Resources of Iranian agarics (Basidiomycota) with an outlook on their antioxidant potential

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Agaric fungi are an important group of macromycetes with diverse ecological and functional properties, yet are poorly studied in many parts of the world. Here, we comprehensively analyzed 558 agaric species in Iran to reveal their resources of edible and poisonous species as well as their ecological guilds and luminescence potential. We also made a thorough survey of the antioxidant activity of the species. Phylogenetic relationships were reconstructed based on nuclear ribosomal LSU and ITS sequences. Our results reveal that agarics of Iran comprise about 189 edible, 128 poisonous, 254 soil saprotrophic, 172 ectomycorrhizal, 146 wood-inhabiting, 18 leaf/litter-inhabiting, 9 parasitic, and 19 luminescent species. Twenty percent of the Iranian agaric species possess antioxidant activity, phylogenetically distributed in four orders and 21 agaric families. About 5% of the antioxidant species can be considered strong antioxidants, many of which are also edible and could be utilized to develop functional foods. This is the first study combining phylogeny and antioxidant potential of agaric mushrooms in a large scale, and the obtained results would guide the selection of agaric taxa to be examined in the future for taxonomic revisions, biotechnological applications, and applied phylogeny studies.

KEYWORDS
basidiomycetes, diversity, gilled mushrooms, ABTS assay, phylogeny

Introduction

Agarics are mushroom-forming fungi also called euagarics and their hymenium is formed on gills. They belong to the subdivision Agaricomycotina, class Agaricomycetes (Moncalvo et al., 2002; Bauer et al., 2006). They produce important natural substances used in agriculture (e.g., strobilurines), medicine (e.g., pleuromutilines), and biotechnology (e.g., polysaccharides; Pointing et al., 2001; Webster and Weber, 2007; Kück et al., 2014; Hyde et al., 2019; Sandargo et al., 2019). Agaricales is the largest fungal order of agaric mushrooms comprising ca. 13,000 known species (Kirk et al., 2008). Thorough investigations of the agarics phylogeny have recently been provided by He et al. (2019) and Varga et al. (2019). Some agarics are important model organisms for research in genetics and basidiome development such as Coprinopsis cinerea and Cyclocebe cylindrica (Herzog et al., 2019).
Among agarics, there are some of the most poisonous mushrooms such as Amanita phalloides, Cortinarius Subgen. Oreliani, and Inosperma erubescens, frequently mixed up with edible mushrooms during culinary collecting and thus causing severe fatalities. Nevertheless, there is a large number of edible agaric mushrooms highly prized for culinary purposes such as Agaricus campestris, Coprinus comatus, Cyclocybe cylindrica, Macrolepia procula, and the worldwide cultivated white button mushroom Agaricus bisporus. Several edible agaric species are saprotrophs and possible to cultivate, but there are also many edible species such as Russula spp. and Lactarius spp. which belong to the ectomycorrhizal ecological guild and thus not cultivable in artificial synthetic media. A number of species such as Lentinula edodes and Flammulina velutipes have culminated as functional mushrooms for developing mushroom-based functional foods and other valued mycochemicals (Chang, 1996; Cateni et al., 2022; Rodríguez-Seoane et al., 2022).

Numerous agarics have also been recognized as sources of antioxidant compounds (e.g., Ferreira et al., 2009; Asatiani et al., 2010; Guo et al., 2012; Wang and Xu, 2014; Sánchez, 2017; Islam et al., 2019; Thu et al., 2020). Antioxidant properties, or the ability to defend against and scavenge/reduce excess free radicals in biological systems, is among the important properties of living organisms and crucial for their survival (Xiao et al., 2020). Mushrooms as one of the most diverse natural antioxidant resources, have received attention in recent decades and are advantageous compared to plants because of their high diversity, fast growth, and culture possibilities (Gargano et al., 2017; Buswell, 2018).

A preliminary checklist of Iranian mushrooms appeared by Ghobad-Nejhad et al. (2020) listing 556 agaric and 29 bolete species. However, the species remain largely unexplored in terms of various important properties. Information about the edible, poisonous, and mycorrhizal agarics in Iran is principally lacking and currently, the antioxidant properties of Iranian agarics have remained largely unexplored.

Due to the lack of knowledge about the diversity of edible, poisonous, and mycorrhizal agarics in Iran, as well as their antioxidant properties, our study aimed to: (i) investigate Iranian agarics and reveal their resources of edible and poisonous species, (ii) present their ecological guilds and bioluminescence potential, and to (iii) explore the antioxidant properties of Iranian agarics and combine it with phylogenetic reconstructions. We believe our results would benefit a wide range of researchers involved in the study of agaric mushrooms.

### Materials and methods

#### Sampling and molecular study

Taxon sampling for the molecular study was primarily done based on the list by Ghobad-Nejhad et al. (2020), supplemented by additional data in the present study. Species current names and species authorities follow Index Fungorum¹ and MycoBank.² Microscopy and morphological studies followed Ghobad-Nejhad et al. (2020). Sequences of the 28S rRNA (nLSU) and the ITS region (covering ITS1, 5.8, and ITS2) were carefully selected from GenBank, with special attention to the quality-controlled sequences (Nilsson et al., 2012) as well as to the authentic sequences obtained from Iranian specimens. For DNA extraction, we sampled more than 20 specimens and 12 samples were successfully sequenced and used in this paper. Genomic DNA was extracted from dried basidiomata using the DNA Extraction Mini Kit (FAVORGEN, Taiwan). The primers used for the amplification cycles were ITS1F/ITS4B or ITS1F/ITS4 (White et al., 1990; Gardes and Bruns, 1993) for the ITS region and LR0R/LR7 or LR0R/LR5 (Hopple and Vilgalys, 1999) for partial nLSU region. All sequences used in the phylogenetic analyses are listed in Table 1.

Two concatenated datasets of nLSU + ITS were constructed, one representing the taxa belonging to the order Agaricales (dataset 1), and the other dataset for taxa of Cantharellales, Polyporales, and Russulales (dataset 2). Contumyces rosellus, the single Iranian agaric Hymenochaetales, was used as an outgroup for both datasets.

Sequences were aligned using MUSCLE (Madeira et al., 2019). To optimize the alignment, problematic columns were reduced with Noisy 1.5.12 (Dress et al., 2008) and were further identified and removed after careful visual inspection. Special attention was paid to excluding the poorly aligned columns of the ITS region and keeping the finely aligned parts. (Sequences of Amanita eliae, Mycena xantholeuca, Pluteus semibulbosus, and Tricholoma ustale were deleted from the final dataset due to poor alignment.)

### Phylogenetic analyses

The sequence datasets were analyzed using Bayesian inference (BI) executed in MrBayes v. 3.2.7a (Ronquist et al., 2012). MrModeltest 2.3 was implemented to infer the best-fit model of nucleotide evolution for each alignment partition in each dataset (Nylander, 2004). Bayesian analyses were run for 40 (dataset 1) and 20 (dataset 2) million generations for four Markov chain Monte Carlo simulations, in two independent runs at the CIPRES Science Gateway (Miller et al., 2010), with the trees and parameters sampled every 5,000 generations, and the first 25% of the generations were discarded as burn-in. Posterior probabilities (PPs) were calculated from the posterior distribution of the retained trees. Maximum likelihood analyses were executed in raxmlGUI v.1.3 (Silvestro and Michalak, 2010) with the same parameters as used by Ghobad-Nejhad et al. (2021). The Bayesian phylograms were retained for tree visualizations and annotations.

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1. www.indexfungorum.org
2. www.mycobank.org
### TABLE 1 Resources of agarics of Iran and their edibility (☺, edible; ☹, poisonous based on own observation in Iran; ☠*, edible if well-cooked but poisonous if raw; ☑, inedible; ○, uncertain or unknown), ecological guild (♠, soil saprotroph; ☼, ectomycorrhizal; ☐, wood-inhabiting; ♣, leaf/litter-inhabiting; ◙, parasitic), luminescence, and antioxidant potential (S, strong; M, moderate; W, weak; ND, not determined; full details provided in the text).

| Species                          | Edibility | Ecological guild | Luminescent | Antioxidant potential | GenBank accession no. |
|---------------------------------|-----------|------------------|-------------|-----------------------|-----------------------|
| *Agaricus arvensis* Schaeff.     | ☺         | ♠                | –           | S                     | MT535720 MH872779     |
| *Agaricus bisporus* (J.E. Lange) Imbach | ☺         | ♠                | –           | SM                    | ON952490 DQ071710     |
| *Agaricus bitorquis* (Quël.) Sac. | ☺         | ♠                | –           | SM                    | MT535709 MT554302     |
| *Agaricus brendelanus* Bobus     | ☺         | ♠                | –           | MW                    | DQ185569 MK277477     |
| *Agaricus brunneolus* (J.E. Lange) Pilát | ☺         | ♠                | –           | ND                    | KU975082 KX083997     |
| *Agaricus campestris* L.         | ☺         | ♠                | –           | SM                    | NR_151745.1 MH866030  |
| *Agaricus depauperatus* (F.H. Møller) Pilát | ☺         | ♠                | –           | ND                    | DQ182530 –            |
| *Agaricus devoniensis* P.D. Orton | ☺         | ♠                | –           | ND                    | EU363036 AF059225     |
| *Agaricus gennadii* (Chatin & Boud.) P. D. Orton | ☺          | ♠                | –           | ND                    | KT951318 KR006606     |
| *Agaricus iodosmus* Heinem.      | ☹         | ♠                | –           | S                     | MT535702 MT554295     |
| *Agaricus iranicus* Mahdizadeh, Safaie, Golhapih, L.A. Parra & Callac | ☽         | ♠                | –           | ND                    | KY474556 KY474559     |
| *Agaricus langei* (F.H. Møller) F.H. Møller | ☻         | ♠                | –           | ND                    | JF797181 –            |
| *Agaricus litoralis* (Wakef. & A. Pearson) Pilát | ☻         | ♠                | –           | ND                    | MT535711 MT554304     |
| *Agaricus moelleri* Wasser       | ☺         | ♠                | –           | ND                    | KX083997              |
| *Agaricus nevsi* Wasser          | ☺         | ♠                | –           | ND                    | MH173866 –            |
| *Agaricus phaeolepidotus* (F.H. Møller) F.H. Møller | ☸         | ♠                | –           | ND                    | MH862921 MH874494     |
| *Agaricus pseudoplatanus* (G. Moreno, Esteve-Rav., Illana & Heykoop) G. Moreno, L.A. Parra, Esteve-Rav. & Heykoop | ☺         | ♠                | –           | ND                    | KT951329 KT951453     |
| *Agaricus pseudoplatanus* (Bobus) Wasser | ☹         | ♠                | –           | S                     | ON952491 MT554325     |
| *Agaricus pseudoplatanus* (Peck) Peck | ☺         | ♠                | –           | M                     | KT951461              |
| *Agaricus subrufescens* Peck      | ☺         | ♠                | –           | ND                    | KT9824789 KR006612     |
| *Agaricus xanthodermus* Genev. | ☹         | ♠                | –           | ND                    | MN860126 MK277500     |
| *Agrocybe acericola* (Peck) Singer | ☾         | ♠                | –           | S                     | MT535714 MT554306     |
| *Agrocybe dura* (Bolton) Singer  | ☾         | ♠                | –           | S                     | MT535701 MT554306     |
| *Agrocybe ochracea* Nauta        | ☽         | ♠                | –           | ND                    | –                     |
| *Agrocybe pallidus* (J.E. Lange) Kühner & Romagn. ex Bon | ☽         | ♠                | –           | ND                    | –                     |
| *Agrocybe pediades* (Fr.) Fayo   | ☾         | ♠                | –           | M                     | ON952487 AY293582     |
| *Agrocybe praecox* (Pers.) Fayo  | ☽         | ♠                | –           | W                     | MT535701 MT554294     |
| *Agrocybe pusiola* (Fr.) R. Heim | ☽         | ♠                | –           | ND                    | DQ389732 MK277505     |

