DEPARTMENT OF HEALTH & HUMAN SERVICES

Public Health Service

Phone: (304) 285-5751
Fax: (304) 285-5820

Centers for Disease Control
and Prevention (CDC)
National Institute for Occupational
Safety and Health (NIOSH)
1095 Willowdale Road
Morgantown, WV 26505-2888

May 13, 2003
HETA 2001-0517

Mr. Keith Heuermann
B.K. Heuermann Popcorn, Inc.
504 W US Hwy 34
Phillips, Nebraska 68865

Dear Mr. Heuermann:

On August 28, 2001, the National Institute for Occupational Safety and Health (NIOSH) received a health hazard evaluation (HHE) request from management at B.K. Heuermann Popcorn, Inc. to evaluate work processes and exposures occurring during the packaging of microwave popcorn. This request was motivated in part by the fact that several workers experienced eye injuries and cough while using a new flavoring in August 2001. The worker that prepares the mixture of oil, flavorings, salt, and coloring, was found to have fixed airways obstruction on evaluation by a pulmonologist soon after this event. NIOSH investigators visited your plant on September 27, 2001, to perform an initial walkthrough, conduct an opening meeting with management and workers, and conduct confidential worker interviews and lung function testing with spirometry. A NIOSH industrial hygiene survey was conducted from December 11 to December 13, 2001. An interim letter containing medical findings, preliminary air sampling results, and recommendations, was sent to you on April 19, 2002. The current letter provides additional air sampling results, additional background information on flavoring-related lung disease in the microwave popcorn industry, and updated recommendations. It also constitutes the final report for this health hazard evaluation.

Background

NIOSH has investigated the occurrence of a rare lung disease, bronchiolitis obliterans, in workers exposed to butter flavorings in microwave popcorn plants and in workers of a flavoring manufacturing plant. Those investigations, and animal studies conducted at NIOSH, have shown that inhalation of flavoring chemicals may lead to lung disease. Studies at NIOSH are in progress to determine which flavoring chemical(s) is responsible, and at what level of exposure effects occur.

In bronchiolitis obliterans, inflammation and scarring occurs in the small airways of the lung and can lead to severe, permanent shortness of breath. The main respiratory symptoms include cough (usually without phlegm) and shortness of breath on exertion. These typically do not improve much when the worker goes home at the end of the workday or on weekends or vacations. Some affected workers have fever, night sweats, or weight loss. Usually symptoms are gradual in onset and progressive, but severe symptoms can occur suddenly. Some cases may not respond to medical treatment. The onset of symptoms in affected workers has occurred from

months to years after the first exposure to flavoring vapors. Spirometry, a test that measures how much and how fast someone can exhale air from their lungs, generally shows fixed airways obstruction (i.e., difficulty blowing air out fast and no response to asthma medications). Whether or not restriction (i.e., decreased ability to fully expand the lungs) may result from flavoring exposure is unknown. Some workers show evidence of fixed airways obstruction on spirometry tests before they develop symptoms of lung disease. Because medical treatment does not reverse the condition, some workers with severe disease have been placed on lung transplant waiting lists.

In addition to lung disease, workers exposed to butter flavoring vapors may develop problems with their eyes and skin. Eye irritation is common, and occasionally workers report chemical burns of the eyes requiring medical treatment. Similarly, exposed workers may report skin irritation, and one worker in another plant developed a disabling skin allergy to butter flavorings.

NIOSH has evaluations in progress at five other microwave popcorn plants. So far we have identified evidence that mixers of oil and flavorings have work-related lung disease at three of these plants. In two plants, packaging workers who work near tanks containing heated oil and flavorings had elevated rates of obstruction on spirometry testing. At one plant, five of six quality control workers, who microwave many dozens of bags of product during their work shift, had obstruction. Currently these findings indicate that the highest risk to workers in microwave popcorn production is from mixing of flavorings with heated oil, working near tanks that hold heated oil and flavorings, and from exposures occurring during the microwave popping of many dozens of bags of product during a work shift.

