

# Flavoring-Related Lung Disease

By LCDR Randy J. Boylstein, M.S., REHS

Since August 2000, NIOSH has investigated the respiratory health hazards associated with exposure to flavorings. Initially, NIOSH received a health hazard evaluation (HHE) request from the Missouri Department of Health and Senior Services to investigate the cause of eight cases of a serious and irreversible obstructive lung disease known as bronchiolitis obliterans in a group of former workers at a microwave popcorn manufacturing plant.

Some of the affected individuals had worked in the mixing room where butter flavorings were mixed with heated soybean oil, salt and colorings. Others had worked in the nearby packaging line area where kernel popcorn was combined with the oil and flavorings mixture in microwavable bags. Four workers from this plant were so severely affected that their physicians placed them on lung transplant waiting lists. In addition to the mixing room and packaging line, workers in the quality control laboratory (where up to 100 bags of microwave popcorn per worker per day were popped for quality testing) also had a high rate of abnormal lung function.

Since 2000, the plant has implemented a variety of exposure controls, including isolation of the mixing room and of all tanks containing the heated oil and flavoring mixture and additional general dilution ventilation and local exhaust ventilation. Workers who enter the mixing room and workers in the quality control laboratory have their lung function checked with spirometry every few months to look for excessive declines in lung function that might be related to exposures to flavoring chemicals.

The investigation at the microwave popcorn plant in Missouri determined that inhalation exposure to butter flavoring chemicals is a risk for occupational lung disease. The lung disease that affected these workers, bronchiolitis obliterans, causes inflammation and scarring of the small airways of the lung and can lead to severe, permanent shortness of breath. The main symptoms are cough and shortness of breath during exertion that typically does not improve when the worker goes home at

the end of the workday. The symptoms usually appear gradually, but severe symptoms can occur suddenly. Most cases have not responded to medical treatment.

The Missouri HHE request has led to intensive NIOSH study performed in collaboration with the microwave popcorn and flavorings industries. Since that time, NIOSH has investigated and published reports of HHEs at five other popcorn plants and three plants where flavorings were used or produced. These reports can be accessed at [www.cdc.gov/niosh/topics/flavorings/#hhe](http://www.cdc.gov/niosh/topics/flavorings/#hhe). NIOSH has also published an alert, *Preventing Lung Disease in Workers Who Use or Make Flavorings*, intended to provide workers and management with guidance on how to identify the hazards associated with working with flavorings and how to protect workers from exposure.

## Flavorings

Flavorings used to make food products are often complex mixtures of natural and manmade substances. Approximately 2,000 different chemicals are used in varying combinations to produce mixtures that impart specific flavor characteristics. The FDA approves flavoring ingredients if they are "generally recognized as safe" for consumption in food. Little assessment of most flavoring chemicals has been made to determine if they pose risk to workers from inhalation in the workplace.

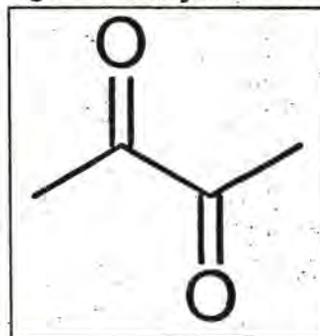
Given the complexity of flavorings mixtures, identifying the potential for respiratory toxicity from different flavoring chemicals is an important and difficult challenge. As noted in the NIOSH alert, the flavorings industry has estimated that more than 1,000 flavoring ingredients have the potential to pose respiratory hazards due to possible volatility and irritant properties (unsaturated aldehydes and ketones, aliphatic aldehydes, aliphatic carboxylic acids, aliphatic amines and aliphatic aromatic thiols and sulfides).

The butter flavoring chemical diacetyl,

a di-ketone, was the predominant volatile organic compound (VOC) in the air at the microwave popcorn plant initially investigated by NIOSH. Diacetyl is also known as 2,3-butanedione or by its Chemical Abstracts Service (CAS) number, 431-03-08. Workers in microwave popcorn manu-

facturing and the flavorings industry are exposed to many other flavoring chemicals besides diacetyl.