(Continued)
TABLE 1 (Continued)

| Species                                | Edibility | Ecological guild | Luminescent | Antioxidant potential | GenBank accession no. |
|-----------------------------------------|-----------|------------------|-------------|-----------------------|-----------------------|
| Agrocybe tabacina (DC.) Konrad & Maubl. | X         | ♠                | –           | ND                    | MW425942 MK277506    |
| Agrocybe vervacti (Fr.) Singer          | X         | ♠                | –           | ND                    | MW243076              |
| Alnicola escharioides (Fr.) Romagn.     | ○         | ○                | –           | ND                    | MZ868014 MK277560     |
| Amanita atkinsoniana Coker              | ○         | ○                | –           | ND                    | MH508267 MH486389     |
| Amanita battarrea (Boud.) Bon           | ○         | ○                | –           | M                     | MH505548 AF04443      |
| Amanita caesarea (Scop.) Pers.          | ○         | ○                | –           | ND                    | OK299150 OK299170     |
| Amanita crocea (Quel.) Singer           | ○         | ○                | –           | M                     | KJ638266 –            |
| Amanita eliae Quel.                     | ○         | –                | ND          | –                     | KF780872 –            |
| Amanita excelsa (Fr.) Bertill.          | ○         | –                | ND          | –                     | MW258873 MW258922     |
| Amanita gemmata (Fr.) Bertill.          | ○         | –                | ND          | –                     | MK580689 AF044457     |
| Amanita lividopallescens (Secr. ex Boud.) | ◄      | ☹               | –           | ND                    | MT535691 MW013165     |
| Amanita pantherina (DC.) Krombh.        | ○         | ♠                | –           | M                     | FR832274 MH486743     |
| Amanita phalloides (Fr.) Link           | ○         | ○                | –           | ND                    | KX449212 KX449230     |
| Amanita rubescens Pers.                 | ○         | ○                | –           | S                     | FR852273 MH486816     |
| Amanita streniformis (Paulet ex Vittad.) Bertill. | ○     | X                | –           | ND                    | MH508614 MH486895     |
| Amanita umbrinoluta (Secr. ex Gillet)   | ○*        | ♠                | –           | ND                    | MH508641 MH486937     |
| Bataille                                | ○*        | ♠                | –           | ND                    | MH508641 MH486937     |
| Amanita vaginata (Bull.) Lam. s.l.      | ○*        | ♠                | –           | M                     | JF907756 –            |
| Amanita verna (Bull.) Lam.              | ○         | –                | ND          | –                     | EU909448 HQ539755     |
| Ampulloclitocybe clavipes (Pers.) Redhead, | ○       | ♠                | –           | ND                    | AF789808 AY639881     |
| Lutzoni, Moncalvo, and Vilgalys         | ○         | ♠                | –           | ND                    | AF789808 AY639881     |
| (seems to be toxic after consumption with alcohol) |           |                  |             |                       |                       |
| Armillaria borealis Marxm. & Korhonen   | ○*        | ♠                | –           | ND                    | KF960524 FJ618728     |
| Armillaria cepistipes Velen.            | ○*        | ♠                | –           | ND                    | FJ903313 KY488767     |
| Armillaria gallica Marxm. & Romagn.     | ○*        | ♠                | –           | ND                    | MW418538 AM269818     |
| Armillaria mellea (Vahl) P. Kumm.       | ○*        | ♠                | –           | ND                    | AF163583 AM269819     |
| Arrenia griseopallida (Desm.) Watling   | ○         | ♠                | –           | ND                    | –                     |
| Asterotheca lycoperdoides (Bull.) Ditmar | X         | ♠                | –           | ND                    | MZ159455 MK277604     |
| Atheloffia flavoalba (Fr.) Redhead,     | X         | ♠                | –           | ND                    | MH857185 MH867232     |
| Moncalvo, Vilgalys, Desjardin, and B.A. Perry |       |                  |             |                       |                       |
| Baeopora myosura (Fr.) Singer           | X         | ♠                | –           | ND                    | MH856301 MH867849     |
| (on conifer cones)                      |           |                  |             |                       |                       |
| Battarrea steventi (Libosch.) Fr.       | X         | ♠                | –           | ND                    | AF215648 –            |
| Bolbitius reticulatus (Pers.) Ricken    | X         | –                | ND          | –                     | JX968249 JX968366     |
| Bolbitius titubans (Bull.) Fr.          | X         | ♠                | –           | ND                    | KR425522 KR425552     |
| Calocybe carneea (Bull.) Donk            | ○         | ♠                | –           | ND                    | AF357028 MK277666     |
| Calocybe chrysenteron (Bull.) Singer    | X         | ♠                | –           | ND                    | KP885639 KP885628     |
| Calocybe gambona (Fr.) Donk             | ○         | ♠                | –           | W                     | MZ159691 AM946414     |
| Calocybe simulans (Bull.) Donk           | ○         | ♠                | –           | ND                    | JF907780 MK277668     |

(Continued)
| Species                                           | Edibility | Ecological guild | Luminescent | Antioxidant potential | GenBank accession no. |
|--------------------------------------------------|-----------|------------------|-------------|-----------------------|-----------------------|
| Callocybe persicolor (Fr.) Singer                 | X         | ♠                | –           | ND                    | KP192564              |
|                                                 |           |                  |             |                       | AF223176              |
| Candellicybe candolleanus (Fr.) D. Wächt. & A. Melter | X         | ♠                | –           | S                     | MT535718              |
|                                                 |           |                  |             |                       | MT534309              |
| Cantharellus alborufescens (Malençon) Papetti & S. Alberti | ♠         |                  | –           | M                     | MH463257              |
|                                                 |           |                  |             |                       | MH463258              |
| Cantharellus cibarius Fr.                        | X         | ♠                | –           | SM                    | KX907204              |
|                                                 |           |                  |             |                       | KX828805              |
| Cantharellus ferruginascens PD. Orton            | X         | ♠                | –           | ND                    | MH463294              |
|                                                 |           |                  |             |                       | MH463295              |
| Chlorophyllum brunneum (Farl. & Burt) Vellinga   | ☹         | ♠                | –           | ND                    | MG742013              |
|                                                 |           |                  |             |                       | MG742022              |
| Chlorophyllum rhacodes (Vittad.) Vellinga        | ☹         | ♠                | –           | M                     | AY081236              |
|                                                 |           |                  |             |                       | AY176345              |
| Clitocybe angustissima (Lasch) P. Kumm. Clitocybe barbularum (Romagn.) P.D. Orton | ☹         | ♠                | –           | ND                    | –                     |
|                                                 |           |                  |             |                       | –                     |
| Clitocybe diatreta (Fr.) P. Kumm.                | ☹         | ♠                | –           | ND                    | –                     |
|                                                 |           |                  |             |                       | –                     |
| Clitocybe metachroa (Fr.) P. Kumm.               | X         | ♠                | –           | ND                    | –                     |
|                                                 |           |                  |             |                       | –                     |
| Clitocybe nubicolor (Batsch) P. Kumm.            | ☹         | ♠                | –           | S                     | –                     |
|                                                 |           |                  |             |                       | –                     |
| Clitocybe phyllephila (Pers.) P. Kumm.           | ☹         | ♠                | –           | ND                    | –                     |
|                                                 |           |                  |             |                       | –                     |
| Clitocybe rufodolatracea Métrod ex Bon           | ☹         | ♠                | –           | ND                    | –                     |
|                                                 |           |                  |             |                       | –                     |
| Clitocybe vibescus (Fr.) Quel.                   | X         | ♠                | –           | ND                    | –                     |
|                                                 |           |                  |             |                       | –                     |
| Clitopaxillus alexandri (Gillet) G. Moreno, Vizzini, Consiglio & P. Alvarado | ☹         | ♠                | –           | W                     | MG321345              |
|                                                 |           |                  |             |                       | MG321393              |
| Clitopilus prunulus (Scop.) P. Kumm.             | ☹         | ♠                | –           | M                     | –                     |
|                                                 |           |                  |             |                       | –                     |
| Collybia tuberosa (Bull.) P. Kumm.               | X         | ♠                | –           | ND                    | –                     |
|                                                 |           |                  |             |                       | –                     |
| Conocybe albipes (G.H. Orth) Hauskn.             | X         | ♠                | –           | ND                    | –                     |
|                                                 |           |                  |             |                       | –                     |
| Conocybe apala (Fr.) Arnolds                     | ♠         | ♠                | –           | ND                    | –                     |
|                                                 |           |                  |             |                       | –                     |
| Conocybe dunensis T.J. Wallace                   | X         | ♠                | –           | ND                    | –                     |
|                                                 |           |                  |             |                       | –                     |
| Conocybe juniana (Velen.) Hauskn. & Svrček       | X         | ♠                | –           | ND                    | –                     |
|                                                 |           |                  |             |                       | –                     |
| Conocybe leucopus Kühner ex Kühner & Watling     | X         | ♠                | –           | ND                    | –                     |
|                                                 |           |                  |             |                       | –                     |
| Conocybe macrocephala Kühner & Watling           | X         | ♠                | –           | ND                    | –                     |
|                                                 |           |                  |             |                       | –                     |
| Conocybe microspora Kühner ex Singer             | X         | ♠                | –           | ND                    | –                     |
|                                                 |           |                  |             |                       | –                     |
| Conocybe ochracea Kühner ex Singer               | X         | ♠                | –           | ND                    | –                     |
|                                                 |           |                  |             |                       | –                     |
| Conocybe olivaceopleaitea E.F. Malysheva*        | X         | ♠                | –           | ND                    | –                     |
|                                                 |           |                  |             |                       | –                     |
| Conocybe pilisella (Pers.) Kühner                | X         | ♠                | –           | ND                    | –                     |
|                                                 |           |                  |             |                       | –                     |
| Conocybe rickenii (Jul. Schaff.) Kühner          | X         | ♠                | –           | ND                    | –                     |
|                                                 |           |                  |             |                       | –                     |
| Conocybe subovalis Kühner & Watling              | X         | ♠                | –           | ND                    | –                     |
|                                                 |           |                  |             |                       | –                     |
| Conocybe tenera (Schaeff.) Fayod                  | ☹         | ♠                | –           | M                     | –                     |
|                                                 |           |                  |             |                       | –                     |
| Contumyces rosellus (M.M. Moser) Redhead, Moncalvo, Vilgalys, and Lutzoni | ☹         | ♠                | –           | ND                    | –                     |
|                                                 |           |                  |             |                       | –                     |
| Coprinellus angulatus (Peck) Redhead             | X         | ♠                | –           | ND                    | –                     |
|                                                 |           |                  |             |                       | –                     |

(Continued)
| Species                                 | Edibility | Ecological guild | Luminescent | Antioxidant potential | GenBank accession no. | ITS        | nLSU       |
|-----------------------------------------|-----------|------------------|-------------|-----------------------|-----------------------|------------|------------|
| *Coprinellus disseminatus* (Pers.) J.E. Lange | X         |                  |             | ND                    | MK050584              | AY207180  |
| *Coprinellus domesticus* (Bolton) Vilgalys, Hopple & Jacq. Johnson | X ☉       |                  |             | S                     | MH856480              | MH868019  |
| *Coprinellus flocculosus* (DC.) Vilgalys, Hopple & Jacq. Johnson | X         |                  |             | ND                    | FN396138              | FN396208  |
| *Coprinellus impatiens* (Fr.) J.E. Lange | X         |                  |             | ND                    | MH856810              | MH868327  |
| *Coprinellus micaceus* (Bull.) Vilgalys, Hopple & Jacq. Johnson | X ☉       |                  |             | S                     | ON952489              | MT554289  |
| *Coprinellus radians* (Desm.) Vilgalys, Hopple & Jacq. Johnson | X         |                  |             | ND                    | KU375662              | KM272009  |
| *Coprinellus silvaticus* (Peck) Gminder | X         |                  |             | ND                    | HQ846986              | HQ847072  |
| *Coprinellus subimpatiens* (M. Lange & A.H. Sm.) Redhead, Vilgalys, and Moncalvo | X         |                  |             | ND                    | MH857001              | MH868522  |
| *Coprinellus truncorum* (Scop.) Redhead, Vilgalys, and Moncalvo | X         |                  |             | S                     | FM878007              | FM876263  |
| *Coprinellus xanthothrix* (Romagn.) Vilgalys, Hopple & Jacq. Johnson | X         |                  |             | ND                    | JN943112              | JN159595  |
| *Coprinopsis atramentaria* (Bull.) Redhead, Vilgalys, and Moncalvo (toxic after consumption with alcohol) | ☀ ☀       |                  |             | SM                    | MH259864              | FN396172  |
| *Coprinopsis brumaeolirosa* (Dennis) Redhead, Vilgalys, and Moncalvo | X         |                  |             | ND                    | JX118664              | JX118817  |
| *Coprinopsis cinerea* (Schaeff.) Redhead, Vilgalys, and Moncalvo | X         |                  |             | M                     | MF161131              | KM272007  |
| *Coprinopsis ephemeroides* (DC.) G. Moreno | X         |                  |             | ND                    | --                    | --        |
| *Coprinopsis friesi* (Quel.) P. Karst. | X         |                  |             | ND                    | --                    | FN396191  |
| *Coprinopsis gonophylla* (Quel.) Redhead, Vilgalys & Moncalvo | X         |                  |             | ND                    | MH856188              | MH867714  |
| *Coprinopsis lagopodi* (P. Karst.) Redhead, Vilgalys & Moncalvo | X         |                  |             | ND                    | MN892574              | AF041488  |
| *Coprinopsis lagopus* (Fr.) Redhead, Vilgalys & Moncalvo | X         |                  |             | ND                    | MH856194              | MH867720  |
| *Coprinopsis macrocephala* (Berk.) Redhead, Vilgalys & Moncalvo | X         |                  |             | ND                    | FN396126              | FN396175  |
| *Coprinopsis marcesciblitis* (Britzelm.) Orstadius & E. Larss. | X         |                  |             | ND                    | ON952484              | FM876278  |
| *Coprinopsis martensii* (P.D. Orton) Redhead, Vilgalys & Moncalvo | X         |                  |             | ND                    | GU234126              | --        |
| *Coprinopsis niveo* (Pers.) Redhead, Vilgalys & Moncalvo | X         |                  |             | ND                    | HQ847032              | HQ847117  |
| *Coprinopsis patouillardii* (Quel.) Gminder | X         |                  |             | ND                    | FN396150              | FN396197  |
| *Coprinopsis pisana* (Bull.) Redhead, Vilgalys & Moncalvo | X ☉       |                  |             | S                     | JN943110              | JQ45885   |
| *Coprinopsis sclerotiger* (Watling) Redhead, Vilgalys & Moncalvo | X         |                  |             | ND                    | MF161091              | MF161132  |

