Popcorn-worker Lung Caused by Corporate and Regulatory Negligence:

An Avoidable Tragedy

DAVID EGILMAN, MD, MPH, CAROLINE MAILLOUX, CLAIRE VALENTIN

Diacetyl-containing butter flavor was identified as the cause of an outbreak of bronchiolitis obliterans (BO) and other lung diseases in popcorn-plant workers. Litigation documents show that the outbreak was both predictable and preventable. The industry trade organization was aware of BO cases in workers at butter-flavoring and popcorn-manufacturing plants but often failed to implement industrial hygiene improvements and actively hid pertinent warning information. Due to weaknesses in the organization and mandates of regulatory bodies, organizations such as NIOSH, OSHA, the FDA, particularly the "generally recognized as safe" (GRAS) system, and the EPA failed to detect and prevent the outbreak, which highlights the need for systemic changes in food-product regulation, including the need for corporations to act responsibly, for stronger regulations with active enforcement, for a restructuring of the GRAS system, and for criminal penalties against corporations and professionals who knowingly hide information relevant to worker protection. *Key words*: diacetyl; popcorn-worker lung; butter flavorings; bronchiolitis obliterans; corporate corruption; GRAS; occupational disease.

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In 2002, Kreiss et al. reported an outbreak of bronchiolitis obliterans (BO) and other lung diseases in popcorn-plant workers in Missouri.[1] The high levels of synthetic diacetyl combined with other elements of the butter flavoring were responsible for the outbreak of BO in the Jasper Popcorn Co., Givaudan Flavors, and other popcorn and flavoring plants.[2,3] It is possible that trace contaminants in synthetic diacetyl also contributed to the toxicity of this and other artificial butter flavors.

We reviewed an extensive number of documents produced during several lawsuits involving exposures to butter flavoring. The documents comprised a mix of internal correspondence, reports, programs, and presentations, as well as depositions of industry representatives and physicians. We also reviewed medical records of workers who died as a result of exposure to synthetic diacetyl. We obtained supplemental information from the internet and PubMed searches. Non-confidential documents are now available in a digital archive at <http://www.egilman.com/browse.php?display=list&dir=butter_flavoring/>.

We used an inductive process described as grounded theory to review the documents.[4] All documents underwent primary review by one author with selected reviews by the coauthors. We grouped material using a matrix by company and by theme. Themes included confidentiality agreements, warnings, regulation, medical information, and hygiene practices. Only the authors had a role in the mechanism of document review, presentation of results, or decision to submit the manuscript for publication, although some information could not be presented because several companies and/or their trade organization deemed it confidential.

While the medical cause of the BO outbreak among popcorn workers appears to have been the exposure to diacetyl, our evaluation of documents and depositions produced in litigation indicates that corporate malfeasance, confidentiality agreements, and inadequate governmental regulations contributed to the severity of the epidemic. Corporations failed to adequately test their products, while medical professionals and regulatory bodies failed to respond to the first cases of disease. Worker illnesses and the early knowledge about the dangers of diacetyl are chronicled below, as well as the link between the outbreak and changes in the butter-flavoring formulation that increased the concentration of diacetyl. The roles of the trade organization, Flavor and Extract Manufacturers Association (FEMA), and individual companies, including Tastemaker/Givaudan Flavors,* Sensient Flavors Inc., and Bush Boake Allen (BBA)/International Flavor & Fra-

Dr. Egilman is Clinical Associate Professor of Community Health, Brown University, 8 North Main Street, Attleboro, MA 02703, U.S.A.; telephone: (508) 472-2809; e-mail: <degilman@egilman.com>. He served as a litigation consultant and expert witness in the popcorn-butter litigation at the request of victims. Caroline Mailloux and Claire Valentin are research assistants, Never Again Consulting, Attleboro, MA.

Address correspondence and reprint requests to Dr. Egilman.

*Although the plant had several owners, upper management generally remained unchanged. In the late 1980s and early 1990s, the plant was affiliated with Mallinckrodt Flavors division (Fries & Fries). In 1992, the plant became a joint venture of Mallinckrodt and Hercules and operated as Tastemaker. In 1997, Roche purchased Tastemaker and the plant became part of Givaudan Flavors, a division of Roche. From 1988 to 1997, the plant was referred to as Tastemaker; from 1997 on, Givaudan.

grances (IFF)† are analyzed. Documents and depositions produced in litigation indicate that the flavoring companies, FEMA, and industry consultants were aware of the problem of BO among their workers but kept this information secret to protect their economic interests. Finally, the systemic regulatory failures, including the inadequacies of the "generally recognized as safe" (GRAS) system, poor worker compensation regulations, and the underhanded system of confidentiality agreements, as well as shortcomings of organizations such as NIOSH and OSHA, are discussed. Policy recommendations are offered.

THE FIRST DEATHS

There are several documented fatalities from BO and reports of countless other workers who have contracted the disease.[2,5] The first three deaths are presented here.

In the late 1980s, JI (index case) a 25-year-old food additive processor developed BO after working for approximately two years at the Cincinnati Tastemaker flavorings plant.[6] She had worked in the liquids-mixing area of the plant and had been exposed to many chemicals, including acetaldehyde and diacetyl.[7] Tastemaker did not provide respiratory protection, and the mixing vats were uncovered.[8] JI left the company in 1987 on disability leave, and died in 1992 at the age of 29. The case was referred to the Montgomery County, Ohio, Coroner's Office for investigation.[9] Suspecting occupational exposures, the coroner sent a letter to Tastemaker in November 1992 inquiring about the "circumstances" of her death and requesting information about chemical exposures as well as her work history.[10]

The second documented death from BO concerns DA, a 52-year-old white woman who had worked as a popcorn packager at the Gilster Mary Lee popcorn-packaging plant in Perryville, Missouri, from 1996 until 2003. A non-smoker, she suffered from a variety of breathing problems, including wheezing, paroxysmal nocturnal dyspnea, and shortness of breath, throughout her employment.[11] Doctors suspected that her symptoms were work-related.[12] Chest x-rays revealed that her lungs had a "ground glass" appearance.[12] The clinical diagnosis was pulmonary arterial hypertensive changes, chronic bronchitis, and bronchiolitis with bronchiectasis.[11] An open lung biopsy taken June 16, 2003, revealed mild nonspecific thickening of some alveolar septa and patchy aggregates of lymphocytes.[11] She died in 2003 from respiratory failure.

