Evaluation of respiratory concerns at a snack food production facility

Kristin J. Cummings, MD, MPH, Chris Piacitelli, MS, CIH, Marcia Stanton, BS, Rachel L. Bailey, DO, MPH

Health Hazard Evaluation Report
HETA 2011-0037-3172
New York
March 2013

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

Tables

Acknowledgments

Abbreviations

ACGIH®	American Conference of Governmental Industrial Hygienists
BOOP	Bronchiolitis obliterans organizing pneumonia
CFR	Code of Federal Regulations
FEV_1	Forced expiratory volume in one second
FVC	Forced vital capacity
HEPA	High-efficiency particulate air
HHE	Health hazard evaluation
Ig	Immunoglobulin
L	Liters
Lpm	Liters per minute
mg/m^3	Milligrams per cubic meter
MSDS	Material safety data sheet
NAICS	North American Industry Classification System
NIOSH	National Institute for Occupational Safety and Health
NSIP	Non-specific interstitial pneumonia
OSHA	Occupational Safety and Health Administration
PBZ	Personal breathing zone
PEL	Permissible exposure limit
ppb	Parts per billion
PPE	Personal protective equipment
REL	Recommended exposure limit
STEL	Short-term exposure limit
TLV	Threshold Limit Value
TWA	Time-weighted average
VOC	Volatile organic compound
VPP	Voluntary Protection Program

Highlights of the NIOSH Health Hazard Evaluation

In December 2010, the National Institute for Occupational Safety and Health (NIOSH) received a confidential employee request for a health hazard evaluation (HHE) at a snack food production facility in New York. The employees submitted the HHE request because of concerns about exposures to flavoring chemicals, seasonings, and materials encountered during cleaning activities, and concerns about lung disease. NIOSH investigators conducted an evaluation that included a visit to the facility in May 2012.

What NIOSH Did

- We interviewed employees, managers, and the company's medical consultant by telephone.
- We reviewed documents, including material safety data sheets, environmental sampling reports, medical records, and the facility's respiratory protection program.
- We toured the facility.
- We conducted in-person, private interviews with 25 employees who were randomly selected by NIOSH from the facility's roster.
- We collected air samples for volatile chemicals during nacho cheese tortilla chip production.
- We collected bulk samples of seasonings and analyzed them in a laboratory for volatile chemicals given off into the air.
- We qualitatively assessed a seasoning hopper's local exhaust ventilation.
- We observed sanitation employees cleaning the processed potato crisp line.
- We collected air samples for sodium hydroxide during sanitation activities.

What NIOSH Found

- Previous air sampling results indicated low concentrations of the butter flavoring chemical diacetyl and higher concentrations of a diacetyl substitute, 2,3-hexanedione, for which toxicity has not been determined.
- Many of the ingredients used at the facility are potential respiratory irritants and/or allergens.

Highlights of the NIOSH Health Hazard Evaluation (continued)

- Many of the cleaning chemicals used at the facility are potential respiratory irritants.
- Material safety data sheets for some seasonings commented on the ability of steam or hot water used during cleaning to increase vapor concentrations. They recommended keeping all heated processes at the lowest necessary temperature to minimize emission of volatile chemicals into the air.
- Material safety data sheets for some seasonings recommended avoiding contact with strong acids, alkali, or oxidizing agents.
- Material safety data sheets for some seasonings recommended the use of chemical-resistant gloves while handling the seasoning.
- An employee developed an uncommon lung disease, hypersensitivity pneumonitis, that treating physicians concluded was related to exposures to organic dusts at the facility.
- Compressed air is used for cleaning in many areas of the facility.
- Sanitation employees periodically clean organic sludge off the surface of an outdoor clarifying tank using pressurized water and no respiratory protection.
- Sanitation employees routinely clean the metered dispensing system and storage containers for a potentially hazardous catalyst used in the production process.
- Handling ventilation filters from the seasoning hoppers, cleaning the carton baler, filling the seasoning bag baler, and sweeping the corn sorting room may generate organic dust in the air.
- Interviewed employees noted respiratory irritation from certain spicy seasonings, but otherwise did not report work-related respiratory symptoms.
- Interviewed employees indicated awareness of the availability of disposable respirators for voluntary use.
- Diacetyl was detected in three air samples at levels that were too low to quantify, and 2,3-pentanedione and 2,3-hexanedione were not detected in any samples.
- Trace amounts of diacetyl were detected in four of the seasoning bulk samples.
- Sodium hydroxide was detected in one air sample at a level that was too low to quantify.

What the Employer Can Do

- Until more is known about the safety of diacetyl substitutes, ensure that ingredients containing these butter flavors are handled as respiratory hazards.
- Follow seasoning manufacturers' recommendations on keeping all heated processes (including sanitation processes using hot water) at the lowest necessary temperature in order to minimize emissions of volatile chemicals into the air.
- Consult with seasoning suppliers and cleaning product suppliers about the possible incompatibility of seasonings with cleaning agents and any need for elimination or substitution.
- Follow seasoning manufacturers' recommendations regarding the use of chemically-resistant gloves.
- Substitute vacuum cleaning with HEPA filters for compressed air cleaning and sweeping wherever feasible.
- Discourage employees from openly shaking or otherwise removing seasoning dust from ventilation filters, and investigate measures that could avoid clogging of the filters.
- Continue to explore ways to reduce dust generation during the handling of seasoning bags, particularly related to filling the seasoning bag baler.
- Require mandatory use of a fit-tested full-facepiece respirator with particulate cartridges for cleaning the clarifying tank.
- Require mandatory use of respiratory protection with HEPA/P100 filters for cleaning the metered dispensing system and storage containers for the catalyst.
- Consider requiring mandatory respiratory protection for other potential dust-generating tasks.
- Encourage employees to report new or ongoing respiratory symptoms, particularly those with a work-related pattern, to the facility's nurse.
- The occurrence of new or ongoing respiratory symptoms in the workforce should prompt consideration of work-related lung disease and re-evaluation of the potential for exposure to respiratory hazards.

What Employees Can Do

- Use local exhaust ventilation systems as instructed by your employer.
- Use caution when handling seasoning bags and ventilation filters to reduce dust generation.
- Follow your employer's rules about mandatory use of respiratory protection and other personal protective equipment and clothing.
- Consider voluntary use of respiratory protection for other tasks that seem dusty.
- Report new or ongoing respiratory symptoms, particularly those with a work-related pattern, to the facility's nurse and your personal physician.

Summary

> A case of an uncommon immune-mediated lung disease occurred in the workforce of a snack food production facility where multiple respiratory irritants and/or allergens are used. We noted opportunities for potential exposure to airborne organic materials that pose a risk of immune-mediated lung disease. We recommend a combination of enhanced engineering controls, modified work practices, and mandatory use of respiratory protection to reduce risk.

In December 2010, the National Institute for Occupational Safety and Health (NIOSH) received a confidential employee request for a health hazard evaluation (HHE) at a snack food production facility in New York. The facility produces potato chips, corn chips, and other savory snack foods. The employees submitted the HHE request because of concerns about exposures to flavoring chemicals, seasonings, and materials encountered during cleaning activities, and concerns about breathing problems and lung disease.

We initiated the evaluation by interviewing employees, managers, treating physicians, the facility's nurse, and the company's medical consultant by telephone. We also reviewed documents provided to NIOSH prior to the site visit, including material safety data sheets. From May 14-16, 2012, we visited the facility. We toured the facility, interviewed managers, the facility's nurse, the respiratory protection program administrator, and 25 randomly selected employees, and observed sanitation activities. We collected air samples during production and sanitation activities and collected bulk samples of seasonings for analysis of volatile organic compounds. We also collected additional documents, including records pertaining to the respiratory protection program.

We found that the facility uses multiple substances that are respiratory irritants and/or allergens and that previous air sampling demonstrated the presence of the butter flavoring chemical diacetyl and diacetyl substitutes. One worker developed an uncommon immune-mediated lung disease, hypersensitivity pneumonitis, during employment that treating physicians concluded was caused by exposures to organic materials at the facility. During our site visit, we noted opportunities for potential respiratory exposure to organic materials from sources including corn and potatoes, seasonings, cardboard, sludge from a clarifying tank, and a catalyst. We detected diacetyl in three air samples at levels that were too low to quantify and found trace amounts of diacetyl in four bulk samples of seasonings. We detected sodium hydroxide in one air sample at a level that was too low to quantify.