(Continued)
TABLE 1 (Continued)

| Species | Edibility | Ecological guild | Luminescent | Antioxidant potential | GenBank accession no. |
|---------|-----------|------------------|-------------|-----------------------|-----------------------|
| Species | Edibility | Ecological guild | Luminescent | Antioxidant potential | GenBank accession no. |
| Coprinopsis scobicola (P.D. Orton) Redhead, Vilgalys & Moncalvo | X | ♦ | – | ND | HQ847021 HQ847106 |
| Coprinopsis ursicola (Berk. & Broome) Redhead, Vilgalys & Moncalvo | X | ♣ | – | ND | MH300615 HQ847101 |
| Coprinus comatus (O.F. Müll.) Pers. | (considered edible in Europe and also cultivated) |
| Coprinus sterquilinus (Fr.) Fr. | X | ♠ | – | ND | MH854689 |
| Cortinarius bivelus (Fr.) Fr. | X | ☀ | – | ND | FR852016 |
| Cortinarius caesiocortinatus Jul. Schäff. | X | ☀ | – | ND | FR852020 |
| Cortinarius casimirii (Velen.) Huijsman | X | ☀ | – | ND | FR851999 |
| Cortinarius cinnabarinus Fr. | X | ☀ | – | ND | HE687043 |
| Cortinarius cinnamomeus (L.) Gray | □ | ☀ | – | ND | NR_131816 KC842483 |
| Cortinarius cotonus Fr. | ☀ | ☀ | – | ND | KC842423 KC842493 |
| Cortinarius decipiens Fr. | X | ☀ | – | ND | HE687042 |
| Cortinarius diasemospermus Lamoure | X | ☀ | – | ND | NR_131875 MK277631 |
| Cortinarius ferrugineovelatus Kytöv., Limmat. & Niskanen | X | ☀ | – | ND | |
| Cortinarius fluvi (M.M. Moser) M.M. Moser | □ | ☀ | – | ND | |
| Cortinarius hildegardiae Schmidt-Stohn, Brandrud & Dima | □ | ☀ | – | ND | MT535704 MT554297 |
| Cortinarius hornuca Fr. | X | ☀ | – | ND | |
| Cortinarius infractus (Pers.) Fr. | X | ☀ | – | ND | |
| Cortinarius olivaceofuscus Kühner | □ | ☀ | – | ND | |
| Cortinarius paracaphehilitous Böhus | X | ☀ | – | ND | |
| Cortinarius parvannulatus Kühner | X | ☀ | – | ND | |
| Cortinarius persoonianus Bidaud | □ | ☀ | – | ND | |
| Cortinarius plururion Jul. Schäff. ex M.M. Moser | X | ☀ | – | ND | |
| Cortinarius uraceonemoralis Niskanen, Limmat., Dima, Kytöv., Bojantchev & H. Lindstr. | □ | ☀ | – | ND | |
| Cortinarius vulgus Fr. | X | ☀ | – | ND | MT935583 |
| Cortinarius versius H. Lindstr. & Melot | X | ☀ | – | ND | MW263848 MW263545 |
| Cortinarius vespertinus (Fr.) Fr. | X | ☀ | – | ND | KC842457 KC842527 |
| Cortinarius vibratilis (Fr.) Fr. | X | ☀ | – | ND | KC842440 KC842510 |
| Crepidotus violaceus (L.) Gray | □ | ☀ | – | W | NR_173726 MK277758 |
| Craterellus cinereus (Pers.: Fr.) Maire | □ | ☀ | – | ND | |
| Craterellus cornucopioides (L.) Pers. | □ | ☀ | – | SM | JF907967 MN227282 |
| Craterellus tubaeformis (Fr.) Quél. | □ | ☀ | – | S | HM468493 MT797698 |
| Crepidotus applanatus (Pers.) P. Kumm. | X | | | ND | MH855941 MH867439 |
| Crepidotus caeputi Velen. | X | | | ND | MW722982 AF205678 |
| Crepidotus cesati (Rabenh.) Sac. | X | | | ND | JF907962 MK277881 |
| Crepidotus crocophyllus (Berk.) Sac. | X | | | ND | FJ598825 AF367939 |
| Crepidotus mollis (Schaeff.) Staude | X | | | ND | AM882996 AM882996 |

(Continued)
| Species                                      | Edibility | Ecological guild | Luminescent | Antioxidant potential | GenBank accession no. |
|---------------------------------------------|-----------|------------------|-------------|-----------------------|-----------------------|
| Crepidotus subverrucisporus Pilát           | X         |                  | –           | ND                    | MT535745 AF67948      |
| Crinellis scabella (Alb. & Schwein.) Murrill| X         |                  | –           | ND                    | MH857177 MH868716     |
| Capnocybe virgineus (Wulfen) Kovalenko      | ☀         | ☀                | –           | ND                    | MT535688 MT554284     |
| Cyepcybe cyliniata (DC.) Vizzini & Angelini | ☀         |                  | –           | MW                    | ON952480 ON930146     |
| Cystoderma aereus (Matt.) Kühner & Romagn.  | ☀ X       | ☀                | –           | ND                    | MH864957 MH876401     |
| (generally edible, but some health problems described after eating) |
| Deconica cappella (Bull.) P.Karst.           | ☀ X       | ☀                | –           | ND                    | MH855878 MH867388     |
| Deconica cymbula (Fr.) Romagn.               | X         | ☀                | –           | ND                    | MT535747 MH867478     |
| Delicatula integella (Pers.) Fayod           | X         | ☀                | –           | ND                    | MZ159362 MK277924     |
| Dermoloma cuneiformum (Fr.) Singer ex Bon    | X         | ☀                | –           | ND                    | MW193843 –            |
| Echinoderma asperum (Pers.) Bon              | ☀         | ☀                | –           | W                     | MH856136 MH867652     |
| (frequently eaten in the Czech Republic, considered poisonous in China) |
| Entoloma griseorubellum (Lasch)             | ☀ ⊙       | ⊙                | –           | ND                    | KC710059 KC710136     |
| Entoloma hirtipes (Schumach. M.M. Moser     | X         | ☀                | –           | ND                    | MN088710 MN088715     |
| Entoloma hirtipes (Schumach. M.M. Moser     | ⊙         | ⊙                | –           | ND                    | – –                  |
| Entoloma majalesis P.D. Orton                | X         | ☀                | –           | ND                    | MW633049 MW633049     |
| Entoloma mammosum (L.) Moser                | ⊙         | ⊙                | –           | ND                    | – –                  |
| Entoloma niphoides Noordel.                  | X         | ☀                | –           | ND                    | – –                  |
| Entoloma rhidophillum (Fr.) P. Kumm.         | ☀         | ⊙                | –           | ND                    | – –                  |
| Entoloma sericellum (Fr.) P. Kumm.          | X         | ☀                | –           | ND                    | KC898453 GQ289190     |
| Entoloma sinuatum (Bull. ex Pers.) P. Kumm.  | ⊙         | ⊙                | –           | ND                    | KC710116 KC710134     |
| Entoloma vernum (S. Lundell)                 | ⊙         | ⊙                | –           | ND                    | MF476911 MF487802     |
| Flammula abnica (Fr.) P. Kumm.               | ⊙ ⊙       | ⊙                | –           | ND                    | MH862103 MH873792     |
| (considered edible in the Czech Republic)    |            |                  | –           | ND                    | – –                  |
| Flammula alnicola (Pers.) P. Kumm.           | ☀ ⊙       | ⊙                | –           | ND                    | – –                  |
| (considered edible in the Czech Republic)    |            |                  | –           | ND                    | – –                  |
| Flammula eumutis (Curtis) Singer             | ☀ ⊙       | ⊙                | –           | ND                    | MH453494 –            |
| Galerina hypnorum (Schrank) Kühner           | ☀         | ☀                | –           | ND                    | OL717128 MK299406     |
| Galerina marginata (Batsch) Kühner           | ☀ ⊙       | ⊙                | –           | ND                    | MK3462103 MK346279    |

(Continued)
| Species                                    | Edibility | Ecological guild | Luminescent | Antioxidant potential | GenBank accession no. | nLSU |
|--------------------------------------------|-----------|------------------|-------------|-----------------------|-----------------------|------|
| Galerina mniophila (Lasch) Kühner          | X         | ♣                | –           | ND                    | AJ585456             | AJ71514 |
| Galerina pumila (Pers.) M. Lange           | X         | ♣                | –           | ND                    | AJ585477             | AJ71546 |
| Galerina sphagnorum (Pers.) Kühner         | X         | ♣                | –           | ND                    | AJ585455             | AJ71510 |
| Gymnopus penetrans (Fr.) Murrill           | ☹         | ♣                | –           | W                     | KR011987             | KR011988 |
| (considered inedible in the Czech Republic) |           |                  |             |                       |                      |      |
| Gymnopus spectabilis (Weinm.) A.H. Sm.    | ☹         | ♣                | –           | S                     | MT535703             | MT554296 |
| (considered inedible in the Czech Republic) |           |                  |             |                       |                      |      |
| Gymnopilus androsaceus (L.) J.L. Mata & R.H. Petersen | X         | ☹                | –           | ND                    | MH657176             | MH686715 |
| Gymnopilus aquosus (Bull.) Antonin & Noordel. | ☹         | ♣                | –           | ND                    | MT535700             | MT554293 |
| Gymnopilus brassicolenus (Romagn.) Antonin & Noordel. | X         | ☹                | –           | ND                    | MZ088117             | MK278106 |
| Gymnopilus dryophilus (Bull.) Murrill      | ☹         | ♣                | –           | W                     | MH589967             | MH589985 |
| (considered poisonous in China)             |           |                  |             |                       |                      |      |
| Gymnopilus erythropus (Pers.) Antonin, Halling & Noordel. | ☹         | ♣                | –           | ND                    | JX536136             | AY207167 |
| Gymnopilus foetidus (Sowerby) J.L. Mata & R.H. Petersen | X         | ☹                | –           | ND                    | KY026682             | KY026682 |
| Gymnopilus fusipes (Bull.) Gray            | ☹         | ♣                | –           | W                     | KY026727             | KY026727 |
| (only young basidiomata edible)             |           |                  |             |                       |                      |      |
| Gymnopilus hybridus (Kühner & Romagn.) Antonin & Noordel. | X         | ☹                | –           | ND                    | MT535705             | MT554299 |
| Gymnopilus inodorus (Pat.) Antonin & Noordel. | X         | ☹                | –           | ND                    | –                   | –     |
| Gymnopilus tergeus (Fr.) Antonin & Noordel. | X         | ☹                | –           | ND                    | –                   | MK278118 |
| Hebeloma birrus (Fr.) Gillet               | ☹         | ♣                | –           | ND                    | JF908029             | –     |
| Hebeloma crustuliniforme (Bull.) Quél.     | ☹         | ♣                | –           | ND                    | MH865615             | MH867674 |
| Hebeloma hiemale Bres.                     | ☹         | ♣                | –           | ND                    | KT591536             | KT591556 |
| Hebeloma incarnatum A.H. Sm.               | ☹         | ♣                | –           | ND                    | KX687211             | –     |
| Hebeloma mesophacum (Pers.) Quél.          | ☹         | ♣                | –           | ND                    | NR_173705            | MK880553 |
| Hebeloma sinapizans (Paullet) Gillet       | ☹         | ♣                | –           | M                     | KT391542             | KT591562 |
| (most frequently wood-inhabiting)           |           |                  |             |                       |                      |      |
| Hemimycena cuscullata (Pers.) Singer       | X         | ☹                | –           | ND                    | DQ484066             | DQ457679 |
| Hidrophilus hymenozgicus (A.H. Sm. & Heder) Birkebak & Adamčík | X         | ☹                | –           | ND                    | KU355304             | KU355389 |
| Hohenbuehelia atrocoerulea (Fr.) Singer    | X         | ☹                | –           | ND                    | KU525860             | KU534052 |
| Hohenbuehelia auriscalpum (Maire) Singer   | X         | ☹                | –           | ND                    | –                   | –     |
| Hohenbuehelia petroleides (Bull.) Schulzer | ☹         | ♣                | –           | ND                    | NR_173155            | KU355402 |
| Homophoron spadiceum (P. Kumm.) Singer     | X         | ☹                | –           | ND                    | MK968340             | MN028523 |
| Oistadus & E. Larss.                       | ☹         | ♣                | –           | ND                    | DQ490627             | DQ457674 |
| (Continued)                                |           |                  |             |                       |                      |      |
### TABLE 1 (Continued)

