# Skin and Respiratory Symptoms in Peanut Inspectors with Peanut Dust and Endotoxin Exposure

*Loren C. Tapp, MD, MS*
*David Sylvain, MS, CIH*

Health Hazard Evaluation Report
HETA 2008-0052-3115
Shann Peanut Company
Ambrose, Georgia
September 2010

DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
*National Institute for Occupational Safety and Health*

**The employer shall post a copy of this report for a period of 30 calendar days at or near the workplace(s) of affected employees. The employer shall take steps to insure that the posted determinations are not altered, defaced, or covered by other material during such period. [37 FR 23640, November 7, 1972, as amended at 45 FR 2653, January 14, 1980].**

# Contents

## Report



## Appendix A



## Appendix B



## Acknowledgments

# Abbreviations

| | |
|---|---|
| µm | micrometer |
| ACGIH® | American Conference of Governmental Industrial Hygienists |
| CFR | Code of Federal Regulations |
| COPD | Chronic obstructive pulmonary disease |
| EU | Endotoxin units |
| EU/m$^3$ | Endotoxin units per cubic meter |
| FDA | Food and Drug Administration |
| FSIS | Federal State Inspection Service |
| GDPH | Georgia Division of Public Health |
| HP | Hypersensitivity pneumonitis |
| IgE | Immunoglobulin E |
| LAL | Limulus amoebocyte lysate |
| mm | Millimeter |
| NAICS | North American Industry Classification System |
| NIOSH | National Institute for Occupational Safety and Health |
| ODTS | Organic dust toxic syndrome |
| OEL | Occupational exposure limit |
| OSHA | Occupational Safety and Health Administration |
| PBZ | Personal breathing zone |
| PEL | Permissible exposure limit |
| PFT | Pulmonary function test |
| PPE | Personal protective equipment |
| PVC | Polyvinyl chloride |
| REL | Recommended exposure limit |
| STEL | Short-term exposure limit |
| TLV | Threshold limit value |
| TWA | Time-weighted average |
| USDA | United States Department of Agriculture |
| VOC | Volatile organic compound |
| WEEL | Workplace environmental exposure limit |

# Highlights of the NIOSH Health Hazard Evaluation

**The National Institute for Occupational Safety and Health (NIOSH) received a request from the Georgia Division of Public Health (GDPH) to evaluate Federal State Inspection Service (FSIS) employees' exposures and work-related symptoms at Shann Peanut Company in Ambrose, Georgia. FSIS employees reported respiratory, skin, gastrointestinal, and flu-like symptoms while grading peanuts in middle to late October 2007.**

## What NIOSH Did

- We visited the facility in December 2007 and October 2008.
- We met with FSIS employees, GDPH and U.S. Department of Agriculture officials, and the facility's owner.
- We checked the respirators and gloves that FSIS employees were given to use to see if they were protective.
- We spoke with FSIS employees confidentially about health concerns and reviewed their medical records.
- We looked for endotoxin in a dust sample taken from the air conditioner filter in the peanut grading room in 2007.
- We analyzed two different samples of peanuts for endotoxin and volatile organic compounds.
- We took air samples for endotoxin in the peanut grading room in 2008.

## What NIOSH Found

- The peanut grading machines released dust indoors.
- FSIS employees were given dust masks that were not approved by NIOSH.
- Many FSIS employees reported skin, intestinal, lung, and flu-like symptoms.
- Endotoxin were found in the air conditioner filter dust, the peanut grading room air, and outdoor air.
- Respiratory abnormalities were found in medical records for some FSIS employees.

## What FSIS Managers Can Do

- Vent peanut grading room dust outdoors.
- Change air conditioner filters routinely.
- Train employees before peanut season begins on agricultural dust hazards and how to prevent exposure.
- Provide NIOSH-approved N95 particulate respirators, and start a respiratory protection program for peanut inspectors.
- Encourage employees to report potential work-related health problems to their supervisor.

- Offer medical follow-up for employees experiencing work-related symptoms.
- Provide nonlatex, powder-free disposable gloves for employees to prevent contact dermatitis.
- Start a management-employee health and safety committee.
- Review injury and illness logs monthly during peanut grading season to monitor work-related symptoms among peanut inspectors.
- Take air samples for endotoxin in FSIS peanut grading rooms throughout the state to further evaluate exposure.

### *What FSIS Employees Can Do*

- Do not eat or drink in the peanut grading room.
- Wear nonlatex, powder-free disposable gloves when needed.
- Wear NIOSH-approved N95 particulate respirators when needed.
- Report any symptoms that you think may be related to work to your supervisor.
- Tell your doctor about your work exposures when seeking treatment for respiratory illness.

# Summary


On November 30, 2007, the GDPH submitted a request for technical assistance to NIOSH to address concerns about health symptoms in FSIS peanut inspectors who worked in the peanut grading room at Shann Peanut Company (Shann) in Ambrose, Georgia. FSIS employees began reporting irritation of the eyes, nose, respiratory tract, and skin; nausea; diarrhea; vomiting; headache; fever; and flu-like symptoms in middle to late October 2007. Prior to our evaluation, FDA and USDA analyzed peanut samples for fungi, mycotoxins, and pesticides. GDPH officials conducted an epidemiologic assessment.

**We found that FSIS employees were exposed to airborne endotoxin during peanut grading. Occupational history, reported symptoms, and medical findings of FSIS employees are consistent with endotoxin exposure and possible chemical exposures such as mycotoxins. We recommend reducing dust exposure, training employees on the hazards of organic dust exposure, and providing FSIS peanut inspectors with appropriate respiratory and skin protection. Additional endotoxin sampling and review of injury and illness logs in peanut grading rooms throughout the state are advised.**

On December 5, 2007, we met with FSIS inspectors, GDPH officials, a USDA official, and the facility owner and walked around the peanut grading facility. We assessed ventilation in the grading room, examined the PPE provided to employees, and collected a sample of dust from the air conditioner filter in the grading room. We spoke with FSIS employees about their health concerns and reviewed their medical records. We later analyzed peanuts sent to us for endotoxin and VOCs. On October 22, 2008, we returned to Shann and conducted PBZ air sampling for endotoxin in the grading room.

In 2007, we found that the grading room machinery did not vent peanut dust outdoors. FSIS inspectors reported wearing dust masks that were not NIOSH approved; they also reported skin, gastrointestinal, respiratory, and flu-like symptoms. Employee medical records reported respiratory abnormalities in seven employees. Endotoxin were found on the air conditioner filter and in peanut samples. During the 2008 site visit, endotoxin were found in the grading room air and outdoor air.

The acute respiratory and flu-like symptoms reported by FSIS employees were consistent with endotoxin exposure. The acute gastrointestinal and skin symptoms reported were consistent with exposure to chemical toxins, possibly mycotoxins. The persistence of symptoms in some workers after being removed from exposure was unusual. Persistent respiratory symptoms could be a result of additional lung insult from cigarette smoking or co-existing disease, such as COPD or asthma. In addition, persistence of symptoms might be explained by employees inadvertently taking home organic dust on their clothing and shoes and in their cars, thus continuing their exposure.

We recommend reducing dust in the peanut grading room by installing ductwork on machines to discharge dust outdoors.
We recommend providing employee training on the hazards of organic dust and ways to prevent exposure, providing appropriate respiratory and skin protection to reduce exposure to irritants and allergens, and encouraging employees to report potential work-related symptoms. FSIS management also should review injury and illness logs and conduct additional endotoxin sampling in FSIS peanut grading rooms throughout the state to monitor trends in work-related illness and exposures.

**Keywords:** NAICS 424590 (Other Farm Product Material Merchant Wholesalers), peanuts, organic dust, endotoxin, skin, respiratory, and gastrointestinal symptoms

# Introduction

On November 30, 2007, the GDPH submitted a request for technical assistance in evaluating respiratory and skin symptoms among state peanut inspectors who worked in the peanut grading room at Shann Peanut Company (Shann) in Ambrose, Georgia. Information provided to NIOSH indicated that FSIS employees began reporting symptoms in middle to late October 2007. Reported symptoms included skin rash; burning, itching, and peeling skin; irritation of the eyes, nose, and respiratory tract; nosebleeds; cough; shortness of breath; nausea; diarrhea; fever; and flu-like symptoms. We evaluated the workplace during site visits in December 2007 and October 2008. Interim letters were sent to the GDPH in January 2008 and October 2008.