Microwave Popcorn Production at B. K. Heuermann Popcorn, Inc.

The packaging of microwave popcorn occurs in a 50 × 75 foot room inside a larger metal-clad warehouse that also houses offices and an upstairs apartment. A solid wall exists between the microwave packaging area and the office/living space with access between them consisting of two walk-through doors. Warehousing of supplies and finished product occurs inside a separate facility on the premises.

The company produces several varieties of microwave popcorn by combining different butter flavorings with popping corn grown exclusively for B.K. Heuermann. On occasion, they have produced bagged popcorn for other companies using recipes specified by the purchaser. It was one of these recipes that caused eye injury and cough in several plant workers in August 2001. Packaging of microwave popcorn using that particular recipe was halted, and the recipe has not been used since. From August 2001 until the NIOSH environmental survey in December 2001, only B.K. Heuermann Popcorn flavoring recipes were used during microwave popcorn packaging operations.

The plant operates an average of 8 days per month, depending on demand, and has only one day-shift of operation. It was reported that there are usually four workers on duty. During the NIOSH environmental sampling visit, there were six workers in the plant. There is a single microwave popcorn bagging line in the plant that produces approximately 27,000 bags of microwave popcorn per day (97 bags/minute). A single exhaust ventilation system serves the production area with four branches extending to various points on the process line: the fixed

portion of the mixing tank lid, the salt shake-out box, and on the bagging line over the flavoring injector and over the bag wrapping operation (where individual microwave popcorn bags are sealed in plastic). During the December 2001 NIOSH visit, there was no general dilution ventilation of the building, except when the external garage door was opened to bring in production supplies or remove finished product. At all other times, all external building doors were closed and an axial wall fan that was present was not in use.

The mixing operation is centrally located inside the facility adjacent to the packaging line. There are no enclosures around the mixing tank or salt shake-out box, however the mixing tank itself does have a lid. Both the mixing tank and the salt shake-out box are under negative pressure from the recently installed ventilation system. Soybean oil is added to the mixing tank in solid blocks. The flavorings and sifted salt are mixed together in 5-gallon buckets and then added to the tank in cold liquid form. One worker spends approximately 60 to 90 minutes per day mixing the flavorings for the day's production. This worker wears a NIOSH-approved half-mask respirator with approved organic vapor/P100 cartridges during mixing and salt sifting operations only. This is the only time any worker in the plant wears respiratory protection. After all ingredients are added to the mixing tank, they are maintained at 115-120°F while constantly stirred. The heated flavorings mixture is pumped to the microwave packaging line where it is combined with popcorn in the microwave bags.

Medical Evaluation Methods and Findings

During our visit to your plant on September 27, 2001, we conducted confidential interviews of five employees and management personnel that normally work or spend time in the production building. A recent temporary worker and another full time worker that were present when the new flavorings were in use in August 2001 were unavailable on this day. After obtaining signed informed consent from all participants, a NIOSH technician performed lung function testing with spirometry before and after administration of albuterol, a medication used in asthma and other obstructive airway conditions to relax airways and increase airflow. We sent participants their spirometry test results in October 2001.

Several workers reported nasal and eye irritation and coughing occurring occasionally prior to August 2001. Others reported these symptoms only in relation to the use of the new flavoring. Spirometry testing revealed that three of the workers had mild or borderline airway obstruction that was unresponsive to albuterol.

The mixer was initially identified as having fixed airways obstruction in late August 2001 after worsening cough during and after the use of the new flavoring led him to seek medical evaluation. Follow-up evaluation of the mixer by his pulmonologist six weeks later showed that his lung function had improved substantially. During part of this time he was treated with prednisone and did not work as a mixer. Repeat follow-up evaluation by his pulmonologist in April and December 2002 showed that his lung function had declined again.