| Species | Edibility | Ecological guild | Luminescent | Antioxidant potential | GenBank accession no. |
|---------|-----------|------------------|-------------|-----------------------|-----------------------|
|         |           |                  |             |                       | ITS                   |
|         |           |                  |             |                       | nLSU                  |
| Hygrophorus acutoconica (Clem.) Singer | ☑ | ♦ | – | ND | OK157438 MK278174 |
| Hygrophorus chlorophana (Fr.) Wünsche | ☑ | ♦ | – | ND | JF908052 MK278164 |
| Hygrophorus esereus (Bull.) Fr. | ☑ | ♦ | – | S | MK088116 AF430279 |
| Hygrophorus mesotephrus Berk. & Broome | ☑ | ♦ | – | ND | MT981695 – |
| Hygrophorus persoonii Arnolds | ☑ | ♠ | – | ND | JF907808 – |
| Hymenoliceps radiatus (Relhan) R.H. Petersen | ☑ | ♣ | – | W | FJ967808 AY207211 |
| Hygrophorus eburneus (Bull.) Fr. | ☑ | ☼ | – | SM | MT535706 MT554300 |
| Hygrophorus mesotephrus Berk. & Broome | ☑ | ☼ | – | SM | MH856121 MH866989 |
| Hygrocybe acutoconica (Clem.) Singer | ☑ | ☼ | – | ND | OK157438 MK278174 |
| Hygrocybe chlorophana (Fr.) Wünsche | ☑ | ☼ | – | ND | JF908052 MK278164 |
| Hygrocybe esereus (Bull.) Fr. | ☑ | ☼ | – | S | MK088116 AF430279 |
| Hygrocybe mesotephrus Berk. & Broome | ☑ | ☼ | – | ND | MT981695 – |
| Hygrocybe persoonii Arnolds | ☑ | ♠ | – | ND | JF907808 – |
| Hymenoliceps radiatus (Relhan) R.H. Petersen | ☑ | ♣ | – | W | FJ967808 AY207211 |
| Hygrophorus eburneus (Bull.) Fr. | ☑ | ☼ | – | SM | MT535706 MT554300 |
| Hygrophorus mesotephrus Berk. & Broome | ☑ | ☼ | – | SM | MH856121 MH866989 |

(Continued)
### TABLE 1 (Continued)

| Species                          | Edibility | Ecological guild | Luminescent | Antioxidant potential | GenBank accession no. | ITS | nLSU |
|----------------------------------|-----------|------------------|-------------|-----------------------|-----------------------|-----|------|
| *Inosperma bongardii* (Weinm.) Matheny & Esteve-Rav. | ☹          | ☀                | –           | ND                    | FN550943               |     |      |
| *Inosperma cookei* (Bres.) Matheny & Esteve-Rav. | ☹          | ☀                | –           | ND                    | AM882956               |     |      |
| *Inosperma erubescens* (A. Blytt) Matheny & Esteve-Rav. | ☹          | ☀                | –           | ND                    | AM882951               |     |      |
| *Inosperma maculatum* (Boud.) Matheny & Esteve-Rav. | ☹          | ☀                | –           | ND                    | MH578017               |     |      |
| *Laccaria amethystina* Cooke     | ☀          | ☀                | –           | W                     | KU685654               |     |      |
| *Laccaria bicolor* (Maire) P.D. Orton | ☀          | ☀                | –           | ND                    | KM067831               |     |      |
| *Laccaria laccata* (Scop.) Cooke | ☀          | ☀                | –           | W                     | KM067835               |     |      |
| *Laccaria tortilis* (Bolton) Cooke | ☀          | ☀                | –           | ND                    | MG519533               |     |      |
| *Lacrymaria lacrymabunda* (Bull.) Pat. | ☹ ☒          | ☀                | –           | ND                    | MK968341               |     |      |
| *Lactarius acris* (Bolton) Gray  | X          | ☀                | –           | ND                    | JQ446084               |     |      |
| *Lactarius circellatus* Fr.      | X          | ☀                | –           | ND                    | FR852038               |     |      |
| *Lactarius delicious* (L.) Gray  | ☹          | ☀                | –           | W                     | KI769672               |     |      |
| *Lactarius fulvissimus* Romagn.  | X          | ☀                | –           | ND                    | FR852027               |     |      |
| *Lactarius rubrocinctus* Fr.     | X          | ☀                | –           | ND                    | UDB005472               |     |      |
| *Lactarius scrobiculatus* (Scop.) Fr. | ☹ ☒          | ☀                | –           | ND                    | KX441098               |     |      |
| *Lactarius serifulus* (DC.) Fr.  | ☹          | ☀                | –           | ND                    | KT165294               |     |      |
| *Lactarius subulicus* (Pers.) Gray | ☹ ☒          | ☀                | –           | ND                    | KX395722               |     |      |
| *Lactarius tabidus* Fr.          | ☹          | ☀                | –           | ND                    | KT165309               |     |      |
| *Lactarius zonarius* (Bull.) Fr. | ☹ ☒          | ☀                | –           | ND                    | FR852035               |     |      |
| *Lactatius glaucescens* (Crossl.) Verbeken | X          | ☀                | –           | ND                    | MT533681               |     |      |
| *Lactatius piperatus* (L.) Roussel | ☹ ☒          | ☀                | –           | SM                    | KF220122               |     |      |
| *Lactatius vellereus* (Fr.) Kuntze | ☹ ☒          | ☀                | –           | SM                    | KF220123               |     |      |
| *Lactatius velemus* (Fr.) Kuntze | ☹          | ☀                | –           | W                     | JQ343936               |     |      |
| *Lentinellus cochleatus* (Pers.) P. Karst. | ☹          | ☀                | –           | ND                    | AF506417               |     |      |
| *Lentinellus serinus* (Fr.) Kühner | ☹          | ☀                | –           | ND                    | MI857168               |     |      |
| *Lentinellus vulpinus* (Sowerby) Kühner & Maire | ☹          | ☀                | –           | ND                    | AS51R230               |     |      |
| *Lentinus cyathiformis* (Schaeff.) Bres. | ☹          | ☀                | –           | ND                    | KM411461               |     |      |
| *Lentinus lepideus* (Fr.) Fr. (inedible in Europe) | ☹          | ☀                | –           | M                     | KM411454               |     |      |
| *Lentinus sajor-caju* (Fr.) Fr. (inedible in Europe) | ☹          | ☀                | –           | MW                    | OL771731               |     |      |
| *Lentinus tigrinus* (Bull.) Fr. (inedible in Europe) | ☹          | ☀                | –           | SM                    | ON952481               |     |      |
| Species                              | Edibility | Ecological guild | Luminescent | Antioxidant potential | GenBank accession no. |
|--------------------------------------|-----------|------------------|-------------|-----------------------|----------------------|
| Lepiota anthomyces (Berk. & Broome)  | ○         | ♠                | –           | ND                    | –                    |
| L. brunneoincarnata Chodat & C. Martin | ○         | ♠                | –           | ND                    | MK651615 MK685374    |
| L. castanea Quail.                   | ○         | ♠                | –           | ND                    | MK685380 MK651688    |
| L. cristata (Bolton) P. Kamm.        | X         | ♠                | –           | ND                    | LT716026 KY418841    |
| L. echinella Quail. & G.E. Bernard   | X         | ♠                | –           | ND                    | AY176366 AY176367    |
| L. felina (Pers.) P. Karst.          | ○         | ♠                | –           | ND                    | MK685381 MK278264    |
| L. helveola Bres.                    | ○         | ♠                | –           | ND                    | MH979466 –           |
| L. leprca (Berk. & Broome) Sacc.     | ○         | ♠                | –           | ND                    | –                    |
| L. blaceae Bres.                     | ○         | ♠                | –           | ND                    | AY176379 AY176380    |
| L. metulipora (Berk. & Broome)       | ○         | ♠                | –           | ND                    | EU681778 MK651673    |
| L. micropholis (Berk. & Broome)      | X         | ♠                | –           | ND                    | –                    |
| L. subalba Kühner ex P.D. Orton      | X         | ♠                | –           | ND                    | AY176489 –           |
| L. subincarnata J.E. Lange           | ○         | ♠                | –           | ND                    | U85329 U85294        |
| L. irina (Fr.) H.E. Bigelow          | ○         | ♠                | –           | ND                    | –                    |
| (edible/inedible in the Europe)      |           |                  |             |                       |                      |
| L. nuda (Bull.) Cooke                | ○         | ♠                | –           | SM                    | KU215619 DQ071713    |
| L. saeva (Fr.) P.D. Orton            | ○         | ♠                | –           | ND                    | MK785234 MH878430    |
| L. squamosus (Pers.) Bridge & Spooner| ○         | ♠                | –           | ND                    | MH043620 MH036179    |
| Leucoagaricus americanus (Peck) Vellinga | ○     | ♠                | –           | ND                    | MT573394 AF482891    |
| Leucoagaricus badhamii (Berk. & Broome) Singer | ○     | ♠                | –           | ND                    | GQ329056 –           |
| Leucoagaricus carneifolius (Gillet) Wasser | X   | ♠                | –           | ND                    | –                    |
| Leucoagaricus heliospilotus (Berk. & Broome) Bon | ○   | ♠                | –           | ND                    | –                    |
| Leucoagaricus leucothites (Vittad.) Wasser | ○   | ♠                | –           | SM                    | MT535726 MT554316    |
| (reported edible in Turkey by Aslim and Oztrak (2011); edible but sometimes caused health problems) | |                  |             |                       |                      |
| Leucoagaricus nympharum (Kalchbr.) Bon | ○     | ♠                | –           | ND                    | EU416310 EU416311    |
| Leucoagaricus roseafulbus (Henn.) Heinem. | ○     | ♠                | –           | ND                    | –                    |
| Leucoagaricus serenus (Fr.) Bon & Bouffard | ○  | ♠                | –           | ND                    | AY176420 AF482893    |
| Leucocoprinus bennonianus (Corda) Singer | ○   | ♠                | –           | ND                    | MH861267 MH873036    |
| Leucocoprinus brebissonii (Godey) Locq. | ○   | ♠                | –           | ND                    | AF482859 AY176446    |
| Leucocoprinus cepistipes (Sowerby) Pat. | X   | ♠                | –           | ND                    | LT716023 KY418838    |
| Leucocoprinus magnusianus (Henn.) Singer | ○  | ♠                | –           | ND                    | –                    |

(Continued)
TABLE 1 (Continued)

| Species                         | Edibility | Ecological guild | Luminescent | Antioxidant potential | GenBank accession no.          |
|---------------------------------|-----------|------------------|-------------|-----------------------|-------------------------------|
|                                 |           |                  |             |                       | ITS                           |
|                                 |           |                  |             |                       | nLSU                          |
| Leucocybe candicans (Pers.) Vizzini, P. Alvarado, G. Moreno & Consiglio | ☀️         | ♠️               | –            | ND                    | KJ681027                      |
|                                 |           |                  |             |                       | KJ681051                      |
| Leucocybe houghtonii (W. Phillips) Halama & Pencakowski            | X         | ♠️               | –            | ND                    | KY474108                      |
| Leucopaxillus compactus (P. Karst.) Neuhoff                       | X         | ♠️               | –            | ND                    | –                             |
| Leucopaxillus giganteus (Sowerby) Singer                          | ☀️         | ♠️               | –            | M                     | JQ639151                      |
|                                 |           |                  |             |                       | JQ639152                      |
| Leucopaxillus piniola J. Favre                                     | ☀️         | ♠️               | –            | ND                    | –                             |
| Lyophyllum atratum (Fr.) Singer                                    | X         | ♠️               | –            | ND                    | KJ461896                      |
|                                 |           |                  |             |                       | KJ461895                      |
| Lyophyllum baceaspernum Romagn.                                     | X         | ♠️               | –            | ND                    | –                             |
| Macrolepiota gigantea (Massoe) Pegler & Lodge                     | ☀️         | ♠️               | –            | S                     | MG867660                      |
|                                 |           |                  |             |                       | AF042591                      |
| Macrolepiota excoriata (Schaeff.) Wasser                           | ☀️         | ♠️               | –            | MW                    | U85313                        |
|                                 |           |                  |             |                       | U85278                        |
| Macrolepiota mastoida (Fr.) Singer                                 | ☀️         | ♠️               | –            | MW                    | HM125532                      |
|                                 |           |                  |             |                       | MH867678                      |
| Macrolepiota permixta (Barla) Pacioni                             | ☀️         | ♠️               | –            | ND                    | HQ412661                      |
|                                 |           |                  |             |                       | –                             |
| Macrolepiota procera (Scop.) Singer                               | ☀️         | ♠️               | –            | SM                    | ON952483                      |
|                                 |           |                  |             |                       | AM946456                      |
| Marasmiellus candidus (Fr.) Singer                                 | ☀️         | ♠️               | –            | ND                    | –                             |
| Marasmiellus confluens (Pers.) J.S. Oliveira                       | X         | ♠️               | –            | ND                    | –                             |
|                                 |           |                  |             |                       | –                             |
| Marasmiellus peronatus (Bolton) J.S. Oliveira                     | X         | ♠️               | –            | S                     | AY256706                      |
|                                 |           |                  |             |                       | –                             |
| Marasmiellus ramealis (Bull.) Singer                              | X         | ⬜️               | –            | ND                    | –                             |
| Marasmius atroabens (Berk.) Mont.                                  | X         | ⬜️               | –            | ND                    | –                             |
| Marasmius corrugiformis Singer                                     | X         | ⬜️               | –            | ND                    | –                             |
| Marasmius epiphyllus (Pers.) Fr.                                   | X         | ⬜️               | –            | ND                    | –                             |
| Marasmius favoloides Henn.                                         | X         | ⬜️               | –            | ND                    | –                             |
| Marasmius ferruginieus Berk. & M.A. Curtis                         | X         | ⬜️               | –            | ND                    | –                             |
| Marasmius haematocephalus (Mont.) Fr.                             | X         | ⬜️               | –            | ND                    | –                             |
| Marasmius oreades (Bolton) Fr.                                     | ☀️         | ♠️               | –            | SM                    | LT716048                      |
| Marasmius rotula (Scop.) Fr.                                       | X         | ⬜️               | –            | ND                    | JN943598                      |
| Marasmius rubriflavus (Theiss.) Singer                             | X         | ⬜️               | –            | ND                    | JN941147                      |
| Marasmius wynneae Berk. & Broome                                    | ☀️         | ♠️               | –            | ND                    | FJ904979                      |
| Megacollybia platyphylla (Pers.) Kotl. & Mair                      | ☀️         | ♠️               | –            | ND                    | MT535698                      |
|                                 |           |                  |             |                       | MT554291                      |
| Melanoleuca cognata (Fr.) Konrad & Maubl.                          | ☀️         | ♠️               | –            | ND                    | –                             |
| Melanoleuca excissa (Fr.) Singer                                   | ☀️         | ♠️               | –            | S                     | MT535742                      |
| Melanoleuca gramminicola (Velen.) Kühner & Maire                  | ☀️         | ♠️               | –            | ND                    | JN616438                      |

