Journal of Food Protection, Vol. 50, No. 11, Pages 933-839 (November 1987)

Pathogenic Fungi Isolated from Desiccated Mushrooms, Seaweed, Anchovies and Rice Sticks Imported from the Orient[1]

NURIA KAZANAS

Division of Microbiology, Food and Drug Administration, Washington, DC 20204

(Received for publication April 9, 1987)

ABSTRACT

Desiccated mushrooms, seaweed, rice sticks and anchovies imported from the Orient were obtained from commercial sources or from products detained by the U.S. Food and Drug Administration and examined for pathogenic fungi. The etiological agents isolated were mycelial and yeast fungi known to produce deep mycoses in humans: sporotrichosis, phaeohyphomycosis, mycetoma, chromoblastomycosis, candidosis and cryptococcosis. Other fungi isolated were opportunistic fungi and/or producers of mycotoxins. Total mold counts in the foods examined varied from 2×10^2 to 5×10^6. The predominant pathogens in the mushrooms were *Sporothrix schenckii* and *Wangiella dermatitidis*, and counts in the mushrooms imported from Thailand and Taiwan were as high as 1×10^6; however, these pathogens were not isolated from rice sticks, seaweed or anchovies. All presumed pathogenic strains were pathogenic for mice by intraperitoneal injection of 1×10^6 to 10^7 conidia in saline suspension. It was concluded that food can harbor "virulent" fungal pathogens and potentially opportunistic invaders as well as potentially toxigenic fungi.

Because the portal of entry of many fungal infections remains obscure, the finding of pathogenic fungi in or on foods is of public health interest. Desiccated mushrooms imported from Taiwan were found to be contaminated with strains of *Sporothrix schenckii (33,35)* and *Wangiella dermatitidis (34,35)* that were virulent in experimental animals. We therefore examined mushrooms and other desiccated foods imported from the Orient for presence and prevalence of fungi known to infect human and/or animal hosts.

The desiccated foods examined are examples of foods imported mostly from the Orient and consumed in the United States. Mushrooms grown in the United States, for example, are sold to consumers either fresh or canned, but not desiccated. All the foods were obtained from commercial sources or were products detained by the U.S. Food and Drug Administration (FDA) because of rodent, bird, canine, feline or insect contamination. Fungi pathogenic to humans or animals can be found in or on the excreta, urine, hair or feathers of these animals. Because of the filth, and perhaps the growing, drying and storage practices in the Orient, desiccated foods were considered a potential vehicle for fungal pathogens.

MATERIALS AND METHODS

The desiccated foods investigated were the mushrooms *Lentinus edodes* (Berk.) Singer, imported from Japan and Hong Kong, and *L. polychrous* from Thailand; "Jew's ear" and "black fungus" mushrooms, *Auricularia polytricha* (Mont.) Sacc., from Taiwan and "black fungus" *A. tenuis* (Lev.) Farl. from Thailand; "white fungus" (jelly fungus), *Tremella fuciformis* Berkeley, from the People's Republic of China; rice sticks from the Philippines; seaweed from Hong Kong and Japan; and anchovies from Thailand. The mushrooms, *L. edodes* (Berk.) Singer and some of the *A. polytricha* (Mont.) Sacc. were purchased in New York City stores specializing in East Asian foods. All other foods were products detained by the FDA in California.

The foods had been packaged in sealed cellophane bags in their country of origin. The material was removed aseptically from the bags, and 10-g portions were weighed out and soaked in 90 ml of sterile diluent (0.85% NaCl in 0.05% Tween 80) for approximately 1 h at room temperature. The foods and soak solutions were transferred to a sterile disposable polyethylene bag and blended in a Stomacher 80 (Colworth, Seward Laboratory, London, UK) for 3 min. From serial 100-fold dilutions prepared with 1 ml of the blended material and 99 ml of diluent, a 1-ml portion of each dilution was plated onto mycobiotic agar (Difco Laboratories, Detroit, MI), rose bengal agar (RBA, Difco) and Sabouraud's dextrose agar (SDA, Difco). The plates were incubated at ambient temperature in the dark, and colonies were counted when growth was observed at days 5 and 10; slow growers were counted on days 15-21. Fungal colonies were isolated and identified in pure culture by standard morphological and physiological criteria.

The microanatomy of isolates grown on modified SDA and potato dextrose agar (PDA) was examined; the sporulation pattern of each isolate was determined on slide cultures on PDA from fungal growth at room temperature. Colonies suggestive of *S. schenckii* were inoculated onto the surface of brain heart infusion (BHI) agar slants and incubated at 37°C for conversion to the yeast phase. Yeast cells were tested with antiserum

[1]*Presented at the Annual Meeting of the Institute of Food Technologists held in Las Vegas, Nevada, June 16-19, 1987.*

labeled with fluorescein isocyanate (Centers for Disease Control, Atlanta, GA), specific for the *S. schenckii* yeast form *(31)*. Colonies suggestive of *W. dermatitidis* were transferred to the surface of SDA to test their ability to grow at 40°C but not at 50°C *(47)*, and their identity was confirmed by a specific exoantigen or microimmunodiffusion test performed as previously described *(24,32)*. Yeast identifications based on assimilation tests were made with the API 20 C system (Analytab Products, Plainview, NY). Microscopic morphology was also considered.