## Background

Peanut growers bring harvested peanuts to Shann, where they are cleaned, dried, graded, and sold. Peanut grading is performed by seasonal FSIS employees. FSIS is the state agency that inspects and grades agricultural products. Peanut grading typically begins in late September or early October and continues into December. Throughout this period, eight to ten FSIS inspectors and aides are assigned to the Shann grading room where they handle peanut samples and operate the grading machines. During the grading season, FSIS inspectors and aides work 8 hours per day plus overtime as needed. FSIS inspector aides have the same work exposures as FSIS inspectors so, to simplify, we will refer to both job titles as FSIS inspectors in this report.

The Shann grading room is at the back of a small, single-story light-frame construction building that houses the Shann offices in the front of the building. The grading room is approximately 30 feet long by 20 feet wide with an 8-foot ceiling and is separated from the office area by a floor-to-ceiling wall. The grading room is accessible from the office area through an interior doorway, which is kept closed when not in use, and through an exterior doorway at the back of the building. The room, equipped with an air-conditioning unit that obtains room air through a supply grill near the floor at one end of the room, recirculates the air back to the room through seven ceiling-mounted diffusers.

Nine peanut grading machines are located along two walls in the grading room. Shann owns the machines, but they are operated and maintained by FSIS employees. Some grading machines are fitted with cyclones (inertial dust collectors for collecting large particulates). At the time of the first NIOSH site visit, the cyclones discharged dust into the grading room; at the time of the second site visit, the cyclones on the foreign material and presizer machines were fitted with PVC piping connected to exhaust vents outside the building (Figure 1). A freestanding ventilation unit beneath the work counter recirculated room air through a filter of undetermined efficiency.

Peanuts arrive at Shann in 10-ton open-top wagons. Shann employees tag each wagon, and dry and clean the peanuts in large machines as needed before grading. The grading process begins with an FSIS inspector using a mechanized probe to collect a sample of peanuts from eight locations within a wagon. The inspector carries the sample to the grading room where it is weighed, and the data are logged into the computer. Samples, which weigh 1500 to 1800 grams each, are brought into the grading room and put into the foreign material machine to separate the peanuts from miscellaneous debris. After debris removal, FSIS inspectors take 500 grams of peanuts from the sample for processing in the presizing, shelling, shaking, and splitting machines. Inspectors handle the samples when placing peanuts into the machines and when performing manual grading tasks at the large work counter in the center of the grading room. This process is repeated throughout the workday for samples that are obtained from wagons containing peanuts from growers.

Figure 1. Peanut grading machine with retrofitted exhaust ventilation duct in 2008

## Prior Government Agency Response: October–December 2007

The following government agencies initiated an investigation in response to reports of health problems among FSIS employees who worked in the Shann grading room during the 2007 season: the GDPH, the Georgia Department of Agriculture, and offices and centers within the FDA and USDA. The epidemiologic investigation by the GDPH found that FSIS peanut inspectors at Shann began experiencing skin irritation and respiratory symptoms on October 16, 2007. FSIS employees related their symptoms to handling peanuts from one particular grower, reporting that these peanuts had an unusual odor. Nine inspectors with symptoms were seen by an infectious disease physician contracted by FSIS who suggested that the symptoms were consistent with exposure to a chemical irritant such as a mycotoxin. None of the peanut inspectors was hospitalized, but symptoms continued after initially handling that particular shipment of peanuts. As a result, the agencies' investigations focused on the peanuts from that specific grower, even though no health problems were reported by that grower's employees or by other employees of the processing company that handled peanuts from that grower. Because of employee health concerns, the Shann grading room was shut down from November 16, 2007, until the last week of December 2007.

The multi-agency investigation, which began prior to NIOSH involvement, included laboratory analyses of suspect peanut samples for mold, mycotoxins (including trichothecene mycotoxins, aflatoxin, *Stachybotrys* toxins, T-2 toxin, zearalenone, deoxynivalenol, ochratoxin, and cyclopiazonic acid), pesticides, and other chemicals. Although several genera of mold were identified in samples of the suspect peanuts, the types and amounts of mold contamination were not unusual. Trichothecene mycotoxins were detected in an initial screening sample; however, the results of this initial testing were only preliminary as the screening tests had not been validated for in-shell peanuts. Confirmatory tests for tricothecene mycotoxins were negative. Additional analyses of multiple samples did not identify mycotoxins. Analyses did not indicate the presence of pesticides or other chemicals in the peanuts.

## Initial Site Visit: December 5, 2007

We made an initial site visit on December 5, 2007. The site visit included an opening conference with District and County Department of Health officials, an official from the Georgia Department of Agriculture, several FSIS employees, and the owner of Shann. We toured the Shann facilities, including the grading room, and interviewed FSIS employees confidentially. During the tour, we observed transport and storage areas, the moisture shed where peanuts are dried, and a peanut cleaning operation performed by Shann employees. In the grading room, FSIS employees explained the steps involved in the peanut grading process and demonstrated the operation of peanut grading machines. Subsequent to the site visit, we reviewed medical records of 13 FSIS employees and reports of laboratory analyses from the FDA.

Confidential employee interviews were held with seven FSIS employees at the Shann facility during our first site visit. One additional FSIS and one Shann employee were later interviewed by phone.

We collected a dust sample from the air conditioner filter in the FSIS grading room and several peanut shells that contained crystalline-like structures. Approximately 2 weeks after the site visit, the Georgia Department of Agriculture provided us with a plastic bag containing peanuts from storage bins that were graded when employee symptoms began ("suspect peanuts") and a separate bag containing other peanuts ("comparison peanuts"). Air conditioner filter dust and peanut samples were analyzed for endotoxin (Appendix A).

Because peanut grading had been suspended prior to our 2007 site visit, we were unable to observe actual grading room operations or conduct exposure monitoring. The grading room was reopened the last week of December 2007 to finish grading the remaining peanuts. FSIS management reported that six different FSIS inspectors worked that week, wearing Tyvek® suits, respiratory protection, goggles, gloves, and foot covers, and that none of these employees reported symptoms.

## Second Site Visit: October 22, 2008

During a second site visit in the 2008 grading season we observed the grading process and conducted air sampling for endotoxin. PBZ air samples were collected on eight FSIS employees inside the grading room. For comparison, an area air sample was collected outdoors, approximately 3 feet above the ground and 30 feet from the entrance to the grading room. A second area air sample was collected in the Shann office employees' lunchroom for comparison. The lunchroom was selected for background sampling because it was in the same building as the grading room and had not been associated with health problems in 2007. Sampling and analytical methods are given in Appendix A.

## Initial Site Visit: December 5, 2007

In December 2007, when an FSIS employee demonstrated how the grading machines operated, we noted that the machines generated and released dust into the grading room air. We were shown single-strap dust masks that were provided to FSIS employees for voluntary use. These masks are not NIOSH-approved and do not provide adequate protection against airborne particulate exposure. No respiratory protection program was in place. In addition, we observed that when the grading machines were in operation, they produced a considerable amount of noise.

At the time of the 2007 site visit, the air-conditioner filter in the grading room had a thick layer of dust. FSIS employees stated that the filter had not been changed during the 2007 grading season. Analysis of the dust sample collected from the filter found 1,500,000 EU/gram of dust, which suggests that endotoxin-containing dust had been released in or near the grading room. Because no one knew how long the filter had been in use, we could not determine when the contaminated dust had been deposited on the filter. Dust from the filter may have been released back into the room.

Analysis for endotoxin in the samples of suspect and comparison peanuts showed that the suspect peanuts contained less endotoxin than the “nonsuspect” peanuts. The endotoxin concentration in the suspect peanut sample was 260 EU/gram; the concentration in the comparison sample was 1400 EU/gram. We do not know, however, if the suspect peanuts that were submitted for analysis were truly representative of the peanuts that were thought to be associated with employees’ symptoms in 2007. Qualitative VOC analysis detected no obvious differences between the two samples of peanuts.