(Continued)
| Species                                                                  | Edibility | Ecological guild | Luminescent | Antioxidant potential | GenBank accession no. | ITS          | nLSU          |
|-------------------------------------------------------------------------|-----------|------------------|-------------|-----------------------|-----------------------|--------------|---------------|
| Melanoleuca grammopodia (Bull.) Fayod                                  | ☺         | ♠                | –           | ND                    | JF908351              | MH868277     |
| Melanoleuca strictipes (P. Karst.) Jul. Schäff.                        | ☺         | ♠                | –           | ND                    | JX429116              | JX429162     |
| Melanoleuca subpulverulenta (Pers.) Métrod                               | ☺         | ♠                | –           | ND                    | JN616473              | –             |
| Note: synonym to M. friesii (Bres.) Bon (Antonín et al., 2022) but identification probably tentative. |
| Montagnea arenaria (DC.) Zeller                                         | ☺         | ♠                | –           | ND                    | NR_173482             | MK278380     |
| Montagnea hausknorchtii Rabenh.                                         | X         | ♠                | –           | ND                    | –                     | –             |
| Mycena acicula (Schaef.) P. Kumm.                                       | X         | ♠                | –           | ND                    | MW540677              | MK278389     |
| Mycena clarvicularis (Fr.) Gillet                                       | X         | ♠                | –           | ND                    | MW540674              | AF042637     |
| Mycena crocata (Schrad.) P. Kumm.                                       | X         | ♠                | –           | ND                    | JF908492              | MH868172     |
| Mycena filopes (Bull.) P. Kumm.                                         | X         | ♠                | –           | ND                    | OM473731              | –             |
| Mycena galericulata (Scop.) Gray                                        | ☺         | ♠                | –           | ND                    | DQ404392              | MH866154     |
| Mycena galeopsis (Pers.) P. Kumm.                                       | X         | ♠                | Treu and Agerer (1990) | ND | FR846482 | AY207250 |
| Mycena haematopus (Pers.) P. Kumm.                                      | ☹         | X                | -           | ND                    | LT716053              | KY148869     |
| Mycena inclinata (Fr.) Quél.                                            | X         | -                | -           | Desjardin et al. (2008) | MK532829 | MK278392 |
| Mycena metata (Fr.) P. Kumm.                                            | X         | -                | -           | ND                    | MZ315004              | –             |
| Mycena pearsoniana Dennis ex Singer                                     | ☺         | -                | -           | ND                    | FN394614              | FN394633     |
| Mycena pelianthina (Fr.) Quél.                                          | ☺         | -                | -           | ND                    | FN394549              | FN394626     |
| Mycena politanii (Bull.) P. Kumm.                                       | X         | -                | Treu and Agerer (1990) | ND | MH856239 | MH867768 |
| Mycena pura (Pers.) P. Kumm.                                            | ☺         | ♠                | Treu and Agerer (1990) | ND | KF913023 | FN394630 |
| Mycena rapiculis J. Favre                                               | X         | -                | -           | ND                    | –                     | –             |
| Mycena sanguinolenta (Alb. & Schwein.) P. Kumm.                         | X         | -                | Desjardin et al. (2008) | ND | MH856662 | AY207257 |
| Mycena xantholeuca Kühner                                               | X         | ♠                | -           | ND                    | MT535719              | MT554310     |
| Myxomphalia maura (Fr.) Hora                                             | X         | -                | Treu and Agerer (1990) | ND | MH856673 | MH868189 |
| Myxomphalia maura (Fr.) Hora                                             | X         | -                | Treu and Agerer (1990) | ND | MH856673 | MH868189 |
| Neofavolus adhaerens (Alb. & Schwein.)                                  | ☺         | ♠                | -           | ND                    | HM356096              | KJ141188     |
| Ossicaulis lignatilis (Pers.) Redhead & Ginns                             | X         | -                | -           | ND                    | MZ159333              | –             |
| Ophiobolister asterosporus (J.E. Lange) Lamoure                           | X         | -                | -           | ND                    | FJ770399              | –             |
| Ophiobolister asterosporus (J.E. Lange) Lamoure                           | X         | -                | -           | ND                    | MF319071              | MF318927     |
| Ophiobolister asterosporus (J.E. Lange) Lamoure                           | X         | -                | -           | ND                    | AF525061              | AF042610     |
| Ophiobolister asterosporus (J.E. Lange) Lamoure                           | X         | -                | -           | ND                    | DQ825426              | AF261397     |

(Continued)
| Species                                      | Edibility | Ecological guild | Luminescent | Antioxidant potential | GenBank accession no. |
|----------------------------------------------|-----------|------------------|-------------|------------------------|-----------------------|
| Ossicaulis salomii Siquier & Bellanger       | ☀         | |              | –          | ND                    | MT535738 MT554327     |
| Panaeolus acuminatus (P. Kumm.) Quél.        | ☀         | |              | –          | ND                    | MH856251 MH86783      |
| Panaeolus campanulatus (L.) Quél.            | ☀         | |              | –          | ND                    | JF908522              |
| Panaeolus fimicola (Fr.) Quél.               | ☀         | |              | –          | ND                    | JF908519 MK278431     |
| Panaeolus olivaceus F.H. Moller              | ☀         | |              | –          | ND                    | MH285992 MK278433     |
| Panaeolus papilionaceus (Bull.) Quél.        | ☀         | |              | –          | ND                    | MH100681 MK278435     |
| Panaeolus plantaginiformis (Lebedeva)        | ☀         | |              | –          | ND                    | MK397579 MK397601     |
| E.F. Malysheva                               |           |                  |             |                        |                       |
| Panaeolus rickenii Hora                      | ☀         | |              | –          | ND                    | JF908523              |
| Panaeolus semiovatus (Sowerby) S. Lundell & Nannf. | ☀ X | |              | –          | ND                    | MH856675 MH868191     |
| Panaeolus speciosus P.D. Orton               | ☀         | |              | –          | ND                    | –                     |
| Panaeolus texutonicus Bride & Métrod         | ☀         | |              | –          | ND                    | –                     |
| Panellus stipicus (Bull.) P. Karst.          | ☀ X       | |              | –          | ND                    | –                     |
| Panus conchatus (Bull.) Fr.                  | ☀️        | |              | –          | M                     | OL477381 OL477382     |
| Parmygotus perforans (Hoffm.) J.S. Oliveira | X         | |              | –          | ND                    | MOL477381 JA406586    |
| Paraspleistia flaccida (Sowerby) Vizzini     | ☀️        | |              | –          | M                     | MZ159662 MZ675572     |
| Parasola auricoma (Pat.) Redhead, Vilgalys & Hopple | ☀️ X | |              | –          | ND                    | MZ859772 MH867468     |
| Parasola hemeroba (Fr.) Redhead, Vilgalys & Hopple | X   | ☀️               |              | –                      | DM163189 FM160720     |
| Parasola leiocephala (P.D. Orton) Redhead, Vilgalys & Hopple | X   | ☀️               |              | –                      | JN943113 JQ045887     |
| Parasola miser (P. Karst.) Redhead, Vilgalys & Hopple | X   | ☀️               |              | –                      | KY828619 KY928638     |
| Parasola plicatilis (Curtis) Redhead, Vilgalys & Hopple | X   | ☀️               |              | –                      | KY828625 KY928643     |
| Parasola scamba (Maire) Petersen             | ☀️        | |              | –          | ND                    | OL707198 AM946473     |
| Phaeomarasmius erinaceus (Fr.) Scherff. ex Romagn. | X   | ☀️               |              | –                      | MH856667 MH868183     |
| Phaeomematoloma myosotis (Fr.) Bon           | X         | |              | –          | ND                    | AF195599 AF195599     |
| Phellorinum herculana (Pers.) Kreisel        | X         | |              | –          | ND                    | JX984569              |
| Phleomana specerae (Fr.) Redhead             | X         | |              | –          | ND                    | MH856159 MK278448     |
| Pholiota adiposa (Batsch) P. Kumm.           | ☀️        | |              | –          | SM                    | MT353689 MT354285     |
| Pholiota astragalina (Fr.) Singer            | X         | |              | –          | ND                    | MT187979 MT228845     |
| Pholiota gummiosa (Lasch) Singer             | ☀️ X      | |              | –          | ND                    | MH861987 MH873679     |
| Pholiota highlandensis (Peck) A.H. Sm. & Heleser | X   | ☀️               |              | –                      | MH148872 MH867483     |
| Pholiota jahnii Tjall.-Beuk. & Bas           | X         | |              | –          | ND                    | MT535737 MT554326     |
| Pholiota populnea (Pers.) Kürper & Tjall.    | ☀️ X      | |              | –          | ND                    | MG735315              |
| Pholiota scamba (Fr.) M.M. Moser             | X         | |              | –          | ND                    | JF908585              |
| Pholiota spumosa (Fr.) Singer                | ☀️ X      | |              | –          | ND                    | MN209776 MN251159     |

(Continued)
| Species                          | Edibility                        | Ecological guild | Luminescent | Antioxidant potential | GenBank accession no. |
|---------------------------------|----------------------------------|------------------|-------------|-----------------------|-----------------------|
| Pholiota squarrosa (Oeder) P. Kumm. | ☺ (edible but very tough; considered poisonous in China) |                   |             | ND                    | MN209778 MN251161     |
| Pholiota squarrosoides (Peck) Sacc. | X (considered edible/poisonous in China) |                   |             | ND                    | JF908591 AF261641     |
| Pholiotoxina aporos (Kits van Wav.) Clémençon | X | ♠ |             | ND        | JX968260 JX968376     |
| Pholiotina arrhenii (Fr.) Singer | X | ♠ |             | ND        | JX968261 JX968377     |
| Pholiotina dryinoides (Cooke) M.M. Moser | X | ♠ |             | ND        | JX968150 JX968267     |
| Pholiotina vexans (P.D. Orton) Bon | X | ♠ |             | ND        | JX968265 JX968380     |
| Pholiotina striipes (Cooke) M.M. Moser | X | ♠ |             | ND        | JX968150 JX968267     |
| Pholiotina vexans (P.D. Orton) Bon | X | ♠ |             | ND        | JX968265 JX968380     |
| Pleurotus ostreatus (Jacq.) P. Kumm. | ☺ | ♦ |             | SM        | MT535734 MT554324     |
| Pleurotus djamor (Rumph. ex Fr.) Boedijn | X | ♦ |             | SM        | EU424306 EU365661     |
| Pluteus umbrosus (Pers.) P. Kumm. | X | ♦ |             | ND        | JX968261 JX968377     |
| Pluteus pellitus (Pers.) P. Kumm. | X | ♦ |             | ND        | JX968261 JX968377     |
| Pluteus petasatus (Fr.) Gillet | X | ♦ |             | ND        | JX968261 JX968377     |
| Pluteus exiguus (Pat.) Sacc. | X | ♦ |             | ND        | JX968261 JX968377     |
| Pluteus lentinus (Schaeff.) P. Kumm. | X | ♦ |             | ND        | JX968261 JX968377     |
| Pluteus semibulbosus (Lasch) Gillet | X | ♦ |             | ND        | JX968261 JX968377     |
| Pluteus thomsonii (Berk. & Broome) Dennis | X | ♦ |             | ND        | JX968261 JX968377     |
| Pluteus umbrosus (Pers.) P. Kumm. | X | ♦ |             | ND        | JX968261 JX968377     |
| Pogonoloma macrocephalum (Schulz.) Sánchez-García | X | ♦ |             | ND        | JX968261 JX968377     |
| Psathyrella bivelata Contu | X | ♦ |             | S         | MT535693 MT554288     |
| Psathyrella clavennis (Berk. & Broome) P.D. Orton | X | ♦ |             | ND        | DQ389683 DQ389683     |

