

MORPHOLOGICAL AND GROWTH CHARACTERISTICS OF MYCELIAL COLLECTIONS OF MEDICINAL XYLOTROPHIC MUSHROOMS (AGARICOMYCETES) DISTRIBUTED IN FORESTS OF NORTHERN IRAN

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The morphological and growth characteristics of mycelial cultures of 24 xylotrophic medicinal Agaricomycetes mushrooms including 12 edible species collected in Mazandaran and Golestan Provinces of Northern Iran were studied for the first time. The morphology of colonies, growth parameters, and an ability to develop *in vitro* teleomorph, presence and form of hyphal clamps, cystidia, loops, asexual spores (anamorphs), crystals and other cultural characteristics of Iranian collections were observed. The obtained data can be used for taxonomic identification of mycelial cultures of studied species/strains during their biotechnological cultivation to obtain mycelial biomass and bioactive compounds.

Keywords: medicinal, edible, xylotrophs, mycelium, morphological characteristics, growth parameters, Northern Iran.

Introduction. The xylotrophic Agaricomycetes fungi or macrofungi are a group of fungal organisms growing on wood or other substrates containing lignin, which develop morphologically different agaricoid, bracket and jelly forms of mushrooms.

Agaricomycetes mushrooms have been used since ancient times as food and medicines however their biological resources and biotechnological potential, particularly in Iran, has not been sufficiently investigated [1–6].

Xylotrophic species are easily isolated, growing and producing fruiting bodies in the culture conditions, which make them appropriate for biotechnological cultivation to obtain mycelial biomass and/or bioactive compounds. The study of biological characteristics of mycelia (morphological, physiological, genetic, etc.) will assist in their taxonomic identification during biotechnological cultivation when development of fruiting bodies (teleomorph) is usually missing. Moreover, species-specific mycelial characteristics are important not only for taxonomic identification of cultures during their biotechnological cultivation [7–12], but also for taxonomic verification and reconstruction of phylogenetically complex species/groups of Agaricomycetes. The morphology and growth characteristics of

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colony, the presence of hyphal clamps, type(s) of asexual spores developed mainly in culture conditions are taxonomically valuable characteristics for Agaricomycetes fungi [13–16]. The formation of thallic oidia and tick-walled vegetative resting structures chlamydospores are the most common types of asexual sporulation described in Agaricomycetes [13]. The formation of calcium oxalic crystals with variable shapes and sizes attached to the cell wall or free is also a characteristic feature of cultures of xylotrophic Agaricomycetes [14–16]. The ability to develop mature fruiting bodies *in vitro* depends on biological, particularly genetic and ecological characteristics of species. Meanwhile, their availability is assisting correct taxonomic identification of species [8, 10, 14].

In the current paper observation of morphological and growth characteristics of mycelial cultures of 24 xylotrophic medicinal and edible Agaricomycetes mushrooms collected in northern forests of Iran is presented.

Materials and Methods.

Fungal Material. Mushrooms were collected from different places of Mazandaran and Golestan Provinces of Northern Iran (see Table) [5]. Dikaryotic cultures of 24 xylotrophic agaricomycetous fungi were isolated by tissue plug method using malt-extract agar (MEA) medium (BBL, USA, 45 g/L) added by 6 mL/L 25% lactic acid [14]. The morphological and growth characteristics of colonies were observed on MEA. Mycelia were grown in 90 mm Petri dishes with ventilation in darkness at 25°C in three replicates.

Study of Growth Characteristics of Mycelia. The cultures were inoculated in the center of Petri dishes (size of inoculum 5 mm³). After incubation, the diameters of colonies were measured daily, until the surface of a dish was completely covered by mycelium. Mycelial growth rate (GR) was calculated according to formula $GR = \Delta d / \Delta t$, where Δd is the difference between diameters of colonies (in mm) during Δt time. The average growth rate (GR_{avr}) was calculated from GR indicators. The growth coefficient (GC) of colonies was calculated according to Bukhalo' formula $GC = d g h / t$, where g is density (1–3) and h is height (in mm) of colony during t growth time (in days) [14].

Morphological Observation. The texture and pigmentation of the colony and agar were described according to Stalpers' scale [15]. Micro-morphological observation of mycelia was performed using light microscope Olympus BH2 equipped to a calibrated drawing tube. Mycelial preparations were obtained by slide-culture method reported previously [7, 10, 11]. Measurements and drawings of mycelial structures were made from slide preparations stained with cotton blue-lactophenol reagent (2 mL 1% aqueous solution of cotton blue in 100 mL lactophenol). The mycelial branching, the presence and form of hyphal clamps, type(s) asexual oidia and chlamydospores, hyphal loops and cystidia, crystalloids and other cultural characteristics were thoroughly observed and photographed.

