

CHAPTER 5.0 DESCRIPTIONS OF THE SPECIES ISOLATED

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5.1 List of species isolated from starch-based food stored at different regimes of water activity.

Ascomycota

1. *Eupenicillium hirayamae* D.B. Scott and Stolk.
2. *Eupenicillium* sp.
3. *Eurotium repens* de Bary
4. *Monascus mucoroides* van Tiegh.

Mitosporic fungi

1. *Aspergillus aculeatus* Iizuka
2. *A. candidus* Link
3. *A. clavatus* Desmazieres
4. *A. flavus* Link
5. *A. fumigatus* Fresenius
6. *A. longivesica* L.H. Huang and Raper
7. *A. niger* van Tiegh.
8. *A. sydowi* (Bain. and Sart.) Thom and Church
9. *A. tamarii* Kita
10. *A. terreus* Thom and Church
11. *A. versicolor* (Vuill.) Tiraboschi.
12. *Curvularia lunata* (Wakker) Boedijn.
13. *Dreschlera* sp.
14. *Moniliella* sp.
15. *Penicillium aurantiogriseum* Dierckx
16. *P. chermesinum* Biourge.
17. *P. chrysogenum* Thom
18. *P. citreonigrum* Dierckx
19. *P. citrinum* Thom
20. *P. expansum* Link
21. *P. griseofulvum* Dierckx
22. *P. griseoroseum* Dierckx \equiv *P. chrysogenum* Thom
23. *P. islandicum* Sopp.

24. *P. minioluteum* Dierckx
25. *P. oxalicum* Currie and Thom
26. *P. pinophilum* Hedge.
27. *P. purpurogenum* O. Stoll
28. *P. rugulosum* Thom
29. *P. simplicissimum* (Oudem.) Thom
30. *P. spinulosum* Thom
31. *P. thomii* Maire
32. *P. variabile* Sopp.
33. *P. verrucosum* Dierckx
34. *P. vinaceum* J. Gilman and E. V. Abbott
35. *Trichoderma* sp.

Zygomycota

1. *Absidia corymbifera* (Cohn) Sacc. and A. Trotter
2. *Cunninghamella polymorpha* Pispek
3. *Mucor circinelloides* Tiegh.
4. *Rhizopus arrhizus* A. Fisch. var. *arrhizus* Ellis
5. *R. microsporus* Tiegh.
6. *Syncephalastrum racemosum* Cohn ex Schrot.

5.2 Descriptions of species

1. *A. aculeatus* : KUMA 027; IMI 352694

(Colony Plate 5.3.1; Plate 5.4.1)

Colony diameter 88 mm in 7 days growing on CDA at 25 °C. **Colonies** plane, producing a dense stand of conidial structures, heavily sporing throughout in purple brown or purple black shades often with a slight grey tan surface; reverse uncoloured; exudate limited. **Conidial heads** initially globose, then splitting into compact divergent columns with diameters 500 - 700 µm. Conidia nearest the vesicles light tan. **Conidiophores** uncoloured or slightly brownish below the vesicle, 1.0 - 2.0 mm long by 9.0 - 10.0 µm in diameter, with smooth wall up to 2.0 µm thick; **vesicles** elongate when young, globose or nearly so when fully developed, heavy-walled, commonly pigmented in brown shades and 48.0 - 60.0

μm in diameter, fertile over the entire surface; **phialides** closely packed, 7.0 - 10.0 μm by 3.0 - 4.4 μm ; **conidia** showing a purplish tinge, conspicuously echinulate ranging from elliptical to globose or nearly so, mostly 3.5 - 4.0 μm by 4.0 - 5.0 μm .

Occurrence and mycotoxins produced. This is the first record of the fungus in Malaysia. This species has not been reported to occur on starch-based food. Mycotoxins produced are secalonic acid D and secalonic acid F (Cole and Cox, 1981).

2. *A. candidus*

(Colony Plate 5.3.2; Plate 5.4.2)

Colony diameter 26 mm in 14 days growing on CDA at 25 °C. **Colonies** velvety persistently white, or becoming cream to yellowish cream; reverse pale yellow; exudate lacking. **Conidial heads** initially globose then splitting into a few divergent columns with diameters 600 - 800 μm occasionally appearing loosely columnar in heads with incomplete development of sterigmatic surface, young heads varying in the same culture from globose masses 200 - 300 μm in diameter to small heads less than 100 μm in diameter; **conidiophores** 500 μm long, and 5.0 - 10.0 μm in diameter, thick-walled, smooth, occasionally septate, colourless or slightly yellowed with age; **vesicles** subglobose to globose, ranging from 10.0 - 30.0 μm , bearing colourless metulae and phialides over the entire surface, but numbers of metulae limited on the smallest head, **metulae** variable 5.0 - 10.0 μm , occasionally septate; **phialides**, usually more uniform in length, 5.0 - 8.0 μm long; **conidia** subglobose to globose, thin-walled, smooth, 2.5 - 3.5 μm ; **sclerotia** when produced at first cream, becoming purple to black, globose, 800 - 1200 μm in diameter.

Occurrence and mycotoxins produced. It has been reported on flour and dough products (Kozakiewicz, 1990). Also predominantly found on stored grain and seeds. These include wheat, oats, barley, sorghum, corn, rice and groundnuts (Pitt and Hocking, 1985). Mycotoxins produced are candidulin, terphenyllin and xanthoascidin (Cole and Cox, 1981).

3. *A. clavatus*

(Colony Plate 5.3.3; Plate 5.4.3)

Colony diameter 56 mm in 14 days growing on CDA at 25 °C. **Colonies** plane and zonate, tending to floccose producing abundant erect conidiophores bearing large, blue green, clavate conidial heads; reverse pale yellow to greenish; exudate lacking. **Conidial heads** initially clavate, large, ranging from 300 - 400 µm by 150 - 200 µm then splitting into a few divergent columns of compacted conidial chains; **conidiophores** 500 - 900 µm in length, 20.0 - 30.0 µm in diameter, thin-walled, smooth, colourless, gradually enlarging at the apex into a clavate **vesicle** which is fertile over an area up to 90.0 - 200 µm in length and 50.0 - 70.0 µm wide; **phialides** varying in size from 2.5 - 3.5 µm by 2.0 - 3.0 µm at the base of the vesicle to 7.0 - 10.0 µm by 2.5 - 3.0 µm at its apex; **conidia** elliptical, smooth mostly 3.0 - 4.0 µm by 2.5 - 3.0 µm.

Occurrence and mycotoxins produced. On starch-based food it is mostly associated with cereals (Flannigan *et al.*, 1984) and has been reported from wheat (Saito *et al.*, 1971a; Wallace *et al.*, 1976), flour and flour products (Graves and Hesseltine, 1966; Saito *et al.*, 1971a), corn (Hesseltine *et al.*, 1981), sorghum seeds and milled rice (Kozakiewicz, 1990). Mycotoxins produced are ascladiol, clavatul and cytochalasin E (Cole and Cox, 1981).

4. *A. flavus* : KUMA 004; IMI 352671

(Colony Plate 5.3.4; Plate 5.4.4)

Colony diameter 64 mm in 7 days growing on CDA at 25 °C. **Colonies** plane, producing abundant conidial structures directly from the substrate mycelium, young conidial heads in bright yellow shades, turning dark yellow green shades and finally becoming cress green with age; reverse uncoloured; exudate clear and abundant. **Conidial heads** typically radiate, splitting into several defined columns 300 - 400 µm in diameter, smaller heads columnar; **conidiophores** thick-walled, uncoloured, coarsely roughened, diameter ranging from 10.0 - 20.0 µm; **vesicles** subglobose to globose, varying from 20.0- 50.0 µm diameter, fertile over three quarters of the surface, typically bearing both metulae and phialides but sometimes bearing phialides alone; **metulae** and **phialides** of similar size, 6.0 - 10.0 µm long;

conidia typically subglobose to globose, coarsely roughened, variable from 3.5 - 5.0 μm in diameter.

Occurrence and mycotoxins produced. This species has been widely reported on a variety of substrates and are commonly found in produce high in oils (Kozakiewicz, 1995). On starch-based food, it has been reported on maize, parboiled rice, sorghum and millet from warmer climates (Moss, 1991). Mycotoxins produced are aflatoxins B₁, B₂, B_{2a}, G₁, G₂, G_{2a}, M₁ and M₂, parasiticol (aflatoxin B₃), cyclopiazonic acid, sterigmatocystin, O-methylsterigmatocystin, dihydro-O-methylsterigmatocystin, versiconal hemiacetal acetate, aflatrem, aspertoxin, aspergillilic acid, β -nitropropionic acid and kojic acid (Cole and Cox, 1981).

5. *A. fumigatus* : KUMA 041; IMI 358402

(Colony Plate 5.3.5; Plate 5.4.5)

Colony diameter 68 mm in 7 days growing on CDA at 25 °C. **Colonies** varying from strictly velvety to deeply felted, blue green to grey green in age; reverse uncoloured; exudate absent. **Conidial heads** columnar, compact, often densely crowded; **conidiophores** short, smooth, up to 300 μm in length by 5.0 - 8.0 μm in diameter, usually more or less green coloured in the upper part; **vesicles** up to 20.0 - 25.0 μm in diameter, often coloured as the conidiophores, usually fertile on the upper half only; **phialides** often pigmented green, 6.0 - 8.0 μm long, crowded with axes roughly parallel to the axis of the conidiophore; **conidia** green echinulate, subglobose to globose, mostly 2.5 - 3.0 μm in diameter.

Occurrence and mycotoxins produced. The most common sources of starch-based food have been cereals, e.g. wheat (Wallace *et al.*, 1976; Pitt and Hocking, 1985), rice (Kuthubutheen, 1979) and barley (Abdel-Kader *et al.*, 1979; Lillehoj and Goransson, 1980). Mycotoxins produced are fumitremorgin A, B and C, TR-2, fumigaclavine A, B and C, fumigatin and spinulosin (Cole and Cox, 1981).

6. *A. longivesica* : KUMA 019; IMI 352686

(Colony Plate 5.3.6; Plate 5.4.6)

Colony diameter 80 mm in 10 days on CDA at 25 °C. **Colonies** velvety to floccose, in blue green to brownish green shades with white aerial hyphae abundant; reverse pale brown; exudate lacking. **Conidial heads** columnar but not splitting into divergent columns; long **conidiophores** 80 - 420 µm long and short conidiophores 60 - 130 µm long; **vesicles** on long conidiophores clavate and on short conidiophores globose; **phialides**, 8 - 10 µm x 3.5 - 4.2 µm or on short conidiophores 4.2 - 7.0 µm x 2.4 - 4.2 µm; **conidia** ellipsoidal, smooth-walled with fragments of connectives, pale green, 4.0 - 4.5 µm by 3.0 - 4.0 µm.

Occurrence and mycotoxins produced. This is the first record of the fungus in Malaysia. This species has not been reported to occur on starch-based food and not known to produce mycotoxins.

7. *A. niger* : KUMA 032; IMI 352699

(Colony Plate 5.3.7; Plate 5.4.7)

Colony diameter 69 mm in 7 days growing on CDA at 25 °C. **Colonies** plane, producing a dense stand of conidial structures, white to yellow mycelium, reverse showing colony colour, exudate clear and limited. **Conidial heads** typically large, initially globose, then radiate or often splitting into two or more loose to reasonably well-defined columns; **conidiophores** borne from surface hyphae 1.0 - 3.0 mm long by 15.0 - 20.0 µm in diameter with heavy, hyaline or in brownish shades, smooth-walled; **vesicles** globose or nearly so, 50.0 - 75.0 µm diameter, bearing closely packed metulae and phialides over the entire surface; **metulae** 10.0 - 15.0 µm long; **phialides** 7.0 - 10.0 µm long; **conidia** globose at maturity, mostly 4.0 - 5.0 µm diameter, appearing brown with walls conspicuously roughened or sometimes striate.

Occurrence and mycotoxins produced. On starch-based food it is most commonly found in rice and corn (Pitt and Hocking, 1985). Produces malformin A₁ (Cole and Cox, 1981).

8. *A. sydowi* : KUMA 018; IMI 352685

(Colony Plate 5.3.8; Plate 5.4.8)

Colony diameter 26 mm in 14 days growing on CDA at 25 °C. **Colonies** plane, moderately deep, velvety to somewhat floccose from interlacing aerial hyphae. **Conidial heads** radiate to nearly globose, small, white to bluish green in colour; exudate lacking; reverse pale to maroon brown with brown pigment diffusing into the surrounding agar. **Conidiophores** borne from surface or aerial hyphae, 300 - 500 µm long by 4.0 - 6.0 µm in diameter, colourless, smooth with thick wall; **vesicles** only slightly swollen, club-shaped 8.0 - 10.0 µm diameter bearing metulae and phialides fertile over almost the entire surface; **metulae** 5.0 - 6.0 µm long; **phialides** 4.0 - 6.0 µm long; **conidia** subglobose to globose, 2.5 - 3.5 µm diameter, with spiny wall.

Occurrence and mycotoxins produced. This species is relatively uncommon in cereals, but has been isolated from barley (Flannigan, 1969; Abdel-Kader *et al.*, 1979), wheat and corn (Moubasher *et al.*, 1972), and flour (Graves and Hesseltine, 1966; Saito *et al.*, 1971b). This species is not known to produce mycotoxin.

9. *A. tamaraii* : KUMA 017; IMI 352684

(Colony Plate 5.3.9; Plate 5.4.9)

Colony diameter 60 mm in 7 days growing on CDA at 25 °C. **Colonies** plane velvety, mycelium inconspicuous, heavily sporulating throughout from bright yellow to olive brown shades at maturity; reverse yellow; exudate lacking. **Conidial heads** compactly columnar; **conidiophores** borne from subsurface or surface hyphae, 300 - 1000 µm long, colourless, usually with rough, thin wall; **vesicles** subglobose to globose, 15.0 - 20.0 µm diameter, fertile over almost the entire surface, bearing both metulae and phialides or less commonly phialides alone; **metulae** 6.0 - 10.0 µm long; **phialides** 6.0 - 8.0 µm long; **conidia** subglobose to globose at maturity, 5.0 - 8.0 µm diameter, brown with characteristic thick, rough to spiny wall.

Occurrence and mycotoxins produced. This is the first record of the fungus in Malaysia. On starch-based food its occurrence is infrequent e.g. wheat (Pitt and Hocking, 1985), barley (Abdel-Kader *et al.*, 1979), corn (Kozakiewicz, 1990) wheat and sorghum (Moubasher *et al.*, 1972). Produces kojic acid (Cole and Cox, 1981).

