THE INVESTIGATION OF THE DIVERSITY OF MACROFUNGI IN COMMUNITY FORESTS OF THAILAND AND THEIR UTILIZATION STUDY

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A community forest:



A source of food

1. The investigation of the diversity and taxonomy on macrofungi in Thailand

Taxonomy and Phylogeny

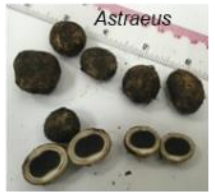
Material and methods

Survey and collection with local villagers



Isolation



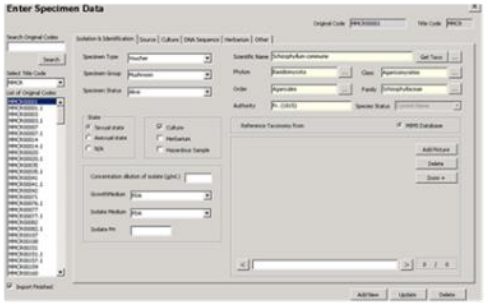




Website: http://biotec-fungi.com



Database



Molecular phylogeny

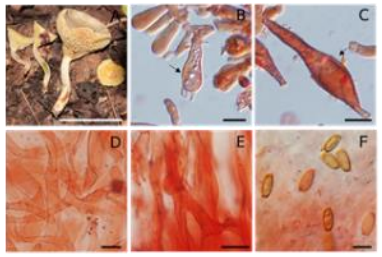
DNA extraction,
Amplification
DNA Sequencing
Phylogenetic analysis



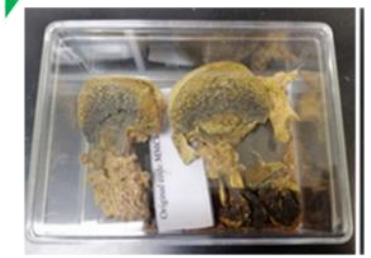
Identification

Morphological study





Herbarium

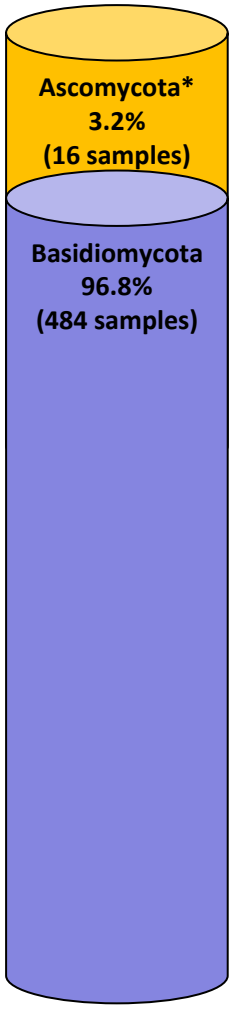


Objectives
To explore the diversity and to identify macrofungal species found in community forests

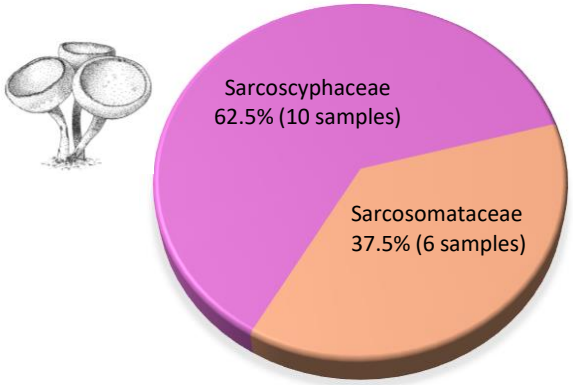


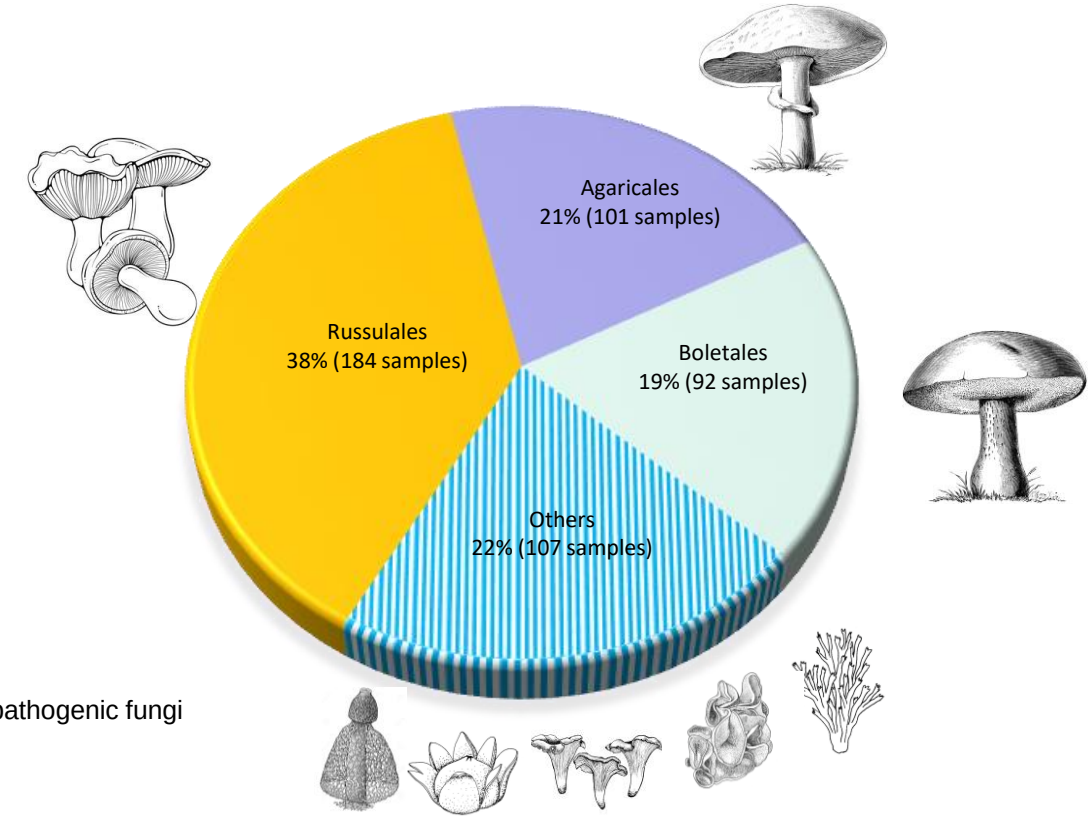
Deciduous dipterocarp forests cover 80% of the community forests in this study.

500 samples were collected



*Note: exclude the entomopathogenic fungi



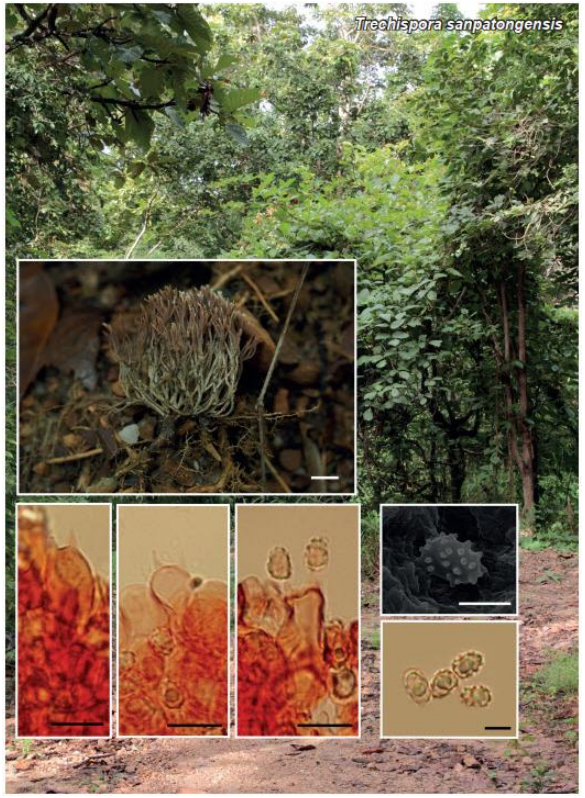


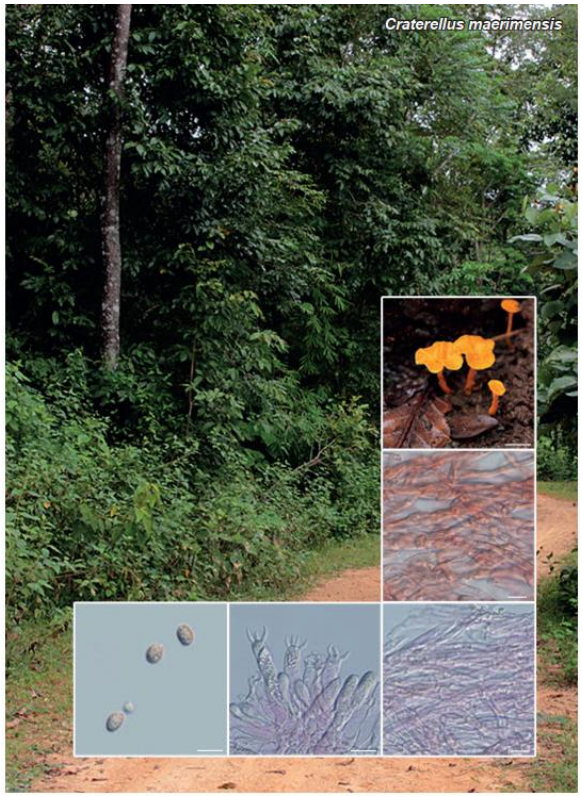
Discovery of new species through biodiversity research as well as taxonomy and nomenclature studies

- Over 30 discovered fungal species
- 15 formally published in international journals
- 5 species are in preparation to describe as new species
- Taxonomic revision of over 3 fungal taxa







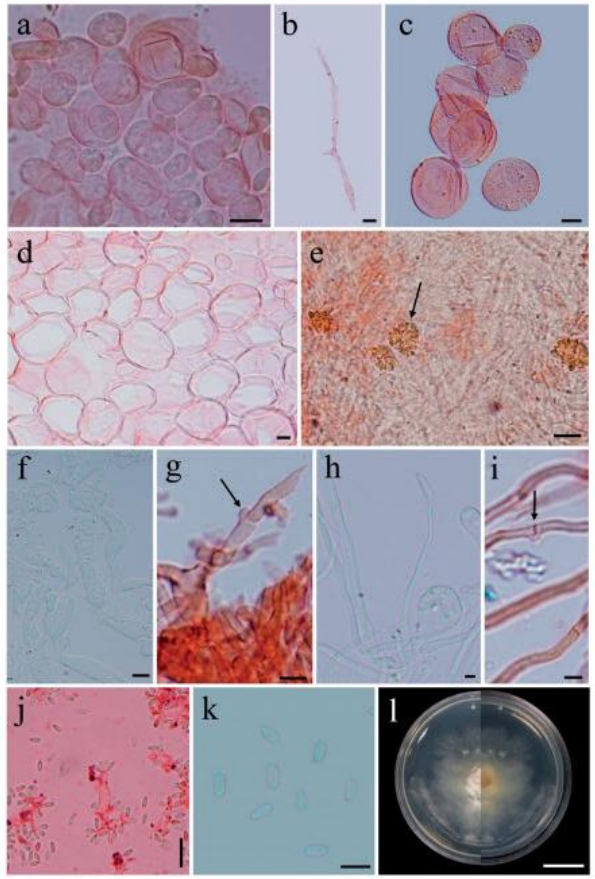


Mycobiology (2021)