Fruiting Bodies Development. The ability of studied cultures to develop fruiting bodies under experimental conditions was studied using agar and solid substrates. The Petri dishes with MEA were inoculated and incubated in darkness at 25°C until the medium was covered by mycelia. Afterwards, the dishes were transferred at 6–8°C for a few days and then again at room temperature 22 ± 2°C. Petri dishes were observed for the development of fruiting bodies during more than 30 days at day/night regime.

Studied collections of xylotrophic medicinal and edible Agaricomycetes mushrooms distributed in Mazandaran and Golestan Provinces of Northern Iran

Species	Strain	Host tree	Natural substrate	Date of collection	Collection site
<i>Armillaria mellea</i> (Vahl.) P. Kummer *	838	<i>Alnus glutinosa</i>	Root of dead tree	26.10.2007	Abbas Abad Behshahr
<i>Auricularia auricula-judea</i> (Bull.) J. Schröt. *	1053	<i>Fagus orientalis</i>	Log	21.02.2009	Abbas Abad Behshahr
<i>Climacodon septentrionale</i> (Fr.) P. Karst.	595	<i>Caprinus betulus</i>	Deposited trunk	9.08.2007	Lagim Sari
<i>Cyclocybe aegerita</i> (V. Brig.) Vizzini *	912	<i>Acer velutinum</i>	Trunk of living tree	12.07.2007	Abbas Abad Behshahr
<i>Flammulina velutipes</i> (Curtis) Singer *	1038	<i>Zelkova carpinifolia</i>	Trunk of living tree	5.12.2008	Abbas Abad Behshahr
<i>Fomes fomentarius</i> (L.) Fr.	1018	<i>Fagus orientalis</i>	Fallen trunk	27.07.2008	Abbas Abad Behshahr
<i>Ganoderma adpersum</i> (Schulzer) Donk	1023	<i>Fagus orientalis</i>	Fallen trunk	22.08.2008	Abbas Abad Behshahr
<i>Ganoderma resinaceum</i> Boud.	1049	<i>Populus nigra</i>	Dead log	30.12.2008	Zagh Marz, Behshahr
<i>Hericium erinaceus</i> (Bull.) Pers. #*	1015	<i>Fagus orientalis</i>	Trunk of living trees	16.07.2008	Ali Abad Katul
<i>Hypholoma lateritium</i> (Schaeff.) P. Kumm. *	801	<i>Fagus orientalis</i>	Dead log	29.10.2009	Sangedeh, Savadkoh
<i>Laetiporus sulphureus</i> (Bull.) Murril *	685	<i>Parrotia persica</i>	Stand living tree	30.08.2007	Abbas Abad Behshahr
<i>Lentinus strigosus</i> Fr. *	444	<i>Fagus orientalis</i>	Cuttet trunk	13.06.2007	Sangedeh, Savadkoh
<i>Lentinus tigrinus</i> (Bull.) Fr. *	1048	<i>Populus nigra</i>	Dead log and root	30.12.2008	Zagh Marz, Behshahr
<i>Lenzites betulina</i> (L.) Fr.	1041	<i>Quercus castaneifolia</i>	Living log	12.12.2008	Abbas Abad Behshahr
<i>Meripilus giganteus</i> (Pers.) P. Karst.	814	<i>Fagus orientalis</i>	Root of dead tree	26.10.2007	Abbas Abad, Behshahr
<i>Mycena inclinata</i> (Fr.) Qué. *	59	<i>Caprinus betulus</i>	Fallen rotted branch	5.04.2007	Fek – Astel Sar, Behshahr
<i>Panellus stipticus</i> (Bull.) P. Karst.	961	<i>Fagus orientalis</i>	Fallen twig	19.10.2007	Abbas Abad, Behshahr
<i>Pleurotus ostreatus</i> (Jacq.) P. Kummer *	1056	<i>Fagus orientalis</i>	Fallen trunk	7.03.2009	Abbas Abad, Behshahr
<i>Polyporus arcularius</i> (Batsch) Fr. *	35	<i>Quercus castaneifolia</i>	Fallen rotted branch	30.03.2007	Fek Astel, Behshahr
<i>Schizophyllum commune</i> Fr.	323	<i>Carpinus betulus</i>	Fallen branch	2.05.2007	Koshehdaran, Tonekabon
<i>Trametes gibbosa</i> (Pers.) Fr.	1020	<i>Fagus orientalis</i>	Fallen trunk	28.08.2008	Abbas Abad, Behshahr
<i>Trametes hirsuta</i> (Wulfen) Pilát	142	<i>Carpinus betulus</i>	Fallen branch	20.04.2007	Fek Astel, Behshahr
<i>Trametes versicolor</i> (L.) Lloyd	53	<i>Carpinus betulus</i>	Branch	30.03.2007	Fek Astel, Behshahr
<i>Tremella mesenterica</i> Retz. *	1052	<i>Carpinus betulus</i>	Fallen branch	6.02.2009	Abbas Abad Behshahr

* – edible species; # – from Golestan Province.