Adult and infant Harlan Sprague-Dawley mice (Harlan Sprague-Dawley Inc., Indianapolis, IN) were injected, respectively, with 1×10^6 to 1×10^7 and 5×10^4 to 1×10^6 conidia suspended in sterile saline solution, using methods previously described *(33,34)*. During the experiment, mice were observed for illness and death. Mice from each experimental group were euthanized on various post infection days up to day 29. The fungus was recovered from infected organs by aseptic techniques *(33)*. Pathogenicity was based on death and/or recovery of the fungus from infected mouse tissue.

RESULTS

Pathogenic and nonpathogenic fungi isolated from desiccated foods imported from the Orient are listed in Table 1. Although the pathogens *S. schenckii* and *W. dermatitidis* were prevalent in the foods, many other genera were represented. *S. schenckii* was recovered from all the mushrooms except *L. edodes* (Berk.) Singer, *T. fuciformis* Berkeley and "Jew's ear." Total mold counts obtained from the foods and counts of these two pathogens are shown in Table 2. "Black fungus" mushrooms imported from Thailand and Taiwan had the highest *S. schenckii* and *W. dermatitidis* counts (1×10^6/g). Total mold counts in those mushrooms were 5×10^6/g.

All *S. schenckii* isolates converted to the yeast form on BHI agar at 37°C; for some of these isolates two transfers were necessary. These yeasts reacted with fluoresceinated antibody specific for the *S. schenckii*. Twelve isolates (approximately 25% of *S. schenckii* isolated) chosen randomly and tested for pathogenicity in adult mice by intraperitoneal (i.p.) injection and gastric gavage (Table 3) were pathogenic to the mice. Pathogenicity was based on the ability of the fungus to infect animal tissue, which sometimes (as in infant mice) caused death.

W. dermatitidis was isolated from three types of mushrooms: *L. tenuis* (Lev.) Farl., *A. polytricha* (Mont.) Sacc., and *L. polychrous*. All *W. dermatitidis* isolates grew at 40°C but not at 50°C and were positive by the exoantigen test. This fungus was also pathogenic for adult and infant mice.

Phialophora verrucosa and *Sporothrix cyanescens* were isolated from two different types of mushrooms imported from Thailand, Taiwan and the People's Republic of China. *Acremonium alabamensis* was isolated from mushrooms and seaweed imported, respectively, from Taiwan and Hong Kong. *Phialemonium obovatum* was isolated only from seaweed imported from Japan. *P. verrucosa, S. cyanescens, P. obovatum* and *A. alabamensis* were pathogenic to adult mice by i.p. injection, but were not tested by gastric gavage. *S. cyanescens* converted to yeast at 37°C and produced a diffusable brown pigment in the agar medium. All the pathogens injected i.p. into adult mice were recovered from the visceral organs on days 10 or 12, and numbers recovered increased by day 26 or 28 after injection; *S. schenckii* and *W. dermatitidis* were recovered on day 3 from infants injected i.p. or inoculated by gastric gavage and as late as days 19-23 from those infants that survived. A *Cladosporium* sp., not recognized morphologically as a pathogen, was not recovered from mice after i.p. injection.

Many representatives of the genus *Aspergillus* were isolated. Some of these isolates *(A. fumigatus, A. flavus* and *A. versicolor)* are known human pathogens; *A. ochraceous* is a suspected pathogen *(42)*. *A. flavus* and *A. ochraceous*, which produce aflatoxin and ochratoxin A, respectively, were the predominant flora recovered from anchovies, with a total mold count mean of 1.25×10^5/g. The remaining isolates (reported only as to genus or as unidentified) were morphologically recognized as nonpathogenic genera.

DISCUSSION

A considerable number and variety of fungal human pathogens were isolated from the imported desiccated foods examined. Desiccated mushrooms, in particular, harbored large numbers of the pathogens *S. schenckii* and *W. dermatitidis*. All the foodborne pathogens tested were pathogenic for mice. Mouse passage of the isolate was unnecessary for demonstrating virulence.

Among the isolated mycelial fungi that produce deep mycoses were *S. schenckii*, the etiological agent of sporotrichosis; *W. dermatitidis, Phialophora richardsiae* and *Aureobasidium pullulans*, agents of phaeohyphomycosis; *P. obovatum*, agent of mycetoma and phaeohyphomycosis; and *P. verrucosa* and *Fonsecaea pedrosoi*, agents of chromoblastomycosis *(1,43,52)*. *S. schenckii, W. dermatitidis, P. verrucosa, F. pedrosoi* and *A. alabamensis* may disseminate to the brain (brain abscess syndrome, meningitis); chromoblastomycosis, elephantiasis and lymphostasis can occur as a result of secondary infections.

To our knowledge, this is the first finding of *P. verrucosa, P. richardsiae, F. pedrosoi, A. alabamensis, P. obovatum* and *S. cyanescens* in or on food; the pathogenicity of the last three had not been demonstrated previously in an experimental mammal. This is also the first report of isolation of *A. alabamensis* and *P. obovatum* from a source other than humans or animals. *S. cyanescens* has been isolated from clinical specimens and from bedroom air *(20)*.

Isolated among the known pathogenic yeasts that also produce deep mycoses were *Candida parapsilosis* and *Rhodotorula rubra*, etiological agents of candidosis; and *Cryptococcus neoformans*, agent of cryptococcosis *(52)*.