Until more is known about the safety of diacetyl substitutes, we recommend that seasonings that contain these substitutes be handled as respiratory hazards. We recommend reducing the potential for respiratory exposures to organic materials through a combination of enhanced engineering controls, modified work practices, and mandatory use of respiratory protection. Results of industrial hygiene evaluations should be interpreted with the

Summary (continued)

knowledge that permissible exposure limits for dust or specific chemicals (where they exist) may not be protective for an immune-mediated health outcome. Employees should be encouraged to report new or persistent respiratory symptoms to the facility's nurse. The occurrence of such symptoms in the workforce should prompt consideration of work-related lung disease, re-evaluation of the potential for exposure to respiratory hazards, and lowering of such exposures.

Keywords: NAICS 311919 (Other Snack Food Manufacturing), hypersensitivity pneumonitis, respiratory symptoms, occupational lung disease, flavorings, diacetyl, organic dust, bioaerosols, seasonings, sanitation, engineering controls, personal protective equipment.

Introduction

In December 2010, the National Institute for Occupational Safety and Health (NIOSH) received a confidential employee request for a health hazard evaluation (HHE) at a snack food production facility in New York. The employees submitted the HHE request because of concerns about exposures to flavoring chemicals, seasonings, and materials encountered during cleaning activities, and concerns about breathing problems and lung disease. The employees indicated that they were not aware of investigations of the facility by the New York State Department of Health and the Occupational Safety and Health Administration (OSHA) done in 2010. We provided the requesting employees with the reports from these previous evaluations, which were focused on exposures to butter flavoring chemicals. After reviewing these reports, in May 2011 the employees reiterated their request for the HHE.

Process Description

The plant employs approximately 500 persons and produces multiple corn, potato, and grain-based snacks. Production activities include receiving, storing, washing, processing, cooking, frying, and packaging. The plant is divided into distinct processing areas, which feed into the packaging area. The processing areas include potato chips, corn chips, tortilla chips, and potato crisps.

Production

Potato chip processing: Potatoes directly from the field are delivered to the processing facility via tractor-trailer trucks several times a day. The potatoes are unloaded onto a conveyor system. An inspection process removes dirt, pebbles, and undesirable potatoes, which are put in a plastic bin. The satisfactory potatoes enter the production process where they are peeled, washed, sliced, and washed again. The process water is treated with a sanitizer to enable re-use. The potato slices enter the fryer. Upon exiting the fryer, unsatisfactory chips are removed and deposited into a bin. The rest of the chips are sorted onto conveyors and seasoned as they move through seasoning tumblers. The potato chips are then conveyed to the packaging area.

Corn chip and tortilla chip processing: There are some differences in production of corn and tortilla chips, but in general corn is delivered via railcars and stored in silos. Corn from the silos is fed into two hoppers in the corn sorting room where it is sorted and sent to the processing area. The corn is processed, which may include soaking and washing. The corn is then ground into meal and cut into the product shape. Tortilla chips are sent through an oven. As with potato chips, the corn chips and tortilla chips are fried and seasoned as they move through seasoning tumblers. In the processing of corn, a catalyst is also added using a metered dispensing system.

Potato crisp processing: This product is made from a blend of potatoes, corn, and grain. The crisps are fed into a fryer and seasoned with salt in a tumbler prior to packaging.

At each processing line in the facility, bags of powdered seasoning are manually emptied into a hopper that feeds the tumbler system. Empty seasoning bags are placed in a bin adjacent to the hopper; each bin is covered with a plastic sheet. The bags are subsequently baled at another location in the plant. In 2003, local ventilation systems with high-efficiency particulate air (HEPA) filters that discharge the filtered air back into the room were installed at the feed areas of the hoppers. Tortilla chip production lines 1 and 2 were also equipped with a local ventilation system in 2005 that includes end caps on the tumblers as well as a seasoning control system serving both tumblers that contains a water bath through which air from the tumblers passes to remove dust particles before the air is sent back into the room. This system was installed for these lines in order to more effectively manage the more frequently used seasonings. Each fryer is equipped with a stack that exhausts hot fryer oil emissions outside through the roof via the chimney effect. Those that are heated with gas also have a gas combustion exhaust stack. The corn chip fryer is insulated, and the insulation is inspected periodically.

Packaging: Loose chips enter the packaging area on conveyor belts and are weighed. The weighing machines are separated by clear plastic curtains. The chips are then packaged into individual bags and then into cardboard boxes for shipping. The packaging machines are operated by packaging machine operators. One of the packaging machines has a vacuum installed to remove broken chips before packaging. Packers fill the cardboard boxes that come from the box drop area. Incoming boxes are sorted and categorized for use in an area adjacent to packaging.

Sanitation

The sanitation process is routinely conducted by trained sanitation personnel who follow a standard process of equipment cleaning and sanitizing. All products used during cleaning and sanitation are stored in color-coded bulk containers in a central location. Members of the sanitation team use a dispensing system for preparation of proper dilutions of product. Cleaning products used include bleach, detergent, sodium hydroxide, nitric acid, and phosphoric acid.

Corn sorting room: The corn sorting room undergoes routine dry sweeping by operators. On a periodic basis, a more extensive cleaning is conducted that includes use of compressed air.

Processing Lines: Detergent and water mixture is added to fill tanks under the potato peeler and slicers and circulated and then drained. Water is then added to rinse out the cleaning chemicals and then a sanitizer is added and run throughout the system. The equipment within processing is rinsed using a combination of low pressure cool water and high pressure hot water (minimum 140° F). After being thoroughly rinsed, a strong alkaline solution is introduced through a foaming process. After proper resident time, the chemical is subsequently removed through high pressure hot water rinse. The frying equipment within processing is also rinsed using a combination of low pressure cool water and high pressure hot water. After being thoroughly rinsed, chemical is introduced to the fryer and mixed with water and then brought up to temperature to "boil out." After boiling out for adequate time, the fryer is drained of the chemical/water mixture and then rinsed thoroughly and the pH checked.

The exterior of the fryer is cleaned using the same process described above. During sanitation, a plastic curtain is drawn around the processing line being cleaned. The building ventilation is changed during the process to maintain the area being cleaned at negative pressure with respect to surrounding areas and keep air from escaping from the enclosed area.

Catalyst system: The metered dispensing system and the storage containers for the catalyst are periodically cleaned.

Packaging: The packaging equipment is cleaned routinely by hand using a combination of cleaning towels, scrapers, and a mild detergent. The areas are first wiped/scraped free of residual snack crumbs. Once minimal residual remains, hard to reach areas may be cleaned using high pressure compressed air, followed by the application of mild detergent. This step is followed by a water rinse to remove any detergent residue and finally, the area is wiped dry to ensure it is clean and sanitized.

Carton baler: The carton baler is manually cleaned periodically.

Clarifying tank: Waste water from production processes is collected in an outdoor clarifying tank. Over the course of several hours, solid matter is allowed to settle out before the water enters the municipal treatment system. The solid matter is removed by an automated system. The clarifying tank is cleaned on an annual basis by two sanitation personnel. The tank is drained and cleaned using high pressure water. This task takes several hours.

Box drop area: This area is routinely swept and a shop vacuum used.

A pest control operator periodically checks pest traps and insect lights, occasionally applies pesticides, and routinely aerates incoming railcars when the corn they are carrying has been treated with phosphine.

Personal Protective Equipment (PPE)

Employees are required to follow Good Manufacturing Practices in all production areas, which includes specific attention to personal hygiene, hair covering, and work practices to prevent product contamination.

Employees in the production areas wear company-provided uniforms and are required to wear steel toe shoes with non-skid soles, hearing protection, and safety glasses/goggles. Employees must go through a Clean Room area where they put on hair covers and beard nets (if applicable), use adhesive rollers on their clothing to remove hair or other debris, and wash their hands with warm water and antimicrobial soap. Finally, employees pass through an air shower to remove any remaining hair and debris before entry to the production area. Jewelry is not allowed in the production area. Workers handling the catalyst at dispensers are required to wear nitrile gloves.

In the production areas, some employees are required to wear rubber, heat resistant, or steel mesh gloves. During the application and rinsing of cleaning/sanitizing chemicals, sanitation personnel are required to wear "full PPE" consisting of waterproof boots, chemical resistant suits made of nylon with a polyurethane film, green rubber gloves, and face shields, in addition to the safety glasses/goggles and hairnets.

