Evaluation of Dust Exposures in a Spice Shop

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Contents

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The cover photo is a close-up image of sorbent tubes, which are used by the HHE Program to measure airborne exposures. This photo is an artistic representation that may not be related to this Health Hazard Evaluation. Photo by NIOSH.

Highlights of this Evaluation

The Health Hazard Evaluation Program received a request from a spice shop. The employer was concerned about employee exposures to dust during spice grinding operations.

What We Did

- We measured the amount of dust in the air.
- We observed work activities, production processes, and personal protective equipment use.
- We interviewed employees. We asked about their work, medical history, and work-related health concerns.

What We Found

- Employees grinding spices had higher exposures to inhalable dust than employees doing other tasks.
- We saw some employees incorrectly using respirators, and employees did not use eye protection.
- Employees reported occasional brief upper respiratory irritation but no persistent symptoms.
- Some employees reported foot pain and swelling from prolonged standing at work.

We evaluated concerns about employee exposure to dust in a spice shop. Exposures were highest for employees grinding, blending, and mixing spices. Employees reported occasional irritation symptoms. We recommend the company install local exhaust ventilation (LEV) to reduce spice dust exposures. Employees should use respiratory protection until LEV is operational.

What the Employer Can Do

- Install local exhaust ventilation in the grinding room with a ventilation engineer.
- Require the use of respiratory protection during the grinding, blending, and mixing of spices until engineering controls are established.
- Enhance employee training on the proper use of personal protective equipment.
- Provide tight-fitting goggles for employees grinding, mixing, and blending spices.
- Provide additional antifatigue mats for employees.
- Encourage employees to report work-related symptoms. Those with persistent work-related symptoms should be evaluated by a physician.

What Employees Can Do

- Wear personal protective equipment properly and consistently.
- Ensure that the plastic curtain to the grinding room is closed during all grinding, blending, and mixing activities.
- Report work-related skin, eye, and respiratory symptoms to your supervisor.
- Remove dust with a high efficiency particulate air filtered vacuum instead of dry sweeping it.

Abbreviations

ACGIH®	American Conference of Governmental Industrial Hygienists
ANSI	American National Standards Institute
CFR	Code of Federal Regulations
HEPA	High efficiency particulate air
LEV	Local exhaust ventilation
mg/m^3	Milligrams per cubic meter
NIOSH	National Institute for Occupational Safety and Health
OEL	Occupational exposure limit
OSHA	Occupational Safety and Health Administration
PEL	Permissible exposure limit
PNOR	Particulates not otherwise regulated
REL	Recommended exposure limit
RH	Relative humidity
TLV®	Threshold limit value
TWA	Time-weighted average

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Introduction

The Health Hazard Evaluation Program received a request from the managers of a spice shop in California because of concerns about employee exposure to dust while grinding spices. During our June 2016 site visit, we met with employer and employee representatives, measured employees' exposures to inhalable dust, and interviewed employees about their work and health.

Background

The company began operations in the winter of 2011. It has been at the current location since 2015. The employer estimated that the shop was approximately 1,500 square feet, including a retail area in the front and a production and storage space in the back of the building. The front retail area had large windows and wooden shelving to display containers of spices. The front door was often left open because the weather was mostly mild, and the shop did not have a mechanical ventilation system. The back of the building contained a small office with sliding doors that could be closed, a large sink for washing equipment, and a small sink for hand washing. Commercial shelves with large containers of bulk spices were on the back wall. Spices were mixed, blended, and ground in a room that was approximately 13 feet by 7.5 feet. This room did not have a door, but it was partitioned off from the rest of the back room by a clear, heavy plastic, food-grade curtain with a Velcro edge (Figure 1). This curtain was intended to contain the dust generated from grinding and mixing of spices.

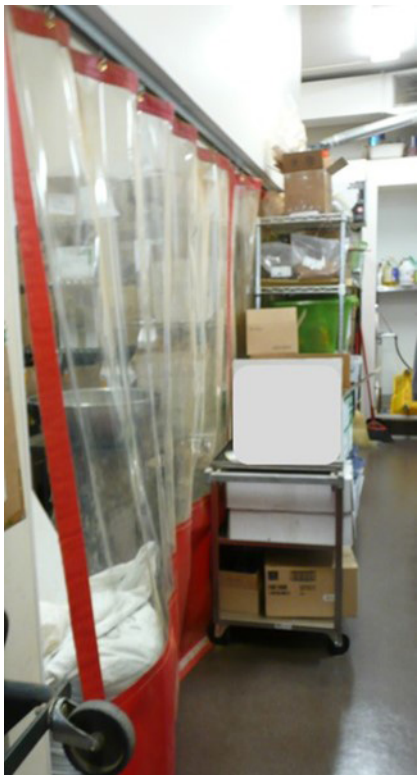

Figure 1. Plastic curtain separating the spice grinding area from the rest of the shop. Photo by NIOSH.

