the mushroom industry.

PARTICIPANT'S REGISTRATION IMS'23

Participants are welcome to register for the upcoming India Mushroom Summit'2023. We are excited to bring together professionals and enthusiasts from the mushroom industry to exchange knowledge, discuss challenges, explore opportunities, and foster growth in this thriving sector. Here's everything you need to know about registering for the conference.

REGISTER By 15 August' 2023 To Receive Discounted Prices.

Registration Information

Conference registration provides delegates access to all three days of the IMS'23 event. The registration fee includes the book of abstracts, refreshments (morning tea, evening tea, and lunch), entry to the Exhibition Hall and participation in the NETWORK DINNER on November 20th only. This registration and fee does not include cost of stay in Delhi during the conference days.

Registration Fee : FOREIGN PARTICIPANTS

Early bird (Till August 15) $490

General registration with payment from August 1st, 2023, to September 30th, 2023: $590

Late booking from October 1st, 2023, to November 15th, 2023: $790

Registration Fee : INDIAN PARTICIPANTS

Early bird (Till August 15) Rs. 5995/-

General (from 01/08/23 – 30/09/23) Rs. 7995/- +GST

Late booking (from 01/10/23 – 15/11/23) Rs. 9995/- +GST

* A special discount of 10% off the registration fee is applicable to students. To avail the discount, please send your requests to info@indiamushroomsummit.com with acceptable proof of being a Student.

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

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

SPEAKER'S REGISTRATION IMS'23

The Summit, to be held on 20 NOV, 21 NOV, 22 NOV, 2023, will include 15-minute oral presentations followed by 5 minutes for questions, dedicated poster sessions and 20-minute invited keynote presentations with a 10-minute Q&A. These events will take place over a three-day period.

REGISTER By 10th August' 2023 To Receive Discounted Prices.

Registration Information

Conference registration provides delegates access to all three days of the IMS'23 event. The registration fee includes the book of abstracts, refreshments (morning tea, evening tea, and lunch), entry to the Exhibition, and participation in the NETWORK DINNER on November 20th. Authors whose abstracts have been accepted must pay the registration fee by September 15th to ensure the publication of their abstracts in the Summit Book of Abstracts.

Registration Fee : FOREIGN SPEAKERS

Early bird (Till August 10th) $490

General registration from August 11th, 2023, to September 30th, 2023: $590

Late booking from October 1st, 2023, to November 15th, 2023: $790

Registration Fee : INDIAN SPEAKERS

Early bird (Till August 15th) Rs. 5995/-

General (from 16/08/23 – 30/09/23) Rs. 7995/- + GST

Late booking (from 01/10/23 – 15/11/23) Rs. 9995/- GST

EXHIBITOR'S REGISTRATION IMS'23

Exhibition booths are offered in multiples of 9 square meters at the India Mushroom Summit. The minimum size for a booth is 9 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.

REGISTER By 10TH August' 2023 To Receive Discounted Prices.

Registration Information

Exhibition booths are offered in multiples of 9 square meters at the India Mushroom Summit. The minimum size for a booth is 9 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.

Exhibition booths are offered in multiples of 9 square meters at the India Mushroom Summit. The minimum size for a booth is 9 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.

For Any Assistance in Logistics or any other Special Handling for Exhibition Please Contact: Info@indiamushroomsummit.com

FOREIGN Companies (Reserve exhibition booths per 9sq.mtr.)

- Early bird (Till August 15th) $2000
- General booking from August 16th, 2023, to September 30th, 2023: $3000

INDIAN Companies (Reserve exhibition booths per 9sq.mtr.)

- Early bird (Till August 15th) Rs.30,000/- + GST
- General booking from August 16th, 2023, to September 30th, 2023: Rs. 50,000/- + GST

For further details and registration for IMS'23, please visit: https://indiamushroomsummit.com

20th ISMS Congress & 26 th NAMC

The deadline for Abstract submission is fast approaching.

20th International Congress on the Science and Cultivation of Edible and Medicinal Mushrooms

26–29th February 2024, JW Marriot Las Vegas Resort & Spa in Las Vegas, Nevada, USA

The 20th ISMS International Congress on the Science and Cultivation of Edible and Medicinal Mushrooms (ISMSC) will be a face-to-face live event held in conjunction with the 26th North American Mushroom Conference (NAMC) in Las Vegas, USA in February 2024.

The Congress will involve concurrent sessions of live oral presentations (12 min presentation with 3 mins for questions), dedicated poster sessions, as well as invited keynote presentations (25min presentation with 5 mins for questions) over a two-day period on the 26th and 27th of the joint event.

REGISTRATION INFORMATION

Conference registration entitles delegates to attend all four days of the combined NAMC and ISMSC event. The registration fee covers the book of abstracts, all scheduled meals, access to the Expo floor, and official receptions. All authors that have had their abstract submissions accepted will need to have paid their registration fee for the event by 15 December to have their abstracts published in the Congress Book of Abstracts.

PRICING

ISMS Member pricing (select member price on the registration page):

- Early bird (17/03/23 to 31/07/23) $895
- General (from 01/08/23 – 30/12/23) $995
- Late booking (from 31/12/23 – 24/02/24) $1095

Standard (non-member) Registration Fees

- Early bird (17/03/23 to 31/07/23) $1395
- General (from 01/08/23 – 30/12/23) $1495
- Late booking (from 31/12/23 – 24/02/24) $1595

As an additional incentive for ISMS members, those who are students, research institutions scientists or university personnel can also use a special promotional code to receive a further $100 discount. Contact ISMS Secretariat at secretariat@isms.biz to receive the code.

Note - ISMS membership is free. Visit the ISMS website membership page to become a member.

For more information and to register for the Congress, visit https://mushroomconference.org/.

ACCOMMODATION

JW Marriot Las Vegas Resort & Spa, Address: 221 North Rampart, Boulevard, Las Vegas

The cost per night is US189/night plus tax. The hotel has limited availability of double occupancy rooms so early bookings are encouraged. For more information and to book your room, click here (https://mushroomconference.org/plan-your-trip/). There are many alternative accommodation options near the conference venue but delegates will need to research and organise these themselves.

SPONSORSHIP / EXHIBITION INQUIRIES

Expo spaces are filling up! There are a limited number of Expo spaces available, and slots are on a first-come, first-served basis. Each Expo space includes one (1) business registration worth $3,000 (for members)/$3500 (for non members), good for all four days of the Conference. Access more information at mushroomconference.org/expo/.

PREPARATION OF ABSTRACTS

Authors are reminded that the deadline for Abstract submissions is **30 September**.

Abstracts can be submitted on any research related to mushrooms or the mushroom industry. The Scientific Committee will allocate submissions on similar areas of research into topic groups that will enable concurrent sessions and poster areas to function effectively at the 20th Congress.

Please note the the abstract and presentation timeline has changed slightly. Information on the preparation of abstracts, how to submit, and the new timeline, is provided here (https://isms.biz/Web/ContentAreas/Events/2024-Congress%20author%20information.aspx).

First Circular of the 12th International Medicinal Mushrooms Conference (IMMC12)

We are pleased to announce the 12th International Medicinal Mushrooms Conference. We invite scientists, students, mycologists, medical doctors, immunologists, contagious disease specialists, naturopaths, biochemists, and all those who are interested in studying and discussing the most current research on medicinal mushrooms and their properties.

BARI, AN UNEXPECTED MEETING POINT BETWEEN EAST AND WEST

Bari is a very charming city, the third-largest city in Southern Italy, in order of the population.

It's incredible the contrast between the folkloristic old town and the cozy city center, full of branded shops and polished aristocratic buildings. Bari is highly multifaceted city, and you really need to discover every single aspect to understand its true core. Known as the "Gateway to the East" due to its long tradition of trade, this capital of Apulia is rich in history: see with your own eyes in the town of Bari Vecchia and surrounding area.

Exploring the historic centre allows us to discover its most authentic character, with signs of its past scattered through the local alleyways and endless examples of age-old traditions passed from generation to generation. Then there is the famous Bari promenade, one of the most beautiful in Italy, overlooking the clear sea and the unique charm of Bari.

Today, this dynamic city, nestled in the heart of the countryside punctuated by white dry-stone walls, is an important university hub.

But it still holds dear the memory of its seafaring exploits of the Middle Ages, as well as its precious monuments and striking churches.

The history of Bari is fascinating and turbulent. The ancient settlement dates back to the Bronze Age, passing from rule by the Peucetians to the Goths, before being fought over by the Byzantines and Lombards. Repeatedly ransacked and destroyed, medieval Bari was conquered by the Saracens and became a small independent Muslim state. It was then taken over by the Franks, before returning to the hands of the Romans, who made it the major Italian political, military and commercial centre of the Eastern Roman Empire. In 1087, with the arrival of the relics of

St Nicholas of Myra, commonly known as Santa Clause, Bari became a thriving religious centre uniting the East and West.

Norman rule in Apulia ensured a long period of prosperity for Bari, though it was still subject to conflict. Rebuilt by the Swabians, it experienced a new peak of splendour, until it declined again under the Angevins, torn apart by struggles between local squires and foreign bankers.

After going to the Aragonese and then the Dukes of Milan in 1464, it was restored to its former glory by Isabella of Aragon in 1500. In 1558, it fell into Spanish hands, experiencing numerous bloody rebellions, and in 1657 it was hit hard by plague. It then passed from Austrian to Bourbon rule, being renewed under French rule in the early 1800s with the construction of the new city.

After being returned to the Bourbons in 1815, it joined the Kingdom of Italy in 1860. This tumultuous history of dominations has left Bari with a unique artistic heritage for all to admire.

Bari is not only art, history, and ancient culture. In fact, a great social life awaits you.

WARNINGS

Bari is a relatively safe city for foreigners. Even though there are some areas to avoid (the main ones are the Libertà, Japigia, San Paolo, and Madonnelle neighborhoods), tourists should not face safety problems other than petty crime, the kind of crime you find in many cities. Use common sense and apply all usual safety precautions.

AVERAGES FOR BARI IN SEPTEMBER

This month is known as a warm month. The average maximum daytime temperature in Bari in September lies at 26.2°C (79.16°F). The average minimum temperature goes down to around 17.1°C (62.78°F) (often the minimum temperature is noted at night). Rainfall during September is moderate with an average of 66mm (2.6 inches). There are generally around 8 rainy days.

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)

INTERNATIONAL SCIENTIFIC COMMITTEE

- Dr. Angela Amazonas (Brazil)
- Prof. Mikheil Asatiani (Georgia)

- Prof. Hikmet Hakan Aydin (Turkey)
- Prof. Susanna Badalyan (Armenia)
- Prof. Lilian Barros (Portugal)
- Prof. Marin Berovic (Slovenia)
- Dr. Maria Maddalena Cavalluzzi (Italy)
- Prof. Shu-Ting Chang (Australia/China)
- Prof. Hui-Chen Lo (Chinese Taipei)
- Prof. Peter C.K. Cheung (Hong Kong, China)
- Dr. Ayman Daba (Egypt)
- Prof. Maria De Angelis (Italy)
- Prof. Maria Letizia Gargano (Italy)
- Dr. John Holliday (USA)
- Prof. Omon S. Isikhuemhen (USA)
- Prof. Boris Jakopovich (Croatia)
- Prof. Carmenza Jaramillo (Colombia)
- Dr Liudmila Kalitukha (Germany)
- Prof. Giovanni Lentini (Italy)
- Prof. Yu Li (China)
- Prof. Ulrike Lindequist (Germany)
- Prof. Miomir Nikšić (Serbia)
- Prof. Naohito Ohno (Japan)
- Dr. Tania Simona Re (Italy)
- Prof. Paola Rossi (Italy)
- Dr. Ángel R. Trigos (Mexico)
- Prof. Vinay K. Varshney (India)
- Prof. Giuseppe Venturella (Italy)
- Prof. Solomon P. Wasser (Israel/Ukraine)
- Prof. Georgios I. Zervakis (Greece)

PUBLISHING COMMITTEE

- Prof. Maria Letizia Gargano
- Prof. Solomon P. Wasser
- Prof. Giuseppe Venturella
- Prof. Georgios I. Zervakis

LOCAL ORGANIZING COMMITTEE

- Honorary Chairmen: Prof. Shu-Ting Chang, Prof. Solomon P. Wasser
- Chairs: Prof. Maria Letizia Gargano & Prof. Giuseppe Venturella
- Organizing Committee: Dr Gaetano Balenzano, Dr Filippo Bosco, Dr Fortunato Cirlincione, Dr Valeria

Ferraro, Dr Giulia Mirabile, Dr Raimondo Pardi, Dr Anna Scaringella

- Secretariat: Dr. Gaetano Balenzano, Dr Raimondo Pardi, Dr Anna Scaringella
- E-mail: secretary@immc12.com

  gaetano.balenzano@uniba.it

  raimondo.pardi@uniba.it

  anna278929@gmail.com

SCIENTIFIC PROGRAM OF CONFERENCE WILL INCLUDE:

- Keynote speeches
- Plenary lectures of invited speakers

Different symposia dedicated to:

- Biodiversity, taxonomy and ecology of medicinal mushrooms;
- Medicinal mushrooms culture collections, cultivation technology and circular economy;
- Biochemistry, biotechnology and pharmacology of medicinal mushrooms;
- Use of medicinal mushrooms in animal husbandry and veterinary medicine;
- Medicinal mushrooms in human pre-clinical and clinical studies;
- Legislation, certification and safety of mushroom-based supplements;
- Medicinal mushrooms as a source of novel functional food and health benefits; Ethnomycology and the therapeutic potential of psychedelic mushrooms

CALL FOR PAPERS

We would be pleased to receive contributions from interested authors that follow the conference themes. Abstracts should focus on current issues relevant to progress in research and/or to industry and should be scientific and/or of technical content.

Your abstracts should clearly define the objectives of the presentation or the topics covered, key conclusions reached, and potential benefits for scientific developments and industry. Abstracts should not be more than 500 words but not less than 300.

Abstracts should be sent to IMMC12 (abstract@immc12.com) before the 15th of February 2024. Text documents must be in Word or PDF format and written according to the template included in the conference web site.

IMPORTANT DATES AND DEADLINES

February 2023	Opening of the conference website
30 April 2023	Distribution of first circular
30 May 2023	Opening of registration
15 February 2024	Distribution of second circular
30 May 2024	Abstract submission deadline
15 June 2024	Notification to authors of abstract acceptance
30 June 2024	Early bird registration deadline

15 July 2024	Full paper submission deadline
31 July 2024	Closing date for registrations and accommodation
23 August 2024	Distribution of final scientific program
23 September 2024	Registration desk opens
24-27 September 2024	IMMC12-2024

For more information visit www.immc12.com

IMMC12 International Medicinal Mushrooms Conference

SPONSORSHIP OPPORTUNITIES AND EXHIBITION TABLE REQUEST FORM

There are a number of sponsorship opportunities for this IMMC9 conference, where scientists from all over the world will meet in an atmosphere of excellence to discuss the most recent advances in medicinal mushroom researches.