10. *A. terreus*

(Colony Plate 5.3.10; Plate 5.4.10)

Colony diameter 46 mm in 14 days growing on CDA at 25 °C. **Colonies** plane, velvety or becoming floccose, with margins irregular, heavily sporulating ranging from avellaneous to wood brown; reverse yellow to brown shades with light brown pigment diffusing into surrounding agar; exudate colourless and abundant. **Conidial heads** long, loosely or compactly columnar with uniform diameter throughout their length; **conidiophores** smooth, 100 - 250 µm long; **vesicles** hemispherical, dome-like, 10.0 - 16.0 µm diameter, fertile over the upper hemisphere, with densely packed, narrow metulae and phialides; **metulae** and **phialides** each 5.0 - 7.0 µm long; **conidia** subglobose to slightly elliptical, smooth, 1.8 - 2.5 µm diameter.

Occurrence and mycotoxins produced. On starch-based food it has been reported from barley (Moubasher *et al.*, 1972), freshly harvested corn (Hesseltine *et al.*, 1981; Bujari and Ershad, 1993) and common on flour, refrigerated dough products (Graves and Hesseltine, 1966) and pasta (Mislivec, 1977). Mycotoxins produced are terreic acid and citrinin (Cole and Cox, 1981).

11. *A. versicolor* : KUMA 039; IMI 358400

(Colony Plate 5.3.11; Plate 5.4.11)

Colony diameter 70 mm in 10 days growing on CDA at 25 °C. **Colonies** plane, velvety, moderately sporing in buff shades to yellow; mycelium white to buff or orange; reverse pale to reddish brown developing into purple brown with age and brown pigment diffusing into surrounding agar; exudate absent. **Conidial heads** small, columnar and yellow in colour; **conidiophores** colourless or yellowish, thick-walled, smooth, 500 -700 µm long; **vesicles** variable, the largest nearly

spherical, 12.0 - 14.0 μm diameter, fertile over the upper half to two-thirds, the smallest scarcely swollen at all and fertile only at the tips, bearing closely packed metulae and phialides; **metulae** 5.5 - 7.0 μm long; **phialides** 5.0 - 7.0 μm long; **conidia** globose, strongly to delicately echinulate, 2.0 - 3.0 μm diameter.

Occurrence and mycotoxins produced. It occurs at harvest on wheat (Moubasher *et al.*, 1972; Pitt and Hocking, 1985) and barley (Flannigan, 1969; Abdel-Kader *et al.*, 1979). Its occurrence is more common in stored products, including wheat (Wallace *et al.*, 1976), corn (Barron and Lichtwardt, 1959) flour (Graves and Hesseltine, 1966; Kurata and Ichinoe, 1967), and milled rice (Pitt and Hocking, 1985). Mycotoxins produced are sterigmatocystin, dihydrosterigmatocystin, 5-methoxysterigmatocystin, dihydrodemethylsterigmatocystin, versicolorin B and C, averufin, norsolorinic acid, aversin, O-methylaversin, cyclopiazonic acid, cyclopiazonic acid imine and bissecodehydrocyclopiazonic acid (Cole and Cox, 1981).

12. *Curvularia lunata*

(Colony Plate 5.3.34; Plate 5.4.14)

Colony diameter 79 mm in 7 days growing on CDA at 25 °C. **Colonies** dark brown, lanose or velvety. **Conidiophores** arising singly or in groups, simple or branched, straight or flexuous, sometimes geniculate, brown and paler near the apex, up to 270 μm long, 4.0 - 8.0 μm wide near the base. **Conidia** 3-septate, curved in the third cell which is usually larger and often darker than the others, smooth-walled, 13.0 - 20.0 x 6.0 - 10.0 μm .

Occurrence and mycotoxins produced. The most common occurrence on starch-based food are cereals, including rice (Kuthubutheen, 1979), barley (Flannigan, 1970; Saito *et al.*, 1971b; Abdel-Kader *et al.*, 1979;) and wheat, corn and sorghum (Moubasher *et al.*, 1972). Known to produce decumbin (Cole and Cox, 1981).

13. *Dreschlera* sp.

(Colony Plate 5.3.35; Plate 5.4.15)

Colony diameter 82 mm in 14 days growing on CDA at 25 °C. **Colonies** dark brown, velvety. Mycelium mostly submerged. **Conidiophores** macronematous, mononematous, sometimes caespitose, straight or flexuous, often geniculate, unbranched, brown and smooth-walled. **Conidia** solitary, straight or slightly curved, clavate, cylindrical with rounded ends, 10.0 - 15.0 µm by 8.0 - 10.0 µm, smooth-walled. Its colour ranges from pale to dark brown, transverse pseudosepta not defined.

Occurrence and mycotoxins produced. The occurrence of *Dreschlera* spp. on cereals have not been reported and are not known to produce mycotoxins.

14. *Eupenicillium hirayamae* :KUMA 001; IMI 258343

(Colony Plate 5.3.32; Plate 5.4.18)

Colony diameter 20 - 30 mm in 7 days growing on CDA at 25 °C. **Colonies** radially sulcate, of dense, brilliant yellow or orange mycelium usually enmeshing cleistothecia and overlaid by funicles of fertile hyphae; conidiogenesis moderate, dull green; exudate clear to pale yellow; reverse apricot to deep orange. **Cleistothecia** buff or yellow, appearing orange or brown from adhering hyphae, 250 - 300 µm diameter, hard, maturing after 4 - 6 weeks; ascospores small and ellipsoidal, yellow, 2.2 - 3.0 µm long, with rough walls and two small longitudinal flanges. **Conidiophores** borne from ropes of aerial hyphae, 10.0 - 50.0 µm long, smooth-walled, strictly monovericillate; **phialides** ampulliform, 6.0 - 8.0 µm long; **conidia** subglobose, 1.8 - 2.8 µm long, smooth-walled (micro-tuberculate in SEM).

Occurrence and mycotoxins produced. This is the first record of the fungus in Malaysia. This species has been mostly isolated from cereals (Pitt, 1979; Pitt and Hocking, 1985). This species is not known to produce mycotoxins.

15. *Eupenicillium* sp. : KUMP 020; IMI 358362

(Colony Plate 5.3.33; Plate 5.4.19)

Colony diameter 26 mm in 14 days growing on CDA at 25 °C. **Colonies** velvety to floccose, deep, mycelium white to bright yellow surrounded by a fringe of submerged hyphae extending 2 mm beyond the aerial growth, slightly sporulating in grey green shades; exudate lacking; reverse pale to bright yellow. **Cleistothecia** dull yellow to brown, 80.0 - 200 µm in diameter; ascospores ellipsoidal, 2.5 - 3.0 µm long. **Conidiophores** borne from aerial hyphae, 50.0 - 100 µm long, smooth walled, strictly monoverticillate; **phialides** ampulliform, 8.0 - 10.0 µm long; **conidia** globose, 2.0 - 2.8 µm diameter, smooth-walled.

16. *Eurotium repens* : KUMA 035; IMI 358396

(Colony Plate 5.3.13; Plate 5.4.12).

Colony diameter 45 mm in 14 days growing on CDA at 25 °C. **Colonies** plane, velvety, mycelium white, yellow or orange, either enmeshing abortive yellow cleistothecia or surmounted by dull green to dull blue conidial heads, or both; reverse from pale to bright yellow or very dark brown in age with brown pigment diffusing into the surrounding agar. **Conidial heads** radiate to very loosely columnar. **Cleistothecia** enveloped in sterile yellow to orange hyphae, bright yellow, spherical, 75.0- 100 µm diameter, maturing at colony centres in 7 - 10 days; **ascospores** yellow, ellipsoidal, 4.8 - 5.5 µm by 4.0 - 4.5 µm, smooth-walled, with equatorial area rounded or somewhat flattened and occasionally indented showing a trace of a longitudinal furrow. **Conidiophores** borne from aerial hyphae, smooth, colourless 500 - 1000 µm long, broadening to a vesicle 15.0- 25.0 µm diameter, fertile over the whole area, bearing phialides only; **phialides** ampulliform, 6.0 - 9.0 µm long; **conidia** ovate to subglobose or globose, variable in size from 4.0 - 6.0 µm diameter, with densely spinulose wall.

Occurrence and mycotoxins produced. This species is of universal occurrence in dried products. On starch-based food it has been reported on wheat (Wallace *et al.*, 1976; Pitt and Hocking, 1985), rice (Pitt and Hocking, 1985), corn (Barron and Lichtwardt, 1959) and bakery products (Kozakiewicz, 1995). This species is not known to produce mycotoxins.

17. *Monascus mucoroides*

(Colony Plate 5.3.36; Plate 5.4.16)

Colony diameter 63 mm in 14 days growing on CDA at 25 °C. **Colonies** white and thinly felty. **Ascomata** profusely produced, hyaline to brownish, 20.0 - 50.0 µm diameter. **Ascospores globose**, 8.0 µm diameter, hyaline and smooth-walled. **Conidia** mostly in short or rather long chains, subglobose to pyriform with a very broadly truncate base, 7.0 - 10.0 µm by 4.5 - 8.0 µm, thin-walled, hyaline, sometimes thick-walled and larger, in short chains or solitary and functioning as chlamydospores.

Occurrence and mycotoxins produced. Its occurrence on starch-based food has not been reported and not known to produce mycotoxins.

18. *Moniliella* sp.

(Colony Plate 5.3.37; Plate 5.4.17)

Colony diameter 68 mm in 7 days growing on CDA at 25 °C. **Colonies** velvety to floccose, buff to yellow brown; exudate clear and abundant; reverse colony colour. **Conidia** of three types are produced, budding cells from hyphal extremities, arthroconidia by differentiation of hyphal tips, and chlamydoconidia, in intercalary or terminal positions on hyphae, solitary or in short chains; budding conidia ellipsoidal, arthroconidia cylindrical, both 4.0 - 6.0 µm long, chlamydoconidia spherical 4.0 - 10.0 µm diameter, with thick brown wall.

Occurrence and mycotoxins produced. *Moniliella* spp. has not been reported to occur on cereals and not known to produce mycotoxins.

19. *Penicillium aurantiogriseum* : KUMP 014; IMI 358356

(Colony Plate 5.3.13; Plate 5.4.20)

Colony diameter 76 mm in 14 days growing on CDA at 25 °C. **Colonies** plane, velvety or floccose; heavily sporing throughout in grey green to dull blue green, surrounded by white mycelium; exudate very small colourless droplets; reverse pale yellow to reddish brown with brownish coloured pigment diffusing into the surrounding agar. **Conidial heads** terverticillate or less commonly biverticillate, asymmetric with **conidiophores** arising from the substratum, 200 - 400 µm long,

with wall finely to conspicuously roughened, or occasionally smooth; **metulae** in verticils of 3 - 4 elements, 10.0 - 12.0 μm long; **phialides** slender, ampulliform, mostly 9.0 - 10.0 μm long; **conidia** subglobose to elliptical, 2.5 - 3.0 μm in diameter, smooth-walled (micro-tuberculate in SEM).

Occurrence and mycotoxins produced. This is the first record of the fungus in Malaysia. It is ubiquitous in maturing or drying crops, principally found on cereals (Pitt and Hocking, 1985) and cereals products e.g. flour (Graves and Hesseltine, 1966), bran (Pitt and Hocking, 1985), pasta (Mislivec, 1977) and bread (Pitt and Hocking, 1985). This species is not known to produce mycotoxins.

20. *P. chermesinum* : KUMA 029; IMI 358371

(Colony Plate 5.3.14; Plate 5.4.21)

Colony diameter 25 mm in 14 days growing on CDA at 25 °C. **Colonies** plane, velvety with colony surface powdery, consisting of an interlacing network of hyphae; white, thin flowery margin, with a fringe of submerged hyphae extending about 3 mm beyond the aerial growth; heavily sporing throughout in light grey green shades, exudate lacking; reverse in pale yellow to flesh colours. **Conidial heads** strictly simple, with **conidiophores** borne as short branches from loosely interwoven and trailing hyphae, smooth-walled, mostly 20.0 - 40.0 μm long by 2.0 - 2.5 μm diameter, with apices enlarged in a vesicle up to 4.0 - 4.5 μm in diameter; **phialides** in compact whorls of 10 - 15 in the verticil, 6.0 - 12.0 μm long, often incurved; **conidia** small, elliptical, smooth-walled (micro-tuberculate in SEM), 2.0 - 2.5 μm long by 1.5 - 2.0 μm diameter.

Occurrence and mycotoxins produced. This is the first record of the fungus in Malaysia. This species has been reported to occur in cereals (Frisvad and Samson, 1991). This species is not known to produce mycotoxins.

21. *P. chrysogenum* : KUMP 017; IMI 358359

(Colony Plate 5.3.15; Plate 5.4.22)

Colony diameter 53 mm in 14 days growing on CDA at 25 °C. **Colonies** lightly radiate, velvety, surrounded by a fringe of submerged hyphae extending about 2 - 3 mm beyond the aerial growth, mycelium white to yellowish, heavily sporing in

greyish turquoise to dull green; exudate lacking; reverse pale yellow and yellow soluble pigment absent. **Conidial heads** asymmetric, commonly branched, with branches and main axes each bearing 2 - 4 metulae, less commonly consisting of a simple terminal verticil of metulae only. **Conidiophore** arising from the substratum, 200 - 400 μm long, with thin smooth wall and apices somewhat inflated; **metulae** 9.0 - 13.0 μm long; **phialides** ampulliform 7.0 - 9.0 μm long; **conidia** elliptical, subglobose to globose, 3.0 - 4.0 μm long by 2.8 - 3.5 μm diameter, smooth-walled (micro-tuberculate in SEM).

Occurrence and mycotoxins produced. It has been reported very commonly on cereals, including rice (Pitt and Hocking, 1985), wheat (Wallace *et al.*, 1976; Pitt and Hocking, 1985), barley (Abdel-Kader *et al.*, 1979), corn (Mislivec and Tuite, 1970; Moubasher *et al.*, 1972; Bujari and Ershad, 1993) and flour (Graves and Hesseltine, 1966; Kurata and Ichinoe, 1967). Produces penicillic acid (Cole and Cox, 1981).

22. *P. citreonigrum* : KUMP 052; IMI 358394

(Colony Plate 5.3.16; Plate 5.4.23)

Colony diameter 29 mm in 14 days growing on CDA at 25 °C. **Colonies** plane, velvety, sporing tardily or less tardily in yellowish green to grey green shades, colony surface powdery, mycelium white in colour; margin crenate with submerged hyphae extending 3 - 4 mm beyond the aerial growth; exudate colourless; reverse in pale to bright yellow. **Conidial heads** simple with **conidiophores** arising from trailing and aerial hyphae, short and slender, 50.0 - 100 μm long by 1.0 - 2.0 μm diameter, smooth-walled and apices slightly enlarged; **phialides** in compact verticils of 8 - 12, 7.0 - 12.0 μm long, with fairly long, tapered necks; **conidia** subglobose to globose, 2.0 - 3.0 μm diameter, smooth-walled (micro-tuberculate in SEM).

Occurrence and mycotoxins produced. This is the first record of the fungus in Malaysia. It has been reported from cereals (Graves and Hesseltine, 1969; Saito *et al.*, 1971a and Pitt and Hocking, 1985). In Japan it is a common cause of spoilage of rice. This species is not known to produce mycotoxins.