Figure 1 Diacetyl Structure



## Evidence of Risk to Workers

The studies that NIOSH performed in the nine plants suggested that diacetyl was a good marker for exposure to butter flavorings and that it was

likely involved in the etiology of lung disease among these workers. NIOSH studies in the initial plant documented a relationship between cumulative exposure to diacetyl vapor over time and abnormal lung function as measured by spirometry. Also, higher cumulative exposure to diacetyl in this plant was associated with having a lower level of forced expiratory volume in one second (FEV1), an important measure of lung function related to obstructive lung disease.

Across all six microwave popcorn plants NIOSH studied, working as a mixer was associated with higher exposure to diacetyl than working in other areas of the plants. People who had ever worked as mixers had more chest symptoms and poorer lung function as measured by lower FEV1 than people who had never worked as mixers. People who had worked as mixers for more than 12 months had more shortness of breath with exertion and lower FEV1 than people who had worked as mixers for less than 12 months.

Toxicology studies show that vapors from heated butter flavorings containing diacetyl can cause airway damage in rats. Preliminary studies show similar damage after exposure to diacetyl alone. In addition, a recent study from the Netherlands shows that chemical workers in a plant which manufactured diacetyl developed

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the same type of lung disease as microwave popcorn workers. These chemical workers likely had fewer chemical exposures than microwave popcorn workers. Four different chemical exposures occurred in the plant in which diacetyl was manufactured—diacetyl, acetoin, acetic acid and acetaldehyde. Overall, current evidence points to diacetyl as one agent causing flavorings-induced lung disease. Other flavoring ingredients may also play a role.

The measurement and control of diacetyl exposure is critical in preventing flavorings-induced lung disease. Diacetyl is a cause of lung disease as a single agent and may serve as a marker for other hazardous flavoring components.

Diacetyl measurements can guide corrective actions, such as respiratory protection and engineering controls, to reduce or eliminate exposures. OSHA does not currently have a permissible exposure limit for diacetyl but recently initiated rulemaking on a standard for diacetyl.

### Analytical Method for Diacetyl Measurement

NIOSH researchers developed and published an analytical method to measure diacetyl in the workplace air, NIOSH Method 2557. Recent investigations have suggested that this method might be affected by relative humidity; preliminary data suggest that high humidity levels may result in an underestimation of true concentrations. Laboratory-based projects are underway to investigate relative humidity and other factors that may impact this method. Based on this work, NIOSH hopes to be able to develop humidity-based correction factors for this method.

NIOSH is also working to develop new methods for the measurement of diacetyl in the workplace. New information will be shared with the public and stakeholders on the NIOSH Flavorings Topic page. For additional information about ongoing evaluation of sampling and analytical methodology, contact NIOSH at (800) 232-2114.

### Control Methods

According to a standard occupational exposure control hierarchy, NIOSH recommends that employers minimize occu-

pational exposures to flavorings or flavoring ingredients. Strategies include:

- Substitute a material or materials that may be less hazardous, after carefully evaluating potential substitutes.
- Use engineering controls such as closed systems, isolation or ventilation.
- Institute administrative controls such as housekeeping and work practices.
- Educate employers and employees to raise their awareness of potential hazards and controls.

## Development of exposure control guidance will be critical in reducing exposures to diacetyl and to the thousands of other chemical flavorings used in the flavorings industry

•Use PPE where needed as an adjunct to primary engineering or administrative controls. Depending on the process, respirators should provide protection against VOCs, acids and particulates.

•Monitor occupational exposures and the status of workers' health, tracking spirometry and symptoms over time and referring workers with falls in FEV1 for medical evaluation.

### Medical Issues

Analyses of data from medical and environmental surveys at six microwave popcorn plants indicate widespread risk for occupational lung disease from exposure to butter-flavoring chemicals. In five of six plants, mixers and/or packaging-area workers with onset of respiratory symptoms after starting work had undergone medical evaluations that revealed fixed airway obstruction and other findings consistent with bronchiolitis obliterans. The findings from medical surveys of current workers at these plants are consistent with the medical evaluations, indicating risk to mixers who combine butter flavorings with heated oil and to packaging-area workers who work near inadequately isolated tanks of heated oil and flavorings. These analyses highlight the high potential for lung disease in mixers of oil and butter flavorings.