The Respiratory Protection Program

The facility has a written respiratory protection program. Disposable N-95 filtering facepiece respirators are required in the corn sorting room during periodic extensive cleaning using compressed air, but not for routine sweeping. Disposable N-95 filtering facepiece respirators are recommended 1) for corn cooks, 2) when cleaning the carton baler, and 3) in the seasoning areas. Maintenance personnel are required to wear half- or full-facepiece respirators with particulate filters when installing or removing insulation at the corn fryers. Pest control operators are required to wear full-facepiece respirators with organic vapor cartridges and particulate filters when applying pesticides and full-facepiece respirators with fumigant cartridges when testing for phosphine gas in the train cars. Half- or full-facepiece respirators are recommended for sanitation personnel who use caustic or acidic cleaning chemicals.

Workers who are required to wear respirators receive annual training, medical evaluation, and qualitative fit-testing. Other workers who choose to use respirators on a voluntary basis receive annual training and review and sign Appendix D (Information for Employees Using Respirators When Not Required under the Standard) of the OSHA Respiratory Protection Standard, 29 Code of Federal Regulations (CFR) 1910.134.

Assessment

Prior to the site visit, we interviewed employees, managers, treating physicians, the facility's nurse, and the company's medical consultant by telephone. We also reviewed documents provided to NIOSH, including reports of prior environmental evaluations by other government agencies and by consultants hired by the company, medical records and workers' compensation records, material safety data sheets (MSDSs) for ingredients and cleaning products, the facility's OSHA Logs of Work-related Injuries and Illnesses for 2006-2011, a facility map, and an employee roster including departments and job titles.

From May 14-16, 2012, we visited the facility. We held an opening meeting with employer and employee representatives. We toured the facility to understand processes, job tasks, controls in place to reduce exposures, and the use of PPE. We interviewed managers, the facility's nurse, and the respiratory protection program administrator. We conducted private interviews about work history and health concerns with 25 employees whom we had randomly selected from the facility's roster to represent a cross-section of the workforce. We collected additional documents, including records pertaining to the respiratory protection program, the hazard communication program, the company's industrial hygiene strategy, PPE requirements, job safety analyses, precautions for handling the sanitizer and the catalyst, and the facility's response to recommendations made by its medical consultant.

We collected air samples for volatile organic compounds (VOCs) during nacho cheese tortilla chip production. Five personal breathing zone (PBZ) and three area air samples were collected using evacuated canisters. The 450-milliliter canisters were equipped with either instantaneous grab sampling attachments (n = 3) or capillary-based flow controllers (n = 5). The air samples were analyzed for VOCs using a pre-concentrator/gas chromatograph/mass spectrometer system pursuant to a recently published method validation study [LeBouf et al. 2012] with the following modifications: the pre-concentrator was a Model 7150 (Entech Instruments, Inc., Simi Valley, California); three additional analyte compounds, the alpha-diketones 2,3-butanedione (diacetyl), 2,3-pentanedione, and 2,3-hexanedione, were included; and qualitatively-identified compounds were compared to National Institute of Standards and Technology 2008 Mass Spectral Library and included in the analytical report if the quality factor was greater than 75%. At present, this canister method is partially validated and is in the process of being reviewed for incorporation into the NIOSH Manual of Analytical Methods.

We also collected bulk samples of seven seasonings that were being used at the time of our air sampling or had ingredients listed in their MSDSs that might contain butter flavoring compounds for headspace analyses using thermal desorption, gas chromatography, and mass spectrometry. Approximately 40 milliters of each seasoning were placed in 50-milliliter sterile polypropylene centrifuge tubes. At the laboratory, a sample of the headspace above each sample was collected at room temperature using a thermal desorption tube and desorbed at 300° C for 10 minutes in a Unity/Ultra automatic thermal desorption system (Markes International, Inc., Cincinnati, Ohio) with an internal focusing trap packed with graphitized carbon sorbents. The thermal unit was interfaced directly to an HP6890A gas chromatograph (Agilent Technologies, Inc., Santa Clara, California) with an HP5973 mass selective detector using a 30-meter HP-1MS fused silica capillary column.

We qualitatively assessed the local exhaust ventilation of a seasoning hopper, using smoke tubes to observe air movement around the seasoning hopper feed area when the door was open during loading of seasonings and when the door was closed. Additionally, we used real-time instruments: a toxiRAE photoionization detector (Model PGM-30, RAE Systems, San Jose, California) to measure total VOCs, and a particulate monitor (pDR-1000AN personal DataRAM, Thermo Scientific Corp., Franklin, Massachusetts) to measure airborne dust, approximately respirable in size.

We observed two sanitation workers cleaning the potato crisp line with a sodium hydroxide cleaner using a foaming process and collected five personal air samples for sodium hydroxide during their sanitation activities. The samples were collected on 37-millimeter diameter, 0.8-micrometer pore size cellulose ester membrane filters in two-piece cassettes at a nominal flow rate of 3 liters per minute (Lpm). The samples were analyzed for sodium using inductively coupled plasma atomic emission spectroscopy according to NIOSH Method 7303 [NIOSH 2003]. Sodium hydroxide results were then calculated from the sodium results assuming all sodium detected was in the form of sodium hydroxide.

At the end of our visit, we held a closing meeting with employer and employee representatives to share our observations and preliminary recommendations.

Results

SUMMARY OF PRIOR INDUSTRIAL HYGIENE EVALUATIONS

The company provided us with reports from nine industrial hygiene consultant investigations at the plant from March 1998 through January 2012. Sampling was conducted for:

- Calcium hydroxide during three investigations and acetic acid and hydrogen peroxide twice in processing areas,
- Sodium hydroxide six times and nitric and phosphoric acids five times during cleaning of equipment,
- Particulates five times on the production lines,
- Diacetyl four times, acetoin and 2,3-hexanedione two times, and 2,3-pentanedione once near application of seasonings,
- Hexavalent chromium three times during stainless steel welding,
- Phosphine once on the pest control operator at the railcars,
- Carbon monoxide three times on forklifts, and
- Noise during five evaluations.

No air concentrations were found to exceed OSHA permissible exposure limits (PELs), American Conference of Governmental Industrial Hygienists (ACGIH®) Threshold Limit Values (TLVs), or NIOSH recommended exposure limits (RELs) [CFR 2012;

ACGIH 2012; NIOSH 2005]. Consultant reports noted noise exposures above the OSHA action level of 85 decibels but below the OSHA PEL of 90 dBA on the A-weighted scale (dBA) in some job classifications. The facility has a hearing conservation program, and employees are required to wear hearing production in all production areas.

We noticed in a November 2008 consultant report a discrepancy between the laboratory-reported air sample volume (33.8 liters [L]) and the volume calculated using the reported sampling time and rate (50 minutes x 0.1 Lpm = 5 L) for nitric acid air sampling. It is possible that the reported 5.9 milligrams per cubic meter of air (mg/m^3) was instead nearly 40 mg/m^3 – well over the short-term exposure limit (STEL) of 10 mg/m^3 for nitric acid. During this same investigation, the consultant surveyed the laboratory hood ventilation system. The consultant measured an acceptable air flow at only one of the two sash height demarcations and recommended removal of the other demarcation.

In an April 2010 industrial hygiene report, the consultant collected four PBZ air samples for particulates not otherwise regulated on employees who empty bags of seasoning into hoppers. Eight-hour time-weighted average (TWA) concentrations ranged from 0.23 mg/m^3 to 3.11 mg/m^3, which were below the OSHA PEL of 15 mg/m^3. The consultant noted that manually compacting the empty bags in bins near the hoppers created visible dust, and he suggested work practice changes to minimize exposure. He also collected a 4.4-hour air sample for diacetyl above a bin for empty seasoning bags between hoppers supplying the nacho cheese and spicy sweet chili lines. He reported 0.57 parts per billion (ppb) of diacetyl. The proposed NIOSH REL for diacetyl is 5 ppb (8-hour TWA) and the proposed 15-minute STEL for diacetyl is 25 ppb [NIOSH 2011]. ACGIH has adopted a TLV for diacetyl of 10 ppb as an 8-hour TWA and 20 ppb as a 15-minute STEL [ACGIH 2012].