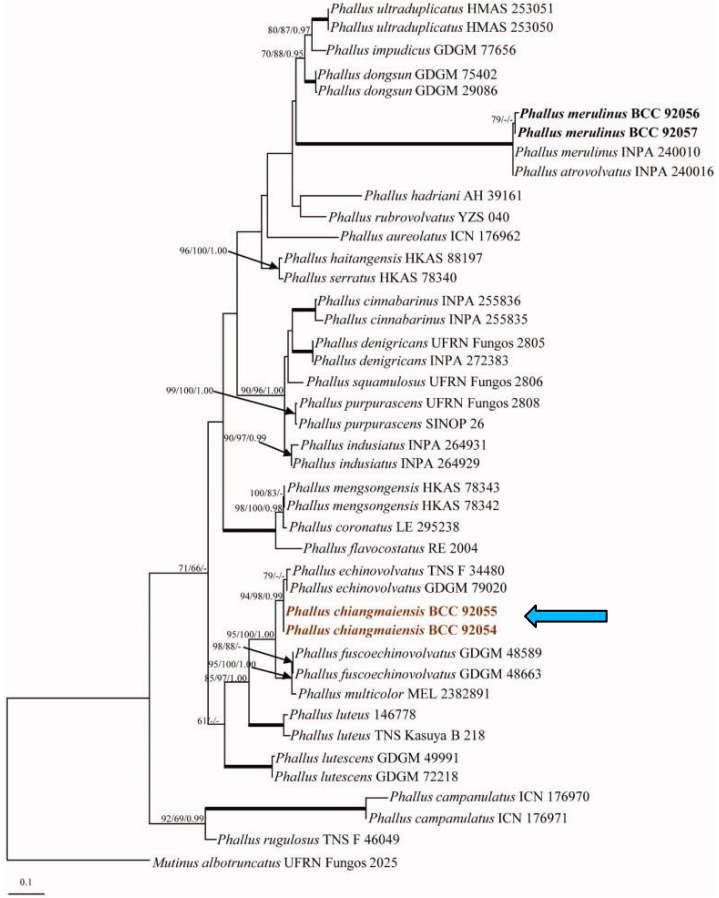
Phallus chiangmaiensis sp. nov.



Phallus chiangmaiensis (BBH 47825, holotype). (a) Mature basidiomata. (b) Reticulate cap. (c) Indusium. (d) Immature basidiomata (egg). (e) Pseudostipe and section of immature basidiomata. Scale bars: a = 50mm, b–e = 10 mm.



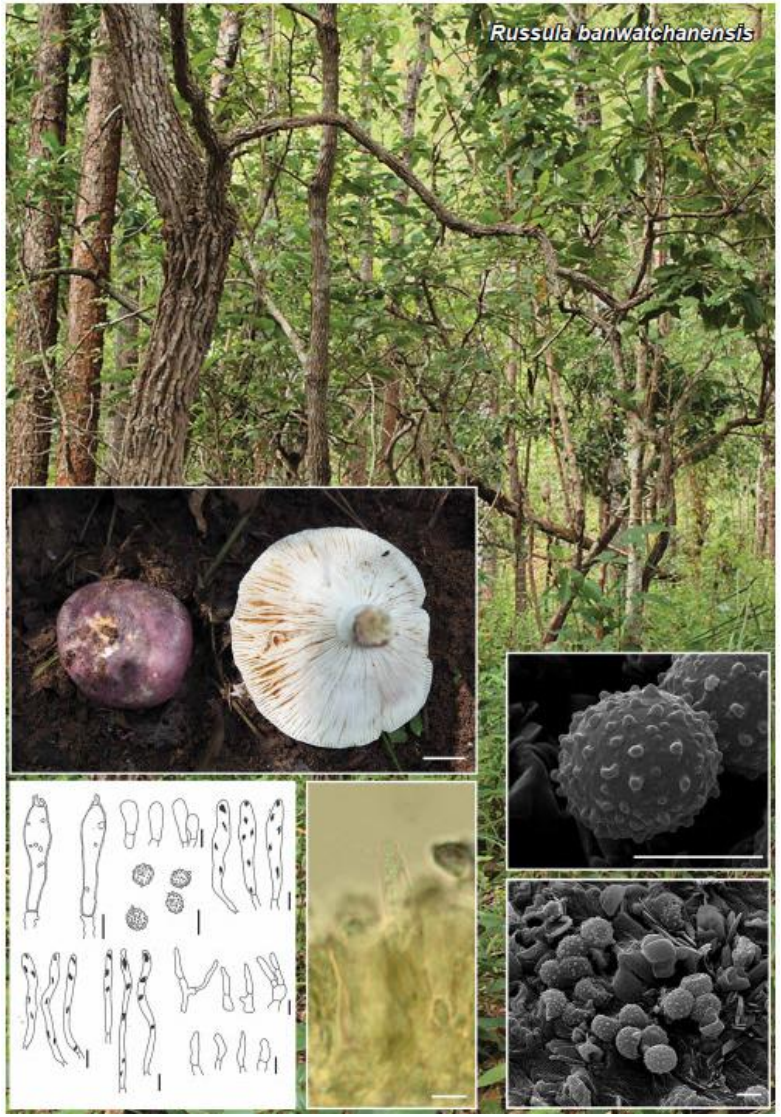
Microscopic features of *Phallus chiangmaiensis*. (a,b) Cap cells and hyphae. (c) Cells of indusium. (d) Cells of pseudostipe. (e) Crystals in volva hyphae (arrowed). (f,g) Volva hyphae with clamp connections (arrowed). (h,i) Rhizomorph hyphae with clamp connections (arrowed). (j) Basidia with sterigmata and basidiospores. (k) Basidiospores. (l) Colony on PDA (surface and reverse plate). Scale bars: a, c–e = 20 mm, b, f–j = 10 mm, g, k = 5 mm, l = 10mm.



Phylogenetic relationships of *Phallus* spp. inferred from ITS sequences. Numbers at the significant nodes represent ML bootstrap values/MP/Bayesian posterior probabilities, multiplied by 100; bold lines in the tree represent 100% bootstrap (BSMP, BSML) and 1.00 posterior probability (BPP).

Fungal Planet 1423 – July 2022

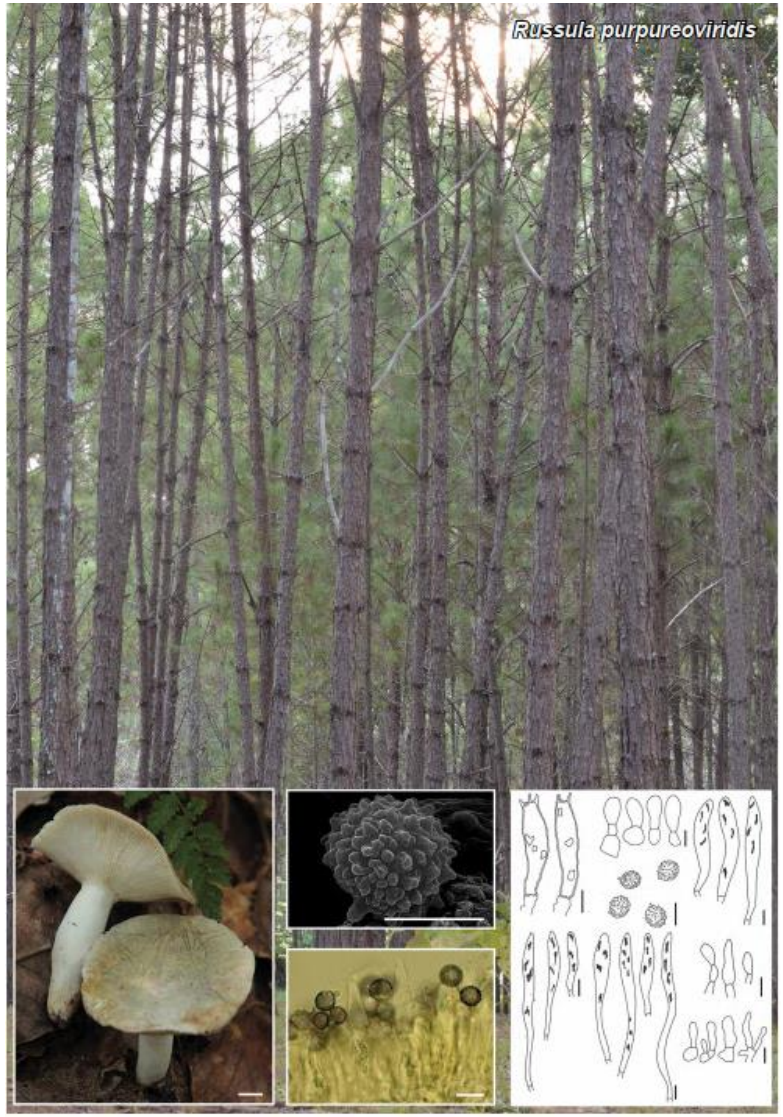
Russula banwatchanensis sp. nov.



Colour illustrations. The dipterocarp forest in Banwatchan watershed, Kanlayaniwattana district, Chiang Mai province, where the holotype was collected.Left top: Basidiomata growing on the soil BBH 49228. Right top and bottom: Scanning electron photograph of spores from BBH 49228. Left bottom: Line drawings all from holotype BBH 49228; basidia (left top), marginal cells and basidiospores (centre), hymenial cystidia near the lamellae edges (right top), pileocystidia near the pileus centre (left bottom), pileocystidia near the pileus margin (centre), hypha terminations near the pileus centre (right centre) and hypha terminations near the pileus margin (right bottom). Centre: hymenial cystidia near the lamellae sides. Scale bars = 10 mm (basidiomata), 10 µm (all other microscopic structures), 5 µm (spores).

Fungal Planet 1424 – July 2022

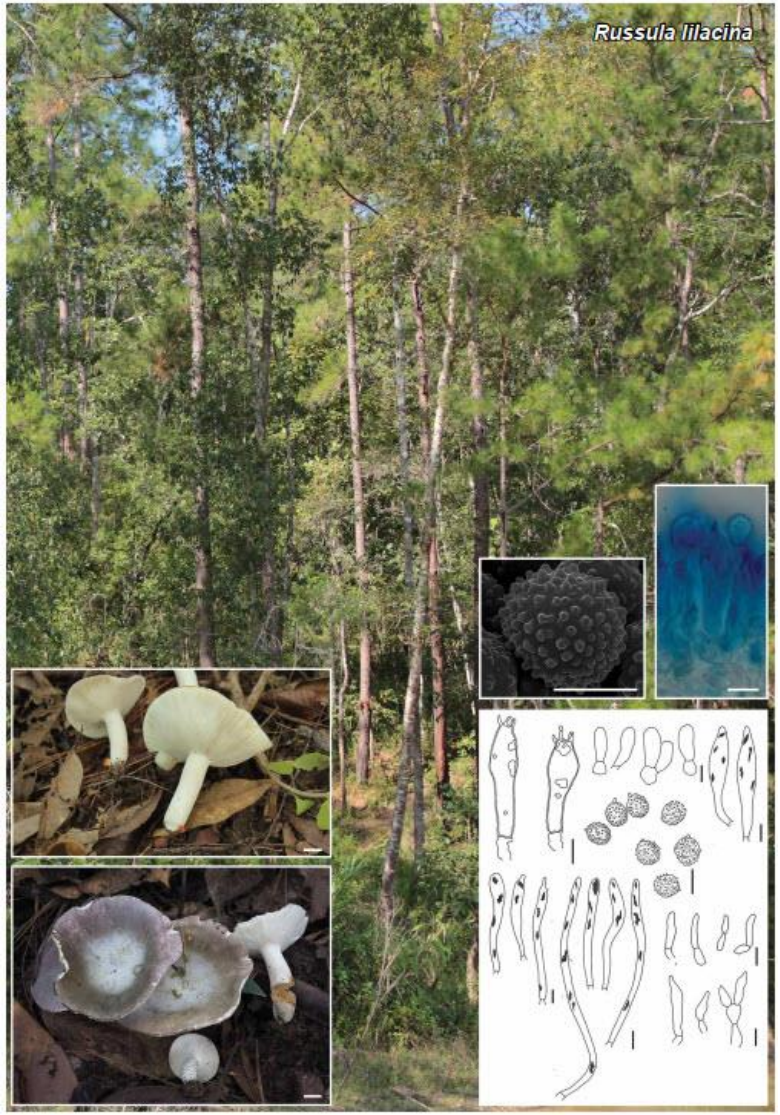
Russula purpureoviridis sp. nov.



