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Three New Records of *Agaricus* (*A. bisporus, A. glabriusculus, A. trisulphuratus*) from district Gujranwala, Pakistan

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Abstract
The current study describes first records of a common edible mushroom (*Agaricus bisporus*) and two inedible mushrooms (*A. glabriusculus* and *A. trisulphuratus*) from district Gujranwala. These three *Agaricus* species were collected during field surveys for the collection of macro-fungi from the Punjab province during rainy seasons of years 2021 and 2022. The comprehensive morphological characterization in terms of morphoanatomical descriptions, macro & micro-photography and illustrations of the collected specimens are provided. Detailed comparison of all three *Agaricus* species with their morpho-anatomically similar species of the genus is also given in the article.

Keywords: *Agaricus*, Basidiomycota, Fungal diversity, New record, Taxonomy

Introduction:

The macrofungal genus *Agaricus* L. (Agaricaceae, Agaricales, Basidiomycota) comprises a number of saprobic species with a lot of medicinal, dietary and ecological importance. The members of this genus live in a variety of tropical and moderate temperate environmental zones (He et al., 2017; Tarafder et al., 2022; Nawaz et al., 2025). These mushrooms found in all continents, with the exception of Antarctica, within variety of climatic conditions (Karunarathna et al., 2016; Chen et al., 2017; Tarafder *et al*., 2022). Members of this genus can grow up in forests, grasslands, plains, dunes or any other environment with decomposing organic materials because they are saprobic in nature (Callac & Chen, 2018). Morphologically, majority of species are distinct in their shape and have fleshy basidiomata that range in size from small to large, pilei of different colors (brown, sometimes blackish, grey, purple, reddish-brown, white or yellow) with a central stipe which possesses a membranous annulus; free lamellae that turns from pink to chocolate brown upon maturity. Anatomically, species have dark brownish basidiospores that are generally elliptical to widely ellipsoid-shaped with a germ pore (with 7.5 × 6.2 µm mean value), with mostly clavate shape to pyriform shaped cheilocystidia (Singer, 1986; Tarafder et al., 2022). Genus *Agaricus* has around 500 species that are known to exist, divided into 6 subgenera along 27 sections (Jaichaliaw et al., 2021; Nawaz et al., 2024; Nawaz et al., 2025). Genus *Agaricus* comprised 40 species in Britain, more then 90 species in Europe, 126 species from India and 44 species along Pakistan (Ahmad et al., 1997; Al-Momany & Saleh, 2009; Ortiz-Santana et al., 2021; Aman et al., 2022; Niazi et al., 2022; Tarafder et al., 2022; Chudhrey et al., 2023; Nawaz *et al.,* 2025).

Gujranwala, a biodiversity-rich site, is third largest rapidly growing industrial city after Karachi and Faisalabad. It sits between the 32°9'0''N and 74°11'0''E with more than 3 million population. The elevation of Gujranwala from sea level is 225 m, expanding over an area of 3,622 km^2 (Altaf et al., 2012; Mahmood et al., 2013; Khan et al., 2015). Climate of district Gujranwala is hot and semi-arid with temperature fluctuations ranging from 5 °C to 46 °C and annual rainfall about 200-500 mm (Ashraf et al., 2016). Its soil is very fertile with loamy, sandy, and silty texture. These unique edaphic and climatic conditions favor unique diversity of macromycetes (Afzaal et al., 2009; Khan et al., 2015; Ashraf et al., 2016; Altaf, 2021; Niazi et al., 2022; Chudhrey et al., 2023; Iqbal et al., 2023).

Although, taxonomic study of genus *Agaricus* from different areas of Punjab is being done by Pakistani mycologists (Niazi et al., 2022; Chudhrey et al., 2023; Iqbal et al., 2023) but district Gujranwala has been least explored regarding mushroom diversity so far. Only two species of *Agaricus* i.e., *A. brunneodiscus* and *A. campestris* have recently been reported from Gujranwala (Chudhrey et al., 2023; Iqbal et al., 2023). In current investigation, three more species of *Agaricus* (*A.*

bisporus, A. glabriusculus, A. trisulphuratus) are being presented which has raised the number to five from Gujranwala.

Material and methods:

Samples collection:

For the collection of *Agaricus* samples, different villages of Gujranwala have been visited several times during monsoon seasons between July to October during the years 2021-2022. Several visited localities for the gathering the specimens included canals, farms, gardens, graveyards, roadsides, village banks, wooden logs, animal dung sites, and parks etc.

Morphological analysis:

At sampling sites, photos of collected fruiting bodies of *Agaricus* were captured. Basidiomata were vouchered, with date of collection, locality, and collector's name. In the field, some macroscopic features of specimens were recorded, mainly in accordance with Largent (1986) and Chen et al. (2015), i.e. color and pileus's size, gills, stipe and presence of annular ring, discoloration and odor etc.

In laboratory, a fan heater was used to dry the specimens and finely packaged in separate paper boxes after drying for the purpose of preservation.

Microscopic analysis:

Slides were make ready in 5% aqueous KOH (w/v) for microscopic examinations. Slides were also prepared in 1% aqueous Congo red solution (w/v) for hyaline structures. Under a light microscope, dimensions of the microscopic characteristics (basidiospores, cheilocystidia, stipitipellis, basidia, pileipellis along with hyphae on the buttom surface of the annulus) were recorded. At least 20 readings were calculated for each anatomical features. Additionally, extreme spore length and width values were also noted. Total number of spores determined for each collection is n, and avgQ is the average of the Q coefficient (length/width ratio). Length of basidia were calculated by excluding the sterigmata and number of sterigmata were also noted.

Results:

The morpho-anatomical explanations of three species i.e., *Agaricus bisporus* sect. Bivelares (GC-13), *A. glabriusculus* sect. Minores (GC-12) and A. *trisulphuratus* sect. Trisulphurati (GC-71), are given in the form of description, micrographs, and illustrations. These species have been collected and reported as new records from a new locality of Punjab, Pakistan, i.e., Gujranwala.

Taxonomy

Taxon # 1:

Agaricus bisporus (J.E. Lange) Imbach, Mitt. Naturf. Ges. Luzern 15: 15 (1946)

Morphological Analysis (Figure 1)

Basidiocarp 5.4-11.7 × 3.6-7.8 cm, delicate and plumpy, epigeous, humicolous, terrestrial, dispersed to social or crowded in nature. **Pileus** 3.4-4.7 × 3.2-3.7 cm, umbonate during initial stage which is concave while young but becomes convex as it matures, squamulose surface, dark brown to bronze-colored furfuraceous, surrounding all around the pileus, brittle, velvety surface, dark chocolaty patches on surface, milky white. **Lamellae** off-white to light pinkish to light brown ultimately dark chocolaty brown in color, closed at young stage, liberated after maturity, subsequently emerges dark chocolate brown at maturity; a dense cluster that is equal, even, closely linked, average, alternates with little lamellulae, ventricose, has even edges, and is not deliquescent. **Stipe** 3.2-4.4 × 1.4-1.9 cm, cylinder-shaped, off-white to pure white, solid, rigid, connected in the center to the pileus, slightly smooth surface. **Annulus or partial veil** observed but linked to the pileus; immature and rudimentary, slightly membranous; not conspicuous. Dark brown spore print. **Volva** missing. **Rhizomorphs** observed. Taste appetizing. **Odor** pleasurable.