All the known pathogenic *Aspergillus* species found are troublesome opportunistic invaders in patients with resis-

TABLE 1. *Fungi isolated from imported desiccated Oriental foods.*

Country of origin	Food	Fungus	Medium of isolation[a]	Pathogenicity[b] Accepted (+)	Questionable (?)	Source
People's Republic of China	Mushrooms *Auricularia tenuis* (Lev.) Farl.	*Aspergillus ochraceus*	RBA		?	Purchased in New York City
		A. versicolor	Myco, SDA	+		
		Malbrachea sp. (?)	Myco			
		Phialophora richardsiae	Myco	+		
		Mucor sp.	SDA			
		Sporothrix schenckii	RBA	+		
		Tricophyton tonsurans	Myco	+		
		Wangiella dermatitidis	Myco	+		
Hong Kong	Mushrooms, *Lentinus edodes* (Berk.) Singer	*Aspergillus* sp.	RBA			Purchased in New York City
		Penicillium sp.	Myco	+		
		Phialophora sp.	Myco	+		
		Rhodotorula rubra	RBA	+		
		Sporothrix cyanescens	RBA		?	
		Unidentified				
Japan	Mushrooms, *L. edodes* (Berk.) Singer	*Phialophora* sp.	Myco, RBA, SDA			Purchased in New York City
		Exophiala sp.	Myco, RBA, SDA	+		
People's Republic of China	White fungus (jelly fungus) mushrooms, *Tremella fuciformis* Berkeley	*Chaetomium* sp.	RBA			Purchased in New York City
		Penicillium sp.	Myco	+		
		Phialophora sp.	Myco			
		Rhizopus stolonifer	RBA		?	
		Unidentified				
Hong Kong	Seaweed	*Phialophora* sp.	SDA			Purchased in New York City
		Acremonium alabamensis	SDA	+[c]		
		Penicillium sp.	SDA	+		
Japan	Seaweed	*Phialemonium obovatum*	SDA	+[d]		Purchased in New York City
		Penicillium sp.	SDA	+		
Taiwan	"Black fungus" mushrooms, *A. polytricha* (Mont.) Sacc.	*Aspergillus flavipes*	RBA		?	Purchased in New York City
		A. ochraceus	RBA		?	
		A. parasiticus	RBA			
		A. versicolor	RBA	+		
		Aspergillus sp.	RBA			
		Aureobasidium pullulans	SDA	+[e]		
		Chaetomium sp.	RBA			
		Doratomyces microsporus	RBA			
		Emericellopsis synnematicola	RBA			
		Mucor sp.	RBA			
		Penicillium brevicompactum	RBA			
		P. citrinum	RBA	+		
		P. simplicissimum	RBA			
		Penicillium sp.	RBA	+		
		Phialophora verrucosa	Myco, RBA	+		
		Rhodotorula sp.	RBA		?	
		Scopulariopsis brevicaulis	Myco	+		
		Sepedonium sp.	RBA			
		Sporothrix cyanescens	RBA		?	
		S. schenckii	RBA	+		
		Stachybotrys sp.	RBA			

Taiwan	"Black fungus" mushrooms, *A. polytricha* (Mont.) Sacc.	*Aspergillus fumigatus*	RBA	+		Purchased in New York City
		Aurobasidium pullulans	SDA	+[e]		
		Cryptococcus neoformans	RBA	+		
		Monocillium sp.	SDA			
		Paecilomyces varioti	Myco	+		
		Phialophora sp.	Myco			
		Rhodotorula rubra	RBA	+		
		Sporothrix schenckii	Myco, RBA	+		
		Wangiella dermatitidis	Myco, RBA	+		
		Unidentified				
		Verticillium sp.	SDA			
Thailand	"Black fungus" mushrooms, *A. tenuis* (Lev.) Farl.	*Aspergillus* sp.	RBA			Detained because of cat/dog/rat hairs; feather fragments; dead adult ants; mites; psocids; insects
		Candida parapsilosis	SDA	+		
		Cylindrophora apiculata	RBA			
		Drechslera sp.	RBA	+		
		Graphium synnemata	RBA	+		
		Phoma sp.	RBA	+		
		Scopulariopsis sp.	RBA			
		Sporothrix schenckii	SDA	+		
		Stemphilium sp.	SDA			
		Unidentified	SDA, RBA			
Thailand	Mushrooms, *Lentinus polychrous*	*Acremonium* sp.	Myco, RBA	+		Detained because of rat/mouse hairs; feathers; beetle larvae; adult mites *Liposcelis* sp.; psocids; unidentified insect fragments
		Blastomyces-like sp.	Myco	+		
		Fonsecaea pedrosoi	Myco	+		
		Fusarium nivale	RBA	+		
		Microsporum ferrugineum	RBA	+		
		Phialophora sp.	Myco, RBA			
		P. verrucosa	Myco	+		
		Sporothrix schenckii	Myco	+		
		Wangiella dermatitidis	Myco, RBA	+		
Taiwan	"Jew's ear" (black fungus) mushrooms, *A. polytricha* (Mont.) Sacc.	*Acremonium alabamensis*	SDA	+[c]		Detained because of whole *Pseudocaeciliid* psocids and wing fragments; whole adult *Cryptolestes pusillui* and *Lasioderma serpicorne;* whole thrips; whole and fragments of unidentified insect mites; feather fragments
		Candida krusei	SDA	+		
		Cladosporium sp.	Myco		?	
		Fusarium sp.	SDA	+		
		Monocillium sp.	Myco			
		Unidentified				
Philippines	Rice sticks	*Aspergillus ochraceus*	SDA, RBA		?	Detained because of dog/cat/rat/mouse hairs; insects (whole and fragments); feathers
		A. fumigatus	SDA	+		
		Drechslera sp.	SDA	+		
		Fusarium nivale	SDA	+		
		Penicillium lavandulum	Myco			
		Unidentified				
Thailand	Anchovies	*Aspergillus flavus*	SDA, RBA	+		Detained because of insect/bird/rodent filth; dog/cat/rat/mouse hairs; mites; ants; insects (whole and fragments)
		A. ochraceus	SDA, RBA		?	
		Aspergillus sp.	SDA			
		Penicillium sp.	SDA	+		
		Unidentified				