Colour illustrations. The dipterocarp forest in Banwatchan watershed, Kanlayaniwattana district, Chiang Mai province, where the holotype was collected. Left: basidiomata growing on the soil BBH 49226. Centre top; scanning electron photograph of spores from BBH 49226. Centre bottom; hymenial cystidia near the lamellae sides. Line drawings all from holotype BBH 49226. Left: basidia (left top), marginal cells and basidiospores (centre), hymenial cystidia near the lamellae edges (right top), pileocystidia near the pileus centre (left bottom), pileocystidia near the pileus margin (centre), hypha terminations near the pileus centre (right centre), and hypha terminations near the pileus margin (right bottom). Scale bars = 10 mm (basidiomata), 10 µm (all other microscopic structures), 5 µm (spores).

Fungal Planet 1425 – July 2022

Russula lilacina sp. nov.



Colour illustrations. The pine forest, Kanlayaniwattana district, Chiang Mai province, where the holotype was collected. Left top and bottom: basidiomata growing on the soil BBH 49227. Right top: scanning electron photograph of spores from BBH 49227 and hymenial cystidia near the lamellae sides. Right bottom; line drawings all from holotype BBH 49227; basidia (left top), marginal cells and basidiospores (centre), hymenial cystidia near the lamellae edges (right top), pileocystidia near the pileus centre (left bottom), pileocystidia near the pileus margin (centre), hypha terminations near the pileus centre (right centre) and hypha terminations near the pileus margin (right bottom). Scale bars = 10 mm (basidiomata), 10 µm (all other microscopic structures), 5 µm (spores).

Fungal Planet 1663 – June 2024

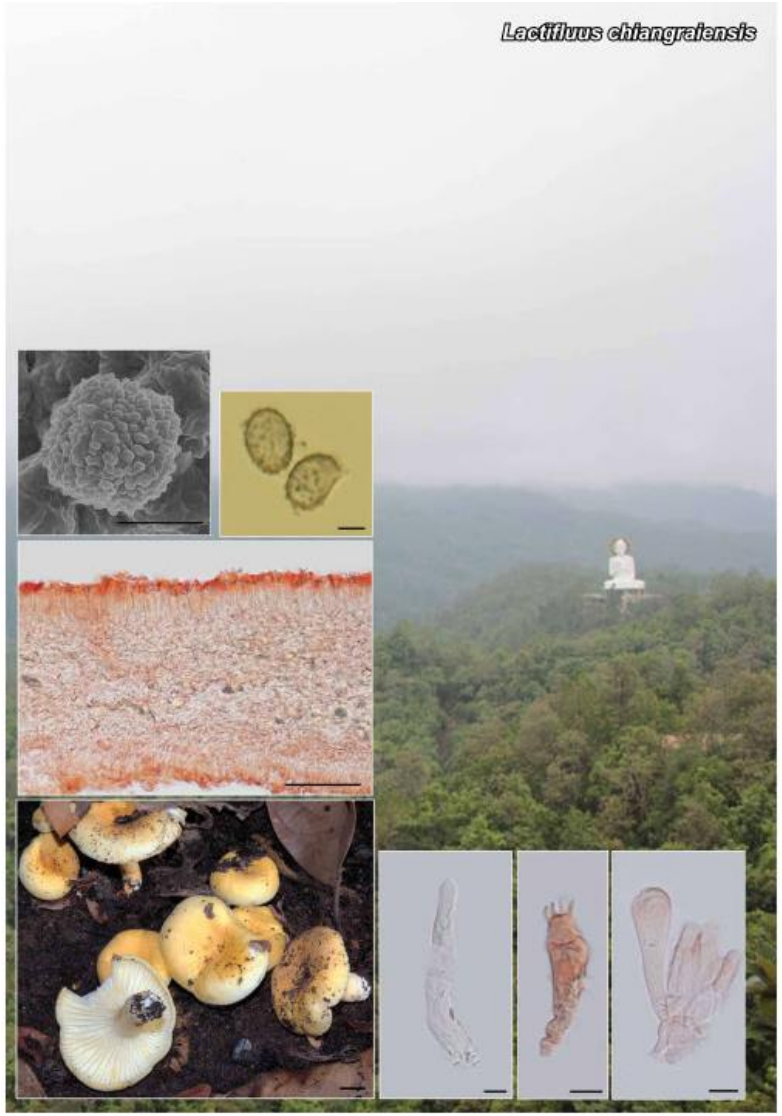
Russula mukdahanensis sp. nov.



Colour illustrations: The deciduous dipterocarp forest, Mueang Mukdahan district, Mukdahan Province, Thailand, where the holotype was collected. Left top: Basidiomata of BBH 48240; Left centre: The hymenium layer with a basidiospore in Melzer's reagent; Centre: Scanning electron photograph of spores from BBH 48240; Left bottom: Basidia and basidiole, cheilocystidia (centre); Right bottom: Pleurocystidia. Scale bars: basidiomata = 10 mm; all other microscopic structures = 10 µm; spores = 5 µm.

Fungal Planet 1449 – December 2022

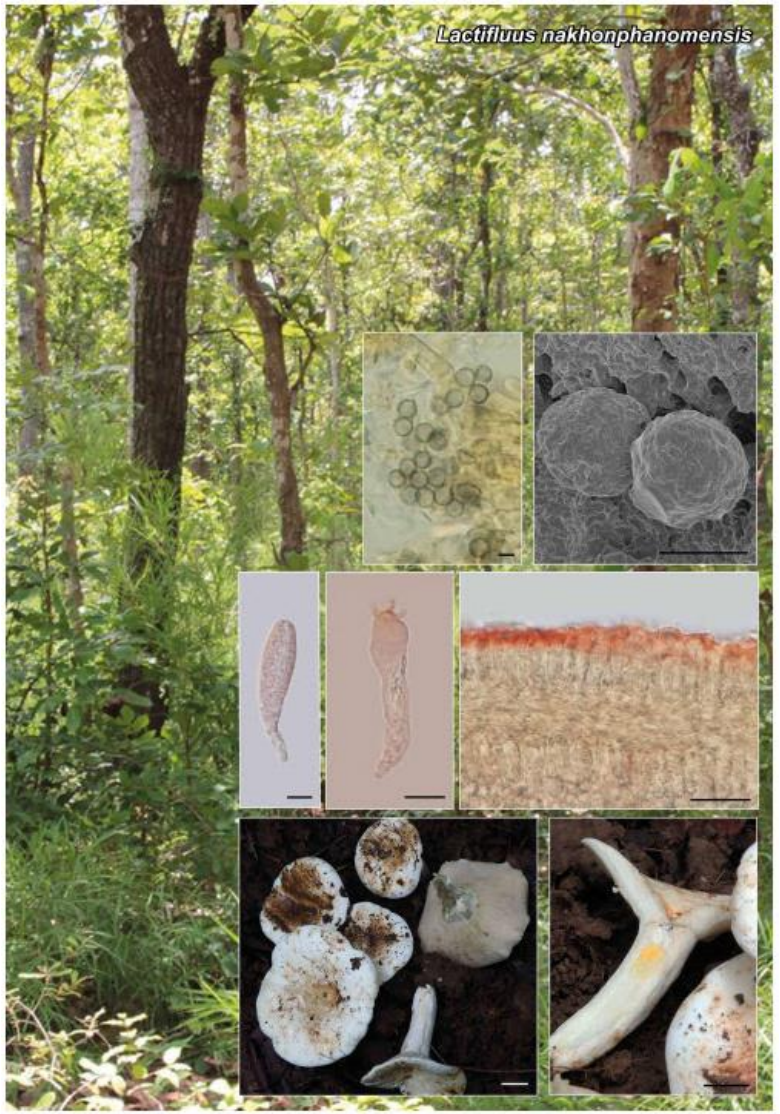
Lactifluus chiangraiensis sp. nov.



Colour illustrations. The dipterocarp forest in Santhat Kut, Wiang Pa Pao district, Chiang Rai province, where the holotype was collected. Basidiocarps growing on soil BBH 48198; cross-section of lamellae; pseudocystidia; basidia; basidioles; SEM of spore and spores in Melzer's reagent. Scale bars = 1 cm (basidiocarps), 50 µm (cross-section of lamellae), 10 µm (all other microscopic structures), 5 µm (spores).

Fungal Planet 1450 – December 2022

Lactifluus nakhonphanomensis sp. nov.



Colour illustrations. Ban Nong Hi Dry Dipterocarp Forest, Pla Pak District, Nakhon Phanom Province, where the holotype was collected. Basidiocarps of BBH 47958 growing on soil; cross-section of lamellae; basidia; cystidia; SEM of spore and spores in Melzer's reagent. Scale bars = 1 cm (basidiocarps), 50 µm (cross-section of lamellae), 10 µm (all other microscopic structures),
5 µm (spores).

Fungal Planet 1451 – December 2022

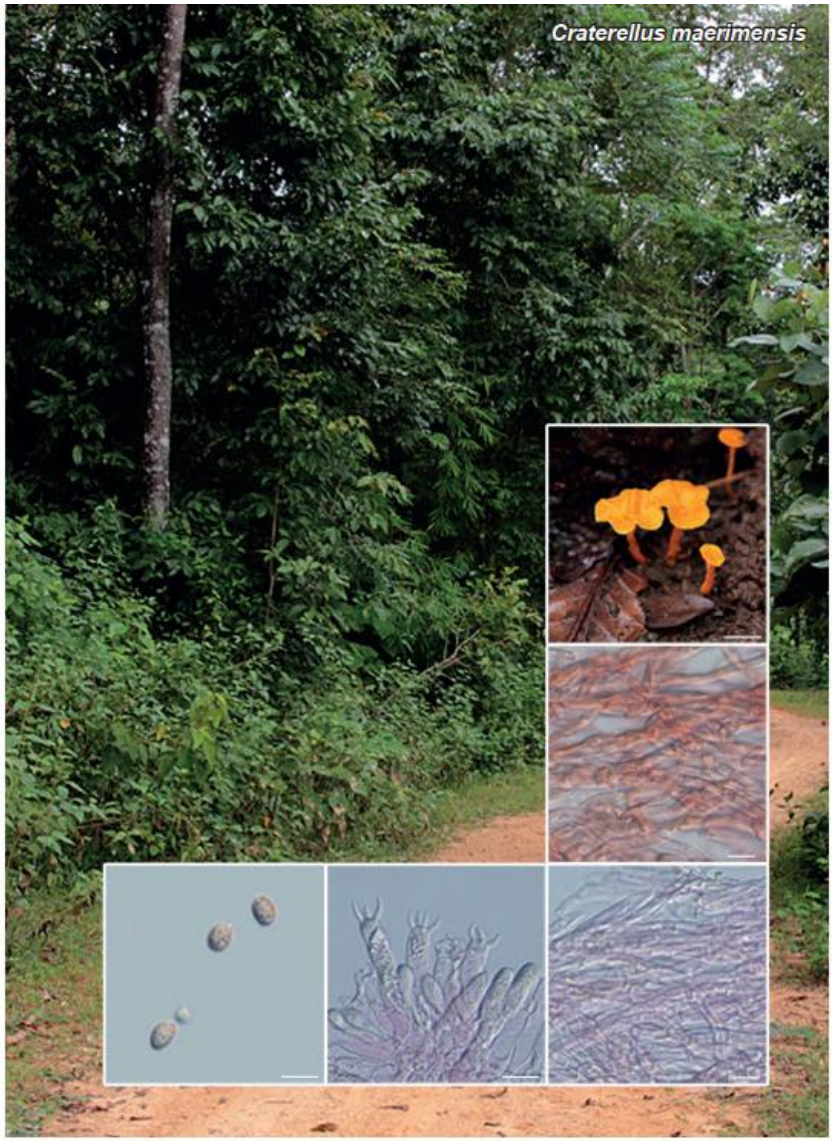
Xerocomus sisongkhramensis sp. nov.