In May 2006, the third BO death was reported. LR had worked at Jasper Popcorn Co., Jasper, Missouri, for 18 months starting in 1995.[13] A lifelong non-smoker with no history of pulmonary complaints, LR began experiencing shortness of breath and a cough in late 1996.[13] In 2000, she visited the Mayo Clinic, where physicians diagnosed bronchiolitis obliterans linked to her exposure to chemicals at the popcorn plant.[13] In the last years of her life, she was confined to a wheelchair with oxygen, suffered from anxiety and depression, and was permanently and totally disabled.[13]

EARLY KNOWLEDGE OF BUTTER-FLAVORING TOXICITY

Allen Parmet, a local physician from Kansas City, recognized an occupational cause for the lung problems after examining a number of patients with similar respiratory symptoms who were exposed to butter flavorings at the Jasper plant. He reported and initiated the investigation into the occupational health hazards at the Jasper, Missouri, plant in 2000.[14] However, the Flavorings and Extract Manufacturer's Association (FEMA) and certain flavoring companies had known about the hazards years before; they had obtained information on the potential toxicity of diacetyl and the resulting BO disease in workers no later than 1986.

In 1976, The Research Institute for Fragrance Materials (RIFM) conducted diacetyl dermal toxicity tests on rabbits.[15] One animal died with evidence of systemic toxicity including dark lungs and a mottled liver. According to their web site, the RIFM database operates with the full cooperation of the Flavor and Extracts Manufacturing Association (FEMA); this indicates that the fragrance and flavor industries has been aware of the potential dangers of diacetyl since at least 1976.[16] However, there is no evidence that the RIFM followed up on this finding with further testing, no pathologic report was ever produced, and FEMA omitted the information on lung and liver toxicity from the toxicology summary on diacetyl that it supplied to NIOSH during the investigation of the Jasper plant.

In 1984–1985, two workers at International Bakers Services, Inc., a plant manufacturing cinnamon bun mix in South Bend, Indiana, developed BO.[17] Although NIOSH concluded that the cases were work-related, they could not identify a specific causal agent(s). At the time, NIOSH did identify diacetyl and many other specific exposures as potential causes and called for the use of a closed manufacturing process. NIOSH recommended:

> In the absence of a specific identified etiology for the two cases of severe obstructive lung disease, every attempt should be made to control airborne dust exposure in the mixing room [. . .] and employees should wear respiratory protective equipment whenever they are in the mixing room.[17]

In 1986, the two workers with BO from International Bakers Services filed lawsuits against Givaudan and 20 other flavoring manufacturers. Many of these manufacturers, including Givaudan, Polarome, and Citrus and Allied, were active FEMA members, and these compa-

†International Flavor & Fragrances completed the acquisition of Bush Boake Allen in 2000.

nies listed FEMA and RIFM personnel as defense witnesses in the case. Plaintiff's expert witnesses identified diacetyl among several other chemicals as the most likely causal agents.[18,19] The experts also identified about 40 chemicals that they felt should be tested for safety.[19] One expert spent ten days in deposition explaining the inadequacies of the manufacturing companies' warnings and testing program.[20] Susan Daum, an occupational physician who analyzed the cases, concluded her affidavit with the admonition:

> The fact that the defendants supplied chemicals to International Bakers Services, Inc. as ultimate users and consumers without having first tested these chemicals for inhalation or taken other appropriate measures to see that they were safe for use by humans is tantamount to using the Blenders at International Bakers Services, Inc., as blue collar guinea pigs. [18]

Finally, in 1993, BASF Germany performed an animal inhalation experiment to determine the LD_{50} for diacetyl.[21] BASF noted that dying animals had "dragging respiration, and gasping respiratory sounds."[21] Autopsy results of the lungs revealed "general congestion as well as focal hyperemia and moderate emphysema."[21] BASF also noted "focal atelectasis in all lobes of lung, bloody edema in the bronchi and intensified hydrothorax."[21]

Manufacturers are ethically and legally bound to possess expert knowledge about their products.‡ They should use this knowledge to both protect their own workers and warn their customers of any hazards associated with the use of their products. Butter-manufacturing companies should have been aware of the early warning signs of the dangers of diacetyl and should have passed this information onto their personnel and customers.[24,25]

CHANGES IN BUTTER-FLAVORING FORMULA

In 2002, Parmet and Von Essen reported on the epidemic of BO cases that appeared in workers at the Jasper popcorn-packaging facility in Missouri in the spring of 2000.[26] Although the diacetyl-containing butter flavor had been used for more than 50 years, this was the first epidemic caused by the flavoring reported in the published medical literature. Information produced by some of the manufacturers in tort litigation helps explain why the epidemic "suddenly" occurred in a plant that, until 1993, had operated without any apparent health problems. These documents reveal that the epidemic coincided with the introduction of a new butter flavoring that contained higher concentrations of diacetyl.

Jasper introduced Bush Boake Allen's (BBA's) new, "more concentrated" butter flavor in bulk in late 1992. This new flavoring contained two or more times the concentration of synthetic diacetyl than the butter flavors it replaced.[27] In addition, the previous flavors had much lower concentrations of synthetic and "natural butter flavorings" and some lacked the known toxins acetoin and acetaldehyde. All the cases of illness that occurred at the Jasper plant were exposed to this "more concentrated" flavoring in addition to other butter flavorings.[28,29]

Furthermore, in 1996, Jasper Popcorn Co. formulated and introduced a new "low fat" butter flavor.[30] This flavoring substituted butter flavor for soybean oil, further increasing the diacetyl concentration in the final flavoring.[29] Other popcorn manufacturers followed a similar process to create "low fat" popcorns.[29] Workers at the Jasper plant noted that the reformulated BBA butter flavoring had a noticeably "harsh" and "irritating" odor.[31]

The introduction of the new flavoring formulas was directly followed by an increase in the severity of the resulting cases. BO cases did not occur prior to 1993 at the Jasper plant, and workers suffered the most precipitous decline in lung function after the introduction of the high-concentration "low fat" flavoring in 1996.[28] The initial cases that occurred were limited to the most heavily exposed workers, i.e., "mixers" who blended the chemicals in uncovered vats. The second wave of disease, which occurred in 1996, coinciding with the introduction of the Jasper "low fat" flavoring, affected the majority of plant workers, including popcorn packers.[30] After Jasper complied with NIOSH's recommendations and introduced workplace controls, no new cases were noted.[32]

Recently, NIOSH researchers exposed rats for 24 hours to the flavorings in order to test their suspicion that the diacetyl-containing butter flavoring was the cause of disease.[33] The exposure "produced severe upper and lower airway changes in animals."[26] Hubbs et al. later reported that fully-formed BBA butter flavor caused more pathologic abnormalities in rats and was more toxic than pure synthetic diacetyl.[3,34,35] These studies provide further evidence that the increase of the diacetyl concentration in the butter flavoring most likely caused the popcorn-lung epidemic. In his 2002