(Continued)
| Species                                      | Edibility | Ecological guild | Luminescent | Antioxidant potential | GenBank accession no. | Notes                                                                 |
|---------------------------------------------|-----------|------------------|-------------|-----------------------|-----------------------|----------------------------------------------------------------------|
| Psathyrella fatua (Fr.) Konrad & Maubl.     | X         | ✗                | –           | ND                    | MT535695 MT554290     |                                                                      |
| Psathyrella helleboresensis D. Deschuyteneer & A. Melzer | X         | ✗                | –           | ND                    | MT535716 MT554308     |                                                                      |
| Psathyrella laevissima (Romagn.) Singer     | X         | ✗                | –           | ND                    | – –                   |                                                                      |
| Psathyrella microrhiza (Lasch) Konrad & Maubl. | X         | ✗                | –           | ND                    | MH856265 MH867801     |                                                                      |
| Psathyrella multipedata (Peck) A.H. Sm.     | X         | ✗                | –           | ND                    | GQ249282 GQ249291     |                                                                      |
| Psathyrella pennata (Fr.) A. Pearson & Dennis | X         | ✗                | –           | ND                    | AM712259 AM712259     |                                                                      |
| Psathyrella piluliformis (Bull.) P.D. Orton  | ☺         | ✗                | –           | ND                    | FN396136 FN396185     |                                                                      |
| Psathyrella prona (Fr.) Gillet              | X         | ✗                | –           | ND                    | MH856268 MH867805     |                                                                      |
| Psathyrella pseudogracilis (Romagn.) M.M. Moser | X         | ✗                | –           | ND                    | MH856200 MH867728     | Edibility unknown by Heleno et al. (2012)                             |
| Pseudoclitocybe cyathiformis (Bull.) Singer  | ☺         | ☺                | –           | ND                    | MT535721 MT554311     |                                                                      |
| Pseudosperma perlatum (Cooke) Matheny & Esteve-Rav. | ☹         | ☼                | –           | ND                    | JQ408767 JQ319698     |                                                                      |
| Pseudosperma rimosum (Bull.) Matheny & Esteve-Rav. | ☹         | ☼                | –           | ND                    | MF278770 EU600853     |                                                                      |
| Resupinatus applicatus (Batsch) Gray        | X         | ✗                | –           | ND                    | JF908672 JF908667     |                                                                      |
| Resupinatus spinulatus (Peck) A.H. Sm.      | ☺         | ☺                | –           | ND                    | MW172321 MW182481     |                                                                      |
| Rhodocollybia acetolens Rauschert           | ☺         | ☼                | –           | ND                    | – –                   |                                                                      |
| Rhodocollybia alutacea (Pers.) Fr.          | ☺         | ☼                | –           | ND                    | SM JF908676 –         |                                                                      |
| Rhodotus palmatus (Bull.) Maire             | X ☼       | ✗                | –           | ND                    | MK287617 MK287618     | (maybe poisonous; edibility considered unknown by Heleno et al. (2012)) |
| Russula acetales Rauschert                  | ☺         | ☼                | –           | ND                    | – –                   |                                                                      |
| Russula atropurpurea Peck [non R. atropurpurea (Krombh.) Britzelm. (= R. undulata Velen.)] | ☺         | ☼                | –           | ND                    | JF908691 KU237550     |                                                                      |
| Russula atrovirens Quél.                    | X         | ☺                | –           | ND                    | KX579812 KX812877     |                                                                      |
| Russula brunneoviolacea Crawshay            | ☺         | ☼                | –           | ND                    | AM113956 –            |                                                                      |
| Russula carminipes J. Blum                  | ☺         | ☼                | –           | ND                    | – KU237523            |                                                                      |

(Continued)
| Species                          | Edibility | Ecological guild | Luminescent | Antioxidant potential | GenBank accession no. | ITS       | nLSU       |
|---------------------------------|-----------|------------------|-------------|-----------------------|-----------------------|-----------|------------|
| Russula claroflava Grove        | ☺         | ☺                | –           | ND                    | KT933997              | KT933858  |
| Russula cyanoxantha (Schaeff.) Fr. | ☺         | ☺                | (chemiluminescence: Bondar et al., 2012; Gitelson et al., 2012) | S | MW646981 | MW646993 |
| Russula delica Fr.              | ☺         | ☺                | (chemiluminescence: Bondar et al., 2012; Gitelson et al., 2012) | W | KX812842 | KX812864 |
| Russula emetica (Schaeff.) Pers. | ☺ ☺       | ☺                | –           | M                     | KX813352              | KX812896  |
| (European R. emetica extremely pungent and inedible/toxic; reported by Kaewnarin et al. (2016) as popular edible mushroom in Thailand) |
| Russula emeticolor J. Schaeffer  | ☺         | ☺                | –           | S                     | MT533680              | MT554277  |
| Russula farinipes Romell        | X         | ☺                | –           | ND                    | KY800361              | KU237561  |
| (edible/poisonous in China)     |
| Russula foetens Pers.           | ☺ ☺       | ☺                | (chemiluminescence: Gitelson et al., 2012) | ND | KT934016 | KT933877 |
| (may cause health problems)     |
| Russula gravolens Romell        | ☺         | ☺                | –           | ND                    | KU205298              | –         |
| Russula grisea Fr.              | ☺         | ☺                | –           | ND                    | MT738286              | MT738262  |
| Russula heterophylla (Fr.) Fr.  | ☺         | ☺                | –           | ND                    | AF418609              | AF325309  |
| Russula integra (L.) Fr.        | ☺         | ☺                | –           | M                     | KYS82682              | KX812899  |
| Russula ionochlora Romagn.      | ☺         | ☺                | –           | ND                    | MW683795              | KU237508  |
| Russula lilacea Quél.           | ☺         | ☺                | –           | ND                    | JN944005              | JN940592  |
| Russula luteotacta Rea          | X         | ☺                | –           | ND                    | JF908652              | KU237512  |
| (edible/poisonous in China)     |
| Russula magnificans Fr.         | ☺         | ☺                | –           | S                     | –                     | –         |
| Russula ochroleuca Pers.        | ☺         | ☺                | (chemiluminescence: Bondar et al., 2012; Gitelson et al., 2012) | ND | HM189900 | KU237519 |
| (may cause health problems)     |
| Russula ochroleucoides Kauffman | X         | ☺                | –           | ND                    | –                     | –         |
| Russula olivacea Pers.          | ☺         | ☺                | –           | M                     | AF418635              | KU237492  |
| Russula pectinata Fr.           | X         | ☺                | –           | ND                    | MW355005              | –         |
| Russula pectinatoides Peck      | ☺ ☺       | ☺                | (edible only when very young) | ND | EU599815 | KU237462 |
| Russula persicina Krombh.        | X         | ☺                | –           | ND                    | HE687094              | KU237494  |
| Russula perlecta Marrill        | ☺         | ☺                | –           | ND                    | –                     | –         |
| Russula puellaris Fr.           | ☺         | ☺                | –           | ND                    | AF418628              | KU237515  |
| Russula quelert Fr.             | ☺         | ☺                | –           | ND                    | KT934007              | KT933868  |
| Russula risigallina (Ratsch) Sac. | ☺         | ☺                | –           | ND                    | JF908685              | –         |
| Russula rosea Maire             | ☺         | ☺                | –           | ND                    | KT933987              | KT933848  |
| Russula rosea Pers.             | ☺         | ☺                | –           | S                     | JN944003              | JN940602  |

(Continued)
| Species                                      | Edibility | Ecological guild | Luminescent | Antioxidant potential | GenBank accession no. |
|----------------------------------------------|-----------|-----------------|-------------|-----------------------|-----------------------|
| Russula silvestris (Singer) Reumaux          | X         | ☀               | –           | ND                    | KX579800              |
| Russula solis Fed. & Winge                   | X         | ☀               | –           | ND                    | AF418627 JN940606     |
| Russula sororia (Fr.) Romell                 | X         | ☀               | –           | ND                    | KF318053              |
| Russula torulosa Bro.                        | X         | ☀               | –           | ND                    | MZ005531              |
| Russula versicolor Jul. Schaff.              | ☀         | ☀               | –           | ND                    | JN944009 JN940594     |
| Russula verna Reumaux Fr.                    | ☀         | ☀               | –           | ND                    | FR852104 AF325321     |
| Russula vinosophorpesa Jul. Schaff.          | X         | ☀               | –           | ND                    | FR852115              |
| Russula violacea (Schaeff.) Fr.              | ☀         | ☀               | –           | ND                    | SMW                   |
| Russula saxempelina (Schaeff.) Fr.           | ☀         | ☀               | –           | ND                    | W                     |
| Saproamanita codinae (Maire) Redhead, Vizzini, Drehmel & Contu | ☀         | ☀               | –           | ND                    | – MK277524            |
| Sarcomyxa serotina (Pers.) V. Papp           | ☀ ☀      | ☀               | –           | ND                    | MH856703 MH866220     |
| Simocybe centunculosa (Fr.) P. Karst.        | ☀         | ☀               | –           | ND                    | MT535746 KTT15786     |
| Sphaugarus paluster (Peck) Redhead & V. Hofst. | X         | ☀               | –           | ND                    | KP192547 MH873802     |
| Strophilurus eaeulentus (Wolfen) Singer       | ☀         | ☀               | –           | W                     | MH104094 AY207299     |
| Strophilurus tenacellus (Pers.) Singer        | X         | ☀               | –           | ND                    | MF063146 MF063102     |
| Stropharia aeruginosa (Curtis) Quel.         | ☀ ☀ X     | ☀               | –           | ND                    | MW492534 MW492637     |
| (edible in the Czech Republic)               |           |                 |             |                       |                       |
| Stropharia coronilla (Bull.) Quel.           | ☀         | ☀               | –           | ND                    | MH856747 MH868269     |
| Stropharia melanosperma (Bull.) Quel.        | ☀         | ☀               | –           | ND                    | – –                   |
| Tricholoma acerbum (Bull.) Quel.             | ☀ ☀ X     | ☀               | –           | M                     | MH628231 MK278598     |
| (inedible in the Czech Republic)             |           |                 |             |                       |                       |
| Tricholoma argyracae (Bull.) Gillet          | ☀         | ☀               | –           | ND                    | GU060278 MK278614     |
| Tricholoma caligatum (Win.) Ricken           | ☀         | ☀               | –           | ND                    | KU058510 KU058548     |
| Tricholoma cingulatum (Alm. et ex Fr.) Jacobasch | ☀         | ☀               | –           | ND                    | MH207811 AY207308     |
| Tricholoma equestre (L.) P. Kumm.            | ☀ ☀       | ☀               | –           | SM                    | EU186278 AM946471     |
| (considered poisonous last years, but may include more species) |           |                 |             |                       |                       |
| Tricholoma fulvum (Fr.) Bigeaz & H. Guill.   | ☀ ☀ X     | ☀               | –           | ND                    | KU058514 KU058552     |
| (inedible in the Czech Republic)             |           |                 |             |                       |                       |
| Tricholoma laccatum (Fr.) Gillet             | ☀         | ☀               | –           | ND                    | LT000131 –            |
| (considered edible in China)                 |           |                 |             |                       |                       |
| Tricholoma orisubens Quel.                   | ☀         | ☀               | –           | ND                    | DQ389724 DQ389734     |
| Tricholoma psamomopus (Kalchbr.) Quel.       | X         | ☀               | –           | ND                    | AF377241              |
| Tricholoma robustum (Alb. & Schwein.) Ricken | ☀ ☀ X     | ☀               | –           | ND                    | AB696699              |
| (inedible in southern Europe)                |           |                 |             |                       |                       |
| Tricholoma scalpturatum (Fr.) Quel.          | ☀         | ☀               | –           | ND                    | JN389305 JN389350     |
| (considered poisonous in China)              |           |                 |             |                       |                       |
| Tricholoma sulphureum (Bull.) P. Kumm.       | ☀         | ☀               | –           | M                     | AY462032 AY462040     |
| Tricholoma terreum (Schaeff.) P. Kumm.       | ☀         | ☀               | –           | MW                    | EU653301 EU653305     |

(Continued)
Edibility, ecological guild and luminescence

The edibility rank of the species (edible, poisonous, inedible) and the ecological guilds (soil saprotrophic, ectomycorrhizal, leaf/litter-inhabiting, wood-inhabiting, parasitic) were assigned based on published literature as well as authors’ knowledge. The edibility of many species is highly subjective and evaluated differently in various countries. Here, the majority of our data are based on central and southern European literature, but even this literature was not necessarily confirmative. Therefore, for some species, more than one rank assignment was inevitably used. Besides the categories “edible” or “poisonous,” category “inedible” was also recognize (noted with symbol X in Table 1) for the species with an unpleasant taste, very small and tiny basidiomata and not usually collected for culinary purposes. Luminescence (bio/chemiluminescent) data were extracted from published literature as mentioned in Table 1 for each species.