The company had eight employees. Typically one or two employees worked in the front retail area and one employee ground spice in the back area. The company was open 7 days per week. Employees generally worked between 10 a.m. and 7 p.m. on weekdays and between 10 a.m. and 5 p.m. on weekends.

An employee poured spices into a mechanical grinder that was operated for approximately 1 minute. The employee then hand sifted the spices through a metal sifter. The larger spices that were not sifted out were then placed back into the grinder for further grinding. This process was repeated until the desired size, which differed by type of spice, was reached. Employees sometimes hand mixed spices in large metal bowls (Figure 2). Sometimes these hand mixed blends were also mechanically ground.

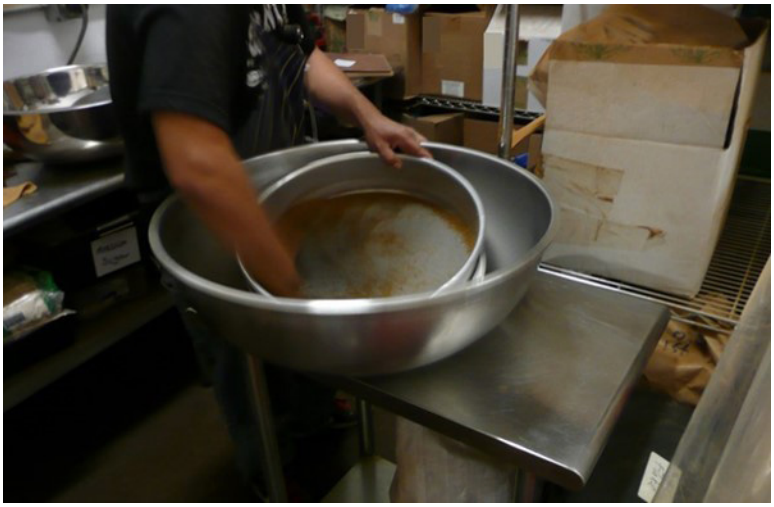

Figure 2. Employee hand mixing spices using a large metal bowl and sieve.

The store contained hundreds of types of spices, but only certain spices were ground on site. These included cinnamon, pepper, ginger, cloves, allspice, mushrooms, fermented black garlic, coriander, cumin, and mustard. Cinnamon was the most common spice that was ground on site. Chilies were not ground on site, though they were handled and packaged by employees. Spices, herbs, and seasonings are classified as food products. The active components in spices are complex chemical mixtures that impart distinctive flavors and aromas to food and can also be used to preserve certain foods. Spices are considered nonhazardous when ingested in reasonable quantities (an exception being allergic reactions in sensitized individuals). Exposure to spice dusts has been reported to cause human health problems through inhalation and skin contact (Appendix A).

In the United States, there are no occupational exposure limits (OELs) specific to spice dusts. They fall under the Occupational Safety and Health Administration (OSHA) class of compounds known as particulates not otherwise regulated (PNOR). The PNOR classification is intended for biologically inert dust, and is commonly referred to as nuisance dust. The California OSHA permissible exposure limit (PEL) for PNOR is 10 milligrams per cubic meter (10 mg/m^3) for total (inhalable) dust. Because of the irritant and allergenic properties of spice dust, from a health perspective, the PEL for PNOR does not adequately protect the

health of employees (Appendix A). Not enough is known about most allergens to establish occupational exposure limits for these compounds [Dotson et al. 2015]. With this in mind, we encourage employers to take the approach that is most protective of employees' health in controlling exposures to spice dust.

Methods

Our primary objectives were to evaluate employees' exposures to inhalable dust and assess work-related health concerns. Our work involved (1) air sampling for inhalable dust, (2) observing work practices, and (3) holding confidential medical interviews with employees. After observing work practices and conducting employee interviews, we determined that a need existed for assessing thermal comfort parameters.

Air Sampling for Inhalable Dust

We collected full-shift personal air samples for inhalable dust for five employees over 2 days. Inhalable dust refers to airborne particles that can enter the nose or mouth during normal breathing and deposit anywhere in the respiratory tract. We collected these air samples using Institute of Medicine samplers with tared 25-millimeter diameter 5-micron pore size polyvinyl chloride filters. The air samples were collected and analyzed for inhalable particulates according to National Institute for Occupational Safety and Health (NIOSH) Method 0600 [NIOSH 2017].