Colour illustrations. The dipterocarp forest in Rural Road NP. 4025, Hat Phaeng Forest, Si Songkhram district, Nakhon Phanom Province, Thailand, where the holotype was collected. Basidiocarps of BBH 48255 growing on soil; stipe; young basidiocarp; pores; mycelium; caulocystidia; pleurocystidia; basidia and basidiospores. Scale bars = 1 cm (basidiocarps, stipe and pores), 10 µm (all other microscopic structures).

Fungal Planet 1625 – June 2024

Craterellus maerimensis sp. nov.

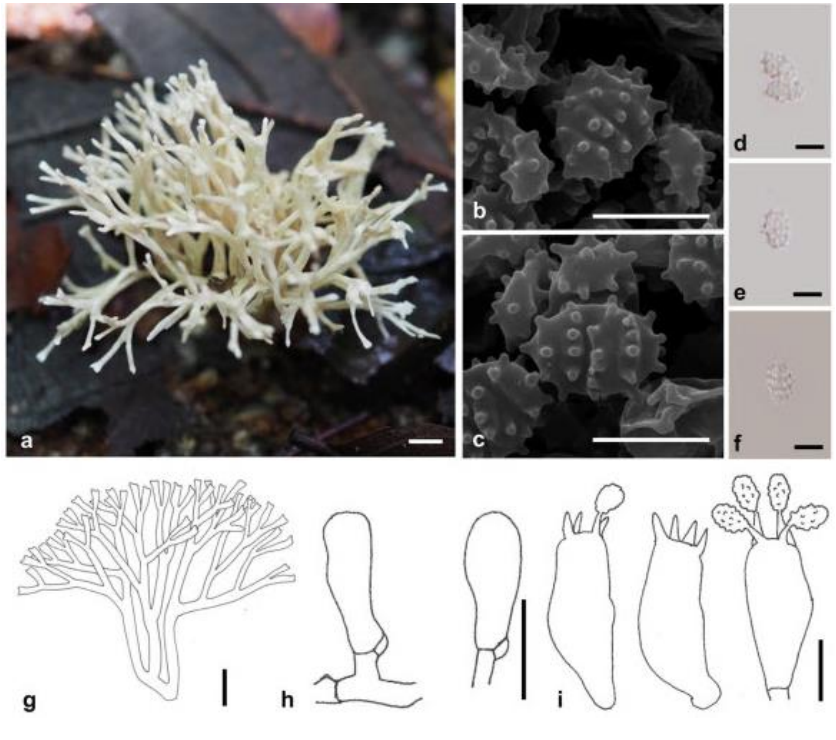


Colour illustrations: The mixed deciduous forest, Mae Rim district, Chiang Mai Province, Thailand, where the holotype was collected. Right top: Basidiomata of BBH 49161; pileipellis; stipitipellis; basidia; basidiospores. Scale bars: basidiomata = 10 mm; all others = 10 µm.

Mycological Progress (2023)

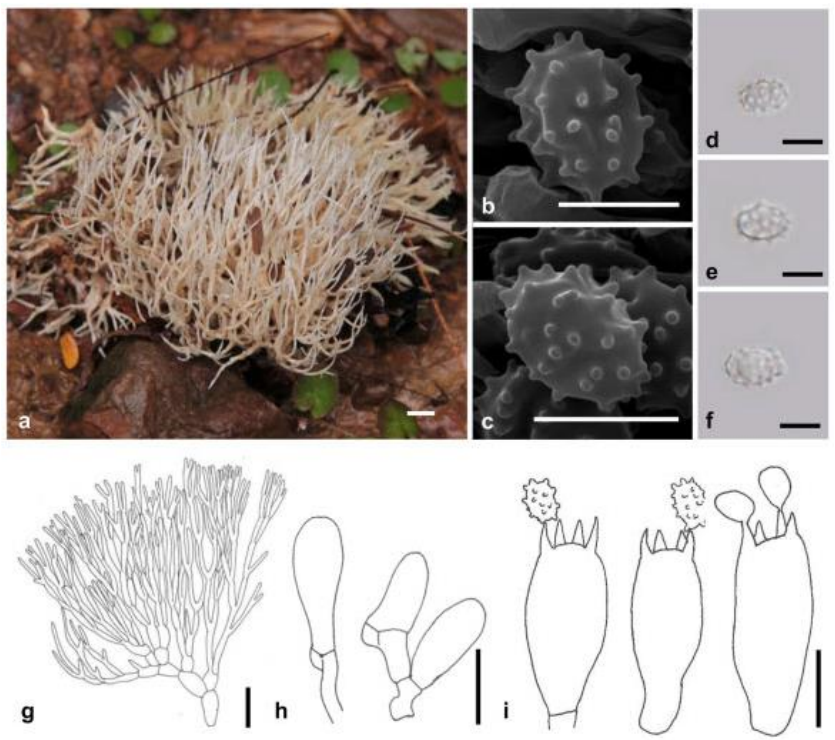
Five new species of *Trechispora* from Northern and Northeastern Thailand

Trechispora khokpasiensis sp. nov.



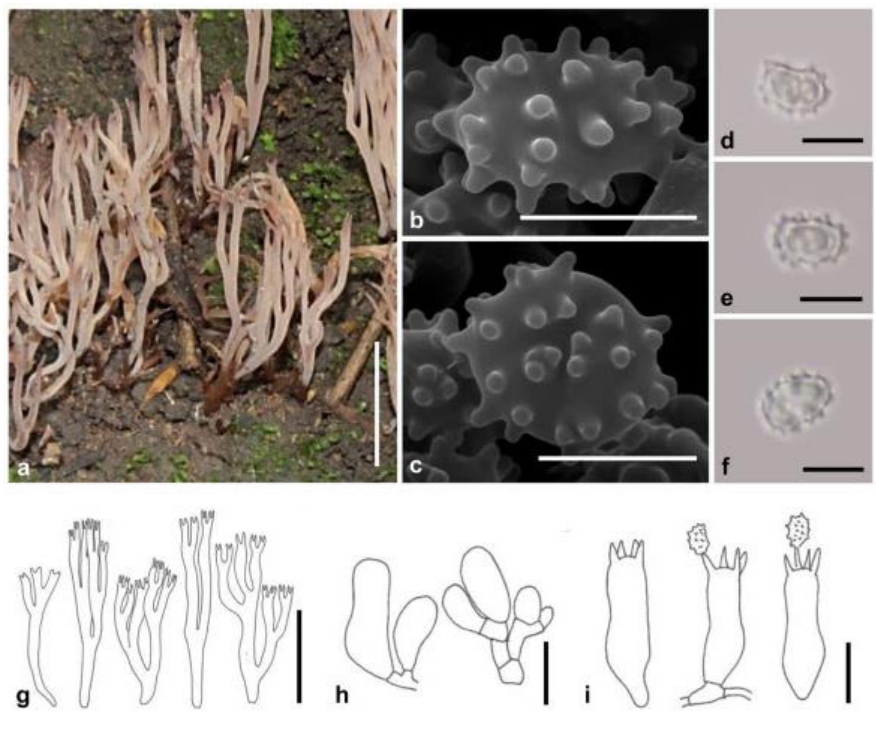
Trechispora khokpasiensis (BBH 47957, holotype). **a** Basidiomata. **b—c** Scanning electron micrographs of basidiospores. **d—f** Basidiospores. **g** Line drawing of basidioma. **h** Young basidia. **i** Basidia with basidiospores. Scale bars: **a**, **g** = 1 cm; **h—i** = 10 µm; **b—f** = 5 µm.

Trechispora saluangensis sp. nov.



Trechispora saluangensis (BBH 49155, holotype). **a** Basidiomata. **b—c** Scanning electron micrographs of basidiospores. **d—f** Basidiospores. **g** Line drawing of basidioma. **h** Young basidia. **i** Basidia with basidiospores. Scale bars: **a**, **g** = 1 cm; **h—i** = 10 µm; **b—f** = 5 µm.

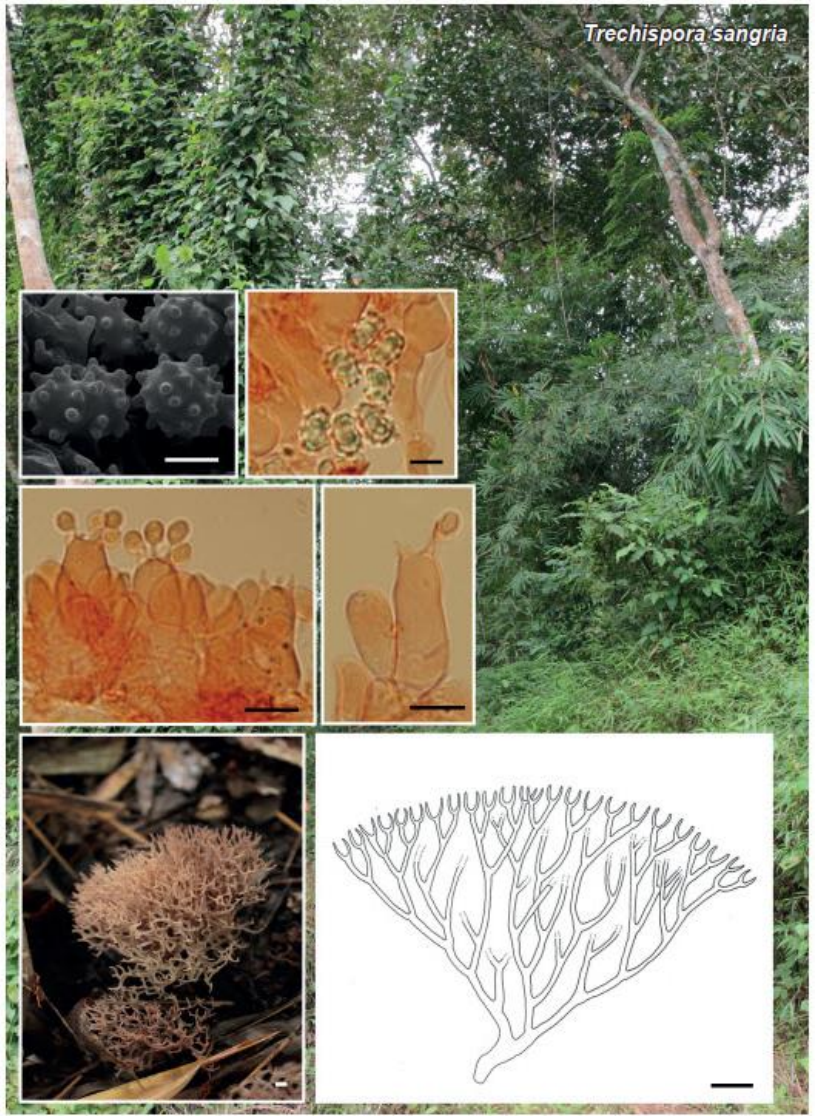
Trechispora sanpapaoensis sp. nov.



