CHEMISTRY AND TOXICOLOGY OF MOLDS ISOLATED FROM WATER-DAMAGED BUILDINGS

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ABSTRACT

There is increasing evidence of health risks associated with damp buildings and homes in which high levels of microbes are found. Although concerns have traditionally centered on microbial pathogens and allergenic effects, recent work has suggested that fungi pose the more serious risk. Evidence is accumulating that certain toxigenic molds are particularly a risk for human health through exposure, via inhalation, of fungal spores. Many of these fungi produce toxins (mycotoxins) some of which have been shown to cause animal and human intoxications, usually in an agricultural setting. The fungus, Stachybotrys chartarum (S. atra) is considered to be one of the more serious threats to people living and working in water-damaged buildings. This mold has a long history of being responsible for animal toxicoses, and in recent years, being associated with infant pulmonary hemosiderosis (bleeding in the lungs) of infants exposed to spores of this fungus in their homes. S. atra produces a variety of potent toxins and immunosuppressant agents, including a novel class of diterpenes (atranones) of unusual structure. More research is needed to determine the impact to health resulting from inhalation of toxigenic mold spores.

INTRODUCTION

In the past twenty years, there is increasing recognition that an important factor in the health of people in indoor environments is the dampness of the buildings in which they live and work (Miller, 1995). Furthermore, it is now appreciated that the principal non-pathogenic biologics responsible for the health problems in such buildings are usually fungi rather than bacteria or viruses (Miller, 1992; 1993). Although fungi in this context have traditionally been viewed as allergens (and in unusual circumstances, pathogens), data have accumulated to show that the adverse health effects resulting from inhalation of fungal spores are due to multiple factors. One factor associated with certain fungi is the production of small molecular weight toxins (mycotoxins) by these fungi (Miller, 1995). Traditionally, mycotoxins are held to be
important in human and animal health because of their production by toxigenic fungi associated
with food and feed (Betina, 1989). However, mycotoxins tend to concentrate in fungal spores
(Sorenson et al., 1987; Larsen and Frisvad, 1994), and thus present a potential hazard to those
inhaling airborne spores. There are well documented cases of mycotoxicosis resulting from
inhalation of toxigenic spores by agriculture workers handling moldy farm material (Autrup et
al., 1991; Autrup et al., 1993), but until recently there have been few reports of such toxicoses
in an urban setting (Jarvis, 1990).

From an agricultural view, the three most important genera of toxigenic fungi are
Fusarium, Aspergillus, and Penicillium. The principal classes of mycotoxins of concern from
ingestion are (fungal genera): the trichothecenes and fumonisins (Fusarium), aflatoxins
(Aspergillus), and the ochratoxins (Aspergillus and Penicillium). There also are numerous
other mycotoxins that intermittently cause problems. Some trichothecenes are acutely toxic
while others are immunosuppressant and cause feed refusal in livestock. Fumonisins and
especially some of the aflatoxins (e.g. B₁) are carcinogenic (Peraica et al., 1999). There is now
overwhelming epidemiological evidence that aflatoxin B₁ in the diet contributes significantly
to the high incidence of liver cancer in many third world countries. Ochratoxin A is nephrotoxic
and a possible cause of urinary tract tumors and Balkan-endemic nephropathy (Peraica et al.,
1999).

In an indoor environment, the toxigenic molds of most concern are Penicillium,
Aspergillus, Chaetomium, and Stachybotrys. However, the specific species of Penicillium and
Aspergillus in the indoor environments differ from those of an agricultural concern. For
agricultural-based mycotoxicoses, P. verrucosum, A. flavus, and A. parasiticus (the latter two
are aflatoxin producers) are of most concern; whereas, indoors, other species such as P.
aurantiogriseum, P. brevicompactum, and A. versicolor are the most important toxigenic
species (Samson, 1999). Often, the picture is confused by the difficulty of species
identification, a situation common in the identification of Penicillium and to a lesser extent of
Aspergillus. Another confounding factor in the evaluation of mold-contaminated buildings is
the fact that levels of airborne spores can not be easily assessed by measuring the colony­
forming units (CFU's)/m³ since such measurements will detect only viable spores (and both
viable and non-viable spores contain mycotoxins), and even there, the number and type of
fungal colonies observed will depend very much upon the media employed among other factors
(Miller, 1993; Tsai et al., 1999).

Stachybotrys chartarum (Ehrenb. ex Link) Hughes (S. atra Corda) has been a source of
focus in recent years due to its association with idiopathic pulmonary hemosiderosis (IPH) in
children, several of whom have died (Etzel et al., 1998; Dearborn et al., 1999). However, the
Penicillium spp. and A. versicolor are far more commonly encountered in water-damaged
buildings than is S. chartarum. The basic reason for this is that the former species grow well
on building material with water activities (aₜ) in the range of 0.8; whereas, S. chartarum
requires aₜ of 0.9 and higher and >0.96 on building material to grow well (Nielsen et al., 1999).
Generally, moisture levels this high are the result of local leaking (e. g. from a broken pipe) and
are confined to a small area, but with leaking roofs, water intrusion can be quite extensive.
There is nothing special about toxigenic fungi in that like all fungi, their growth properties
depend upon substrate, temperature and water activity (Samson, 1999).

SECONDARY METABOLITES OF THE INDOOR MOLDS

Table 1 lists the more common fungi (and their associated mycotoxins) encountered in
damp indoor environments. For the most part, the mycotoxins in Table 1 have been found to be
produced by these fungi in laboratory cultures, and in only a few cases have these mycotoxins
actually been shown to be produced when cultured on building materials (Nielsen et al., 1998a;
1999) or been isolated from mold-contaminated buildings (Andersson et al., 1997; Nielsen et