23. *P. citrinum* : KUMP 015; IMI 358357

(Colony Plate 5.3.17; Plate 5.4.24)

Colony diameter 26 mm in 14 days growing on CDA at 25 °C. **Colonies** radiately sulcate towards the centre, velvety, mycelium white, colony surface powdery, surrounded by a fringe of submerged hyphae extending about 1 mm beyond the aerial growth, more or less heavy sporing in pale blue green shades becoming artemisia green at maturity, with zonation evident in some strains; exudate abundant as pale yellow to straw coloured droplets; reverse in pale yellow to orange shades with yellow to orange coloured pigment diffusing into the surrounding agar. **Conidial heads** consisting of a terminal whorl of 3 - 4 divergent metulae. **Conidiophores** smooth-walled arising from the substratum or aerial hyphae, 50.0 - 200 µm long by 3.5 - 3.0 µm diameter; **metulae** 15.0 - 28.0 µm long, with apices enlarged in a vesicle up to 4.0 µm in diameter; **phialides** crowded and parallel, in clusters of 6 - 10 elements in the verticil, 7.0 - 10.0 µm long, usually tapering to a conspicuous short narrowed neck; **conidia** subglobose to globose, 3.0 - 3.8 µm diameter, smooth-walled (micro-tuberculate in SEM).

Occurrence and mycotoxins produced. Its most common sources of starch-based food are milled grains and flour (Graves and Hesseltine, 1966; Kurata and Ichinoe, 1967) and rice and corn (Kozakiewicz, 1992). Produces citrinin (Cole and Cox, 1981).

24. *P. expansum* : KUMP 035; IMI 358377

(Colony Plate 5.3.18; Plate 5.4.26)

Colony diameter 48 mm in 14 days growing on CDA at 25 °C. **Colonies** plane zonate, with surface typically tufted (coremial) in one or more annular bands, with adjacent areas velutinous to floccose, mycelium white, very heavily sporing throughout in yellow green to blue green with the ripening of the conidia, margin white with submerged hyphae extending about 1 - 2 mm beyond the aerial growth; exudate clear and limited; reverse yellow to deep brown with yellowish brown pigment diffusing into the surrounding agar. **Conidial heads** asymmetrical, two- or three-stage branched. **Conidiophores** primarily arising from the substratum or surface hyphae, singly, in fascicles or in definite coremia, 150 - 400 µm long by

3.0 - 4.0 μm diameter, smooth-walled; **rami** 20.0 - 25.0(60.0) μm long, typically appressed against the main axis; **metulae** appressed in verticils of 2 - 6 elements, 10.0 - 15.0 μm long; **phialides** closely packed, ampulliform to almost cylindrical, 8.0 - 11.0 μm long, with short collula; **conidia** subglobose to elliptical, 2.5 - 3.0 μm in long axis, smooth-walled (micro-tuberculate in SEM).

Occurrence and mycotoxins produced. It is not frequent on cereals. Isolations have been reported from corn (Mislivec and Tuite, 1970), wheat and rice (Pitt and Hocking, 1985). Mycotoxins produced are patulin and citrinin (Cole and Cox, 1981).

25. *P. griseofulvum* : KUMP 039; IMI 358381

(Colony Plate 5.3.19; Plate 5.4.25)

Colony diameter 46 mm in 14 days growing on CDA at 25 °C. **Colonies** velvety to funiculose, moderately deep, radiately sulcate, surface texture granular, surrounded by white mycelium, moderate to heavy sporing in bluish green at the margin and greenish grey centrally; exudate clear in very small droplets; reverse pale or dull yellow with reddish amber coloured pigment diffusing into the surrounding agar. **Conidial heads** asymmetrical, irregularly two- to four-stage branched. **Conidiophores** borne in clusters from a common origin, smooth to definitely rough, sinuous, 400 - 500 μm long by 3.0 - 4.0 μm diameter; **rami** strongly divergent, 15.0 - 20.0(30.0) μm long; **metulae** short, 7.0 - 9.0 μm long, usually in groups of 2 - 4 closely appressed elements in the verticil; **phialides** closely packed, exceptionally short, 4.5 - 6.0 μm long, abruptly tapering to short collula; **conidia** ellipsoidal, sometimes subglobose, 2.0 - 2.5 μm long, smooth-walled (micro-tuberculate in SEM).

Occurrence and mycotoxins produced. This is the first record of the fungus in Malaysia. It is of common occurrence on cereals, including barley (Abdel-Kader *et al.*, 1979; King *et al.*, 1981), corn (Mislivec and Tuite, 1970), rice (Kozakiewicz, 1995), wheat (Jimenez *et al.*, 1991) and flour (Graves and Hesseltine, 1966; Saito *et al.*, 1974; Pitt and Hocking, 1985). Known to produce dechlorogriseofulvin (Cole and Cox, 1981).

26. *P. griseoroseum* : KUMP 013; IMI 358355

(Colony Plate 5.3.20; LM Plate 5.4.27)

This species is regarded as synonymous with *P. chrysogenum*. **Colony diameter** 46 mm in 14 days growing on CDA at 25 °C. **Colonies** plane, dense, velvety, lightly floccose to funiculose with ropes of hyphae present, surface texture powdery, heavily sporing in blue green shades; exudate lacking; reverse pale to bright yellow with pale yellow pigment diffusing into the surrounding agar. **Conidial heads** asymmetrical bearing 2 - 4 metulae. **Conidiophores** arising from the substratum with smooth thin wall and inflated apices; **metulae** 8.0 - 12.0 µm long; **phialides** ampulliform, 6.0 - 8.0 µm long; **conidia** subglobose, 2.0 - 2.5 µm diameter, smooth-walled.

Occurrence and mycotoxins produced. Its occurrence and production of mycotoxins is similar to *P. chrysogenum*.

27. *P. islandicum* : KUMP 033; IMI358375

(Colony Plate 5.3.21; Plate 5.4.28)

Colony diameter 33 mm in 14 days growing on CDA at 25 °C. **Colonies** plane, velutinous to floccose, mycelium orange to red, dominating the colony appearance, heavily sporing in dark yellow green shades; exudate abundant as clear, large sticky droplets; reverse orange brown to rust brown and rust brown colour diffusing into the surrounding agar. **Conidial heads** typically biverticillate and symmetrical. **Conidiophores** short, borne from aerial hyphae, 30 - 65 µm long, occasionally directly from the substratum, measuring then 100 - 150 µm long, smooth-walled; **metulae** closely appressed in verticils of 4 - 6, 8.0 - 10.0 µm long; **phialides** closely packed, acerose, 7.0 - 8.0 µm long, with abruptly narrowing collula; **conidia** elliptical, mostly 3.0 - 3.5 µm long, with smooth thick-walled (micro-tuberculate in SEM).

Occurrence and mycotoxins produced. This is the first record of the fungus in Malaysia. This species is an active agent of spoilage in cereals stored a little above safe moisture content and is the principal cause of "toxic yellow rice" (Saito *et al.*, 1971a). It has been isolated from wheat, rice, maize and flour (Kozakiewicz, 1992). Mycotoxins produced are 8-chlororugulovasine A, emodin,

erythroskyrin, skyrin, luteoskyrin, cyclochlorotine and islanditoxin (Cole and Cox, 1981).

28. *P. minioluteum* : KUMP 003; IMI 358345

(Colony Plate 5.3.22; Plate 5.4.30)

Colony diameter 36 mm in 14 days growing on CDA at 25 °C. **Colonies** plane, lightly zonate, occasionally almost velutinous, mycelium white to brownish red, weakly sporing in brownish green shades; exudate lacking; reverse pink to brownish red with pink pigment produced into the surrounding agar. **Conidial heads** typically biverticillate and symmetrical, consisting of a single terminal verticil of appressed metulae, sometimes different length, 3 - 8 elements in the verticil. **Conidiophores** borne from aerial hyphae, usually from ropes of hyphae, very short, 25 - 40(-60) µm long, with wall smooth to finely roughened, relatively heavy and sometimes pigmented; **metulae** 11.0 - 15.0 µm long; **phialides** acerose, 9.0 - 11.0 µm long, with gradually tapering collula; **conidia** small, elliptical with ends somewhat pointed to subglobose, 3.0 - 5.0 µm long, with wall comparatively thick and smooth (micro-tuberculate in SEM).

Occurrence and mycotoxins produced. This is the first record of the fungus in Malaysia. This species has not been reported to occur in starch-based food and not known to produce mycotoxins.

29. *P. oxalicum* : KUMP 018; IMI 358360

(Colony Plate 5.3.23; Plate 5.4.29)

Colony diameter 82 mm in 14 days growing on CDA at 25 °C. **Colonies** plane, velvety, mycelium usually inconspicuous, in floccose areas white, surrounded by a fringe of submerged hyphae extending 2 mm beyond the aerial growth, heavily sporing throughout in dark grey green shades with the ripening of the conidia; exudate lacking; reverse pale to yellow or pinkish shades. **Conidial heads** typically biverticillate asymmetrical. **Conidiophores** borne from surface mycelium, 200 - 400 µm long, with smooth thin-walled; **metulae** appressed consisting of 2 - 4 elements in a verticil, mostly 15.0 - 25.0 µm long with apices enlarged in a vesicle up to 7.0 µm diameter; **phialides** parallel, in verticils of 6 - 10 elements,

acerose, 10.0 - 15.0 μm long; **conidia** strongly elliptical, smooth-walled with conspicuous connectives between them (reticulate in SEM), mostly 5.0 - 6.0 μm long by 3.5 - 4.5 μm .

Occurrence and mycotoxins produced. This is the first record of the fungus in Malaysia. It is the most common species isolated from freshly harvested corn. It has also been reported from barley (Abdel-Kader *et. al.*, 1979), wheat (Pitt and Hocking, 1985) and flour (Graves and Hesseltine, 1966). Known to produce secalonic acid D (Cole and Cox, 1981).

30. *P. pinophilum* : KUMP 050; IMI 358392

(Colony Plate 5.3.24; Plate 5.4.31)

Colony diameter 74 mm in 14 days growing on CDA at 25 °C. **Colonies** plane, floccose, deep, surface overlaid by a loose network of yellow to yellow green aerial hyphae and sometimes pink mycelium developing, surrounded by a fringe of submerged hyphae extending 2 mm beyond the aerial growth, sporng moderately in centre and poorly at margins with conidial areas grey green; exudate lacking; reverse bright yellow to orange brown shades. **Conidial heads** typically biverticillate and symmetric, with occasional asymmetrical side rami; **conidiophores** smooth walled, arising as short branches from ropes of hyphae, 100 - 400 μm long; **rami** when present, about 20.0 - 50.0 μm long; **metulae** cylindrical, consists of 3 - 4 elements in the verticil, 10.0 - 15.0 μm long; **phialides** acerose, in crowded clusters of 2 - 6 elements in the verticil, 10.0 - 15.0 μm long; **conidia** conspicuously fusiform, smooth-walled (reticulate in SEM), 3.0 - 5.0 μm by 2.0 - 2.8 μm .

Occurrence and mycotoxins produced. This is a new record of the fungus in Malaysia. This species has not been reported to occur on starch-based food and not known to produce mycotoxins.

31. *P. purpurogenum* : KUMP 047; IMI 358389

(Colony Plate 5.3.25; Plate 5.4.32)

Colony diameter 69 mm in 14 days growing on CDA at 25 °C. **Colonies** plane, velvety, dense, mycelium bright yellow or red due to encrusted hyphae, heavily

sporing throughout in deep yellow green shades; exudate lacking; reverse usually developing reddish brown to dark reddish purple shades. **Conidial heads** compact, typically biverticillate and symmetrical. **Conidiophores** erect, septate, arising from the substratum and measuring up to 100 - 150 μm long, smooth-walled; **metulae** numbering 3, 5 or 8 elements, 10.0 - 14.0 μm long; **phialides** lanceolate, slender, tapering gradually to a long narrowed neck, 10.0 - 12.0 μm long; **conidia** elliptical to subglobose, sometimes more or less apiculate, mostly 3.0 - 4.0 μm by 2.5 - 3.0 μm , thick-walled, smooth or irregularly roughened (micro-tuberculate in SEM).

Occurrence and mycotoxins produced. This is a new record of the fungus in Malaysia. This species has been widely isolated from cereals (Pitt and Hocking, 1985), including corn (Mislivec and Tuite, 1970), rice, wheat, flour and barley (Saito *et al.*, 1971a and 1974). Mycotoxins produced are rubratoxin A and rubratoxin B (Cole and Cox, 1981).

32. *P. rugulosum* : KUMP 028; IMI 358370

(Colony Plate 5.3.26; Plate 5.4.33)

Colony diameter 34 mm in 14 days growing on CDA at 25 °C. **Colonies** plane, low, margin white with submerged hyphae extending about 3 mm beyond the aerial growth, consisting of a fairly tough, close-textured basal felt, in white to orange brown shades, poorly sporing producing a light grey effect; exudate prominent as colourless droplets; reverse initially colourless becoming vinaceous or orange-red either in localized areas or throughout and no coloured pigment diffusing into the surrounding agar. **Conidial heads** typically biverticillate and symmetrical, but sometimes fractional or irregular. **Conidiophores** borne from surface or aerial hyphae 50.0 - 100 μm long, smooth-walled; **metulae** usually consisting 2 to 3 elements, about 9.0 - 12.0 μm long cylindrical; **phialides** acerose, tapering gradually to a long narrowed neck, in clusters of 5 to 8 elements in the verticil, 8.0 - 11.0 μm long; **conidia** elliptical, with pointed ends, 3.5 - 4.0 μm by 2.8 - 3.0 μm in diameter, thick-walled, smooth, or roughened (reticulate in SEM).

Occurrence and mycotoxins produced. This is a new record of the fungus in Malaysia. It is not widely isolated from starch-based food except on rice (Pitt and Hocking, 1985) and flour (Kurata and Ichinoe, 1967). Known to produce rugulosin (Cole and Cox, 1981).

33. *P. simplicissimum* : KUMP 019; IMI 358361

(Colony Plate 5.3.27; Plate 5.4.34)

Colony diameter 68 mm in 14 days growing on CDA at 25 °C. **Colonies** plane, deeply velvety, mycelium white, surrounded by a fringe of white submerged hyphae extending about 1 mm beyond the aerial growth, heavily sporing throughout in blue green to grey green shades; exudate lacking; reverse in pale yellow shades. **Conidial heads** typically asymmetric and divaricate. **Conidiophores** arising from substratum or aerial hyphae, with wall finely roughened, varying greatly in dimensions, ranging from 200 - 800 µm or more in length; **metulae** in a verticil of 2 - 4 elements, variable, mostly 12.0 - 20.0 µm long; **phialides** in whorls of 3 - 10 elements in the verticil, mostly 10.0 - 13.0 µm long; **conidia** initially elliptical but frequently appearing subglobose, mostly 3.0 - 4.0 µm in long axis, smooth-walled (micro-tuberculate in SEM).

Occurrence and mycotoxins produced. This is a new record of the fungus in Malaysia. This species has been reported to be isolated from cereals (Frisvad and Samson, 1991). Mycotoxins produced are penicillic acid and decumbin (Cole and Cox, 1981).