Microscopic Analysis (Figures 2 & 3)

Basidiospores 7.4-9.3 × 5.2-7.0 µm, Q= 1.3-1.6, avgQ= 1.38, broadly ellipsoidal shaped, generally hard walled, dark brownish 5% KOH, plane, and without a germ pore. **Basidia** 16.5-25.8 × 9.2-11.0 µm, shape clavate obclavate, called bisporic so two sterigmata observed, base width 3.2-5.2 µm, and bisterigmata having length of 2.3 m, cytoplasmic, thin-walled, and hyaline to light brown. **Cheilocystidia** 19.2-25.8 × 9.2-13.2 µm, thin-walled, clavate to barrel-shaped, flat, and transparent in 5% KOH. **Pleurocystidia** not observed. **Tramal cells** missing. **Pileipellis** 4.5-12.4 µm, complex wall characteristics, extremely branching interwoven hyphae, thin to wide, moderately constricted at the septal area. **Stipitipellis** composed of attenuate-circumscribe, interwoven, having septum, and forked mycelium, 5.2-7.8 µm in width, transparent in 5% KOH. **Clamp** links not observed.

Material Studied:

Locality: Village Kot Shah Qazi, Tehsil & District Gujranwala, Punjab, Pakistan**.** Habit: Solitary**.** Habitat: damp humus alongside a canal**.** Host: Found growing underneath *Acacia nilotica* (L.), at 226 m a.s.l. Date of Collection: 12-08-2021. Collected by: Samra Saeed**.** Voucher ID: GC-13. Herbarium No.: NYGCU_26_01.

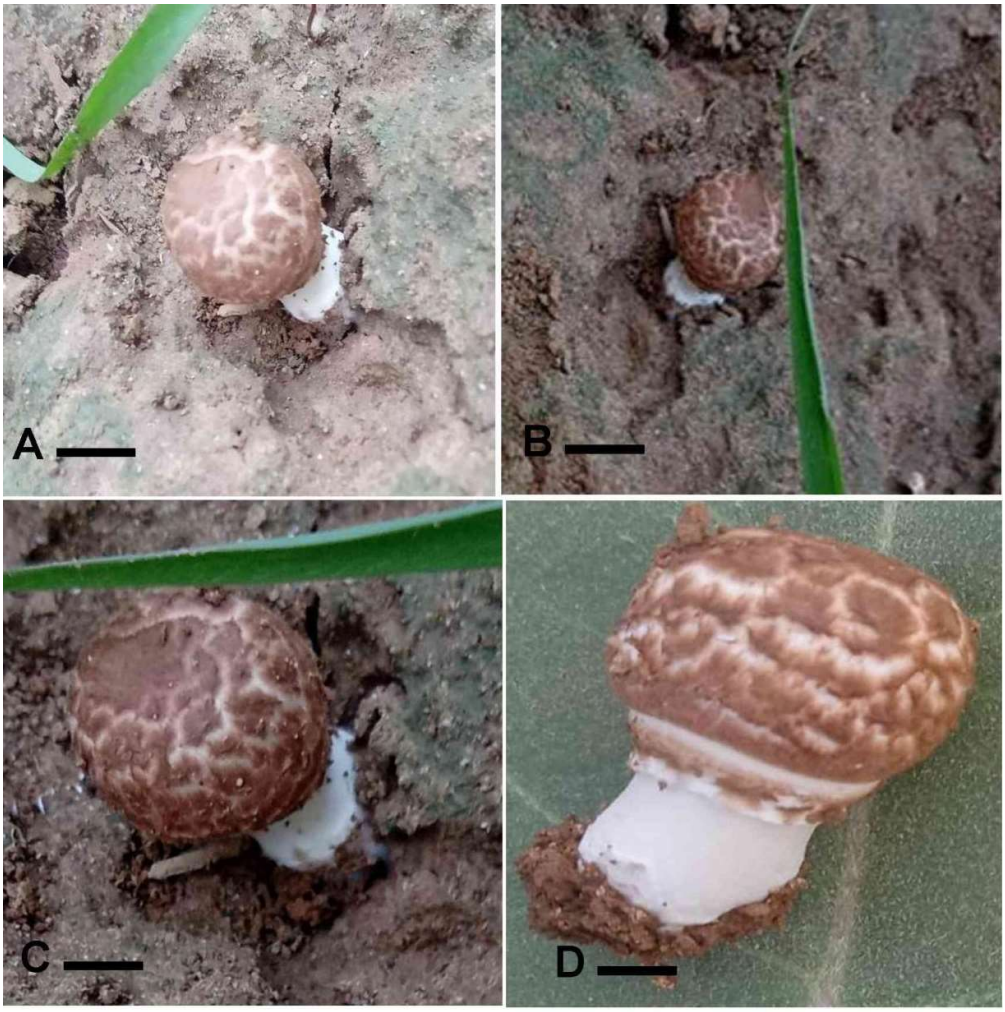

Figure 1: Figs. A-D. Different views showing morphology of basidiomata of *Agaricus bisporus* (GC-13). **Scale bar:** A= 1 cm, B= 1.5 cm, C & D= 0.5 cm.

Taxon # 2:
Agaricus glabriusculus S. Hussain, in Hussain & Sher, Mycol. Progr. 18(6): 799 (2019)
Morphological Analysis (Figure 4)
Basidiocarp 4.0-5.6 × 3.4-4.2 cm, delicate, epigeous, pulpy, humicolous, small, soft, and sole to dispersed. **Pileus** 2.8-3.5 × 1.0-1.5 cm, hemispherical to conical bell-shaped, sub-conical to convex, with appendiculate borders, umbonate, incurved nature, pure white to off-white in hue; dark brown to copper reddish color in the center, fibrillose in nature, with patches or squamules that resemble ginger, light brownish to dark brownish, and a surface covered in dark brown flakes, strewn from the center to the periphery, giving smooth velvety texture, a off-white to light pinkish tone that matures to a dark brown hue. **Lamellae** free, thin, average, complex, alternate with tiny lamellulae, size range diverges, maturing from off-white creamy to light pink to brown to dark brown after maturity. **Stipe** 2.4-3.0 × 0.8-1.4 cm, pure white beyond the annulus and off-white to light brown from below than the annulus; faintly thicker from the center; centrally joined; equal but thin or tapering from base, having persistent, lengthy striations on the surface, being slightly bendable from the base, and being covered in dirt among the rhizomorphs. **Annulus or partial veil** present, membrane-like, somewhat superior, fragile, pendant like, off-white to white in hue. **Volva** not present. **Rhizomorphs** in shape of wide solid threads. **Taste** unchecked. **Odor** pleasurable.