In May 2010, OSHA visited the facility after a complaint was filed by a local occupational medicine physician about employees "experiencing breathing difficulties following exposure to flavorings and seasonings used in manufacturing, and cleaning chemicals used during sanitation process." OSHA and an industrial hygiene consultant hired by the facility collected concurrent air samples. On PBZ samples from a tortilla chip line operator, the consultant detected 3.02 ppb of diacetyl, 3.98 ppb of acetoin, and 234 ppb (subsequently recalculated as 159 ppb) of 2,3-hexanedione, while OSHA detected 1.7 ppb of diacetyl and no acetoin or 2,3-hexanedione. There are no occupational exposure guidelines for acetoin or 2,3-hexanedione. Concurrent PBZ air samples for sodium hydroxide, phosphoric acid, and nitric acid on workers cleaning equipment such as fryers and ovens found air concentrations below the established occupational exposure limits of OSHA and ACGIH.

In July 2010, the New York State Department of Health collected samples for flavoring compounds at the facility and requested technical assistance from NIOSH to provide air sampling equipment and analytical laboratory services. Industrial hygienists from the health department collected bulk samples and area and PBZ air samples at the facility. Headspace analyses detected diacetyl, 2,3-pentanedione, 2,3-hexanedione, and acetoin in two bulk samples of ingredients. When the area and PBZ air samples were tested for diacetyl, 2,3-pentanedione, 2,3-hexanedione, and 2,3-heptanedione, none of these flavoring compounds were detected in the area air sample collected at a tortilla chip line seasoning hopper or PBZ air sample collected on a worker at the tortilla chip line whose job included emptying seasonings into the hopper. The minimum detectable concentrations ranged from 2 to 3 ppb for the samples. The NIOSH proposed REL for 2,3-pentanedione is 9.3 ppb TWA with a proposed STEL of 31 ppb [NIOSH 2011]. Occupational exposure guidelines do not exist for 2,3-heptanedione. Two other air samples were also collected for total VOC screening using thermal desorption tubes; however, these samples may have been mislabeled or contaminated, and therefore were uninterpretable. The consultant again collected concurrent samples in addition to a PBZ air sample on a worker who cleaned conveyors in the packaging area. Concentrations of diacetyl, acetoin, and 2,3-hexanedione were below the analytical laboratory's limit of detection for these three air samples. The minimum detectable concentrations ranged from 3.5 ppb to 6.1 ppb for diacetyl; 3.4 ppb to 6.0 ppb for acetoin; and 530 ppb to 930 ppb for 2,3-hexanedione.

The January 2012 industrial hygiene survey included PBZ sampling for diacetyl and 2,3-pentanedione on workers using nacho cheese seasoning during tortilla chip production. Diacetyl concentrations were less than 1.7 ppb and 2.4 ppb for the 3-hour and 2-hour sampling periods, respectively, while 2,3-pentanedione concentrations were less than 5.7 ppb and 8.3 ppb.

SUMMARY OF PRIOR MEDICAL CONSULTANT EVALUATION

In 2011, the company requested that a pulmonary physician review information pertaining to employee occupational respiratory health. The consultant recommended that the facility 1) develop processes to ensure engineering controls were functionally effective, 2) fine-tune work practices to minimize exposure to airborne seasonings, and 3) train employees on the types of adverse health effects that are associated with materials used in the facility and how to minimize such exposures. In response, the facility reported that it 1) developed process control sheets that are filled daily by operators, 2) had the air handling units inspected to ensure they met and exceeded state regulations, 3) developed an employee input protocol for optimal ventilation during cleaning activities, 4) provided training to workers on numerous occasions, and 5) encouraged employees to report work-related concerns to the facility's safety and occupational health coordinator.

NIOSH EVALUATION

Workplace Observations and Employees' Reports

We found the facility clean and organized. We observed employees in the production area wearing facility uniforms, hair covers, beard nets (if applicable) and PPE such as hearing protection, eye protection, and steel-toe shoes with non-skid soles. N95 filtering facepiece respirators were available for use and "recommended," though not "required," for some areas or tasks.

We noted opportunities for potential respiratory exposure to organic particles. In production, we noted that manually emptying bags of powdered seasonings into a hopper that feeds the tumbler system may generate dust. We observed workers using different handling techniques, from very gentle to aggressive, when cutting and emptying seasoning bags into seasoning hoppers and disposing of seasoning bags in the waste bag bins. Some of these techniques generated plumes of dust in the worker's breathing zone. Each waste bin had a plastic cover.

Local exhaust ventilation was installed on the seasoning hoppers to reduce operators' exposure to dust while loading the hoppers. However, employees described attempting to clean clogged filters by removing the filters from the ventilation units and shaking them in the open or hitting them against the hoppers. This activity would be expected to generate airborne dust. In addition, employees indicated that filling the seasoning bag baler with the used bags was a dusty task. Formal industrial hygiene evaluation of this task had not been conducted prior to the NIOSH visit.

We noted that compressed air is used for cleaning in many areas of the facility during sanitation. This practice has the potential to create exposures to irritating or sensitizing ingredients found in settled dust. In addition, routine cleaning of the corn sorting room involves sweeping, which may generate organic dust. Formal industrial hygiene evaluation of this task had not been conducted prior to the NIOSH survey. Furthermore, the periodic cleaning of the carton baler was described by employees as a dusty task. Formal industrial hygiene evaluation of this task had not been conducted prior to the NIOSH survey. Another task that could aerosolize organic material, including microbial antigens, is the cleaning of the clarifying tank.

We observed two instances of employees who were not wearing the jacket component of the chemical suit while using pressurized water to rinse chemicals from equipment. The PPE matrix provided by the company indicated that the jacket component was required for this task. The employees' exposed skin (arms and face) became extremely wet from splashing, which may present an opportunity for dermal exposure to cleaning chemicals.

MSDS Review

We reviewed 45 unique MSDSs for materials used at the facility, including 30 seasonings, 10 cleaning products, four other ingredients, and the sanitizer added to the process water to enable its re-use. The cleaning products contained a variety of agents, including bleach (sodium hypochlorite), acids, and sodium hydroxide. All of the MSDSs that we reviewed indicated that the material posed both skin and eye irritant hazards. In addition, 43 MSDSs indicated that the material posed a respiratory irritant hazard. Eleven MSDSs, including those for 10 different seasonings and the one for the catalyst, indicated that the material posed an allergic hazard. Although none of the MSDSs for the cleaning products mentioned an allergic hazard, we noted that two of the cleaning products contained quaternary ammonium compounds, which have been described as sensitizers [Quirce and Barranco 2010]. Several of the seasoning MSDSs commented on the ability of steam or hot water used during cleaning to increase vapor concentrations. The MSDSs recommended keeping all heated processes at the lowest necessary temperature to minimize emission of volatile chemicals into the air. In addition, in the section on Stability and Reactivity, some seasoning MSDSs recommended avoiding contact with strong acids, alkali, or oxidizing agents. Finally, some seasoning MSDSs recommended the use of chemical-resistant gloves while handling the seasoning.

Health Concerns

Interviewed employees noted concerns about respiratory irritation from certain spicy seasonings, exposure to cardboard dust, dust generated when shaking out filters from the seasoning hopper, dust generation during baling of seasoning bags, skin irritation from sweating, excessive heat in the facility during the summer months, and ergonomic issues for some tasks that involve heavy lifting. They were generally aware of the availability of disposable respirators for voluntary use, although few reported using these respirators.

We found that a facility employee developed an uncommon lung disease, hypersensitivity pneumonitis, during employment. This condition occurs when a person's immune system becomes sensitized and reacts to something that a person repeatedly breathes into the lungs from his or her environment. Typically the sensitizing material comes from plants, animals, bacteria, or fungi. The immune reaction causes inflammation in the lungs and symptoms such as shortness of breath, cough, fever, and fatigue. The symptoms may improve when the person is away from the sensitizing material. Over time, if the person continues to breathe in the sensitizing material, irreversible scarring of the lungs can occur, leading to permanent disability or death. Additional details about this case follow, with the employee's written permission.

Case report: A 32-year-old man without a history of respiratory illness or smoking began working at the facility in 1998. A spirometry test at hire showed forced vital capacity (FVC) of 5.81 L (92% of predicted), forced expiratory volume in 1 second (FEV_1) of 4.09 L (80% of predicted), and FEV_1/FVC ratio of 70%. He worked in the sanitation department from 1998 to 2003 and moved to the packaging department in 2003. In 2008, he returned to the sanitation department, with tasks as described in the section of this report entitled Process Description, Sanitation.