Thermal Comfort

We measured temperature and relative humidity (RH) in the spice grinding area and in the retail shop over 2 days with calibrated TSI Q-Trak™ Indoor Air Quality monitors. Temperature and RH affect how employees perceive their indoor environment. We compared the temperature and RH levels to American National Standards Institute (ANSI)/ASHRAE thermal comfort guidelines for summer [ANSI/ASHRAE 2013]. The ANSI/ASHRAE Standard 55-2013, Thermal Environmental Conditions for Human Occupancy, specifies conditions in which 80% or more of the occupants would be expected to find the environment thermally comfortable [ANSI/ASHRAE 2013]. Several factors affect thermal comfort including air movement, operative temperature, RH, clothing levels, and an individual's work activities. The U.S. Environmental Protection Agency recommends that RH be maintained below 60% (ideally 30%–50%) to prevent mold growth. Very low RH levels may contribute to dry and irritated mucous membranes of the eyes and airways [Wolkoff and Kjaergaard 2007].

Confidential Medical Interviews

We interviewed all seven available employees including the managers. One part-time employee was not working during our site visit. During these interviews, we asked about their work, medical history, and work-related health concerns.

Results and Discussion

Air Sampling for Inhalable Dust

Table 1 shows the full-shift personal air sampling results for inhalable dust by job title. Ten samples were collected over 2 days. The highest inhalable dust concentrations (7.4 mg/m^3 and 8.7 mg/m^3) were measured on the employees working in the grinding room. These employees ground spices using the mechanical grinder and also mixed and blended bulk spices by hand and with a commercial blender. The concentrations measured in the shop were within the range of values reported in the scientific literature for employee exposures in spice mills and seasoning factories. A study of spice mill workers reported geometric mean inhalable dust concentrations of 2.06 mg/m^3, with concentrations ranging from not detected to 47.64 mg/m^3 [van der Walt et al. 2013]. Another study of spice mill workers reported inhalable dust concentrations of 1.0 to 29.9 mg/m^3 [van der Walt et al. 2010]. A study in a seasoning factory found median inhalable spice dust concentrations of 12 mg/m^3 in the packaging area (range: 3.9–150 mg/m^3), 4.8 mg/m^3 in mixing (range: 0.9–16 mg/m^3), and 9 mg/m^3 in grinding (range: 1.9–22 mg/m^3) [IRSST 2012]. Other studies have found total spice dust concentrations ranging from 0.03 mg/m^3 to 59.8 mg/m^3 in various types of workplaces [IRSST 2012; Lacey et al. 2006]. Concentrations of inhalable dust measured on all of the other employees who were neither mixing spices nor working in the grinding or blending rooms were all less than 1 mg/m^3.

Table 1. Personal air sample results for inhalable dust

Job title	Day	Sample duration (minutes)	TWA concentration (mg/m^3)*
Grinding	2	329	8.7
Grinding	1	447	7.4
Manager/retail	1	462	0.81
Retail	2	439	0.78
Retail	1	363	0.53
Retail	2	383	0.52
Manager/retail	2	461	0.50
Retail	1	403	0.47
Manager	1	385	0.29
Manager	2	412	[0.20]

TWA = Time-weighted average

*The minimum quantifiable concentration of inhalable dust ranged from 0.20–0.28 mg/m^3.

[ ] = Estimated concentration; this concentration was between the minimum detectable and minimum quantifiable concentrations.

Thermal Comfort

Table 2 summarizes the temperature and RH levels measured in the spice grinding and retail areas. On the basis of a mean monthly outdoor temperature of 65°F for the month we sampled, in the naturally ventilated space, ANSI/ASHRAE recommends that indoor temperatures range from 68°F to 81°F. The temperatures of the naturally ventilated areas we sampled fell within that range. ANSI/ASHRAE does not have RH recommendations for spaces not served by mechanical ventilation systems. The RH levels measured in the shop were within the range recommended by the U.S. Environmental Protection Agency to prevent mold growth.

Table 2. Temperature and relative humidity measurements in the spice shop

Location	Day	Temperature °F (range)	% RH (range)
Spice grinding area	1	76–81	47–58
Spice grinding area	2	75–79	46–54
Retail area	1	73–75	49–52
Retail area	2	73–75	47–51

Workplace Observations

The shop did not have a mechanical heating or cooling system. The front door to the shop was kept open at all times during our visit. A small section of a ventilation duct in the rear of the shop had an opening cut into it, and the shop owner reported that it was serving as an air return. The shop did not have any control over this system and was not responsible for its maintenance. It reportedly served numerous tenants in the commercial spaces adjacent to the shop.

We observed some settled dust outside of the spice grinding room. We observed employees dry sweeping this spice dust throughout the shop. Dry sweeping increases the potential for employees to breathe spice dust by putting it into the air. We also observed vacuuming of spice dust with a vacuum cleaner that was not equipped with a high efficiency particulate air (HEPA) filter. HEPA filters are able to capture small dust particles and remove them from the air. Vacuums without HEPA filtration are not as effective in capturing these small particles and will put them back into the air of the shop.