Name of Organization / Country / Company	
Primary Contact Person: *Name*: *Mobile phone*: *E-mail*:	
Secondary Contact Person: *Name*: *Mobile phon*	
I need an Exhibit Table:	☐ YES ☐ NO
I would like to contribute as:	☐ Platinum Sponsor ☐ Gold Sponsor ☐ Silver Sponsor ☐ Bronze Sponsor ☐ Patron Sponsor ☐ Other

PLATINUM (€ 30,000)

- Three complimentary conference registrations for the entire three days
- VIP seating at all conference keynote plenary sessions
- Most prominently displayed name on banner and sponsorship boards at all functions
- Company logo and web link on IMMC9 conference website
- Full page color ad in Conference Program and Exhibitor Guide
- Sponsorship acknowledgment in all conference printed materials
- Company promotional literature included in registration packet
- Exhibit table

GOLD (€ 15,000)

- Two complimentary conference registration for the entire three days
- VIP seating at all conference keynote plenary sessions
- Very prominently displayed name on banner and sponsorship boards at all functions Company logo and web

link on conference website

- ½ page color ad in Conference Program and Exhibitor Guide
- Sponsorship acknowledgment in all conference printed materials
- Company promotional literature included in registration packet
- Exhibit table

SILVER (€ 10,000)

- One complimentary conference registration for the entire three days
- VIP seating at one of the conference's keynote plenary sessions
- Prominently displayed name on banner and sponsorship boards at all functions
- Company logo on conference website
- Sponsorship acknowledgment in Conference Program and all conference printed materials
- Company promotional literature included in registration packet
- Exhibit table

BRONZE (€ 5,000)

- Prominently displayed name on banner and sponsorship boards at all functions
- Company logo on conference website
- Sponsorship acknowledgment in Conference Program and all conference printed materials
- Exhibit table

PATRON (€ 1,000)

- Name displayed on banner and sponsorship boards at all functions
- Sponsorship acknowledgment in Conference Program and all conference printed materials

Additional Sponsorship Opportunities

Listed below are the other unique sponsorship opportunities including conference events, meals, interest sessions, and some specialty items. We are also happy to explore customizing a sponsorship that meets your budget and program requirements, and compliments theconference.

Welcome Reception Sponsor	**€ 3,000**
Congress Dinner	**€ 15,000**
Conference Welcome Bag Sponsor	**€ 7,500**
Lunch Sponsor (one day)	**€ 7,500**
Coffee break standard Sponsor	**€ 2,500**
Coffee break superior Sponsor	**€ 3,500**
Scholarship Sponsor (multiple available)	**€ 1,000 each**

For more information on sponsorships, please contact secretary@immc12.com

We would like to extend our deep appreciation to all our partners and sponsors who will help make the IMMC12 Conference possible.

FULL PAPERS

Excellent papers of the IMMC12 will be published in the International Journal of Medicinal Mushrooms (IJMM). Please send the full paper according to journal format of the IJMM before **15 July 2024** if the IMMC12 secretary informs you of your abstract acceptance.

If you have any academic question, please send e-mail to secretary@immc12.com

Registration form is available starting **30 of May 2023** on the conference website www.immc12.com

Please print your registration form and send it to secretary@immc12.com

E-Poster

IN SUBSTITUTION OF THE TRADITIONAL POSTER SESSION (NOR PAPER POSTER NEITHER MOUNTING AREA WILL BE PROVIDED BY THE IMMC12 ORGANIZATION), IMMC12 ORGANIZE THE ELECTRONIC POSTER SESSION, OR E-POSTER SESSION.

GUIDELINES FOR PRESENTERS

ARE AVAILABLE AT HTTPS://WWW.IMMC12.COM/POSTER.HTML

PAYMENT INFORMATION

Payment can be made only by bank transfer

ACCOUNT FOR NATIONAL AND INTERNATIONAL TRANSFERS IN EUROS	
BENEFICIARY	Comitato Organizzatore Convegno IMMC12-2024 Bari
BANK	Che Banca! Filiale Milano Sede, Agenzia 0100
ADDRESS	Viale Luigi Bodio 37, 20158 Milano (Italy)
ABI	03058
CAB	01604
BIC/SWIFT Code (for SEPA area)	MICSITM1XXX
BIC/SWIFT Code (for NON SEPA area)	MICSITM3XXX
IBAN	IT91 T030 5801 6041 0057 2392 323

For any bank transfer made from outside the Euro zone, please be aware of bank service charges. All bank charges for remittances are to be borne by the participant.

Failure to pay this fee will result in an incomplete registration.

If you have any question about payment, please send e-mail to secretary@immc12.com

REGISTRATION

Please note that individual registrations can be made ONLY using registration form available starting 30 of May 2023 on the conference website www.immc12.com.

All prices are in Euros and include VAT 22%.

REGISTRATION FEES

	EARLY BIRDS (until 30 May, 2024)	NORMAL (after 30 May, 2024)
REGULAR ATTENDEES	500,00 €	550,00 €
PHD STUDENTS, RESEARCH FELLOWS[1]	300,00 €	350,00 €
ACCOMPANYING PERSON WITH LUNCHES	350,00 €	380,00 €
ACCOMPANYING PERSON WITHOUT LUNCHES	200,00 €	250,00 €

[1]PhD students and Research fellow registration forms must be accompanied by a signed letter from the head of Department attesting to student status.

The fee does not include accommodation costs.

REGISTRATION PACKAGE

The registration package for the participants includes:

Access to the conference and poster sessions, conference bag, final printed program, proceedings of the Conference, welcome cocktail reception, lunch on each conference day, coffee/tea/refreshment breaks, conference dinner, certificate of attendance.

Accompanying persons are entitled only to: welcome cocktail reception, lunch (only if required in the registration form) conference dinner.

INSURANCE

The registration fees do not include insurance of participants against accidents, sickness, cancellation, theft, property damage or loss. Participants are advised to arrange adequate personal insurance.

CONFIRMATION

Upon receipt of the registration form(s) with the appropriate fees, confirmation will be sent. Once registered, registrations cannot be changed to another fee category.

CANCELLATION OF REGISTRATION AND REIMBURSEMENT POLICY

Cancellations received before 30th June 2024 will be subject to a 40% surcharge on all monies paid. From this date onward, until 31st July 2024, cancellations will incur a 60% surcharge on all monies paid. From that date onward, no repayments will be made in the event of cancellation. Please note that refunds will be issued only after the end of the meeting.

ACCOMMODATION

To make room reservations, participants should use the link on the IMMC12 website at www.immc12.com/accommodation.html

Rooms are being held at the IMMC12 venue hotel at special rates. Accommodation at **The Nicolaus Hotel Bari - HO Collection (4 stars) includes breakfast. THE ACCOMMODATIONS WILL BE ARRANGED ON THE BASIS OF FIRST COME, FIRST SERVED. SINCE THE AREA**

OF BARI ATTRACTS A SIGNIFICANT NUMBER OF TOURISTS EACH YEAR, WE STRONGLY RECOMMEND TO BOOK YOUR ROOM IN ADVANCE.

Once the availability of rooms at the Hotel Nicolaus has ended, participants will be arranged at the HI Hotel Bari, which is part of the same chain Ho Collection and is located 15-minute walk from the conference venue.

Alternatively, participants can independently decide to stay in one of the city's many hotels and B&Bs.

Since all activities of the IMMC12 will take place within the space of **The Nicolaus Hotel Bari - HO Collection** (conferences, meetings, display of posters and lunches), accommodation in this hotel is very advantageous and convenient.

All hotel rates are in Euros, per room/night, including service, breakfast and 22% VAT. The city of Bari does not currently have a city tax for accommodation.

The Nicolaus Hotel Bari - HO Collection

https://www.thenicolaushotel.com/
Via C.A. Ciasca 27, 70124 - Bari Phone - +39 080 5682111
Fax - +39 080 5042058
Email - info@nicolaushotel.com

I Presidenti del Comitato Organizzatore / The Presidents of Organizing Committee

Prof. Maria Letizia Gargano

Prof. Giuseppe Venturella

Research progress

Mushroom husbandry: A tool for pollution control and waste management with job opportunities and revenue for rural communities and farm settlements

Victor S. Ekun [1], Clementina O. Adenipekun [1], Olufunmilayo Idowu [2], Peter M. Etaware [1]

[1]*Department of Botany, Faculty of Science, University of Ibadan, Oyo State, Nigeria;*
[2]*Mushroom Cultivation Unit, NIHORT, Ibadan, Oyo State, Nigeria*

Abstract: Most rural communities in Africa openly dispose untreated wastes in water and on land, resulting in environmental pollution and the spread of deadly diseases in human (e.g., cholera, typhoid), plants (e.g., wilt, gall/wart, rot), and animals (e.g., skin/gut infections). Therefore, conversion of untreated wastes to substrate for mushroom cultivation was the focus of this research. Wild edible mushrooms (chemical-free) and wastes were collected, sorted, profiled and analyzed using standard laboratory techniques. Physicochemical profiling of the wastes showed the presence of lignin (<30%), cellulose (<60%), and hemicellulose (<58%) that are mildly impervious, non-biodegradable substances which can mostly be degraded by mushrooms. The results showed that mushroom spawn-production period was reduced by 11, 15, 16 and 16% on rice straw for Sample 1 (23¼ days), Sample 2 (21¼ days), Sample 3 (20¼ days) and Sample 6 ($22^{1}/_{10}$ days), respectively; 10 and 7% on sawdust for Sample 4 (23½ days) and Sample 5 ($20^{3}/_{5}$ days), respectively. Developmental periods were also reduced by 9, 12, 14, 3, and 9% when grown on *G. sepium* (i.e., 26½, 25½, 24¾, 25¾ and $29^{1}/_{10}$ days for Samples 1, 2, 3, 5 and 6, respectively), and 9% on *M. indica* (i.e., 26½ days for Samples 4). The yield was increased by 7% on *Cedrus odorata* (Samples 1 and 2), 11% on *G. sepium* (Samples 3), and 7% on *M. indica* (Samples 4 and 5). The outcome of the research showed that more money and job opportunity can be created from waste re-use rather than waste disposal.

Keywords: Wastes re-use, Africa, Environmental pollution, Mushroom husbandry, Diseases

Waste Management Bulletin, Volume 1, Issue 4, March 2024, Pages 15-22

Effects of Button Mushroom *Agaricus bisporus* (Agaricomycetes) and Soybean Oil on Storage Characteristics of Chicken Sausage

Haijuan Nan [1,2], Tetiana Stepanova [2], Bo Li [1]

[1]*School of Food Science, Henan Institute of Science and Technology, Xinxiang City, P.R. China;*

[2]*Food Technologies Faculty, Sumy National Agrarian University, Sumy, Ukraine*

Abstract: To investigate the effect of *Agaricus bisporus* and soybean oil as complex fat substitutes on the storage characteristics of chicken sausages, a pre-mixture of *A. bisporus* and soybean oil (1:2) was used to replace 0% (CK), 30% (T30), 60% (T60), and 90% (T90) of pork back fat in chicken sausages. The changes in color (brightness value, L*; redness value, a*; and yellowness value, b*), texture, pH, and total viable count of the sausages were examined at 1, 5, 10, 15, 20, 25, 30 and 35 d of storage at 4°C, respectively. The results showed that *A. bisporus* and soybean oil altered the color of the sausages. At the same storage time, compared with CK, L* values of fat-reduced chicken sausages decreased

significantly, while a* values increased significantly ($P < 0.05$), b* values increased significantly ($P < 0.05$) at the 10 d of storage. During storage, L* and a* values of CK gradually decreased and b* values gradually increased, fat-reduced sausages exhibited opposite trends in a* values and b* values compared with CK. The hardness and chewiness of fat-reduced sausages increased significantly ($P < 0.05$) compared with CK at the same storage time. During storage, the overall hardness of fat-reduced sausages increased, and the springiness and chewiness fluctuated. T60 did not change significantly in cohesiveness throughout the storage period ($P < 0.05$). The pH of fat-reduced sausage was relatively stable during storage. The higher the amount of *A. bisporus* added, the greater the pH. The pH of T60 did not change throughout the storage period. *A. bisporus* and soybean oil showed some antibacterial effect on sausage and the minimum shelf life of chicken sausage with *A. bisporus* was 25 d. In conclusion, *A. bisporus* and soybean oil increased the redness and hardness of the sausages during storage, but the pH and total viable bacteria count remained relatively stable. T60 displayed the most stable storage properties among them, making it the optimum method for the manufacturing of fat-reduced chicken sausages.

Keywords: *Agaricus bisporus*, soybean oil, fat substitutes, storage characteristics, chicken, sausage, antibacterial effect, medicinal mushrooms

International Journal of Medicinal Mushrooms, Volume 25, Issue 9, 2023, pp. 73-83; DOI: 10.1615/IntJMedMushrooms.2023049470

***Hericium erinaceus*, in combination with natural flavonoid/alkaloid and B3/B8 vitamins, can improve inflammatory burden in Inflammatory bowel diseases tissue: an *ex vivo* study**

Antonietta Gerarda Gravina[1*†], Raffaele Pellegrino[1†], Giovanna Palladino[1], Annachiara Coppola[1], Giovanni Brandimarte[2], Concetta Tuccillo[3], Fortunato Ciardiello[3], Marco Romano[1] and Alessandro Federico[1]

[1]*Hepatogastroenterology Unit, Department of Precision Medicine, University of Campania "Luigi Vanvitelli", Naples, Italy;*
[2]*Division of Internal Medicine and Gastroenterology, Cristo Re Hospital, Rome, Italy;*
[3]*Medical Oncology Unit, Department of Precision Medicine, University of Campania "Luigi Vanvitelli", Naples, Italy*

Abstract: *Hericium erinaceus*, berberine, and quercetin are effective in experimental colitis. It is unknown whether they can ameliorate inflammatory bowel diseases in humans. This ex vivo study aimed to evaluate the anti-inflammatory potential of a nutraceutical compound of HBQ-Complex® (*H. erinaceus*, berberine, and quercetin), biotin, and niacin in inflammatory bowel disease patients. Tissue specimens were obtained either from Normal-Appearing Mucosa (NAM) or from Inflamed Mucosa (IM) in 20 patients with inflammatory bowel disease. mRNA and protein expression of COX-2, IL-10, and TNF-a were determined in NAM and IM biopsy samples (T0). IM samples were then incubated in HBQ-Complex® (with the addition of niacin and biotin), and COX-2, IL-10, and TNF-a tissue levels were evaluated at 120 minutes (T1) and 180 minutes (T2). Incubation with this compound resulted in a progressive decrease in gene and protein COX-2 and TNF-a expression at T1/T2 in the IM. IL-10 showed an opposite trend, with a progressive increase of mRNA and protein expression over the same time window. HBQ-Complex® (with the addition of niacin and biotin) decreased the expression of proinflammatory cytokines at the mRNA and protein levels in IBD tissue. On the contrary, mRNA and protein expression of the anti-inflammatory cytokine IL-10 showed a progressive increase.

Keywords: inflammatory bowel disease, *Hericium erinaceus*, quercetin, berberin, biotin, niacin,

Crohn's disease, ulcerative colitis

Frontiers in Immunology, 03 July 2023, DOI 10.3389/fimmu.2023.1215329

TBG-136, a Schizophyllum commune-derived β-glucan benefits gut microbiota and intestinal health: A randomized, double-blind, and placebo-controlled clinical trial

Hui-Yeon Jang [1], Su-Jin Jung [1,2], Eun-Ock Park [1], Soo-Dong Kim [3], Je-Kyoung Kim [3], Soo-Wan Chae [1,2], Youn–Soo Cha [4,*], Seung-Ok Lee [1,2,5,*]

[1] *Clinical Trial Center for Functional Foods, Jeonbuk National University Hospital, Jeonbuk 54907, Republic of Korea;*
[2] *Biomedical Research Institute of Jeonbuk National University Hospital, Jeonbuk 54907, Republic of Korea;*
[3] *Quegen Biotech. Co., Ltd, Siheung, 15112, Republic of Korea*
[4] *Department of Food Science and Human Nutrition & K-Food Research Center, Jeonbuk National University, Jeonbuk 54896, Republic of Korea;*
[5] *Department of Gastroenterology and Hepatology, Jeonbuk National University, Medical School, Jeonbuk 54896, Republic of Korea*

Abstract: β-glucan exerts beneficial biological activities such as immunoregulatory, anticancer, antioxidative, antiaging, and wound healing. However, the effects of β-glucan on constipation have not been thoroughly studied. Thus, the present study aimed to investigate the effects of β-glucan-derived from *Schizophyllum commune* supplementation (TBG-136) on gut microbiota and intestinal health in constipated subjects. As a result, *Lactobacillus* was significantly increased in the TBG-136 group compared to the placebo group ($P < 0.05$) after 8 weeks of TBG-136 supplementation. Additionally, TBG-136 group significantly improved the rectosigmoid CTT and the number of defecations compared to the placebo group ($P < 0.05$). Thus, β-glucan derived from *Schizophyllum commune* helps individuals' health and quality of life by increasing the beneficial bacteria and improving symptoms of constipation.