Trechispora sanpapaoensis (BBH 47980, holotype). **a** Basidiomata. **b—c** Scanning electron micrographs of basidiospores. **d—f** Basidiospore. **g** Line drawing of basidioma. **h** Young basidia. **i** Basidia with basidiospores. Scale bars: **a**, **g** = 5 cm; **h—i** = 10 µm; **b—f** = 5 µm.

Fungal Planet 1665 – June 2024

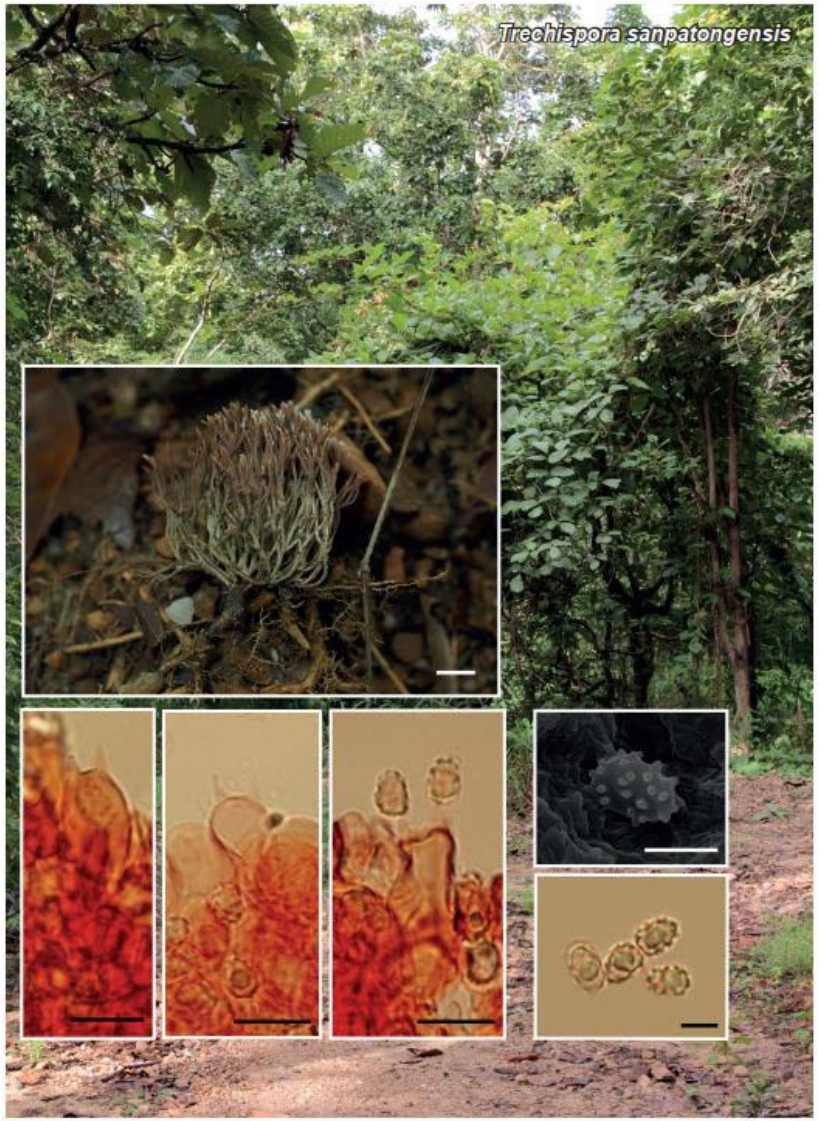
Trechispora sangria sp. nov.



Colour illustrations: The mixed deciduous forest, Mae Sot district, Tak Province, Thailand, where the holotype was collected (background photo). Left bottom: Basidiomata growing on the soil of BBH 49635 and line drawing of basidiomata; Left centre: Basidia with basidiospores; Basidiospores, scanning electron photograph of spores from BBH49635. Scale bars: basidiomata = 10 mm; basidia = 10 µm; basidiospore = 5 µm.

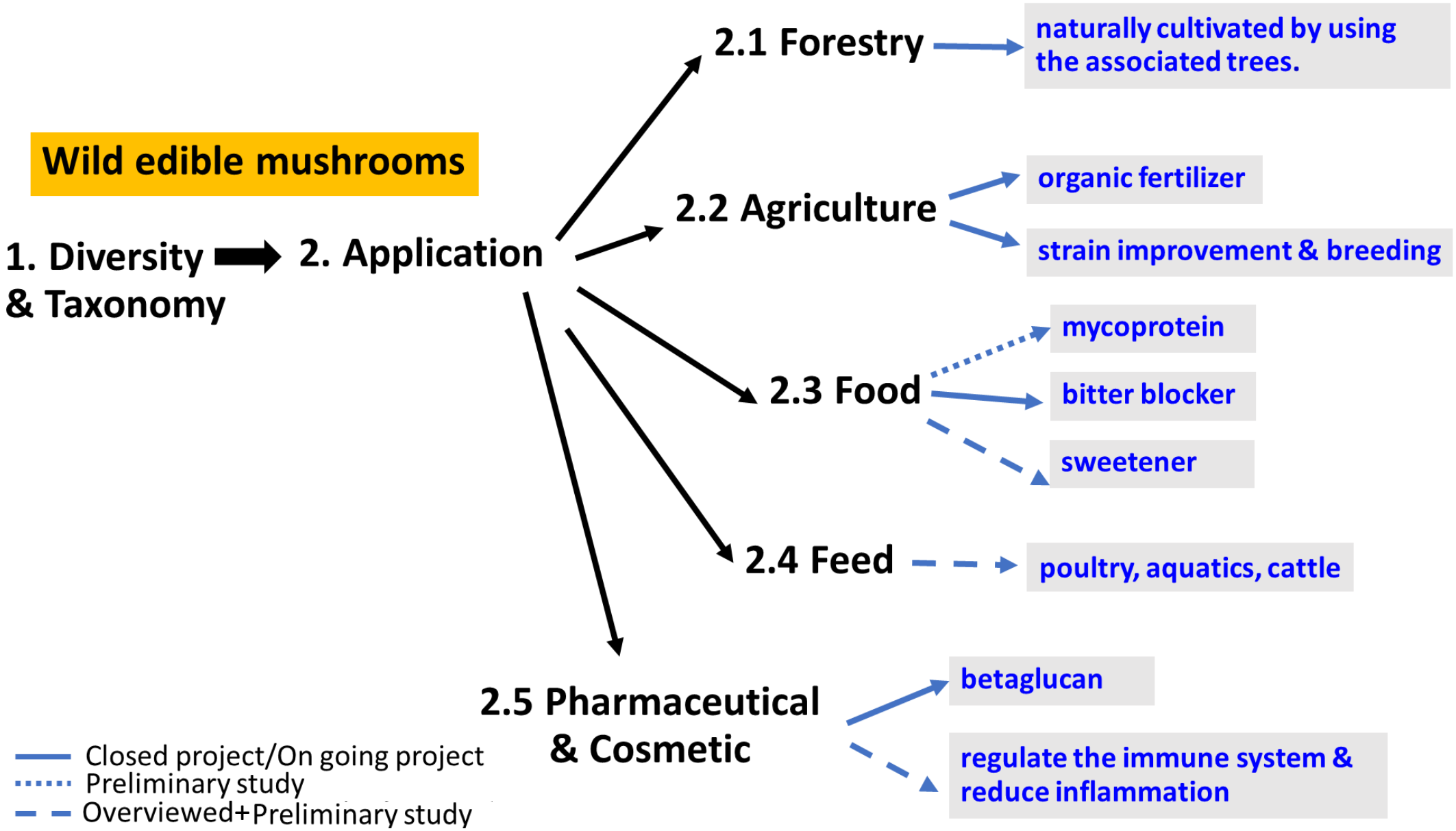
Fungal Planet 1666 – June 2024

Trechispora sanpatongensis sp. nov.



Colour illustrations: The deciduous dipterocarp forest, San Pa Tong district, Chiang Mai province, where the holotype was collected (background photo); Left top: Basidiomata growing on the soil of BBH 49634. Left bottom: Basidia. Centre: Basidia with basidiospores. Right bottom: Basidiospores, scanning electron photograph of spores from BBH 49635. Scale bars: basidiomata = 10 mm; basidia = 10 µm; basidiospores = 5 µm.

2. The utilization studies



Importance of wild edible mushrooms to the local villagers







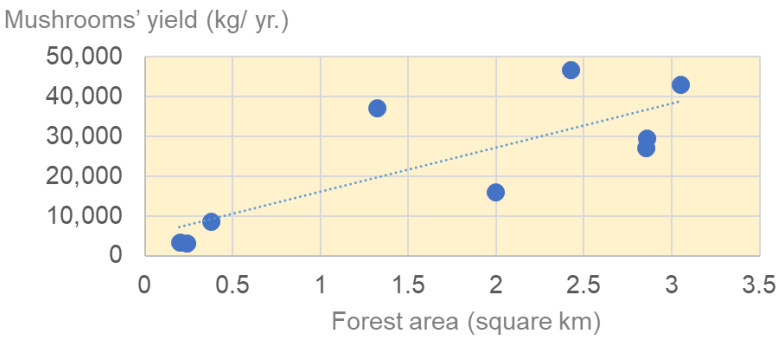


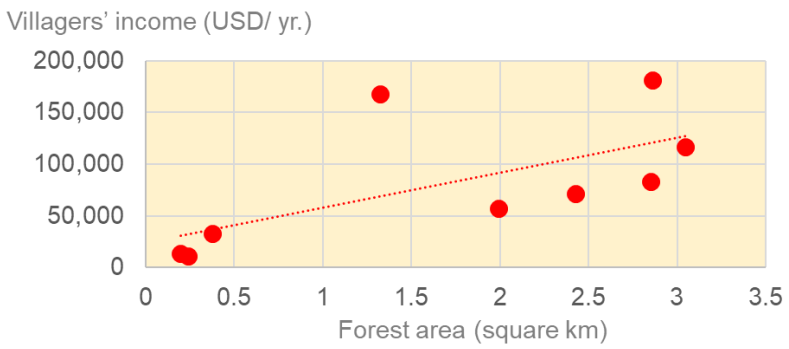


Local market price of some wild edible mushrooms

Mushrooms	Price (THB/kg)	Price (USD/kg)
Amanita	100-300	2.8- 8.3
Astraeus	120-350	3.3- 9.7
Auricularia auricula	60-90	1.7- 2.5
Boletus	40-150	1.1- 4.2
Clitocybe	30-100	0.8- 2.8
Craterellus	80-150	2.2- 4.2
Lactarius volemus	40	1.1
Lentinus polychrous	100-400	2.8- 11.1
Lentinus praerigidus	60-200	1.7- 5.6
Lentinus squarrosulus	80	2.2
Russula albida	80	2.2
Russula emitica	40-150	1.1- 4.2
Russula foetens	40-150	1.1- 4.2
Russula nigricans	40-100	1.1- 2.8
Termitomyces	120-200	3.3- 5.6
Termitomyces albiceps	80-400	2.2- 11.1
Termitomyces microcarpus	60-300	1.7- 8.3