Employees used personal protective equipment to reduce spice dust exposures. The employer provided aprons, disposable black nitrile gloves, earmuffs, and safety glasses. During our visit, employees always wore nitrile gloves when working in the grinding and blending area. Employees sometimes wore earmuffs as hearing protection when using the grinding machine. No employees were observed to be using safety glasses. Some employees reported that the safety glasses provided to them were not tight-fitting and did not protect their eyes from spice dust. Employees were observed to be sweating when working in the enclosed grinding area.

For respiratory protection, NIOSH-approved N95 filtering facepiece respirators (Grande CDN3S) were available for voluntary use to reduce particulate exposures during the grinding

and mixing of spices. We observed that employees working in the grinding room usually wore these respirators when grinding, mixing, and blending spices. However, we observed some of the employees wearing the respirator incorrectly, such as wearing both straps around the base of the neck or not using the bottom strap at all. We also observed that some employees had facial hair that interfered with the seal of the respirator to the face. Employees were not given a copy of Appendix D of the California OSHA respiratory standard (https://www.dir.ca.gov/title8/5144d.html).

Additionally, an antifatigue mat was placed on the floor where employees stood behind the check-out counter in the retail area.

Confidential Medical Interviews

Of the seven interviewed employees, the average age was 39 years (range: 25–61); three were female. Job titles included managers, retail, and grinder employees. The managers worked in all parts of the store and did administrative work in the office in the back area; the retail employees mainly worked in the front retail space. The two grinder employees reported most of their time was spent grinding spices (mostly cinnamon) or blending spices in the grinding area.

All employees reported some exposure to spices, including measuring spices, hand-filling spice jars, and handling chilies for packaging. The two grinder employees reported that spice dust was sometimes visible in the air and would settle onto surfaces, including their skin, during grinding and blending activities. These two employees reported mild skin irritation with skin exposure to ground cinnamon, especially if their skin was sweaty. Two employees reported health concerns related to prolonged standing at work, including pain in feet and occasional swelling of ankles. Two employees reported concerns about the lack of air circulation in the grinding area, which sometimes led to uncomfortably high temperatures in addition to spice dust accumulation. Four of the employees reported mild, upper respiratory irritation (burning sensation of the nasal mucous membranes and in the back of the throat, runny nose, and cough) that lasted a few seconds to a few minutes when they were exposed to chilies. No employees reported persistent skin or respiratory symptoms.

All employees reported wearing gloves when handling chili peppers or measuring spices. Most employees also reported wearing aprons. When handling ghost chili peppers, one of the world's hottest chili peppers, employees reported voluntarily wearing an N95 filtering facepiece particulate respirator. Both grinder employees reported wearing N95 filtering facepiece respirators when grinding or mixing all spices. The grinder employees also reported wearing black nitrile gloves over vinyl gloves and ear plugs or earmuffs when grinding and blending spices.

Allergic contact dermatitis and urticaria (hives) have been reported in response to skin exposure to certain spices [Zuskin et al. 1988a]. Occupational asthma has been linked to exposure to a range of spices, including cinnamon, paprika, mace, coriander, aniseed, garlic, and onion [Sastre et al. 1996; van der Walt et al. 2010, 2013]. There is also evidence that exposure to airborne spice dusts may increase symptoms such as shortness of breath, cough, bronchitis, and sinusitis [Zuskin et al. 1988b]. These symptoms can be acute and occur during a single work shift, or become chronic with repeated exposure. Occupational rhinoconjunctivitis has been found among spice workers handling garlic, onion, fennel seed, and saffron. Factors that predispose an individual to the

development of occupational asthma include atopy (having a history of atopic eczema, allergic rhinitis, or asthma), prior allergic sensitization to the specific occupational allergen, occupational rhinoconjunctivitis, airway hyperresponsiveness, genetic factors, and smoking [van der Walt and Jeebhay 2010]. Although no employees reported persistent respiratory or skin symptoms, preventative steps can be taken to lessen exposures to spices in airborne dust and on skin surfaces so employees do not develop these symptoms in the future.

As previously mentioned, in the United States, there are no OELs specific to spice dusts. It is difficult to create OELs for chemicals that are allergens as there is typically limited concentration-response data for these chemicals [Dotson et al. 2015]. Because certain spices contain chemicals that can be irritants or allergens, the most appropriate strategy is to minimize airborne exposure to the dust. In general, approaches to controlling the dust can incorporate engineering controls, administrative controls, and personal protective equipment. Engineering strategies to control spice dusts could include improving the process design by selecting equipment that minimizes aerosol generation. Additionally, isolation of the spice dust by enclosing work areas where spice dust generation occurs could also help prevent spice dust releases. The use of local exhaust ventilation (LEV) can help prevent employee exposure during grinding and mixing operations. Keeping the spice grinding room under negative pressure with regard to the surrounding areas, would ensure that air is flowing into the room and that air containing spice dusts does not escape. Administrative controls can also help reduce employee exposures. In this shop improving work practices to ensure good workplace hygiene and improving material handling techniques to limit dust and aerosol generation would be beneficial. Preventing or minimizing skin exposure through good work practices and use of personal protective equipment is also needed to prevent dermatitis. Employees who become sensitized or who develop occupational asthma or allergic contact dermatitis would be at risk for subsequent reactions.

