Unusual but important sources of industrial and home mold exposures

*Symposium*: New insights into mold-related symptoms and disease and potential housing-related solutions

Karin Pacheco, MD, MSPH
Division of Environmental and Occupational Health Sciences
Disclosures

- Karin Pacheco  Nothing to disclose
Learning Objectives

At the end of the talk, participants will:

► Recognize jobs with known or possible occupational exposures to mold.
► Know the fungal enzymes associated with food production.
► Identify some common mold exposures in the home.
Mold is everywhere

► Inadvertent exposure: water damage and secondary mold contamination at home and in the workplace.

► Exposure as part of a natural or industrial process.

► Exposure as part of daily life.
Use of mold products in nature & industry

► Mold enzymes – a natural recycling process

- Fertilize gardens
- Speed decay of garbage and fallen leaves
- Thousands of different types of fungi grow on and absorb food from soil, wood, decaying organisms, living plants & other organisms.
- After the devastating forest fires in Yellowstone National Park, mold was the first to begin the natural process of decaying the leftover material and building a base for new plants & trees.
Inadvertent exposure to mold in the workplace

Locations:
- Office buildings
- Crawl spaces, attics, basements
- Reused industrial spaces
Inadvertent exposure to mold in the workplace

- **Building water damage:**
  - rain, snow,
  - floods, water leaks,
  - burst pipes, water features etc.

- **Areas requiring remediation**
  - Carpets
  - Drywall
  - Structural components

- **Inadequate remediation**
Industrial use of Fungal Enzymes

► Used to catalyze many different industrial processes - proteolytic breakdown and conversion.

► ~ 200 fungal enzymes purified, characterized, and used in industrial processes.

► Excellent examples of HMW occupational allergens that mediate disease through IgE.

Industrial use of Fungal Enzymes

Most widely used derived from genus *Aspergillus*:

- **α-Amylase**: cleaves long chain carbohydrates into simpler sugars including maltose.
- **Xylanase**: hemicellulase that breaks down hemicellulose, component of plant cell walls.
- **Cellulase**: hydrolizes cellulose into glucose.

Fungal enzymes: food industry

- Baking: α-amylase, cellulase, hemicellulase, lipase

- Brewing beer: cellulase, glucosidase, protease.
  - Beer requires water, a starch source, a flavoring such as hops, and brewer’s yeast (*Saccharomyces cerevisiae*) to catalyze fermentation.

Lautering = separate the wort (sugar solution) from the grains
Fungal enzymes: food industry

► Wine

- Commercial blend of hemicellulases, glucanases and glycosidases sold with pectinases.
- EU requires that all the enzymes are produced by *Aspergillus niger*, with the exception of glucanase which is produced by *Tricoderma harzianium*.
Fungal enzymes: food industry

- **Soy sauce, sake, rice vinegar:** *Aspergillus oryzae*
- **Cheese flavoring:** *Penicillium roqueforti, camemberti*
- **Digestive powders:** Biodiastase, Flaviastase (*A. niger*).
  - Beano: alpha-galactosidase (*A. niger*).
Industrial Fungal Enzymes

- **Textiles:** α-amylase, cellulase, lipase, protease, and xylanase make enzyme washed jeans
Industrial Fungal Enzymes

- Pulp and paper production: cellulase, hemicellulase, lipase, xylanase.

Figure 2. Xylanase application process flow-sheet.
Fungal Enzymes: use in waste degradation

- Organic waste streams: cereal straw, oil palm fronds, garden waste, prunings, contain high content of cellulose.

- Cellulose and hemicellulose can produce energy (ethanol), when converted to glucose & other sugars, chemicals (lactic acid) or animal feed for ruminants.

Fungal enzymes used to break down lignin

- Lignin is the obstacle: lignin in plant cell walls is a recalcitrant aromatic polymer which provides plants rigidity and protection against pathogens.
- Lignin forms complexes with cellulose and hemicellulose – the lignocellulose complex – that hampers breakdown of these carbohydrates.
Fungal enzymes: use in waste degradation

► Currently, chemicals and physical treatments (steam explosion) break down (hemi) cellulose. Disadvantages include the energy costs and the production of new (toxic) waste streams.

► White rot fungi degrade lignocellulose; some species are selective lignin degraders.

► These fungi are safe, low energy requiring alternatives.
Fungal Enzymes: use in biofuels
Mold contaminates metal working fluids (MWF)

- MWF cool machines that process metal.
- Processes that use MWF:
  - Metal machining – cutting, grinding, polishing
  - Forging – pressure on heated metal to form metal parts in shape of dies, and
  - Stamping – cold rolled steel stamped out into parts.

Mold in the workplace: Types of MWF

► Straight (mineral oil, natural, neat) = 100% petroleum oil, used prior to 1970s

► Non-straight = water-based oils with corrosion inhibitors, dyes, biocides.
  - Emulsified = emulsion of mineral oil and water
  - Semisynthetic = small amounts of mineral oil
  - Synthetic = no mineral oils

► Fluids collected in sumps around the machine and are reused after metal particles filtered out.
Mold in the workplace: MWF contamination

- MWF are not sterile: with repeated use, organisms grow in the MWF and in biofilms that adhere to pipes & containers.

- Reported as causing work-related asthma, HP, chronic bronchitis, rhinitis, Pontiac fever ( legionella), Humidifier fever (endotoxin).
Mold in the home: beer, bread, cheese
Other mold in the home

► Soy sauce
► Saki
► Salami
  ▪ Raw sausage meat
  ▪ Ferments for a day
  ▪ Stuffed into casings with salt and spices
  ▪ Casings treated with an edible mold, *Penicillium* culture as well. Mold imparts flavor, helps the drying process and prevents spoilage during the curing process.
Mold in the medicine cabinet

- Red rice yeast fermented with *Monascus purpureus*

- Fermentation derived Statin drugs:
  - Mevastatin, *Penicillium*
  - Lovastatin (Mevacor) *Aspergillus terreus*
  - Simvastatin (Zocor) *Monascus purpureus*
  - Pravastatin (Pravachol) *Nocardia autotrophica*

- Antibiotics: penicillin, cephalosporins, fusafungine, fumagillin, alamethicin, fusidic acid, brefeldin A, and cerrucarin A
More mold in the medicine cabinet

► Anticancer compounds: *Penicillium* synthesizes paclitaxel, vinblastine, podophyllotoxin.
► Anti-fungals: *Penicillium* synthesizes griseofulvin
► Immunosuppressives
  ▪ Mycophenolic acid (CellCept): *Penicillium stoloniferum*
  ▪ Cyclosporine: *Tolypocladium inflatum*.
► Ergot alkaloids from *Penicillium* and *Aspergillus*: cafergot, dihydroergotamine, methysergide, Parkinson’s disease bromocriptine, lisuride, cabegoline, pergolide; and LSD.
Most unusual source of mold health effects in the home

- Effect on old, green wallpaper.

- In the 19th century, bright green wallpaper was very fashionable: but prepared using arsenic compounds.

- In damp rooms, fungi living on the wallpaper paste turned the arsenic salts into highly toxic trimethylarsine gas.

  - No bedbugs
  - Infant deaths
  - Chronic illnesses
In summary: consider these unusual sources of mold exposure

- Water damaged buildings
- Fungal enzymes used in baking, cheese production, fermentation of beer and wine, textiles, paper and pulp production, biofuels and waste degradation
- Contamination of metal working fluids
- Mold in the medicine cabinet
- Mold in the wallpaper