Qualitative microscopic analysis of peanut shells containing small, glassy crystals found that the crystals displayed many, but not all, of the optical properties of quartz. In the absence of elemental or x-ray diffraction analysis to supplement optical microscopy, the crystals were reported as “possible quartz.” Dust, which accompanied the peanut shell sample, contained insect parts, synthetic fibers, trichomes (hair-like structures found on plant surfaces), cellulose, hair, wood dust, starch, skin cells, pollen, opaque material, and a brownish/orange dust that appeared to be peanut dust.

## Second Site Visit: October 22, 2008

None of the FSIS employees who worked in the Shann grading room in 2007 was employed in the grading room in 2008. While the 2007 staff reported a distinctive, unusual odor that they associated with peanuts from a particular grower, the 2008 staff stated that they had not noticed any unusual odors, nor had they experienced health problems during the 2008 season. The lead FSIS inspector in 2008 stated that approximately one third of the peanuts that had been graded during the preceding few days were from the grower of the suspect peanuts in 2007. She also noted that the air-conditioner filter had been changed several times since our initial site visit. Respiratory protection was voluntary, and none of the employees wore respiratory protection in the grading room. FSIS employees did not wear hearing protection or gloves. Employees did not eat or drink in the grading room.

The results of PBZ air sampling for endotoxin are presented in Table 1. TWA concentrations are reported for the actual sampling periods. The geometric mean PBZ concentration was 320 EU/m$^3$. The range was 170 to 680 EU/m$^3$. Area samples indicated TWA concentrations of 9.8 EU/m$^3$ in the lunchroom and 380 EU/m$^3$ outdoors.

The highest TWA exposure to endotoxin occurred near the B-side foreign materials machine, where miscellaneous debris was separated from the peanut samples. This was one of two foreign material machines that had been retrofitted with PVC pipe to discharge dust outdoors. The PVC pipe connection, however, still allowed the cyclone to discharge partly into the room, rather than discharging entirely outdoors.

Airborne dust was not observed at the foreign material machines or elsewhere in the grading room on the sampling date. As shown in Table 2, particle-count data suggest that fewer airborne particles were present in the grading room than in the lunchroom and outdoors. During the site visit, tractors and wagons generated visible airborne dust that appeared to result in the relatively high outdoor particle counts.

## Employee Interviews

We attempted to contact all full-time FSIS peanut inspectors and all part-time FSIS inspectors who had reported symptoms to the Georgia District Epidemiologist. The list provided by the Epidemiologist indicated that nine full-time and five part-time employees had reported symptoms. Eight FSIS employees (six of nine full-time and two of 16 part-time employees) who worked at the Shann facility in the 2007 peanut season were interviewed either in person (seven) or by phone (one). For this evaluation, full-time employees were defined as working more than 15 days at the Shann grading facility. We could not reach three full-time and three part-time FSIS employees. We interviewed one additional Shann employee by phone who had reported symptoms to family members.

Of the eight interviewed FSIS employees, the average age was 41 years (range: 20 to 66 years), and the average number of years worked as an FSIS inspector was 9 (range: 1 to 25 years). Of the six full-time employees, the average number of days worked at Shann was 35 (range: 29 to 39 days). The two part-time employees worked 3 and 4 days at Shann. No employees worked at other peanut grading sites after the Shann peanut grading room was shut down in November 2007. Seven employees were female, and seven were current smokers.

Employees reported grading peanuts with an odd odor beginning on October 12, 2007. Between October 16, 2007, and November 1, 2007, six of the eight employees reported skin irritation (i.e., described as having one or more of the following: burning; itching; mild edema; erythema; or papular rash) and eye, nose, and throat irritation. One reported eye, nose, and throat irritation without rash, and one reported rash, but no eye, nose, and throat irritation. Seven employees reported headaches and six reported diarrhea; four of the six also had nausea, vomiting, or loss of appetite. Five reported flu-like symptoms including fatigue, body aches, chills, cough, and shortness of breath. Seven employees reported smoking cigarettes; only one reported respiratory symptoms that existed prior to this peanut season. No employees wore protective gloves. Reportedly, dust masks provided for workers were rarely worn.

Our evaluation focused on FSIS employees and did not include an evaluation of the 10 to 12 Shann employees; however, one Shann employee who worked outside reported persistent symptoms of cough, shortness of breath, and wheezing that began in early to mid-October 2007.

## Medical Record Review

Medical records of 13 FSIS employees were reviewed, including records of the eight interviewed employees and five employees who were not interviewed. The additional five FSIS employees included one part-time and two full-time FSIS peanut inspectors who worked at Shann, one FSIS office employee who worked at a different location and handled paperwork from Shann, and one FSIS employee reporting symptoms and on the GDPH Epidemiologist's list, but whose work history could not be found. Ten of these employees were seen by an infectious disease physician, ten by a pulmonary medicine physician, five by an occupational medicine clinic, five by an employer-contracted physician knowledgeable in occupational medicine, two by a dermatologist, one by a nephrologist, and one by a medical toxicologist. All 13 employees were diagnosed with "toxic exposure" or "occupational exposure consistent with an irritant chemical" by at least one physician.

Medical record reviews showed that 12 employees reported skin burning, itching, or rash, and most reported this was the first symptom to occur. Ten of these 12 employees had skin findings on medical examination; seven had findings of papules, plaques, or skin lesions described as exzematous, erythematous, scaly, or excoriated; one had redness of the face and upper arms; one had redness and mild swelling of both hands and forearms; and one who reported an intermittent rash had no skin findings on initial exam, but on a later exam had two skin lesions with no description on the lower extremities. Two of the 12 employees reported that their skin symptoms had resolved before their first examination on November 20, 2007. Two employees were referred for dermatological consultation, and two employees did not keep their follow-up appointments. Diagnoses in those with persistent rash included contact dermatitis (one employee) and fungal infection of the scalp (one employee); two were referred for further evaluation by an allergist.

Twelve employees reported respiratory symptoms; one employee reported symptoms resolving after November 15, 2007, when the grading room was shut down, one reported a dry cough, but no other symptoms, and ten were seen by a pulmonologist. Of these ten, all underwent chest x-rays (all with normal results) and pulmonary function testing; seven displayed obstructive or restrictive lung changes on pulmonary function testing, two had normal pulmonary function testing, and one had very mild changes interpreted as within normal limits by the pulmonologist. The seven employees with lung changes were diagnosed with one or more of the following: reactive airways disease, COPD, emphysema, chronic tobacco abuse, or asthma. Because of the smoking history of these employees, we were unable to assess if the abnormal lung findings were due to the effects of smoking, workplace exposures, or a combination of both.

Six FSIS employees had blood analyses for total IgE and blood immunoassay testing (ImmunoCAP®) for HP (referred to as the Farmer's Lung Panel). The Farmer's Lung Panel included 16 allergens: 12 fungi and mold allergens; one feather mix; and one pigeon, one pork, and one beef allergen. Two of six employees had elevated total IgE, indicating a history of a Type I hypersensitivity disorder such as allergic rhinitis, allergic asthma, atopic dermatitis, food allergy, allergic urticaria (hives), and anaphylaxis. No employees had detectable reactions to the Farmer's Lung Panel.

Additional diagnoses not suspected to have a relationship with work exposures among the 13 employees included recurrent urinary tract infection, anemia, gastroesophageal reflux disease, possible peptic ulcer disease, and possible irritable bowel syndrome. Chronic diagnoses included diabetes mellitus, hypertension, and chronic hepatitis C infection.

# Discussion

Even though a definitive causal relationship cannot be established, analysis of air and dust samples suggests that exposure to endotoxin during the 2007 grading season may have been sufficient to explain the acute respiratory and flu-like symptoms experienced by the employees. The acute skin symptoms experienced by FSIS employees were most consistent with a chemical exposure such as a mycotoxin. However, Manfreda et al. found skin itch and rash to be associated with endotoxin exposure [Manfreda et al. 1986].