Keywords: *Schizophyllum commune,* β-glucan, Gut bacteria, Intestinal health, Constipation

Journal of Functional Foods 107 (2023) 105668

Performance of Various Agroforestry Wastes for the Cultivation of Elm Oyster Mushroom *Hypsizygus ulmarius* (Agaricomycetes) in India and Its Biochemical Constituents

Aditya [1], R. S. Jarial [2], J.N. Bhatia [3]

[1]*National Institute of Food Technology Entrepreneurship and Management, Kundli 131028, Haryana, India*;
[2]*Department of Plant Pathology, Dr. Y.S. Parmar University of Horticulture and Forestry, College of Horticulture and Forestry, Neri, Hamirpur-177001, Himachal Pradesh, India;*
[3]*Chaudhary Charan Singh Haryana Agricultural University, Hisar 125004, Haryana, India*

Abstract: *Hypsizygus ulmarius*, a species with high biological efficiency, is multi-nutrient and is a medically good source of myco-chemicals. A study was carried out to evaluate different types of spawn to produce *H. ulmarius* utilizing various agroforestry wastes. Among seven different grain substrates evaluated, pearl millet grains were found to be the best substrate for spawn production as it supports much faster (11 d) and enhanced growth of *H. ulmarius*. A minimum period (13.67 d) was recorded for the complete spawn run, time taken for the first flush (20.33 d) along with the maximum number (38.33) of sporocarps produced in the wheat straw substrate. The longest stipe length (6.40 cm) was however, recorded in pine needles while the maximum (9.10 cm) cap diameter was found in maize straw substrate spawned with pearl millet grains spawn. Out of seven locally available substrates evaluated for production and yield parameters of *H. ulmarius*, maximum yield (640.00 g/0.5 kg dry substrate) having 128 percent biological efficiency was obtained when the wheat straw substrate was used significantly followed by wheat and maize grains spawn on the same substrate. Minimum time for spawn run, maximum number of sporocarps, maximum yield and biological efficiency was recorded in wheat straw substrate showing the best production substrate for *H. ulmarius* using pearl millet grains spawn. The results showed that agroforestry wastes can be alternatively used as potential substrates for cultivating *H. ulmarius. H. ulmarius* contain high amounts of proteins, carbohydrates, dietary fibers, unsaturated fatty

acids, enzymes, and plenty of minerals among the commercially cultivated species. This mushroom has a good profile of vitamins, including B_1 (thiamine), B_2 (riboflavin), B_3 (niacin), A (retinol) and C (ascorbic acid), all of which are suitable for diet formulation and act as sources of energy.

Keywords: *Hypsizygus ulmarius*, agroforestry, biological efficiency, grain spawn, phytochemicals, substrates, yield, medicinal mushrooms

International Journal of Medicinal Mushrooms, Volume 25, Issue 8, 2023, pp. 55-62; DOI: 10.1615/IntJMedMushrooms.2023049037

Review of postharvest processing of edible wild-grown mushrooms

Chuanmao Zheng [1,2], Jieqing Li [1], Honggao Liu [3], Yuanzhong Wang [2]

[1] *College of Agronomy and Biotechnology, Yunnan Agricultural University, Kunming 650201, China;*
[2] *Medicinal Plants Research Institute, Yunnan Academy of Agricultural Sciences, Kunming 650200, China;*
[3] *Yunnan Key Laboratory of Gastrodia and Fungi Symbiotic Biology, Zhaotong University, Zhaotong 657000, Yunnan, China*

Abstract: Edible wild-grown mushrooms, plentiful in resources, have excellent organoleptic properties, flavor, nutrition, and bioactive substances. However, fresh mushrooms, which have high water and enzymatic activity, are not protected by cuticles and are easily attacked by microorganisms. And wild-grown mushroom harvesting is seasonal the harvest of edible wild-grown mushrooms is subject to seasonality, so their market availability is challenging. Many processing methods have been used for postharvest mushroom processing, including sun drying, freezing, packaging, electron beam radiation, edible coating, ozone, and cooking, whose effects on the parameters and composition of the mushrooms are not entirely positive. This paper reviews the effect of processing methods on the quality of wild and some cultivated edible mushrooms. Drying and cooking, as thermal processes, reduce hardness, texture, and color browning, with the parallel that drying reduces the content of proteins, polysaccharides, and phenolics while cooking increases the chemical composition. Freezing, which allows mushrooms to retain better hardness, color, and higher chemical content, is a better processing method. Water washing and ozone help maintain color by inhibiting enzymatic browning. Edible coating facilitates the maintenance of hardness and total sugar content. Electrolytic water (EW) maintains total phenol levels and soluble protein content. Pulsed electric field and ultrasound (US) inhibit microbial growth. Frying maintains carbohydrates, lipids, phenolics, and proteins. And the mushrooms processed by these methods are safe. They are the focus of future research that combines different methods or develops new processing methods, molecular mechanisms of chemical composition changes, and exploring the application areas of wild mushrooms.

Keywords: Edible wild-grown mushrooms, Drying, Packaging, Preservation, Processing, Postharvest

Food Research International, Volume 173, Part 1, November 2023, 113223

Understanding the effects of carbon and nitrogen starvation on the comparative secretomes of *Ganoderma boninense* and *Ganoderma tornatum*

Shahirah Balqis Dzulkafli [1 2], Abrizah Othman [1], Benjamin Yii Chung Lau [1], Zain Nurazah [1], Jayanthi Nagappan [1], Umi Salamah Ramli [1], Saiful Anuar Karsani [2 3]

[1] *Malaysian Palm Oil Board, No 6, Persiaran Institusi, Bandar Baru Bangi, 43000, Kajang, Selangor, Malaysia;*
[2] *Institute of Biological Sciences, Faculty of Science, Universiti Malaya, 50603, Kuala Lumpur, Malaysia;*
[3] *Universiti Malaya Centre for Proteomics Research (UMCPR), Malaysia*

Abstract: Ganoderma *boninense* is the most pathogenic fungal species of oil palm trees. However, there is limited understanding of the host - pathogen interaction. Secreted proteins play a critical role during the early infection process which involves competition between the fungal and host populations for nutrient resources necessary for continual growth. To identify the secreted proteins that may play a role in pathogenicity during infection stage, we compared the secretome profiles of *G. boninense* versus *G. tornatum* under carbon and nitrogen starvation by using shotgun proteomics approach. In total, 250 non-redundant proteins were identified, and statistical data analysis indicated that 68 proteins were increased while 104 proteins decreased in abundance in T3 for *G. boninense* whereas in *G. tornatum*, 42 proteins were increased, and 27 proteins were decreased in abundance in T3. Further investigation via bioinformatic tools helped us to classify the carbohydrate-active enzymes (CAZymes) proteins into four classes: oxidoreductases, transferases, hydrolases, and glyceraldehyde-3-phosphate dehydrogenase (GAPDH). Interestingly, oxidoreductase enzymes were identified only in *G. boninense*. These putative proteins might contribute to the different levels of pathogenicity of *G. boninense* and *G. tornatum* toward oil palm. The newly discovered protein information may help researchers better understand the secretory mechanisms of *G. boninense* and the process by which it invades oil palm root tissues. The discovered seretome proteins, along with their subclassification and functional annotation also serve as a database for *Ganoderma* species that is easy to access and retrieve.

Physiological and Molecular Plant Pathology; Volume 127, September 2023, 102084

Effect of oxyresveratrol on the quality and membrane lipid metabolism of shiitake mushroom (*Lentinus edodes*) during storage

Ben Niu [1], Yingchang Fei [1], Ruiling Liu [1], Hangjun Chen, Xiangjun Fang, Weijie Wu, Honglei Mu, Haiyan Gao

[1]State Key Laboratory for Managing Biotic and Chemical Threats to the Quality and Safety of Agro-products, Key Laboratory of Post-Harvest Handling of Fruits, Ministry of Agriculture and Rural Affairs, Key Laboratory of Fruits and Vegetables Postharvest and Processing Technology Research of Zhejiang Province, Food Science Institute, Zhejiang Academy of Agricultural Sciences, Hangzhou 310021, China

Abstract: The effect of oxyresveratrol on postharvest quality and membrane lipid metabolism of shiitake mushroom was investigated. The result exhibited that oxyresveratrol retarded browning, maintained firmness and alleviated occurrence of decay of shiitake mushroom. The oxidation and hydrolysis of membrane phospholipids were suppressed by oxyresveratrol treatment, which was associated with reduced LOX and PLD activities and increased SOD and CAT activities. The membrane lipidomics of shiitake mushroom was determined by LC-MS. 385 lipid species and 13 fatty acids in membrane lipids were identified by multiple reaction monitoring method. Compared with control group, the phospholipic acid and lysophospholipid reduced by 29.24% and 21.29% in oxyresveratrol-treated group, respectively, which alleviated hydrolysis of phospholipid. Meanwhile, oxyresveratrol maintained the unsaturation of fatty acids and alleviated oxidation of phospholipid. These results demonstrated that oxyresveratrol could play a dual role of inhibiting the oxidation and hydrolysis of phospholipids to mitigate cellular damage of shiitake mushroom.

Food Chemistry, Volume 427, 30 November 2023, 136700

Cordyceps sinensis (yarsagumba): Pharmacological properties of a mushroom

Author links open overlay panelSanjukta Sen [1 4], Dipanjan Karati [2], Rosy Priyadarshini [3], Tarun Kumar Dua [4], Paramita Paul [4], Ranabir Sahu [4], Gouranga Nandi [4]

[1] Gitanjali College of Pharmacy, Lohapur, Nalhati, Birbhum, West Bengal 731237, India;

[2] School of Pharmacy, Techno India University, West Bengal, Kolkata 700091, India;

[3] College of Pharmaceutical Sciences, Puri, Baliguali, Odisha 752002, India;

[4] Department of Pharmaceutical Technology, University of North Bengal, Raja Rammohunpur, Darjeeling, West Bengal 734013, India

Abstract

Introduction

Yarsagumba (*Cordyceps sinensis* or *Ophiocordyceps sinensis*) is a fungus that parasitizes ghost moth larvae and produces a fruiting body prized as herbal medicine, belonging to the Ophiocordycipitaceae family. Cordyceps species are also known as traditional Chinese medicine (TCM) as it has wide applications in the pharmaceutical and health sectors. For thousands of years, Yarsagumba has been recognized in Nepal. It is one of the world's most promising medicinal mushrooms. Its unusual life cycle and wide range of medical applications piqued scientists' curiosity throughout the previous three decades. The purpose of this review is to compile information on Yarsagumba, including its history, cultivation, taxonomic characteristics, and many therapeutic uses, as well as phytochemical and pharmacological studies completed to date.

Methods

Different sources and distribution of the fungus have been presented along with its life cycle, morphology, collection procedure, and history as traditional Chinese medicine. Various chemical constituents of the fungus have been presented in tabular form with their significance as nutrients and traditional medicine. Various pharmacological activities have also been presented in tabular form with their mechanism of action, which include antiasthmatic, antineoplastic, antibacterial, aphrodisiac, cardioprotective, anti-cancer, immunomodulator, etc. Different adulteration methods and standardization approaches have also been summarized.

Results

This review summarizes various aspects of yarsagumba relevant to its uses as traditional Chinese medicine.

Conclusion

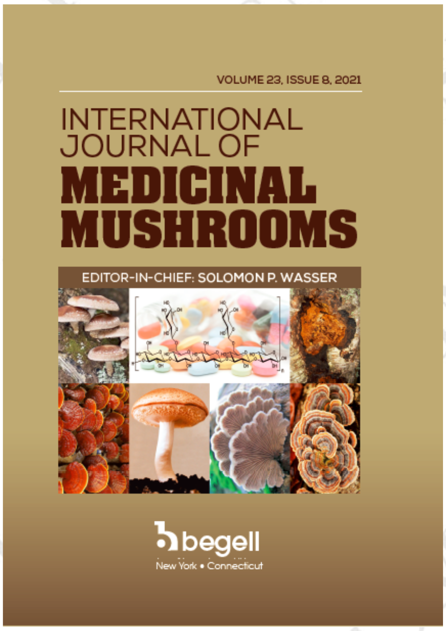
Despite its scientific advancement, further research is needed, particularly in the design of dosage forms and analysis that will lead to the most effective use of this most expensive medicinal fungus.

Keywords: Yarsa gumba, *Cordyceps sinensis,* Caterpillar fungus, *Ophiocordyceps sinensis,* Cordycepic acid

Pharmacological Research - Modern Chinese Medicine, Volume 8, September 2023, 100294

International Journal of Medicinal Mushrooms Call for Papers

About *International Journal of Medicinal Mushrooms*



International Journal of Medicinal Mushrooms is a journal covering the technologies/fields/categories related to Applied Microbiology and Biotechnology (Q3); Drug Discovery (Q3); Pharmacology (Q3). It is published by Begell House Inc.. The overall rank of International Journal of Medicinal Mushrooms is 12651. According to SCImago Journal Rank (SJR), this journal is ranked 0.376. SCImago Journal Rank is an indicator, which measures the scientific influence of journals. It considers the number of citations received by a journal and the importance of the journals from where these citations come. SJR acts as an alternative to the Journal Impact Factor (or an average number of citations received in last 2 years). This journal has an h-index of 33. The best quartile for this journal is Q3.

The ISSN of International Journal of Medicinal Mushrooms journal is 15219437. An International Standard Serial Number (ISSN) is a unique code of 8 digits. It is used for the recognition of journals, newspapers, periodicals, and magazines in all kind of forms, be it print-media or electronic. International Journal of Medicinal Mushrooms is cited by a total of 531 articles during the last 3 years (Preceding 2021).

International Journal of Medicinal Mushrooms Impact Score 2021-2022

The impact score (IS) 2021 of International Journal of Medicinal Mushrooms is 1.57, which is computed in 2022 as per its definition. The impact score (IS), also denoted as Journal impact score (JIS), of an academic journal is a measure of the yearly average number of citations to recent articles published in that journal. It is based on Scopus data.

Aims and Scope

The rapid growth of interest in medicinal mushrooms research is matched by the large number of disparate groups that currently publish in a wide range of publications. The *International Journal of Medicinal Mushrooms* is the one source of information that will draw together all aspects of this exciting and expanding field - a source that will keep you up to date with the latest issues and practice. The *International Journal of Medicinal Mushrooms* publishes original research articles and critical reviews on a broad range of subjects pertaining to medicinal mushrooms, including systematics, nomenclature, taxonomy, morphology, medicinal value, biotechnology, and much more. Papers on new techniques that might promote experimental progress in the aforementioned field are also welcomed. In addition to full-length reports of original research, the journal publishes short communications and interesting case reports, together with literature reviews. Letters to the editor on topics of interest to readers are also published.

For More Information and Submittion

https://www.begellhouse.com/journals/medicinal-mushrooms.html

International Journal of
Medicinal Mushrooms

2023, Vol. 25, Issue no.8

International Journal of
Medicinal Mushrooms

2023, Vol. 25, Issue no.9

Points and Reviews

Mycochemicals in Wild and Cultivated Mushrooms: Nutrition and Health

Francesca Cateni[1], Maria Letizia Gargano[2], Giuseppe Procida[1], Giuseppe Venturella[3], Fortunato Cirlincione[3], Valeria Ferraro[3]

[1]Department of Chemical and Pharmaceutical Sciences, University of Trieste, Piazzale Europa, 1, 34127 Trieste, Italy;
[2]Department of Agricultural and Environmental Science, University of Bari Aldo Moro, Via Amendola 165/A, 70126 Bari, Italy;
[3]Department of Agricultural, Food and Forest Sciences, University of Palermo, Viale delle Scienze, Bld. 5, 90128 Palermo, Italy

Orgainal Published on Phytochem Rev (2022) 21:339–383

Abstract: The mushrooms have contributed to the development of active ingredients of fundamental importance in the field of pharmaceutical chemistry as well as of important tools in human and animal health, nutrition, and functional food. This review considers studies on the beneficial effects of medicinal mushrooms on the nutrition and health of humans and farm animals. An overview of the chemical structure and composition of mycochemicals is presented in this review with particular reference to phenolic compounds, triterpenoids and sterols, fatty acids and lipids, polysaccharides, proteins, peptides, and lectins. The nutritional value and chemical composition of wild and cultivated mushrooms in Italy is also the subject of this review which also deals with mushrooms as nutraceuticals and the use of mushrooms in functional foods. The nutraceutical benefits of UV irradiation of cultivated species of basidiomycetes to generate high amounts of vitamin D2 is also high- lighted and the ability of the muhsrooms to inhibit glycation is analyzed. Finally, attention is paid to studies on bioactivities of some Italian wild and cultivated mushrooms with particular reference to species belonging to the genus *Pleurotus*. The review highlights the potential of medicinal mushrooms in the production of mycochemicals that represent a source of drugs, nutraceutical, and functional food.