Conclusions

Concentrations of inhalable spice dusts measured on employees grinding spices ranged from 7–9 mg/m^3, over half the California OSHA PNOR OEL. These concentrations are similar to those found in studies of spice mill employees with allergy and asthma-like symptoms. Concentrations of inhalable spice dusts measured on employees who were not grinding spices were less than 1 mg/m^3. Employees reported occasional brief upper respiratory irritation from work exposures but no persistent symptoms. As some spice dusts have been reported to be allergens, and the dusts are capable of causing occupational asthma and dermatitis, we encourage the employer to take the approach that is most protective of employees' health in controlling exposures to spice dust. Installing LEV and improving work practices and material handling techniques to limit dust and aerosol exposures to the lowest feasible limits are needed to reduce employee exposures. Although respiratory protection was worn by employees when grinding spices during our visit, its use was voluntary and employees did not always use it correctly, which limits the protection provided by the respirator. Until LEV is installed at the site, employees grinding, mixing, and blending spices should be required to wear respiratory protection.

Recommendations

On the basis of our findings, we recommend the actions listed below. We encourage the spice shop to use a labor-management health and safety committee or working group to discuss our recommendations and develop an action plan. Those involved in the work can best set priorities and assess the feasibility of our recommendations for the specific situation at the spice shop.

Our recommendations are based on an approach known as the hierarchy of controls (Appendix A). This approach groups actions by their likely effectiveness in reducing or removing hazards. In most cases, the preferred approach is to eliminate hazardous materials or processes and install engineering controls to reduce exposure or shield employees. Until such controls are in place, or if they are not effective or feasible, administrative measures and personal protective equipment may be needed.

Engineering Controls

Engineering controls reduce employees' exposures by removing the hazard from the process or by placing a barrier between the hazard and the employee. Engineering controls protect employees effectively without placing primary responsibility of implementation on the employee.

1. Install LEV in the grinding room to control the release of spice dusts at the point of generation. Contact a licensed ventilation engineering company that is familiar with particulate control in the food industry to help design a suitable system. It would also be good practice to put the spice grinding room under negative pressure with respect to adjacent areas.
2. Ensure that the plastic curtain to the grinding room is closed during all grinding, blending, and mixing activities. This will reduce the amount of dust settling in areas outside of the grinding room.
3. Provide additional antifatigue mats for employees.
4. Provide a stool(s) behind the counter for employees to sit or lean on periodically during the day.

Administrative Controls

The term administrative controls refers to employer-dictated work practices and policies to reduce or prevent hazardous exposures. Their effectiveness depends on employer commitment and employee acceptance. Regular monitoring and reinforcement are necessary to ensure that policies and procedures are followed consistently.

1. Prohibit dry sweeping of spice dust in the shop. Dry sweeping can push dust into the air that employees can breathe in.
2. Use a vacuum equipped with a HEPA filter (to remove fine particles) instead of dry sweeping dust. Ensure that the HEPA filter is changed regularly.
3. Educate employees on the health and safety hazards in the workplace and reporting procedures for injuries and illnesses related to work.

4. Encourage employees to report work-related skin, eye, and respiratory symptoms to their supervisor. Employees who report work-related symptoms should be evaluated by a physician experienced in occupational medicine or allergy medicine. Those with persistent work-related skin symptoms should be evaluated by a dermatologist knowledgeable about workplace exposures.
5. Maintain a log of reported employee injuries and illnesses related to work. This allows managers to look for trends in injury/illness events that can then trigger evaluation of potential hazards.
6. Measure noise exposures to employees working with the mechanical grinder to determine whether noise levels are above NIOSH or OSHA exposure limits.

Personal Protective Equipment

Personal protective equipment is the least effective means for controlling hazardous exposures. Proper use of personal protective equipment requires a comprehensive program and a high level of employee involvement and commitment. The right personal protective equipment must be chosen for each hazard. Supporting programs such as training, change-out schedules, and medical assessment may be needed. Personal protective equipment should not be the sole method for controlling hazardous exposures. Rather, personal protective equipment should be used until effective engineering and administrative controls are in place.