The cultures of *Hericium erinaceus*, *Flammulina velutipes* and *Pleurotus ostreatus* were also grown on wood substrates of host plants such as beech

(*Fagus orientalis* Lipsky), persimmon (*Diospyros lotus* L.) and Chinese box (*Euonymus japonica* L.F.) trees. The 2–3 × 6–7 cm pieces of wood were soaked in bottles overnight, sterilized for 30 min at 120°C, then inoculated by mycelia and incubated at the dark, then at day/night regime, as described for Petri dishes.

The collected specimens of mushrooms are deposited at the Mycological herbarium of Passand forest and rangeland station of Mazandaran province of Iran [5]. The mycelial cultures are preserved at the Fungal Culture Collection (FCC-YSU) of the Yerevan State University, Armenia [16].

Results and Discussion.

Growth Characteristics. Based on GR_{avr} indicators, the collections of studied xylotrophs were divided into three groups: slowly growing species with $GR_{avr} < 4.0$ mm/d (*Armillaria mellea*, *Hericium erinaceus*, *Panellus stipticus*); medium-growing species with $GR_{avr} = 4.0–10.0$ mm/d (*Auricularia auricula-judea*, *Climacodon septentrionale*, *Hypholoma lateritium*, *Ganoderma adspersum*, *Flammulina velutipes*, *Fomes fomentarius*, *Lentinus strigosus*, *Lenzites betulina*, *Mycena inclinata*, *Meripilus giganteus*, *Pleurotus ostreatus*, *Schizophyllum commune*, *Trametes hirsuta*, *Trametes versicolor*) and fast-growing species with $GR_{avr} > 10$ mm/d (*Cyclocybe aegerita*, *Laetiporus sulphureus*, *Polyporus arcularius*, *Ganoderma resinaceum*, *Lentinus tigrinus*, *Trametes gibbosa*, *Tremella mesenterica*) (see the List).

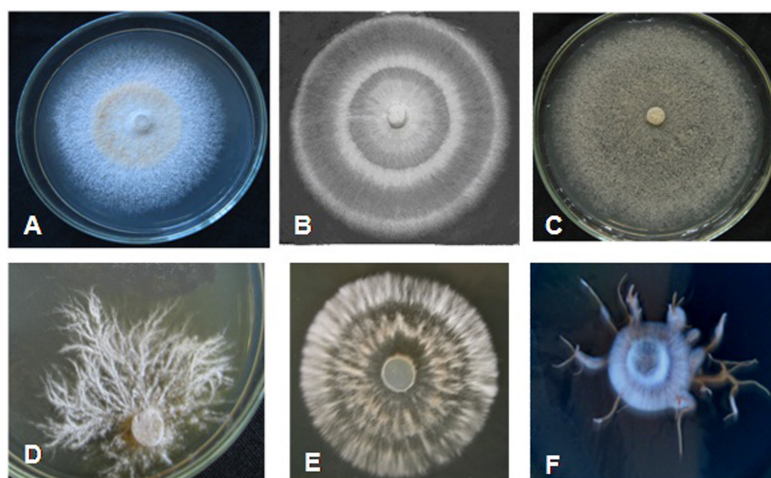


Fig. 1. Mycelial colonies of several Iranian mushrooms: *Flammulina velutipes* (A); *Ganoderma adspersum* (B); *Laetiporus sulphureus* (C); *Hericium erinaceus* (D); *Meripilus giganteus* (E) and *Armillaria mellea* (F).

Based on GC indicators, the studied collections of xylotrophs were divided into 3 groups: $GC < 10$ (*H. erinaceus*, *P. stripticus*); $GC = 10–30$ (*A. mellea*, *A. auricular-judae*, *M. inclinata*, *M. giganteus*, *G. adspersum*, *C. septentrionale*, *T. gibbosa*) and $GC > 30$ (*C. aegerita*, *F. velutipes*, *L. betulina*, *L. sulphureus*, *P. arcularis*, *S. commune*, *T. versicolor*, *T. hirsute*, *T. mesenterica*) (see the List).

The correlation between GR_{avr} and GC was revealed. The colony with lower GR_{avr} and density values have low GC, except *A. mellea* that has the lowest GR_{avr} , but the highest GC, due to increased height and density of mycelial colony.