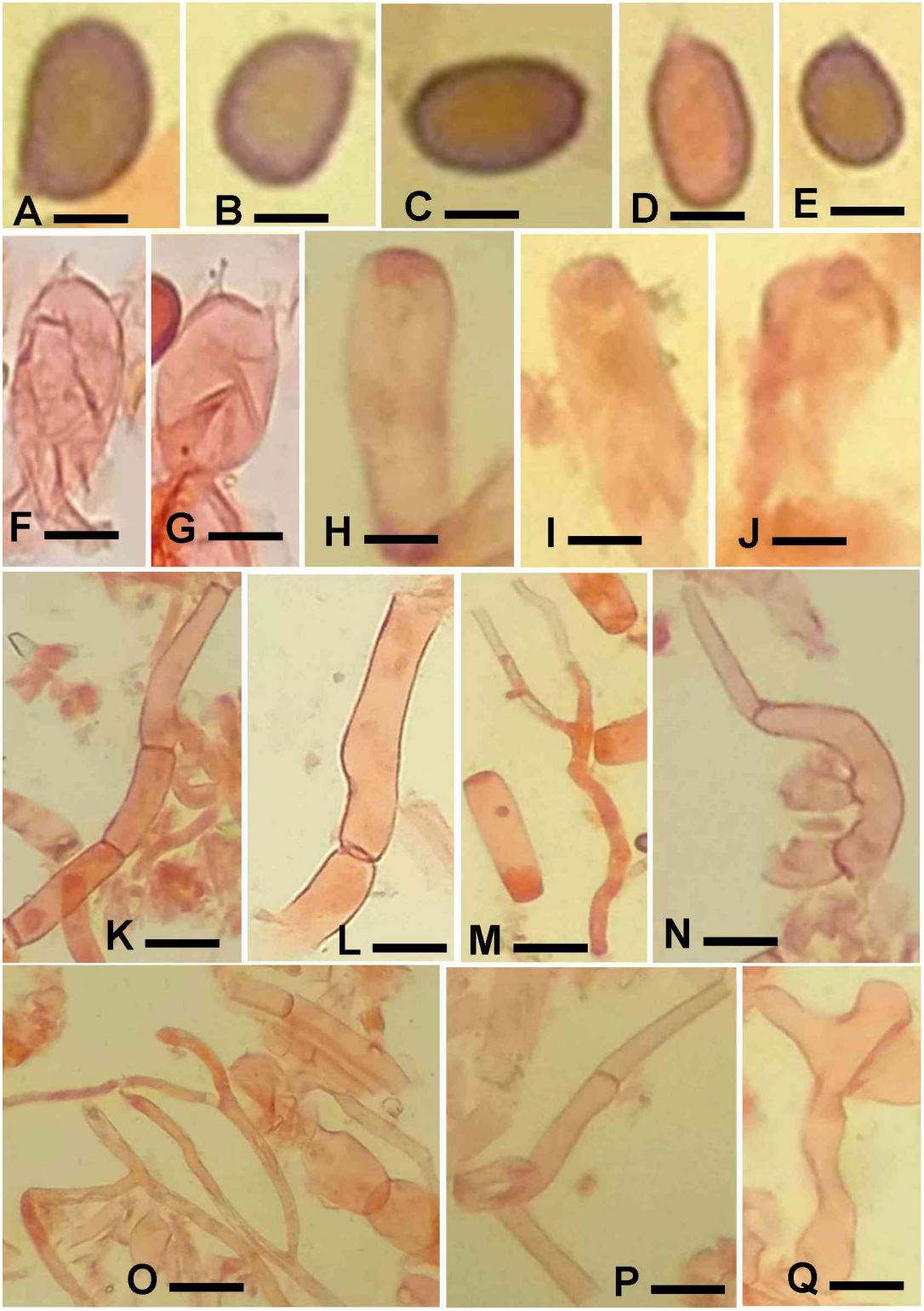

Figure 2: Figs. A-Q. Light micrographs of microscopic features of *Agaricus bisporus* (GC-13). A-E. Basidiospores. F & G. Basidia. H-J. Cheilocystidia. K-N. Pileipellis. O-Q. Stipitipellis. **Scale bar:** A&B= 2.5 µm, C&D= 3 µm, E= 3.5 µm, F= 6 µm, G= 5 µm, H,I&Q= 7.5 µm, J= 5.5 µm, K= 17 µm, L= 9.5 µm, M&N= 14 µm, O&P= 15 µm.

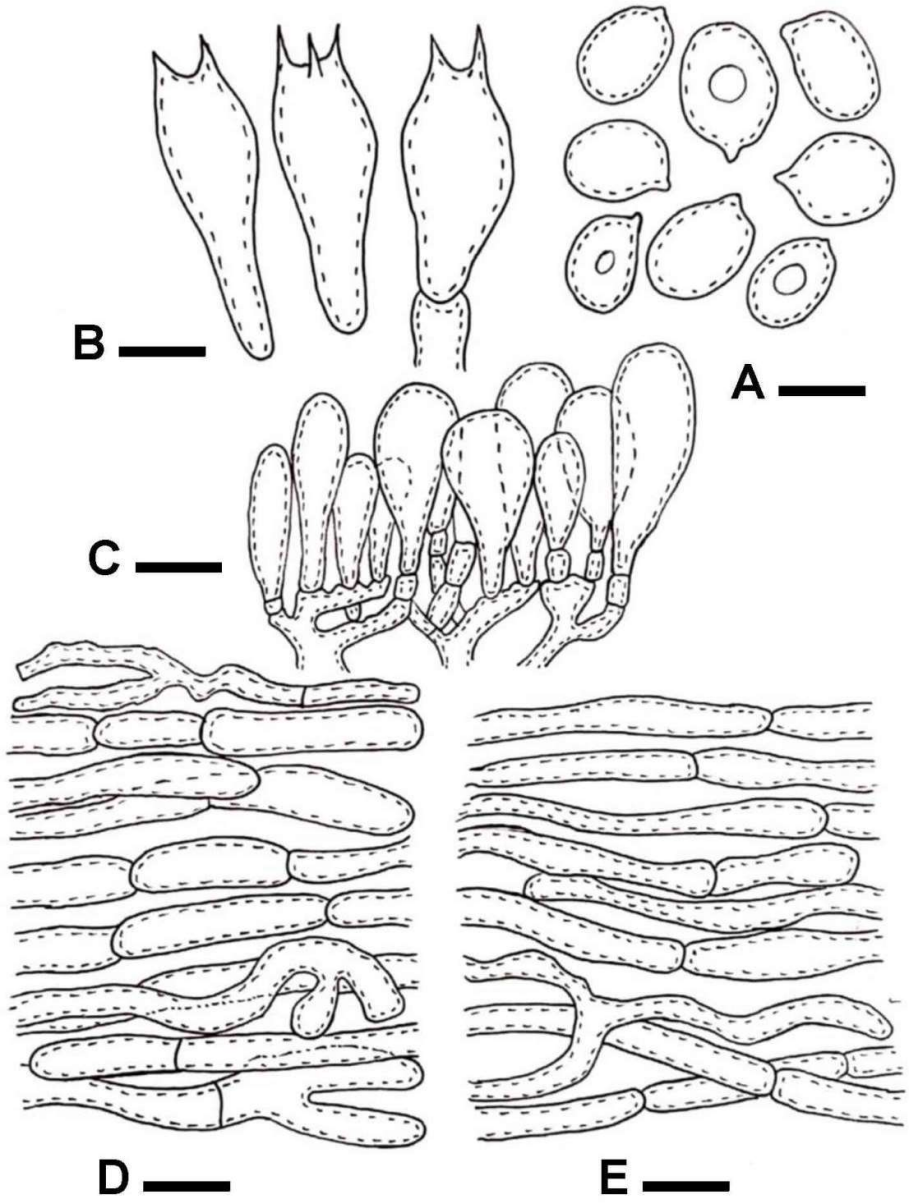

Figure 3: Figs. A-E. Illustrations of microscopic features of *Agaricus bisporus* (GC-13). A. Basidiospores. B. Basidia. C. Cheilocystidia. D. Pileipellis. E. Stipitipellis. **Scale bar:** A= 4.5 µm, B= 6 µm, C= 8 µm, D= 14 µm, E= 10 µm.

Microscopic Analysis (Figures 5 & 6)

Basidiospores 5.8-6.8 × 3.8-4.7 µm, Q= 1.2-1.6, avgQ= 1.5, granular, smooth, ellipsoidal to faintly barrel-shape, somewhat ovoid to lenthend size, lavender to inky dark color, chocolaty greenish brown at the centre, having oil droplets, thick walled, germ pore present, apedicellate. **Basidia** 22.7-31.5 × 9.8-14.3 µm, 3.5-5.4 µm, primarily clavate, base broad, 1.5-2.7 µm sterigmata, thin from pedicel, bisporic to tetrasporic in nature, narrow bounded and droplets of oil present. **Cheilocystidia** 20.7-28.7 × 10.5-16.8 µm, generally clavate to barrel-shaped in shape, partitioned cells, and with thin walls. **Pleurocystidia** 25.6-37.8 × 14.5-20.8 µm, usually thin walled, widely fusiform in shape, some utriform. **Tramal cells** missing. **Pileipellis** consist of hyphae, 4.4-14.0 µm wide, posses cytoplasmic contents, majority with septate and having branching, with thick walls, rare pileipellis elements also found, ranged in size from narrow to wide. **Stipitipellis** composed of hyphae, 9.8-17.2 µm wide, rigid walled, septate, protuberant, with branches that posses cytoplasm. **Clamp** link nots noticed.