1. Require employees who grind spices to use NIOSH-approved respirators (N95 or greater) while grinding spices until LEV or other engineering controls can be installed. Implementation should follow the California OSHA respiratory protection standard (https://www.dir.ca.gov/title8/5144.html). The California OSHA document, *Respiratory Protection in the Workplace: A Practical Guide for Small-Business Employers* (https://www.dir.ca.gov/dosh/dosh_publications/respiratory.pdf), details the steps required to comply with their respiratory protection standard.
2. Review the proper use of personal protective equipment including respirators, eye protection, and hearing protection with employees at the shop to ensure that it is worn correctly and whenever needed.
3. Ensure that employees do not have beard growth that interferes with the sealing surface of respirators.
4. Ensure employees always use nitrile gloves to avoid direct skin contact with spices. This is especially important for spices that are skin irritants or known or suspected to cause skin rash such as thyme, turmeric, cinnamon, or garlic powder although other spices may also cause occupational dermatitis.
5. Purchase tight-fitting goggles that employees can use when grinding, mixing, and blending spices to prevent spice dust from reaching the eyes. Goggles that fit tightly on one employee, may not fit tightly on other employees depending on the size and shape of an individual's face.

Appendix A: Occupational Exposure Limits and Health Effects

NIOSH investigators refer to mandatory (legally enforceable) and recommended OELs for chemical, physical, and biological agents when evaluating workplace hazards. OELs have been developed by federal agencies and safety and health organizations to prevent adverse health effects from workplace exposures. Generally, OELs suggest levels of exposure that most employees may be exposed to for 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 if their exposures are maintained below these levels. Some may have adverse health effects because of individual susceptibility, a pre-existing medical condition, or a hypersensitivity (allergy). In addition, some hazardous substances act in combination with other exposures, with the general environment, or with medications or personal habits of the employee to produce adverse health effects. Most OELs address airborne exposures, but some substances can be absorbed directly through the skin and mucous membranes.

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 short-term exposure limits or ceiling values. Unless otherwise noted, the short-term exposure limit is a 15-minute TWA exposure. It should not be exceeded at any time during a workday. The ceiling limit 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; 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. These limits are enforceable in workplaces covered under the Occupational Safety and Health Act of 1970.
- NIOSH recommended exposure limits (RELs) are recommendations based on a critical review of the scientific and technical information and the adequacy of methods to identify and control the hazard. NIOSH RELs are published in the *NIOSH Pocket Guide to Chemical Hazards* [NIOSH 2010]. NIOSH also recommends 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.
- Another set of OELs commonly used and cited in the United States is the American Conference of Governmental Industrial Hygienists (ACGIH) threshold limit values (TLVs). The TLVs are developed by committee members of this professional organization from a review of the published, peer-reviewed literature. TLVs are not consensus standards. They 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 2017].

Outside the United States, OELs have been established by various agencies and organizations and include legal and recommended limits. The Institut für Arbeitsschutz der Deutschen Gesetzlichen Unfallversicherung (Institute for Occupational Safety and Health of the German Social Accident Insurance) maintains a database of international OELs from European Union member states, Canada (Québec), Japan, Switzerland, and the United States. The database, available at http://www.dguv.de/ifa/GESTIS/GESTIS-Internationale-Grenzwerte-für-chemische-Substanzen-limit-values-for-chemical-agents/index-2.jsp, contains international limits for more than 2,000 hazardous substances and is updated periodically.

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))]. This is true in the absence of a specific OEL. It also is important to keep in mind that OELs may not reflect current health-based information.

When multiple OELs exist for a substance or agent, NIOSH investigators generally encourage employers to use the lowest OEL when making risk assessment and risk management decisions. NIOSH investigators also encourage use of the hierarchy of controls approach to eliminate or minimize workplace hazards. This includes, in order of preference, the use of (1) substitution or elimination of the hazardous agent, (2) engineering controls (e.g., LEV, 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. Control banding focuses on how broad categories of risk should 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 existing OELs.

Summary of Workplace Exposures to Spice Dust

In the United States, there are no OELs for spice dusts. Exposure to spice dust would be classified by OSHA as PNOR, also commonly referred to as nuisance dust. The PNOR designation is intended for biologically inert dusts. Because of the irritant and allergenic properties of spice dust, from a health perspective, we believe the PNOR designation does not adequately protect the health of employees.

In a study of 61 male spice grinders working in 14 factories in Singapore, 49% reported symptoms of upper respiratory tract irritation (sneezing and runny nose) [Chan et al. 1990]. The study reported that the symptoms were greatest in the first few weeks of employment and did not recur in half of the affected workers. None of the spice grinders had symptoms of allergic skin disease or asthma. Area air concentrations of total dust ranged from 0.03 to 0.82 mg/m^3 with a mean value of 0.15 mg/m^3. Personal air sampling, as we did in our evaluation, was not conducted in this study.