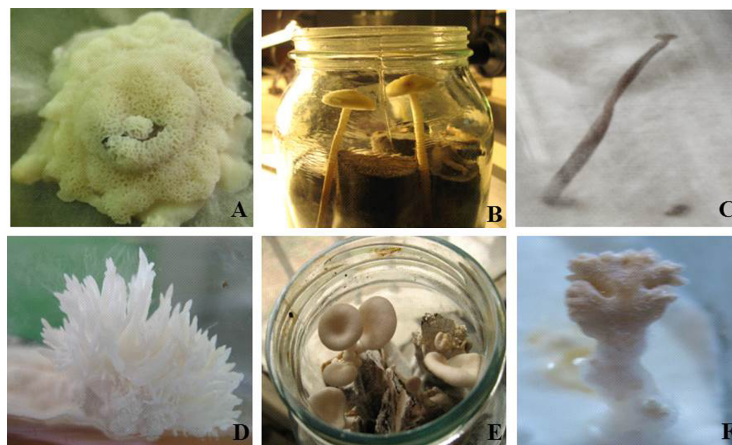


Fig. 2. *In vitro* fruiting bodies development in *M. giganteus* on MEA (A); *F. velutipes* on wood pieces of *Diospyros lotus* (B) and on MEA (C); *H. erinaceus* on MEA (D); *P. ostreatus* on wood of *F. orientalis* (E) and *S. commune* on MEA (F).

Morphological Characteristics. Studied cultures of xylotrophs have formed morphologically different species-specific colonies on MEA described in the List below (Fig. 1, A–F). In our experimental conditions, the development of fruiting bodies was observed in *H. erinaceus*, *F. velutipes*, *M. giganteus*, *P. ostreatus* and *S. commune* on both agar and wood substrates of *F. orientalis* and *D. lotus* trees (Fig. 2, A–F).

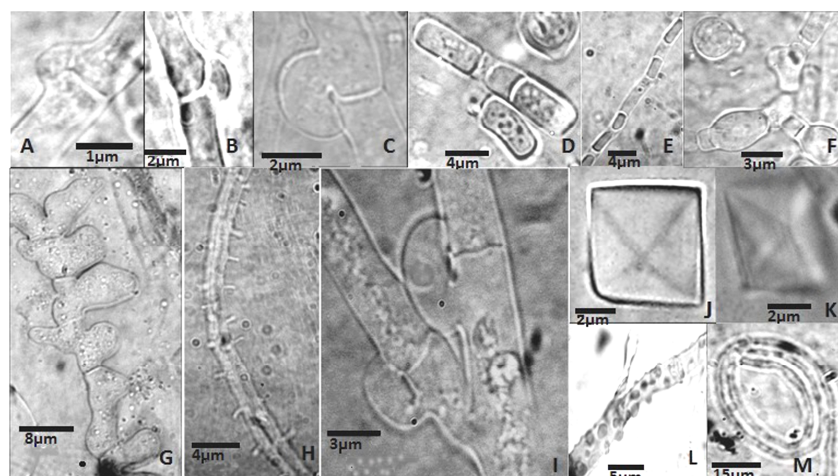


Fig. 3. Mycelial structures of Iranian collections: hyphae and clamps in *T. mesentrica* (A and C), *F. fomentarius* (B), *S. commune* (I); oidia in *L. sulphureus* (D), *A. auricula-judea* (E); chlamydo-spores in *L. sulphureus* (F); cuticular cells in *A. mellea* (G); hyphal toxocysts in *S. commune* (H); wart-like hyphal crystalloids in *C. aegerita* (L); tetrahedral chrystalloids in *G. adspersum* (J) and *T. versicolor* (K); hyphal loops in *A. auricula-judea* (M). Scal bars 1 μm (A); 2 μm (B, C, J and K); 3 μm (F and I); 4 μm (D, E and H); 5 μm (L), 8 μm (G) and 15 μm (M).

The presence of clamps at the hyphal septa approves the dikaryotic status of mycelia in Agaricomycetes. The frequency of occurrence, shape and size of clamps (single, pairs, whorls, round, oval, almond-shaped, giant, small) are considered

species-specific criteria. The round-shaped single clamps were observed in all dikaryotic cultures, except *A. mellea* and *M. giganteus*, in which the clamps were absent (Fig. 3, A, B, C, I).

Asexual oidia were observed in all species, except *A. mellea*, *C. aegerita*, *G. adspersum*, *H. lateritium*, *P. ostreatus* and *S. commune* (Fig. 3, D, E). Tick-walled chlamydospores or chlamydospore-like swellings were developed in *C. septentrionale*, *H. erinaceus*, *G. adspersum*, *G. resinaceum*, *F. velutipes*, *L. sulphureus*, *L. tigrinus*, *L. betulina*, *M. giganteus*, *P. arcularius*, *S. commune* and *T. gibbosa* (Fig. 3, F; 4, A–C).