The persistent nature of symptoms in some employees was puzzling because, generally, in an acute exposure, once a person is removed from the exposure to either endotoxin or mycotoxin, the symptoms slowly get better and resolve within a few days to a few weeks [Kirkhorn and Garry 2000; Spurzem 2002; Eduard 2009]. One possibility is that employees carried dust on their clothing and shoes into their cars and homes, and so continued having some exposure and symptoms. Another possibility is that co-existing health conditions may have increased susceptibility, worsened symptoms, and caused longer recuperation times. Some employees who are "allergic" individuals, or have a propensity to develop allergies, may have developed an allergy to an unidentified ingredient in the peanut dust.

Symptoms were reported among all full-time FSIS inspectors, but not other employees, with one exception. The high prevalence of respiratory symptoms reported among full-time FSIS employees at Shann suggests that the exposure was an irritant compound because all persons would be equally susceptible, unlike an allergenic compound, which would affect only allergic individuals. The wide range of biological activity associated with endotoxin exposure including inflammatory, hemodynamic, and immunological responses could explain the respiratory and flu-like symptoms among the FSIS employees. The high prevalence of acute skin symptoms could be explained by skin exposure to an irritant compound, which could include chemicals sprayed on the plants and soil as pesticides, plant residues on the peanut samples that could cause acute urticarial skin symptoms, or mycotoxins. Although intense efforts by USDA and FDA were taken to find mycotoxins or unusual fungal species in the peanut samples, none were found, and the peanuts were released for further processing. It is possible that the sample of suspect peanuts subjected to this testing did not contain the same contaminant as the peanuts that made the employees sick.

Exposure to organic dust occurs in many agricultural industries. Organic dust typically contains a variety of substances including vegetable products, insect fragments, pollens, pesticides, bird and rodent urine and feces, and bacteria and fungi. Some fungi produce mycotoxins. Mycotoxin production seems to be affected by environmental conditions. Mycotoxins, depending on their potency and concentration, have been associated with health symptoms in agricultural environments.

Microorganisms in organic agricultural dust include Gram-negative bacteria, which are characterized by the presence of endotoxin in the outer bacterial cell wall membrane. Endotoxin, a lipopolysaccharide complex, is released when the bacteria die and disintegrate. Exposure to endotoxin can lead to symptoms of cough, wheeze, shortness of breath, chest tightness, and conjunctivitis. Continued or repeated exposure can result in chronic health effects including chronic bronchitis, reactive airway dysfunction syndrome, asthma, chronic airways obstruction, HP, and emphysema [Castellan 1995]. A NIOSH publication providing information on agricultural dust exposures and ODTS can be found at http://www.cdc.gov/niosh/docs/94-102/pdfs/94-102.pdf. Additional information on agricultural dust, endotoxin, and mycotoxin is given in Appendix B.

The presence of endotoxin in air samples collected in 2008 suggests that airborne endotoxin exposure is likely during peanut grading and other activities where peanut crops are handled or processed. Endotoxin concentrations in all but one PBZ air sample appear to equal or exceed the 8-hour TWA exposure limit of 200 EU/m$^3$ established by the Dutch Expert Committee on Occupational Standards [DECOS 1998]. In 1998, the Dutch Expert Committee on Occupational Standards recommended a health-based exposure limit of 50 EU/m$^3$, which was later raised to 200 EU/m$^3$ to accommodate economic feasibility for the agricultural industry [DECOS 1998].

# Conclusions

Analysis of peanut bulk samples and air conditioner dust in 2007 and area and PBZ air samples in 2008 provides evidence that FSIS peanut inspectors are at risk of exposure to airborne endotoxin during routine operations in FSIS peanut grading rooms. Although airborne endotoxin concentrations in grading rooms can vary between seasons, crops, and locations, air samples collected in the Shann grading room in 2008 indicate that exposure to airborne endotoxin may exceed levels that have been associated with symptoms of cough, wheeze, shortness of breath, chest tightness, mucous membrane irritation, and signs of acute airflow obstruction [Castellan et al. 1987; Smid et al. 1994; Milton et al. 1996].

The acute respiratory and flu-like symptoms reported in 2007 by FSIS employees and the associated medical findings are consistent with endotoxin exposure. However, the persistence of symptoms reported by some employees after being removed from exposure does not fit with recognized endotoxin- or mycotoxin-related illness. We suspect that this may have resulted from "take-home" contamination (i.e., endotoxin in peanut dust that was carried home on employees' clothing) and which may have resulted in continued exposure to endotoxin while away from work. In addition, some employees may have been more susceptible to lung and skin disorders or had co-existing pulmonary or skin disease.

# Recommendations

NIOSH strongly encourages employers to use a "hierarchy of controls" approach for protecting workers from occupational safety and health hazards. This hierarchy can be summarized as follows:

- Elimination
- Substitution
- Engineering controls
- Administrative controls
- Personal protective equipment

Control methods at the top of the list are potentially more effective and protective than those at the bottom. Following the hierarchy normally leads to the implementation of inherently safer systems, ones where the risk of illness or injury has been substantially reduced.

Elimination and substitution, while most effective at reducing hazards, also tend to be the most difficult to implement in an existing process, and do not apply to FSIS grading rooms. Engineering controls, the next tier in the hierarchy, are used to remove a hazard or place a barrier between the worker and the hazard. Well-designed engineering controls, such as local exhaust ventilation, which can be highly effective in protecting workers and is typically independent of worker interactions, can provide a high level of protection.

Administrative controls are management-dictated work practices and policies to reduce or prevent exposures to workplace hazards. The effectiveness of administrative changes in work practices for controlling workplace hazards is dependent on management commitment and employee acceptance. Regular monitoring and reinforcement are necessary to ensure that control policies and procedures are not circumvented in the name of convenience or production.

Because PPE is the least effective means for controlling employee exposures, proper use of PPE requires a comprehensive program and calls for a high level of employee involvement and commitment to be effective. The use of PPE requires the choice of the appropriate equipment to reduce the hazard and the development of supporting programs such as training, change-out schedules, and medical assessment if needed. PPE should not be relied upon as the sole method for limiting employee exposures. Rather, PPE should be used until engineering and administrative controls can be demonstrated to be effective in limiting exposures.

## Engineering Controls

1. Install or modify ductwork on all cyclone-equipped machines to discharge dust outdoors. If working properly, the cyclone dust collectors installed on some of the grading machines should capture coarse dust; however, cyclones will not capture fine particles. Unless ducted outdoors, these fine dust particles will be released into the peanut grading room, where the dust may be inhaled by grading room employees. A simple way to reduce exposure to agricultural dust and endotoxin would be to install ductwork on the cyclones to discharge fine particles outdoors.
2. Inspect and change the air conditioner filter routinely and document in a maintenance log.

## Administrative Controls

1. Conduct employee training at the beginning of each peanut grading season to educate employees on best work practices to limit dust exposure, proper hygiene (e.g., employees should not bring food or drink into the peanut grading room), PPE use, and potential hazards of organic dust exposure.
2. Encourage employees to report all potential work-related skin and respiratory symptoms to their supervisors. Because the work-relatedness of skin and respiratory diseases may be difficult to establish, employees with possible work-related health problems should be fully evaluated by a physician, preferably one familiar with occupational conditions. A complete evaluation would include a full medical and occupational history, a medical exam, a review of exposures, possibly diagnostic tests (such as pulmonary function testing or skin patch testing), and complete follow-up to note the progress of the affected employee. Individuals with definite or possible occupational diseases or illnesses should be protected from exposures to substances that cause or exacerbate the disease or illness. In some cases of

allergic respiratory or skin disease, employees may have to be reassigned with retention of pay and employment status to areas where exposure is minimal or nonexistent.

3. Establish an employee-management health and safety committee or working group to discuss the recommendations in this report and develop an action plan. Those involved in the work can best set priorities and assess the feasibility of our recommendations for the specific situations in the peanut grading room.