Material Studied:

Locality: Shareef town, Tehsil & District Gujranwala, Punjab, Pakistan. Habit: flourishing

solitary. Habitat: damp humus alongside a canal. Host: at surface of moist ground near *Dalbergia sissoo* Roxb. field, at 226 m a.s.l. Date of Collection: 18-08-2021. Collected by: Samra Saeed & Saliha Rukhsar. Voucher ID: GC-12. Herbarium No.: NYGCU_26_02

Figure 4: Figs. A-D. Morphology of basidiomata of *Agaricus glabriusculus* (GC-12). A & B. Different views of basidioma in natural habitat. C. View of lamellae and annulus features. D. Pileus view. **Scale bar: A=** 4.5 cm, **B=** 1.5 cm, **C=** 0.6 cm, **D=** 0.2 cm.

Taxon # 3:

Agaricus trisulphuratus Berk., Ann. Mag. nat. Hist., Ser. 5 15: 386 (1885)

Morphological Analysis (Figure 7):

Basidiocarp 5.3-7.5 × 2.7-3.4 cm, found single to cluster form, terrestrial, epigeous, humicolous nature**. Pileus** 2.7-3.6 × 1.8-2.4 cm, semicircular, widely conical in shape at juvenile stage, after maturity convex to umbonate, dry, surface covered in a profusion of squamules that resemble fluffy fibrillose type spines, highly ochre color at middle area, blonde to highly ochre to blowsy orange red from periphary, with well defined margins. **Lamellae** complex, congested, not attached, heteromorphic edges at first, creamy then varying from light orange to dusty grey to dark brown at the end. **Stipe** 4.4-5.0 × 0.5-0.9 cm, smooth surface, light orange from upside of annulus, scaly, shaggy, bright orange under the annulus, attached by center, growing laterally from ground, surface coated with squamules; color not vanished with touch. **Annulus or partial veil** exist, shaggy appearance due to shaggy squamules, necklace-like hanging, highly orched color comparable to stalk, difficult to discern. **Volva** missing. **Rhizomorphs** observed. Taste or flavor not noted.

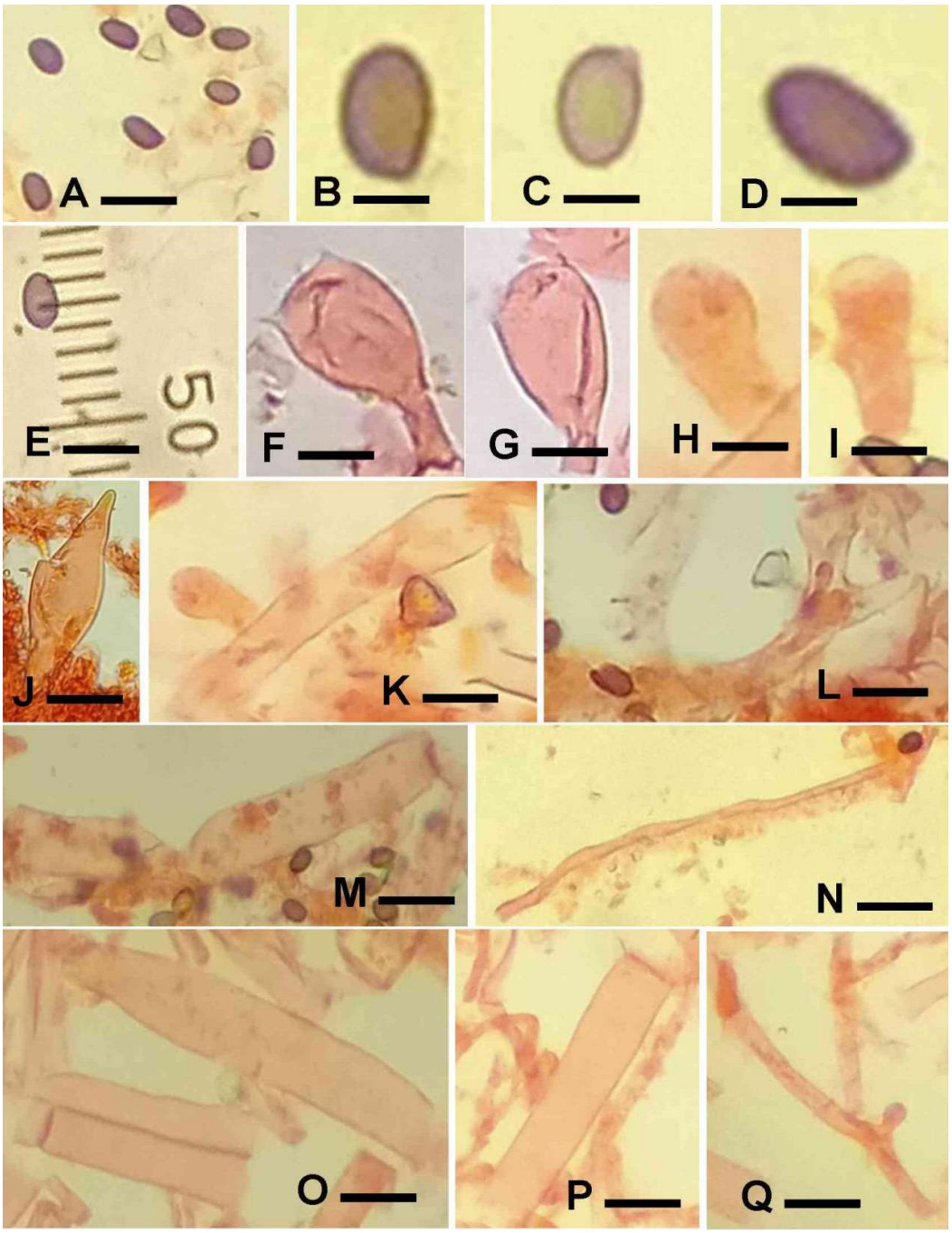

Figure 5: Figs. A-Q. Light micrographs of microscopic features of *Agaricus glabriusculus* (GC-12). A-E. Basidiospores. F & G. Basidia. H & I. Cheilocystidia. J. Pleurocystidia. K-N. Pileipellis. P-Q. Stipitipellis. **Scale bar:** A= 15.5 µm, B= 6 µm, C= 4.5 µm, D= 5.3 µm, E= 11.2 µm, F= 7.5 µm, G= 8 µm, H= 9 µm, I= 13 µm, J= 14.5 µm, K= 26 µm, L= 30 µm, M= 20 µm, N= 32.5 µm, O= 15.5 µm, P= 19 µm, Q= 45 µm.