‡In a 1941 internal document, the company Owens–Corning Fiberglass defined corporate responsibility, explaining, "From a humanitarian point of view, no company can afford to subject its employees to an unknown hazard. From a cold business point of view, no company can afford to jeopardize its own existence by subjecting itself to the liability of unknown hazards that may be encountered by those to whom it supplies the material."[22] Furthermore, the 1965 Restatement of Torts states, "One who, in the course of his business, profession or employment, or in any other transaction in which he has a pecuniary interest, supplies false information for the guidance of others in their business transactions, is subject to liability for pecuniary loss caused to them by their justifiable reliance upon the information, if he fails to exercise reasonable care or competence in obtaining or communicating the information."[23]

report, Parmet noted, in regard to a worker at the Jasper plant,

> There was significant improvement in his lung function and eye symptoms after exposure to this product ended and after corticosteroid therapy. These observations suggest that cessation of exposure is important for the treatment of this syndrome.[26]

INDUSTRY-WIDE KNOWLEDGE: "HIDING THE BALL"

Rather than warn workers and customers, the companies and their industry organization engaged in concerted action to hide information. The real history of the development of knowledge relating to the toxicity of diacetyl has come to light through the production of previously secret corporate documents and court testimony of corporate employees. The available history of each company is reviewed here, although some gaps in the information may still exist.

Cases of BO at Tastemaker/Givaudan Flavors

In 1992, following the death of the index case (JI) at Tastemaker, a second worker, JW, developed severe obstructive lung disease. A 1994 biopsy revealed that his condition had deteriorated and that he had developed chronic bronchiolitis.[36] JW worked in a different building than the index case, in a processing area where he was exposed to diacetyl but not acetaldehyde.[7] A third worker in the same processing area, CW, developed BO.[7]

After JI became ill, Tastemaker replaced her with MSM. MSM developed BO in 1993. Her private treating physician, concluded that "her symptoms are associated with her work environment."[37] Since MSM could no longer work, Tastemaker replaced her with RG. In 1996, the same physician, Dr. Baughman, determined that RG had developed BO "as a result of her exposure to chemical vapors" at work.[38] Although the plant provided RG with a respirator, she reported an acute overexposure to acetaldehyde in 1995.[39]

In 1998, Givaudan paid MSM and RG $8,750 each to settle complaints with the Ohio Bureau of Workers' Compensation that claimed that Givaudan had failed to follow specific safety requirements.[40,41]

Prior Knowledge at Tastemaker /Givaudan

In 1992, Tastemaker plant management began to investigate the outbreak of BO among workers.[42] Two years later, Tastemaker retained Dr. Stuart Brooks, the head of occupational medicine at the University of Cincinnati, to investigate BO cases among its manufacturing workers. By 1994, Brooks was aware of "five or six" cases of BO in workers at Tastemaker.[43] He submitted a special respiratory questionnaire and a final investigative protocol to Tastemaker in April 1995.[44] The proposed four-phase "Respiratory Health Inventory Program," with a $50,000 budget, was never implemented. Shortly thereafter, Tastemaker fired Brooks.[43]

In 1995, Tastemaker obtained a copy of the 1986 NIOSH Health Hazard Evaluation of the outbreak of BO at International Bakers Services, Inc., which had used a variety of flavorings, including diacetyl butter.[45] Although NIOSH never determined the specific cause of this outbreak, in 1995, Tastemaker toxicologist Nancy Higley determined that out of about 47 listed chemicals the International Baker and Tastemaker employees shared exposures to only three: acetaldehyde, benzaldehyde, and diacetyl.[45] Although Tastemaker was aware of NIOSH's interest in the issue and despite the fact that the Tastemaker plant is 5 miles from NIOSH's main offices in Cincinnati, Tastemaker (later Givaudan) never reported these cases to NIOSH or requested that NIOSH perform a free workplace hazard evaluation.[45]

Shortly after terminating Dr. Brooks, Tastemaker established a consulting agreement with James Lockey, MD, and the University of Cincinnati Division of Occupational and Environmental Medicine. Although NIOSH Fellows rotated through the occupational medicine clinic at the university, Lockey did not report the cases of BO to NIOSH at the time.[46] Tastemaker never shared Brooks' reports with Lockey, and, as part of their consulting agreements, both Brooks and Lockey had signed confidentiality agreements.[10,46]

Finally, as early as 1991, Givaudan had developed and marketed dicetyl-free substitute butter flavorings.[47] Yet, even after diacetyl came under suspicion, the companies continued to primarily sell dicetyl-containing butter flavorings.

Workplace Practices at Tastemaker/Givaudan

In 1992, Tastemaker instituted a three-year program to replace and repair its antiquated ventilation system and make some other improvements in plant ventilation.[42] Even after the improvements were implemented, Mr. Biscopink, vice president of operations at Tastemaker, noted that, "The large blend room was blending a butter flavor, which I understand is very dusty by nature. The room when observed was in horrible condition. [. . .] Just walking into the room it was difficult for me to breathe."[48] When John Hochstrasser, the Director of Environmental Health and Safety, sampled for dusts, he noted, "I used the same protective equipment that employees used in those operations. And from that, I could judge whether the powders were penetrating through the dust masks. And we found that they were. . . ."[42] Following this inspection, Tastemaker (later Givaudan) replaced the paper masks with full-face piece respirators, although they still failed to warn their workers or their customers, the popcorn manufacturing plants, of the health risks associated with their product.

Between 1995 and 1997, the University of Cincinnati occupational health team conducted an epidemiologic study of current employees, which included a health history questionnaire and pulmonary function testing (PFT). Roy McKay, director of Occupational Pulmonary Services at University of Cincinnati, was on the team called to run the program. At his deposition, he expressed his frustration with the restrictions Tastemaker placed on his work:

> [I]t's hard to get a person to want to wear a respirator if they don't feel there's a need to wear the respirator. And I was not—I was limited into the type of language and wording I can use to describe the potential respiratory hazard that may exist. And that made it difficult with regard to worker training and reporting on deficiencies and things that we would find. **I was reminded never to say the word bronchiolitis obliterans to any of the workers, for example.**[49] [Emphasis added]

Although Tastemaker held a meeting with its employees to explain the PFT and respirator program, Tastemaker refused to allow McKay to provide information concerning exposure and risk to the affected workers. Tastemaker further requested that McKay not put his observations into writing.