[a]RBA, rose bengal agar; myco, mycobiotic agar; SDA, Sabouraud's dextrose agar.
[b]Pathogenicity based on McGinnis, M.R. (ref. *42*).
[c]See ref. *68*.
[d]See ref. *43*.
[e]See ref. *1*.

TABLE 2. *Counts of total molds and predominant pathogens,* Sporothrix schenckii *and* Wangiella dermatitidis, *in imported desiccated Oriental foods.*

Country of origin	Food	Pathogen	Medium	Batch	Pathogen count/g	Mold count/g
People's Republic of China	Mushrooms, *Auricularia tenuis* (Lev.) Farl.		RBA			2.0×10^3
		S. schenckii	RBA	1	2×10^1	
		W. dermatitidis	Myco	1	1×10^1	
Hong Kong	Mushrooms,		RBA	1		3.0×10^2
Japan	*Lentinus edodes* (Berk.) Singer		Myco	1		2.7×10^2
People's Republic of China	"White fungus" (jelly fungus) mushrooms, *Tremella fuciformis* Berkeley			1		1.0×10^3
Taiwan	"Black fungus" mushrooms, *A. polytricha* (Mont.) Sacc.	*S. schenckii*	RBA	1	7.0×10^2	2.5×10^3
		S. schenckii	RBA	2	5.0×10^3	1.7×10^4
		S. schenckii	RBA	3	4.0×10^3	3.5×10^3
		S. schenckii	SDA	4	7.0×10^3	2.0×10^4
		S. schenckii	Myco	5	2.0×10^1	2.0×10^2
		S. schenckii	Myco	6	1.0×10^2	1.0×10^6
		W. dermatitidis	Myco	5	8.0×10^1	
			Myco	7	1.0×10^6	5.0×10^6
			RBA	3	3.0×10^2	
			Myco	8	1.0×10^3	3.0×10^3
Thailand	"Black fungus" mushrooms, *A. tenuis* (Lev.) Farl.	*S. schenckii*	SDA	1	4.0×10^4	4.0×10^5
		S. schenckii	SDA	2	2.0×10^5	3.0×10^5
		S. schenckii	SDA	3	1.0×10^6	5.0×10^6
Taiwan	"Jew's ear" mushrooms, *A. polytricha* (Mont.) Sacc.		SDA	1		3.4×10^4
Hong Kong	Seaweed		SDA	1		6.0×10^2
Japan	Seaweed		SDA	1		3.0×10^3
Thailand	Anchovies		SDA	1		1.0×10^5
			SDA	2		1.5×10^5

tance abnormalities *(48,54)*. *Aspergillus* has emerged as a major pathogen not only in immunosuppressed patients with prolonged granulocytopenia but also in cancer patients treated with immunosuppressive drugs. Although yeasts appear more prevalent than mycelial fungi in cancer patients *(5-7,19,63)*, *A. flavus* and *A. fumigatus* largely represent the latter *(25,30,44,53,64)*. Patients' predominant microbial flora varies considerably from hospital to hospital, but the fungal pathogens involved are usually *Candida* spp., *Aspergillus* spp., *C. neoformans* and various genera of the *Zygomycetes*. All these genera were represented among the mold populations of the desiccated foods. Because of concern about the mode of entry of fungal pathogens into patients, the feeding of sterile foods in hospitals has been recommended *(57,65)*. *A. flavus* and *A. ochraceous* are also well known for producing aflatoxin and ochratoxin, respectively. In this survey, these fungi were isolated from several foods and found to be the predominat flora in anchovies (total mold count 1.2×10^5/g).

Some fungal metabolites in food produce gastrointestinal disturbances in animals. Some genera known to produce such metabolites *(67)* were isolated from the desiccated foods: *Penicillium* and *Phoma*, producing frebeldin A (=decumbin=cyanein); *Chaetomium*, producing chetomin; and *Fusarium*, producing deoxynivalenol (=vomitoxin). The two latter are acutely toxic and hemorrhagic, with *Fusarium* spp. also producing T-2 toxin; *Aspergillus* produces emodin and oxalic acid. (The isolates were not tested for actual toxin production.) Traces of mycotoxins in food and a combination of various toxins in trace amounts are detrimental to experimental animals *(36)*.