In another study investigating thyme farmers in Poland, occupational dermatitis was reported in 4 of 46 farmers who threshed (separating seeds and stems from the leaves) dried thyme plants [Spiewak et al. 2001]. The symptomatic workers reported a history of work-related

rash that began within 5 to 30 minutes of threshing the dried thyme. This activity created a coarse powder, which was reportedly associated with high exposures to thyme dust. Skin itching, erythema (reddening of the skin), and swelling were found on the uncovered skin of the face, neck, and hands of the symptomatic workers. Rhinitis (runny nose) was reported in two of the thyme farmers, and conjunctivitis (pinkeye) was reported in one worker. Thyme-specific immunoglobulin E (an antibody produced by the immune system that mediates allergic reactions) was found in one symptomatic worker and two asymptomatic workers. Exposure to bacteria, bacterial endotoxins, and fungal allergens were also reported, the source of which was epiphytic (naturally occurring on the plant) organisms on the thyme plants (and presumably on other spice plants as well). The study concluded that thyme dust is capable of causing occupational contact dermatitis through airborne exposures possible through an irritant mechanism. However, exposures to fungal allergens and bacteria may aggravate or enhance the effects of exposure to thyme dust alone.

In a study of 45 spice factory workers in Yugoslavia (matched with an unexposed comparison group of workers of the same sex, age, and smoking status), intradermal skin prick testing with mixed spice dust allergen showed positive skin reactions in 73% of the exposed workers and 33% of the unexposed workers [Zuskin et al. 1988a]. The study showed a statistically significant difference for allergic skin reactions (skin prick testing), chronic respiratory symptoms, and increased immunoglobulin E serum levels of spice dust antigens between the factory workers and unexposed workers. The symptomatic workers reported a high prevalence of acute respiratory symptoms during the work shift, and the prevalence of chronic respiratory conditions was significantly higher in the exposed workers compared to the unexposed population. The study suggested that immunologic reactions are frequent in spice workers and may be related to acute symptoms and lung function changes.

In 2002, a case of bronchiolitis obliterans organizing pneumonia was reported in a 43-year-old spice process technician working at a potato chip manufacturer [Alleman 2002]. Bronchiolitis obliterans organizing pneumonia, a restrictive lung disease, can be reversible with medical treatment (oral steroids) but if left untreated, can be irreversible and disabling. The employee worked at the plant for 7 years and frequently complained of sneezing, nasal and eye irritation, and sinus congestion. The work included filling a misting device that sprayed spices onto potato chips. The work required manually pouring the dried spice mixtures into the feed hopper of the misting machine, then cleaning the machine with a brush and using compressed air. The worker did not use respiratory protection. Many different types of seasoning and spices were used in the machine including salt, pepper, onion, garlic, and paprika. The list of spice ingredients was not given and results of quantitative exposure assessments were not mentioned. The report concluded that there was an occupational association between bronchiolitis obliterans organizing pneumonia and exposures to spice dusts in this case patient. No other cases of bronchiolitis obliterans organizing pneumonia in spice workers have been reported in the medical literature.

The International Labour Organization has reported that occupational dermatitis has been associated with exposures in the spice processing industry to mint, laurel, parsley, rosemary, thyme, cinnamon, chicory, cloves, garlic, nutmeg, and vanilla. The International Labour Organization Encyclopedia reports that respiratory symptoms including occupational asthma

have been associated with dust exposures from Brazilian ginseng, parsley, black pepper, cinnamon, cloves, coriander, garlic, paprika, chilies, along with the bacteria and endotoxins in dusts from grains and herbs [International Labour Organization 2011].

Occupational exposure to paprika dust (and an occupational disease known as paprika-splitters lung) has long been known to cause hypersensitivity pneumonitis, a respiratory disease that causes inflammation of the lung tissues from exposure to organic dusts and allergens in exposed workers [Seaton and Morgan 1975]. Inhalation of a chemical called substance P and capsaicin, the active ingredient in hot peppers and paprika, has been reported to cause a dose-dependent contraction of human bronchi in experimental studies. Inhalation of capsaicin in human volunteers caused dose-dependent coughing in subjects with mild asthma.

Noor et al. [2000] compared spice workers from three spice-processing factories in Selangor, Malaysia, to a group of university staff. They measured airborne particulate matter smaller than 10 micrometers and found the mean level in areas near spice workers to be approximately 2.5 mg/m^3 and the mean level in university areas to be 0.1 mg/m^3. They performed pulmonary function testing on nonsmoker and nonasthmatic participants and found significant reductions in lung function (vital capacity, forced vital capacity, and forced expiratory volume in 1 second) among spice workers compared to university staff. They also found significantly greater reports of respiratory symptoms among spice workers compared to university staff. Their findings suggest that exposure to high airborne levels of spice dust leads to increased prevalence of respiratory symptoms and decreased lung function [Noor et al. 2000].