In early 1997, Hochstrasser, the Director of Environmental Health and Safety at Tastmaker/Givaudan, became so frustrated with the company's inability to protect employees that he threatened to shut the plant down.[42] Shortly thereafter, Givaudan fired Hochstrasser.[50] In 1999, Hochstrasser filed a personal lawsuit against Givaudan alleging that he had been wrongfully discharged because of his "continuous insistence of fastidious observance of environmental and worker safety laws and regulations."[10] Hochstrasser claimed that management had impaired his efforts to protect worker health and that he had been given "advice from legal counsel" against discussing BO and other lung diseases of workers at Tastemaker.[51] Givaudan settled the suit, agreeing to pay Hochstrasser an annual annuity of $25,000 for 20 years.[42]

As a result of Givaudan's inadequate response, yet another plant worker developed bronchiolitis in 2005 from exposure at the Cincinnati plant.[52,53] OSHA recently completed an industrial hygiene inspection of that plant.[54] Despite the fact that Givaudan had made supplemental payments to some of its workers who had contracted BO to settle complaints that the illnesses had been caused by specific violation of Ohio safety rules, OSHA cited the plant for merely failing to disclose the availability of exposure records. The penalty was $0. There is no standard with which exposure levels of diacetyl could be compared so no other violation was cited.[54] As a result, OSHA failed to enforces the general-duty clause of the OSH act.

FEMA

The Flavor and Extract Manufacturers Association (FEMA) is a trade organization whose members include many of the butter-flavoring manufacturers. FEMA's purpose, according to its general counsel, is to "provide the members with assistance in safety assessment, provide the members with assistance in compliance with regulatory issues and to provide a forum for discussion of scientific and regulatory and safety issues that are important to the members."[55] FEMA has stated that as part of its mission it sought to keep the industry "to the extent possible, self-regulatory."[56] As the trade organization, FEMA could have played a powerful role in preventing the epidemic of lung disease by gathering and disseminating critical information regarding the dangers of diacetyl to its members. Unfortunately, FEMA's failure to provide adequate safety and regulatory oversight and to communicate important warning information to its members highlights the inadequacy of self-regulation.

According to one FEMA board member, FEMA relies heavily on its members to fully disclose all relevant information about health hazards:

> If there were questions about an ingredient or a product in the industry, the members would have shared the issues with each other and then either their own regulatory or toxicological staffs or the staffs working with the FEMA staff would evaluate the problem and the cause of the problem to determine what the cause was. And if there was a—a link, then appropriate action would be taken with respect to the ingredient either to—to change the way it was manufactured, to inform customers, or simply to suggest that in the plants, flavoring plants themselves, that better ventilation or working conditions be handled. . . . if we didn't get information, we obviously couldn't act on information.[57]

By 1996, Tastemaker (later Givaudan) had eight confirmed cases of BO and one death reported by the Ohio coroner, which they suspected was BO-related.[58] Dr. Lockey and personnel from Tastemaker met with FEMA's general counsel, John Hallagan, to inform him of the cases. Lockey informed FEMA,

> If we assume that the autopsy data is correct, you only see bronchiolitis obliterans one out of 40,000 times at autopsy. Clinically, we're seeing it 6 out of 300 times. So if you adjust the denominator to 40,000 that would be 800 per 40,000. I think the point I was making there is that the prevalence of this disease in this limited population is much higher than we expect.[58]

Conflicting reports exist regarding the number of cases of BO of which FEMA was aware. In 1997 and 1998, Hallagan called and visited members to ask whether they knew of any cases of BO.[55] Some members were already aware of the BASF study regarding the dangers of diacetyl but did not share this information with FEMA.[59] In 1997, in response to Tastemaker/ Givaudan's disclosure of BO cases, FEMA held an industry-wide meeting, "Respiratory Health and Safety in the Flavor Manufacturing Workplace," to inform members of workplace health issues. Although Givaudan disclosures had prompted the meeting, no one from Givaudan mentioned the cases of BO at the conference, and FEMA even agreed not to disclose Givaudan's identity, since the company was concerned about bad publicity.[10] By choosing to conceal Givaudan's identity, both the company and FEMA undermined the dissemination of important warning information. Furthermore, FEMA informed its members that it was aware of only one confirmed case of BO, misrepresenting the extent of industry knowledge on the dangers of diacetyl. Thus, while the 1997 conference could have been a powerful moment to share information about health hazards, it was a missed opportunity, and it falsely reassured the industry that the case of BO was an isolated event.

Sensient Flavors, Inc.

In response to their knowledge about the real and potential hazards of chemicals used in the plant, including diacetyl, Sensient, another butter-flavorings manufacturer, implemented a number of safety programs to protect its own employees. For example, by at least 1992, Sensient had begun medical evaluations and testing for respirator fittings for employees at its facility.[60] By at least 1997, Sensient had a written hazard-communication program.[61] This program included information about instructing employees on how to read and use Material Safety Data Sheets (MSDSs) and other safety warnings and precautions. The program outlined a system for ensuring that all products received into and used within the plant were labeled with appropriate warnings.

In 2004, Sensient actively concealed knowledge about irreversible obstructive lung disease by deleting detailed information about the harmful effects of diacetyl from proposed MSDSs. The environmental regulatory manager at Sensient Flavors in charge of MSDSs, Elizabeth O'Connor, created a report for diacetyl in May 2004 based on regulatory information from suppliers as well as agencies such as OSHA and FEMA. The original MSDS contained the following warning:

> Warning Summary: Dust may be irritating to skin, eyes, and respiratory passages. Vapor inhalation *may cause irreversible obstructive lung disease.* [Emphasis added][61]

Sensient's corporate counsel reviewed the proposed warning, and, after a series of meetings, they decided to delete the language about irreversible obstructive lung disease.[61] No doctor, toxicologist, or expert from NIOSH was consulted about the issue of irreversible lung disease.[61] Following legal consultation, the new MSDS sent to customers in October 2004 read:

> Warning Summary: Dust and/or vapors may be irritating to skin, eyes, and respiratory passages, *may cause air way injury or lung disease.* (Emphasis added][61]

Thus, even with knowledge from chemical suppliers and regulatory agencies about the harmful effects of diacetyl, Sensient removed accurate warnings about irreversible obstructive lung disease at the recommendation of Sensient lawyers.

Bush Boake Allen (BBA) and International Flavor & Fragrances (IFF)

Knowledge and industrial hygiene. Like Sensient, BBA (later IFF) received warning information from suppliers and was aware of the potential hazard related to diacetyl in its butter flavor. For instance, the 1991 MSDS IFF received from its supplier, Berjé International, clearly warned that workers needed a "positive pressure self-contained breathing apparatus" for respiratory protection when working with diacetyl.[62] IFF also obtained information about the respiratory hazards directly from its diacetyl suppliers, Gist Brocades. Gist Brocades' 1997 MSDS, received in 2001, included the BASF data and stated that inhalation was, "Harmful: possible risk of irreversible effects through inhalation."[63] However, IFF failed to pass this warning on to its customers.