It is extremely difficult to isolate pathogenic fungi from foods that are highly contaminated with fungi and/or bacteria, especially if the pathogenic fungi are present in

TABLE 3. *Pathogenicity for mice of some pathogenic fungi isolated from imported desiccated Oriental mushrooms and seaweed.*

Country of origin	Food	Fungus	I.p. injection adult mouse	Gastric gavage infant mouse	Isolates tested
People's Republic of China	*Auricularia tenuis* (Lev.) Farl.	*Sporothrix schenckii*	Pathogenic	Pathogenic	2
		Wangiella dermatitidis	Pathogenic	Pathogenic	1
Hong Kong	*Lentinus edodes* (Berk.) Singer	*S. cyanescens*	Pathogenic	Pathogenic	1
Taiwan	*A. polytricha* (Mont.) Sacc.[a]	*Phialophora verrucosa*	Pathogenic	ND[b]	1
		S. cyanescens	Pathogenic	ND	1
		S. schenckii	Pathogenic	Pathogenic	4
Thailand	*A. tenuis* (Lev.) Farl.	*S. schenckii*	Pathogenic	Pathogenic	2
	L. polychrous	*P. verrucosa*	Pathogenic	ND	1
		S. schenckii	Pathogenic	ND	4
		W. dermatitidis	Pathogenic	Pathogenic	1
Tawain	"Jew's ear" mushrooms ("black fungus") *A. polytricha* (Mont.) Sacc.	*Acremonium alabamensis*	Pathogenic	ND	1
		Cladosporium sp.[d]	Nonpathogenic	ND	1
Hong Kong	Seaweed	*A. alabamensis*	Pathogenic	ND	1
Japan	Seaweed	*Phialemonium obovatum*	Pathogenic	ND	1

[a]Package labeled "black fungus."
[b]Not done.
[c]Package labeled "Jew's ear."
[d]Not recognized morphologically as a pathogenic species.

small numbers. The slow growers, in particular, were sometimes overgrown by other fast-growing fungi and thus were lost or difficult to separate into pure cultures. Of the three isolation media used, RBA was a good isolation medium for *S. schenckii*, *W. dermatitidis* and *Aspergillus* spp., having the advantage over SDA of inhibiting many bacteria. Mycobiotic agar, which inhibits bacteria and many saprophytic yeasts and molds, also inhibits important pathogenic yeasts of the genera *Cryptococcus* and *Candida;* this medium was also a good isolation medium for *S. schenckii* and *W. dermatitidis*. SDA supports the growth of yeasts, molds and bacteria; therefore it was not effective when the microbial load was high. All three media, however, were useful and necessary for isolation of a wide range of fungal species. Thus effectiveness of the medium depends on the fungus present in the food and the microbial load.

Since animal excreta, hair and feathers and insects can be carriers of pathogenic fungi *(4,12-14,27-29, 40,46,50,55,58,60,61,65,66)*, this filth could be a source of fungi in or on foods. The agricultural process for cultivating mushrooms (i.e., growth in compost, manure, straw and soil or on wood chips) may also be a contributing factor. *S. schenckii* for example, has been isolated from soil, water, decaying wood, plants and plant products, animal dung, sphagnum moss, hay and straw *(17,18,26,39,59)*. *W. dermatitidis*, which normally grows in soil or on wood and organic debris *(15,22)*, has been isolated from bats *(51)* and the environment *(45)*. *Pseudoallescheria boydii* has been isolated in large numbers from beef cattle manure *(10)*, and other fungi *(49)* have been isolated from horse manure. Therefore, the mushrooms that were among the foods tested and found to harbor the widest range of pathogenic genera and highest number of pathogens, may very well have been contaminated before and/or during drying and storage.

Whether pathogenic fungi penetrate the body from the gastrointestinal tract is a question often asked in relation to the possible foodborne etiology of mycoses. The health significance of foodborne pathogenic fungi, as opposed to mycotoxin-producing fungi, has been demonstrated in mice *(33,35)*. In humans, involvement of the gastrointestinal tract by pathogenic fungi has been recognized *(2,3,8,9,11,16,21,23,38,41,52,62)*. *S. schenckii* and *W. dermatitidis* have been associated with human gastrointestinal mycoses *(11,16,37,56)*. Since these foodborne fungi are known human pathogens and the portal of entry of many fungal infections remains obscure, recovery of the fungi from foods indicates a potential hazard to human health.

ACKNOWLEDGMENTS

The author thanks Joseph D. Eifert and Michael L. Zimmerman, FDA, Los Angeles District Office, for supplying detained foods; George J. Jackson and Philip B. Mislivec, FDA, Washington, DC, for reviewing the manuscript and for confirming the *Penicillium* species, respectively; Kent H. McKnight, Northern Region Beltsville Agricultural Research Center, Beltsville, MD, for providing the scientific names of some mushrooms; Arvind A. Padhye, Centers for Disease Control, Atlanta, GA, for confirmation of *S. cyanescens;* Lois A. Tomlinson for editorial assistance; and Sarah Butler and Jamie V. Lee for typing the manuscript.