The formation of crystalloids is a characteristic feature of xylotrophic Agaricomycetes. The tetra- and octahedral crystals were mainly observed in agar medium during cultivation of *C. aegerita*, *G. adspersum*, *M. giganteus*, *P. ostreatus* and *T. versicolor* (Fig. 3, J and K).

The well-developed hyphal loops were described in *A. auricula-judea*, *F. fomentarius*, *F. velutipes*, *L. sulphureus*, *M. giganteus*, *P. stipticus*, *P. ostreatus* and *S. commune* (Fig. 3, M).

Critical Alphabetical List of Morphological and Growth Characteristics of Studied Iranian Collections of Xylotrophic Medicinal Mushrooms

***Armillaria mellea*.** Colony is white to brown, cottony, convex, forming rhizomorphs, agar brown (Fig. 1, F). The $GR_{avr}=0.74\text{ mm/d}$; $GC=11.5$. Cuticular cells are hyaline at first then swelled when matured, closely attached to form pseudoparenchyma (Fig. 3, G). Hyphal clamps are absent. Numerous small crystalloids on the surface of hyphae are observed.

***Auricularia auricula-judea*.** Colony is white, convex, cottony, margin even, agar pinkish. The $GR_{avr}=4.71\text{ mm/d}$; $GC=16.0$. Hyphal width is $1.6\text{--}4.0\ \mu\text{m}$. Round-shaped single clamps ($1.6\text{--}4 \times 2.4\text{--}6.4\ \mu\text{m}$) were frequently observed. Cylindrical oidia ($1.6\text{--}2.0 \times 4.1\text{--}8.0\ \mu\text{m}$) and hyphal loops are present (Fig. 3, E, M). Small crystalloids are observed on the surface of hyphae.

***Climacodon septentrionale*.** Colony is white, creamy-brownish, cottony and downy to farinaceous with concentric zones, agar brown. The $GR_{avr}=4.9\text{ mm/d}$; $GC=19.79$. Hyphal width is $2.0\text{--}6.9\ \mu\text{m}$. Hyphal clamps are absent. Numerous apical hyphal swellings and chlamydospores ($4.2\text{--}6.7 \times 5.8\text{--}8.3\ \mu\text{m}$) are formed. Hyphal loops are present.

***Cyclocybe aegerita*.** Colony is white, cottony-fimbriated, margin even, agar unchanged. The $GR_{avr}=10.5\text{ mm/d}$; $GC=70.31$. Hyphal width is $2.0\text{--}5.6\ \mu\text{m}$. Round-shaped single, rarely paired clamps ($2.4\text{--}4.0 \times 5.6\text{--}8.0\ \mu\text{m}$) are frequent. Oidia and chlamydospores are not observed. Shapeless and wart-like small crystals on the surface of hyphae are observed (Fig. 3, L).

***Flammulina velutipes*.** Colony is white, yellowish-brown from the center, cottony-farinaceous, felty, margin even, agar yellowish (Fig. 1, A). The $GR_{avr}=5.4\text{ mm/d}$; $GC=36.6$. Fruiting bodies easily developed on MEA and wood pieces of *D. lotus* after two weeks of growth (Fig. 2, B, C). Hyphal width is $2.4\text{--}6.4\ \mu\text{m}$. Small, round-shaped single clamps ($4.0\text{--}1.6 \times 8.0\text{--}4.8\ \mu\text{m}$) are frequently observed. Apical and intercalary spherical to ellipsoid chlamydospores ($7.2\text{--}8.0 \times 11.2\text{--}14.4\ \mu\text{m}$) and cylindrical oidia ($2.2\text{--}3.3 \times 6.7\text{--}8.9\ \mu\text{m}$) are numerous (Fig. 4, A).

***Fomes fomentarius*.** Colony is white, cottony, becoming creamy to brown, fealty to suede, agar brownish. The $GR_{avr}=8.85\text{ mm/d}$; $GC=29.43$. Hyphal width is

1.6–6.4 μm . Round-shaped single clamps (1.6–4.0 \times 2.4–8.0 μm) are frequently forming (Fig. 3, B). Cylindrical and ellipsoid oidia (2.4–16.0 \times 2.4–22.4 μm) are present. Chlamydo-spores were not seen. Rod-shaped, tetra- and octahedral crystalloids were described (Fig. 3, J).