Industrial Hygiene Survey Methods and Results

NIOSH conducted air sampling for three days of full-shift operation on December 11-13, 2001. Almost all samples were collected for the duration of the work shift. Area samples were obtained at every workstation each day, and all workers wore a personal sampler for ketones each of the three days. In addition to the workers in the microwave popcorn packaging facility, NIOSH also collected samples in the research and development testing area. This testing area is in a separate facility approximately four miles away from the packaging line. Here, raw popcorn is popped theater-style with hot oil only (no flavorings) and sampled for taste, texture, shape, size, hull, etc. On Wednesday, December 12, 2001 one array of area samples and three personal samples (representing 100% of workers in the testing area) were collected. Samples in the research and development facility were only collected on one day since flavorings are not used in the area.

Area sampling arrays contained sampling media for diacetyl and acetoin (ketones commonly found in butter flavorings), respirable and total dust, total volatile organic compounds, particle size distribution, and acetic acid. The personal samplers consisted of a sampling pump worn on the belt and a sorbent tube clipped on the shirt in the breathing zone of each worker. These personal samples were analyzed for diacetyl and acetoin only. Additional information on each sampling media is shown in Table 1.

The results from all of the area samples collected are shown in Table 2. Table 3 shows the results from all of the personal samples. Figure 1 and Figure 2 graphically show the results for diacetyl and acetoin obtained from the area samples and the personal samples, respectively.

Exposure limits for diacetyl and acetoin have not been established by NIOSH, OSHA, or ACGIH. Compared to initial diacetyl and acetoin air concentrations measured by NIOSH at a Missouri microwave popcorn plant where many workers have developed lung disease, the concentrations of these chemicals at B.K. Heuermann Popcorn, Inc. were lower (based on area sampling results). The concentrations of diacetyl first measured by NIOSH at the Missouri plant ranged from 2.3 to 98 ppm for mixers and 0.3 to 6.8 ppm for machine operators and packaging workers. At B.K. Heuermann, the ranges were 0.25 to 1.0 ppm for the mixer and 0.4 to 1.2 ppm for the machine operator and packaging workers. Initial acetoin concentrations at the Missouri plant ranged from 0.08 to 12.2 ppm for mixers and up to 1.5 ppm for machine operators and packaging workers. At B.K. Heuermann, the acetoin concentrations were 0.2 to 0.9 ppm for the mixer and 0.5 to 1.3 ppm for the machine operator and packaging workers. While this comparison is based on area sampling, the level of diacetyl and acetoin exposures found from personal sampling show very similar results. Diacetyl and acetoin were found at the research and development facility at levels below the limit of quantitation (approximately 0.01 ppm) and below the limit of detection (0.01 ppm), respectively.

Major compounds detected on all sorbent tubes were diacetyl, acetoin, nonanone, toluene, and butyl cellosolve. The first three are common ingredients in butter flavorings. Major compounds detected from headspace analysis of the two flavorings used at B.K. Heuermann during the NOSH visit were diacetyl, acetoin, nonanone, and several others. Toluene and butyl cellosolve were only seen in very low amounts in the headspace analysis of the bulk flavorings. Thus, the exposures to toluene and butyl cellosolve noticed from the thermal desorption tubes in the area

baskets are probably from another source. None of these compounds were quantitated as part of this analysis, but it qualitatively describes many of the VOCs that workers could be exposed to during normal production operations.

No acetic acid was detected in any of the samples taken at either the microwave popcorn production facility or the research and development testing area.

Dust levels at B.K. Heuermann Popcorn were below the OSHA PEL for particulate not otherwise regulated of 15 mg/m^3 for total dust and 5 mg/m^3 for respirable dust (29 CFR 1910.1000, Table Z-1). The particle size distributions were sampled with cascade impactors for all areas, including the research and development facility, on December 12, 2001. A cascade impactor was located in the mixing area on all three days of sampling. The three particle size distributions for the mixing operation showed mass median aerodynamic diameters (MMADs) ranging from 4.2 to 7.6 micrometers. The three particle size distributions from the microwave machine operator, catcher and palletizer areas showed MMADs ranging from 4.1 to 5.3 micrometers. The slightly larger MMAD noticed in the mixing area could be attributed to salt sifting which is performed immediately adjacent to the mixing tank where the sampling basket was located. The MMAD for the sample collected in the research and development area was 3.3 micrometers.