In 1991, workers at BBA's butter-flavorings manufacturing areas developed severe eye and skin irritation.[64] In 1992, after researching these problems, BBA proposed air monitoring for diacetyl and acetoin and implemented a mandatory respirator program for its workers.[65] In the course of implementing the respirator program, BBA found that many of the diacetyl-exposed workers had abnormal lung function.[66] BBA never followed up on these findings, nor is there any evidence that they reported these abnormalities to the affected workers.

In 1995, BBA's safety committee performed a literature review on the toxicity of diacetyl in response to an outbreak of eye injuries in workers mixing butter flavor. They discovered the 1993 German BASF study on the toxicity of diacetyl in animals.[67] Beginning at least in 2001, BBA, now owned by IFF, instructed its workers to "start running cold water through all of the heating jackets," in order to cool the butter flavor to around room temperature (83–85 F) before adding the diacetyl.[68] Such instructions indicate that the company was aware of the dangers of diacetyl vapors at high tem-

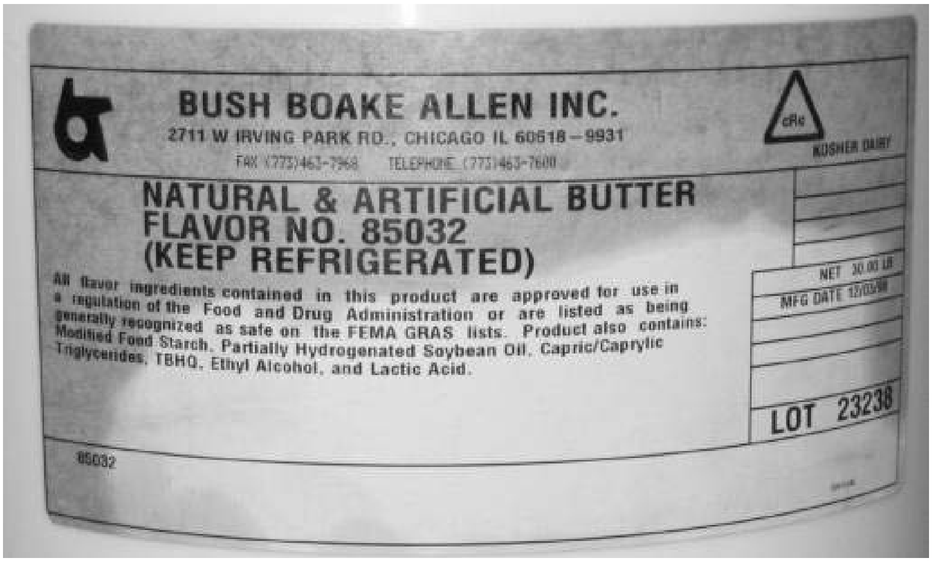

Figure 1—BBA label: example of an anti-warning. The label reads: Flavor ingredients contained in this product are approved for use in a regulation of the Food and Drug Administration or are listed as being generally recognized as safe on the FEMA GRAS lists. Product also contains: Acidified Food Starch, Partially Hydrogenated Soybean Oil, Capric/Caprylic Triglycerides, TBHQ, Ethyl Alcohol, and Lactic Acid.

peratures, although it did not pass this warning information on to its customers. The company then implemented a closed manufacturing process that minimized its own workers' exposures.[67] After the implementation of the closed manufacturing process and the temperature changes, BBA/IFF noted no further health problems and discarded the health information on diacetyl, again without warning customers.[67]

Anti-warnings: BBA misled customers. Not only did BBA fail to warn its customers of health risks, it misled customers with anti-warnings: language in or near warning statements that falsely reassures consumers.[69] Like Sensient, BBA used anti-warnings to minimize warnings about the adverse health effects of its butter flavor. A 1993 internal BBA memo noted, "our compounders feel they can be better protected by respirators that work effectively on the butter flavors [. . .] If we provide everyone with a mask, properly fit and train all Compounders, enforce proper storage of the masks, I think we will have a safer Compounding Department."[70] Yet, in the same year, BBA sent out MSDSs that told product users that respirators were "not normally required" and that there were "no known health hazards."[71] An internal memo in 1995 recommended that BBA "remove contradictory hazard statements from BBA produced MSDS."[72] However, BBA did not correct the butter-flavoring MSDSs.

Furthermore, the BBA label anti-warning (Figure 1) stated that "all flavor ingredients contained in this product are approved for use in a regulation of the Food and Drug Administration or are listed as being generally recognized as ***safe*** on the Flavor and Extract Manufacturers Association (FEMA) GRAS lists."[73] [Emphasis added] Since the GRAS evaluation process does not require any evaluation of potential worker hazard by the FDA, this statement creates the misimpression that ingredients have been tested and pose no risk to humans. In addition, the label listed only the harmless contents of the mixture, including food starch, soybean oil, capric acid, ethyl alcohol, and lactic acid, but failed to list the known toxic components such as diacetyl and acetaldehyde.[73] BBA claimed the use of these chemicals comprised a trade secret and could therefore be legally omitted from the MSDS listing requirement.[74] Thomas Bates, a BBA industrial hygienist, explained that diacetyl was never identified within any MSDS because of the trade-secret exemption but that all butter-flavoring companies knew that diacetyl was in butter flavor. He admitted that, in fact, it was "not a secret."[74] Finally, OSHA regulates acetaldehyde, so including it as an ingredient would have suggested that industrial hygiene evaluation of air levels and toxicity was required. In these ways, BBA omitted important information regarding occupational health risks and misled customers to believe in the safety of their products.