Ganoderma adpersum. Colony is white, cottony or farinaceous, felty to pellicular, olive brown, frequently wrinkled to form pseudoparenchyma (Fig. 1, B). The $\text{GR}_{\text{avr}} = 7.9 \text{ mm/d}$; $\text{GC} = 17.39$. Hyphal width is 1.6–6.4 μm . Single rounded clamps are frequent (1.6–4.0 \times 4.0–6.4 μm). In pseudoparenchymatous part of aging colony numerous round to ellipsoid cuticular cells (5.4–7.8 \times 4.5–8.2 μm) are described. Oidia are not observed. Tetra- and octahedral crystals (4.5–9.5 \times 5.1–9.2 μm) are numerous (Fig. 3, J).

Ganoderma resinaceum. Colony is white, slightly raised to appressed, cottony, felty to farinaceous. The $\text{GR}_{\text{avr}} = 10.5 \text{ mm/d}$; $\text{GC} = 25.3$. Hyphal width is 2–4.8 μm . Round-shaped single clamps (2.0–5.6 \times 4.0–6.4 μm) are often. Species specific thick-walled round, ovoid to ellipsoid chlamydo-spores (gastero-spores) (6.4–10.4 \times 8.8–14.4 μm) are numerous. Oidia are absent. Tetra- and octahedral crystals are described in the agar.

Hericium Erinaceus. Colony is white, cottony-downy or downy-farinaceous, remaining so or becoming lumps-cottony with mycelial strands, agar unchanged (Fig. 1, D). The $\text{GR}_{\text{avr}} = 2.85 \text{ mm/d}$, $\text{GC} = 3.25$. Hyphal width is 2.0–5.6 μm . Round-shaped single clamps (1.2–2.4 \times 4.0–6.8 μm) are frequent. Apical hyphal swellings and chain of intercalary chlamydo-spores (5.6–6.4 \times 8.8–14.5 μm) are numerous. The formation of fruiting bodies was observed only on MEA after six weeks of growth (Fig. 2, D).

Hypholoma lateritium. Colony is white, downy, cottony, becoming dense yellowish-brown, felty-velvety, margin even, agar yellowish-brown. The $\text{GR}_{\text{avr}} = 4.92 \text{ mm/d}$; $\text{GC} = 21.65$. Hyphal width is 1.2–7.2 μm . Single round-shaped clamps are often (1.6–4.8 \times 3.2–7.2 μm). Sub-globose to ellipsoid oidia (2.4–4.0 \times 5.6–9.0 μm) are observed.

Laetiporus sulphureus. Colony is light ochre-yellow to light ochre-salmon, dusty granular, agar unchanged (Fig. 1, C). The $\text{GR}_{\text{avr}} = 12.0 \text{ mm/d}$; $\text{GC} = 77.14$. Hyphal width is 2.4–11.0 μm . Hyphal clamps are almost absent, while cylindrical, sub-globose to ellipsoid oidia (6.5–10.5 \times 9.6–25.0 μm) are described. Thick-walled apical and intercalary chlamydo-spores (6.3–8.2 \times 9.1–11.8 μm) and terminally developed aleuvric spores (6.4–7.3 \times 9.1–10.9 μm) on the branched conidiogenic hyphae are abundant (Fig. 3, D and F; 4, C).

Lentinus strigosus. Colony is white, cottony, radially growing, agar unchanged. Fruiting bodies have appeared after four weeks of growth on MEA. The $\text{GR}_{\text{avr}} = 5.62 \text{ mm/d}$; $\text{GC} = 20.27$. Hyphal width is 2.4–6.0 μm . Single round-shaped clamps (1.5–3.0 \times 5.6–9.0 μm) are frequently observed. Oidia are cylindrical, subglobose to ellipsoid (5.0–6.7 \times 12.5–20.2 μm). Chlamydo-spores are not seen. Aggregated on the surface of hyphal apex crystalloids are observed.

Lentinus tigrinus. Colony is white, radially growing, becoming beige-brown, cottony to leathery, agar changed to brown. Fruiting bodies have appeared after four weeks of growth on MEA. The $\text{GR}_{\text{avr}} = 12.0 \text{ mm/d}$; $\text{GC} = 28.93$. Hyphal width is 1.0–6.0 μm . Single small round-shaped clamps (1.5–3.0 \times 3.0–6.0 μm) are often. Cylindrical oidia (2.4–3.3 \times 22.2–29.1 μm) and tick-walled fusiform terminal and intercalary-developed chlamydo-spores (5.5–8.0 \times 1.5–17.0 μm) are observed. Small crystalloids on the hyphal surface are numerous.