34. *P. spinulosum* : KUMP 004; IMI 358346

(Colony Plate 5.3.28; Plate 5.4.35)

Colony diameter 55 mm in 14 days growing on CDA at 25 °C. **Colonies** plane, zonate, dense, velutinous to floccose, mycelium bright yellow surrounded by a fringe of submerged hyphae extending 2 mm beyond the aerial growth, moderately sporing in blue green shades; exudate lacking; reverse bright yellow developing into dark brown shades. **Conidial heads** usually strictly monoverticillate but with an occasional branch. **Conidiophores** arising mainly from the substratum with stipes 100 - 300 µm long or from aerial hyphae with

stipes much shorter, 25.0 - 50.0 μm long, thin-walled, smooth to definitely rough; **phialides** few in number, about 6 - 10 elements in the verticil, mostly 6.0 - 9.0 μm long; **conidia** mostly subglobose to globose, usually 3.0 - 3.5 μm in diameter, conspicuously roughened or spinulose (micro-tuberculate in SEM).

Occurrence and mycotoxins produced. This is a new record of the fungus in Malaysia. It has been reported most frequently from wheat and flour (Kurata and Ichinoe, 1967; Pitt and Hocking, 1985). Known to produce penitrem A (Cole and Cox, 1981).

35. *P. thomii* : KUMP 012; IMI 358354

(Colony Plate 5.3.29; Plate 5.4.36)

Colony diameter 67 mm in 14 days growing on CDA at 25 °C. **Colonies** plane, velvety to lightly floccose, surrounded by white mycelium, heavily sporing throughout in grey green shades; exudate abundant, as clear, small droplets; reverse in pale yellow to brownish shades. **Conidial heads** strictly simple. **Conidiophores** arising primarily from the substratum and from interlacing aerial hyphae with walls delicately echinulate, variable in length up to 300 - 400 μm long; **phialides** crowded, 8 - 12 elements in the verticil, usually 8.0 - 13.0 μm long, with long narrow collula; **conidia** elliptical to subglobose, mostly 3.0 - 3.5 μm in long axis, smooth-walled (micro-tuberculate in SEM).

Occurrence and mycotoxins produced. This is a new record of the fungus in Malaysia. In food, most isolations has been reported from cereals i.e. wheat (Pitt and Hocking, 1985) and barley (Abdel-Kader *et al.*, 1979; Lillehoj and Goransson, 1980). Known to produce penicillic acid (Cole and Cox, 1981).

36. *P. variabile* : KUMP 025; IMI 358367

(Colony Plate 5.3.30; Plate 5.4.37)

Colony diameter 39 mm in 14 days growing on CDA at 25 °C. **Colonies** plane, zonate, velvety, heavily sporing in deep blue green to grey green shades; exudate lacking; reverse developing orange shades beneath the sporulating areas, remaining white in non-sporing areas. **Conidial heads** typically biverticillate and symmetrical. **Conidiophores** arising from the basal felt often short 10.0 - 20.0 μm

long or in marginal areas of older colonies directly from the substratum, commonly 100 - 200 μm long, smooth-walled; **metulae** in a verticil of 5 to 7 elements varying in length from 12.0 - 16.0 μm long, slightly inflated at apex; **phialides** acerose in clusters of 5 to 7 elements in the verticil, about 11.0 - 16.0 μm long; **conidia** strongly elliptical with pointed ends mostly 4.0 - 5.0 μm by 2.5 - 3.5 μm in diameter, smooth-walled or faintly roughened (micro-tuberculate in SEM).

Occurrence and mycotoxins produced. This is a new record of the fungus in Malaysia. It has been isolated principally from cereals i.e. wheat and flour (Graves and Hesseltine, 1966; Pitt and Hocking, 1985), corn (Mislivec and Tuite, 1970), rice (Saito *et al.*, 1971a) and barley (Abdel-Kader *et al.*, 1979). Known to produce rugulosin (Cole and Cox, 1981).

37. *P. verrucosum* : KUMP 027; IMI 358369

(Colony Plate 5.3.31; Plate 5.4.38)

Colony diameter 69 mm in 14 days growing on CDA at 25 °C. **Colonies** plane, velvety, heavily sporing in blue green shades, mycelium white surrounded by a fringe of submerged hyphae extending about 1 mm beyond the aerial growth; exudate abundant, colourless and small; reverse pale yellow to brown. **Conidial heads** asymmetric, usually consisting of a main axis with or without one or more appressed rami, sometimes appearing monoverticillate. **Conidiophores** arising either as short branches from trailing or ascending hyphae mostly less than 50.0 μm long, or from the substratum and up to 200 - 250 μm long, wall finely roughened; **rami** appressed, 20 - 30 μm long; **metulae** irregularly produced, commonly in groups of 2 - 4 often at different levels, measuring 8.0 - 15.0(20.0) μm by 2.5 - 3.0 μm ; **phialides** closely packed and few in the verticil, 7.0 - 10.0 μm by 3.0 - 3.5 μm , bottle-shaped, tapering abruptly to a very short narrowed neck; **conidia** globose to subglobose, 4.0 - 5.0 μm in long axis, smooth-walled or irregularly and finely roughened.

Occurrence and mycotoxins produced. This is a new record of the fungus in Malaysia. This species has been reported to be isolated from cereals (Frisvad and Samson, 1991). Known to produce rugulovasine A (Cole and Cox, 1981).

38. *P. vinaceum* : KUMA 043; IMI 358404

(Cultures not available for photography)

Colony diameter 25 mm in 14 days growing on CDA at 25 °C. **Colonies** radially sulcate, deep, with undulating margin surrounded by a fringe of submerged hyphae extending about 1 mm beyond the aerial growth, and showing some funiculose arrangement of vegetative hyphae, sporing very lightly throughout in pale blue to pale grey green shades, with colony surface remaining persistently white; exudate abundantly produced in pale yellow to deep vinaceous shades; reverse in vinaceous shades with pale yellow coloured pigment diffusing slowly into the surrounding agar. **Conidial heads** usually simple, seldom branched but occasionally producing diverging rami. **Conidiophores** commonly borne from aerial hyphae, short, seldom exceeding 50.0 µm long, smooth-walled with apices very slightly enlarged, **phialides** usually consisting of a cluster of 2 - 5 elements in the verticil, 6.0 - 7.5 µm long, terminating in a conspicuous tapered neck, somewhat divergent; **conidia** subglobose to globose when mature, with ends apiculate when young, 2.0 - 2.5 µm diameter, with walls appearing slightly irregular or roughened.

Occurrence and mycotoxins produced. This a new record of the fungus in Malaysia. This species has not been reported to occur on starch-based food and not known to produce mycotoxins.

39. *Trichoderma* sp.

(Colony Plate 5.3.38; Plate 5.4.13)

Colony diameter 82 mm in 4 days growing on CDA at 25 °C. **Colonies** often irregular in outline or with isolated tufts evident, of white to yellow mycelium, with bright blue green conidia developing; reverse pale or yellowish. **Conidiophores** consisting of highly branched structures, with a stipe bearing branches and the branches rebranching, all at approximately at right angles, to form a pyramidal shape, with each branch bearing phialides irregularly; **phialides** ampulliform, commonly 5.0 - 7.0 by 3.0 - 3.5 µm, larger when borne apically, bearing conidia singly; **conidia** often adhering in small clusters, globose, 2.5 - 3.2(4.0) µm diameter, smooth-walled.

Occurrence and mycotoxins produced. *Trichoderma viride* has been reported from stored grains, including wheat (Pitt and Hocking, 1985), rice (Saito *et al.*, 1971a), barley (Flannigan, 1969; Abdel-Kader *et al.*, 1979). Mycotoxins produced are trichodermin and viridiol (Cole and Cox, 1981).

40. *Absidia corymbifera*

(Colony Plate 5.3.39; Plate 5.4.39)

Colony diameter 71 mm in 5 days growing on MEA at 25 °C. **Colonies** deeply floccose mycelium, coloured mid grey by sporangia; reverse pale. **Sporangiophores** borne from aerial hyphae, stipes irregularly branched; **sporangia** hyaline, 15.0 - 50.0 µm diameter, appearing pyriform due to external conical columellae; **columella** pyriform, 10.0 - 30.0 µm diameter, sometimes with small projections on the apices or with collarettes above the base, in age collapsing inward from the apex to form funnel shaped structures; **sporangiospores** hyaline, broadly ellipsoidal to spheroidal, 3.0 - 6.0 µm long, smooth-walled.

Occurrence and mycotoxins produced. On starch-based food this species has been isolated mostly from wheat (Wallace *et al.*, 1976, Pitt and Hocking, 1985), barley (Flannigan, 1969; Abdel-Kader *et al.*, 1979) and cereal products such as flour (Graves and Hesseltine, 1966) and bran (Pitt and Hocking, 1985). This species is not known to produce mycotoxins.

41. *Cunninghamella polymorpha*

(Colony Plate 5.3.40; Plate 5.4.40)

Colony diameter 40 mm in 2 days growing on MEA at 25 °C. **Colonies** greyish; reverse pale to yellowish grey. **Sporophores** borne from vegetative hyphae, at first simple, non-septate, erect, ascending, producing mostly verticillate branching at the distal portion. Branching very rare in the lower portion. Branches up to 107 by 10.0 µm (only simple ones), secondary branching very common. Fertile heads up to 65.0 µm diameter. Terminal vesicles subglobose to globose or oval, up to 43.0 by 46.0 µm diameter. Secondary vesicles of similar shape but smaller, up to 30.0 by 23.0 µm. **Sporangiola** mostly ellipsoidal to lacrymoid, 7.0 - 10.0(13.0) by 6.0 - 8.0(10.0) µm, some globose. 5.0 - 8.0(9.0) µm diameter, spines short.

Occurrence and mycotoxins produced. This species has not been reported to be isolated from food and not known to produce mycotoxins.

42. *Mucor circinelloides*

(Colony Plate 5.3.41; Plate 5.4.43)

Colony diameter 55 mm in 2 days growing on MEA at 25 °C. **Colonies** appearing pale grey by sporangia; reverse uncoloured. **Sporangiophores** borne from aerial hyphae, stipes commonly branched, often sympodially; **sporangia** spherical, 25.0 - 50.0 µm diameter, sometimes up to 80.0 µm; **columella** roughly spherical, up to 50.0 µm diameter; **sporangiospores** hyaline, ellipsoidal, mostly 4.5 - 7.0 µm long, smooth walled. Chlamydoconidia uncommon, spherical, cylindrical or rather irregular, up to 15.0 µm diameter. Zygosporangia not formed in pure culture.

Occurrence and mycotoxins produced. This species has been isolated from cereals but not known to produce mycotoxins.

43. *Rhizopus arrhizus*

(Colony Plate 5.3.42; Plate 5.4.41)

Colony diameter covering the whole plate in 2 days growing on MEA at 25 °C. **Colonies** low and sparse; grey due to sporangia, mycelium fine, white; reverse greyish. **Sporangiophores** mostly borne from surface hyphae, with stipes arising from small, sometimes inconspicuous rhizoids or merely hyphal swellings; **sporangia** spherical, 100 - 200 µm diameter, **collumella** 75.0 - 150 µm diameter, in age collapsing to form umbrella shapes; **sporangiospores** ellipsoidal to angular, 5.0 - 7.0 µm long, with striate wall.

Occurrence and mycotoxins produced. On starch-based food this species has been isolated from wheat (Pitt and Hocking, 1985). Known to produce fumigaclavine B (Cole and Cox, 1981).

44. *Rhizopus microsporus*

(Colony Plate 5.3.43; Plate 5.4.42)

Colony diameter 65 mm in 2 days growing on MEA at 25 °C. **Colonies** grey due to sporangia; reverse greyish. Rhizoids well-developed. **Sporangiophore** arising from, often in pairs. **Sporangia** greyish black, powdery in appearance, up to 100 µm diameter, collumellae cylindrical, occasionally globose, 70.0 by 50.0 µm. **Sporangiospores** angular to broadly ellipsoidal, up to 7.0 by 6.0 µm, striate.

Occurrence and mycotoxins produced. This species has not been reported to be isolated from starch-based food. Mycotoxins produced are rhizonin A and rhizonin B (Cole and Cox, 1981).

45. *Syncephlastrum racemosum*

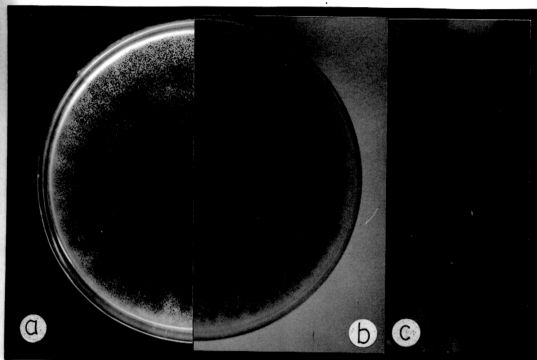
(Colony Plate 5.3.44; Plate 5.4.44)

Colony diameter 38 mm in 2 days growing on MEA at 25 °C. **Colonies** sparse to moderately dense, mid to deep grey; reverse pale or greyish. **Sporangiophores** borne from aerial hyphae, stipes long and branched or produced as short side branches from fertile hyphae; sporangial heads 30.0 - 80.0 µm diameter, with **sporangiospores** formed linearly within cylindrical sacs (merosporangia) borne on spicules around the columella; **columella** spherical or nearly so, 10.0 - 50.0 µm diameter, brown with walls smooth except at merosporangium attachment points, usually collapsing irregularly; **sporangiospores** adhering in chains of up to 10, becoming brown, irregular in size and shape, spherical to cylindrical, 3.0 - 5.0 (- 10) µm diameter or long, smooth-walled.

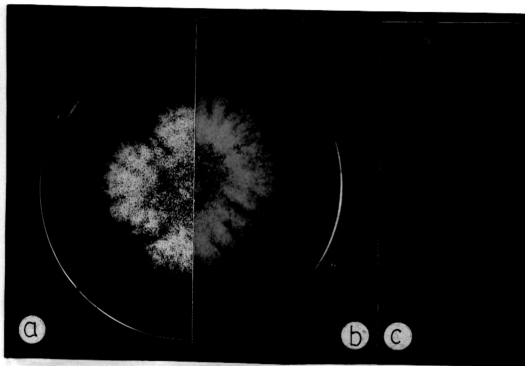
Occurrence and mycotoxins produced. On starch-based food, this species has been isolated from cereals (Flannigan, 1969; Pitt and Hocking, 1985). This fungus is not known to produce mycotoxins.