REFERENCES

1. Anonymous. 1986. First isolation of *Aureobasidium pullulans* reported. Mycology Observer 6(3):4
2. Aguiar, E., W. C. Morales, and A. T. Londero. 1980. Gastrointestinal entomophthora mycosis caused by *Basidiobolus haptosporus*. Mycopathologia 72:101-105.
3. Ajello, L., L. K. Georg, R. T. Steigbigel, and C. J. K. Wang. 1974. A case of phaeohyphomycosis caused by a new species of *Phialophora*. Mycologia 66:490-498.
4. Aho, R. 1983. Saprophytic fungi isolated from the hair of domestic and laboratory animals with suspected dermatophytosis. Mycopathologia 83:65-73.
5. Aisner, J., L. K. Kvols, and E. A. Sickles. 1976. Transtracheal selective bronchial brushing for pulmonary infiltrates in patients with cancer. Chest 69:367-371.
6. Aisner, J., S. C. Schimpff, J. C. Sutherland, V. M. Joung, and P. M. Weirnick. 1974. *Torulopsis glabrata* pneumonitis in patients with cancer. J. Am. Med. Assoc. 230:584-585.
7. Aisner, J., S. C. Schimpff, J. C. Sutherland, V. M. Joung, and P. M. Weirnick. 1976. *Torulopsis glabrata* infections in patients with cancer: increasing incidence and relationship to colonization. Am. J. Med. 61:23-25.
8. Araujo, R. C., A. A. Agostini, N. R. Pereira, A. V. Magalhaes, and A. N. Raick. 1977. Ficomicose gastrica. p. 72. *In* Abstract of papers. XII Cong. Soc. Brasil. Pat.
9. Baker, R. D. 1971. Mucormycosis. pp. 832-918. *In* R. D. Baker et al. (eds.), The pathological anatomy of mycoses. Springer-Verlag, Berlin, West Germany.
10. Bell, R. G. 1976. The development in beef cattle manure of *Petriellidium boydii* (Shear) Mallock, a potential pathogen for man and cattle. Can. J. Microbiol. 22:552-556.
11. Boggs, T. R., and H. Fried. 1925. *Sporothrix* infection of the large intestine and fingernails. Bull. Johns Hopkins Hosp. 37:164-169.
12. Buck, J. D. 1986. A note on the experimental uptake and clearance of *Candida albicans* in a young captive gull *(Larus* sp.). Mycopathologia 94:59-61.
13. Burkitt, D. P., A. M. M. Wilson, and D. B. Jelliffe. 1964. Subcutaneous phycomycosis: a review of 31 cases seen in Uganda. Br. Med. J. 1:1669-1672.
14. Chaturvedi, V. P., H. S. Randhawa, S. Kini, and Z. U. Khan. 1986. Survivial of *Blastomyces dermatitidis* in the gastrointestinal tract of an orally infected insectivorous bat, *Rhinopoma hardwickei* Gray. J. Med. Vet. Mycol. 24:349-352.
15. Conti-Diaz, I. A., J. E. MacKinnon, and F. Civila. 1978. Isolation and identification of black yeasts from the environment in Uruguay. pp. 109-114. *In* The black and white yeasts. Proceedings of the 4th International Conference on the Mycoses. Pan Am. Health Org., Washington, scientific publication no. 356.
16. Cortella, E. 1937. Un caso di sporotrichosis. G. Med. Aeto. Adige. 9:645.
17. D'Alessio, D. J., L. J. Leavens, G. B. Strumpf, and C. D. Smith. 1965. An outbreak of sporotrichosis in Vermont associated with sphagnum moss as the source of infection. N. Engl. J. Med. 272:1054-1058.
18. DeBeurmann, L., and H. Gourgerot. 1908. Decoverte du *Sporotrichum beurmanni* dans la nature. Bull. Mem. Soc. Hop. Paris 26:733-738.
19. DeGregorio, M. W., W. M. F. Lee, C. A. Linker, R. A. Jacobs, and C. A. Ries. 1982. Fungal infections in patients with acute leukemia. Am. J. Med. 73:543-548.
20. de Hoog, G. S., and G. A. de Vries. 1973. Two new species of *Sporothrix* and their relation to *Blastobotrys nivea*. Antonie van Leeuwenhoek 39:515-520.
21. de Hoog, G. S., and E. J. Hermanides-Nijhof. 1977. The black yeast and allied hyphomycetes. p. 1-223. *In* Studies in mycology, no. 15. Centraalbureau voor Schimmelcultures, Baarn, The Netherlands.
22. Dixon, D. M., J. H. Shadomy, and S. Shadomy. 1980. Dematiaceous fungal pathogens isolated from nature. Mycopathologia 70:153-161.
23. Douvin, D., Y. Lefichoux, and C. Huguet. 1975. Phycomycos gastrique. Diagnostique anatomo-pathologique et mycologyque precoce. Evaluation favourable sous traitement medicale puis chirugical. Arch. Anat. Pathol. 23:133-138.
24. Espinel-Ingroff, A., S. Shadomy, T. M. Kerkering, and H. J. Shadomy. 1984. Exoantigen test for differentiation of *Exophiala jeanselmei and Wangiella dermatitidis* isolates from other dematiaceous fungi. J. Clin. Microbiol. 20:23-27.
25. Feld, R., J. P. Bodey, V. Rodriguez, and M. Luna. 1976. Causes of death in patients with malignant lymphoma. Am. J. Med. Sci. 268:97-106.
26. Garrett, H. D., and J. B. Robbins. 1960. An unusual occurrence of sporotrichosis. Arch. Dermatol. 82:570-571.
27. Hasenclever, H. F., and R. M. Kogan. 1975. *Candida albicans* associated with the gastrointestinal tract of the common pigeon *(Columbia livia)*. Sabouraudia 13:116-120.
28. Hub'alek, Z. 1975. Distribution of *Cryptococcus neoformans* in a pigeon habitat. Folia Parasitol. (Praha) 22:73-79.
29. Imwidthaya, S. A., A. Plangpatanapanichya, and N. Sripathomswat. 1982. *Basidiobolus* in toad's excreta in Thailand. J. Med. Asoc. Thai. 65:420-425.
30. Inagaki, J., V. Rodriguez, and G. P. Bodey. 1974. Cause of death in cancer patients. Cancer 33:568-573.
31. Kaplan, W., and M. S. Ivens. 1960. Fluorescent antibody staining of *Sporotrichum schenckii* in cultures and clinical materials. J. Invest. Dermatol. 35:151-159.
32. Kaufman, L., P. Standard, and A. A. Padhye. 1983. Exoantigen tests for the immunoidentification of fungal cultures. Mycopathologia 82:3-12.
33. Kazanas, N. 1986. Foodborne *Sporothrix schenckii:* Infectivity for mice by intraperitoneal and intragastric inoculation with conidia. Mycopathologia 95:3-16.
34. Kazanas, N. 1986. Pathogenicity of a fungus resembling *Wangiella dermatitidis* isolated from edible mushrooms. Appl. Environ. Microbiol. 51:261-267.
35. Kazanas, N. 1986. Pathogenic fungi in foods: A problem for humans? pp. 879-886. *In* Proceedings of the 2nd World Congress on Foodborne Infections and Intoxications, Vol. II. Institute of Vet. Med., Robert von Ostertag-Institute, Berlin, Germany.
36. Kazanas, N., R. W. Ely, M. L. Fields, and J. W. Erdman, Jr. 1984. Toxic effects of fermented and unfermented sorghumn meal diets naturally contaminated with mycotoxins. Appl. Environ. Microbiol. 47:1118-1125.
37. Krutzsch, P. H., and R. H. Watson. 1978. Isolation of *Coccidioides immitis* from bat guano and preliminary findings of laboratory infectivity of bats with *Coccidioides immitis*. Life Sci. 22:679-684.
38. Lawson, H. H., and A. Schamaman. 1974. Gastric phycomycosis. Br. J. Surg. 61:743-746.
39. Mackinnon, J. E., I. A. Conti-Diaz, E. Gezuela, E. Civila, and S. de Luz. 1969. Isolation of *Sporothrix schenckii* from nature and considerations of its pathogenicity and ecology. Sabouraudia 7:38-45.
40. Mantovani, A. 1978. The role of animals in the epidemiology of mycoses. Mycopathologia 65:61-66.
41. Matsumoto, T., A. A. Padhye, L. Ajello, P. G. Standard, and M. R. McGinnis. 1984. Critical review of human isolates of *Wangiella dermatitidis*. Mycologia 76:232-249.
42. McGinnis, M. R. 1980. Laboratory handbook of medical mycology. Academic Press, New York.
43. McGinnis, M. R., W. Gams, and M. N. Goodwin, Jr. 1986. *Phialemonium obovatum* infection in a burned child. J. Med. Vet. Mycol. 24:51-55.
44. Meunier, C., F. M. Cruciani, and J. K. Ersky. 1983. Oral prophylaxis with miconazole or ketoconazole of invasive fungal disease in neutropenic cancer patients. Eur. J. Cancer Clin. Oncol. 19:43-48.
45. Nishimura, K., and M. Miyaji. 1982. Studies on a saprophyte of
con't. p. 944