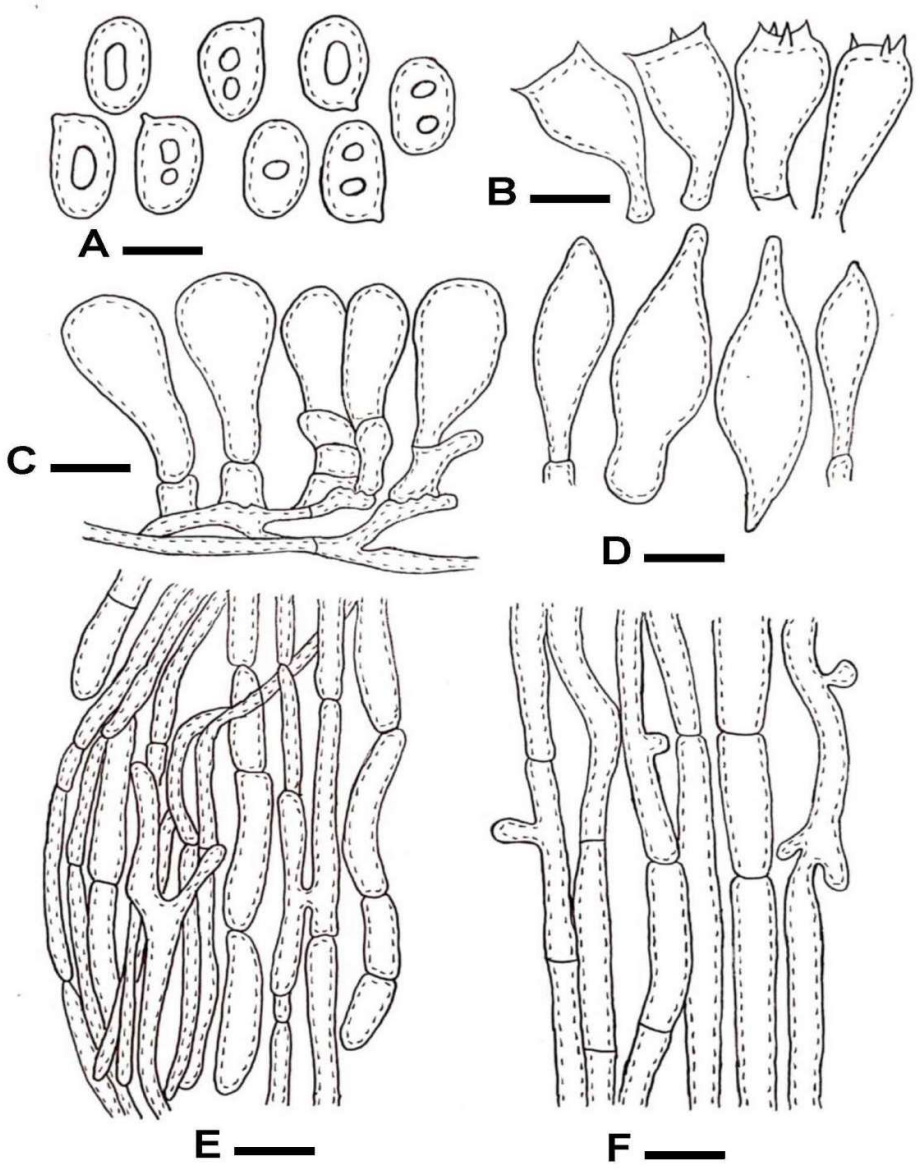

Figure 6: Figs. A-F. Illustrations of microscopic features of *Agaricus glabriusculus* (GC-12). A. Basidiospores. B. Basidia. C. Cheilocystidia. D. Pleurocystidia. E. Pileipellis. F. Stipitipellis. **Scale bar:** A= 6 µm, B&C= 11 µm, D= 8 µm, E&F= 35 µm.

Microscopic Analysis (Figures 8 & 9)

Basidiospores 4.6-8.2 × 2.8-4.8 µm, Q= 1.3-1.5, avgQ= 1.2, elliptical shaped, with groove, smooth, absence of breach hole, bronzed, having oil drops, having wide endosporum. **Basidia** 16.2-18.8 × 12.5-15.4 µm, hyaline, thick walled, club-shaped to wide. **Cheilocystidia** 20.5-23.7 × 12.6-15.6 µm, hyaline, generally club-shaped to barrel-shaped, with somewhat spiky facet and a narrow bottom. **Pleurocystidia** not recorded. **Tramal cells** noticed, 23.5-42.4 × 14.5-28.5 µm, shape varies to subglobose from globose. **Pileipellis** 4.2-5.6 µm, branched, septate, bent, cylinder-shaped, not smooth, rough light spiney surface. **Stipitipellis** 4.7-6.8 µm, broad, branching observed, septate, cylindrical shaped, uneven surface, having a spiky surface.

Material Studied:

Locality: Shabir town, Tehsil & District Gujranwala, Punjab, Pakistan. Habitat: collected from hillock, growing beside greenery. Host: Found underneath *Acacia nilotica* (L.), at 226 m a.s.l. Date of Collection: 24-07-2021. Collected by: Samra Saeed. Voucher ID: GC-71. Herbarium No.: NYGCU_26_03

Figure 7: Figs. A-F. Morphology of basidiomata of *Agaricus trisulphuratus* (GC-71). A & B. View of basidioma in natural habitat and pileus surface having squamules. C. Stipe attachment and crowded lamellae. D-F. Different views of sample showing lamellae, annulus and stipe. **Scale bar:** A,C&F= 1 cm, B&D= 1.25 cm, E= 1.4 cm.