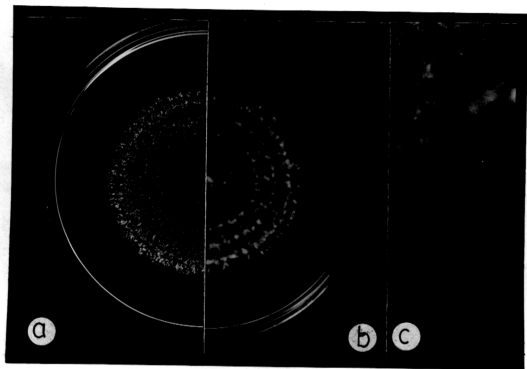
5.3.1 *Aspergillus aculeatus* (7 days on CDA)



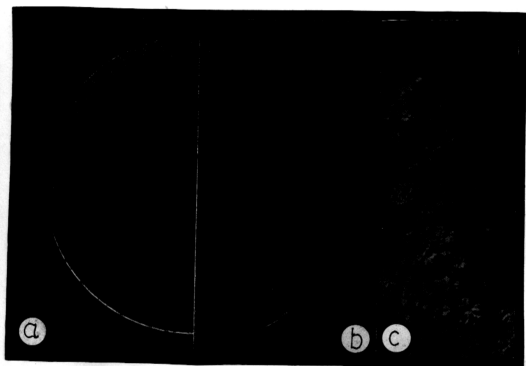
5.3.2 *Aspergillus candidus* (14 days on CDA)



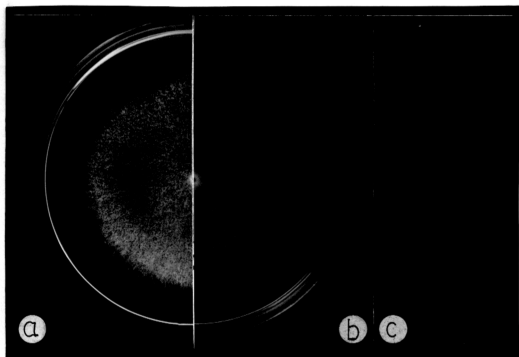
5.3.3 *Aspergillus clavatus* (14 days on CDA)



5.3.4 *Aspergillus flavus* (7 days on CDA)



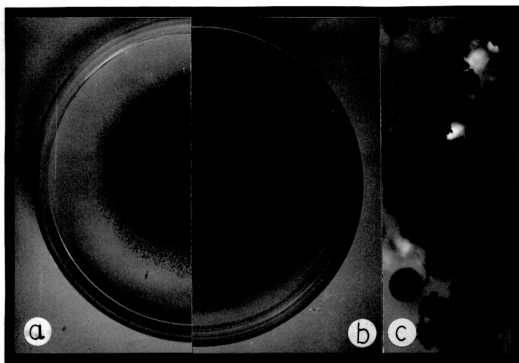
5.3.5 *Aspergillus fumigatus* (14 days on CDA)



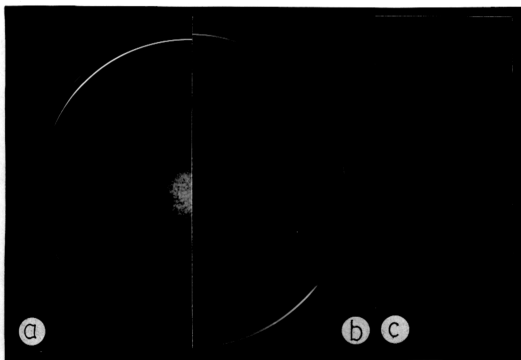
5.3.6 *Aspergillus longivesica* (7 days on CDA)



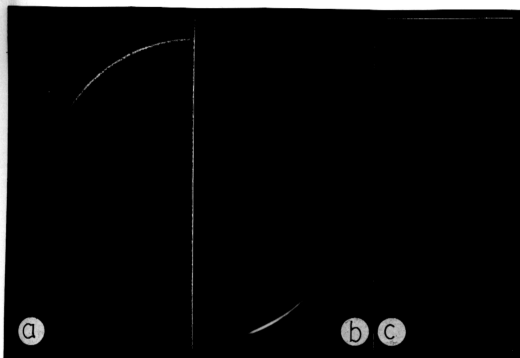
5.3.7 *Aspergillus niger* (7 days on CDA)



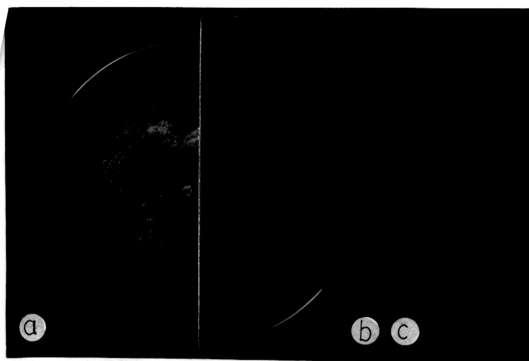
5.3.8 *Aspergillus sydowi* (14 days on CDA)



5.3.9 *Aspergillus tamarii* (7 days on CDA)



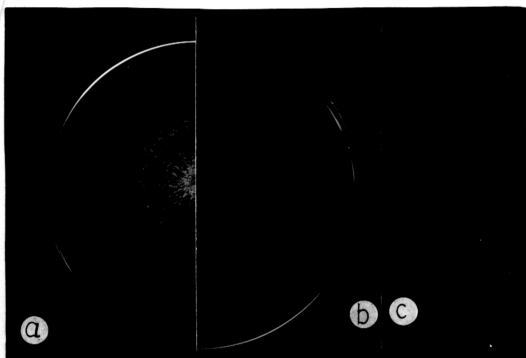
5.3.10 *Aspergillus terreus* (14 days on CDA)



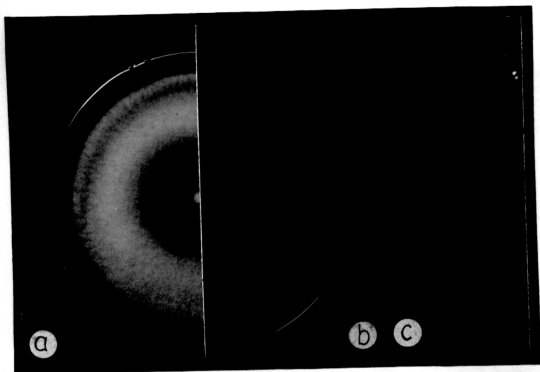
5.3.11 *Aspergillus versicolor* (14 days on CDA)



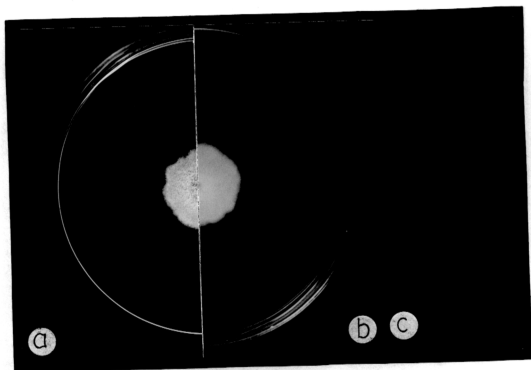
5.3.12 *Eurotium repens* (14 days on CDA)



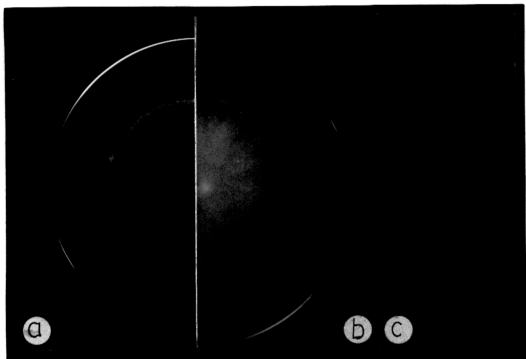
5.3.13 *Penicillium aurantiogriseum* (14 days on CDA)



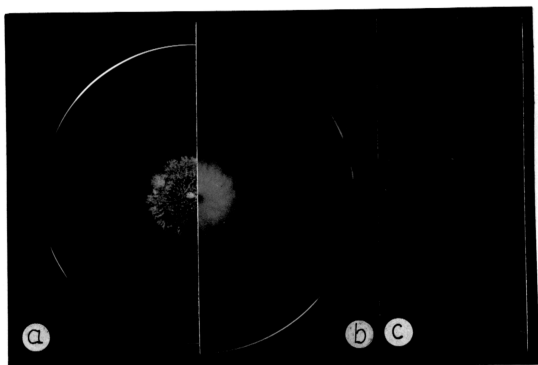
5.3.14 *Penicillium chermesinum* (14 days on CDA)



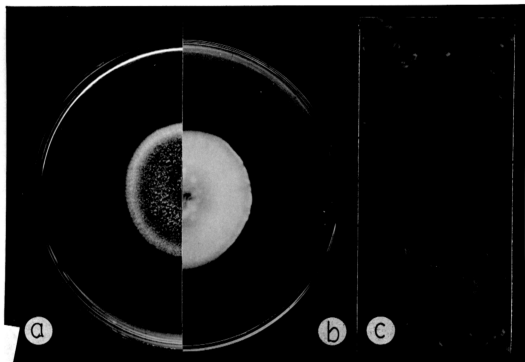
5.3.15 *Penicillium chrysogenum* (14 days on CDA)



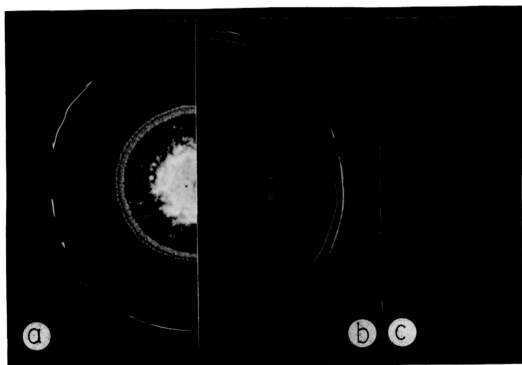
5.3.16 *Penicillium citreonigrum* (14 days on CDA)



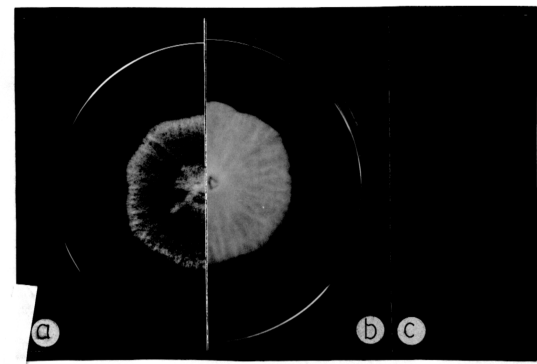
5.3.17 *Penicillium citrinum* (14 days on CDA)



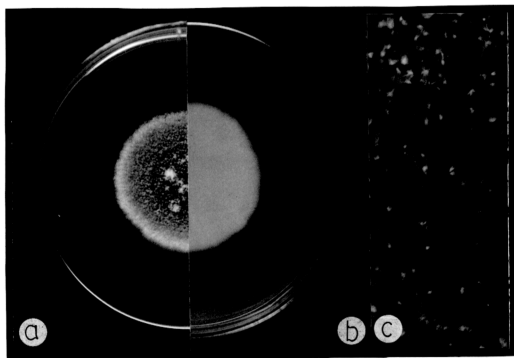
5.3.18 *Penicillium expansum* (14 days on CDA)



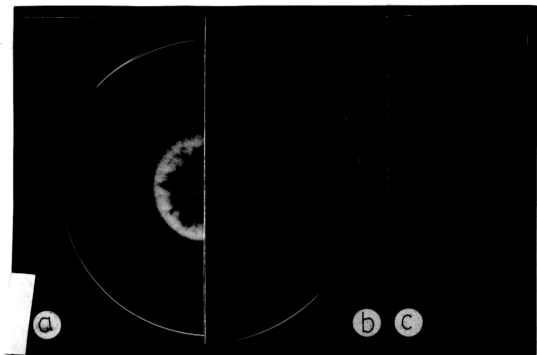
5.3.19 *Penicillium griseofulvum* (14 days on CDA)



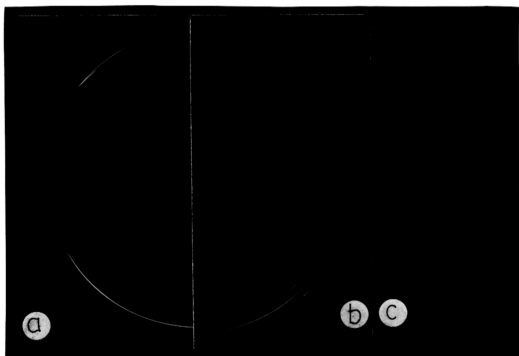
5.3.20 *Penicillium griseoroseum* (14 days on CDA)



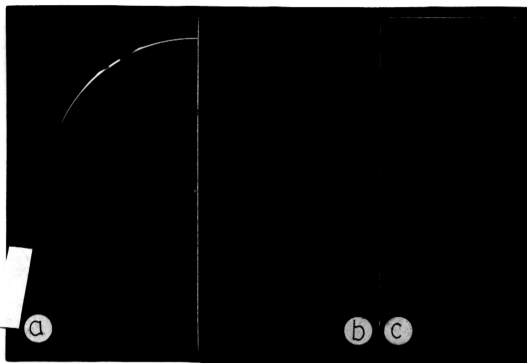
5.3.21 *Penicillium islandicum* (14 days on CDA)



5.3.22 *Penicillium minioluteum* (14 days on CDA)



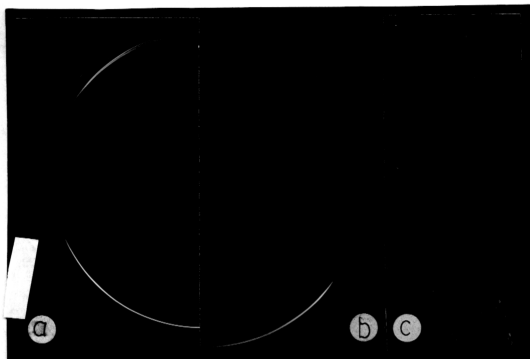
5.3.23 *Penicillium oxalicum* (14 days on CDA)



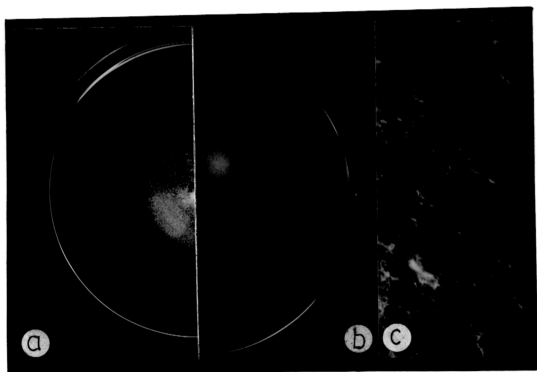
5.3.24 *Penicillium pinophilum* (14 days on CDA)