Graphic abstract

Sample	Molecular Weight (kDa)	Monosaccharide Composition (%)[a]						
		Glc	Rham	Gal	Xyl	Ara	Man	Fru
PEPS-A	—	94.8	—[b]	—	—	—	5.2	—
PEPS-B	—	60.8	—	—	—	—	3.0	36.2
PEPS-A1	68	100	—	—	—	—	—	—
PEPS-A2	43	100	—	—	—	—	—	—

[a]Individual components were identified by comparison with standard sugars.
[b]Not detected.

Keywords: Fungal diversity, Cultivation, Mycochemicals, Chemical structures, Nutrition

Abbreviations

AGLs	Acidic glycosphingolipids
BEPF	*Boletus edulis* Polysaccharides
BRMs	Biological response modifiers
CBAEP	Cibacron blue affinity-purified protein
COSY	Correlation spectroscopy
FAB-MS	Fast atom bombardment
FAME	Fatty acid methyl esters
FIP	Immunomodulatory proteins
FT-IR	Fourier-transformed infrared spectroscopy
GC	Gas chromatography
GLC–MS	Gas-liquid chromatography–mass spectrometry
GLS	Glycosphingolipids
GSH	Glutathione peroxidase
HBA	Hydroxybenzoic acid
HCA	Hydroxycinnamic acid
HIV	Human immunodeficiency viruses
HMBC	Heteronuclear multiple bond coherence
HMG-CoA	β-Hydroxy β-methylglutaryl-CoA
HMQC	Heteronuclear multiple quantum coherence
HPLC–MS	Liquid chromatography–mass spectrometry
HS-ITEX	Head Space ‘‘In Tube Extraction’’
GC-MS	Technique and gas chromatography
IEC	Ion-exchange chromatography
iNKT	Invariant natural killer cell
LCB	Long-chain base
LDG-M	*Lactarius deliciosus* Polysaccharides

MHS-SPME	Multiple headspace-solid phase microextraction
MIC	Minimum inhibitory concentration
MM	Medicinal mushrooms
MUFA	Monounsatured fatty acid
NMR	Nuclear magnetic resonance
NOESY	Nuclear overhauser effect spectroscopy
OMW	Olive mill wastewaters
PELPS	*Pleurotus eryngii* var. *elaeoselini* polysaccharides
PEPE	*Pleurotus eryngii* Purified polysaccharides
PSK	Polysaccharide K
PSP	Polysaccharide peptide
PUFA	Polyunsaturated fatty acid
ROESY	Rotating-frame nuclear overhauser effect correlation spectroscopy
RVP	*Russula virescens* Polysaccharide
SEC	Size-exclusion chromatograpy
SFA	Saturated fatty acid
SPG	Schizophyllan
TLC	Thin layer chromatography
TOCSY	Total correlation spectroscopy
TPC	Total phenolic content
VOC	Volatile organic compounds

Continued from previous issue:

Mycochemicals in functional foods

As mentioned, today's concept of food is changing, becoming more complex. ''Functional food'' namely conventional food is consumed as part of the daily diet.

This type of food positively affects one or more physiological functions of the human body is proven; therefore, in addition to the nutritional intake, they contribute to maintaining the state of wellness, improving health, and reducing the risk of disease.

This concept is flanked by that of "food supplements'' which, compared to the previous ones, constitute a concentrated source of nutrients or substances with nutritional and/or physiological effect; they are marketed in various dose forms, including tablets, capsules, gummies, and powders, as well as drinks and energy bars and aim to provide nutrients to fulfil the nutritional requirement of an individual.

Mushrooms are functional food, because of their nutritional features: they are hypocaloric and a good source of high-quality dietary fiber. Their carbohydrate content as glycogen (and not of starch) is low.

They also have significative digestible proteinsand all the essential amino acids required by an adult and often deficient in plants, as well as various vitamins and mineral elements in content often at higher levels than vegetables.

Therefore, in addition to taking a leading role in diseases such as hypertension, cholesterol, obesity, etc.) and they provide an efficient alternative in areas with widespread malnutrition.

Mushrooms show potential for obtaining fortified foods, improving nutrition, and adding health benefits.

Table 7 Bioactivities of some Italian wild and cultivated mushrooms

Mushrooms species	Bioactive compound or extract	Activity and mechanisms		References
Agaricus bisporus	Polysaccharides	Scavenging activity, metal chelating activity, reducing power; anti-hypoxic activity		Li et al. (2015)
	Lectin (ABL)	Anticancer	Inhibition of proliferation of cancerous human epithelial colon cells (HT29) in vitro	Ismaya et al. (2020)
			Inhibition of MCF-7 (breast cancer cells) and Caco-2 cancer cell proliferation in vitro	
		Antineoplastic	Suppressed proliferation of retinal pigment epithelium (RPE) cells, and subsequent lowering of proliferative vitreoretinopathy;	Ismaya et al. (2020)
			Slows down proliferation of human ocular fibroblast and reduces collagen lattice contraction in vitro	
		Antiviral	Strong inhibition against human immunodeficiency virus type-1 (HIV-1) reverse transcriptase (IC50 of 8 μM) in vitro;	Ismaya et al. (2020)
	Mannose-binding protein (Abmb)	Anticancer	Inhibits proliferation of MCF-7 breast cancer cells at 12.5 μM and arrests growth at lower concentrations in vitro	Ismaya et al. (2020)
	Methanolic and aqueous extracts	Anti-inflammatory, analgesic, antipyretic, antioxidative and antimicrobial (in mice and/or in vitro)		Bose et al. (2019)
	Polysaccharide	Immunostimulatory and antitumor bioactivity in vivo and in vitro		Atila et al. (2017)
	Fruiting body extracts	Immunostimulating	On activated human peripheral blood mononuclear cells (PBMCs) and induced synthesis of interferon gamma (IFN-γ)	Atila et al. (2017)
		Antitumor	Inhibition on cell proliferation of HL-60 leukemia cells and other leukemia human cell lines via the induction of apoptosis;	Atila et al. (2017)
			Suppression of aromatase activity, inhibition on breast cancer cell proliferation, and decrease in mammary tumor formation in vivo	Atila et al. (2017)
	UFA	Antitumor	Inhibition on aromatase activity	Atila et al. (2017)
	Arginine	Antitumor	Delay of tumor growth and metastasis	Atila et al. (2017)
	Lovastatin	Antitumor	Anti-cancer effects in the triple-negative breast cancer cell line MDA-MB-231	Atila et al. (2017)
		Antihyperlipidemic	Reduction of cholesterol level in serum and/or liver	Atila et al. (2017)
	Sterols	Antihyperlipidemic	Reduction in cholesterol absorption and thereby lowered plasma cholesterol and LDL cholesterol	Atila et al. (2017)
	Fruiting body extracts	Antidiabetic	Decreased severity of streptozotocin-induced diabetes in rat	Atila et al. (2017)
	α-glucans	Antidiabetic	Lowered producing lipopolysaccharide-induced TNFa	Atila et al. (2017)
	Polysaccharides and phenolics	Scavenging of superoxide, hydroxyl and DPPH radicals and hydrogen peroxide, enhancement of the activities of antioxidant enzymes in sera, liver, and heart of mice		Zhang et al. (2016)

Table 7 continued

Mushrooms species	Bioactive compound or extract	Activity and mechanisms		References
	Proteoglycan	Antitumor	Involvement of NK cells and induction ofgene expression of nitric oxide by transcription factor and NF-kappa B downstream signalling, interferon-γ and interleukin, that activate NK cells	Chaturvedi et al. (2018)
Boletus edulis	Polysaccharide (BEP)	Immunomodulatory	Reduction of tumor mass in Renca tumor bearing mice; stimulation of splenocytes proliferation, increase in NK cell and CTL activities in spleen	Wang et al. (2014a)
	Polysaccharides	Antioxidant activity		Zhang et al. (2018)
	Lectin	Hemagglutinating activity;		Zheng et al. (2007)
		Mitogenic activity in mouse splenocytes;		
		Antiviral	Inhibition of human immunodeficiency virus-1 reverse transcriptase	
	Phenolics	Antioxidative	Inhibition of lipid oxidation	Ma et al. (2018)
	Prepared for consumption mushrooms	Antioxidative	High antioxidant activity against ABTS, DPPH and in FRAP assay	Jaworska et al. (2015)
	Ethanolic and hot water extracts	Antioxidative		Tsai et al. (2007)
	Polysaccharide (BPS)	Antidiabetic	Inhibition of oxidative stress and inflammation in rats liver	Xiao et al. (2019)
Coprinus comatus	Ethyl acetate extract	Antitumor	Activity against ovarian cancer cell lines SKOV-3 and SW-626 and reduced viability of human ovarian cancer cells; Apoptosis induction in ovarian cancer cells (ES-2) via both extrinsic and intrinsic pathways	Venturella et al. (2019)
	Aqueous suspension	Antioxidative	increase of antioxidative status of liver homogenate and prevention of histological changes in liver cross sections in oxidative stressed rats	Popović et al. (2010)
	Fruiting body extract	Antiaggregant	Inhibition of platelet aggregation induced by ADP via a P2Y12 receptor	Poniedziałek et al. (2019)
	Ethanolic and water extract	Antioxidant and scavenging property		Li et al. (2010)
	Laccase	Antiviral	Inhibition of human immunodeficiency virus type 1 (HIV-1) reverse transcriptase	Ma et al. (2018)
		Antitumor	Suppression of proliferation of tumor cell lines HepG2 and MCF7	Ma et al. (2018)
	γ-aminobutyric acid (GABA)	Hypotensive		Tsai et al. (2007)
Cyclocybe aegerita	Polysaccharides	Anti-ageing	Increased cell viability and β-Gal viability, prevention of G1-phase cell-cycle arrest, decreased mitochondrial membrane potential	Liu et al. (2020c)
		Antidiabetic	Inhibition of iNOS expression, reduction of blood glucose level	Liu et al. (2020c)

Table 7 continued

Mushrooms species	Bioactive compound or extract	Activity and mechanisms		References
	Water extract	Anti-angiogenic	In vitro inhibition of vascular endothelial growth factor (VEGF)-induced proliferation inHUVECs; down-regulation of intracellular reactive oxygen species (ROS) level and VEGF secretion in Caco-2 cells; decrease in the migration of endothelial cells (ECs)	Lin et al. (2017)
	Proteins	Antitumor	Against different tumor cell lines; stimulation of immune response; enhanced splenocyte cytotoxic activity and mRNA level of cytokines in mice	Liang et al. (2011)
	Ageritin (ribotoxin-like protein)	Antitumor	Cytotoxicity and cell death promoting effects towards CNS model cell lines (SK-N-BE(2)-C, U-251 and C6); extrinsic apoptotic pathway by initially activating caspase-8	Landi et al. (2017b) and Ruggiero et al. (2018)
	Galectin (AAL)	Antitumor	Anti-metastasis activity in breast cancer, anti-proliferation activity against 4T1 cells	Yang et al. (2018)
	Ceramide	Antitumor	Inhibition of the proliferation of stomach, breast and CNS cancer cell lines in vitro	Diyabalanage et al. (2008)
		Anti-inflammatory	Inhibition on cyclooxygenase enzymes COX-1 and -2	
	Hot-water and ethanolic extracts	Antioxidative		Tsai et al. (2006, 2007)
	Methanolic extract (FAF)	Antioxidative and cyclooxygenase (COX) enzyme inhibitory activity		Zhang et al. (2003)
Lactarius deliciosus	Methanolic extract	Antioxidant and free radical scavenging activity		Kosanić et al. (2016)
		Antimicrobial	Inhibition of bacteria (*Bacillus cereus, B. subtilis, Proteus mirabilis, E. coli, Staphylococcus aureus*) and fungi (*Aspergillus niger, Penicillium expansum, P. chrysogenum, Alternaria alternata, Trichoderma viride, Cladosporium cladosporioides, Mucor mucedo, Fusarium oxysporum, Candida albicans*)	
		Anticancer	Growth inhibition in HeLa, A549 and LS174 cell lines	
	Aqueous and/or ethanol extract	Antioxidative		Xu et al. (2019)
		Antihyperglycemic	Inhibitory effects on α-amylase and α-glucosidase	
Macrolepiota procera	Methanolic extract	Antioxidant and free radical scavenging activity;		Kosanić et al. (2016)
		Antimicrobial	Inhibition of bacteria (*Bacillus cereus, B. subtilis, Proteus mirabilis*) and fungi (*Aspergillus niger, Penicillium expansum, Alternaria alternata, Trichoderma viride, Cladosporium cladosporioides, Fusarium oxysporum, Candida albicans*)	
		Anticancer	Growth inhibition in HeLa, A549 and LS174 cell lines	

Table 7 continued

Mushrooms species	Bioactive compound or extract	Activity and mechanisms		References
	Mushroom extract	Antioxidant activity		Islam et al. (2019)
	Powder of freeze, dried and irradiated mushrooms	Antioxidant activity		Fernandes et al. (2013)
Russula virescens	Polysaccharide (RVP)	Antioxidant activity		Sun et al. (2010a, b)
	Phenolics			
Russula cyanoxantha	Phenolics	Antioxidant activity		
Tuber magnatum	Water and/or methanol extract	Anti-inflammatory	Inhibition of COX-1 and 12-LOX pathway products synthesis	Beara et al. (2014)
		Antitumor	Cytotoxicity against some tumour cell lines (HeLa, MCF7, HT-29)	
		Antioxidative		
Tuber melanosporum	Polysaccharides	Antitumor	Activities against A549, HCT-116, HepG2, HL-60, and SK-BR-3 cells lines	Lee et al. (2020) and Patel et al. (2017)
	Anandamide (endocannabinoid)	Antitumor	Inhibited on angiogenesis of highly invasive and metastatic breast cancer cells; Stimulation of non-apoptotic cell death in COX-2 overexpressed colorectal cancer cells	Lee et al. (2020) and Patel et al. (2017)
	Methanolic extract	Antioxidative	Inhibition of lipid oxidation	Villares et al. (2012)
Tuber spp.	Flavonoids	Antioxidative, anti-inflammatory, anti-mutagenic, and anticancer		Lee et al. (2020)
	Ergosterol	Antioxidant, anti-inflammatory, and antihyperlipidemic		Lee et al. (2020)
	Oleic acid	Antitumor	Suppression of overexpression of HER2; induction of cancer cell apoptosis	Lee et al. (2020)
		Hypocholesterolemic		
	L-tyrosine	Anti-depressant		Patel et al. (2017)

Although knowledge about the therapeutic properties of mushrooms is now quite extensive, their incorporation into foods to produce fortified foods is not so widespread today. However, various research has been undertaken in recent years in this direction, demonstrating how the addition of extracts or compounds of medicinal mushrooms, such as *Pleurotus* spp., into processed food, increases their sensory, nutritional, functional, or nutraceutical features (Carrasco-Gonza´lez et al. 2017; Reis et al. 2017; Lavelli et al. 2018; Salehi 2019).