Antioxidant properties

Antioxidant properties of the species were obtained via published references as well as own experiments performed in the present study (Tables 1, 2; Supplementary Table 1). A thorough literature survey was performed to extract and summarize the available data on the antioxidant properties of the agaric species. Published references were searched via Google Scholar, PubMed, and other standard repositories. Each literature was scrutinized carefully, avoiding poor quality and ambiguous data. Disqualified literature, unpublished data, and papers published in non-standard journals were removed from our analyses. In total, ca. 300 literature were surveyed and ca. 170 references were cited in this work and in Supplementary material. The majority of studies reported the antioxidant potential as EC₅₀ values, i.e., half maximal effective concentration, based on DPPH (2,2-diphenyl-1-picrylhydrazyl) and ABTS (2,2′-azino-bis-3-ethylbenzothiazoline-6-sulfonic acid) assays. To have an approximate comparison of the antioxidant potential of the species, we tentatively categorized the EC₅₀ values as strong, moderate, and weak. For this, the EC₅₀ values reported in different studies. We preferred to keep the data as is for any future reference so that we assigned more than one code to classify the antioxidant potential of these species (e.g., SM standing for strong to moderate). (In a number of studies the EC₅₀ values less than 1 mg/ml were considered as “strong” (S), EC₅₀ values ranging from 1 to 10 mg/ml as “moderate” (M), and EC₅₀ values more than 10 mg/ml were tentatively considered as “weak” (W) antioxidants (Table 1). For several species, we found different EC₅₀ values reported in different studies. We preferred to keep the data as is for any future reference so that we assigned more than one code to classify the antioxidant potential of these species (e.g., SM standing for strong to moderate).
antioxidant potential had been expressed only as radical scavenging activity% (RSA %). For these, the RSAs >80% were hesitantly considered as strong, RSA 50%–80% as moderate, and RSA < 50% were tentatively considered as weak, paying careful attention also to the values from the antioxidant standards; see Supplementary Table 1). In the cases where the antioxidant potential values were contrasting in different studies, we preferred to keep the data as is for any future reference, and therefore the antioxidant potential of the corresponding species are shown here with the combined codes SM, MW, and SMW, where applicable (Table 1).

Dried basidiomata from 24 species were sampled and examined for their antioxidant potential via ABTS assay following Re et al. (1999). Voucher samples were deposited at the Iranian Cryptogamic Herbarium (ICH) herbarium (acronym by Index Herbariorum) or at MG personal collection. The ABTS solution (7 mM) was prepared in 2.45 mM potassium sulfate and was kept at room temperature in the dark for 16 h. The mixture was then mixed with phosphate-buffered saline (PBS) as a control, and the absorbance reached 0.7 ± 0.02 at 734 nm. The extract samples with final concentrations of 0.01, 0.025, 0.05, 0.075, and 0.1 mg/ml were mixed with 980 μl of Trolox.

### Table 2: The EC50 values and the percentage of radical scavenging activity (RSA) obtained by ABTS assays in this study.

| Species                        | Voucher        | RSA % at different concentrations | EC50 mg/ml |
|--------------------------------|----------------|-----------------------------------|------------|
|                                |                | 0.01 mg/ml | 0.025 mg/ml | 0.05 mg/ml | 0.075 mg/ml | 0.1 mg/ml |          |
| Agaricus arvensis              | Ghobad-Nejhad 4295 | 14.22      | 22.07       | 32.35       | 43.63       | 54.92      | 0.10 ± 0.003 |
| Agaricus bitorquis             | Ghobad-Nejhad 4284 | 16.60      | 22.75       | 35.67       | 47.58       | 59.10      | 0.08 ± 0.003 |
| Agaricus todomasus             | Ghobad-Nejhad 4277 | 26.85      | 29.78       | 37.33       | 43.88       | 50.43      | 0.09 ± 0.021 |
| Agaricus pseudoplatensis       | Ghobad-Nejhad 4278 | 38.94      | 39.54       | 43.20       | 45.86       | 48.13      | 0.11 ± 0.004 |
| Agrocybe dura                  | Ghobad-Nejhad 4299 | 26.32      | 27.48       | 30.41       | 31.34       | 33.27      | 0.31 ± 0.004 |
| Armillaria mella               | Ghobad-Nejhad 4394 | 14.25      | 15.25       | 16.79       | 18.53       | 20.11      | 0.55 ± 0.016 |
| Cantharellus alborufescens     | Ghobad-Nejhad 4408 | 11.45      | 12.07       | 12.83       | 13.79       | 14.66      | 1.09 ± 0.06  |
| Coprinopsis atramentaria       | Ghobad-Nejhad 4406 | 7.54       | 9.42        | 12.15       | 15.68       | 18.81      | 0.34 ± 0.021 |
| Coprinopsis comatus            | Ghobad-Nejhad 4407 | 8.17       | 10.15       | 13.45       | 16.74       | 19.03      | 0.34 ± 0.028 |
| Cortinarius persoonianus       | Ghobad-Nejhad 4206 | 17.44      | 19.24       | 23.25       | 25.25       | 28.26      | 0.27 ± 0.019 |
| Gymnopilus spectabilis         | Ghobad-Nejhad 4207 | 18.76      | 21.13       | 25.62       | 29.91       | 33.20      | 0.20 ± 0.001 |
| Hymenopellis radicata          | Ghobad-Nejhad 4204 | 20.19      | 20.70       | 21.50       | 22.09       | 22.78      | 1.05 ± 0.06  |
| Hypholoma fasciculare          | Ghobad-Nejhad 4201a | 29.47      | 35.57       | 48.41       | 60.25       | 72.09      | 0.05 ± 0.007 |
| Lentinus tigrinus              | Ghobad-Nejhad 4397 | 7.14       | 8.09        | 9.68        | 11.26       | 12.16      | 0.75 ± 0.01  |
| Leucogaricus leucothites       | Ghobad-Nejhad 4279 | 19.46      | 20.80       | 22.90       | 25.10       | 27.50      | 0.35 ± 0.001 |
| Melanoleuca exscissa           | Ghobad-Nejhad 4375 | 28.27      | 29.61       | 31.50       | 34.07       | 36.90      | 0.24 ± 0.009 |
| Pholiota aurivella             | Ghobad-Nejhad 600 | 38.83      | 39.48       | 40.61       | 41.54       | 42.84      | 0.26 ± 0.016 |
| Pleurotus cornucopiae          | Ghobad-Nejhad 4308 | 24.75      | 25.60       | 27.23       | 28.77       | 30.32      | 0.41 ± 0.001 |
| Pleurotus eryngii              | Ghobad-Nejhad 1086 | 32.30      | 33.14       | 35.26       | 37.11       | 38.40      | 0.26 ± 0.011 |
| Pleurotus ostreatus            | Ghobad-Nejhad 4403 | 6.66       | 8.20        | 10.58       | 12.85       | 15.33      | 0.46 ± 0.003 |
| Pleurotus cervinus             | Ghobad-Nejhad 4271 | 13.14      | 18.16       | 27.11       | 34.96       | 44.83      | 0.11 ± 0.002 |
| Panaeolus bivelata             | Ghobad-Nejhad 4303 | 36.34      | 37.11       | 38.40       | 39.69       | 40.18      | 0.31 ± 0.062 |
| Russula emetica                | Ghobad-Nejhad 4149 | 44.45      | 45.19       | 46.42       | 47.66       | 48.01      | 0.14 ± 0.028 |
| Xerula pudens                  | Sohrabi 30619   | 31.78      | 33.55       | 35.80       | 37.55       | 39.55      | 0.22 ± 0.002 |
| Trolox                         |                |           |             |             |             | 0.023 ± 0.011 |
ABTS solution. The absorbance at 734 nm was measured after 6 min. The percentage of radical scavenging activity was calculated by the following equation, where A stands for absorbance (Öztürk et al., 2011):

\[
\text{Scavenging activity (\%)} = \frac{(A \text{ control} - A \text{ sample})}{A \text{ control}} \times 100
\]

The EC_{50} values were obtained through interpolation from linear regression analysis (Supplementary Figure 1). Trolox was used as a positive control at different concentrations (0.005, 0.01, 0.015, 0.02, 0.025, and 0.03 mg/ml).

**Results**

The results of our survey on the resources of agaric species in Iran are summarized in Table 1. Altogether, 558 agaric species from five orders were surveyed for their resources of edible and poisonous species, their ecological guilds, bioluminescence, and antioxidant potential. The two species Conocybe olivaceopileata and Inocybe ionolepis were added here to the Iranian mycota (see Table 1).

**Phylogeny**

The Agaricales dataset consisted of 428 taxa and 1,341 characters of which, 243 characters were constant, 144 variable, and 954 characters were informative. The best-fit evolutionary model suggested by MrModeltest was GTR + I + G for each of the LSU and ITS partitions. The Agaricales phylogram is shown in Figure 1. Nineteen families were phylogenetically retrieved with moderate to good posterior probabilities (PPs) and were shown in colored boxes, while the rest of the taxa were incertae sedis or received low to moderate branch support.

The species with antioxidant data were distributed in all the families shown in colored boxes except for the two families Entolomataceae and Inocybaceae (Figure 1). For some families such as Bolbitiaceae, Marasmiaceae, and Tubariaceae, there was only a single species with antioxidant activity, while other families such as Agaricaceae, Psathyrellaceae, and Pleurotaceae contained several antioxidant species.

Dataset 2 (Cantharellales, Polyporales, Russulales) consisted of 71 taxa and 1,528 characters of which, 279 characters were constant, 347 variable, and 902 characters were informative. The best-fit evolutionary model as suggested by MrModeltest was GTR + G for each of the LSU and ITS partitions. The phylogram obtained from the analyses of dataset 2 is presented in Figure 2. The orders Polyporales, Russulales, and Cantharellales were retrieved as moderate to well-supported monophyletic clades (PPs 0.75, 0.94, and 1.00, respectively). (For Polyporales, the two families Panaceae and Polyopaceae were not retrieved. Moreover, Panellus stipitatus found a position close to the outgroup Contumyces rosellus, and we could not solve this.) The species with antioxidant data were distributed within the three orders in the phylogram (Figure 2). Out of six Cantharellales agaric members in Iran (Ghobad-Nejhad et al., 2020), four species have antioxidant data (Figure 2; Craterellus cinereus had no good LSU/ITS, so is missing in the phylogeny here). Polyporales has nine agaric species in Iran, four of which possess antioxidant activity (Figure 2). Russulales has 60 agaric species in Iran (Ghobad-Nejhad et al., 2020) from which, 16 species have antioxidant data (Figure 2; Table 1). Contumyces rosellus is the only Hymenochaetales agaric in Iran and has no antioxidant data.

Altogether, there were 50 agaric species lacking both ITS and LSU sequences and so did not appear in the phylogenetic analyses (Table 1); these species also lacked antioxidant data, except for Russula nigricans which was scored as a “strong” antioxidant species (Table 1).

**Edibility, ecological guild, and luminescence**

Results of the survey on edibility, ecological guilds, and luminescence of agaric species occurring in Iran are shown in Table 1 and Figures 3, 4. It is revealed that about 189 species of agars in Iran can be classified as edible, 128 species as poisonous, and 271 species as inedible (Table 1; Figure 3). Moreover, 10 species can be assigned as edible only if well-cooked, whereas the edibility of 30 species is uncertain or unknown.

Concerning ecological guilds, our results show that about 254 species of agars in Iran are soil saprotrophic, 172 species ectomycorrhizal, 146 species wood-inhabiting, 18 species leaf/litter-inhabiting, and nine species are parasitic (Table 1; Figure 4). Parasitic species include Armillaria borealis, A. cepistipes, A. gallica, Collybia tuberosa, Pleurotus eryngii, P. nebrodensis which are sapro-parasitic, Gymnopus fusipes which is wood-inhabiting parasitic, and Asterophora lycoperdoides which grows on basidiomata of Lactarius and Russula species (Table 1).

Among 558 agaric species in Iran, 19 species are categorized as luminescent (Table 1). These include Armillaria (four spp.), Collybia tuberosa, Flammulina velutipes, Mycena (six spp.), Omphalotus olearius, Panellus stipitatus, and Russula (five spp.). The six species with chemiluminescence include Russula anthracina, R. cyanoxantha, R. delica, R. foetens, R. ochroleuca, as well as Panellus stipitatus.