Because flavoring-related decreased lung function can occur before the onset of symptoms, relying solely on self-reporting of respiratory symptoms by workers as a way to identify early lung disease is insufficient to prevent clinically significant irreversible lung disease. Therefore, regularly scheduled medical monitoring with spirometry for workers who enter mixing rooms or perform quality control popping of product in microwave ovens is essential for early detection of declines in lung function that may indicate flavoring-related lung disease.

Workers exposed to butter-flavoring chemicals in the manufacture of other food products besides microwave popcorn may also be at risk for occupational lung disease. Clinicians should consider this possibility if they are evaluating respiratory symptoms or impairment in patients with a history of work in food production or in flavoring-manufacturing plants. Diagnosis of lung disease that is possibly flavoring-related in such workers should prompt further evaluation of the affected workers' workplace and coworkers to identify ongoing risks, if any, so that disease in other workers can be prevented.

### Consumer Risk

Although NIOSH does not evaluate the risk to consumer/nonoccupational exposures, an EPA study characterized the chemicals released when microwave popcorn is cooked. Seventeen different brands of microwave popcorn were tested. The compounds measured during popping and opening included butter flavoring components such as diacetyl, butyric acid, acetoin, propylene glycol, 2-nonanone and triacetin and bag components such as p-xylene and perfluorinated alcohol 8:2 telomer.

The greatest chemical quantity is emitted when the bag is opened post-popping; more than 80% of the total chemical emissions occur at this time. The study was not designed to measure the exposure a consumer would get when s/he makes microwave popcorn at home. Instead, it measured what chemicals are emitted when a person makes it and opens the bag.

Recent media reports described a consumer who popped two or more bags of microwave popcorn every day and developed lung problems. Consumer risk remains unclear since cause was not

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established in this case. Nonetheless, microwave popcorn manufacturers are now advertising a changed formulation of flavorings that reports "no added diacetyl." Diacetyl is present in some substitutes such as starter distillates.

### Future Work

NIOSH is interested in HHE requests in flavored-food production, including food service workers who grill with butter-flavored oils. NIOSH has project proposals for industry-wide studies in flavorings and food production. Our toxicology group has initiated more animal studies of flavoring chemicals and laboratory work is in progress to determine whether historical diacetyl measurements must be adjusted for relative humidity.

Another important need is research that documents exposures and develops engineering controls for the food flavoring production industry. Few data document occupational exposures in flavoring manufacturing. Furthermore, no model or standard guidance is available for engineering controls in flavorings production. As a result, a wide range of systems is in use, many with marginal effectiveness.

Development of exposure control guidance will be critical in reducing exposures to diacetyl and to the thousands of other chemical flavorings used in the flavorings industry (the majority of which lack occupational exposure limits). Many producers in this industry are small and do not have adequate in-house occupational health expertise to address exposure control; NIOSH can help them.

Visit the NIOSH flavorings topic page at [www.cdc.gov/niosh/topics/flavorings](http://www.cdc.gov/niosh/topics/flavorings) to access HHE reports, the alert and other documents concerning worker exposures to flavorings. This website is revised regularly as new information on occupational flavoring-related lung disease becomes available. Individuals can request additional information by sending an e-mail to [flavorings@cdc.gov](mailto:flavorings@cdc.gov). ■

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These professionals could help focus this effort to appropriate devices so the practice of dedicated SH&E professionals would not be unnecessarily burdened or disrupted.

We urge you to look into this matter and if DHS is pursuing such a program nationally to help see to it that DHS is required to follow administrative law and work with Congress, other federal agencies, stakeholders and the public to determine appropriate means for achieving its laudable goal of helping protect the American people from terrorist attacks.