Mushroom weights and values from 9 community forests in the northeastern and the west of Thailand



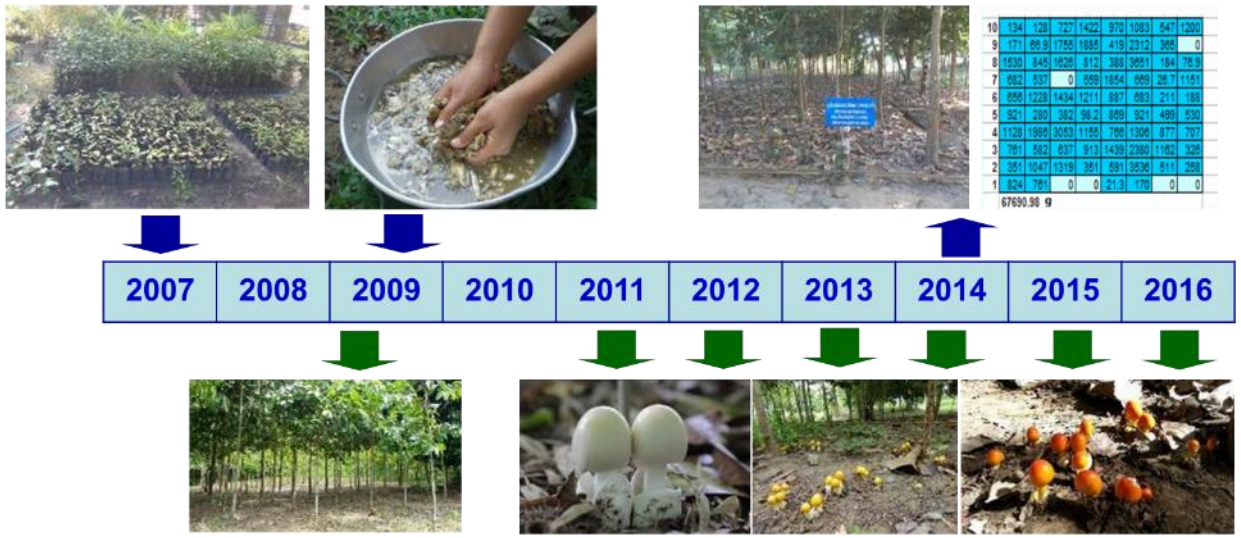


- **Wild mushrooms are usually a type of non-timber forest product with the most value.**

Forestry

Edible ectomycorrhizal mushrooms for reforestation and as food source of rural communities

The timeline of *Amanita* cultivation



2007: *Dipterocarpus alatus* seedlings were planted onto the bare land.

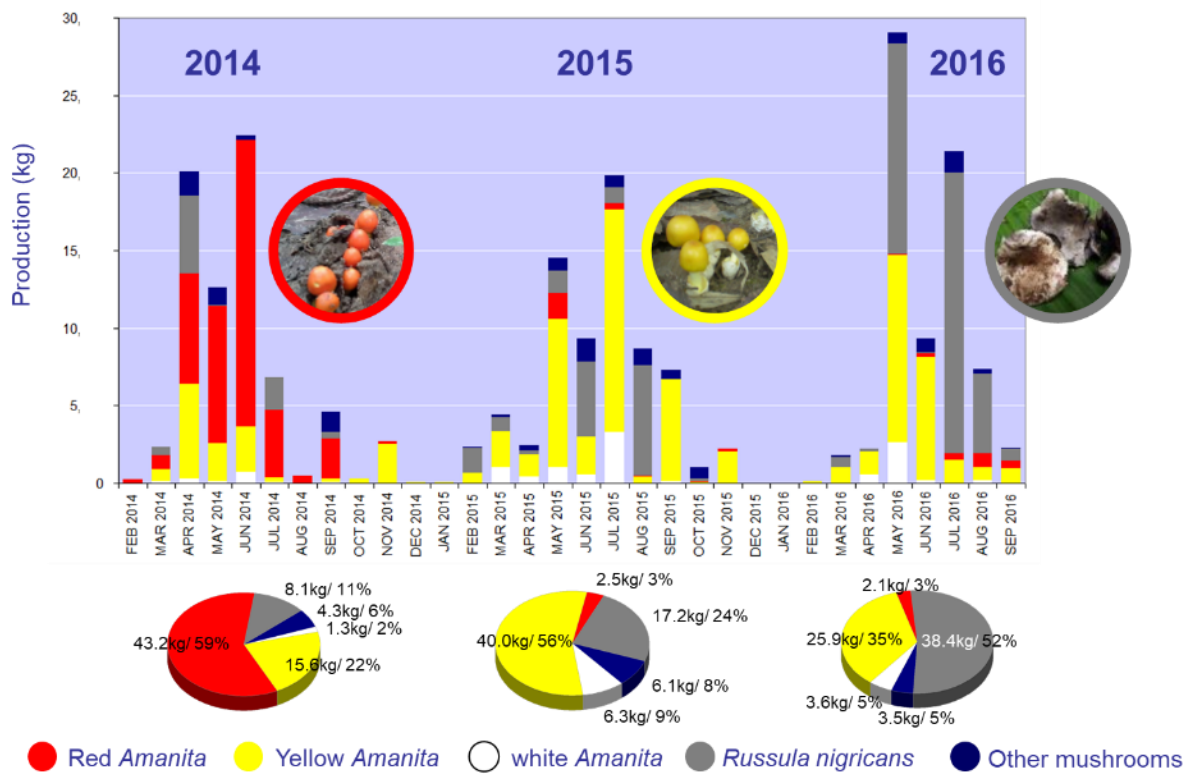
2009: Settlement of Dipterocarpus alatus

2009: The *Amanita* inoculum was inoculated into roots of *D. alatus.*

Since 2011: Occurrence of the *Amanita* caps

2014: The study plot was set and the mushroom productivity has been recorded.

Dynamic of edible mushroom productivity in the study plot



- **Many wild edible mushrooms can be naturally cultivated by using the associated trees.**
- **a source of food and provide income for villagers living around.**
- **provide food security, reduce the risk of harvesting poisoned mushrooms to consume and sale**

Some villagers learn to cultivate the mushrooms in their own land by our technology transfer.







White *Amanita* on a paddy-field ridge with a row of host trees, Sisaket province







Yellow *Amanita* in a dipterocarp plot, Surin province

Agriculture

Plant growth promotor (Organic fertilizer)



Mushroom mycelium, Bacteria, Actinomyces



Agricultural waste

Liquid Organic fertilizer (LOF)