In early 2009, he noted onset of watery eyes, nasal congestion, sneezing, and cough that he initially attributed to a cold. His symptoms progressed, and he began to experience shortness of breath, particularly on exertion, and chest tightness, accompanied by fatigue, intermittent chills and fevers, and weight loss. His worsening cough was generally dry. Tasks at work that exacerbated his symptoms included cleaning processing lines and fryers using chemical cleaners and high pressure water, cleaning in packaging using compressed air, baling used seasoning bags, cleaning the carton baler, handling the sanitizer, cleaning the clarifying tank, and cleaning the metered dispensing system and the storage containers for the catalyst. He did not use respiratory protection for any tasks. In mid-2009, he transferred back to packaging due to his declining health, but his symptoms continued to worsen. He noticed that he developed blisters on the palms of his hands after dry-wiping spicy seasonings off packaging machines.

In late 2009, he sought medical care for his symptoms, first with primary care and later with pulmonary and occupational medicine specialists. Spirometry showed FVC of 3.39 L (57% of predicted), FEV_1 of 2.67 L (57% of predicted), and FEV_1/FVC ratio of 79%. There was no significant response to bronchodilator. Total lung capacity by plethysmography was 6.96 L (90% of predicted) and residual volume was 3.20 L (152% of predicted), indicating air trapping. His diffusing capacity was 29.15 milliliter per minute per millimeter of mercury (77% of predicted). High-resolution computed tomography (HRCT) of the chest with contrast showed diffuse centrilobular ground-glass opacities and mosaic attenuation, but no evidence of thromboemboli. The HRCT also showed enlargement of the main pulmonary artery consistent with pulmonary hypertension. Oxygen saturation on room air was 87% at rest and 83% with ambulation. He was started on supplemental oxygen, which he used when he was not at work. His symptoms did not improve with a one-week trial of an oral corticosteroid medication (prednisone). He began to experience difficulty getting to his vehicle at the end of a shift due to severe shortness of breath and fits of cough productive of bloody sputum (hemoptysis). He also noted blurry vision, dizziness, and nausea that was brought on by smells at work. He did not respond to a combination inhaler containing a bronchodilator and a corticosteroid (Advair) or to another one-week trial of prednisone. He left work in March 2010, at which point he had lost 70 pounds. He was short of breath at rest and remained hypoxic, with an oxygen saturation of 90-94% at rest with supplemental oxygen at 4 Lpm.

He ultimately underwent thoracoscopic lung biopsy that revealed mild, cellular chronic interstitial pneumonia consistent with chronic hypersensitivity pneumonitis. It was accentuated around the bronchioles and characterized by a lymphoplasmacytic infiltrate within alveolar septae. There were scattered lymphoid follicles with germinal centers and scattered multinucleated giant cells and loose non-necrotizing granulomas, especially in peribronchiolar interstitium. An extensive search did not identify a specific cause. Erythrocyte sedimentation rate was normal. Serum rheumatoid factor was elevated at 31, but other serologies (anti-CCP, anti-SSA, anti-SSB, anti-SCL70, ANA profile, ANA pattern and titer) were normal. Serum immunoglobulin (Ig)G was elevated and serum IgA and IgM were normal. Serum precipitins to grain dust and, since he was known to keep a pet lovebird in his home, to parakeet droppings, parrot droppings, lovebird serum, and lovebird droppings, were analyzed, and all were negative.

Away from work, he noted improvement in his symptoms. He experienced prompt resolution of the eye and nasal symptoms, the hemoptysis, and the fever and chills. Over time, his cough gradually improved, and he began to gain back some of the weight he had lost. One year after leaving the workplace, his cough had nearly resolved, and his breathlessness had improved somewhat, though he remained short of breath at rest and on exertion. Spirometry showed FVC of 4.79 L (84% of predicted), FEV_1 of 3.60 L (80% of predicted), and FEV_1/FVC ratio of 75%. Diffusing capacity was 37.6 ml/mmHg/min (91% of predicted). Four months later, there was evidence of further improvement in lung function. Spirometry in August 2011 showed FVC of 5.14 L (90% of predicted), FEV_1 of 3.96 L (85% of predicted), and FEV_1/FVC ratio of 77%. Diffusing capacity was 38.2 ml/mmHg/min (117% of predicted). At rest on room air, oxygen saturation was 94% but fell to 91% during a short walk on supplemental oxygen at 2 Lpm. He remained on supplemental oxygen at night and as needed. In late 2011, exercise tolerance testing on room air showed reduced exercise tolerance (66% of predicted workload and 59% of predicted oxygen consumption). Arterial blood gas analysis on room air showed a low partial pressure of oxygen of 59 mm Hg, corresponding to an oxygen saturation of 90%. Total lung capacity was 8.6 L (110% of predicted), and residual volume was 3.44 L (181% of predicted), demonstrating persistent air trapping.

On the basis of the clinical, radiological, and histopathological findings, he was diagnosed with hypersensitivity pneumonitis. Multiple consulting physicians concluded that his disease was caused by workplace exposures at the facility. They cited the likely exposure to airborne organic materials in the workplace, the substantial improvement in his clinical status following removal from the workplace, the absence of findings of autoimmune disease, the absence of immune response to the lovebird in his home, and the improvement despite the persistence of the lovebird in his environment.

Our review of the OSHA Logs of Work-related Injuries and Illnesses for 2006-2011, in-person interviews with 25 employees, and outreach to area pulmonologists did not reveal additional cases of hypersensitivity pneumonitis or other lung disease in employees of this facility as of mid-2012.

NIOSH Air Sampling

Diacetyl, 2,3-pentanedione, and 2,3-hexanedione were not detected in the five PBZ canister samples from the processing line operators during nacho cheese tortilla chip production, as shown in Table 1. The detection limits ranged from 2.8 to 6.0 ppb for diacetyl, 3.4 to 7.2 ppb for 2,3-pentanedione, and 3.2 to 6.8 ppb for 2,3-hexanedione. Although diacetyl was detected in three area samples collected instantaneously near the seasoning hopper, it was not quantifiable. Because it was detected between the detectable level of 1.3 ppb and the quantifiable level of 4.3 ppb, the reported concentrations of 1.4 to 1.7 ppb are considered estimates. The area samples did not detect 2,3-pentanedione or 2,3-hexanedione (detection limits of 1.5 and 1.6 ppb, respectively). The detection limit for one of the PBZ samples (6.0 ppb) was higher than the NIOSH proposed REL for diacetyl of 5 ppb; all other limits of detection and estimated concentrations were below any proposed or established occupational exposure guideline values. Ethanol, acetone, and isopropyl alcohol were detected in the canister samples at concentrations less than 1 part per million and well below any occupational exposure guidelines.

Table 2 shows the headspace analyses of bulk samples of seasonings. Trace amounts of diacetyl, but no other alpha-diketone compounds, were found in four of the seven samples: barbeque, honey barbeque, cheddar sour cream, and chili cheese.

In our qualitative ventilation assessment of the seasoning hopper's local exhaust ventilation at tortilla chip line 2, smoke was drawn into the hopper from all points in the feed zone where bags of seasoning are loaded with the door open. With the door closed, air flow was neutral at the door seams. Using the real-time particulate and VOC monitors at the rear filter exhaust of the seasoning hopper, we found no change in the concentrations of 1.1 parts per million total VOCs and 0.4 mg/m^3 particulate immediately before and while loading seasoning from a bag.

During the sanitation activities at the potato crisp line, sodium hydroxide was detected on one sample collected for 289 minutes on a sanitation worker (Table 3). The estimated concentration of 0.02 mg/m^3 was between the detectable level of 0.01 mg/m^3 and the quantifiable level of 0.04 mg/m^3 for the sample. The other worker's long-term sample was not at a detectable concentration, and the 16-minute samples collected on both workers were each less than their detectable concentration of 0.21 mg/m^3. These measurements were well below the occupational exposure guidelines. The OSHA PEL for sodium hydroxide is an 8-hour time-weighted average of 2 mg/m^3. The NIOSH REL and ACGIH TLV are ceiling limits of 2 mg/m^3 that should not be exceeded at any time.

Discussion

We responded to an HHE request from employees at a snack food production facility who expressed concerns about exposure to flavoring chemicals, seasonings, and materials encountered during cleaning activities, and respiratory health.