As always, ASSE and its 32,000 mem-

ber SH&E professionals across the globe, including 1,300 members in New York State, stand ready to provide you and your staff with whatever resources may be needed to help resolve this concern. Please contact Dave Heidom, JD, manager of government affairs and policy, at [dheidom@asse.org](mailto:dheidom@asse.org) or (847) 768-3406 if there are any questions or if our members could be helpful. Thank you for your time and attention to this matter.

Sincerely,

*Michael W. Thompson, CSP*

Michael W. Thompson, CSP  
2007-08 ASSE President

## Ergonomics Branch a Valuable Resource for IHPS Members

ASSE's Ergonomics Branch is a highly valued resource for effective ergonomic practices. ASSE has long recognized the importance of ergonomics by supporting educational programs and by sponsoring ergonomics topics at annual Professional Development Conferences. The Ergonomics Branch goes a step further by providing a forum for members to be at the forefront of ergonomics issues as the science of ergonomics evolves and technology changes. Branch members have the opportunity to network and to share successful business practices, establish and contribute to standards of practice

and influence government affairs. We know many ergonomic questions and concerns exist in industrial hygiene and we are available to provide assistance and networking opportunities.

To join the Ergonomics Branch, visit [www.asse.org/practicespecialties](http://www.asse.org/practicespecialties) or call ASSE Customer Service at (847) 499-2929. Membership in the Ergonomics Branch is free to members of the Industrial Hygiene Practice Specialty. For more information, contact Branch Chair, Jerry Chingoharris, [jchingo@aspe.com](mailto:jchingo@aspe.com).



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## Measuring & Monitoring Ionizing Radiation

By Lawrence A. Mauerman, MAS, P.E., CSP

Two years ago, *The Monitor* published a small article I wrote on ionizing radiation (Mauerman, 2005). In that article, I mentioned that it was the first of a two-part series and that the second installment would be forthcoming. It never happened. Recently, several of my colleagues contacted me to ask what happened. Also, several personal experiences here at the university have reminded me to write the second article. Here is part two of the article series.

### The Goiânia Incident

Some years ago, I had the opportunity to live in Brazil. Part of that time was spent in the city of Goiânia. The city is one of Brazil's 20th-century experiments in moving its state capitals from their often inaccessible colonial locations to places that are easier to access and that would serve better as the focal points of regional growth and development.

At the time I lived there, Goiânia was already 28 years old and was showing real promise of fulfilling its mandate. Not only was it stimulating the development of the State of Goiás, but it had also become the jumping-off point for the nation's new capital,

Brasília, then under construction. It was a lovely city with winding, tree-lined avenues and parks. The 9 months I lived there are among my most cherished memories.

Imagine my surprise several years later when Goiânia became the unlikely site of one of the world's major nuclear incidents and a symbol, along with Chernobyl and Three-Mile Island, of all that can go wrong—both real and imagined—in the nuclear world.

The story of how the incident came about is both interesting and informative. It did not involve the meltdown of an enormous nuclear power plant nor did it involve an explosion in an industrial facility, a natural disaster or anything similar. In fact, the circumstances leading to the event are so unremarkable that, if it were not for the immediate effects it had on those it involved directly and the lasting mark it has left on the community, it would not have been noticed at all. As it has turned out, it is still considered second only to Chernobyl as the most important nuclear incident of all time.

In 1971, a cancer treatment clinic had been built near a charity hospital in downtown Goiânia. A cesium-137 radiation therapy

device was installed in the clinic but was replaced by a more modern cobalt device in 1978.

In 1985, the clinic with the cobalt device was moved to a newer location, but the cesium device was left in the old clinic building, which, because of legal entanglements, remained unoccupied for years. Later, it was said that it was the legal troubles which prevented clinic personnel from returning and removing the cesium device.

By 1987, part of the old building had been torn down, and what was left had large holes in the walls. Access to the structure was unguarded and unimpeded. Homeless people routinely slept inside to get out of the rain.

On Sept. 13, 1987, two men who made a living by scavenging entered the building and removed the large lead cylinder from the cesium device and took it to one of their houses. They tried—unsuccessfully—to hammer the device open.

Finally, on Sept. 16, using sharp tools, they managed to break through the iridium "window"; as a result, they received high doses of gamma radiation as they observed the deep blue light that

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