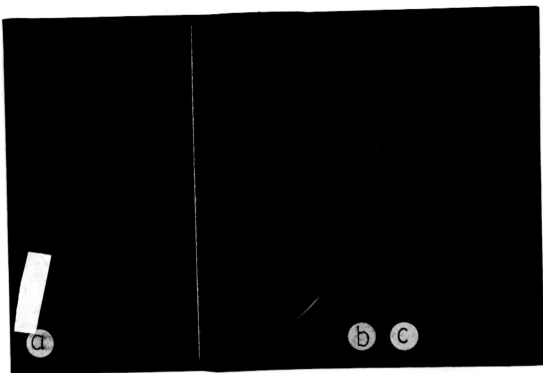
5.3.25 *Penicillium purpurogenum* (14 days on CDA)



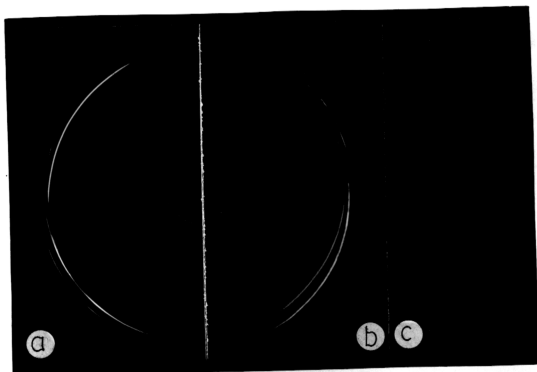
5.3.26 *Penicillium rugulosum* (14 days on CDA)



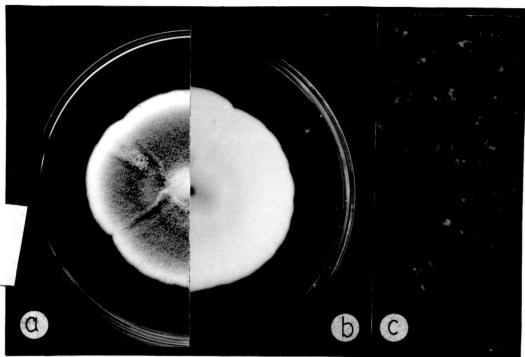
5.3.27 *Penicillium simplicissimum* (14 days on CDA)



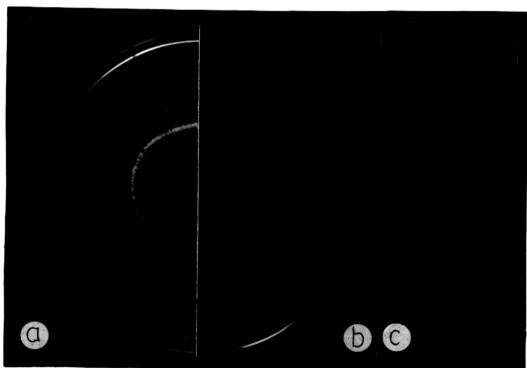
5.3.28 *Penicillium spinulosum* (14 days on CDA)



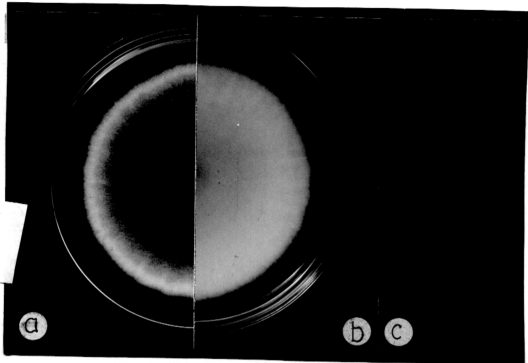
5.3.29 *Penicillium thomii* (14 days on CDA)



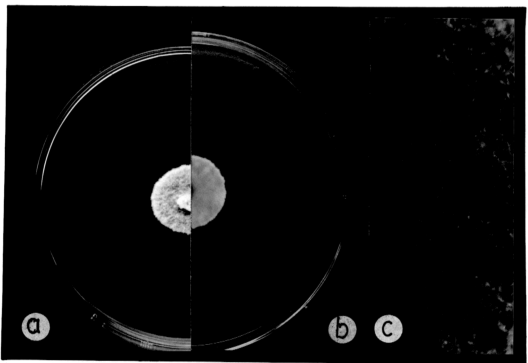
5.3.30 *Penicillium variable* (14 days on CDA)



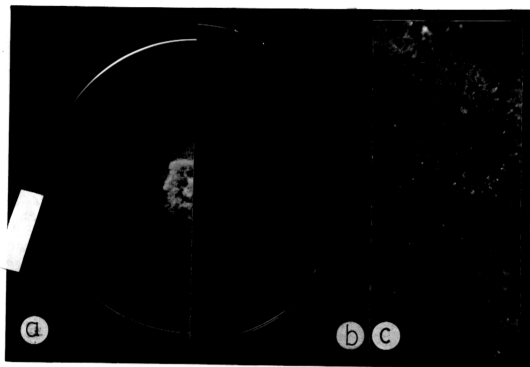
5.3.31 *Penicillium verrucosum* (14 days on CDA)



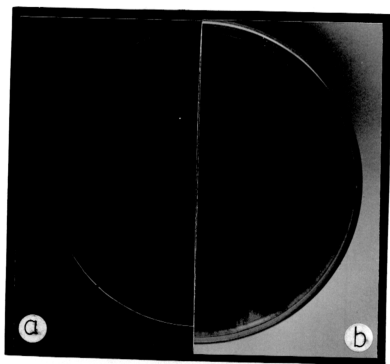
5.3.32 *Eupenicillium hirayamae* (14 days on CDA)



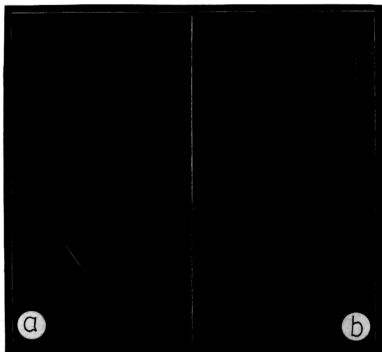
5.3.33 *Eupenicillium* sp. (14 days on CDA)



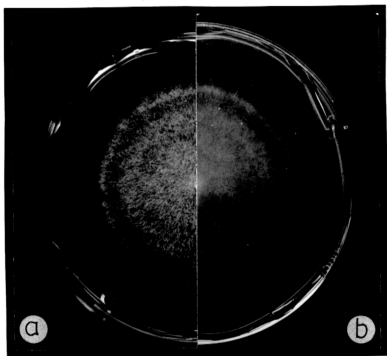
5.3.34 *Curvularia lunata* (7 days on CDA)



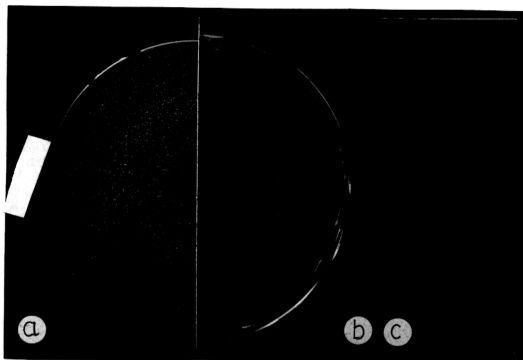
5.3.35 *Dreschlera* sp. (7 days on CDA)



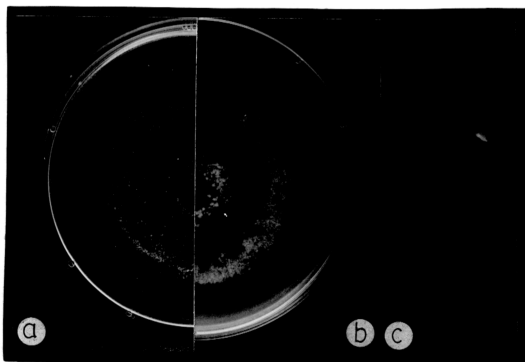
5.3.36 *Monascus mucoroides* (7 days on CDA)



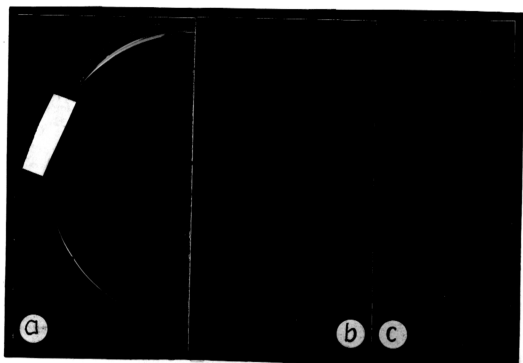
5.3.37 *Moniliella* sp. (14 days on CDA)



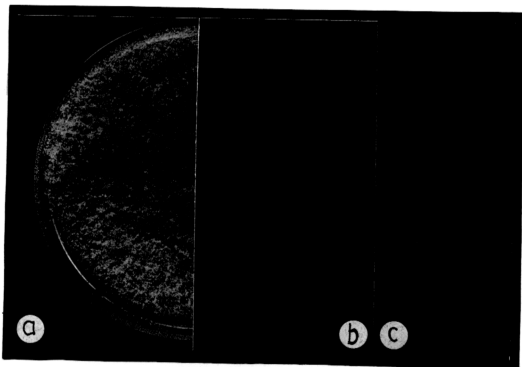
5.3.38 *Trichoderma* sp. (7 days on CDA)



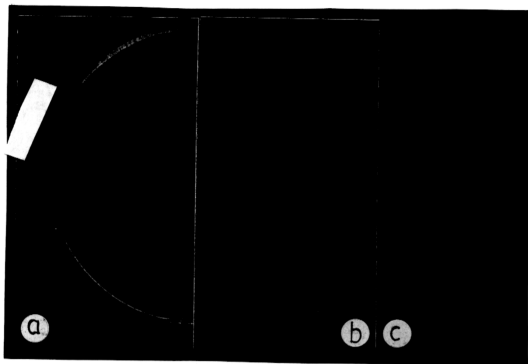
5.3.39 *Absidia corymbifera* (6 days on MEA)



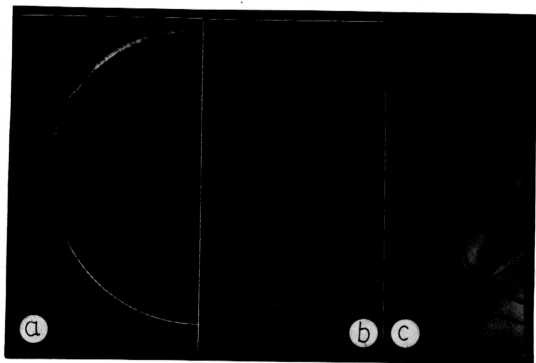
5.3.40 *Cunninghamella polymorpha* (6 days on MEA)



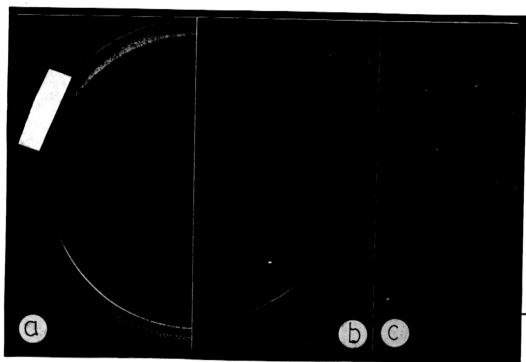
5.3.41 *Mucor circinelloide* (6 days on MEA)



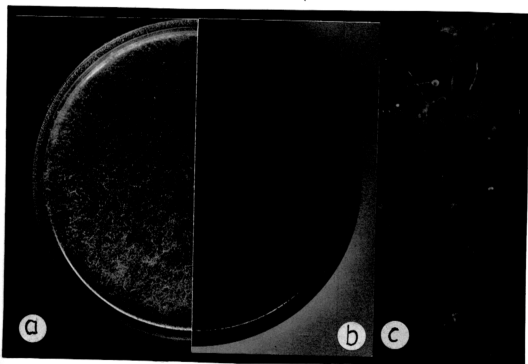
5.3.42 *Rhizopus arrhizus* (6 days on MEA)



5.3.43 *Rhizopus microsporus* (6 days on MEA)



5.3.44 *Synccephalastrum racemosum* (6 days on MEA)



5.4 Light microscope and scanning electron microscope (SEM) plates of

fungi from starch-based food

5.4.1 *Aspergillus aculeatus*

a Conidial head

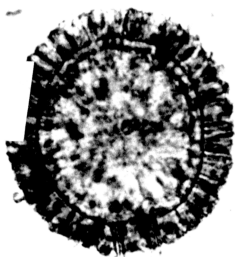
b Conidia

5.4.2 *Aspergillus candidus*

a Small conidial head

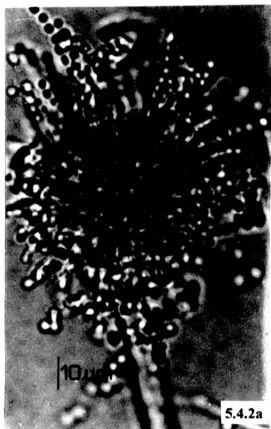
b Conidia

c Large conidial heads



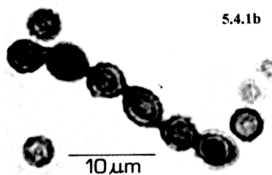
10μm

5.4.1a



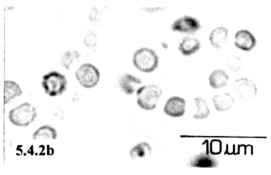
10μm

5.4.2a



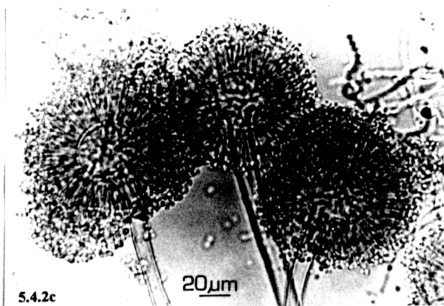
5.4.1b

10μm



5.4.2b

10μm



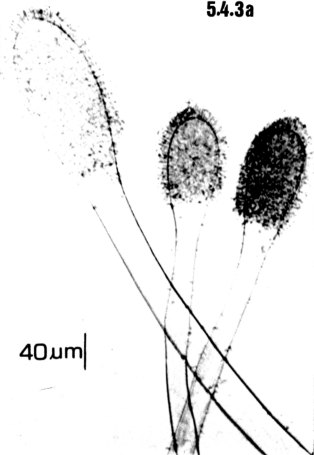
5.4.2c

20μm

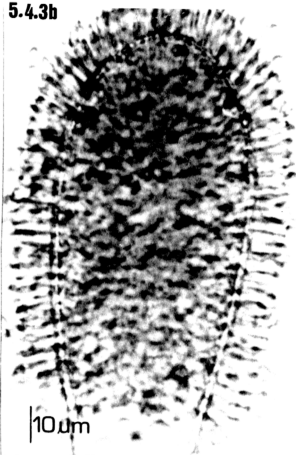
5.4.3 *Aspergillus clavatus*
a - b Conidial heads
c Conidia