The potential of mushroom powder to enrich baked (bread, biscuits, and cakes) and extruded (breakfast cereals, snacks) cereal products with fiber for the production of fitness-promoting foods (low in calories, cholesterol, and fat) is remarkable. Gaglio et al. (2019) evaluated the effect of partially replacing wheat flour with *P. eryngii* powder (5 and 10% w/w) in baked bread; the fermentation process has not undergone any alterations, the final product had positive physical and organoleptic characteristics with the advantage of having higher concentrations of thiamin, riboflavin and pantothenic acid and, more importantly, supplied biotin, cobalamin, and cholecalciferol generally absent in wheat bread.

Another study on *P. eryngii* (Kim et al. 2010) demonstrated how biscuits supplemented with mushroom powder showed significantly increased total phenol compound content, ferric reducing antioxidant power (FRAP), and DPPH radical scavenging activity, maintaining appreciable organoleptic and rheological properties. Also, *A. bisporus* powder was evaluated by Kumar and Barmanray (2007) as a supplement for fortified biscuits, that showed a significantly higher protein content with good overall acceptability. *P. eryngii* β-glucan-rich fractions (BGRFs) have been tested as an ingredient of wheat semolina pasta (Kim et al. 2016), obtaining the best results in terms of qualitative, textural, and sensory characteristics with a concentration of 4%, in addition to higher beneficial properties.

Studies carried out by Lu et al. (2016, 2018) have shown that the inclusion of powdered *A. bisporus* and *B. edulis* mushrooms in wheat semolina allows to obtain a pasta with more fibre and less starch, therefore with a lower glycemic power and higher antioxidant properties. Equally positive results have been achieved in snack products supplemented with *A. bisporus* and *B. edulis* powder (Singla et al. 2009; Lu et al. 2020).

Mushrooms have also been tested to enrich other types of foods. Exploiting the high fiber and protein content, *A. bisporus* powder has been used for the production of functional meat products with better emulsion characteristics and textural properties (Kurt and Genc¸celep 2018).

Barros et al. (2011) demonstrated that *B. edulis* extracts protect beef burgers from lipid peroxidation and also give them greater antioxidant potential, while a study by Stojkovic´ et al. (2015) revealed that the methanolic extract of *B. aureus* Schaeff. helps to increase the shelf-life of meat, protecting it from food contaminating bacteria. An interesting application of *Pleurotus* spp. concerns fortified dairy foods. A study carried out by Pelaes Vital et al. (2015) showed how adding *P. ostreatus* aqueous extract to milk leads to the production of yogurt with an increased *Streptococcus thermophiles* and *Lactobacillus bulgaricus* CFU, polyphenols content, and enhanced antioxidant activity, and improved rheological properties.

Soy milk added with polysaccharide extract of *P. eryngii* shows an increased vitality of *Bifidobacterium longum* and reduced pH during yogurt fermentation (Li and Shah 2016). The incorporation of *P. ostreatus* in the cheese mixture as a fresh and dried mushroom has resulted in cream cheese with higher ash, protein, and mineral contents, as well as an increase in lipolytic and proteolytic bacteria and excellent storage performances (Khider et al. 2017). The incorporation of *C. aegerita* powder has also proven to increase the antioxidant properties of cream cheese, as well as giving it more appreciated sensory characteristics (Petrovic´ et al. 2015). The extract of *A. bisporus* has proved effective in preserving yogurt from the pathogen *Listeria monocytogenes* (Stojkovic´ et al. 2014). Moreover, a study conducted by Proserpio et al. (2019) involved the addition of *P. ostreatus* powder in vegetable soups, resulting in a product with a higher content of bioactive ß-glucans and good palatability at a concentration of 2%.

Although the results obtained so far are remarkably promising, much remains to be done; in addition to enlarging the fans of mushroom species potentially valuable as food fortifiers, further study is needed on various parameters such as the bioaccessibility of bioactive compounds, especially considering the different production steps that a processed product undergoes, their bioavailability, possible interactions with the food matrix and possible interferences with the bioavailability or absorption of the various nutrients. This path is even necessary so that their relevance and effectiveness can be recognized and thus ruled also from a legislative point of view, in order to achieve the important objective of large-scale marketing of healthy food products that promote physical well-being.

Conclusions

The review reveals the great potential of mushrooms in the production of mycochemicals that represent a rich source of drugs, nutraceutical, and functional food. The mycochemicals isolated and identified from mushrooms are bioactive compounds belonging to different chemical classes.

The present study describes the chemical composition of Italian wild and cultivated mushrooms as a source of bioactive metabolites for further development of drugs.

The application of mushrooms for health purposes is recent in the Western areas but still slowly growing. In European markets, nutraceuticals are not yet a widespread and established product and, in most cases, imported from Asia. Due to the vacant and imprecise regulations, we often have to deal with nutraceuticals of dubious composition and without guaranteed quality standards. Most Western countries, moreover, follow the rules of the WHO, DSHEA (Dietary Supplement Health and Education Act), and EFSA (European Food Safety Agency) in which plant or MM extracts are dietary supplements. So clinical studies are not required before their introduction in the market. These markets, therefore, have enormous potential for development, which can only be achieved through intensive research and the spreading of knowledge to educate and raise awareness in this respect among consumers and society because very few people are still aware of the benefits and importance of MMs.

The research on medicinal mushrooms in Italy needs to undertake more extensive studies to ascertain the medicinal properties of the mushroom species.

The final objective of the newborn Italian Medicinal Mushrooms Society is to improve the quality of life and the state of health of people, also in the vision of an increasingly integrated medicine. The animal farming sector could also benefit from the inclusion of mushrooms, MMs supplements, or fortified feed in the animal diet, as well as, for example, from the possibility of using alternative and natural antibiotics and antivirals.

Besides, mushrooms represent an economic crop that fits with the circular economy and the recycling of agro-industrial wastes. Finally, mushrooms are also able to provide nutritional support in areas with malnutrition and economically depressed areas.

(End)

References

Alshammaa DAS (2017) Phytochemical investigation and quantitative comparison of Ergosterol between *Agaricus bisporus* and *Pleurotus ostreatus* by HPLC and GC-MS methods. Int J Pharm Sci Rev Res 44(2):215–220

Anandhi R, Annadurai T, Anitha TS et al (2013) Antihypercholesterolemic and antioxidative effects of an extract of the oyster mushroom, *Pleurotus ostreatus*, and its major constituent, chrysin, in Triton WR-1339-induced hypercholesterolemic rats. J Physiol Biochem 69:313–323. https://doi.org/10.1007/s13105-012-0215-6

Antunes F, Marc¸al S, Taofiq O et al (2020) Valorization of mushroom by-products as a source of value-added compounds and potential applications. Molecules 25:2672. https://doi.org/10.3390/molecules25112672

Aprea E, Romano A, Betta E et al (2015) Volatile compound changes during shelf life of dried *Boletus edulis*: comparison between SPME-GC-MS and PTR-ToF-MS analysis. J Mass Spectrom 50:56–64. https://doi.org/10.1002/jms. 3469

Arbaayah HH, Umi KY (2013) Antioxidant properties in the oyster mushrooms (*Pleurotus* spp.) and split gill mushroom (*Schizophyllum commune*) ethanolic extracts. Mycosphere 4:661–673

Atila F, Owaid MN, Shariati MA (2017) The nutritional and medical benefits of *Agaricus bisporus*: a review. J Microbiol Biotech Food Sci 7(3):281–286. https://doi.org/10. 15414/jmbfs.2017/18.7.3.281-286

Ayaz FA, Torun H, O¨ zel A et al (2011) Nutritional value of some wild edible mushrooms from the Black Sea region (Turkey). Turk J Biochem 36(4):385–393

Barros LL, Cruz T, Baptista P et al (2008) Wild and commercial mushrooms as source of nutrients and nutraceuticals. Food Chem Toxicol 46:2742–2747. https://doi.org/10.1016/j.fct. 2008.04.030

Barros L, Barreira J, Grangeia C et al (2011) Beef burger patties incorporated with *Boletus edulis* extracts: lipid peroxidation inhibition effects. Eur J Lipid Sci Technol 113(6):737–743. https://doi.org/10.1002/ejlt.201000478

Beara IN, Lesjak MM, Cˇ etojevic´-Simin DD et al (2014) Phenolic profile, antioxidant, anti-inflammatory and cytotoxic activities of black (*Tuber aestivum* Vittad.) and white (*Tuber magnatum* Pico) truffles. Food Chem 165:460–466. https://doi.org/10.1016/j.foodchem.2014.05.116

Bederska-Łojewska D, S´ wia˛tkiewicz S, Muszyn´ ska B (2017) The use of Basidiomycota mushrooms in poultry nutrition—a review. Anim Feed Sci Technol 230:59–69. https:// doi.org/10.1016/j.anifeedsci.2017.06.001

Bellesia F, Pinetti A, Bianchi A et al (1988) The volatile organic compounds of black truffle (*Tuber melanosporum* Vitt.) from middle Italy. Flavour Frag J 13:56–58. https://doi.org/ 10.1002/(sici)1099-1026(199801/02)13:1%3c56::aid-ffj692%3e3.0.co;2-x

Bellesia F, Pinetti A, Tirillini B et al (2001) Temperature-dependent evolution of volatile organic compounds in *Tuber borchii* from Italy. Flavour Frag J 16:1–6. https://doi.org/ 10.1002/1099-1026(200101/02)16:1%3c1::aid-ffj936%3e3.0.co;2-y

Biscaia SMP, Carbonero ER, Bellan DL et al (2017) Safe therapeutics of murine melanoma model using a novel antineoplasic, the partially methylated mannogalactan from *Pleurotus eryngii*. Carbohydr Polym 178:95–104. https://doi.org/10.1016/j.carbpol.2017.08.117

Bobovcˇa´k M, Kuniakova´ R, Gabrizˇ J et al (2010) Effect of Pleuran (β-glucan from *Pleurotus ostreatus*) supplementation on cellular immune response after intensive exercise in elite athletes. Appl Physiol Nutr Metab 35(6):755–762. https://doi.org/10.1139/h10-070

Bonanno A, Di Grigoli A, Vitale F et al (2019) Effects of diets supplemented with medicinal mushroom myceliated grains on some production, health, and oxidation traits of dairy ewes. Int J Med Mushrooms 21(1):89–103. https://doi.org/ 10.1615/IntJMedMushrooms.2018029327

Bose S, Mandal SK, Hossain P et al (2019) Phytochemical and pharmacological potentials of *Agaricus bisporus*. Res J Pharm Technol 12(8):3811–3817. https://doi.org/10.5958/ 0974-360x.2019.00653.x

Bovi M, Cenci L, Perduca M et al (2013) BEL b-trefoil: a novel lectin with antineoplastic properties in King bolete (*Boletus edulis*) mushrooms. Glycobiology 23(5):578–592. https://doi.org/10.1093/glycob/cws164

Bulam S, U¨ stu¨n NS, Peks¸en A (2019) Evaluation of nutritional and medicinal values of edible wild and cultivated *Pleurotus ostreatus*. Turk J Agric Food Sci Technol 7(12):2054–2061. https://doi.org/10.24925/turjaf.v7i12. 2054-2061.2730

Butkhup L, Samappito W, Jorjong S (2018) Evaluation of bioactivities and phenolic contents of wild edible mushrooms from northeastern Thailand. Food Sci Biotechnol 27(1):193–202. https://doi.org/10.1007/s10068-017-0237-5

C¸ agˇlarirmak N (2011) Edible mushrooms: an alternative food item. In: Savoie JM, Foulongne-Oriol M, Largeteau M, Barroso G (eds) ICMBMP 2011. Proceedings of the 7th international conference on mushroom biology and mushroom products; October 4–7; Arcachon, France, pp 548–554

Carrasco-Gonza´lez JA, Serna-Sald´ıvar SO, Gut´ıerrez-Uribe JA (2017) Nutritional composition and nutraceutical properties of the *Pleurotus* fruiting bodies: potential use as food ingredient. J Food Compost Anal 58:69–81. https://doi.org/ 10.1016/j.jfca.2017.01.016

Cateni F, Zacchigna M, Caruso Bavisotto C et al (2018) Structural characterization of polysaccharides of a productive strain of the culinary-medicinal king oyster mushroom, *Pleurotus eryngii* (Agaricomycetes), from Italy. Int J Med Mushrooms 20(8):717–726. https://doi.org/ 10.1615/intjmedmushrooms.2018027011

Cateni F, Zacchigna M, Procida G et al (2020) Polysaccharides from *Pleurotus eryngii* var. *elaeoselini* (Agaricomycetes), a new potential culinary-medicinal oyster mushroom from Italy. Int J Med Mushrooms 22(5):431–444. https://doi.org/

10.1615/intjmedmushrooms.2020034539

Cayan F, Deveci E, Tel-Cayan G et al (2018) Phenolic acid profile of six wild mushroom species by HPLC-DAD. Chem Nat Compd 54(5):985–986. https://doi.org/10.1007/ s10600-018-2529-2

Cerigini E, Palma F, Barbieri E et al (2008) The *Tuber borchii* fruiting body-specific protein TBF-1, a novel lectin which interacts with associated *Rhizobium* species. FEMS Microbiol Lett 284:197–203. https://doi.org/10.1111/j. 1574-6968.2008.01197.x

Chaturvedi VK, Agarwal S, Gupta KK et al (2018) Medicinal mushroom: boon for therapeutic applications. 3 Biotech 8(8):334. https://doi.org/10.1007/s13205-018-1358-0

Chen SY, Ho KJ, Hsieh YJ et al (2012) Contents of lovastatin, caminobutyric acid and ergothioneine in mushroom fruiting bodies and mycelia. LWT Food Sci Technol 47:274–278. https://doi.org/10.1177/1934578x1100600207

Chen HP, Zhao ZZ, Li ZH et al (2018) Anti-proliferative and anti-inflammatory lanostane triterpenoids from the polish edible mushroom *Macrolepiota procera*. J Agric Food Chem 66:3146–3154. https://doi.org/10.1021/acs.jafc. 8b00287.s002

Cheung PCK (2013) Mini-review on edible mushrooms as source of dietary fiber: preparation and health benefits. Food Sci Hum Wellness 2:162–166. https://doi.org/10. 1016/j.fshw.2013.08.001

Citores L, Ragucci S, Ferreras JM et al (2019) Ageritin, a ribotoxin from popular mushroom (*Agrocybe aegerita*) with defensive and antiproliferative activities. ACS Chem Biol 14(6):1319–1327. https://doi.org/10.1021/ acschembio.9b00291.s001

Correˆa RCG, Brugnari T, Bracht A et al (2016) Biotechnological, nutritional and therapeutic uses of *Pleurotus* spp. (Oyster mushroom) related with its chemical composition: a review on the past decade findings. Trends Food Sci Tech 50(4):103–117. https://doi.org/10.1016/j.tifs.2016.01.012

Costa R, Tedone L, De Grazia S et al (2013) Multiple headspace-solid-phase microextraction: an application to quantification of mushroom volatiles. Anal Chim Acta 770:1–6. https://doi.org/10.1016/j.aca.2013.01.041

Costa R, De Grazia S, Grasso E et al (2015) Headspace-solid- phase microextraction-gas chromatography as analytical methodology for the determination of volatiles in wild mushrooms and evaluation of modifications occurring during storage. J Anal Methods Chem 2015:Article ID 951748, 10 pp. https://doi.org/10.1155/2015/951748

D'Auria M, Rana GL, Racioppi R et al (2012) Studies on volatile organic compounds of *Tuber borchii* and *Tuber asa-foetida*. J Chromatogr Sci 50:775–778. https://doi.org/ 10.1093/chromsci/bms060

De Felice S (1989) The nutraceutical revolution: fueling a powerful. New International Market

Dewick PM (2009) Medicinal natural products: a biosynthetic approach, 3rd edn. Wiley, Chichester. https://doi.org/10. 1021/jm901204h

Ding Z, Lu Y, Lu Z et al (2010) Hypoglycaemic effect of comatin, an antidiabetic substance separated from *Coprinus comatus* broth, on alloxan-induced-diabetic rats. Food Chem 121:39–43. https://doi.org/10.1016/j.foodchem. 2009.12.001