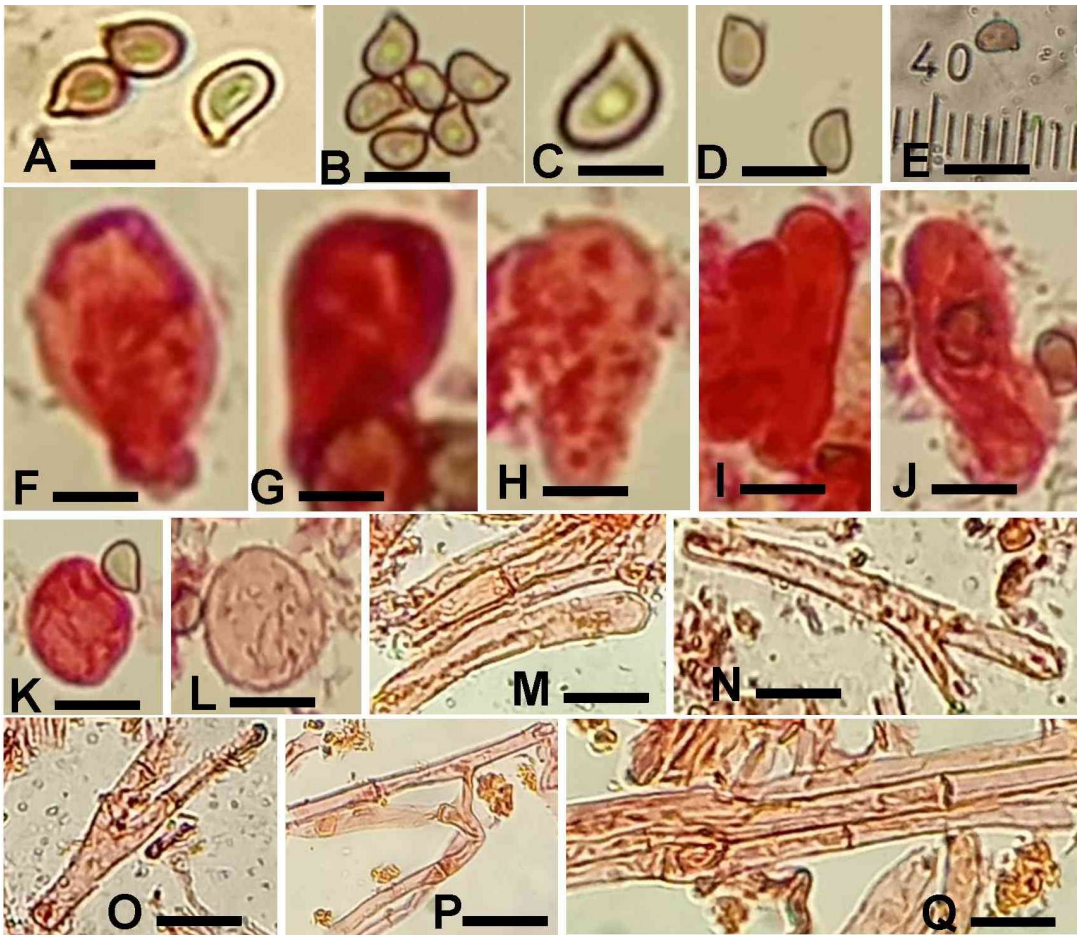

Figure 8: Figs. A-Q. Light micrographs of microscopic features of *Agaricus trisulphuratus* (GC-71). A-E. Basidiospores. F-H. Basidia. I & J. Cheilocystidia. K & L. Tramal cells. M-O. Pileipellis. P & Q. Stipitipellis. **Scale bar:** A= 6 µm, B&D= 8 µm, C= 4 µm, E= 10.5 µm, F&G= 6 µm, H= 5.5 µm, I&Q= 13.5 µm, J= 10 µm, K= 19.5 µm, L= 16.5 µm, M,N&O= 10 µm, P= 28 µm.

Discussion:

Carl Linnaeus firstly identified and named the genus *Agaricus* in 1753, and *A. campestris* served as the type species of the genus under family Agaricaceae. The following article explain *Agaricus bisporus* (Sample-13), *A. glabriusculus* (Sample-12) and *A. trisulphuratus* (Sample-71) are studied on the basis of their morphological and anatomical features. *A. bisporus* being the most edible mushroom, have a variety of nutrient rich compounds i.e. carbohydrates, fibers, protein, lipids, vitamins and minerals along with several active substances like vital amino acids, fatty acids, glycoproteins, lipopolysaccharides, nucleosides, peptides, polysaccharides and triterpenoids, together make this mushroom, an anti-cancer, anti-diabetic, anti-hypercholesterolemic, anti-hypertensive, anti-microbial, antioxidant and hepatoprotective agent (Atila et al., 2021).

A. bisporus (GC-13) is identified by their bisporic nature of the basidia found in microscopic analysis. Previous literature of Pakistan has shown reports of this species from Khanspur, (Khyber Pakhtunkhwa) and Lahore (Punjab) (Ahmad, 1980; Ahmad et al., 1997; Niazi et al., 2022).

Agaricus bisporus can be deceived by *A. bitorquis* (Quél.) Sacc. due to their morphological resemblance. Both these species belongs to sect. Bivelares which was firstly described by Kauffman. *A. bisorus* is morphologically different from *A. bitorquis* because latter species have a smooth surface of pileus along with double annulus with respect to examined species bearing a squamulose pileus surface with single annular ring. Microscopically, latter species is easily differentiated from the examined species by the existence of 4-spored basidia while examined specimen have 2-spored basidia as bisporic nature (Li et al., 2014; Karunarathna et al., 2016).

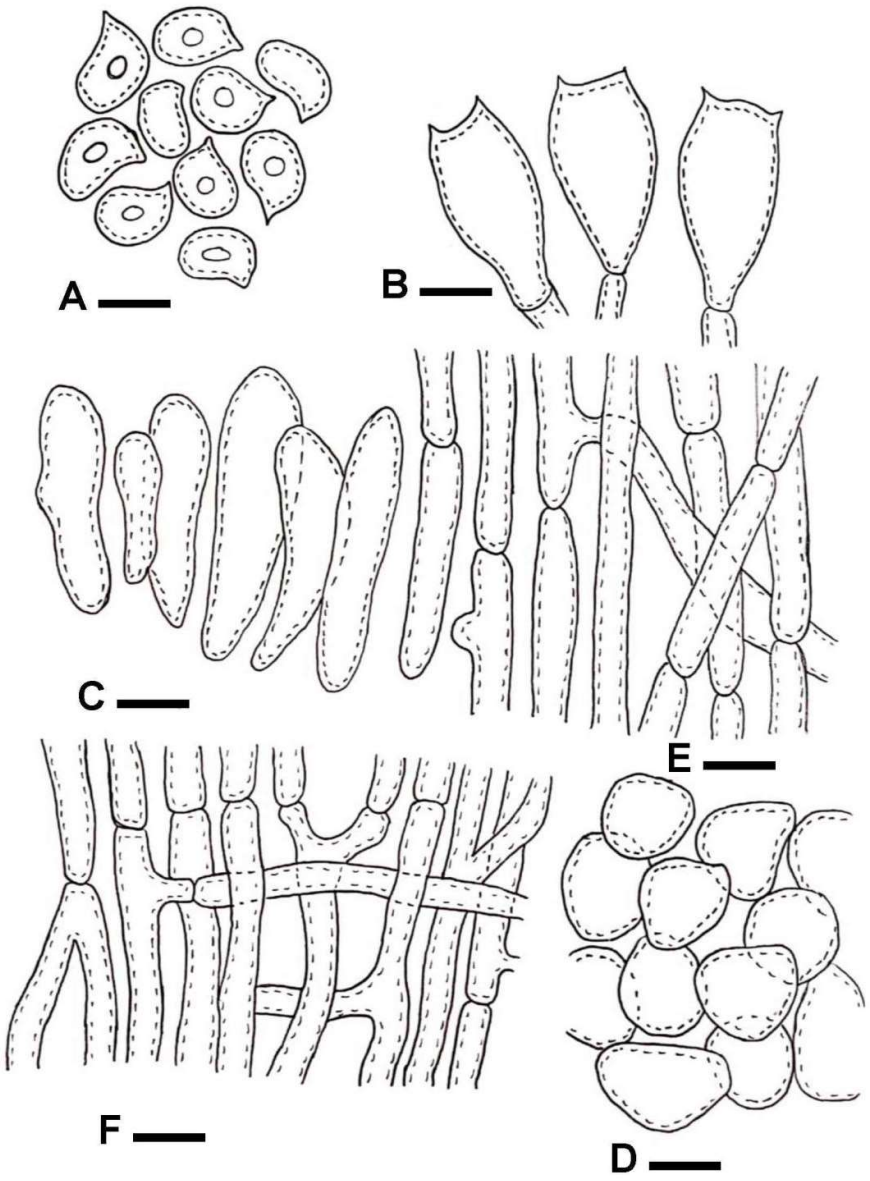

Figure 9: Figs. A-F. Illustrations of microscopic features of *Agaricus trisulphuratus* (GC-71). A. Basidiospores. B. Basidia. C. Cheilocystidia. D. Tramal cells. E. Pileipellis. F. Stipitipellis. **Scale bar:** A= 5 µm, B&E= 8 µm, C= 10 µm, D= 16 µm, F= 11 µm.

The physical characteristics of *A. bisporus* and *A. campestris* are also similar, however the anatomical characteristics of the two species vary. The color and shape of the basidiospores fluctuate in both species. The latter specimen have ellipsoid or largely ellipsoid to ovoid basidiospores which are greenish to pale brownish in 5% KOH. While, on the other hand, the examined specimen has basidiospores that are brown in KOH and ellipsoid to broadly ellipsoid in shape (Kaur et al., 2016). A detailed comparison of *Agaricus bisporus* with morphological and anatomical similar species of the genus *Agaricus* belonging to different sections is described in the Table 1.