5.4.4 *Aspergillus flavus*
a Conidial head
b Conidia

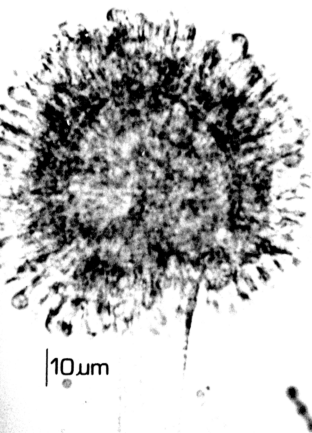
5.4.3a



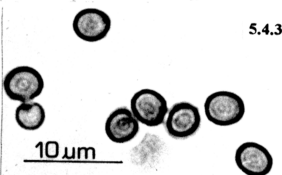
5.4.3b



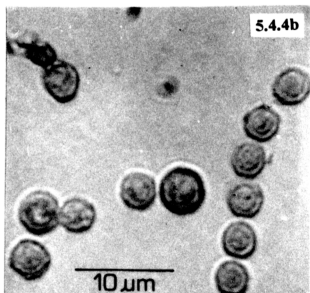
5.4.4a



5.4.3c



5.4.4b



5.4.5. *Aspergillus fumigatus*

a - b Conidial heads

c Conidia

5.4.6 *Aspergillus longivesica*

a - b Conidial heads

c Conidia

5.4.5. *Aspergillus fumigatus*

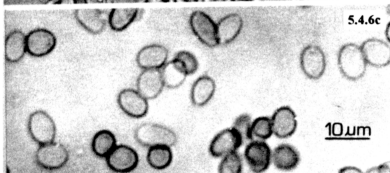
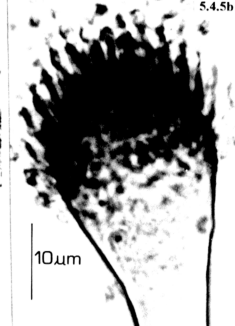
a - b Conidial heads

c Conidia

5.4.6 *Aspergillus longivesica*

a - b Conidial heads

c Conidia



5.4.7 *Aspergillus niger*

a Conidial head

b Conidia

5.4.8 *Aspergillus sydowii*

a Conidial head

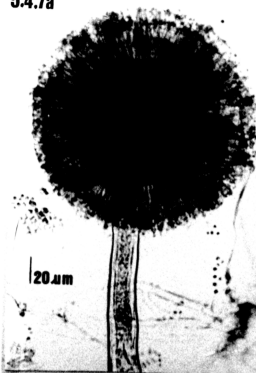
b Conidia

5.4.9 *Aspergillus tamarii*

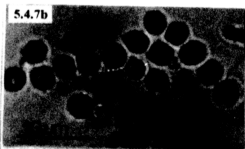
a - b Conidial heads

c Conidia

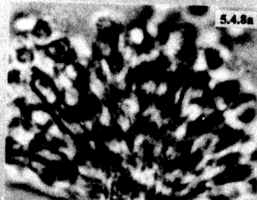
5.4.7a



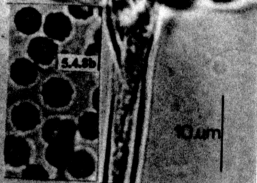
5.4.7b



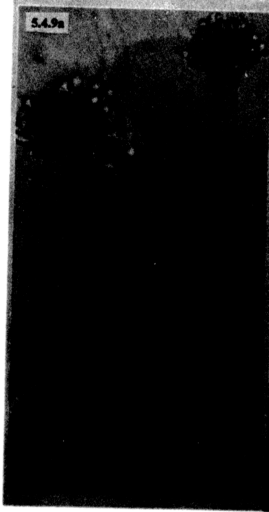
5.4.8a



5.4.8b



5.4.9a



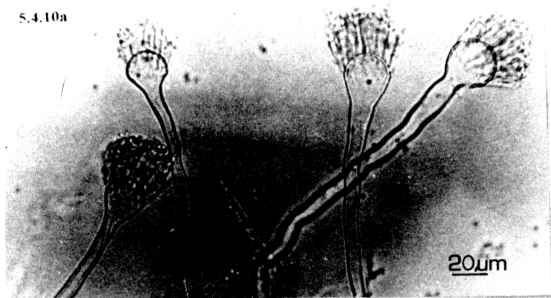
5.4.9b



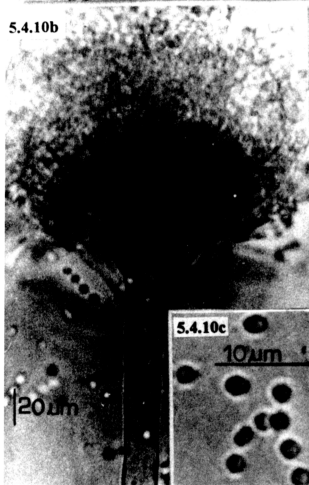
5.4.10 *Aspergillus terreus*
a - b Conidial heads
c Conidia

5.4.11 *Aspergillus versicolor*
a Conidial head
b Conidia

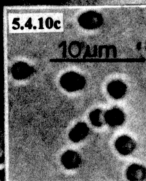
5.4.10a



5.4.10b



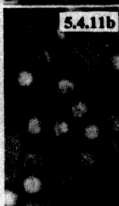
5.4.10c



5.4.11



5.4.11b



5.4.12 *Eurotium repens*

a Conidial head

b Cleistothecium

c Ascospores

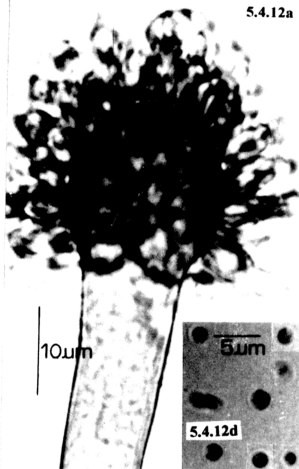
d Conidia

5.4.13 *Trichoderma* sp.

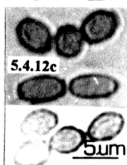
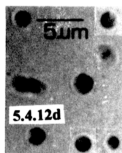
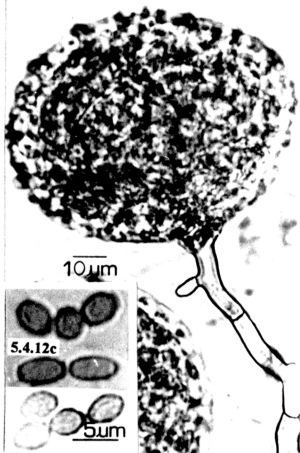
a Conidiophore and conidia

b Conidia

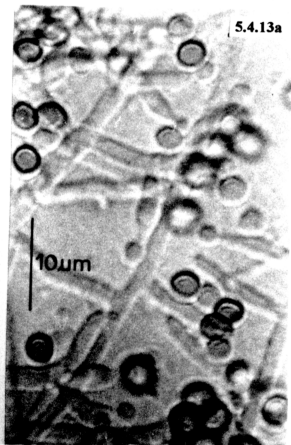
5.4.12a



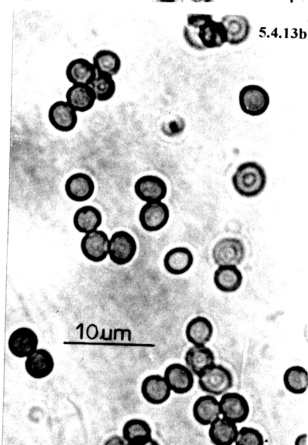
5.4.12b



5.4.13a



5.4.13b



5.4.14 *Curvularia lunata*

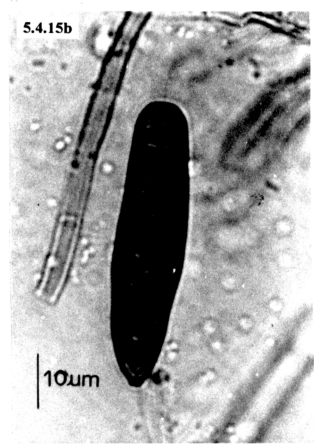
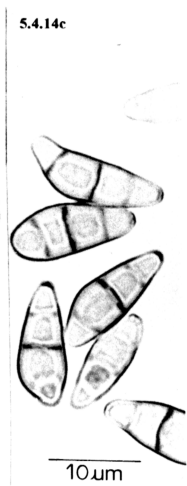
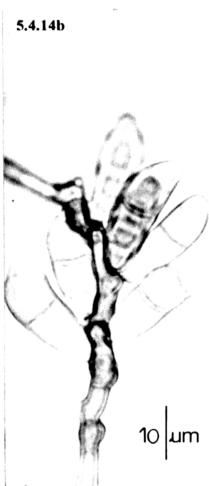
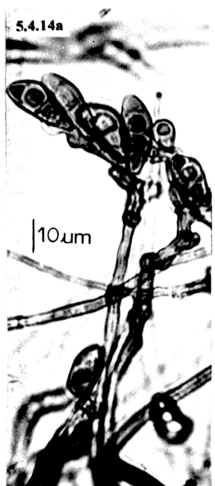
a - b Conidiophores with attached conidia

c Conidia

5.3.15 *Dreschlera* sp.

a Conidiophore bearing a conidium

b A conidia



5.4.16 *Monascus mucoroides*

a Conidia in chains

b Single conidia

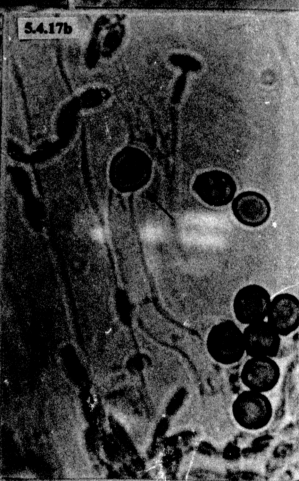
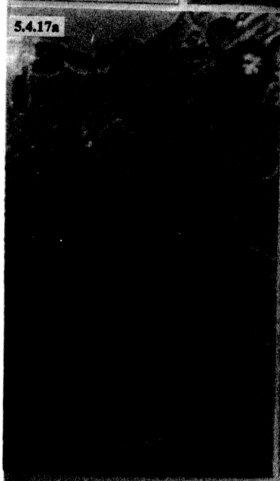
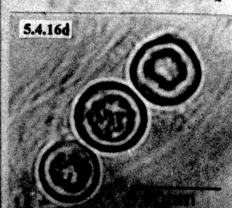
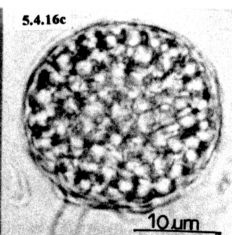
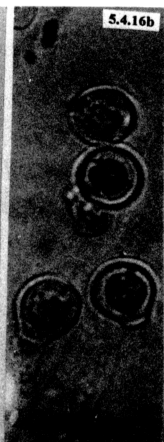
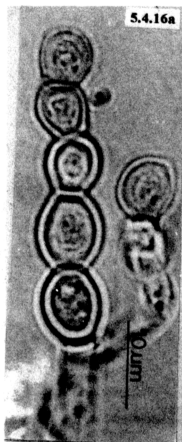
c Cleistothecium

d Ascospores

5.4.17 *Moniliella* sp.

a Conidia

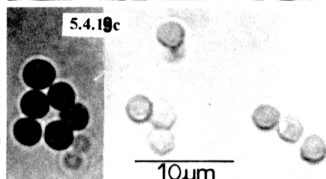
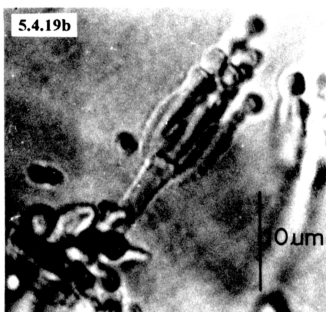
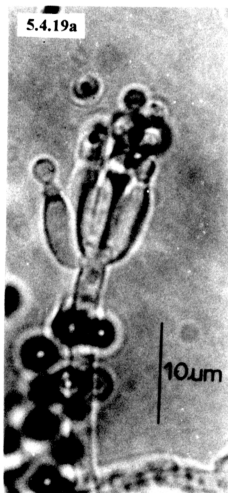
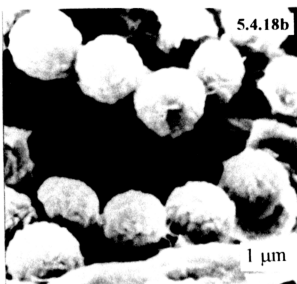
b Chlamydosporidia (showed by arrow)



5.4.18 *Eupenicillium hirayamae*

a SEM micrograph of conidial head
b SEM micrograph of conidia

5.4.19 *Eupenicillium* sp.
a -b Conidial head
c Conidia



5.4.20 *Penicillium aurantogriseum*

a - b Conidial heads

c Conidia

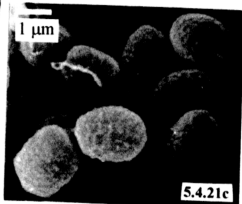
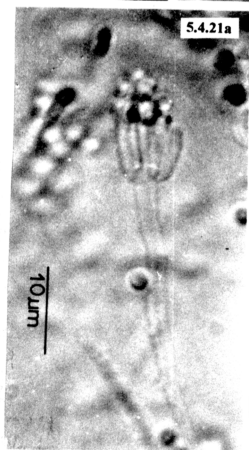
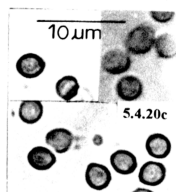
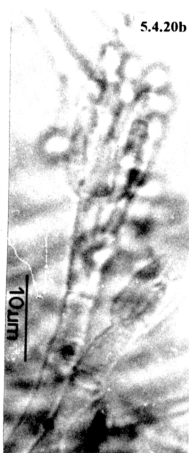
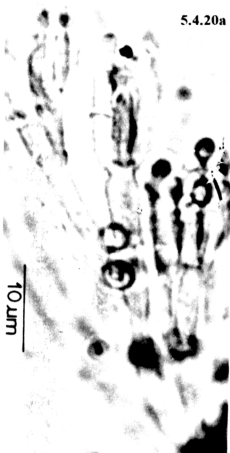
d SEM micrograph of conidia

5.4.21 *Penicillium chermesinum*

a Conidial head

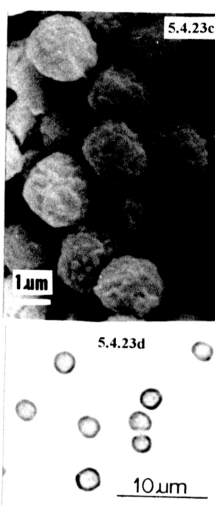
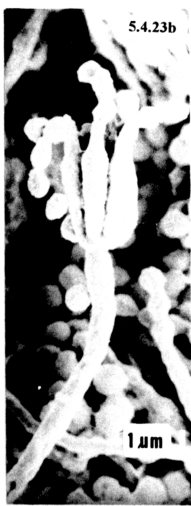
b Conidia

c SEM micrograph of conidia



5.4.23 *Penicillium citreonigrum*
a - b SEM micrograph of conidial head
c SEM micrograph of conidia
d Conidia