23. Marth, E. M. 1967. Aflatoxins and other mycotoxins in agricultural products. J. Milk Food Technol. 30:192-198.
24. Pohlmeier, M. M., and L. B. Bullerman. 1978. Ochratoxin production by a *Penicillium* species isolated from cheese. J. Food Prot. 41:829.
25. Restaino, L., K. K. Komatsu, and J. Syracuse. 1981. Effects of acids on potassium sorbate inhibition of food-related microorganisms in culture media. J. Food Sci. 47:134-138,143.
26. Restaino, L., L. M. Lenovich, and S. Bills. 1982. Effect of acids and sorbate combinations on the growth of four osmophilic yeasts. J. Food Prot. 45:1138-1142.
27. Rice, A. C., and C. S. Pederson. 1954. Factors affecting growth of *Bacillus coagulans* in canned tomato juice. II. Acidic constitutents of tomato juice and specific organic acids. Food Res. 19:124-131.
28. Rusul, G., F. E. El-Gazzar, and E. H. Marth. 1986. Growth of and aflatoxin production by *Aspergillus parasiticus* in a medium containing potassium chloride or a mixture of potassium chloride and sodium chloride. J. Food Prot. 49:880-885.
29. Shih, C. N., and E. H. Marth. 1972. Production of aflatoxin in a medium fortified with sodium chloride. J. Dairy Sci. 55:1415-1419.
30. Strzelecki, E., H. S. Lillard, and J. C. Ayres. 1969. Country cured hams as a possible source of aflatoxin. Appl. Microbiol. 18:938-939.
31. Subramanian, C. S., and E. H. Marth. 1968. Multiplication of *Salmonella typhimurium* in skimmilk with and without added hydrochloric, lactic and citric acids. J. Milk Food Technol. 31:323-326.
32. Sutic, M. J., J. C. Ayres, and P. E. Koehler. 1972. Isolation and aflatoxin production of molds isolated from country cured hams. Appl. Microbiol. 23:656-658.
33. Woolford, M. K. 1975. Microbiological screening of food preservatives, cold sterilants and specific antimicrobial agents as potential silage additives. J. Sci. Food Agric. 26:229-237.
34. Yousef, A. E., and E. H. Marth. 1981. Growth and synthesis of aflatoxin by *Aspergillus parasiticus* in the presence of sorbic acid. J. Food Prot. 44:736-741.
35. Yousef, A. E., S. M. El-Gendy, and E. H. Marth. 1980. Growth and biosynthesis of aflatoxin by *Aspergillus parasiticus* in cultures containing nisin. Z. Lebensm. Unters. Forsch. 171:341-343.