IFF attempts to warn customers. In 2004, IFF's insurance carrier refused coverage for bodily injuries related to "diacetyl containing butter flavors sold for use in popcorn."[75] Following this, in 2005, IFF, which had purchased BBA, became the first butter flavor manufacturer to create a new and improved MSDS to warn its customers.[76,77] In addition, IFF initiated a program to explain the changes in the MSDS and labels of their products to their customers.[78] Shortly thereafter, IFF stopped selling diacetyl containing butter flavorings to all customers except ConAgra.[78] IFF conditionally agreed to sell to ConAgra because of its "well known corporate citizenship including safety and health."[79] IFF modified its butter flavor MSDS to inform ConAgra of the respiratory risks of exposure and needed worker protection measures. It required that ConAgra acknowledge the receipt of the MSDS for butter flavors and sign a statement that indicated that its manufacturing facilities, including co-packers, were reading and following the MSDS information for the butter flavors.[75] ConAgra believed those demands were unusual and not specific. When IFF refused to answer ConAgra's questions about the hazards of the butter flavor, ConAgra refused to comply with IFF's demands. IFF ceased sales and Givaudan replaced IFF as ConAgra's diacetyl butter-flavoring supplier.[79,80]

REGULATORY FAILURES: "DROPPING THE BALL"

EPA TSCA Reporting Requirement

Under Section 4 of the EPA's Toxic Substances Control Act, passed in 1976, manufacturers must keep records of significant adverse reactions related to health or the environment resulting from use of a chemical and must report any unpublished health and safety studies with respect to the chemical to the EPA. Under section 8e of the Act, manufacturers of chemicals or any person who "obtains information that reasonably supports the conclusion that such substance or mixture presents a substantial risk of injury to health or the environment, must promptly report the information to EPA."[81] The flavorings industry did not comply with the TSCA requirements; only one company filed a section 8e report in 2004. As a federal regulatory body, the EPA must enforce its TSCA requirements in order to protect the public health.

Inadequacy of the GRAS System

Unbeknownst to consumers and occupational health professionals, regulation of some substances added to food has been abdicated to industry.[82] The 1958 Food Additives Amendment§ to the Federal Food, Drug, and Cosmetic Act exempted substances "generally recognized by experts qualified by scientific training and experience to evaluate its safety, as having been adequately shown through scientific procedures ... to be safe under the conditions of intended use" from food additive status.[83] Thus, as interpreted by the FDA, if a group of scientists hired by an industry organization determines that a substance is "safe," the FDA does not regulate the substance as a food additive and does not require agency review or approval before use.

The Food Additives Amendment instigated FEMA to establish an expert panel of scientists, which it claims has been "rigorously evaluating the safety of flavoring substances under conditions of intended use" for more than 40 years.[83] The FEMA expert panel notes, "Substances generally recognized as safe (GRAS) by the FEMA Expert Panel are not considered to be food additives, and are excluded from mandatory pre-market approval by the Food and Drug Administration."[83] Since the flavoring industry often refers to its food products as "generally recognized as safe (GRAS)," workers and customers often assume the products are safe when inhaled or when they otherwise come into contact with the mucous membranes or skin. However, the GRAS process does not evaluate substances for these risks.

Despite the fact that occupational exposures to GRAS chemicals have caused occupational diseases, OSHA does not regulate any substances added to food, including any evaluation of worker health problems. Furthermore, NIOSH does not routinely evaluate worker exposures to GRAS compounds. Under their mandates, both OSHA and NIOSH could regulate occupational hazards related to substances added to food, although the FDA is often assumed to have entirely reviewed the safety of all substances. As a result, regulation of the occupational hazards associated with GRAS substances falls through the cracks of bureaucratic overlap. It is evident from the diacetyl example that the GRAS system needs to be radically restructured and the oversight of each federal regulatory body must be more clearly delineated.

The Dangers of Industry Self-regulation

Key NIOSH staff, including Kay Kreiss and Richard Kanwal, recognized that butter flavorings labeled "GRAS" were widely used and that workplace controls in plants where workers used them were completely inadequate.[84] Kreiss knew the investigation into the hazard had to be expanded, but NIOSH management cut a deal with FEMA that stopped NIOSH investigations and allowed FEMA members to investigate themselves.[84] Kreiss recognized that this was folly and told the Baltimore Sun that, "We [NIOSH personnel] need to get into some of these plants because we don't have confidence that the flavoring industry has taken steps to actually prevent this disease, and we need to determine how widespread the exposure may be."[5]

Although the OSH act of 1971 gave NIOSH the right to inspect any plant, NIOSH chief spokesman Fred Blosser, removed the threat of use of this right, telling the *Baltimore Sun*, "You've got to ask if the expenditure of time, effort and money to go the forced-entry route to get into a plant is going to result in actions that benefit the workers. The answer is probably not."[5] Dr. Richard Lemen, a former 26-year career NIOSH employee, including service as its acting director, called this NIOSH position a "dangerous philosophy."[5] The threat of forced entry was often substantial enough to gain NIOSH entry and stimulate "voluntary" workplace improvements. Indeed, Lemen notes that, "without exerting its right of entry, NIOSH is reverting to the days before Congress created it and OSHA, when scientific study of worker health depended on the willingness of employers and workers died needlessly."[5]

§Public Law 85-929.72 Stat. 1784 (1958) codified at 21 USC Section 348 (1988).

In 2005, a case of BO at a flavorings manufacturing facility was reported to Cal/OSHA. Kreiss reported that, "We [NIOSH personnel] were told by staff members of the California Health department that [the trade association] made it clear that it did not want NIOSH involved in any of the California flavoring plants."[5] Both Kanwal and Kreiss felt it was wrong to hand the investigation over to the industry and felt the public health agency should handle the concern itself.

The industry hired Cecile Rose, MD, who did not feel that working for FEMA represented a conflict of interest. She told the *Sun* that her investigations had "found no major health problems, just 'mild abnormalities' in 16 workers."[5] However, a worker at a flavoring plant from 1988 to 2006, XX, may have a different view of the impact of self-regulation and physician conflicts on worker health.

XX participated in a National Jewish-sponsored respiratory screening program run by Dr. Rose beginning in 2004.[85] Dr. Rose found that he had abnormal lung function and referred him to his local physician, but did not inform him of the outbreak of BO at flavorings facilities. As a result, XX could not inform his physician of the potential risk of BO, and XX's physician, unaware of the bronchiolitis problem, did not consider this particular diagnosis. XX's physician was unable to determine the cause of his breathing problem, diagnosed his disease as asthma, and treated him with steroids. The physician referred him to an occupational health specialist, who reviewed multiple MSDSs from XX's worksite. He too was unable to determine whether any of these exposures had caused XX's disease. National Jewish documented XX's continued decline in lung function on an annual basis when it conducted screenings at this facility. In May 2006, his employer flew XX to National Jewish Hospital, where he was evaluated by Dr. Rose. About a month later, she told XX that his lung function had declined so far that he could no longer work at the plant. XX left work June 17, 2006. After leaving work he asked for and received his medical file from the flavorings company. The file contained a letter from Dr. Rose to the company indicating that she had diagnosed XX as having work-related BO.[85] Dr. Rose never informed NIOSH, OSHA, or state health authorities of this case. As the case illustrates, when federal bodies leave safety regulation and surveillance in the hands of the industry, they jeopardize worker safety and public health.