4. Conduct a noise survey in the peanut grading room to determine if a hearing conservation program is needed to protect peanut inspectors from gradual loss of hearing from excessive noise. Noise-induced hearing loss is an irreversible condition that progresses with exposure to excessive noise. Elements of an effective hearing conservation program include exposure monitoring, audiometric testing, hearing protectors, training, and recordkeeping. For additional information, see the OSHA website at http://www.osha.gov/dts/osta/otm/noise/hcp/index.html and booklet at http://www.osha.gov/Publications/osha3074.pdf.

5. Although we are not aware of health problems among FSIS peanut graders during previous seasons or at other locations, it is possible that symptoms have occurred but were not recognized. FSIS management should review and monitor injury/illness logs of all grading locations periodically (e.g., monthly) during peanut grading season to identify work-related respiratory illness. If respiratory illness is reported, the work location should undergo an environmental evaluation to characterize endotoxin exposure. FSIS managers should report clusters of illness to GDPH to identify public health risks that may be associated with the handling and grading of peanuts. (See the GDPH website at http://health.state.ga.us/epi/disease/report.asp for more information on reporting illness clusters.) This information would enable public health agencies to develop interventions to ensure the safe handling and processing of peanuts.

6. Conduct PBZ sampling for endotoxin in FSIS peanut grading rooms throughout the state to characterize exposures. PBZ sampling results will help determine if additional engineering controls may be needed in addition to the cyclone dust collector exhaust systems that are on some machines.

## Personal Protective Equipment

1. Provide FSIS peanut inspectors with NIOSH-approved N95 particulate filtering facepiece respirators in the context of a respiratory protection program when exposure to organic dust cannot be avoided. Respiratory protection should be provided in the context of a written respiratory protection program that includes the following elements:

    - Respiratory program administration
    - Respirator selection
    - Respirator inspection
    - Permissible practices for respirator use
    - Respirator storage
    - Respirator limitations
    - Respiratory protection training
    - Fit testing
    - Program evaluation
    - Medical surveillance

    More information on the OSHA respirator standard is available at http://www.osha.gov/SLTC/respiratoryprotection/index.html.

2. Provide disposable nonlatex, powder-free gloves for FSIS peanut inspectors to reduce skin exposure to skin irritants and allergens.
3. Educate employees on the hazards of agricultural dust exposure and the possible hazard of taking contamination home on work clothes. Employees should not wear contaminated clothing from work to home.

# References


Castellan R, Olenchock S, Kinsley K, Hankinson J [1987]. Inhaled endotoxin and decreased spirometric values: an exposure response relation for cotton dust. N Engl J Med *317*(10):605–610.

Castellan RM [1995]. Respiratory health effects of inhaled endotoxins: byssinosis and beyond. In: McDuffie H, Dosman J, Semchuk K, Olenchock S, eds. Agricultural Health and Safety - Workplace, Environment, Sustainability. Boca Raton, FL: CRC Press, pp. 97–100.

DECOS [1998]. Endotoxins: health-based recommended occupational exposure limit. The Hague, Netherlands: Health Council of The Netherlands, Dutch Expert Committee on Occupational Standards.

Eduard W [2009]. Fungal spores: A critical review of the toxicological and epidemiological evidence as a basis for occupational exposure limit setting. Crit Rev Toxicol *39*(10):799–864.

Kirkhorn SR, Garry VF [2000]. Agricultural lung diseases. Environ Health Perspect *108*(suppl 4):705–712.

Manfreda J, Holford-Strevens V, Cheang M, Warren CPW [1986]. Acute symptoms following exposure to grain dust in farming. Environ Health Perspect *66*:73–80.

Milton DK, Wypij D, Kriebel D, Walters MD, Hammond SK, Evans JS [1996]. Endotoxin exposure-response in a fiberglass manufacturing plant. Am J Ind Med *29*(1):3–13.

Smid T, Heederick D, Houba R, Quanger PH [1994]. Dust- and endotoxin-related acute lung function changes and work-related symptoms in workers in the animal feed industry. Am J Ind Med *25*(6):877–888.

Spurzem JR, Romberger DJ, Von Essen SG [2002]. Agricultural lung disease. Clin Chest Med *23*:795–810.

Table 1. Air sampling results for endotoxin (October 2008)

| Job Title | Location | Time (minutes) | Concentration (EU/m³)* | TWA Concentration (EU/m³)† |
|---|---|---|---|---|
| Inspector | Weigh-in | 0830–1141 (191) | 360 | 260 |
| | | 1330–1657 (207) | 160 | |
| Aide | Grain analysis computer | 0823–1141 (198) | 220 | 200 |
| | | 1335–1658 (203) | 190 | |
| Inspector | A-side | 0825–1142 (197) | 380 | 340 |
| | | 1331–1658 (207) | 300 | |
| Inspector | A-side sheller | 1023–1143 (80) | 860 | 550 |
| | | 1336–1517 (101) | 310 | |
| Aide | A-side | 0852–1141 (169) | 470 | 470 |
| Aide | B-side foreign materials | 0829–1141 (192) | 780 | 680 |
| | | 1322–1656 (214) | 590 | |
| Inspector | B-side splitter | 0827–1141 (194) | 200 | 170 |
| | | 1313–1658 (225) | 140 | |
| Lead Inspector | B-side presizer | 0820–1143 (203) | 290 | 210 |
| | | 1314–1654 (220) | 140 | |
| — | Area sample Shann lunch room | 0930–1651 (441) | 9.8 | 9.8 |
| — | Outdoor area sample | 0838–1650 (492) | 380 | 380 |
| Dutch Expert Committee on Occupational Standards 8-hour TWA exposure limit‡ | | | | 200 |

* EU/m³ – Endotoxin units per cubic meter of air. 15 EUs = 1 nanogram endotoxin
† TWA concentration for the morning and afternoon sampling periods
‡ Prior to adopting the 200 EU/m³ limit as an economically feasible limit for the agricultural industry, the Dutch Committee proposed a health-based 8-hour TWA limit of 50 EU/m³.

Table 2. Average number of particles per liter of air by particle size

| Particle Size (µm) | Location | | | |
| --- | --- | --- | --- | --- |
| | Grading Room (n=7) | Lunch Room (n=5) | Outdoor | |
| | | | (n=5) | (n=1)* |
| 0.3 | 10,000 | 37,000 | 63,000 | 72,000 |
| 0.5 | 3100 | 4300 | 4000 | 9400 |
| 1.0 | 4300 | 2900 | 1100 | 10,000 |
| 3.0 | 2300 | 840 | 490 | 4900 |
| 5.0 | 310 | 43 | 35 | 840 |
| 10.0 | 310 | 22 | 30 | 1600 |

Each value is the arithmetic mean of n counts, where n = number of measurements.

* This measurement is reported separately because of the apparent difference between the size distribution of particles in this outdoor measurement versus that of the other five outdoor measurements.

## Initial Site Visit: December 5, 2007

Air-conditioner dust and peanuts from each bulk sample were sent to EMLab P&K (Cherry Hill, New Jersey; Phoenix, Arizona) to be analyzed for endotoxin (a component of the cell membrane of Gram-negative bacteria). Samples were analyzed using the LAL assay, kinetic chromogenic method [Cambrex 2005]. For these analyses, 9 EU were equivalent to one nanogram of endotoxin.

The peanut shells that contained crystalline-like structures were prepared and analyzed by polarized light microscopy according to NIOSH Method 9002 [NIOSH 2010]. Microscopy was performed by the NIOSH Division of Applied Research and Technology, Chemical Exposure and Monitoring Branch.