5.4.22 *Penicillium chrysogenum*
a - b SEM micrograph of conidial head
c SEM micrograph of conidia
d Conidia



d Conidia

c SEM micrograph of conidia

a - b SEM micrograph of conidial head

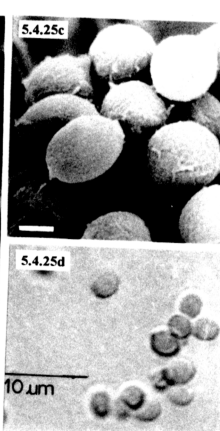
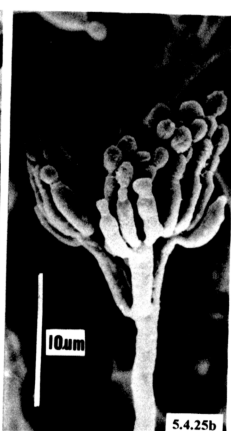
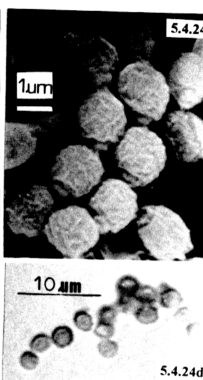
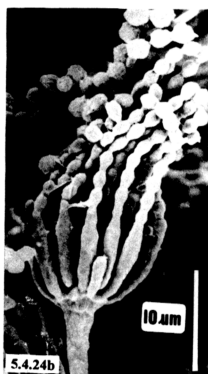
S.4.25 Penicillium griseofulvum

d Conidia

c SEM micrograph of conidia

a - b SEM micrograph of conidial heads

S.4.24 Penicillium citrinum



5.4.26 *Penicillium expansum*

a - b Conidial heads

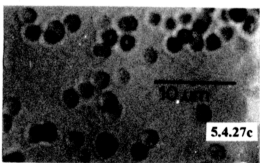
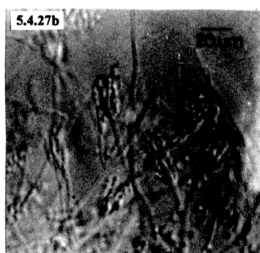
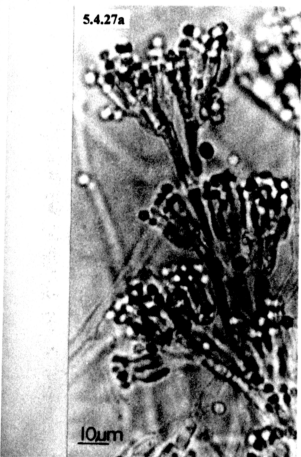
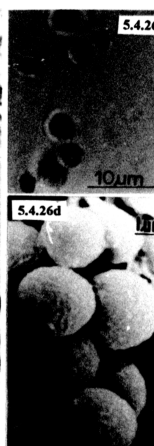
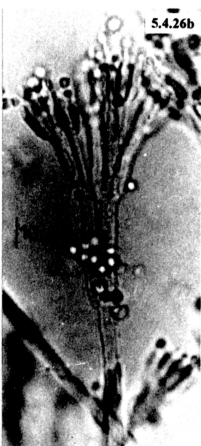
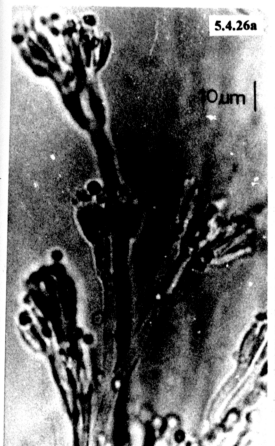
c Conidia

d SEM micrograph of conidia

5.4.27 *Penicillium griseorosum*

a - b Conidial heads

c Conidia

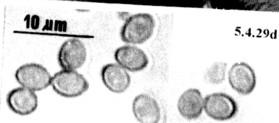
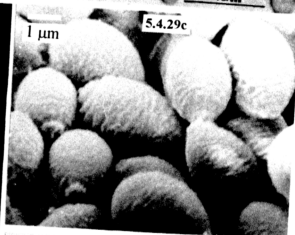
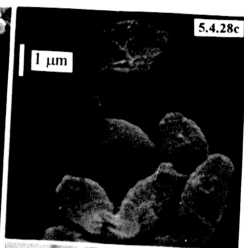
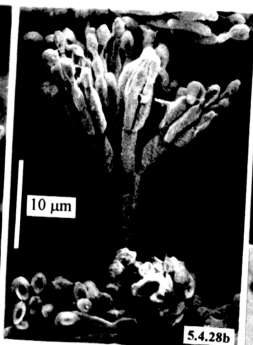


5.4.28 *Penicillium islandicum*

- a - b SEM micrograph of conidial head
- c SEM micrograph of conidia
- d Conidia

5.4.29 *Penicillium oxalicum*

- a - b SEM micrograph of conidial head
- c SEM micrograph of conidia
- d Conidia



5.4.30 *Penicillium minioluteum*

a Conidial head

b Conidia

c SEM micrograph of conidia

5.4.31 *Penicillium pinophilum*

a - b Conidial heads

c Conidia

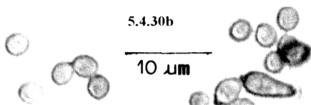
d SEM micrograph of conidia

5.4.30a



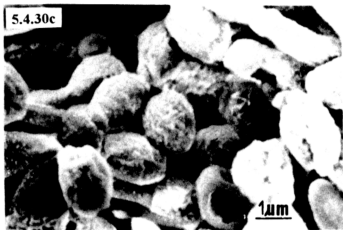
5.4.30b

10 μm



5.4.30c

1 μm



5.4.31a

10 μm



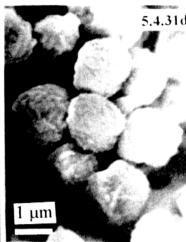
5.4.31b

10 μm



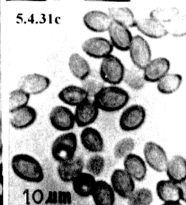
5.4.31d

1 μm



5.4.31c

10 μm

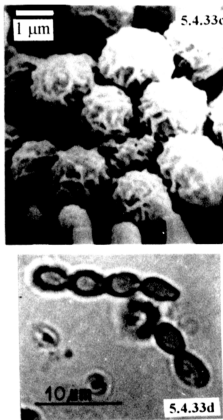
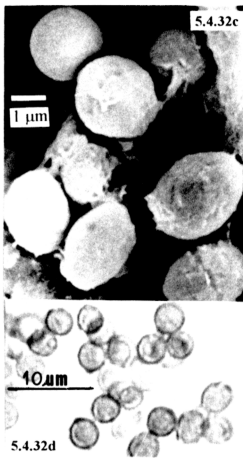
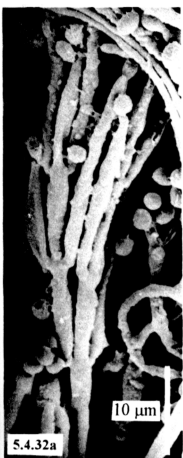


5.4.33 *Penicillium rugulosum*

- a - b SEM micrograph of conidial head
c SEM micrograph of conidia
d Conidia

5.4.32 *Penicillium purpogenum*

- a - b SEM micrograph of conidial head
c SEM micrograph of conidia
d Conidia



5.4.34 *Penicillium simplicissimum*

a - b SEM micrograph of conidial head

c SEM micrograph of conidia

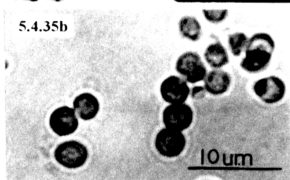
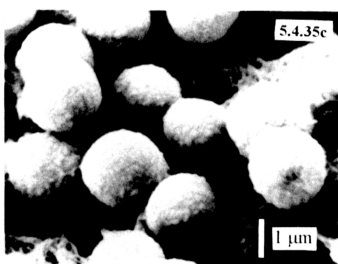
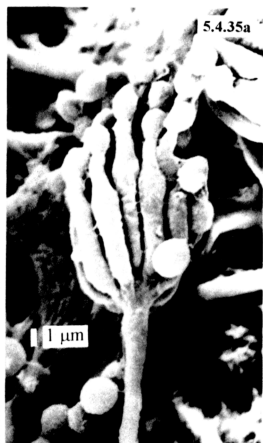
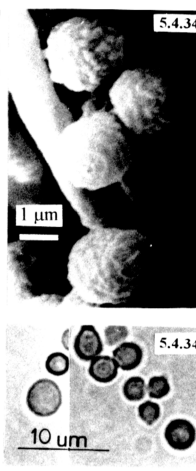
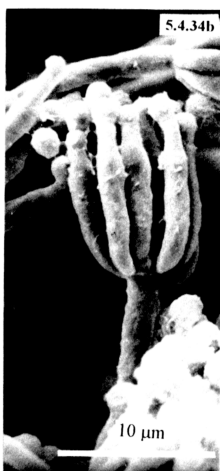
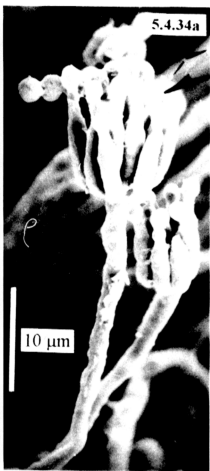
d Conidia

5.4.35 *Penicillium spinulosum*

a SEM micrograph of conidial head

b Conidia

c SEM micrograph of conidia

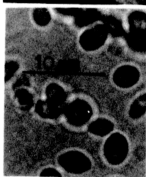
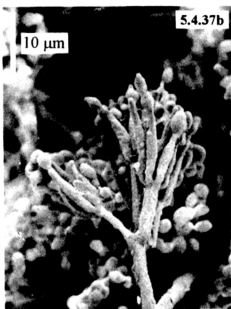
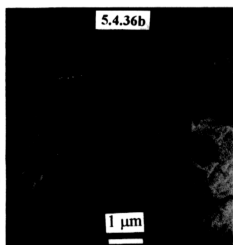


5.4.36 *Penicillium thomii*

a SEM micrograph of conidial head
b SEM micrograph of conidia

5.4.37 *Penicillium variable*

a - b SEM micrograph of conidial head
c SEM micrograph of conidia
d Conidia

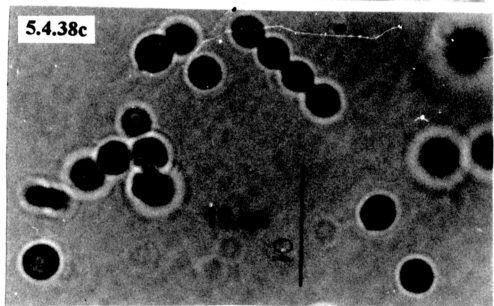
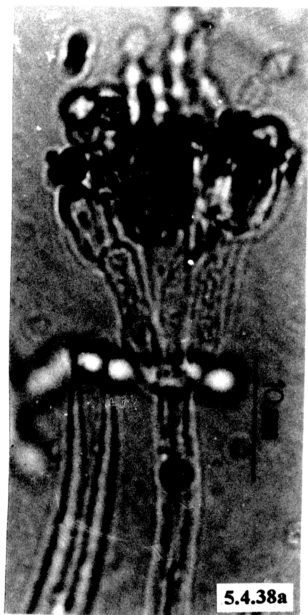


5.4.37d

5.4.38 *Penicillium verrucosum*

a - b Conidial head

c Conidia



5.4.39 *Absidia corymbifera*

a - b Apophysate sporangia

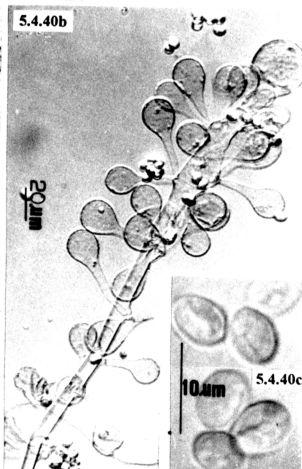
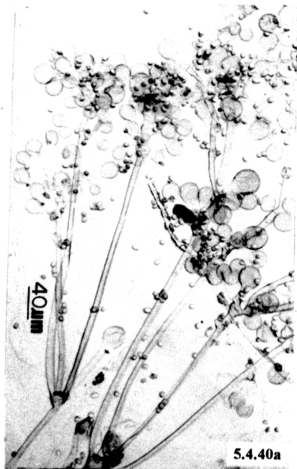
c Sporangiospores

5.4.40 *Cunninghamella polymorpha*

a - b Sporangioophores terminating in fertile vesicles bearing pedicellate,

unispored sporangia

c Sporangiospores



c Sporangiospores

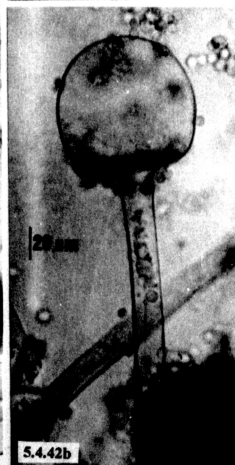
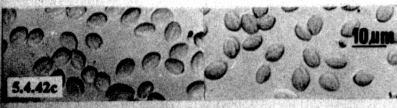
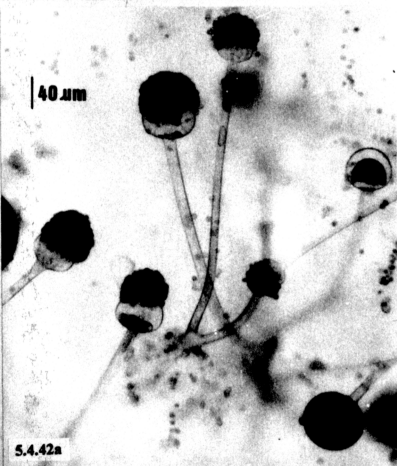
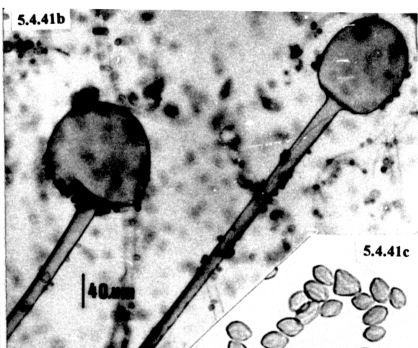
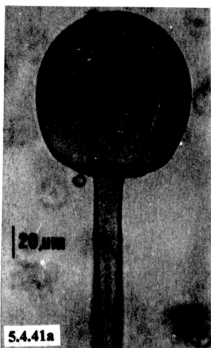
a - b Sporangioophores terminating in apophysate sporangia

5.4.41 *Rhizopus arrhizus*

c Sporangiospores

a - b Sporangioophores terminating in apophysate sporangia

5.4.42 *Rhizopus microsporus*



5.4.43 *Mucor circinelloides*

- a - b Sporangioophores terminating in non-apophysate sporangia
- c Collumella
- d Sporangiospores

5.4.44 *Syncephalastrum racemosum*

- a - b Sporangioophores terminating in vesicles bearing uniseriate sporangia
- c Sporangiospores