**Antioxidant potential**

Results of our survey on the antioxidant potential of agaric species occurring in Iran are shown in Table 1 and Figure 5 (see also Supplementary Table 1 for details on the antioxidant potential of the species and the corresponding references). According to the results, antioxidant activity data is available for 113 species phylogenetically distributed in four orders (Agaricales, Cantharellales, Russulales, Polyporales).
and 21 agaric families including 17 families in the Agaricales (Strophariaceae, Hymenogastraceae, Tubariaceae, Bolbitiaceae, Cortinariaceae, Lyophyllaceae, Tricholomataceae, Psathyrellaceae, Agaricaceae, Omphalotaceae, Marasmiaceae, Physalacriaceae, Amanitaceae, Pluteaceae, Mycenaceae, Pleurotaceae, Hydnangiaceae; Figure 1), as well as Hydnaceae (=Cantharellaceae), Russulaceae, Polyporaceae, and Panaceae (Figure 2, families not shown on the tree). However, 445 species still lack information on their antioxidant potential (for a handful of species, the available antioxidant values in the literature had been expressed only by other methods such as TEAC and FRAP; as far as these cases were very few, they were not taken into account here, to keep the rest of the data comparable). The antioxidant potential of 24 species was assayed in this study and their EC_{50} values are reported in Table 2. Species assayed for the first time in this study included: Agaricus iodosmus, A. pseudopratensis, Agrocybe dura, Cantharellus alborufescens, Cortinarius persoonianus, Hymenopellis radicata, Melanoleuca excissa, Psathyrella bivelata, Russula emeticolor, and Xerula pudens (Table 2; Supplementary Table 1). In general, the EC_{50} values of the agaric species ranged between 0.0015 mg/ml (for Psathyrella candolleana) up to 31.42 mg/ml (for Tricholoma terreum).

Among the 113 species having antioxidant data, 27 species could roughly be classified as “strong,” 25 species as “strong to moderate,” 27 species as “moderate,” nine species as “moderate to weak,” and 20 species could be tentatively regarded as “weak” antioxidants (Figure 5). Some of the species in the S category are Agaricus arvensis, Agrocybe dura, Amanita rubescens, Cantharellomyces candolleanus, Clitocybe nebularis, Coprinellus micaceus, Coprinopsis picaea, Craterellus tubaeformis, Gymnopilus spectabilis, Hygrophorus eburneus, Hypsizygus ulmarius, Macrocybe gigantea, Marasmiellus peronatus, Mycenastrum corium, Russula anthracina, Russula cyanoxantha, Russula

![Phylogram from the combined nLSU+ITS sequence dataset representing the phylogenetic relationships of Iranian Agaricales. Posterior probabilities (PPs) ≥0.8 are shown as light lilac dots on the nodes. Terminals in red are species with antioxidant activity and the letters inside brackets are the tentative antioxidant codes: S, strong; M, moderate; W, weak (see the text for full details).](image-url)
emeticolor, Russula nigricans, Russula rosea, and Xerula pudens (Table 1).

The overall phylogenetic distribution of the agaric species with antioxidant data is shown in Figures 1, 2. Russula nigricans was the only species in our dataset with antioxidant data but lacked LSU/ITS DNA sequences in GenBank, so could not be used in our phylogenetic analyses.

**Discussion**

In this study, we comprehensively investigated the resources of agarics in Iran. Indeed, no published data have yet been available on number of recorded edible, poisonous, and other agarics in Iran, so the present work fills in these gaps. It is shown that there are currently about 189 edible, 128 poisonous, 254 soil
saprotrophic, 172 ectomycorrhizal, 146 wood-inhabiting, 19 leaf/litter-inhabiting, 9 parasitic, and 19 luminescent agaric species in the country. The two species Conocybe olivaceopileata and Inocybe ionolepis were newly added to the Iranian mycota, new DNA sequences were obtained from Iranian samples, and the first phylogenetic reconstruction was provided for agarics of Iran. Evidently, this work is not final and therefore further studies of Iranian fungal diversity would add new species to the list presented here. About 500 agaric species belonging to the five orders Agaricales, Cantharellales, Polyporales, Russulales, and Hymenochaetales were phylogenetically analyzed based on nLSU + ITS sequence datasets. Thorough analyses with additional gene regions and vouched samples must be utilized in the future to resolve the phylogenetic relationships of Iranian agarics. Yet, the preliminary phylogenetic analysis of agaric species presented here would help to inspire the investigation of many taxa in need of taxonomic revision. Phylogeny backbones can be used for visualization of the phylogenetic distribution of species possessing particular characteristics, herein, antioxidant potential, but also other features in the future. For instance, phylogenetic assessments have been used to screen the pleuromutilin-producing basidiomycete species (Harley et al., 2009), fungal strains capable of degrading industrial compounds (Navarro et al., 2021), or other natural products (Adamek et al., 2019).

For a few species, the edibility assignment was based on own observation in Iran, but as stated earlier, most of the species were categorized based on available knowledge on central and southern European species. (It might be relevant to note that a number of previous studies have shown a high similarity of the Iranian mycota to that of Europe, e.g., Ghobad-Nejhad et al., 2012; Ghobad-Nejhad and Bernicchia, 2019.) Basically, edibility assignments should always be regarded with caution and it is generally recommended to avoid consuming raw or insufficiently identified mushrooms. There are still noticeable gaps in the knowledge of edible/poisonous mushrooms identification in Iran and the level of education, public awareness, and citizen science is far from medium standards. Concerning usage of edible fungi in Iran, published references are lacking, and our available data is fragmentary. In the reports and statistics on mushroom poisoning in Iran, there is no proper documentation of the species involved or at best, the species are only ambiguously characterized (Kiarsi et al., 2019).

The present work calculated as many as about 172 ectomycorrhizal agaric species for Iran. Ectomycorrhizal fungi are essential components of forest ecosystems to supply the symbiont trees with water and nutrients such as phosphorus and nitrogen, and therefore are highly important in forest sustainability (Varma and Hock, 2013). A large number of ectomycorrhizal agarics are also edible and may be harvested in the wild for culinary use, so they are in need of immediate conservation actions (Vaario and Matsushita, 2021); this is the case, especially with the Cantharellus species in northern Iran (Parad et al., 2018, 2020).

In this study, we listed 146 wood-inhabiting agaric species for Iran. There have been several studies on the diversity and taxonomy of wood-inhabiting aphylophoroid fungi in Iran (e.g., Hallenberg, 1981; Ghobad-Nejhad and Hallenberg 2012; Amoopour et al., 2016; Ghobad-Nejhad and Langer, 2017; Nazari Mahroo et al., 2018; Ghobad-Nejhad and Bernicchia, 2019) but agarics growing on wood in Iran have not been studied...
systematically. Wood rotting fungi play a key role in terrestrial carbon cycling and have high potential in biotechnology, enzyme industry, biorefinery, and bioremediation of waste material and recalcitrant compounds (Gadd, 2001; Nguyen et al., 2018; Mäkelä et al., 2021). While Polyporales members are best known for their wood decomposition ability, genomic studies have revealed that several Agaricales taxa have evolved the enzymatic machinery comparable to the white-rot Polyporales (Floudas et al., 2020; Ruiz-Dueñas et al., 2020).

Another aspect surveyed in this study for the Iranian agaric species was bioluminescence. Bioluminescence, i.e., the ability of organisms to emit visible light, has been developed independently in the evolution of different organisms. Concerning fungi, 109 fungal taxa are known to exhibit bioluminescence all of which (except one Xylariales) are white-spored saprotrophic Basidiomycota distinguished in four phylogenetic lineages (Chew et al., 2015; Ke and Tsai, 2022) all sharing the same type of luciferin and luciferase (Oliveira et al., 2012). Interestingly, it has been shown that luminescence could be linked to the antioxidant/radical scavenging defense mechanism against some environmental stress factors (Vydryakova and Bissett, 2016; Oba et al., 2017). Moreover, the fungal bioluminescence capacity can be used in environmental biomonitoring of metals or organic compounds and to develop toxicity tests (Ke and Tsai, 2022).

In this work, a thorough survey was done to reveal the antioxidant potential of 558 agaric species and a new approach was used to combine antioxidant data with phylogeny of the species. Ten species were subjected to antioxidant analyses for the first time, belonging to the genera Agaricus, Agrocybe, Cantharellus, Cortinarius, Hymenopellis, Melanoleuca, Psathyrella, Russula, and Xerula. ABTS assay is one of the most frequently used methods for quantification of antioxidant activity of mushrooms. Numerous antioxidant assays have been introduced which are usually classified into two groups based on the mechanism of action: single electron transfer and hydrogen atom transfer (Tan and Lim, 2015; Xiao et al., 2020). Compared to other methods, ABTS has the advantage of involving more or less both mechanisms (Prior et al., 2005). Yet, more examinations are required to fully investigate the antioxidant capacity of the species studied here, and to quantify and characterize the underlying bioactive compounds. Here, we could roughly assume antioxidant data for 20% of agaric species (113 spp.), but noted that 80% of the species (445 spp.) have no antioxidant data. This is noteworthy compared to the fact that antioxidant tests are among the most popular bioactivity assays and it may show that macrofungi have remained little studied in this regard. The highest antioxidant capacities (the lowest EC\textsubscript{50} values) were shown by the species categorized as S (27 spp.) and then as SM (25 spp.; Table 1; Figure 5). As noted earlier, in several cases, various EC\textsubscript{50} values had been reported in different studies for some species, so that we assigned more than one code for them. We emphasize that such classification is approximate and for detailed comparisons, more precise methods are recommended to be applied. For five species, the EC\textsubscript{50} measures ranged significantly, in a way that the code assignment could only be expressed as SM: Pleurotus djamor, P. eringii, P. ostreatus, P. pulmonarius, and Russula virescens. Of course, differences in the solvents, standards, modifications in the assays procedures, and even identification issues can account for the different measures under the same species name. Ideally, the identity of the voucher specimens should be fully characterized and the species should be assayed with exactly the same procedure so as to be able to have the best quality comparisons. In general, for the studies where both ABTS and DPPH assays had been conducted, ABTS values seemed to slightly outperform the DPPH values, showing lower EC\textsubscript{50} measures. Many of the species in the S or “strong” antioxidant category are edible: Agaricus arvensis, Agrocybe dura, Amanita rubescens, Candolleomyces candolleanus, Clitocybe nebularis, Craterellus tubaeformis, Hygrophorus eburneus, Hymenogastrum, Macrocybe gigantea, Russula anthracina, R. cyanoxantha, R. emeticolor, R. nigricans, R. rosea, and Xerula pudens (Table 1). Oxidative stress is the root of a cascade of numerous acute and chronic human diseases (Kosanic et al., 2013). Diets rich in natural antioxidants enforce the native defense system and protect against oxidative damage (Ferreira et al., 2009). Mushroom species that are edible and possess high level of biological activities with perspectives on promoting human health are considered noteworthy candidates for developing functional foods and nutra-pharmaceutical products (Kozarski et al., 2015; Lu et al., 2020; Niego et al., 2021; Shaffique et al., 2021; El Sheikh, 2022). It is evident that thorough analyses are needed to fully characterize the mycochemical constitutes of such species and their various bioactivities.

Our results pave the avenue for advanced studies on edible, poisonous, saprotrophic, ectomycorrhizal, wood-inhabiting, parasitic, luminescent, and antioxidant species of agarics of Iran. Twenty percent of the Iranian agaric species possess antioxidant activity, phylogenetically distributed in four orders and 21 agaric families. About 5% of the antioxidant species can be considered strong antioxidants, many of which are also edible and could be utilized for the development of functional foods. Various edible agaric species are grown commercially in the world, while only 1–2 are commonly grown in Iran (personal comm.). Ectomycorrhizal and wood-inhabiting species are important components of forest sustainability. Forests in Iran are very scanty, comprising less than 10% of the total country area, and are on the verge of severe depletion due to numerous anthropological and environmental threats. Yet, Iranian old-growth forests, categorized as part of the northern hemisphere glacial refugia (Ghobad-Nejhad et al., 2012, 2020), harbor a rich reservoir of agaric fungi with diverse characteristics and beneficial aspects. Resources of Iranian agarics provide valuable opportunities for biotechnology and mycochemistry, and should be regarded for preservation and habitat conservation. Our preliminary phylogenetic trees would guide the selection of agaric taxa to be examined in the future for taxonomic revisions, biotechnological applications, and
applied phylogeny studies. The thorough survey of antioxidant data of 558 agaric species would provide the state of the knowledge on agarics examined so far and the remaining gaps to be filled in the future.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found in the article/Supplementary material.

Author contributions

MG-N conceptualized and designed the study, performed the molecular study and provided the first draft. VA contributed to the trait assignments. MG-N, VA, and EL wrote the manuscript. MG-N and MM performed the experiments. All authors contributed to the article and approved the submitted version.

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Conflict of interest

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

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fmicb.2022.1015440/full#supplementary-material

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