The other specimen (GC-12) collected from Shareef town, Gujranwala, is identified as *A. glabriusculus* belonging to *Agaricus* section Minores due to its glabrous pileus. The main characteristics of section Minores are listed below; i.e. buttom annulus's facet is not floccose. The general veil is either absent or insufficient (Zhao et al., 2016; Chen et al., 2017; Parra et al., 2018; Tarafder et al., 2022). Section Minores in *Agaricus* is the deceptive section, with about 80 identified species, which projected to include 200 kind (Chen

et al., 2017; He et al., 2017, 2018; Bashir et al., 2024; Nawaz et al., 2025).

This inedible specimen, *A. glabriusculus,* collected in current study has previously been reported from districts Malakand, Qaldara of Khyber Pakhtunkhwa, and District Toba Tek Singh of Punjab Province, Pakistan (Ahmad et al., 1997; Hussain & Sher, 2019; Niazi et al., 2022; Bashir et al., 2024; Nawaz et al., 2025). Inferred from evolutionary research is that *A. jingningensis* M.Q. He & R.L. Zhao, and *A. catenatus* M.Q. He & R.L. Zhao are *A. glabriusculus'*s alleged closest cousins. The magnitude and form of the *A. glabriusculus'*s basidiospores are equivalent with both of these species's spores. *A. glabriusculus* can be recognized by its pileus, which is noticeably smaller than that of *A. jingningensis* ranges from 30-75 mm and *A. catenatus* ranges from 48 mm (He et al., 2017). When compared with *Agaricus badiosquamulosus,* it is distinguished by its dark brown squamules with purplish tinges, whereas *A. glabriusculus* has small pinkish fibrils on the surface of the pileus when it is young. Later, the pileus is covered with dark brown squamules that are thick near the disc. Intense yellowish-orange staining on the stipe and pileus covering of *A. badiosquamulosus*. While there is no discolouration in *A. glabriusculus* (Bashir et al., 2024).

Agaricus pseudopallens M.Q. He & R.L. Zhao having a smooth and slightly fibrillose pileus is one more species in the category of Minores. In contrast to *A. glabriusculus*, this new species, which was recently discovered in China, varies by possessing minute basidiospores (5.4-6.0 × 2.8-3.4 µm) (He et al., 2017). *A. gemlii* also share resemblance in pileus shape with *A. glabriusculus.* Detailed comparison of *A. glabriusculus* with the related species is given in Table 2 .

Agaricus trisulphuratus Berk., is 3rd species of this genus, which was collected during this study. It is distinguished by the pileus shape which is semicircular to conical or convex to umbonate with vivid orange or reddish orange hue. Its surface is covered by plenty of squamules that resemble to fluffy spines and have basidiospores of 4.6-8.2 × 2.8-4.8 µm. This inedible species has previously been reported in Pakistan from Changa Manga forest, Lahore and Daphar Plantation (Ahmad, 1980; Khalid & Iqbal, 1996; Ahmad et al., 1997; Niazi et al., 2022). *A. trisulphuratus* can be confused with *A. crocopeplus* Berk. & Broome, due to their morphological resemblance i.e., pileus color and shape. Both are initially semicircular to convex with golden bright orange color having large yellowish orange squamules on the surface. However, these can be differentiated as *A. trisulphuratus* has light orange to greyish dusty orange lamellae while *A. crocopeplus* having orange to dark brown lamellae (Greeshma et al., 2015). An other member from *A.* subgenus *Lanagaricus* section Trisulphurati is *Hypholoma cinnabarinum.* According to the results of phylogenetic research, *H. cinnabarinum* not a part of genus *Hypholoma*; instead the part of *Agaricus* subgenus *Lanagaricus*, and its morphological characteristics also match with *Agaricus trisulphuratus* (Heinemann, 1974; Vellinga, 2004; Su et al., 2014). *A. trisulphuratus* also show morphological resemblance with *Cyptotrama asprata* (Berk.) Redhead & Ginns, due to its pileus shape and surface but different in pileus color and anatomical studies (Harkonen et al., 2003; Njogu et al., 2009). A detailed comparison of *A. trisulphuratus* with morphological and anatomical similar species of different genera belonging to different sections are mentioned in the Table 3.

Conclusion:

Since Pakistan is a biodiversity rich country and ecological and soil conditions of Punjab supports the growth of these macro-mycetes, therefore current study was conducted to explore the diversity of economically important genus *Agaricus*, from district Gujranwala. This study yielded three new records of *Agaricus* species for district Gujranwala.

Table 1. A comparison of *Agaricus bisporus* with morphologically and anatomically similar species of different sections.

Sr. No.	Name of Species	Morphological Characters							Anatomical Characters				References
		Pileus's size	**Pileus's color**	**Pileus's shape & surface**	**Color of lamellae**	**Attachment of lamellae**	**Size & surface of stipe**	**Color of stipe**	**Basidiospores's size**	**Basidiospores's shape**	**Size & shape of basidia**	**Size & shape of cheliocystidia**	
1	*A. agrinferus* Kerrigan & Callac	5.2-8.6 cm in diam.	Pale to muddy, becoming brown at maturity	Broadly convex to flat after maturity, fibrillose	Pallid to dull pinkish ultimately become dark brown	Free	3.2-7.8 × 1.2-1.8 cm, rarely glabrous surface, floccose	Creamy to light orange	5.6-6.6 × 4.3-4.8 µm	Broadly ellipsoid to ellipsoid	16.8-25.6 × 7.6-10.2 µm, clavate to cylindrical	14.8-34.2 × 4.2-14.8 µm, mostly cylindrical	Kerrigan et al. (2008); Jaichaliaw et al. (2021)
2	*A. bisporus* (J.E. Lange) Imbach, (GC-13)	2.4-3.7 × 2.2-2.7 cm in diam.	Dark brown to bronze	Umbonate to concave then convex at maturity with chocolaty squamulose patches	Light pinkishbrown to dark chocolaty brown	Free	3.2-4.4 × 1.4-1.9 cm, slightly smooth surface	Off-white to pure white	6.4-8.3 × 4.7-6.2 µm	Broadly ellipsoidal to oblong, mostly broadly ellipsoid	15.5-24.8 × 8.5-10.4 µm, clavate to obclavate	18.5-26.4 × 8.3-14.6 µm, clavate to cylindrical	Present study
3	*A. bitorquis* (Quél.) Sacc.	3.8-7 × 1.2-1.7cm in diam.	Greyish white from center to brownish maroon edges	Concave to flat with silky smooth surface	Dark brown	Free	3.5-4 × 1.3–1.8 cm, fibrous surface with white to brown fibrils	White to light brown	5.5-8.5 × 3.8-5.8 µm	Broadly ellipsoid	17-25 × 5-8 µm, clavate	14-20 × 5-7 µm, clavate	Li et al. (2014); Karunarathna et al. (2016)

4	*A. campestris* L.	4.2-4.6 cm in diam.	Creamy white	Strongly convex to plano-convex, Silky or unwrinkled	Pink at young to chocolate brown when mature	Free	3.0-4.3 × 1.7-3.5 cm, fibrous surface	White to off-white	5.4-8.5 × 4.3-5.7 µm	Ellipsoid or broadly ellipsoid to ovoid	25.7-28.5 × 7-12 µm, Clavate to slightly clavate	17-27 × 5.7-9.0 µm, clavate	Mitchell & Walter (1999); Kaur et al. (2016).
5	*A. devoniensis* P.D. Orton	3.5-7.3 cm in diam.	White	Convex broadly, glabrous or obscurely surface having fibrillose	Pale to dark chocolaty brown with maturity	Free	4.8-7.8 × 1.2-1.5 cm, erect-fibrillose above the annulus, glabrous or innately fibrillose below annulus	Obscure to dull white	6.2-6.8 × 4.8-5.5 µm	Broadly ellipsoid	19.4-23.5 × 8.8-10.2 µm, clavate	20.5-32.2 × 10.8-14.2 µm, clavate to subglobose	Kerrigan et al. (2008)

Table 2. A comparison of *Agaricus glabriusculus* with morphological and anatomical similar species of different sections.