Suspect and nonsuspect peanuts were submitted to the NIOSH Division of Applied Research and Technology, Chemical Exposure and Monitoring Branch, for qualitative headspace analysis of VOCs. Each set of peanuts was provided to the laboratory in a separate plastic bag, with both sets inside a larger plastic bag. Because plastic is known to give off VOCs, headspace samples were collected inside each individual bag containing peanuts, and inside the empty outer bag as a control or blank sample. Headspace samples were collected on stainless steel thermal desorption tubes that contained three beds of sorbent material: Carbopack Y™ (90 mg), Carbopack B™ (115 mg), and Carboxen 1003™ (150 mg). Prior to sampling, the tubes were conditioned by heating at 375°C for 1.5 hours. The thermal desorption tubes were analyzed by an automatic thermal desorption system with an internal focusing trap packed with graphitized carbon sorbents. The thermal unit was interfaced directly to a chromatograph with a mass selective detector. A 30-meter Rtx-1MS fused silica capillary column was used for the analyses. In addition, several peanuts from each set were extracted with methanol. Three peanuts were placed in a 30-milliliter glass vial, about 10 milliliters of methanol was added, and the vials were tumbled gently overnight to aid extraction. The methanol extracts were analyzed by gas chromatography-mass spectrometry.

## Second Site Visit: October 22, 2008

Air samples were collected with endotoxin-free 3-piece 37-mm closed-face cassettes, preloaded with 0.45-µm pore-size polycarbonate membrane filters. Samples were collected with AirCheck2000 personal air sampling pumps (SKC, Eighty Four, Pennsylvania) calibrated at 2 liters per minute preshift and postshift with a DryCal DC Lite primary airflow meter (Bios International Corp., Butler, New Jersey). Endotoxin analysis was performed by EMLab P&K (Cherry Hill, New Jersey; Phoenix, Arizona) using the LAL assay, kinetic chromogenic method. For air sample analysis, 15 EU were equivalent to one nanogram of endotoxin.

An ART Instruments model HHPC-6 handheld airborne particle counter (ART Instruments, Grants Pass, Oregon) was used in the grading room, Shann lunch room, and outdoors. Particle count data were reported during three 21-second periods in the morning, and three periods during the afternoon; 1 liter of air was sampled during each period. The particle counter provided a real-time estimate of the number of airborne particles having an aerodynamic diameter no greater than 10 µm, the upper size limit of the respirable particulate fraction. This information was displayed simultaneously in six size ranges for each sample.

## References

Cambrex [2005]. Limulus Amebocyte Lysate (LAL), Kinetic-QCL. Catalog Number: 50-650U. Walkersville, MD.

NIOSH [2010]. NIOSH manual of analytical methods (NMAM®). 4th ed. Schlecht PC, O'Connor PF, eds. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication 94–113 (August, 1994); 1st Supplement Publication 96–135, 2nd Supplement Publication 98–119; 3rd Supplement 2003–15. [http://www.cdc.gov/niosh/nmam/]. Date accessed: July 2010.

# Appendix B: Occupational Exposure Limits and Health Effects

In evaluating the hazards posed by workplace exposures, NIOSH investigators use both mandatory (legally enforceable) and recommended OELs for chemical, physical, and biological agents as a guide for making recommendations. OELs have been developed by Federal agencies and safety and health organizations to prevent the occurrence of adverse health effects from workplace exposures. Generally, OELs suggest levels of exposure that most employees may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. However, not all employees will be protected from adverse health effects even if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a preexisting medical condition, and/or a hypersensitivity (allergy). In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the employee to produce health effects even if the occupational exposures are controlled at the level set by the exposure limit. Also, some substances can be absorbed by direct contact with the skin and mucous membranes in addition to being inhaled, which contributes to the individual's overall exposure.

Most OELs are expressed as a TWA exposure. A TWA refers to the average exposure during a normal 8- to 10-hour workday. Some chemical substances and physical agents have recommended STEL or ceiling values where health effects are caused by exposures over a short period. Unless otherwise noted, the STEL is a 15-minute TWA exposure that should not be exceeded at any time during a workday, and the ceiling limit is an exposure that should not be exceeded at any time.

In the United States, OELs have been established by Federal agencies, professional organizations, state and local governments, and other entities. Some OELs are legally enforceable limits, while others are recommendations. The U.S. Department of Labor OSHA PELs (29 CFR 1910 [general industry]; 29 CFR 1926 [construction industry]; and 29 CFR 1917 [maritime industry]) are legal limits enforceable in workplaces covered under the Occupational Safety and Health Act. NIOSH RELs are recommendations based on a critical review of the scientific and technical information available on a given hazard and the adequacy of methods to identify and control the hazard. NIOSH RELs can be found in the *NIOSH Pocket Guide to Chemical Hazards* [NIOSH 2005]. NIOSH also recommends different types of risk management practices (e.g., engineering controls, safe work practices, employee education/training, personal protective equipment, and exposure and medical monitoring) to minimize the risk of exposure and adverse health effects from these hazards. Other OELs that are commonly used and cited in the United States include the TLVs recommended by ACGIH, a professional organization, and the WEELs recommended by the American Industrial Hygiene Association, another professional organization. The TLVs and WEELs are developed by committee members of these associations from a review of the published, peer-reviewed literature. They are not consensus standards. ACGIH TLVs are considered voluntary exposure guidelines for use by industrial hygienists and others trained in this discipline "to assist in the control of health hazards" [ACGIH 2009]. WEELs have been established for some chemicals "when no other legal or authoritative limits exist" [AIHA 2009].

Outside the United States, OELs have been established by various agencies and organizations and include both legal and recommended limits. Since 2006, the Berufsgenossenschaftliches Institut für Arbeitsschutz

(German Institute for Occupational Safety and Health) has maintained a database of international OELs from European Union member states, Canada (Québec), Japan, Switzerland, and the United States available at http://www.dguv.de/bgia/en/gestis/limit_values/index.jsp. The database contains international limits for over 1250 hazardous substances and is updated annually.

Employers should understand that not all hazardous chemicals have specific OSHA PELs, and for some agents the legally enforceable and recommended limits may not reflect current health-based information. However, an employer is still required by OSHA to protect its employees from hazards even in the absence of a specific OSHA PEL. OSHA requires an employer to furnish employees a place of employment free from recognized hazards that cause or are likely to cause death or serious physical harm [Occupational Safety and Health Act of 1970 (Public Law 91–596, sec. 5(a)(1))]. Thus, NIOSH investigators encourage employers to make use of other OELs when making risk assessment and risk management decisions to best protect the health of their employees. NIOSH investigators also encourage the use of the traditional hierarchy of controls approach to eliminate or minimize identified workplace hazards. This includes, in order of preference, the use of: (1) substitution or elimination of the hazardous agent, (2) engineering controls (e.g., local exhaust ventilation, process enclosure, dilution ventilation), (3) administrative controls (e.g., limiting time of exposure, employee training, work practice changes, medical surveillance), and (4) personal protective equipment (e.g., respiratory protection, gloves, eye protection, hearing protection). Control banding, a qualitative risk assessment and risk management tool, is a complementary approach to protecting employee health that focuses resources on exposure controls by describing how a risk needs to be managed. Information on control banding is available at http://www.cdc.gov/niosh/topics/ctrlbanding/. This approach can be applied in situations where OELs have not been established or can be used to supplement the OELs, when available.

## Agricultural Dust

Organic dust exposure is known to occur in many agricultural industries. Organic dust is made up of a variety of substances including vegetable products, insect fragments, microbes, endotoxin, pollens, pesticides, and bird and rodent urine and feces, among others. Microbes and their toxins are known biohazards in organic dust, having broad chemical and specific allergenic properties. Acceptable levels of airborne microbes have not been established, primarily because relatively low air concentrations of allergens may cause allergic reactions in susceptible individuals. Approximately one of every six individuals in the United States is reported to have allergies [Blumenthal 1998], with about 30% of the population having the predisposition to becoming allergic [Simon 2000]. It is well known that predisposed individuals exposed to airborne organic dust containing fungal, bacterial, plant, or animal antigens can develop hypersensitivity illnesses, including allergic rhinitis, allergic asthma, and HP to airborne organic materials [Castellan 1995; Balmes 1996a; Melo and Cartier 1996; Rose 1996].

The current strategy for evaluating microbial contamination involves identifying sources of microbial growth and components, and potential routes of spread. Air samples for microbes, endotoxin, or other microbial components can be collected to document the presence of suspected microbial contaminants.