Ding X, Hou Y, Hou W et al (2015) Structure elucidation and anti-tumor activities of water-soluble oligosaccharides from *Lactarius deliciosus* (L. ex Fr.) Gray. Pharmacogn Mag 11(44):716–723. https://doi.org/10.4103/0973-1296. 165559

Diyabalanage T, Mulabagal V, Mills G et al (2008) Health- beneficial qualities of the edible mushroom, *Agrocybe aegerita*. Food Chem 108:97–102. https://doi.org/10.1016/ j.foodchem.2007.10.049

Dulay RMR, Sanguesa KB, Ablaza JLT et al (2015) Bioactive myco-nutrients of aseptically cultured fruiting bodies of Coprinus comatus (O.F. Mu¨ll.) Pers. on rice bran-enriched ruminants' dung. IJBPAS 4(4):1896–1908

Ergo¨nu¨l PG, Ergo¨nu¨l B, Kalyoncu F et al (2012) Fatty acid compositions of five wild edible mushroom species collected from Turkey. Int J Pharmacol 8(5):463–466. https:// doi.org/10.3923/ijp.2012.463.466

Erjavec J, Kos J, Ravnikar M et al (2012) Proteins of higher fungi—from forest to application. Trends Biotechnol 30:259–273. https://doi.org/10.1016/j.tibtech.2012.01.004 Feeney MJ, Miller AM, Roupas P (2014) Mushrooms—biologically distinct and nutritionally unique. Nutr Today 49:301–307. https://doi.org/10.1097/nt. 0000000000000063

Feng T, Li ZH, Dong ZJ et al (2011) Non-isoprenoid botryane sesquiterpenoids from basidiomycete *Boletus edulis* and their cytotoxic activity. Nat Prod Bioprospect 1:29–32. https://doi.org/10.1007/s13659-011-0005-9

Fernandes A, Barros L, Barreira JCM et al (2013) Effects of different processing technologies on chemical and antioxidant parameters of *Macrolepiota procera* wild mushroom. LWT Food Sci Technol 54:493–499. https://doi.org/10.1016/j.lwt.2013.06.027

Fernandes A, Barreira JCM, Antonio AL et al (2015) Exquisite wild mushrooms as a source of dietary fiber: analysis in electron-beam irradiated samples. LWT -Food Sci Technol 60:855–859. https://doi.org/10.1016/j.lwt.2014.10.050

Ferreira ICFR, Barros LL, Abreu RMV (2009) Antioxidants in wild mushrooms. Curr Med Chem 16:1543–1560. https://doi.org/10.2174/092986709787909587

Fleming A (1929) On the antibacterial action of cultures of a *Penicillium*, with special reference to their use in the isolation of *B*. *influenzae*. Br J Exp Pathol 10:226–236. https:// doi.org/10.1093/clinids/2.1.129

Fogarasi M, Socaci SA, Dulf FV et al (2018) Bioactive compounds and Volatile Profiles of Five Transylvanian Wild Edible Mushrooms. Molecules 23:3272–3286. https://doi. org/10.3390/molecules23123272

Fontana S, Flugy A, Schillaci O et al (2014) *In vitro* antitumor effects of the cold-water extracts of Mediterranean species of genus *Pleurotus* (Higher Basidiomycetes) on human colon cancer cells. Int J Med Mushrooms 16(1):49–63. https://doi.org/10.1615/intjmedmushr.v16.i1.50

Fu Z, Liu Y, Zhang Q (2016) A potent pharmacological mushroom: *Pleurotus eryngii*. Fungal Genom Biol 6(1):1000139. https://doi.org/10.4172/2165-8056. 1000139

Gaglio R, Guarcello R, Venturella G et al (2019) Microbiological, chemical and sensory aspects of bread supplemented with different percentages of the culinary mushroom *Pleurotus eryngii* in powder form. Int J Food Sci Technol 54:1197–1205. https://doi.org/10.1111/ijfs. 13997

Gallotti F, Lavelli R (2020) The effect of UV irradiation on vitamin D2 content and antioxidant and antiglycation activities of mushrooms. Foods 9:1087. https://doi.org/10. 3390/foods9081087

Gargano ML, van Griensven LJL, Isikhuemhen OS et al (2017) Medicinal mushrooms: valuable biological resources of high exploitation potential. Plant Biosyst 151(3):548–565. https://doi.org/10.1080/11263504.2017.1301590

Gasecka M, Mleczek M, Siwulski M et al (2016) Phenolic and flavonoid content in *Hericium Erinaceus*, *Ganoderma Lucidum* and *Agrocybe aegerita* under selenium addition. Acta Aliment 45(2):300–308. https://doi.org/10.1556/066.2016.45.2.18

Giavasis I (2014) Bioactive fungal polysaccharides as potential functional ingredients in food and nutraceuticals. Curr Opin Biotechnol 26:162–173. https://doi.org/10.1016/j. copbio.2014.01.010

Gil-Ramirez A, Pavo-Caballero C, Baeza E et al (2016) Mushrooms do not contain flavonoids. J Funct Foods 25:1–13. https://doi.org/10.1016/j.jff.2016.05.005

Golak-Siwulska I, Kaluz_ ewicz A, Spiz_ewski T et al (2018) Bioactive compounds and medicinal properties of Oyster mushrooms (*Pleurotus* sp.). Folia Hort 30(2):191–201. https://doi.org/10.2478/fhort-2018-0012

Grangeia C, Heleno SA, Barros LL et al (2011) Effects of trophism on nutritional and nutraceutical potential of wild edible mushrooms. Food Res Int 44:1029–1035. https:// doi.org/10.1016/j.foodres.2011.03.006

Grothe T, Stadler M, Koepcke B et al (2013) Terpenoids spiro ketal compounds with lxr agonists activity, theiruse and formulation with them. U.S. Pat. Appl. Publ. US 20130338219 A1 20131219

Gru¨ndemann C, Reinhardt JK, Lindequist U (2020) European medicinal mushrooms: do they have potential for modern medicine? An update. Phytomedicine 66:153131. https:// doi.org/10.1016/j.phymed.2019.153131

Harki E, Bouya D, Dargent R (2005) Maturation-associated alterations of the biochemical characteristics of the black truffle *Tuber melanosporum* Vitt. Food Chem 99:394–400 Hasnat MA, Pervin M, Debnath T et al (2014) DNA protection, total phenolics and antioxidant potential of the mushroom *Russula virescens*. J Food Biochem 38:6–17. https://doi.org/10.1111/jfbc.12019

He P, Li F, Huang L et al (2016) Chemical characterization and antioxidant activity of polysaccharide extract from spent mushroom substrate of *Pleurotus eryngii*. J Taiwan Inst Chem Eng 69:48–53. https://doi.org/10.1016/j.jtice.2016.

10.017

Heleno SA, Barros LL, Sousa MJ et al (2011) Targeted metabolites analysis in wild *Boletus* species. LWT Food Sci Technol 2011(44):1343–1348. https://doi.org/10.1016/ j.lwt.2011.01.017

Heleno SA, Ferreira RC, Antonio AL et al (2015) Nutritional value, bioactive compounds and antioxidant properties of three edible mushrooms from Poland. Food Biosci 11:48–55. https://doi.org/10.1016/j.fbio.2015.04.006

Helrich K (1990) Association of Official Analytical Chemists, Official methods of analysis. 15 edn. Arlington, VAHess J, Wang Q, Gould T et al (2018) Impact of *Agaricus bisporus* mushroom consumption on gut health markers inhealthy adults. Nutrients 10:1402. https://doi.org/10.3390/ nu10101402

Hou Y, Liu L, Ding X et al (2016) Structure elucidation, proliferation effect on macrophage and its mechanism of a new heteropolysaccharide from *Lactarius deliciosus* Gray. Carbohydr Polym 152:648–657. https://doi.org/10.1016/j. carbpol.2016.07.064

Hou Y, Wang M, Zhao D et al (2019) Effect on macrophage proliferation of a novel polysaccharide from *Lactarius deliciosus* (L. ex Fr.) Gray. Oncol Lett 17(2):2507–2515. https://doi.org/10.3892/ol.2018.9879

Hu Q, Du H, Ma G et al (2018) Purification, identification and functional characterization of an immunomodulatory protein from *Pleurotus eryngii*. Food Funct 9(7):3764–3775. https://doi.org/10.1039/c8fo00604k

Islam T, Ganesan K, Xu B (2019) New insight into myco- chemical profiles and antioxidant potential of edible and medicinal mushrooms: a review. Int J Med Mushrooms 21(3):237–251. https://doi.org/10.1615/ intjmedmushrooms.2019030079

Ismaya WT, Tjandrawinata RR, Rachmawati H (2020) Lectins from the edible mushroom *Agaricus bisporus* and their therapeutic potentials. Molecules 25:2368. https://doi.org/ 10.3390/molecules25102368

Itonori S, Aoki K, Sugita M (2004) Glycosphingolipids in edible fungi and their biological activities. Foods Food Ingredients J Jpn 209(3):211–218

Jaworska G, Pogon´ K, Skrzypczak A (2015) Composition and antioxidant properties of wild mushrooms *Boletus edulis* and *Xerocomus badius* prepared for consumption. J Food Sci Technol 52(12):7944–7953. https://doi.org/10.1007/ s13197-015-1933-x

Jeon SM, Bok SH, Jang MK et al (2001) Antioxidative activity of naringin and lovastatin in high cholesterol-fed rabbits. Life Sci 69(24):2855–2866. https://doi.org/10.1016/s0024- 3205(01)01363-7

Jiang X, Teng S, Wang X et al (2018) The antidiabetic and antinephritic activities of *Tuber melanosporum* via modulation of Nrf2-mediated oxidative stress in the db/db mouse. Oxid Med Cell Longev 2018:7453865. https://doi. org/10.1155/2018/7453865

Jing N, Shi J, Li G et al (2012) Determination of fatty acids from mushrooms using high performance liquid chromatography with fluorescence detection and online mass spectrometry. Food Res Int 48:155–163. https://doi.org/10. 1016/j.foodres.2012.02.014

Jing H, Li J, Zhang J et al (2018) The antioxidative and anti- aging effects of acidic- and alkali-extractable mycelium polysaccharides by *Agrocybe aegerita* (Brig.) Sing. Int J Biol Macromol 106:1270–1278. https://doi.org/10.1016/j. ijbiomac.2017.08.138

Kakon AJ, Choudhury MBK, Shusmita S (2012) Mushroom is an ideal food supplement. J Dhaka Natl Med Coll Hos 18:58–62. https://doi.org/10.3329/jdnmch.v18i1.12243

Kalacˇ P (2009) Chemical composition and nutritional value of European species of wild growing mushrooms: a review. Food Chem 113:9–16. https://doi.org/10.1016/j.foodchem. 2008.07.077

Kalacˇ P (2012) A review of chemical composition and nutritional value of wild-growing and cultivated mushrooms. J Sci Food Agric 93:209–218. https://doi.org/10.1016/j. foodchem.2008.07.077

Kalaras MD, Richie JP, Calcagnotto A (2017) Mushrooms: a rich source of the antioxidants ergothioneine and glutathione. Food Chem 233:429–433. https://doi.org/10. 1016/j.foodchem.2017.04.109

Kalogeropoulos N, Yanni AE, Koutrotsios G et al (2013) Bioactive microconstituents and antioxidant properties of wild edible mushrooms from the island of Lesvos, Greece. Food Chem Toxicol 55:378–385. https://doi.org/10.1016/j.

fct.2013.01.010

Khatun S, Islam A, Cakicioglu U (2015) Nutritional qualities and antioxidant activity of three edible oyster mushrooms (*Pleurotus* spp.). NJAS-Wagen J Life Sc 72–73:1–5. https://doi.org/10.1016/j.njas.2012.03.003

Khaund P, Joshi SR (2014) Enzymatic profiling of wild edible mushrooms consumed by the ethnic tribes of India. J Korean Soc Appl Biol Chem 57(2):263–271. https://doi. org/10.1007/s13765-013-4225-z

Khider M, Seoudi O, Abdelaliem YF (2017) Functional processed cheese spreads with high nutritional value as supplemented with fresh and dried mushrooms. Int J Food Sci Nutr 6(1):2327–2716. https://doi.org/10.11648/j.ijnfs. 20170601.18

Kikuchi T, Motoyashiki N, Yamada T et al (2017) Ergostanetype sterols from King Trumpet Mushroom (*Pleurotus eryngii*) and their inhibitory effects on Aromatase. Int J Mol Sci 18:2479–2489. https://doi.org/10.3390/ ijms18112479

Kikuchi T, Kitaura K, Katsumoto A et al (2018) Three bisabolane-type sesquiterpenes from edible mushroom *Pleurotus eryngii*. Fitoterapia 129:108–113. https://doi.org/10. 1016/j.fitote.2018.06.021

Kikuchi T, Isobe M, Uno S et al (2019) Strophasterols E and F: rearranged ergostane-type sterols from *Pleurotus eryngii*. Bioorg Chem 89:103011. https://doi.org/10.1016/j.bioorg. 2019.103011

Kim YJ, Jung IK, Kwak EJ (2010) Quality characteristics and antioxidant activities of cookies added with *Pleurotus eryngii* powder. Korean J Food Sci Technol 42(2):183–189

Kim SH, Lee J, Heo Y et al (2016) Effect of Pleurotus *eryngii* mushroom β-glucan on quality characteristics of common wheat pasta. J Food Sci 81(4):C835–C840

Kivrak I, Kivrak S, Harmandar M (2014) Free amino acid profiling in the giant puffball mushroom (*Calvatia gigantea*) using UPLC–MS/MS. Food Chem 158:88–92. https:// doi.org/10.1016/j.foodchem.2014.02.108

Kosanic´ M, Rankovic´ B, Rancˇic´ A et al (2016) Evaluation of metal concentration and antioxidant, antimicrobial, and anticancer potentials of two edible mushrooms *Lactarius deliciosus* and *Macrolepiota procera*. J Food Drug Anal 24:477–484. https://doi.org/10.1016/j.jfda.2016.01.008

Koutrotsios G, Kalogeropoulos N, Stathopoulos P et al (2017) Bioactive compounds and antioxidant activity exhibit high intraspecific variability in *Pleurotus ostreatus* mushrooms and correlate well with cultivation performance parameters. World J Microbiol Biotechnol 33:98. https://doi.org/ 10.1007/s11274-017-2262-1

Kozarski MS, Klaus AS, Niksic MP et al (2014) Polysaccharides of higher fungi: biological role, structure and antioxidativeactivity. Chem Ind 68:305–320. https://doi.org/10.2298/ hemind121114056k

Kumar K (2015) Role of edible mushrooms as functional foods—a review. South Asian J Food Technol Environ 1(3–4):211–218

Kumar K, Barmanray A (2007) Nutritional evaluation and storage studies of button mushroom powder fortified biscuits. Mushroom Res 16(1):31–35

Kumar S, Pandey AK (2013) Chemistry and biological activities of flavonoids: an overview. Sci World J, Article ID 162750. https://doi.org/https://doi.org/10.1155/2013/162750

Kurt A, Genc¸celep H (2018) Enrichment of meat emulsion with mushroom (*Agaricus bisporus*) powder: impact on rheological and structural characteristics. J Food Eng 237:128–136. https://doi.org/10.1016/j.jfoodeng.2018.05. 028

La Guardia M, Venturella G, Venturella F (2005) On the chemical composition and nutritional value of *Pleurotus* taxa growing on umbelliferous plants (Apiaceae). J Agric Food Chem 53:5997–6002. https://doi.org/10.1021/ jf0307696

Landi N, Pacifico S, Ragucci S et al (2017a) Pioppino mushroom in southern Italy: an undervalued source of nutrients and bioactive compounds. J Sci Food Agric 97:5388–5397. https://doi.org/10.1002/jsfa.8428

Landi N, Pacifico S, Ragucci S et al (2017b) Purification, characterization and cytotoxicity assessment of Ageritin: the first ribotoxin from the basidiomycete mushroom *Agrocybe aegerita*. Biochim Biophys Acta 1861:1113–1121. https://doi.org/10.1016/j.bbagen.2017. 02.023