Lenzites betulina. Colony is white, slightly raised, floccose to woolly, patchy and felty, margin even, agar unchanged. Fruiting bodies have appeared after three weeks of growth on MEA. The $GR_{avr}=9.15\text{ mm/d}$; $GC=36.81$. Hyphal width is $1.0\text{--}5.0\ \mu\text{m}$. Single round-shaped clamps ($1.5\text{--}3.0\times 4.5\text{--}10.0\ \mu\text{m}$) are present at almost each septum. Chlamydo-spores are rarely observed ($9.1\text{--}10.9\times 12.7\text{--}14.5\ \mu\text{m}$), while oidia are absent. Numerous comb-like hyphae are described.

Meripilus giganteus. Colony is white, radially growing to form raised zones, light brown to cinnamon brown, wood or dark brown, margin even, agar bleached, yellowish (Fig. 1, E). Coral-like fruiting bodies have appeared after four weeks of cultivation on MEA (Fig. 2, A). The $GR_{avr}=6.75\text{ mm/d}$; $GC=16.96$. Hyphal width is $2.5\text{--}9.0\ \mu\text{m}$. Hyphal clamps are absent. Cylindrical oidia ($6.1\text{--}6.9\times 22.6\text{--}26.1\ \mu\text{m}$), apical and intercalary chlamydo-spores ($8.7\text{--}12.7\times 9.7\text{--}15.7\ \mu\text{m}$) are observed. Hyphal loops, tetrahedral and rod-shaped crystalloids are numerous.

Mycena inclinata. Colony is cottony-white with concentric zones, later ochraceous-brown to light-brown, agar unchanged. The $GR_{avr}=6.67\text{ mm/d}$; $GC=16.44$. Hyphal width is $2.5\text{--}4.0\ \mu\text{m}$. Single round-shaped clamps ($1.5\text{--}2.5\times 4.0\text{--}5.5\ \mu\text{m}$) are present at almost each septum. Oidia ($1.0\text{--}2.0\times 9.0\text{--}12.5\ \mu\text{m}$) are observed, while chlamydo-spores are absent. Complex hyphal loops are often.

Panellus stipticus. Colony is cottony, appressed, nasty white, margin even, agar unchanged. The $GR_{avr}=3.0\text{ mm/d}$; $GC=3.3$. Hyphal width is $1.5\text{--}6.5\ \mu\text{m}$. Single rounded clamps ($2.5\text{--}3.0\times 3.0\text{--}7.5\ \mu\text{m}$) are often. Cylindrical and rectangular oidia ($0.25\text{--}0.6\times 1.25\text{--}3.1\ \mu\text{m}$) are abundantly developed. Chlamydo-spores are absent, while rare crystalloids are described.

Pleurotus ostreatus. Colony is white, slightly raised, radially growing, cottony, woolly to felty, margin uneven, agar unchanged or bleached. Fruiting bodies easily developed on MEA and *F. orientalis* wood substrate (Fig. 2, E). The $GR_{avr}=6.62\text{ mm/d}$; $GC=21.56$. Hyphal width is $3.0\text{--}9.0\ \mu\text{m}$. Single round-shaped clamps ($2.5\text{--}3.0\times 4.0\text{--}7.0\ \mu\text{m}$) are often. Blastocyst round-shaped structures on the extending at the base hyphal outgrowth are observed. Small rod-shaped and tetrahedral crystalloids are abundant.

Polyporus arcularius. Colony is white to creamy, brownish to vinaceous, woolly, felty, appressed, margin even, agar unchanged. The $GR_{avr}=10.1\text{ mm/d}$; $GC=32.5$. Fruiting bodies developed after seven weeks of growth on MEA and two months of growth on *F. orientalis* and *E. japonica* wood pieces at room conditions. Hyphal width is $1.5\text{--}5.0\ \mu\text{m}$. Single round-shaped clamps ($1.6\text{--}3.0\times 4.0\text{--}7.5\ \mu\text{m}$) are frequently formed. Intercalary chlamydo-spores ($4.2\text{--}6.0\times 6.0\text{--}9.7\ \mu\text{m}$) and oidia ($1.2\text{--}2.0\times 3.8\text{--}5.7\ \mu\text{m}$) are observed. Irregularly thick-walled horn-like generative hyphae and hyphal loops are described.

Schizophyllum commune. Colony is white, cottony, locally woolly, floccose woolly or plumose, becoming felty white, margin raised, uneven, agar unchanged. Fork-shaped fruiting bodies with distinguished lamellas, basidia and basidiospores are formed after four weeks of growth on MEA (Fig. 2, F). The $GR_{avr}=6.35\text{ mm/d}$; $GC=36.6$. Hyphal width is $1.5\text{--}8.0\ \mu\text{m}$. Single round-shaped clamps ($2.5\text{--}3.0\times 7.0\text{--}10.5\ \mu\text{m}$) are present at almost each septum (Fig. 3, I). Intercalary ellipsoid ($4.5\text{--}7.0\times 6.5\text{--}14.5\ \mu\text{m}$) and terminally sub-spherical ($6.5\text{--}7.0\times 9.5\text{--}11.0\ \mu\text{m}$) chlamydo-spores are numerous (Fig. 4, B). Species specific apical hyphal outgrowths or toxocysts are observed (Fig. 3, H).