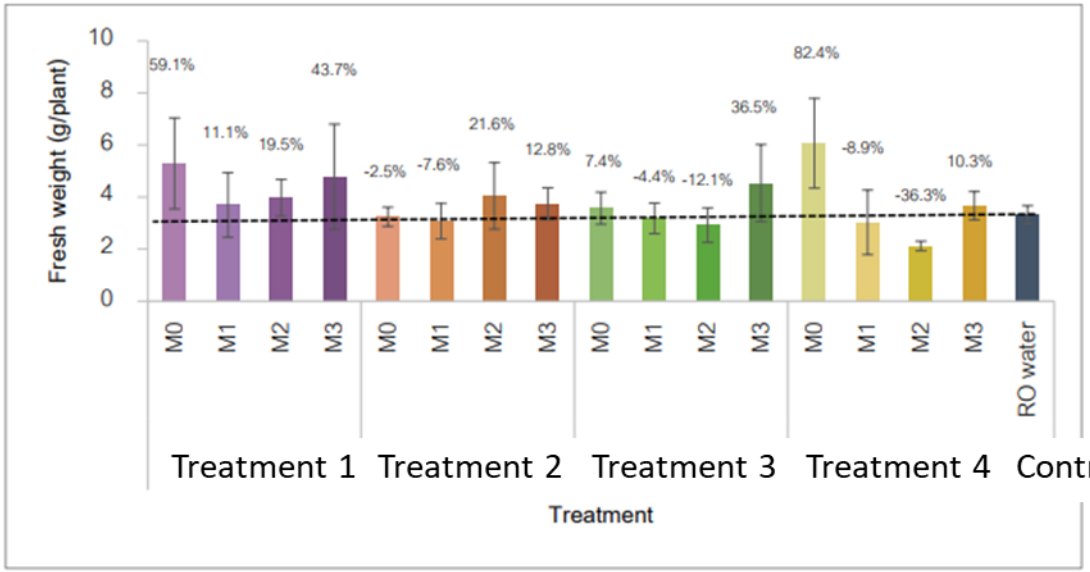


Greenhouse test

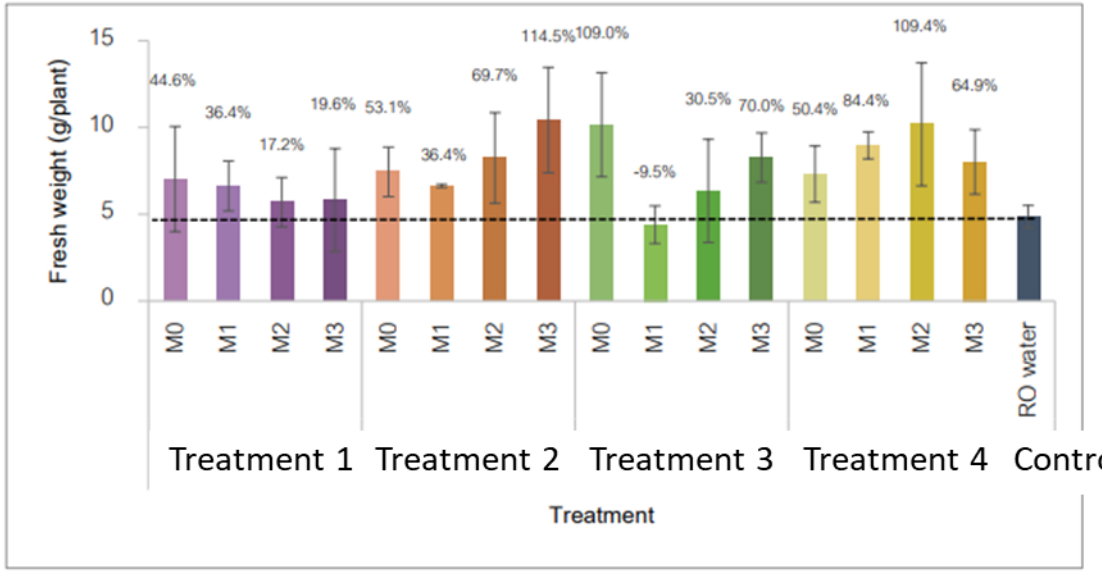


Field test

Chinese Kale - Nakhon Pathom

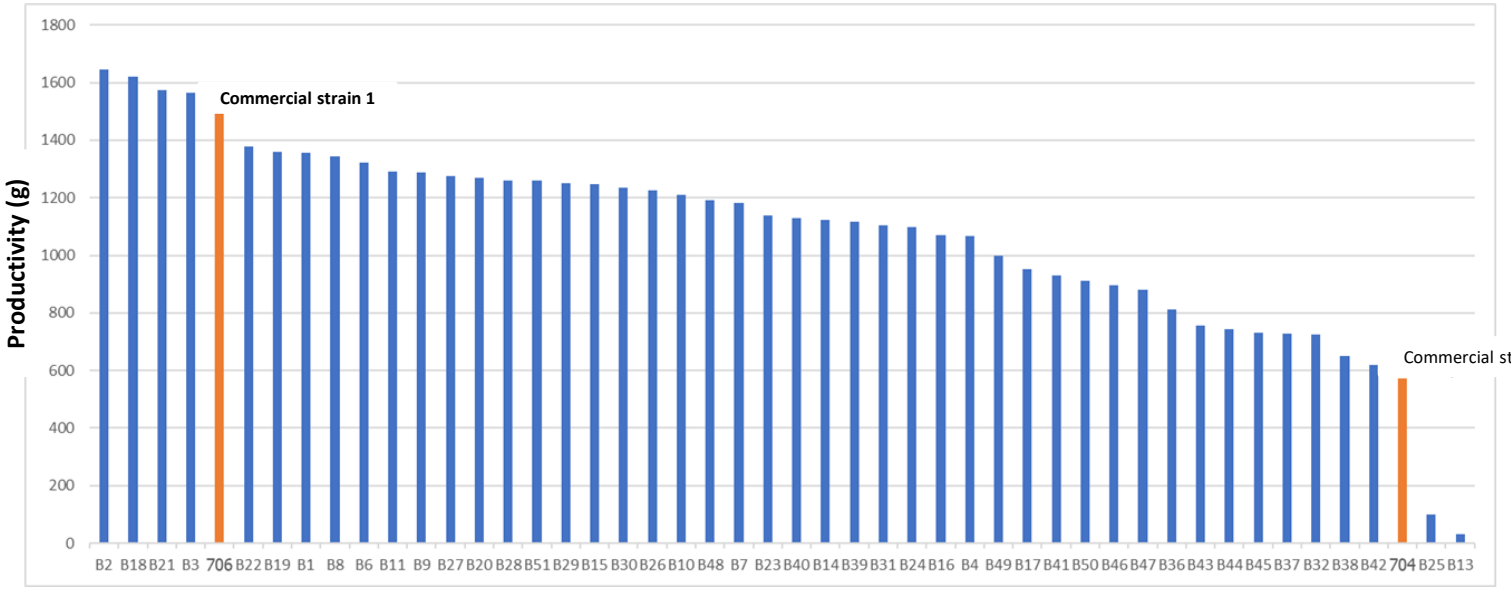


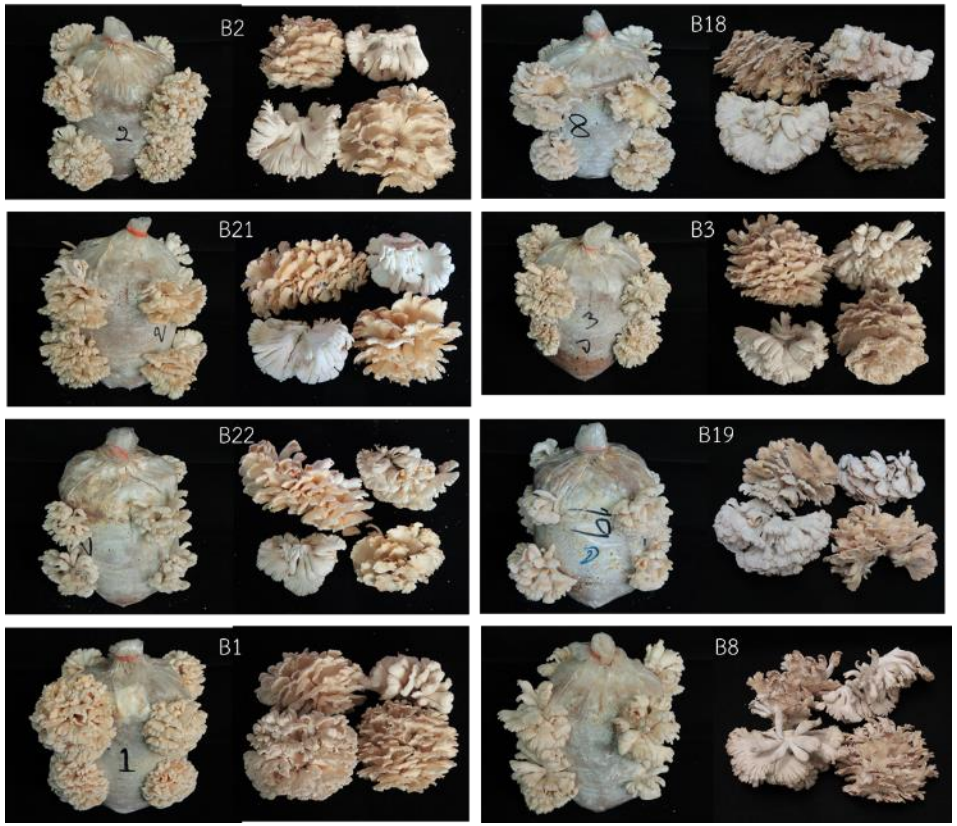
Chinese Kale - Ayutthaya



Agriculture

Strain improvement & breeding





Our breeding strains

- The higher productivity than commercial strains
- Size are larger than commercial strains
- The color are paler than commercial strains
- The mushroom cluster are larger than commercial strains
- The Taste better than commercial strains (No bitter when eaten raw
- The texture is better than commercial strains (Not as tough as commercial strains)
- Mild smell than commercial strains







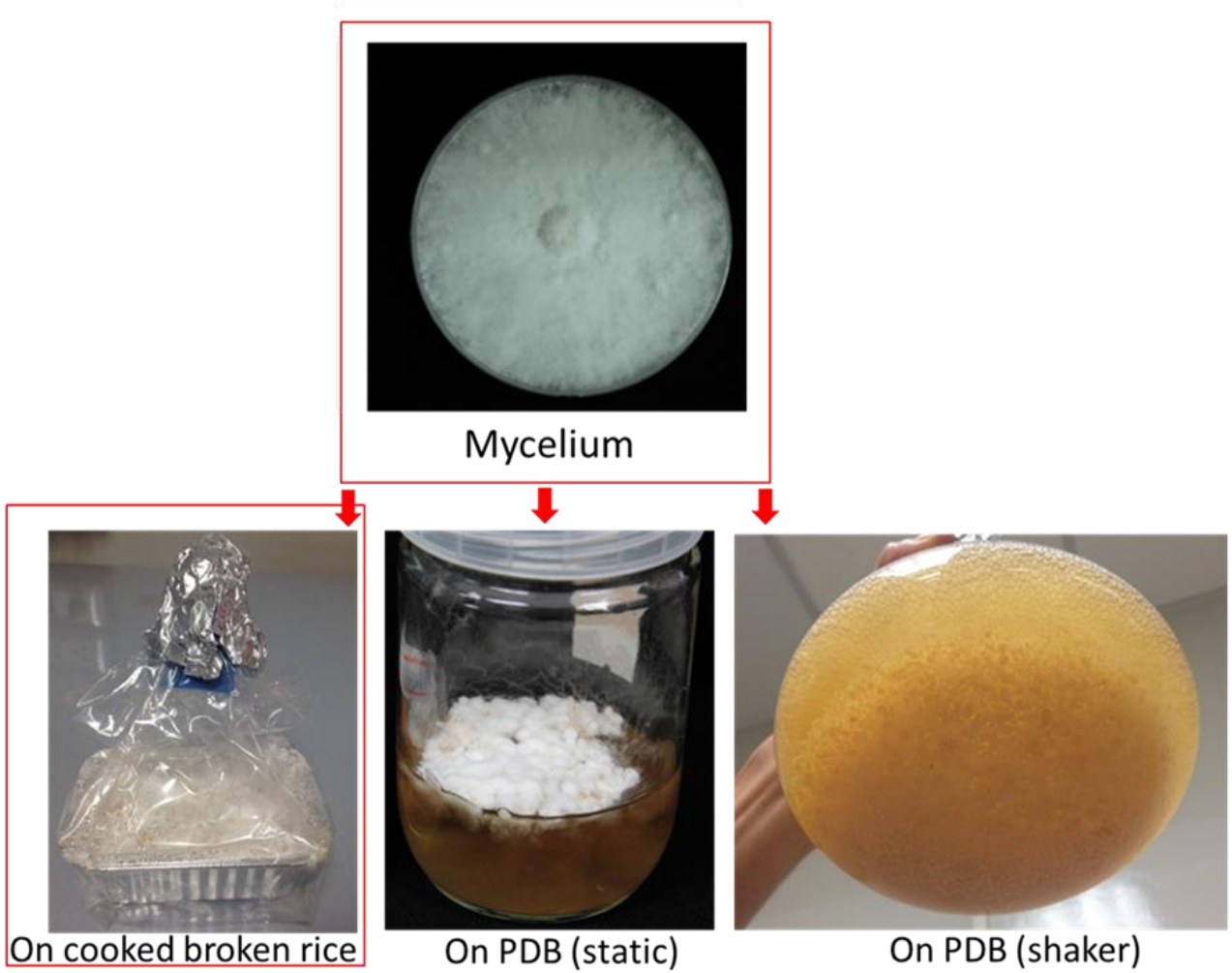




Sample plant-based meat products from our breeding strains

Food

Mushroom-based functional food products (mycoprotein)



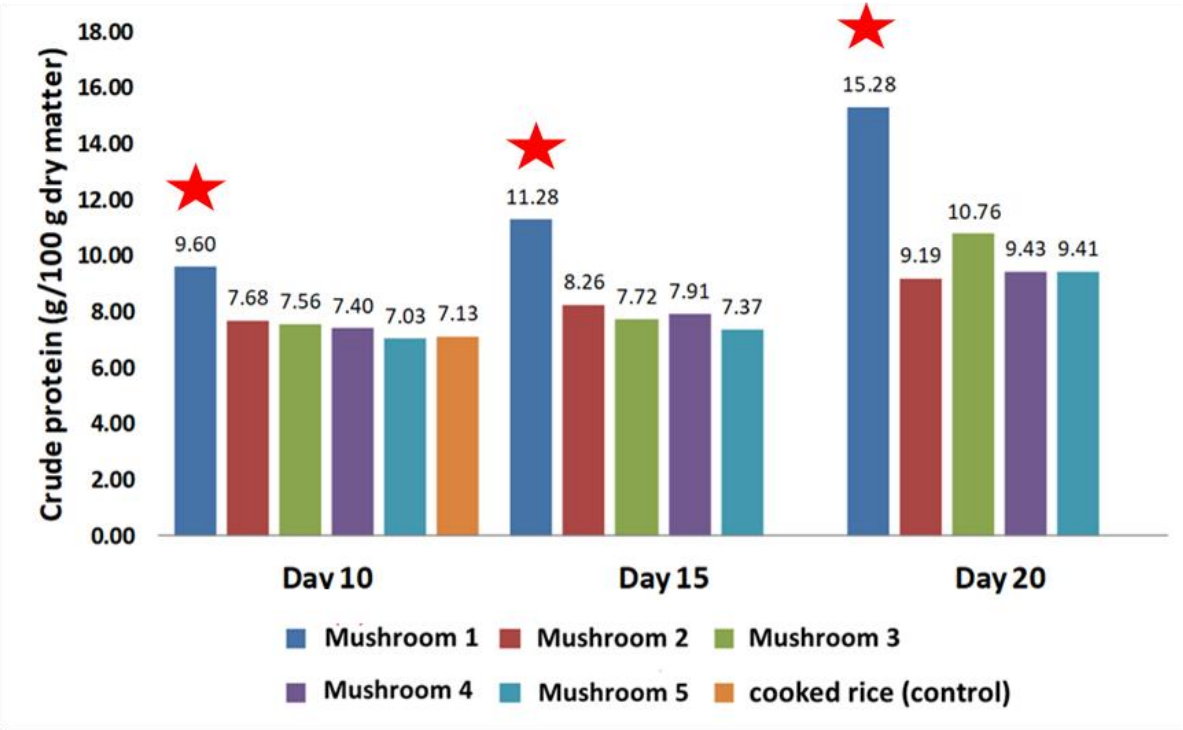


Figure 1 crude protein on dry basis of 5 mushrooms grown on cooked rice on Days 10, 15, and 20