Lavelli V, Proserpio C, Gallotti F et al (2018) Circular reuse of bio-resources: the role of *Pleurotus* spp. in the development of functional foods. Food Funct 9:1353–1372. https:// doi.org/10.1039/c7fo01747b

Leal AR, Barros LL, Barreira JCM et al (2013) Portuguese wild mushrooms at the ‘‘pharma–nutrition’’ interface: Nutritional characterization and antioxidant properties. Food Res Int 50:1–9. https://doi.org/10.1016/j.foodres.2012.10.012

Lee SR, Lee D, Lee HJ et al (2017) Renoprotective chemical constituents from an edible mushroom, *Pleurotus cornucopiae* in cisplatin-induced nephrotoxicity. Bioorg Chem 71:67–73. https://doi.org/10.1016/j.bioorg.2017.01.012

Lee H, Nam K, Zahra Z, Farooqui MQU (2020) Potentials of truffles in nutritional and medicinal applications: a review. Fungal Biol Biotechnol 7:9. https://doi.org/10.1186/ s40694-020-00097-x

Li S, Shah NP (2016) Characterization, antioxidative and bifidogenic effects of polysaccharides from *Pleurotus eryngii* after heat treatments. Food Chem 197:240–249. https://doi. org/10.1016/j.foodchem.2015.10.113

Li B, Lu F, Suo X et al (2010) Antioxidant properties of cap and stipe from *Coprinus comatus*. Molecules 15:1473–1486. https://doi.org/10.3390/molecules15031473

Li HJ, Chen HY, Fan LL et al (2015) *In vitro* antioxidant activities and in vivo anti-hypoxic activity of the edible mushroom *Agaricus bisporus* (Lange) Sing. Chaidam Mol 20:17775–17788. https://doi.org/10.3390/ molecules201017775

Li X, Zhang X, Ye L et al (2019) LC-MS-Based Metabolomic approach revealed the significantly different metabolic profiles of five commercial truffle species. Front Microbiol 10:2227. https://doi.org/10.3389/fmicb.2019.02227

Li H, Wang X, Xiong Q et al (2020) Sulfated modification, characterization, and potential bioactivities of polysaccharide from the fruiting bodies of *Russula virescens*. Int J Biol Macromol 154:1438–1447. https://doi.org/10.1016/j.ijbiomac.2019.11.025

Liang Y, Chen Y, Liu H et al (2011) The tumor rejection effect of protein components from medicinal fungus. Biomed Prev Nutr 1:245–254. https://doi.org/10.1016/j.bionut. 2011.06.006

Lin S, Ching LT, Lam K et al (2017) Anti-angiogenic effect of water extract from the fruiting body of *Agrocybe aegerita*. LWT Food Sci Technol 75:155–163. https://doi.org/10. 1016/j.lwt.2016.08.044

Liping S, Xuejiao S, Yongliang Z (2016) Preparation, characterization and antiglycation activities of the novel polysaccharides from *Boletus sinicus*. Int J Biol Macromol 92:607–614. https://doi.org/10.1016/j.ijbiomac.2016.07. 014

Liu Y, Zhao Y, Yang Y et al (2013) Structural characteristics and hypoglycemic activity of polysaccharides from *Coprinus comatus*. Bioact Carbohydr Dietary Fibre 2:164–169. https://doi.org/10.1016/j.bcdf.2013.10.001

Liu W, Yu G, Yu W et al (2017) Autophagy inhibits apoptosis induced by *Agrocybe aegerita* lectin in hepatocellular carcinoma. Anti-Cancer Agent ME 17(2):221–229. https:// doi.org/10.2174/1871520616666160404112645

Liu G, Ye J, Li W et al (2020a) Extraction, structural characterization, and immunobiological activity of ABP Ia polysaccharide from *Agaricus bisporus*. Int J Biol Macromol 162:975–984. https://doi.org/10.1016/j.ijbiomac. 2020.06.204

Liu X, Zhang Z, Xu L et al (2020b) Dioscorea saponin transforms the structure of truffle exo-polysaccharide and enhances its antioxidant activity. LWT Food Sci Technol 127:109417. https://doi.org/10.1016/j.lwt.2020.109417

Liu X, Liu D, Chen Y et al (2020c) Physicochemical characterization of a polysaccharide from Agrocybe aegirita and its anti-ageing activity. Carbohydr Polym 236:116056. https://doi.org/10.1016/j.carbpol.2020.116056

Lu X, Brennan MA, Serventi L et al (2016) How the inclusion of mushroom powder can affect the physicochemical characteristics of pasta. Int J Food Sci Technol 51:2433–2439. https://doi.org/10.1111/ijfs.13246

Lu X, Brennan MA, Serventi L et al (2018) Addition of mushroom powder to pasta enhances the antioxidant content and modulates the predictive glycaemic response of pasta. Food Chem 264:199–209. https://doi.org/10.1016/j.foodchem.2018.04.130

Lu X, Brennan MA, Narciso J et al (2020) Correlations between the phenolic and fibre composition of mushrooms and the glycaemic and textural characteristics of mushroom enriched extruded products. LWT Food Sci Technol 118:108730. https://doi.org/10.1016/j.lwt.2019.108730

Luo A, Luo A, Huang J et al (2012) Purification, characterization and antioxidant activities *in vitro* and *in vivo* of the polysaccharides from *Boletus edulis* Bull. Molecules 17:8079–8090. https://doi.org/10.3390/ molecules17078079

Ma G, Yang W, Zhao L et al (2018) A critical review on the health promoting effects of mushrooms nutraceuticals. Food Sci Hum Well 7:125–133. https://doi.org/10.1016/j. fshw.2018.05.002

Manach C, Scalbert A, Morand C et al (2004) Polyphenols: Food sources and bioavailability. Am J Clin Nutr 79:727–747. https://doi.org/10.1093/ajcn/79.5.727

Matei E, Louis JM, Jee JG et al (2011) NMR solution structure of a cyanovirin homolog from wheat head blight fungus. Proteins 79:1538–1549. https://doi.org/10.1002/prot. 22981

Minato K, Ohara A, Mizuno M (2017) A proinflammatory effect of the β-glucan from *Pleurotus cornucopiae* mushroom on macrophage action. Mediat Inflamm 17:8402405/18402405/9. https://doi.org/10.1155/2017/8402405

Mitsou EK, Saxami G, Stamoulou E et al (2020) Effects of rich in B-glucans edible mushrooms on aging gut microbiota characteristics: an *in vitro* study. Molecules 25:2806. https://doi.org/10.3390/molecules25122806

Motoshima RA, da Rosa T, F, da C Mendes L, et al (2018) Inhibition of *Leishmania amazonensis* arginase by fucogalactan isolated from *Agrocybe aegerita* mushroom. Carbohydr Polym 201:532–538. https://doi.org/10.1016/j. carbpol.2018.08.109

Nagy M, Socaci S, Tofana˘ M et al (2017) Chemical composition and bioactive compounds of some wild edible mushrooms. Bull UASVM Food Sci Technol 74(1):1. https://doi.org/10. 15835/buasvmcn-fst:12629

Nowacka N, Nowak R, Drozd M et al (2014) Analysis of phenolic constituents, antiradical and antimicrobial activity of edible mushrooms growing wild in Poland. LWT Food Sci Technol 59:689–694. https://doi.org/10.1016/j.lwt.2014. 05.041

Nowak R, Nowacka-Jechalke N, Juda M et al (2018) The preliminary study of prebiotic potential of Polish wild mushroom polysaccharides: the stimulation effect on *Lactobacillus* strains growth. Eur J Nutr 57:1511–1521. https://doi.org/10.1007/s00394-017-1436-9

Nowakowski P, Naliwajko SK, Markiewicz-Zukowska R et al (2020) The two faces of *Coprinus comatus*—functional properties and potential hazards. Phytother Res. https://doi. org/10.1002/ptr.6741

Nuhu A, Nam YK, Gyun SP et al (2011) Antioxidant, phenolic compounds concentration, xanthine oxidase and tyrosinase inhibitory activities of *Pleurotus cornucopiae*. Aust J Basic Appl Sci 5(3):229–239

Oguri S (2020) *Pleurotus cornucopiae* mycelial lectin (PCL-M): purification and detection of the activity on mycelial surface. Methods Mol Biol 2132:445–2452. https://doi.org/ 10.1007/978-1-0716-0430-4_43

Oloke JK, Adebayo EA (2015) Effectiveness of immunotherapies from oyster mushroom (*Pleurotus* species) in the management of immunocompromised patients. Int J Immunol 3(2–1):8–20. https://doi.org/10.11648/j.iji.s. 2015030201.12

O¨ ztu¨rk M, Duru ME, Kivrak S et al (2011) *In vitro* antioxidant, anticholinesterase and antimicrobial activity studies on three *Agaricus* species with fatty acid compositions and iron contents: a comparative study on the three most edible mushrooms. Food Chem Toxicol 49:1353–1360. https:// doi.org/10.1016/j.fct.2011.03.019

Palacios I, Lozano M, Moro C et al (2011) Antioxidant properties of phenolic compounds occurring in edible mushrooms. Food Chem 128:674–678. https://doi.org/10.1016/ j.foodchem.2011.03.085

Palazzolo E, Gargano ML, Venturella G (2012) The nutritional composition of selected wild edible mushrooms from Sicily (southern Italy). Int J Food Sci Nutr 63(1):79–83. https://doi.org/10.3109/09637486.2011.598850

Papoutsis K, Grasso S, Menon A et al (2020) Recovery of ergosterol and vitamin D2 from mushroom waste—Potential valorization by food and pharmaceutical industries. Trends Food Sci Technol 99:351–366. https://doi.org/10. 1016/j.tifs.2020.03.005

Parmar R, Kumar D (2015) Study of chemical composition in wild edible mushroom *Pleurotus cornucopiae* (Paulet) from Himachal Pradesh, India by using Fourier transforms infrared spectrometry (FTIR), Gas chromatography-mass spectrometry (GCMS) and X-ray fluorescence (XRF). Biol Forum 7(2):1057–1066

Patel Y, Naraian R, Singh VK (2012) Medicinal properties of *Pleurotus* species (Oyster mushroom): a review. World J Fungal Plant Biol 3(1):1–12

Patel S, Rauf A, Khan H et al (2017) Potential health benefits of natural products derived from truffles: a review. Trends

Food Sci Technol 70:1–8. https://doi.org/10.1016/j.tifs. 2017.09.009

Peintner U, Schwarz S, Mesic A et al (2013) Mycophilic or mycophobic? Legislation and guidelines on wild mushroom commerce reveal different consumption behaviour in European countries. PLoS ONE 8(15):e63926. https://doi.org/10.1371/journal.pone.0063926

Pelaes Vital AC, Goto PA, Hanai LN et al (2015) Microbiological, functional and rheological properties of low fat yogurt supplemented with *Pleurotus ostreatus* aqueous extract. LWT Food Sci Technol 64:1028–1035. https://doi.org/10.1016/j.lwt.2015.07.003

Petrovic´ J, Glamocˇlija J, Stojkovic´ D et al (2015) Nutritional value, chemical composition, antioxidant activity and enrichment of cream cheese with chestnut mushroom *Agrocybe aegerita* (Brig.) Sing. J Food Sci Technol 52(10):6711–6718. https://doi.org/10.1007/s13197-015-1783-6

Pietrzak-Fiec´ko R, Galgowska M, Bakula S (2016) Fatty acid composition in wild *Boletus edulis* from Poland. Ital J Food Sci 28(3):402–411. https://doi.org/10.14674/1120-1770/ ijfs.v42

Pirillo A, Capatano AL (2014) Nutraceuticals: definitions, European regulations and clinical applications (Nutraceutica: definizione, regolamentazione e applicazioni). Giorn Ital Farmacoecon Farmacoutiliz 6(4):23–30

Pizzoferrato L, Manzi P, Bertocchi F et al (2000) Solid state ^{13}C CP MAS NMR spectroscopy of mushrooms gives directly the ratio between proteins and polysaccharides. J Agric Food Chem 48:5484–5488. https://doi.org/10.1021/ jf000448j

Poniedziałek B, Siwulski M, Wiater A et al (2019) The effect of mushroom extracts on human platelet and blood coagulation: *in vitro* screening of eight edible species. Nutrients 11:3040. https://doi.org/10.3390/nu11123040

Popovic´ M, Vukmirovic´ S, Stilinovic´ N et al (2010) Anti-oxidative activity of an aqueous suspension of commercial-preparation of the mushroom *Coprinus comatus*. Molecules 15:4564–4571. https://doi.org/10.3390/molecules15074564

Proserpio C, Lavelli V, Laureati M et al (2019) Effect of *Pleurotus ostreatus* powder addition in vegetable soup on ß-glucan content, sensory perception, and acceptability. Food Sci Nutr 7:730–737. https://doi.org/10.1002/fsn3.917

Punelli F, Reverberi M, Porretta D et al (2009) Molecular characterization and enzymatic activity of laccases in two *Pleurotus* spp. with different pathogenic behaviour. Mycol Res 113:381–387. https://doi.org/10.1016/j.mycres.2008.11.018

Rathore H, Prasad S, Sharma S (2017) Mushroom nutraceuticals for improved nutrition and better human health: a review. PharmaNutrition 5:35–46. https://doi.org/10.1016/j.phanu. 2017.02.001

Reis FS, Martins A, Barros LL et al (2012) Antioxidant properties and phenolic profile of the most widely appreciated cultivated mushrooms: a comparative study between in vivo and in vitro samples. Food Chem Toxicol 50:1201–1207. https://doi.org/10.1016/j.fct.2012.02.013

Reis FS, Martins A, Vasconcelos MH et al (2017) Functional foods based on extracts or compounds derived from mushrooms. Trends Food Sci Technol 66:48–62. https:// doi.org/10.1016/j.tifs.2017.05.010

Ren XM, Li DF, Jiang S et al (2015) Structural basis of specific recognition of non-reducing terminal N-acetylglucosamine by an *Agrocybe aegerita* lectin. PLoS ONE 10(6):e0129608/1-e0129608/15. https://doi.org/10.2210/ pdb4tqk/pdb

Reverberi M, Di Mario F, Tomati U (2004) β-glucan synthase induction in mushrooms grown on olive mill wastewaters. Appl Microbiol Biotechnol 66:217–225. https://doi.org/10. 1007/s00253-004-1662-y

Rodrigues DMF, Freitas AC, Rocha-Santos TAP et al (2015) Chemical composition and nutritive value of *Pleurotus citrinopileatus* var *cornucopiae*, *P. eryngii*, *P. salmoneo stramineus*, *Pholiota nameko* and *Hericium erinaceus*. J Food Sci Technol 52(11):6927–6939. https://doi.org/10. 1007/s13197-015-1826-z

Ruggiero A, Garc´ıa-Ortega L, Ragucci S et al (2018) Structural and enzymatic properties of Ageritin, a novel metal-dependent ribotoxin-like protein with antitumor activity. BBA-Gen Subj 1862:2888–2894. https://doi.org/10.1016/j.bbagen.2018.09.010

Ruthes AC, Smiderle FR, Iacomini M (2015) D-Glucans from edible mushrooms: a review on the extraction, purification and chemical characterization approaches. Carbohydr Polym 117:753–761. https://doi.org/10.1016/j.carbpol.2014.10.051

Salehi F (2019) Characterization of different mushrooms powder and its application in bakery products: a review. Int J Food Prop 22(1):1375–1385. https://doi.org/10.1080/ 10942912.2019.1650765

Sande D, de Oliveira GP, Fidelis de Moura MA et al (2019) Edible mushrooms as a ubiquitous source of essential fatty acids. Food Res Int 125:108524. https://doi.org/10.1016/j. foodres.2019.108524

Sarma D, Saha AK, Datta BK (2018) Bioactive compounds with special references to anticancer property of oyster mushroom *Pleurotus ostreatus*. J Pharmacogn Phytochem 7(4):2694–2698