Sr. No.	Name of Species	Morphological Characters							Anatomical Characters				References
		Pileus's size	**Pileus's color**	**Pileus's shape & surface**	**Color of lamellae**	**Attachment of lamellae**	**Size & surface of stipe**	**Color of stipe**	**Basidiospores's size**	**Basidiospores's shape**	**Size & shape of basidia**	**Size & shape of cheliocystidia**	
1	*A. catenatus* M.Q. He & R.L. Zhao	4.5-5.2 cm in diam.	Mostly white, light brown to reddish-brown from center	Fibrillose surface with convex to umbonate	Pinkish brown to chocolaty brown	Far free	5.2-5.6 × 0.5-0.6 cm, smooth, having fibrils below annulus	White	4.6-5.6 × 2.6-3.6 µm	Ellipsoidal	14.6-20.4 × 4.6-7.8 µm, clavate	20.8-28.5 × 10.2-16.6 µm, Catenulate to different shapes, appear as chain	He et al. (2017); Hussain & Sher (2019)
2	*A. badiosquamulosus* H.Bashir & Khalid	3.0-5.2 cm in diam.	dark brown to creamy white on margins	parabolic to convex, slightly umbonate, fibrils on the surface	Light pink to mouse grey	Free, crowded	3.0–6×0.5–1 cm, slightly bulbous at base, partially stuffed	Off-white to light rusty	6-6.5 × 4.5-4.8 µm	Subglobose to broadly ellipsoid	16.2-22.4 × 7.4-8.5 µm, narrowly clavate in most specimens	11.5–20.5×6.5–11 µm, broadly clavate, multiseptate	Bashir et al. (2024)
3	*A. gemlii* L.A. Parra, Arrillaga, Ribes & Callac	2.5-6.5 cm in diam.	Purple	Conical to convex, redish to purplish fibrils on the surface	Light purple to brown	Free	5.0-5.4 × 0.4-0.7 cm, mostly smooth	Light brown	5.2-5.6 × 3.2-3.8 µm	Ellipsoidal	12.6-18.6 × 5.4-7.8 µm, mostly clavate	14.4-20.8 × 6.5-8.6 µm, clavate	He et al. (2017, 2018b)
4	*A. glabriusculus* S. Hussain (GC-12)	3.0-3.6 × 1.1-1.5 cm in diam.	Pure white to off-white; dark brown to	Hemispherical to conical or sub-conical to convex,	Cream or off-white to light pink, dark brown after	Free	2.4-3.0 × 0.8-1.4 cm, having continued lengthy striations on surface	Pure white beyond annulus & off-white to	6.2-7.0 × 4.2-4.7 µm	Broadly ellipsoid to faintly cylindrical	22.7-31.5 × 9.8-14.3 µm, clavate	19.7-27.8 × 11.5-15.8 µm, broadly clavate to cylindric	Present study

			copper reddish from center	fibrillose nature with dark brown flakes	maturity			light brown at base				al	
5	*A. jingningensis* M.Q. He & R.L. Zhao	3.3-7.6 cm in diam.	Brown redish to puplish	Convex to umbonate, coverd by purple to brownish fibrillose	Pinkish woody to dark brown with maturity	Free	6 × 0.4-0.8 cm, witish fibrils below the annulus	Mostly white	4.2-5.3 × 3.0-3.6 µm	Ellipsoid in shape	12.6-18.6 × 5.4-7.8 µm, mostly clavate	14.5-20.4 × 9.6-8.5 µm, clavate to ellipsoid al	He et al. (2017)
6	*A. pseudopallens* M.Q. He & R.L. Zhao	2.3-3.8 cm in diam.	White to slightly greyish	Mostly convex,w hitish to grayish fibrillose on the surface	Light brownish pink to dark brown	Free	2.5-5.4 × 0.4-0.8 cm, smooth surface	White to greyish	5.2-5.8 × 3- 3.5 µm	Ellipsoidal to broadly ellipsoid	13.4-18.8 × 19.2-6.0 µm, clavate to broadly clavate	Absent	He et al. (2017); Hussain & Sher (2019)

Table 3. A comparison of *Agaricus trisulphuratus* with morpho-anatomical similar species of different genera.

Sr. No.	**Name of Species**	**Morphological Characters**							**Anatomical Characters**				**References**
		Pileus's size	**Pileus's color**	**Pileus's shape & surface**	**Color of lamellae**	**Attachment of lamellae**	**Size & surface of stipe**	**Color of stipe**	**Size of basidiospores**	**Basidiospores's shape**	**Size & shape of basidia**	**Size & shape of cheliocystidia**	
1	*A. crocopeplus* Berk. & Broome	6.4-6.6 cm in diam	Orange to yelowish orange brown	Convex to become flattened, surface with large orange squamules	Dark brown	Free	6.0-6.5 × 0.4-0.6 cm, having minute fibrillose	Creamy orange	6.4-8.1 × 3.2-4.6 µm	Ellipsoidal	15.4-18.2 × 5.2-8.3µm, clavate	18.6-22.8 × 10.4-13.5 µm, clavate	Greeshma et al. (2015)
2	*A. trisulphuratus* Berk. (GC-71)	2.7-3.6 × 1.8-2.4 cm in diam.	Golden bright orange or reddish orange	Semicircular or conical to convex or umbonate, bright orange squamules	Creamy to light orange to greyish dusty orange	Free	4.4-5.0 × 0.5-0.9 cm, surface covered with squamules	Light orange to bright orange	4.6-8.2 × 2.8-4.8 µm	Ellipsoidal having suprahilar depression	17.2-19.8 × 11.5-14.4 µm, clavate to widely clavate	19.5-22.7 × 11.6-14.6 µm, mostly clavate to cylindrical	Present study

				like fluffy fibrillose spines									
3	*Cyptotrama asprata* (Berk.) Redhead & Ginns	3-5 cm-wide	Bright-orange	Convex shaped, having tufty pointed yellowish orange scales	Mostly white	Free	4 × 0.6-1 cm, having fibrous surface	Concolorous with pielus color	8.2-8.5 × 5.0-5.6 µm	Elliptical	18.5-22.6 × 9.4-11.6 µm, clavate	22.5-24.6 × 9.8-12.5 µm, mostly clavate	Harkonen et al. (2003); Njogu et al. (2009)
4	*Cystoagaricus trisulphuratus* (Berk.) Singer	1.2-3.3 cm in diam.	Reddish orange	Convex shaped, surface covered by small thick flocculose	Pale pinkish to dark vinaceous brown	Free	1.2-5.4 × 0.1-0.4 cm, with concolorous surface	Reddish orange	5.0-6.6 × 3.4-4.2 µm	Ellipsoid	15.5-19.6 × 6.5-9.6 µm, broadly clavate	22.5-28.8 × 9.5-14.6 µm, broadly clavate	Senthilarasu & Kumaresan (2016); Hawkeswood et al. (2021)
5	*Hypholoma cinnabarinum* Teng	3.2-6.4 cm in diam.	Creamy orange to bright orange	Convex to plano-convex in shaped, surface with pale orange to orange 6squamules	Pale blackish brown to blackish brown w	Free	5.2-7.4 × 0.5-1.5 cm, pale orange to orange squamules	Creamy color above annulus to bright orange below annulus	5.2-6.5 × 3.5-4.5 µm	Ovoid to ellipsoid in shape	13.2-16.4 × 6.4-7.8 µm, clavate	21.2-27.4 × 8.4-12.5 µm, broadly clavate to subfusiform	Su et al. (2014)

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