***Trametes gibbosa*.** Colony is white, cottony, cottony-floccose, farinaceous creamy, appressed to raised, agar yellowish. The $GR_{avr} = 13.8 \text{ mm/d}$; $GC = 15.0$. Hyphal width is $2.5\text{--}7.2 \mu\text{m}$. Single round-shaped clamps ($1.6\text{--}4.0 \times 4.0\text{--}8.0 \mu\text{m}$) are often. Irregularly tick-walled generative hyphae are observed. Chlamydo spores ($6.7\text{--}8.3 \times 6.7\text{--}11.7 \mu\text{m}$) are present, while oidia are absent. Numerous tetra- and octahedral crystals are described.

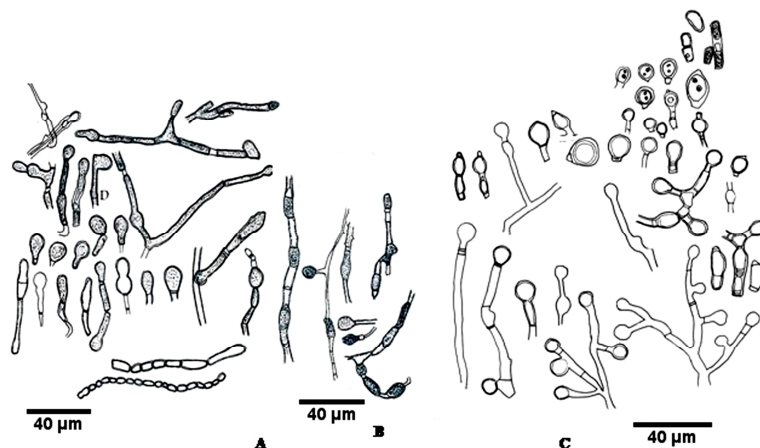


Fig. 4. Chlamydo spores in cultures of *F. velutipes* (A), *S. commune* (B) and *L. sulphureus* (C). Scal bars $40 \mu\text{m}$.

***Trametes hirsuta*.** Colony is white, cottony woolly, compact woolly to felty, frequently tufted or reticulate, yellow-brown, agar unchanged. The fruiting bodies development is observed after two weeks of growth on MEA. The $GR_{avr} = 8.71 \text{ mm/d}$; $GC = 56.0$. Hyphal width is $2.5\text{--}8.0 \mu\text{m}$. Single round-shaped clamps ($1.5\text{--}5.0 \times 5.0\text{--}9.0 \mu\text{m}$) are often. Oidia and chlamydo spores are not observed, while numerous tetra- and octahedral crystals are described.

***Trametes versicolor*.** Colony is white, woolly or woolly floccose, felty-suede, agar unchanged. The $GR_{avr} = 9.34 \text{ mm/d}$, $GC = 54.17$. Hyphal width is $1.2\text{--}5.6 \mu\text{m}$. Single round-shaped clamps ($1.5\text{--}4.0 \times 3.2\text{--}7.2 \mu\text{m}$) are frequently revealed. Oidia and chlamydo spores are not observed. Tetra- and octahedral crystals are abundant (Fig. 3, K).

***Tremella mesenterica*.** Colony is white, reticulate hairy, downy, woolly-felty, margin even, agar unchanged. The $GR_{avr} = 14.0 \text{ mm/d}$; $GC = 67.5$. Hyphal width is $2.5\text{--}5.5 \mu\text{m}$. Single round-shaped clamps ($1.5\text{--}5.0 \times 5.5\text{--}13.0 \mu\text{m}$) are often (Fig. 3, A, C). Cylindrical oidia ($0.5\text{--}1.2 \times 1.8\text{--}4.0 \mu\text{m}$) are observed, while chlamydo spores are not seen. Small, wart-shaped crystalloids are described on the surface of hyphae.

Conclusion. The morphological and growth characteristics of vegetative mycelial structures of Iranian collections of 24 xylotrophic medicinal and edible Agaricomycetes mushrooms were observed for the first time. Several mycelial characteristics are taxonomically significant and could assist in the correct identification of fungal cultures of studied species/strains during their biotechnological cultivation to obtain mycelial biomass and bioactive compounds.

Received 28.02.2019

Reviewed 04.05.2019

Accepted 17.05.2019

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