## Endotoxin

Endotoxin is a lipopolysaccharide complex found in the outer cell wall of Gram-negative bacteria that is released when the bacteria die [Hagmar et al. 1990; Olenchock 1997]. Gram-negative bacteria are ubiquitous in the environment. Endotoxin produces a wide range of biological responses including blood vessel changes, inflammation, and allergic reactions. Airborne endotoxin exposures between 45 and 400 EU/$m^3$ have been associated with symptoms of cough, wheeze, shortness of breath, chest tightness and mucous membrane irritation, and signs of acute airflow obstruction [Castellan et al. 1987; Smid et al. 1994; Milton et al. 1996]. Chronic health effects that have been associated with airborne endotoxin exposures include chronic bronchitis, bronchial hyperreactivity, chronic airways obstruction, HP, and emphysema [Castellan 1995]. A permanent decrease in pulmonary function, along with respiratory symptoms, has been reported in epidemiologic studies [Milton 1999]. Endotoxin exposure has also been associated with skin itch and rash [Manfreda et al. 1986], but has not been well documented.

Interactions between endotoxin exposure and smoking may increase the risk of respiratory symptoms [Manfreda et al. 1986]. Experimentally, an interaction between bacterial and fungal spores and endotoxin was shown to enhance the development of ODTS [Kirkhorn and Garry 2000].

Endotoxin has become accepted as a cause for human health effects in recent years; however, no universally accepted OELs have been developed because of the variability of sampling and analytical methods, and because of a lack of data showing a consistent dose-response relationship. The LAL assay is the most commonly used method of analyzing endotoxin [Milton 1999].

In the Netherlands, the Dutch Expert Committee on Occupational Standards has recommended a health-based exposure limit of 50 EU/$m^3$ for exposure to airborne endotoxin in the working environment, averaged over an 8-hour working day [Spaan et al. 2006]. This was based on epidemiologic studies showing evidence of respiratory health effects at concentrations near this level [Castellan et al. 1987; DECOS 1998; Zock et al. 1998]. This exposure limit was later raised to 200 EU/$m^3$ to accommodate economic feasibility for the agricultural industry [DECOS 1998].

## Organic Dust Toxic Syndrome and Hypersensitivity Pneumonitis

HP, which is called "farmer's lung" in agricultural workers, and ODTS have both been related to airborne exposure to high levels of organic dust and endotoxin and have many similarities. Symptoms of both diseases occur 4–8 hours after exposure and result in self-limited flu-like illness with chest tightness, shortness of breath, dry cough, fever, chills, muscle aches, and fatigue. Symptoms of ODTS usually resolve within 2–12 days after removal from exposure and no allergic sensitization occurs. In HP, sensitization develops, and symptoms may progress in one third of patients. ODTS cannot be distinguished from HP by clinical symptoms; further pulmonary evaluation such as PFTs, oxygen saturation, and chest x-ray, is needed. In ODTS, these will be normal [Kirkhorn and Garry 2000]. In HP, oxygen saturation will be low, and PFTs will usually show restrictive lung abnormalities, but may show either restrictive or obstructive abnormalities in chronic disease. Chest x-ray findings may show small, scattered nodules; diffuse, patchy infiltrates (ground glass appearance); linear interstitial markings; or they may be normal. Abnormal findings on bronchoalveolar lavage or high-resolution computerized tomography are often needed to confirm a diagnosis of HP, and lung biopsy is needed in some cases [Balmes 1999b; Lacasse et al. 2003].

A continuum of respiratory illnesses may exist depending on the level of exposure. For example, high-level exposures may cause ODTS-like symptoms but with x-ray findings and decreased oxygen saturation (normally not found with ODTS). Repeated subacute exposures may lead to unrecognized loss of lung function. Persons who develop antibodies (i.e., the body recognizes the foreign substance as an allergen) to molds and thermophilic bacteria, which are commonly found in organic dust, may or may not have allergic symptoms. Up to 90% of those with acute symptoms will have antibodies, but persons without symptoms can also have antibodies, so their presence does not indicate disease. Once a person is sensitized, continued low exposure to organic dust can lead to progressive irreversible lung disease, including emphysema [Kirkhorn and Garry 2000].

## Fungi and Mycotoxin

Like bacteria, fungi are ubiquitous in the environment, and many types of fungi produce mycotoxins. Fungi can produce health effects by four mechanisms: infections (e.g., pulmonary aspergillosis); irritant reactions (e.g., burning, blistering skin); allergic reactions (e.g., allergic rhinitis); and toxic reactions (e.g., gastrointestinal symptoms from ingesting mycotoxins) [Trout et al. 2004]. Mycotoxins are nonvolatile fungal metabolites that do not nourish the fungi or have any apparent physiologic function, but may help reduce competition from other organisms. Many fungi capable of producing mycotoxins do not produce mycotoxins at all times, but appear to be affected by the type of fungi; genetic susceptibility of the host plant; and environmental characteristics such as moisture content, temperature, aeration, microbial population, and stress factors. They are also hard to classify because of their diverse chemical structures and biological effects [Bennett and Klich 2003]. Antibiotics (penicillin), immunosuppressants (cyclosporin A), and cholesterol-lowering medications (lovastatin) are examples of mycotoxins that benefit human health [Sudakin 2003].

Exposure to fungi and their mycotoxins can occur by ingestion, inhalation, or skin contact. Depending on the route of exposure, concentration, and type of mycotoxin, exposure to mycotoxins may lead to a variety of health effects, including toxic effects of the kidney, liver, nervous system, and gastrointestinal tract; birth defects; hormonal imbalance; immunosuppression; cancer; and skin irritation [Bennett and Klich 2003]. The most commonly recognized health effects are from acute or chronic ingestion of mycotoxin-contaminated foods, particularly nuts and grains. This type of exposure has been associated with gastrointestinal illness (nausea, vomiting, diarrhea, abdominal cramping). For example, cases of trichothecene mycotoxicosis from eating bread made from wheat contaminated with *Aspergillus* and *Fusarium* were identified in India [Bhat et al. 1989].

Human illness from mycotoxins has also been associated with bioaerosol exposures in agricultural or industrial environments. Most recent reviews of stachybotryotoxicosis have been in regard to indoor environments; recent reviews regarding occupationally-related agricultural exposure were not found [Sudakin 2003]. Russian investigators reported stachybotryotoxicosis in humans who had contact with straw or hay in areas where horses had the disease [Drobotko 1942]. These individuals reportedly developed severe dermatitis, chest pain, sore throat, bloody rhinitis, cough, and (in some) leucopenia [Drobotko 1942; Newberne 1974; Hintikka 1977]. In experimental human studies, mold placed on the skin reproduced this clinical syndrome [Drobotko 1942; Forgacs 1972]. An outbreak of stachybotryotoxicosis was reported in Eastern Europe in 1977. Twenty-three agricultural workers loading moldy hay developed shortness of breath, sore throat, bloody nasal discharge, and burning and watering eyes. The affected workers also had reddened, swollen, crusted skin on the face, and dermatitis in the groin and buttocks. Employee symptoms occurred within 24 hours of exposure and resolved within 1 week of cessation of exposure [Andrassy 1979; Page and Trout 2001].

## References

ACGIH [2009]. 2009 TLVs® and BEIs®: threshold limit values for chemical substances and physical agents and biological exposure indices. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

AIHA [2009]. 2009 Emergency response planning guidelines (ERPG) & workplace environmental exposure levels (WEEL) handbook. Fairfax, VA: American Industrial Hygiene Association.

Andrassy K, Horvath I, Lakos T, Toke Z [1980]. Mass incidence of mycotoxicoses in Hajdu-Bihar County, translated. Mykosen *23*(3):130–133.

Balmes J [1996a]. Asthma. In: Harber P, Schenker B, Balmes J, eds. Occupational and environmental respiratory disease. St. Louis, MO: Mosby-Year Book, Inc., pp. 189–200.

Balmes J [1996b]. Hypersensitivity pneumonitis. In: Harber P, Schenker B, Balmes J, eds. Occupational and environmental respiratory disease. St. Louis, MO: Mosby Year Book, Inc., pp. 201–215.