Flavorings (alpha-diketones)

Air sampling results from prior evaluations conducted by government agencies and private consultants hired by the company indicated low concentrations of the butter flavoring chemical diacetyl and higher concentrations of a diacetyl substitute, 2,3-hexanedione, for which toxicity has not been determined. Our air sampling also found low concentrations of diacetyl, while 2,3-pentanedione and 2,3-hexanedione were not detected. Occupational exposure to diacetyl can cause bronchiolitis obliterans, a rare lung disease in which the lung's small airways become scarred, leading to breathlessness [NIOSH 2011]. It is important to note that bronchiolitis obliterans is distinct from hypersensitivity pneumonitis, the lung disease diagnosed in one of this facility's employees. Studies of laboratory animals exposed to the diacetyl substitute 2,3-pentanedione indicate that it is also toxic to the respiratory system [Morgan et al. 2012; Hubbs et al. 2012]. Little is known about the toxicity of other diacetyl substitutes including 2,3-hexanedione.

Seasonings

We reviewed MSDSs for 30 seasonings used at the facility. All of these seasonings were noted by their manufacturers to be respiratory irritants and 10 were noted to be allergens. Seasonings are a diverse group of substances, many plant-derived, with potential respiratory health effects. Seasonings were implicated in a disabling case of bronchiolitis obliterans organizing pneumonia (BOOP) that occurred in a worker at another snack food production facility [Allenman and Darcey 2002]. In that case, the worker's primary responsibility was to empty bags of seasoning into a hopper, a task he described as "very dusty." Immune reactions to curry powder and ground pepper were associated with a fatal case of non-specific interstitial pneumonia (NSIP) in a curry sauce production facility [Ando et al. 2006]. Allergy to some seasonings (paprika, coriander, mace, garlic, onion, and chili pepper) has been associated with occupational asthma [Sastre et al. 1996; Añibarro et al. 1997; van der Walt et al. 2010]. In spice factory workers, immune response to spice dust was common (73%) and associated with respiratory symptoms of cough, chest tightness, and throat irritation [Zuskin et al. 1988].

Cleaning products

In our review of MSDSs for 10 cleaning products used at the facility and the sanitizer added to process water to enable its re-use, all but two were noted by their manufacturers to be respiratory irritants. The cleaning compounds included acidic and caustic agents. Two of the cleaning compounds contained quaternary ammonium compounds. Company consultant air sampling has always found cleaning compound components to be present only at levels below occupational exposure guidelines, as did our sampling for sodium hydroxide during a cleaning operation; however, the discrepancy in reported values for nitric acid during one company sampling event raised the possibility of an overexposure. Although nitric acid was found at acceptable levels on other occasions, it may be useful to investigate any apparent differences in the conditions that may have led to the possible higher exposure so that overexposures can be avoided in the future. Cleaning products (including bleach, sodium hydroxide, and quaternary ammonium compounds) pose a risk of asthma, which may occur through an irritant or allergic mechanism [Quirce and Barranco 2010; Labrecque 2012]. In addition, acute respiratory distress syndrome in relation to exposure to cleaning products has been reported [Mapp et al. 2000]. Furthermore, the health effects of combining cleaning products with seasonings during sanitation activities are unknown, but some seasoning MSDSs suggested this may pose a hazard.

The facility-provided PPE matrix prescribes the use of a full chemical suit during application of chemicals as well as during rinsing of chemicals from equipment. The matrix does not require the use of a full chemical suit during rinsing activities not involving the use of chemicals. We observed employees rinsing chemicals without the chemical suit jacket. Because of the potential for splashing of chemicals during the rinsing process, we agree with the matrix that a full chemical suit should be utilized during rinsing activities.

Hypersensitivity pneumonitis

We found that an employee developed an uncommon immune-mediated lung disease, hypersensitivity pneumonitis, that treating physicians concluded was related to exposures to sensitizing organic dusts at work. Hypersensitivity pneumonitis has been reported with exposure to a wide variety of antigens including from fungi, bacteria, animals, and insects [Selman et al. 2012]. Because this condition involves an immune response, sensitized individuals may react to a relatively small amount of an organic agent and PELs, if they exist, may not be protective [NIOSH 1998]. During our visit, we noted the following multiple opportunities for exposure to organic materials that could pose a risk of hypersensitivity pneumonitis:

Corn and Potatoes

It has long been recognized that whole kernel corn is commonly infected by fungal species [Bothast et al. 1974; Greene et al. 1992] and that unpeeled and peeled raw potatoes are associated with multiple bacteria and fungi [Doan and Davidson 2000]. Corn dust contaminated by fungi and bacteria was implicated in a case of hypersensitivity pneumonitis in a farm worker who grew and stored corn [Moreno-Ancillo et al. 2004]. Immune reaction to fungal antigens was associated with hypersensitivity pneumonitis in an onion and potato sorter [Merget et al. 2008]. We noted that routine sweeping in the corn sorting room may generate airborne corn dust and that using compressed air for cleaning in production and packaging areas may generate airborne corn and potato dust that may contain fungal or bacterial materials.

Seasoning

The diagnosis of hypersensitivity pneumonitis can be challenging, as lung biopsy specimens do not always reveal the classic findings of granulomatous inflammation. Hypersensitivity pneumonitis may mimic BOOP or NSIP pathologically [Lacasse et al. 2012]. Thus, the occurrence of BOOP in a snack food worker who emptied bags of seasonings into a hopper [Allenman and Darcey 2002] and NSIP in a curry sauce worker [Ando et al. 2006] may actually reflect a risk of hypersensitivity pneumonitis with seasoning exposures. We found that although the company has been proactive in installing engineering controls to reduce seasoning exposures, some work practices may create opportunities for exposure to seasoning dust. These practices include attempts to clean clogged filters from the local exhaust ventilation on the seasoning hoppers, placing empty seasoning bags in bins, and filling the seasoning bag baler. Unfortunately, in the case of the clogged filters, the engineering control provided to prevent worker exposure to seasonings during the hopper loading is presenting a new source of potential exposure. The fact that workers need to unclog its filters suggests the current system for keeping the filters clear needs to be improved.

Cardboard

An investigation of an outbreak of hypersensitivity pneumonitis in an industrial setting demonstrated that corrugated cardboard dust (and heating-cooling ventilation units containing open spray chambers) contaminated with the fungus *Aureobasidium pullulans* was a source of exposure that contributed to disease [Woodard et al. 1988]. In that outbreak, some affected workers required removal from exposure to corrugated cardboard to prevent symptoms. During our visit, we noted that activities associated with the area where incoming boxes are sorted and categorized for use could generate airborne cardboard dust. In particular, cleaning out the carton baler may result in exposure to cardboard dust that might contain fungal materials.

Clarifying Tank Contents

Hypersensitivity pneumonitis can occur with exposure to a variety of bioaerosols of rotting plant materials (grains, sugarcane, mushrooms, compost, cork, wood) or contaminated water systems [Selman et al. 2012]. The clarifying tank serves as a holding tank for a mixture of water and solid plant materials that are undergoing decomposition, accounting for the accumulation of sludge on the surface of the tank. This mixture would be expected to contain multiple microbial antigens from both bacteria and fungi. The annual cleaning activities by sanitation personnel using high pressure water likely generate bioaerosol exposures, which could pose a risk for hypersensitivity pneumonitis.

Catalyst

The catalyst used at the facility is noted by its manufacturer to cause allergic respiratory reactions. Given that similar catalysts have been associated with hypersensitivity pneumonitis [Selman et al. 2012], it is feasible that the catalyst used at the facility could pose a similar risk for this immune-mediated lung disease. Cleaning the metered dispensing system and the storage containers may create exposure opportunities.

Respiratory Protection

With the exception of periodic extensive cleaning of the corn sorting room using compressed air, the facility does not require mandatory respiratory protection for any of these potential exposures. The facility does indicate that respirators are "recommended" for some of these potential exposures.

Conclusions

The facility uses multiple substances that are respiratory irritants and/or allergens, and air sampling has demonstrated use of diacetyl and diacetyl substitutes. One worker developed hypersensitivity pneumonitis during employment and improved away from work, suggesting a workplace exposure was responsible. Reducing the risk of work-related immune-mediated lung disease in a facility with multiple potential causative agents is challenging. It requires a prudent approach that does not rely solely on PELs, which may not be protective for this type of health outcome.

While many controls are already in place to reduce exposures to airborne organic materials, flavorings, and cleaning chemicals, we

Conclusions (continued)

noted potential opportunities for exposure during our site visit that can be addressed through enhanced engineering controls, modified work practices, and mandatory use of respiratory protection.