Material Safety Data Sheets (MSDSs)

OSHA requires suppliers to provide MSDSs to all facilities where their products are used. Since at least 1985, the Research Institute for Fragrance Materials (RIFM) along with FEMA has created a Flavor or Fragrance Ingredient Data Sheet (FFIDS), which flavoring companies have relied on to create their own MSDSs.[86] Although flavoring companies are highly competitive and refuse, in some cases, to disclose information they consider "trade secrets," the FFIDS allows companies to avoid competition regarding the relative safety of their products. This standardization of warnings allows companies to avoid competition regarding safety, including accusations by competitors that a product is more dangerous than another. Standardization of warning also allows companies to share health and safety information among themselves but hide it from their customers, workers, and government agencies (Appendix). For example, FEMA and its members never provided NIOSH with the 1993 BASF animal inhalation study in the popcorn-lung cases. They did not disclose the relative percentages of diacetyl and other toxic components of the butter flavorings, nor did they relate specific hygiene information about temperature and volatility. All this information was produced in tort litigation, and one of the authors (DE) forwarded it to NIOSH. Anti-trust action may be an underused regulatory intervention to penalize companies for concerted action that results in substandard warnings.

Furthermore, the 1997 FEMA conference included a lecture concerning misinformation that is often included in labels and MSDSs. The lecture included a list of potential problems with MSDSs, called "MSDS watch outs."[87]

Flavoring companies failed to implement the FEMA recommendations and their MSDSs contained (often identical) outdated information. None reported information from the NIOSH investigations from 1985 until 2004. Furthermore, the industries' MSDSs violated the "watch out" suggestions by recommending that users use an "approved respirator" and "adequate ventilation" without explaining the particular type of respirator or ventilation required for specific exposures. For instance, Givaudan's MSDS simply called for "adequate" ventilation, a term which Givaudan's industrial hygienist, Glenn Ingraham, called subjective.[88] No MSDS informed users of the workplace controls that manufacturers had implemented to eliminate exposures in their own plants, such as closed manufacturing processes, mandatory respirator programs, and cooling the mix below 85°F to reduce air levels prior to the addition of diacetyl. Unfortunately, it was only in 2004, in response to a twenty-million-dollar verdict for one of the popcorn-butter-flavor victims, that some flavoring manufacturers initiated improvements of their MSDSs and labels.[57] OSHA is now developing an enforcement initiative for compliance officers to review and evaluate the adequacy of MSDSs.[89] MSDS review should be accompanied by the threat of substantial financial penalization when companies fail to provide full disclosure and accurate information.

Workers' Compensation Laws

Strengthening state requirements for reporting occupational diseases is another promising avenue for control and prevention of diseases. In a 1990 report for the Centers for Disease Control and Prevention, Freund et al. state, "Although state reporting requirements for occupational disease may be disjointed systems that are currently plagued by underreporting and a lack of follow-up and control efforts, they exist because there is need for case identification of illnesses that require control and prevention."[90]

Currently, the Ohio Administrative Code, like other state codes, requires that physicians immediately report certain occupational diseases, including occupational asthma but not BO.[91] The private physician associated with the University of Cincinnati, Dr. Robert Baughman, who examined the three workers from the Tastemaker plant in 1992 and 1993, suspected that they all had BO. He was not required to report these under Ohio law. Tastemaker consultants Drs. Lockey and Brooks thought that several of the workers had occupational asthma, which should have been reported to health authorities.[58] Unfortunately, many physicians are uninformed of the regulations. Complete reporting and vigilant surveillance might have allowed the Ohio health department and NIOSH to discover the increased incidence of BO in workers and prevent future cases. Workers' compensation bureaus and state health departments should be required to refer all cases of occupational disease to NIOSH for possible investigation.

Furthermore, the Constitution of the State of Ohio states that workers can receive supplemental compensation for their disease if the employer failed "to comply with any specific requirement for the protection of the lives, health or safety of employees."[92] Except for the case of CW,¶ neither Tastemaker nor its subsequent owner Givaudan ever reported the confirmed cases to the Ohio Bureau of Workers' Compensation. In the future, the requirement that companies report occupational disease cases to compensation bureaus should be enforced and health authorities should use this information as a basis for investigation and control of workplace hazards. Currently, the State of Ohio tracks workers' compensation records to identify excessive lead exposures. Expanding the scope of the workers' compensation surveillance would allow the state to detect new and/or unusual clusters of occupational disease in the future. As Freund et al. (1990) recommended in their report to the Centers for Disease Control and Prevention, "uniform and streamlined requirements; coherent systems for data gathering, intervention, analysis, and dissemination; and innovative programs" are essential to effectively prevent occupational diseases.[90]

Confidentiality Agreements

The BO outbreak among popcorn workers also raises concerns related to the use of confidentiality agreements. As part of their consulting agreements with Tastemaker (later Givaudan), both Dr. Brooks and Dr. Lockey signed confidentiality agreements. The agreements were signed by Karen Duros, the company's general counsel, and read, "Copies of all written reports and correspondence regarding the project should be sent to me and marked 'privileged and confidential, prepared at the request of ***counsel*** with Givaudan.' "[10] [Emphasis added] Unlike consulting reports to Givaudan personnel, reports to legal counsel may not have to be disclosed during relevant litigation or at the request of government regulatory authorities, such as OHSA and NIOSH. Tobacco companies pioneered the ruse of labeling medical and other health information "prepared for legal counsel" to conceal important health and safety information.[95] Courts have declared that such documents are either not privileged or that in some cases the practice falls under the crime–fraud exception to legal privilege.[95]

Although Dr. Lockey wanted to publish his findings in 1995, he was unable to do so until 2002 since his confidentiality agreement prohibited publication.[58] In 2002, he submitted a copy of an abstract of his findings to the American Thoracic Society (ATS) and to Givaudan. In response, on June 24, 2002, Givaudan's lawyer sent Dr. Lockey a letter that outlined his confidentiality agreement and which stated,

> [As Tastemaker's new owner, Givaudan] has a right to request that you return all information in your possession relating in any way to the services you provided to Tastemaker. . . . In addition, Givaudan hereby requests that you do not disseminate any Tastemaker confidential information by way of public lecture, seminar, speaking engagement, or written publication unless you have received prior written permission from Givaudan to do so.[96]

By 1995, Dr. Lockey realized that the outbreak of BO was not limited to a single plant, and that workers throughout the flavoring industry needed to be protected.[58] In an effort to convince Givaudan to allow him to publish, Dr. Lockey told Givaudan that they had responded

¶To obtain worker compensation a worker must file a claim within two years after he recognizes the disease–work relationship. In 1999, Givaudan prepared a report of occupational injury for CW, the only African-American to develop BO, which they had him sign, and subsequently forwarded to the Ohio Bureau of Workers' Compensation. This form indicated that the BO diagnosis in CW had been made by company consultant physician James Lockey in 1995 and that CW had become aware of the occupational relationship long before the two-year statute of limitations. By signing the Givaudan prepared report, CW unknowingly relinquished his rights to medical coverage and compensation for financial loss due to his work injury.[94,95]

appropriately to the outbreak by hiring him and implementing workplace controls.[58] Givaudan then allowed his presentation to proceed; although, they requested that he stop publication of an ATS press release because the company did not want the information to receive publicity.[58] Dr. Lockey checked and assured them that the press had ignored the press release.