A cross-sectional study of 150 spice mill workers was conducted in South Africa. The study included air sampling for inhalable spice dust and airborne allergen exposure, questionnaires to assess worker health, immunological testing of blood to determine sensitization, and spirometry and fractional exhaled nitric oxide testing. The mean inhalable dust concentration was 2.06 mg/m^3. Spice-dust-related asthma-like symptoms were reported by 17% of workers. Spice-dust-related ocular-nasal and asthma-like symptoms were strongly associated with higher airborne garlic levels (> 0.235 micrograms per cubic meter) among exposed workers. The authors concluded that inhalable particulate dust levels as low as 2 mg/m^3 are not protective against asthma and obstructive lung disease and spice mill workers are at an increased risk of becoming sensitized to airborne allergens [van der Walt et al. 2013].

References

ACGIH [2017]. 2017 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 Env Med *44*(3):215–216, http://dx.doi.org/10.1097/00043764-200203000-00001.

ANSI/ASHRAE [2013]. Thermal environmental conditions for human occupancy. American National Standards Institute/ASHRAE standard 55-2013. Atlanta, GA: ASHRAE.

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

Chan OY, Lee CS, Tan KT, Thirumoorthy T [1990]. Health problems among spice grinders. Occup Med *40*(3):111–115, http://dx.doi.org/10.1093/occmed/40.3.111.

Dotson GS, Maier A, Siegel PD, Anderson SE, Green BJ, Stefaniak AB, Codispoti CD, Kimber I [2015]. Setting occupational exposure limits for chemical allergens – understanding the challenges. J Occup Environ Hyg *12*(Suppl 1):S82–S98, http://dx.doi.org/10.1080/15459624.2015.1072277.

International Labour Organization [2011]. International Labour Organization encyclopedia of occupational health and safety. Geneva, Switzerland, http://www.iloencyclopaedia.org/part-x-96841/agriculture-and-natural-resources-based-industries/specialty-crops/specialty/ginseng-mint-and-other-herbs.

IRSST [2012]. Characterization of dusts in the food seasonings sector. Report R-761. Montreal, Quebec, Canada: Institut de recherché Robert-Sauvé en santé et en sécurité du travail, www.irsst.qc.ca/media/documents/PubIRSST/R-761.pdf.

Lacey SE, Conroy LM, Franke JE, Wadden RA, Hedeker DR, Forst LS [2006]. Personal dust exposures at a food processing facility. J Agromedicine *11*(1):49–58, http://dx.doi.org/10.1300/J096v11n01_06.

NIOSH [2010]. 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. 2010-168c, http://www.cdc.gov/niosh/npg/.

NIOSH [2017]. NIOSH manual of analytical methods (NMAM). 5th ed. O'Connor PF, Ashley K, 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 No. 2014-151, http://www.cdc.gov/niosh/nmam.

Noor H, Sansi W, Othman Z, Mohamad F [2000]. Effects of spice dust on lung function and respiratory symptoms in spice factory workers in Selangor. Pertanika J Trop Agric Sci *23*(2):61–66, http://psasir.upm.edu.my/3729/.

Sastre J, Olmo M, Novalvos A, Ibanez D, Lahoz C [1996]. Occupational asthma due to different spices. Allergy *51*(2):117–120, http://dx.doi.org/10.1111/j.1398-9995.1996.tb04568.x.

Seaton A, Morgan K [1975]. Hypersensitivity pneumonitis. In: Morgan and Seaton, eds. Occupational lung diseases. 2nd ed. Philadelphia, PA: W.B. Saunders Company.

Spiewak R, Skorska C, Dutkiewicz J [2001]. Occupational airborne contact dermatitis caused by thyme dust. Contact Dermatitis *44*(4):236–239, http://dx.doi.org/10.1034/j.1600-0536.2001.044004235.x.

van der Walt A, Jeebhay MF [2010]. Work-related allergy and asthma to inhaled spices – a review. Curr Allergy Clin Immunol *23*(4):186–192, http://hdl.handle.net/10520/EJC21686.

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, https://doi.org/10.1159/000283038.

van der Walt A, Singh T, Baatjies R, Lopata AL, Jeebhay MF [2013]. Work-related allergic respiratory disease and asthma in spice mill workers is associated with inhalant chili pepper and garlic exposures. Occup Environ Med *70*(7):446–452, https://doi.org/10.1136/oemed-2012-101163.

Wolkoff P, Kjaergaard SK [2007]. The dichotomy of relative humidity on indoor air quality. Environ Int *33*(6):850–857, https://dx.doi.org/10.1016/j.envint.2007.04.004.

Zuskin E, Kanceljak B, Skuric Z, Pokrajac D, Schachter EN, Witek TJ, Maayana S [1988a]. Immunological and respiratory findings in spice factory workers. Environ Res *47*(1):95–108, http://dx.doi.org/10.1016/S0013-9351(88)80024-0.

Zuskin E, Skuric Z, Kanceljak B, Pokrajac D, Schachter EN, Witek TJ [1988b]. Respiratory findings in spice factory workers. Arch Environ Health *43*(5):335–339, http://dx.doi.org/10.1080/00039896.1988.9934944.

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