Recommendations

On the basis of our findings, we recommend the following actions to create a more healthful workplace.

Elimination and Substitution

Elimination and substitution of a toxic/hazardous process material have traditionally been highly effective means for reducing hazards. However, these may not be feasible approaches in this facility, given the array of potential hazards that might be subject to elimination or substitution and the limited information on the toxicity of substitutes. Substitution for diacetyl is particularly challenging, as little is known about the health effects of substitute flavorings. Available information on the diacetyl substitute 2,3-pentanedione indicates that it has similar toxicity to diacetyl, which raises concerns that other substitutes with similar chemical structure may also be respiratory toxins.

1. Until more is known about the safety of diacetyl substitutes, handle ingredients that contain these butter flavoring chemicals as respiratory toxins.
2. Given cautions in some seasoning MSDSs about avoiding contact with strong acids, alkali, or oxidizers, consult with seasoning suppliers and cleaning product suppliers about the compatibility of seasonings with cleaning agents and, if incompatibilities are identified, the need for elimination or substitution.

Engineering Controls

Engineering controls reduce exposures to employees by removing the hazard from the process or placing a barrier between the hazard and the employee. Engineering controls can be very effective at protecting employees without placing primary responsibility of implementation on the employee.

1. Substitute vacuum cleaning with HEPA filters for compressed air cleaning and sweeping throughout the

facility wherever feasible.

2. Investigate new engineering measures to prevent the clogging of the filters used for the local ventilation of the seasoning hoppers. Monitoring pressure differentials across the hopper may be useful in evaluating the effectiveness of controls.
3. Explore engineering controls, such as local exhaust ventilation, to reduce dust generation during the handling of seasoning bags, particularly related to filling the seasoning bag baler.
4. If not already done, follow the recommendations of the previous consultant regarding the laboratory hood sash demarcation.

Administrative Controls

Administrative controls are employer-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 employer commitment and employee acceptance. Regular monitoring and reinforcement is necessary to ensure that control policies and procedures are not circumvented in the name of convenience or production efficiency.

1. Follow seasoning MSDS recommendations on keeping all heated processes (including sanitation processes using hot water) at the lowest necessary temperature in order to minimize emissions of volatile chemicals into the air.
2. Develop and disseminate clear guidelines for the maintenance and replacement of the filters from the local exhaust ventilation on the seasoning hoppers. Employees should be discouraged from attempting to openly shake or otherwise remove dust from clogged filters.
3. Continue to explore work practices to reduce dust generation during the handling of seasoning bags, particularly related to filling the seasoning bag baler. Continue to keep the bins for empty seasoning bags covered.
4. Encourage employees to report respiratory symptoms to the facility's nurse. The occurrence of new or ongoing respiratory symptoms in the workforce should prompt consideration of work-related lung disease and re-evaluation of the potential for exposure to respiratory hazards.

Personal Protective Equipment (PPE)

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 employer and employee involvement and commitment to be effective.

Determining the need for respiratory protection in the face of an immune-mediated lung disease is challenging. In addition to traditional sources of information such as PELs and industrial hygiene sampling results, managers should consider the substance's potential to stimulate the immune system, even at relatively low levels of exposure.

1. Follow seasoning MSDS recommendations regarding the use of chemically resistant gloves.
2. Ensure the PPE matrix outlining personal protection requirements during chemical handling and cleaning processes is followed.
3. Require mandatory use of a fit-tested full-facepiece respirator with particulate cartridges for cleaning the clarifying tank. Although this task is conducted relatively infrequently, the likelihood of microbial growth on the tank, the use of pressurized water, and the length of time the task takes suggest the potential for substantial bioaerosol exposure.
4. Require mandatory use of respiratory protection with HEPA/P100 filters (as per the product MSDS) for cleaning the metered dispensing system and storage containers for the catalyst, which is a recognized allergen and may be similar to other substances that have been known to cause immune-mediated lung disease.
5. Consider requiring mandatory use of respiratory protection for tasks that have the potential to generate organic dust. These tasks include cleaning the carton baler, filling the seasoning bag baler, and sweeping the corn sorting room. If formal industrial hygiene evaluations are conducted to inform decisions about respiratory protection, consider that traditional PELs may not be protective for immune-mediated lung disease.
6. Continue the hearing conservation program.

Recommendations (continued)

Other Issues

1. Investigate any apparent differences in the conditions that may have led to the possible higher exposure to nitric acid on one occasion in November 2008, so that future occurrences can be avoided.

Update since Site Visit

On October 18, 2012, a team from OSHA visited the facility for a Voluntary Protection Program (VPP) evaluation. As part of the VPP evaluation, the VPP team leader met with the facility's manager to discuss the HHE and the preliminary recommendations that we made during our site visit in May 2012.

Our preliminary recommendations and the facility's responses follow.

1. Consider ways of incorporating vacuum cleaning in place of the use of compressed air throughout the plant.

Response: The manager reported that the facility had taken multiple steps to reduce the use of compressed air for cleaning. These steps included the introduction of vacuums into the packaging area and the development of new cleaning protocols in the production areas.

2. Require mandatory use of a full-facepiece respirator for employees conducting cleaning of the clarifying tank.

Response: The manager reported that the company agreed with this recommendation and was in the process of identifying one to two employees for medical clearance and respirator fit testing, so that employees could use respiratory protection during cleaning of the clarifying tank in the future.

3. Conduct further assessment of the need for mandatory respiratory protection for tasks that may be dusty, including cleaning the box baler, filling the seasoning bag baler, and sweeping the corn sorting room.

Response: The manager reported that the company agreed to evaluate these tasks for respirator usage.

References

ACGIH [2012]. 2012 TLVs® and BEIs®: threshold limit values for chemical substances and physical agents and biological exposure indices. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

Alleman T, Darcey DJ [2002]. Case report: bronchiolitis obliterans organizing pneumonia in a spice process technician. J Occup Environ Med *44*(3):215-216.

Ando S, Arai T, Inoue Y, Kitaichi M, Sakatani M [2006]. NSIP in a curry sauce factory worker. Thorax *61*(11):1012-1013.

Añibarro B, Fontela JL, De La Hoz F [1997]. Occupational asthma induced by garlic dust. J Allergy Clin Immunol *100*(6 Pt 1):734-738.

Bothast RJ, Rogers RF, Hesseltine CW [1974]. Microbiology of corn and dry milled corn products. Cereal Chemistry *51*(6):829-838.

CFR [2012]. Code of Federal Regulations. Washington, DC: U.S. Government Printing Office, Office of the Federal Register.

Doan CH, Davidson PM [2000]. Microbiology of potatoes and potato products: a review. J Food Prot *63*(5):668-683.

Greene RV, Gordon SH, Jackson MA, Bennett GA [1992]. Detection of fungal contamination in corn: potential of FTIR–PAS and –DRS. J Agric Food Chem *40*(7):1144-1149.

Hubbs AF, Cumpston AM, Goldsmith WT, Battelli LA, Kashon ML, Jackson MC, Frazer DG, Fedan JS, Goravanahally MP, Castranova V, Kreiss K, Willard PA, Friend S, Schwegler-Berry D, Fluharty KL, Sriram K [2012]. Respiratory and olfactory cytotoxicity of inhaled 2,3-pentanedione in sprague-dawley rats. Am J Pathol *181*(3):829-844.

Labrecque M [2012]. Irritant-induced asthma. Curr Opin Allergy Clin Immunol *12*(2):140-144.

Lacasse Y, Girard M, Cormier Y. [2012]. Recent advances in hypersensitivity pneumonitis. Chest *142*(1):208-217.

LeBouf RF, Stefaniak AB, Virji MA [2012]. Validation of evacuated canisters for sampling volatile organic compounds in healthcare settings. J Environ Monit *14*(3):977-983.

Mapp CE, Pozzato V, Pavoni V, Gritti G [2000]. Severe asthma and ARDS triggered by acute short-term exposure to commonly used cleaning detergents. Eur Respir J *16*(3):570-572.

Merget R, Sander I, Rozynek P, Raulf-Heimsoth M, Bruening T [2008]. Occupational hypersensitivity pneumonitis due to molds in an onion and potato sorter. Am J Ind Med *51*(2):117-119.

Moreno-Ancillo A, Dominguez-Noche C, Gil-Adrados AC, Cosmes PM [2004]. Hypersensitivity pneumonitis due to occupational inhalation of fungi-contaminated corn dust. J Invest Allergol Clin Immunol *14*(2):165-167.