Bennett HW, Klich M [2003]. Mycotoxins. Clin Microbiol Rev *16*(3):497–516.

Bhat RV, Ramakrishna Y, Beedu SR, Munshi KL [1989]. Outbreak of trichothecene mycotoxicosis associated with consumption of mould-damaged wheat products in Kashmir Valley, India. Lancet *333*(8628):35–37.

Blumenthal M [1998]. Principles of genetics. In: Middleton E, Ellis E, Yunginger J, Reed C, Adkinson N, Busse W, eds. Allergy principles and practice. 5th ed. St. Louis, MO: Mosby-Year Book, Inc., pp. 28–39.

Castellan RM [1995]. Respiratory health effects of inhaled endotoxins: byssinosis and beyond. In: McDuffie H, Dosman J, Semchuk K, Olenchock S, eds. Agricultural health and safety: workplace, environment, sustainability. Boca Raton, FL: CRC Press, pp. 97–100.

Castellan R, Olenchock S, Kinsley K, Hankinson J [1987]. Inhaled endotoxin and decreased spirometric values: an exposure response relation for cotton dust. N Engl J Med *317*(10):605–610.

CFR. Code of Federal Regulations. Washington, DC: U.S. Government Printing Office, Office of the Federal Register.

DECOS [1998]. Endotoxins: health-based recommended occupational exposure limit. The Hague, Netherlands: Health Council of The Netherlands, Dutch Expert Committee on Occupational Standards.

Drobotko DV [1942]. Stachybotryotoxicosis: a new disease of horses and humans. Report presented at the Academy of Science, USSR, January 12–16, 1942, translated.

Forgacs J [1972].Stachybotryotoxicosis. In: Kadis S, Ciegler A, Ajl S, eds. Microbial toxins. Vol. 8. New York, NY: Academic Press, pp. 95–128.

Hagmar L, Schütz A, Hallberg T, Sjöholm A [1990]. Health effects of exposure to endotoxins and organic dust in poultry slaughter-house workers. Int Arch Occup Environ Health *62*(2):159–164.

Hintikka E [1977]. Stachybotryotoxicosis as a veterinary problem. In: Rodricks J, Hesseltine C, Mehlman M, eds. Mycotoxins in human and animal health. Park Forest South, IL: Pathotox Publishers, pp. 277–284.

Kirkhorn SR, Garry VF [2000]. Agricultural lung diseases. Environ Health Perspect *108*(suppl 4):705–712.

Lacasse Y, Selman M, Costabel U, Dalphin JC, Ando M, Morell F, Erkinjuntti-Pekkanen R, Muller N, Colby TV, Schuyler M, Cormier Y [2003]. Clinical diagnosis of hypersensitivity pneumonitis. Am J Respir Crit Care Med *168*(8):952–958.

Manfreda J, Holford-Strevens V, Cheang M, Warren CPW [1986]. Acute symptoms following exposure to grain dust in farming. Environ Health Perspect *66*:73–80.

Melo JL, Cartier A [1996]. Occupational asthma. In: Harber P, Schenker B, Balmes J, eds. Occupational and environmental respiratory disease. St. Louis, MO: Mosby-Year Book, Inc., pp. 420–432.

Milton DK [1999]. Endotoxin and other bacterial cell-wall components. In: Macher J, ed. Bioaerosols: assessment and control. Cincinnati, OH: American Conference of Governmental Industrial Hygienists, pp. 23-1 to 23-14.

Milton DK, Wypij D, Kriebel D, Walters MD, Hammond SK, Evans JS [1996]. Endotoxin exposure-response in a fiberglass manufacturing plant. Am J Ind Med *29*(1):3–13.

Newberne PM [1974]. Mycotoxins: toxicity, carcinogenicity, and influence of various nutritional conditions. Environ Health Perspect 9:1–32.

NIOSH [2005]. NIOSH pocket guide to chemical hazards. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2005–149. [http://www.cdc.gov/niosh/npg/]. Date accessed: July 2010.

Olenchock S [1997]. Airborne endotoxin, In: Hurst CJ, Knudsen GR, McInerney MJ, Stetzenbach LD, Walter MV, eds. Manual of environmental microbiology. Washington, DC: ASM Press, pp. 661–665.

Page EH, Trout DB [2001]. The role of Stachybotrys mycotoxins in building-related illness. AIHAJ *62*(5): 644–648.

Rose C [1996]. Hypersensitivity pneumonitis. In: Harber P, Schenker B, Balmes J, eds. Occupational and environmental respiratory disease. St. Louis, MO: Mosby-Year Book, Inc., pp. 201–215.

Simon HU [2000]. CRC desk reference for allergy and asthma. Boca Raton, FL: CRC Press, p. 52.

Smid T, Heederick D, Houba R, Quanger PH [1994]. Dust- and endotoxin-related acute lung function changes and work-related symptoms in workers in the animal feed industry. Am J Ind Med *25*(6):877–888.

Spaan S, Wouters IM, Oosting I, Doekes G, Heederik D [2006]. Exposure to inhalable dust and endotoxins in agricultural industries. J Environ Monit *8*(1):63–72.

Sudakin DL [2003]. Trichothecenes in the environment: relevance to human health. Toxicol Letters *143*(2):97–107.

Trout DB, Seltzer JM, Page EH, Biagini RE, Schmechel D, Lewis DM, Boudreau AY [2004]. Clinical use of immunoassays in assessing exposure to fungi and potential health effects related to fungal exposure. Ann Allergy Asthma Immunol *92*(5):483–492.

Zock J, Hollander A, Heederik D, Douwes J [1998]. Acute lung function changes and low endotoxin exposures in the potato processing industry. Am J Ind Med *33*(4):384–391.

# Acknowledgments and Availability of Report

The Hazard Evaluations and Technical Assistance Branch (HETAB) of the National Institute for Occupational Safety and Health (NIOSH) conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer or authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found. HETAB also provides, upon request, technical and consultative assistance to federal, state, and local agencies; labor; industry; and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

The findings and conclusions in this report are those of the authors and do not necessarily represent the views of NIOSH. Mention of any company or product does not constitute endorsement by NIOSH. In addition, citations to websites external to NIOSH do not constitute NIOSH endorsement of the sponsoring organizations or their programs or products. Furthermore, NIOSH is not responsible for the content of these websites. All Web addresses referenced in this document were accessible as of the publication date.

This report was prepared by Loren C. Tapp and David Sylvain of HETAB, Division of Surveillance, Hazard Evaluations and Field Studies. Analytical support was provided by Joe Fernback and Ardith Grote of the Division of Applied Research and Technology, Bureau Veritas North America (Novi, Michigan), and EmLabs P&K (Cherry Hill, New Jersey). Health communication assistance was provided by Stefanie Evans. Editorial assistance was provided by Ellen Galloway. Desktop publishing was performed by Robin Smith.

Copies of this report have been sent to employee and management representatives at FSIS and Shann Peanut Company, the state health department (Georgia Division of Public Health), and the Occupational Safety and Health Administration Regional Office.  The report may be viewed and printed at http://www.cdc.gov/niosh/hhe/. Copies may be purchased from the National Technical Information Service at 5825 Port Royal Road, Springfield, Virginia 22161.

*This page intentionally left blank.*

**Below is a recommended citation for this report:**
NIOSH [2010]. Health hazard evaluation report: skin and respiratory symptoms in peanut inspectors with peanut dust and endotoxin exposure, Ambrose, GA. By Tapp L, Sylvain D. U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, NIOSH HETA No. 2008-0052-3115.

*National Institute for Occupational Safety and Health*

**Delivering on the Nation's promise: Safety and health at work for all people through research and prevention.**

To receive NIOSH documents or information about occupational safety and health topics, contact NIOSH at:

**1-800-CDC-INFO** (1-800-232-4636)

TTY: 1-888-232-6348

E-mail: cdcinfo@cdc.gov

or visit the NIOSH web site at: **www.cdc.gov/niosh.**

For a monthly update on news at NIOSH, subscribe to NIOSH eNews by visiting **www.cdc.gov/niosh/eNews.**

SAFER • HEALTHIER • PEOPLE™