Lockey faced the same dilemma as Roy McKay when Givaudan prevented McKay from telling workers the full extent of the BO hazard as part of the respiratory program. McKay agonized over his predicament; he explained,

> I wasn't freely permitted to, in my opinion, fully describe the severity of the respiratory condition that could develop and at the—and since people that had a high interest in trying to figure out what was going on seemed to be extremely stressed there was a—it was kind of in this position all right, am I doing more good by staying here and being able to have the surveillance program and a strong respiratory protection program, try and keep that strong, or if they're dissatisfied with me then I leave, then what happens when I leave.[49]

Both Lockey and McKay faced a Hobson's choice: they could violate the confidentiality agreements and disclose vital information, or they could attempt to protect workers by continuing to collaborate with the company but keep the information secret. When a lawyer who represented injured workers at Jasper contacted him, Dr. Lockey explained his choice stating that sometimes in the interest of public health you have to keep things confidential.[96] Physicians and corporate consultants should not have to face this dilemma. Confidentiality agreements that prohibit disclosure of important information that may impact public health to state and federal authorities, such as NIOSH, OSHA, and the FDA, should be illegal. Criminal penalties should be applied to corporations and private physicians who fail to disclose this information, and Congress should grant immunity from litigation to physicians and others for violation of confidentiality agreements in these situations.

RECOMMENDATIONS FOR FIXING THE SYSTEM

Corporate responsibility, professional vigilance, and proper federal and state regulations could have prevented the epidemic of lung disease related to flavorings that has already led to three deaths and countless illnesses. To prevent future outbreaks of disease in workers and consumers, it is recommended that the federal government regulate all potential hazards from food and substances added to food, including those currently considered to be GRAS or "generally recognized as safe." The Delaney clause of the 1958 Food Additives Amendment, which bans the use of food additives that are known animal carcinogens, must be extended to GRAS substances. Furthermore, flavorings should be evaluated for possible allergenic and cardiac effects and for synergistic effects with other substances. The FDA should set minimum testing requirements, modeled after its drug testing program, for all substances added to food. The federal government should also vigilantly survey post-marketing data to detect abnormal disease occurrences.

Secondly, federal regulation must be extended to protect workers exposed to these substances from occupational health hazards. Federal regulatory bodies such as NIOSH and OSHA should have clearly delineated responsibilities that allow them to ensure that flavorings and other GRAS substances are tested for inhalational and occupational hazard. Since FEMA already has a list of chemicals that it believes are most likely to be hazardous to workers and consumers, the FDA, EPA, OSHA, and NIOSH should prioritize chemicals to be tested based on likelihood of exposure, likelihood and severity of adverse health effects, and extent of use. Based on this list, OSHA should require companies to perform these tests in addition to enforcing the general-duty standard for occupational safety.[97]

Thirdly, the federal government must evaluate tort reform in relation to public health disasters. Litigation remains one of the most importance means for determining how and why public health disasters, such at the BO epidemic, occur. No other process in the legal or regulatory system produces a similar kind or volume of information. Such information should be made publicly available to protect the public health. To paraphrase George Santayana, those who cannot decipher the past are condemned to repeat it.[98] A valuable model for the use of litigation discovery in public health education is the Legacy Tobacco Documents Library at the University of California, San Francisco, which houses 7 million documents related to advertising, manufacturing, marketing, sales, and scientific research of tobacco products. Since tort reform has limited public health litigation, the government must develop other vehicles, such as developing section 8e of TSCA, obligating companies to produce documents that may help prevent other public health disasters.

Finally, corporate responsibility must be enforced. Companies should be required to report occupational disease outbreaks to OSHA and NIOSH and state public health agencies; failure to do so should be criminalized. In addition, physicians and other health consultants should be given immunity from prosecution under confidentiality agreements when disclosing information to government authorities in the interest of public health. The popcorn-lung epidemic highlights the fact that in every instance, professionals, corporations, and federal authorities must prioritize health and safety over short-term profit in order to protect workers, customers, and the public.

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Appendix

Public versus Flavoring Industry Private Knowledge of Butter Flavoring Risk

Flavoring Industry Knowledge	**Public Knowledge**
1977—RIFM animal study shows lung changes in dead animals exposed to diacetyl breathing and gasping after exposure to diacetyl	
1985—RIFM report states that diacetyl is “harmful by inhalation”	
1985—Animal study provided to RIFM shows death, labored breathing and gasping after exposure to diacetyl	
1985—FEMA model MSDS states that inhalation capable of producing systemic toxicity[80]	
	1986—Two workers mixing “cinna-butter” containing diacetyl diagnosed with BO
1988 First case of BO at Tastemaker (later Givaudan) in a butter-flavoring manufacturing worker	
1988–2005—15 cases of BO and other severe lung disease, including one death, in Tastemaker/Givaudan Cincinnati plant	
1989—Animal study provided to RIFM shows shortness of breath in diacetyl-exposed animals	
1991—Eye and skin irritation in exposed workers in BBA butter-flavoring plant	
1991—BBA received Berje International MSDS, which clearly warned that workers needed a “positive pressure self-contained breathing apparatus” for respiratory protection when working with diacetyl.	
1991—Diacetyl monitoring in manufacturing area in BBA butter-flavoring plant	
1993—First Jasper case evaluated by FEMA consultant who subsequently ran industry meeting on respiratory hazards in flavoring industry in 1997	
1993— BASF study revealed severe lung damage caused by diacetyl in rats	
1993—Respirator program for diacetyl workers in BBA butter-flavoring plant	
1994—Closed system planned in butter room for safety concerns at BBA	
1997—IFF receives Gist Brocades MSDS, which includes BASF data	
	2000—Alan Parmet, astute local physician, reported severe lung disease in popcorn workers; arranged for NIOSH study
	2001—NIOSH identified butter flavoring as a possible cause of severe lung damage in popcorn workers
	2002—NIOSH conducted animal studies that revealed butter flavoring causes severe lung damage
	2004—Author (DE) provided 1993 BASF study to NIOSH
	2005—New case of lung disease at Givaudan related to occupational exposure
	2006—XX developed BO while in FEMA/National Jewish Hospital surveillance program