Morgan DL, Jokinen MP, Price HC, Gwinn WM, Palmer SM, Flake GP [2012]. Bronchial and bronchiolar fibrosis in rats exposed to 2,3-pentanedione vapors: implications for bronchiolitis obliterans in humans. Toxicol Pathol *40*(3):448-465.

NIOSH [1998]. Criteria for a recommended standard. Occupational exposure to metalworking fluids. 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. 98-102.

NIOSH [2003]. NIOSH Manual of Analytical Methods (NMAM). U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication Number 2003-154.

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. Available at www.cdc.gov/niosh/npg/. Date accessed: March 2013.

NIOSH [2011]. Draft criteria for a recommended standard: occupational exposure to diacetyl and 2,3-pentanedione. 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. 20XX-XXX. August 12, 2011 External Review Draft. Available at http://www.cdc.gov/niosh/docket/archive/pdfs/NIOSH-245/DraftDiacetylCriteriaDocument081211.pdf. Date accessed: March 2013.

Quirce S, Barranco P [2010]. Cleaning agents and asthma. J Investig Allergol Clin Immunol *20*(7):542-550.

Sastre J, Olmo M, Novalvos A, Ibañez D, Lahoz C [1996]. Occupational asthma due to different spices. Allergy *51*(2):117-120.

Selman M, Pardo A, King TE Jr [2012]. Hypersensitivity pneumonitis: insights in diagnosis and pathobiology. Am J Respir Crit Care Med *186*(4):314-324.

van der Walt A, Lopata AL, Nieuwenhuizen NE, Jeebhay MF [2010]. Work-related allergy and asthma in spice mill workers - the impact of processing dried spices on IgE reactivity patterns. Int Arch Allergy Immunol *152*(3):271-278.

Woodard ED, Friedlander B, Lesher RJ, Font W, Kinsey R, Hearne FT [1988]. Outbreak of hypersensitivity pneumonitis in an industrial setting. JAMA *259*(13):1965-1969.

Zuskin E, Kanceljak B, Skuric Z, Pokrajac D, Schachter EN, Witek TJ, Maayani S [1988]. Immunological and respiratory findings in spice-factory workers. Environ Res *47*(1):95-108.

Table 1. Air sampling results for diacetyl, 2,3-pentanedione, and 2,3-hexanedione (in parts per billion) using evacuated canisters, May 2012.

Sample type	Field blank	Field blank	Personal	Personal	Personal	Personal	Personal	Area	Area	Area
Job title or work area			Tortilla chip 1 operator	Tortilla chip 1 operator	Tortilla chip 2 operator	Tortilla chip 2 operator	Tortilla chip 2 operator	Tortilla chip 2 seasoning hopper - at front near worker while loading from bag	Tortilla chip 2 seasoning hopper - at filter exhaust before loading from bag	Tortilla chip 2 seasoning hopper - at filter exhaust while loading from bag
Sampling time			8:52 - 11:23*	12:14 - 14:11	10:18 - 10:33	9:02 - 10:18, 10:33 - 12:17†	12:17 - 14:26	10:21	11:14	11:24
Duration (minutes)			151	117	15	180	129	Instant	Instant	Instant
Canister ID	520	540	531	521	538	512	513	511	537	546
2,3-butanedione (diacetyl)	< 0.9	< 0.9	< 6.0	< 4.5	< 3.0	< 2.8	< 3.7	[1.6]	[1.4]	[1.7]
2,3-pentanedione	< 1.1	< 1.1	< 7.2	< 5.5	< 3.6	< 3.4	< 4.4	< 1.6	< 1.6	< 1.6
2,3-hexanedione	< 1.0	< 1.0	< 6.8	< 5.2	< 3.4	< 3.2	< 4.2	< 1.5	< 1.5	< 1.5

*removed canister immediately after sampler tubing separated from canister

†disengaged flow controller and removed canister from 10:18 to 10:33 while collecting a 15-minute sample in canister 538

< = not detected; value is limit of detection

[ ] = detected but not quantifiable; value is estimated measurement between limit of detection and limit of quantification

Note: Nacho cheese seasoning was used all day on tortilla chip line 2; operators for both tortilla chip lines 1 and 2 loaded bags for line 2, but it was primarily operated by the tortilla chip line 2 operator. Tortilla chip line 1 remained down all day for cleaning after a production run with sweet chili seasoning.

Table 2. Alpha-diketone compounds detected in headspace analyses of bulk seasoning samples, May 2012.

Sample ID	Seasoning	Collection site	Alpha-diketone detected
1	Nacho cheese	Tortilla chip line 2	None
2	Ranch	Tortilla chip line 1	None
3	Barbeque	Potato chip line	Trace diacetyl
4	Honey barbeque	Corn chip line	Trace diacetyl
5	Cheddar sour cream	Warehouse	Trace diacetyl
6	Spicy sweet chili	Warehouse	None
7	Chili cheese	Warehouse	Trace diacetyl

Table 3. Air sampling results for sodium hydroxide using filter cassettes via NIOSH Method 7303, May 2012.

Sample type	Person	Job title	Sample ID	Flow (Lpm)	Sampling times	Sample duration (minutes)	Sample mass (µg)	Sample concentration (mg/m³)	Consecutive sample duration (minutes)	Consecutive sample concentration (mg/m³)	8-hr time-weighted average concentration† (mg/m³)
Personal	Worker A	Sanitor - cleaning potato crisp production line with sodium hydroxide cleaner	NE-01	3	9:13 - 12:22, 12:38 - 14:18	289	[18]	[0.02]	289	[0.02]	[0.01]
			NE-02	3	12:22 - 12:38	16	< 10	< 0.21	16	< 0.21	
Personal	Worker B	Sanitor - cleaning potato crisp production line with sodium hydroxide cleaner	NE-00	3	9:11 - 10:01*	50	< 10	< 0.07	291	< 0.02	< 0.01
			NE-06	3	10:01 - 12:22, 12:38 - 14:18	241	< 10	< 0.01			
			NE-08	3	12:22 - 12:38	16	< 10	< 0.21	16	< 0.21	
Field Blank			NE-03			0	< 10				
			NE-05			0	< 10				

*cassette fell off onto dry floor; replaced with sample NE-06
†entire cleaning task sampled, so zero exposure assumed for periods not sampled
< = not detected; value is limit of detection
[ ] = detected but not quantifiable; value is estimated measurement between limit of detection and limit of quantification
µg = microgram
mg/m³ = milligrams per cubic meter of air
Lpm = liters per minute

Acknowledgments and Availability of Report

The Respiratory Disease Hazard Evaluation and Technical Assistance Program (RDHETAP) of 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 (OSH) Act of 1970, 29 U.S.C. 669(a)(6), or Section 501(a)(11) of the Federal Mine Safety and Health Act of 1977, 30 U.S.C. 951(a)(11), which authorizes the Secretary of Health and Human Services, following a written request from any employers 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.

RDHETAP 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 disease.

Mention of any company or product does not constitute endorsement by NIOSH. In addition, citations to websites external to NIOSH do no 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 Kristin J. Cummings, Chris Piacitelli, Marcia Stanton, and Rachel L. Bailey, of the Field Studies Branch, Division of Respiratory Disease Studies. Field support was provided by Randy Boylstein. Laboratory support was provided by Ryan LeBouf. Desktop publishing was performed by Tia McClelland. The authors thank Kathleen Fedan and Nicole Edwards for their thoughtful reviews.

Copies of this report have been sent to employee and employer representatives, the New York State Department of Health, and the OSHA Regional Office. This report is not copyrighted and may be freely reproduced. The report may be viewed and printed at www.cdc.gov/niosh/hhe/. Copies may be purchased from the National Technical Information Service (NTIS) at 5825 Port Royal Road, Springfield, Virginia 22161.

Below is a recommended citation for this report:
NIOSH [2013]. Health Hazard Evaluation Report: Evaluation of respiratory concerns at a snack food production facility, New York. Morgantown, WV: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, NIOSH HETA No. 2011-0037-3172

NIOSH *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:

1-800-35-NIOSH (1-800-356-4674)

Fax: 1-513-533-8573

E-mail: pubstaft@cdc.gov
or visit the NIOSH web site at:
http://www.cdc.gov/niosh/hhe

SAFER • HEALTHIER • PEOPLE™