Schillaci D, Arizza V, Gargano ML, Venturella G (2013) Antibacterial activity of Mediterranean Oyster mushrooms, species of genus *Pleurotus* (Higher Basidiomycetes). Int J Med Mushrooms 15(6):591–594. https://doi.org/10.1615/IntJMedMushr.v15.i6.70

Selvamani S, El-Enshasy HA, Dailin DJ et al (2018) Antioxidant compounds of the edible mushroom *Pleurotus ostreatus*. Int J Biotechnol Wellness Ind 7:1–14. https:// doi.org/10.6000/1927-3037.2018.07.01

Singla R, Ghosh M, Ganguli A (2009) Phenolics and antioxidant activity of a ready-to-eat snack food prepared from the edible mushroom (*Agaricus bisporus*). Nutr Food Sci 39(3):227–234. https://doi.org/10.1108/00346650910957474

Smiderle FR, Ruthes AC, van Arkel J (2011) Polysaccharides from *Agaricus bisporus* and *Agaricus brasiliensis* show similarities in their structures and their immunomodulatory effects on human monocytic THP-1 cells. BMC Complem Altern Med 11:58. https://doi.org/10.1186/1472-6882-11- 58

Souilem F, Fernandes Aˆ , Calhelha RC et al (2017) Wild mushrooms and their mycelia as sources of bioactive compounds: Antioxidant, anti-inflammatory and cytotoxic properties. Food Chem 230:40–48. https://doi.org/10. 1016/j.foodchem.2017.03.026

Srikram A, Supapvanich S (2016) Proximate compositions and bioactive compounds of edible wild and cultivated mushrooms from Northeast Thailand. Agric Nat Resour 50:432–436. https://doi.org/10.1016/j.anres.2016.08.001

Stojkovic´ D, Reis FS, Glamoclija JM et al (2014) Cultivated strains of *Agaricus bisporus* and *A. brasiliensis*: chemical characterization and evaluation of antioxidant and antimicrobial properties for the final healthy product— natural preservatives in yoghurt. Food Funct 5(7):1602–1612. https://doi.org/10.1039/c4fo00054d

Stojkovic´ D, Reis FS, Ciric A et al (2015) *Boletus aereus* growing wild in Serbia: chemical profile, in vitro biological activities, inactivation and growth control of food-poisoning bacteria in meat. Int J Food Sci Technol 52(11):7385–7392. https://doi.org/10.1007/s13197-015-1853-9

Su S, Ding X, Fu L et al (2019) Structural characterization and immune regulation of a novel polysaccharide from Maerkang *Lactarius deliciosus* Gray. Int J Mol Med 44(2):713–724. https://doi.org/10.3892/ijmm.2019.4219

Sun YX, Liu JC, Yang XD et al (2010a) Purification, structural analysis and hydroxyl radical-scavenging capacity of a polysaccharide from the fruiting bodies of *Russula virescens*. Process Biochem 45:874–879. https://doi.org/10. 1016/j.procbio.2010.02.007

Sun Z, Zhang L, Zhang B et al (2010b) Structural characterisation and antioxidant properties of polysaccharides from the fruiting bodies of *Russula virescens*. Food Chem 118:675–680. https://doi.org/10.1016/j.foodchem.2009. 05.036

Surup F, Hennicke F, Sella N (2019) New terpenoids from the fermentation broth of the edible mushroom *Cyclocybeaegerita*. Beilstein J Org Chem 15:1000–1007. https://doi. org/10.3762/bjoc.15.98

Tala MF, Qin J, Ndongo JT et al (2017) New azulene-type sesquiterpenoids from the fruiting bodies of *Lactarius deliciosus*. Nat Prod Bioprospect 7:269–273. https://doi. org/10.1007/s13659-017-0130-1

Talkad MS, Das RK, Bhattacharjee P et al (2015) Establishment of enzyme inhibitory activities of lovastatin, isolated from *Pleurotus ostreatus*. Int J Appl Sci Biotechnol 3(3):408–416. https://doi.org/10.3126/ijasbt.v3i3.12932

Taofiq O, Gonza´lez-Parama´s AM, Martins A et al (2016) Mushrooms extracts and compounds in cosmetics, cosmeceuticals and nutricosmetics —a review. Ind Crop Prod 90:38–48. https://doi.org/10.1016/j.indcrop.2016.06.012

Tejedor-Calvo E, Morales D, Marco P et al (2020) Screening of bioactive compounds in truffles and evaluation of pressurized liquid extractions (PLE) to obtain fractions with biological activities. Food Res Int 132:109054. https://doi. org/10.1016/j.foodres.2020.109054

Tsai YS, Huang SJ, Mau JL (2006) Antioxidant properties of hot water extracts from *Agrocybe cylindracea*. Food Chem

98:670–677. https://doi.org/10.1016/j.foodchem.2005.07. 003

Tsai SY, Tsai HL, Mau JL (2007) Nutritional value, chemical composition, antioxidant activity and enrichment of cream cheese with chestnut mushroom *Agrocybe aegerita* (Brig.) Sing. (Agaricomycetideae). Int J Med Mushrooms 9:47–55. https://doi.org/10.1007/s13197-015-1783-6

Tsai SY, Huang SJ, Lo SH et al (2009) Flavour components and antioxidant properties of several cultivated mushrooms. Food Chem 113:578–584. https://doi.org/10.1016/j. foodchem.2008.08.034

Valverde ME, Herna´ndez-Pe´rez T, Paredes-Lo´ pez O (2015) Edible Mushrooms: improving human health and promoting quality life. Int J Microbiol Article ID 376387:14 pp. https://doi.org/10.1155/2015/376387

Vanamu E (2012) *In vitro* antimicrobial and antioxidant activities of ethanolic extract of lyophilized mycelium of *Pleurotus ostreatus* PQMZ91109. Molecules 17:3653–3671. https://doi.org/10.3390/ molecules17043653

Venturella G, Palazzolo E, Saiano F et al (2015) Notes on a new productive strain of king oyster mushroom, *Pleurotus eryngii* (higher Basidiomycetes), a prized Italian culinary- medicinal mushroom. Int J Med Mushrooms 17(2):199–206. https://doi.org/10.1615/ intjmedmushrooms.v17.i2.110

Venturella G, Saporita P, Gargano ML (2019) The potential role of medicinal mushrooms in the prevention and treatment of gynecological cancers: a review. Int J Med Mushrooms 21(3):225–235. https://doi.org/10.1615/ intjmedmushrooms.2019030289

Verma NK, Singh AP, Singh VK (2019) *Agaricus bisporus* (Fungi): chemical constituents and pharmacological activities—a review. AJPCR 7(2):82–87

Vetter J (2003) Data on sodium content of common edible mushrooms. Food Chem 81(4):589–593. https://doi.org/ 10.1016/s0308-8146(02)00501-0

Villares A, Garc´ıa-Lafuente A, Guillamo´n E et al (2012) Identification and quantification of ergosterol and phenolic compounds occurring in *Tuber* spp. Truffles J Food Compos Anal 26:177–182. https://doi.org/10.1016/j.jfca. 2011.12.003

Vita F, Taiti C, Pompeiano A et al (2015) Volatile organic compounds in truffle (*Tuber magnatum* Pico): comparison of samples from different regions of Italy and from different seasons. Sci Rep 5:12629. https://doi.org/10.1038/ srep12629

Vita F, Lucarotti V, Alpi E et al (2017) Proteins from *Tuber magnatum* Pico fruiting bodies naturally grown in different areas of Italy. Proteome Sci 11:7. https://doi.org/10.1186/ 1477-5956-11-7

Vita F, Franchina FA, Taiti C et al (2018) Environmental conditions influence the biochemical properties of the fruiting bodies of *Tuber magnatum* Pico. Sci Rep 8:7243. https:// doi.org/10.1038/s41598-018-25520-7

Wang S, Marcone MF (2011) The biochemistry and biological properties of the world's most expensive underground edible mushroom: Truffles. Food Res Int 44:2567–2581. https://doi.org/10.1016/j.foodres.2011.06.008

Wang S, Bao L, Han J et al (2013a) Pleurospiroketals A-E, Perhydrobenzannulated 5,5-Spiroketal sesquiterpenes from edible mushroom *Pleurotus cornucopiae*. J Nat Prod 76:45–50. https://doi.org/10.1021/np3006524

Wang S, Bao L, Zhao F et al (2013b) Isolation, identification, and bioactivity of monoterpenoids and sesquiterpenoids from the mycelia of edible mushroom *Pleurotus cornucopiae*. J Agric Food Chem 61:5122–5129. https://doi.org/ 10.1016/j.foodchem.2013.11.062

Wang D, Sun SQ, Wu WZ et al (2014a) Characterization of a water-soluble polysaccharide from *Boletus edulis* and its antitumor and immunomodulatory activities on renal cancer in mice. Carbohydr Polym 105:127–134. https://doi. org/10.1016/j.carbpol.2013.12.085

Wang L, Zhang R, Ma Z et al (2014b) A feruloyl esterase (FAE) characterized by relatively high thermostability from the edible mushroom *Russula virescens*. Appl Biochem Biotech 172(2):993–1003. https://doi.org/10.1007/s12010-013-0536-0

Wang XM, Zhang J, Wu LH et al (2014c) A mini-review of chemical composition and nutritional value of edible wild-grown mushroom from China. Food Chem 151:279–285. https://doi.org/10.1016/j.foodchem.2013.11.062

Wani BA, Bodha RH, Wani AH (2010) Nutritional and medicinal importance of mushrooms. J Med Plant Res 4(24):2598–2604. https://doi.org/10.5897/jmpr09.565

Wasser SP (2014) Medicinal mushroom science: current perspectives, advances, evidences, and challenges. Biomed J 37:345–356. https://doi.org/10.4103/2319-4170.138318

Weijn A, Van den Berg-Somhorst DBPM, Slootweg JC et al (2013) Main phenolic compounds of the melanin biosynthesis pathway in bruising-tolerant and bruising-sensitive buttom mushroom (*Agaricus bisporus*) strains. J Agric Food Chem 61:8224–8231. https://doi.org/10.1021/ jf4020558

Wu X, Huang C, Chen Q et al (2014) A novel laccase with inhibitory activity towards HIV-I reverse transcriptase and antiproliferative effects on tumor cells from the fermentation broth of mushroom *Pleurotus cornucopiae*. Biomed Chromatogr 28:548–553. https://doi.org/10.1002/bmc. 3068

Xiao Y, Chen L, Fan Y et al (2019) The effect of boletus polysaccharides on diabetic hepatopathy in rats. Chem- Biol Interact 308:61–69. https://doi.org/10.1016/j.cbi. 2019.05.013

Xu Z, Fu L, Feng S et al (2019) Chemical composition, antioxidant and antihyperglycemic activities of the wild *Lactarius deliciosus* from China. Molecules 24:1357. https://doi.org/10.3390/molecules24071357

Yang Q, Yin Y, Pan Y et al (2018) Anti-metastatic activity of *Agrocybe aegerita* galectin (AAL) in a mouse model of breast cancer lung metastasis. J Funct Foods 41:163–170. https://doi.org/10.1016/j.jff.2017.12.058

Yap H-YY, Tan N-H, Ng S-T et al (2018) Inhibition of protein glycation by tiger milk mushroom [*Lignosus rhinoceros* (Cooke) Ryvarden] and search for potential anti-diabetic activity-related metabolic pathways by genomic and transcriptomic data mining. Front Pharmacol 9:103. https://doi. org/10.3389/fphar.2018.00103

Yeh CW, Kan SC, Lin CC et al (2016) Polyhydroxylated steroids and triterpenoids from an entophytic fungus, *Hypocreales* sp. NCHU01 isolated from *Tuber magnatum*. J Taiwan Inst Chem E 64:22–30. https://doi.org/10.1016/j. jtice.2016.03.049

Yilmaz N, Tu¨rkekul I, Bulut S et al (2013) Fatty acid composition in ten mushroom species collected from middle black sea region of Turkey. Asian J Chem 25(3):1216–1220. https://doi.org/10.14233/ajchem.2013.12599a

Zhang Y, Mills GL, Nair MG (2003) Cyclooxygenase inhibitory and antioxidant compounds from the fruiting body of an edible mushroom, *Agrocybe aegerita*. Phytomedicine 10:386–390. https://doi.org/10.1078/0944-7113-00272

Zhang A, Xiao N, He P et al (2011) Chemical analysis and antioxidant activity in vitro of polysaccharides extracted from *Boletus edulis*. Int J Biol Macromol 49:1092–1095. https://doi.org/10.1016/j.ijbiomac.2011.09.005

Zhang J, Ma Z, Zheng L et al (2014) Purification and antioxidant activities of intracellular zinc polysaccharides from *Pleurotus cornucopiae* SS-03. Carbohydr Polym 111:947–954. https://doi.org/10.1016/j.carbpol.2014.04.074

Zhang JJ, Li Y, Zhou T et al (2016) Bioactivities and health benefits of mushrooms mainly from China. Molecules 21:938. https://doi.org/10.3390/molecules21070938

Zhang L, Hu Y, Duan X et al (2018) Characterization and antioxidant activities of polysaccharides from thirteen boletus mushrooms. Int J Biol Macromol 113:1–7. https:// doi.org/10.1016/j.ijbiomac.2018.02.084

Zhao YY, Shen X, Chao X et al (2011) Ergosta-4,6,8(14),22- tetraen-3-one induces G2/M cell cycle arrest and apoptosis in human hepatocellular carcinoma HepG2 cells. Biochim Biophy Acta Gen Subj 4:384–390. https://doi.org/10.1016/ j.bbagen.2010.12.005

Zhao H, Li H, Lai Q et al (2019) Antioxidant and hepatoprotective activities of modified polysaccharides from *Coprinus comatus* in mice with alcohol-induced liver injury. Int J Biol Macromol 127:476–485. https://doi.org/10.1038/ s41598-018-30104-6

Zheng S, Li C, Ng TB et al (2007) A lectin with mitogenic activity from the edible wild mushroom *Boletus edulis*. Process Biochem 42:1620–1624. https://doi.org/10.1016/j. procbio.2007.09.004

Zhou S, Liu Y, Yang Y et al (2013) Separation and structural elucidation of a polysaccharide CC30w-1 from the fruiting body of *Coprinus comatus*. Bioact Carbohydr Dietary Fibre 1:99–104. https://doi.org/10.1016/j.bcdf.2013.03.003

Zhu MJ, Du F, Zhang GQ et al (2013) Purification a laccase exhibiting dye decolorizing ability from an edible mushroom *Russula virescens*. Int Biodeterior Biodegrad 82:33–39. https://doi.org/10.1016/j.ibiod.2013.02.010

Zˇ urga S, Nanut MP, Kos J et al (2017) Fungal lectin MpL enables entry of protein drugs into cancer cells and their subcellular targeting. Oncotarget 8(16):26896–26910. https://doi.org/10.18632/oncotarget.15849

Call for Papers

Aiming to build the relationship between the members and the Society, the publication of the newsletters was proposed before the launching of the Society. The newsletters represent one of the key official publications from the Society. Contents of the newsletters will include notifications of the decisions made by the committee board, reviews or comments contributed by ISMM committee members, conferences or activities to be organized, and the status updated in research, industrialization, and marketing for medicinal mushrooms. The newsletters will be released quarterly, by the first Monday of every January, April, July, and October, with possible supplementary issues as well. The Newsletter is open to organizations or professionals to submit news, comments, or scientific papers relating to medicinal mushroom research, marketing, or industry.

Contact information

For any inquiry in membership enrollment, subscribing to ISMM newsletters, upcoming activities and events organized by ISMM, or submitting news reports, statements, or manuscripts to the Society, please contact the secretariat's office in Beijing, China.

ISMM Secretariat Office, Beijing
Room D-1216, Jun Feng Hua Ting,
No. 69 West Beichen Road,
Chaoyang District, Beijing 100029, China.
Tel: +86-10-58772596, 87109859
Fax: +86-10-58772190
E-mail: ismm.org@gmail.com
Website: http://www.ismm2013.com/