Kazanas, *con't. from p. 939*

Exophiala dermatitidis isolated from a humidifier. Mycopathologia 77:173-181.
46. Ogundro, V. W. 1979. Thermophilic and thermotolerant fungi in poultry droppings in Nigeria. J. Gen. Microbiol. 115:253-254.
47. Padhye, A. A., M. R. McGinnis, and L. Ajello. 1978. Thermotolerance of *Wangiella dermatitidis*. J. Clin. Microbiol. 8:424-426.
48. Pennington, J. E. 1977. *Aspergillus* pneumonia in hematologic malignancy. Arch. Inst. Med. 137:769-771.
49. Pointelli, E., M. A. Santa-Maria, and G. Garetta. 1981. Coprophilic fungi of the horse. Mycopathologia 74:89-105.
50. Refai, M., M. Taha, S. A. Selim, F. Elshabourii, and H. H. Yousseff. 1983. Isolation of *Cryptococcus neoformans, Candida albicans* and other yeasts from pigeon droppings in Egypt. Sabouraudia 21:163-165.
51. Reis, N. R., and W. N. Mok. 1979. *Wangiella dermatitidis* isolated from bats in Manaus, Brazil. Sabouraudia 17:213-218.
52. Rippon, J. W. 1982. Medical mycology. The pathogenic fungi and the pathogenic actinomycetes. W. B. Saunders Co., Philadelphia.
53. Robin, B. 1984. Oral candidiasis in cancer patients. South. Med. J. 77:312-314.
54. Romett, J. L., and R. K. Mewnan. 1982. Aspergillosis of the nose and paranasal sinuses. Laringoscope 92:764-766.
55. Sarosi, G. A., and D. S. Serstock. 1976. Isolation of *Blastomyces dermatitidis* from pigeon manure. Am. Rev. Respir. Dis. 114:1179-1183.
56. Sautter, R. E., M. D. Bliss, D. Morrow, and R. E. Lee. 1984. Isolation of *Exophiala jeanselmei* associated with esophageal pathology. Three cases, laboratory and clinical features. Mycopathologia 87:105-109.
57. Seeliger, H. P. R., and G. Scroeter. 1984. Prevention of fungal infections in hospitalized patients. Infect. Immun. 12:143-150.
58. Seenappa, M., L. W. Stobbs, and A. G. Kempton. 1979. The role of insects in the biodeterioration of Indian red peppers by fungi. Int. Biodeterior. Bull. (Ibdba) 15:96-103.
59. Singer, J. I., and J. E. Muncie. 1952. Sporotrichosis: etiologic considerations and report of additional cases from New York. N. Y. Med. J. 52:2147-2153.
60. Staib, F., and S. K. Mishra. 1975. Contributions to the strain-specific virulence of *Cryptococcus neoformans*. Animal experiments with two *C. neoformans*-strains isolated from bird manure. Zentralbl. Bakteriol. Orig. A 230:81-85.
61. Swinne-Desgain, D. 1975. *Cryptococcus neoformans* of saprophytic origin. Sabouraudia 75:303-308.
62. Symmers, W. S. 1972. Histopathology of phycomycosis. Ann. Soc. Belge Med. Trop. 52:365-390.
63. Timothi, E., P. D. Kiehn, F. Fitzroy, and M. S. Edwards. 1980. The prevalance of yeasts in clinical specimens from cancer patients. Am. J. Clin. Pathol. 73:518-521.
64. Velegraki, A., A. Mitroussia-Ziouva, E. Marcelos, and O. Marcelou-Kinti. 1981. Frequency of coprophilic fungi in bird droppings and laboratory animal feces. Acta Microbiol. Hell. 25:175-181.
65. Vidotto, V., M. Clerico, L. Franzin, L. Lucchini, and A. Sinicco. 1986. Fungal colonization in patients with cancer of the upper respiratory tract. Mycopathologia 96:97-101.
66. Vining, L. K., and R. J. Weeks. 1974. A preliminary chemical and physical comparison of blackbird-starling roost soils which do not contain *Histoplasma capsulatum*. Mycopathol. Mycol. Appl. 54:541-548.
67. Watson, D. H. 1985. Toxic fungal metabolites in food. CRC Crit. Rev. Food Sci. Nutr. 22:177-198.
68. Witle, C., S. Wess, T. Cleary, and E. Gyore. 1984. Fungal cerebritis from intravenous drug abuse. J. Forensic Sci. 29:260-268.