Mushroom-based functional food products

Research and development

1. Strain selection of mushrooms (fast growing, odorless, phytase enzyme production)

2. Cultivation of mushroom mycelium on plant-based materials

Low-cost plant-based

Broken-milled rice:
high folate



preliminary study

3. Development of food products

4. Sensory testing (lab scale; 30-50 persons)

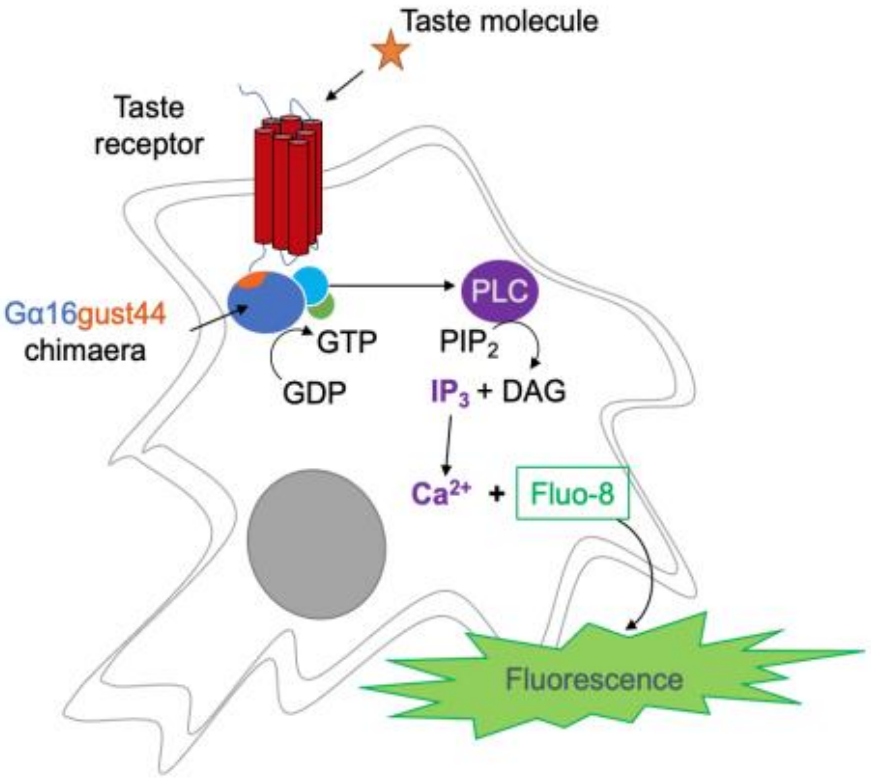
Products

1. Flour (protein content, amino acid content, low glycemic Index)



preliminary study from *Schizophyllum commune*

Bitter blocker

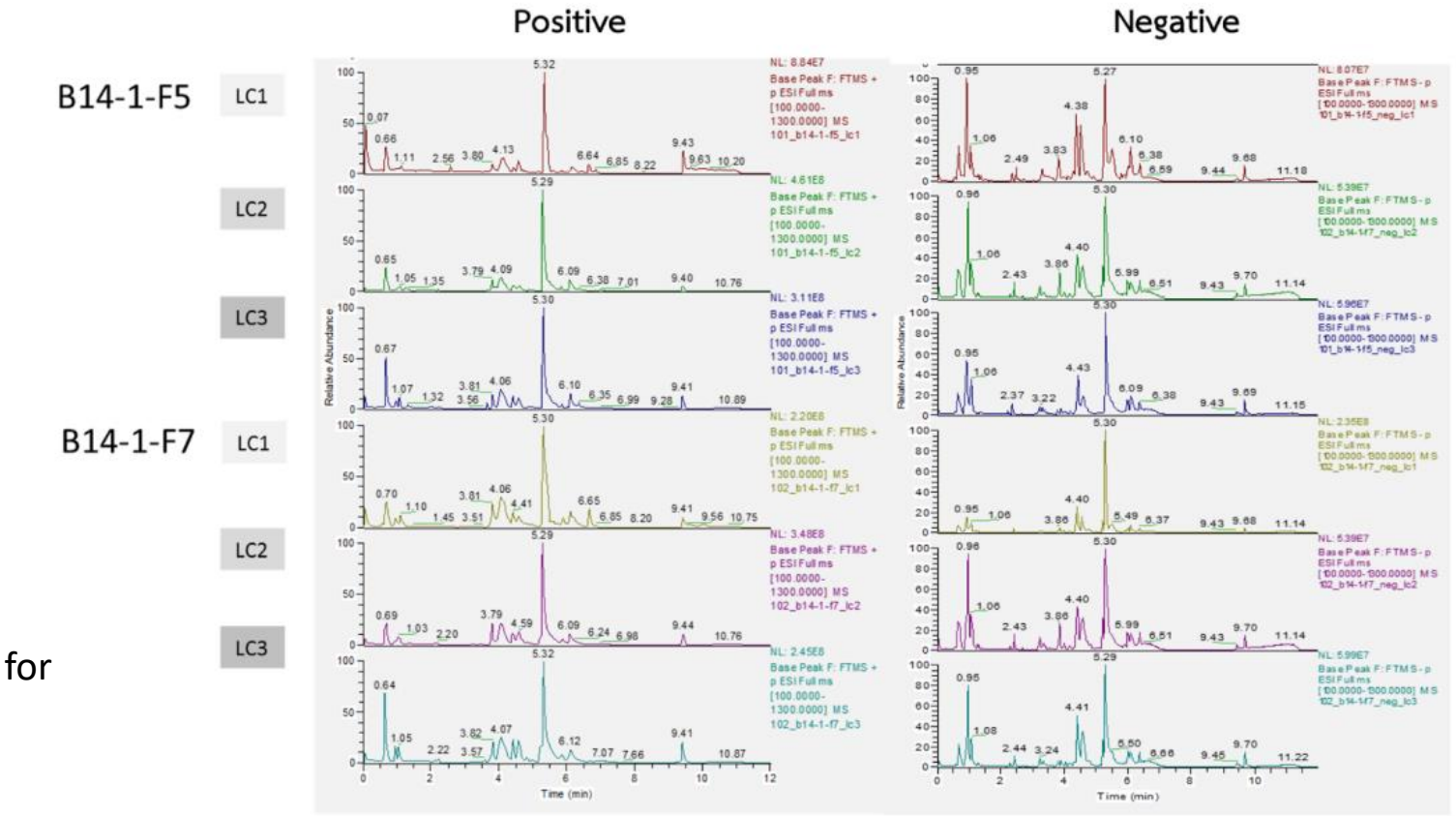


A schematic illustration of cell-based functional assay for bitter taste receptors.



Hericium erinaceus

(a) Stop time 1



Food

Sweetener

SWEETENERS IN MUSHROOMS

Bonnet, J.L. (1959). Bull. Soc. Mycol. France 75: 215-352.
'Occurrences of mannitol in *Amanita*, *Boletus*, *Coprinus*, *Lactarius*, *Polyporus*, *Russula*'

Niederpruem, D.J. & Hunt, S. (1967) Polyols in *Schizophyllum commune*. *Am. J. Bot 54: 241-245.*
'The mycelium contained glucose, fructose, mannitol and glycerol (strain 699), as well as arabitol (strain 845).'

Cho et al. (2014). J. Mushrooms 12 (4): 316-323
'Sugar and sugar alcohol contents (g/l) in fruiting bodies of edible and medicinal mushrooms'

	P.L.	C.M.	S.C.	H.E.	C.V.	P.R.	A.A.	T.F.	S.I.	L.E.	A.B.	P.E.	F.V.	P.O.	P.C.
Glucose	0	2.35	8.95	14.88	0	0	0	0	0	0	0	0	0	0	0
Fructose	1.5	0	2.23	119.96	0	0	0	0.8	0	34.43	0	0	92.68	0	0
Glycerol	0.69	0	3.76	4.40	3.05	6.11	7.01	14.76	12.32	44.03	0	69.74	3.57	0	15.21
Solbitol	0	0	0	0	0	0	0	0	0	0.07	0	0.1	0.72	0.23	0.28
Mannitol	0	0	0	0	0	0	0	0	0	1.03	2.96	0	0	0	0.78

P.L.: *Phellinus linteus*, C.M.: *Cordyceps militaris*, S.C.: *Sparassis crispa*, H.E.: *Hericium erinaceum*, C.V.: *Coriolus versicolor*, P.R.: *Phylloporia ribis*, A.A.: *Auricularia auricula-judae*, T.F.: *Tremella fucifomis*, S.I.: *Sarcodon imbricatus*, L.E, *Lentinus edodes*, A.B.: *Agaricus bisporus*, P.E.: *Pleurotus eryngii*, F.V.: *Flammulina velutipes*, P.O.: *Pleurotus ostreatus*, P.C.: *Pleurotus cornucopiae*. .





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SHROOM SWEETENER

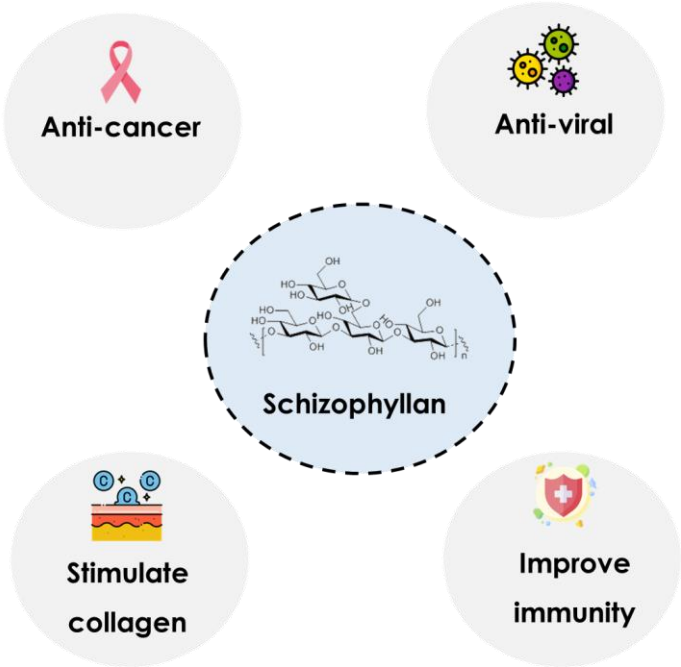
Mushroom Sweetener
AUSTRALIA

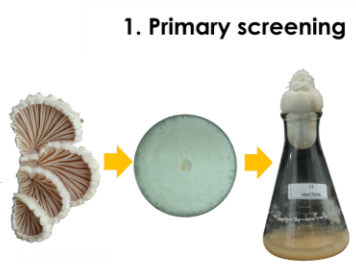
Pharmaceutical & Cosmetic

Betaglucan



Production of Schizophyllan by Liquid Cultures of *Schizophyllum commune*







- *S. commune* MMCR256 showed the highest schizophyllan production.
- There are 5 factors that effect the production: Glucose, Yeast Extract, Manganese sulfate & Trace element, Glutamic acid
- The results revealed greater production of schizophyllan to 10.39 g/L & biomass of 26.28 g/L.

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THANK YOU FOR YOUR ATTENTION