Discussion

Flavorings are complex mixtures of dozens of ingredients, many of which have irritant properties that may contribute to the development of lung disease. The effects of these ingredients may be additive, such that exposure to a concentration of compound which would not cause harm as a sole exposure, may be harmful if combined with exposures to other compounds. During our industrial hygiene survey at your plant, we measured the air levels of diacetyl and acetoin, two common ingredients in butter flavoring, as indicators of exposure to butter flavoring vapors. Ongoing animal experiments at NIOSH indicate that diacetyl is one of the chemicals in butter flavoring that can lead to airway injury. The other chemical components that may contribute to toxicity, and the levels of exposure that are considered safe, are still not known. Recommended air exposure limits have not been established for most chemicals that are used in flavorings. Also not known is the relative safety of powdered flavorings compared to liquids or pastes. Powders that are formulated to have lower emissions of volatile flavoring chemicals may pose lower risk. However, inhalation of airborne dust when handling these flavorings may increase worker risk for lung problems.

As mentioned previously, fixed obstruction has occurred in mixers in three other plants. The mixer at this plant reports that he is a lifelong non-smoker and had no symptoms or history of lung disease prior to coming to work at your plant. Although it is possible that he had pre-existing disease, it is more likely that he developed fixed airways obstruction as a result of exposure to butter flavorings in the plant. Whether this type of exposure is also responsible for the other two workers with decreased lung function is unknown.

It is difficult to know if the mixer was affected by one or more of the flavorings that you regularly use, or one of the new ones used in August 2001. The mixer reports having had a cough while working as a mixer for two years prior to the use of the new flavorings. It is possible that the new flavorings exacerbated a condition caused by your regular flavorings. One

of your regular flavorings was also used (along with others) at the Missouri plant where many workers were affected. Vapors from this flavoring also caused severe injury to cells lining the airways of rats when they were exposed in an experiment at NIOSH.

One way to attempt to determine if present levels of exposure at B. K. Heuermann Popcorn, Inc. may pose risk is to compare exposures at this plant to those that have been associated with lung health effects in other plants. The area concentrations for diacetyl measured by NIOSH at the Missouri plant (prior to the installation of exposure controls) for oil mixers, machine operators, catchers (packers), and palletizers (stackers) were higher than personal exposures we measured at B. K. Heuermann in December 2001. Acetoin exposures at B.K. Heuermann were similar to the Missouri acetoin concentrations for machine operators, packers, stackers. Missouri oil mixers were exposed to higher acetoin concentrations. However, we still do not know how low exposures need to be to eliminate risk. At a plant in Iowa that we evaluated after a mixer developed fixed obstructive lung disease, mixing room diacetyl air concentrations were lower than those we measured at your plant. The mixing room in the Iowa plant also had general dilution ventilation and local exhaust ventilation of mixing and holding tanks. The findings from the Iowa plant strongly suggest that mixers may be at increased risk due to short-term higher exposures even when ventilation maintains low average exposures. Higher exposures may occur during measuring flavorings, pouring them manually into tanks of heated soybean oil, or when looking into tanks, especially if respiratory protection is not consistently and appropriately utilized. The recurrence of decreased lung function in the mixer in your plant may indicate the presence of continued hazardous exposures to him and possibly other workers.

What can be inferred from comparisons between B.K. Heuermann Popcorn, Inc. and other plants is limited for several reasons. The flavorings used vary from plant to plant such that the chemical ingredients in the mixtures may be different. Workers at the Missouri and Iowa plants may be at greater risk because they work 20 or more days a month, while those at B.K. Heuermann work fewer than 8 days a month on average in microwave popcorn production. The plants that NIOSH evaluated in Missouri and Iowa are much larger than B. K. Heuermann Popcorn, Inc. They have many mixing and holding tanks for heated oil and flavorings. Their mixers spend most of their work shifts preparing the oil and flavoring mixtures compared to the mixer at your plant. Exposures at B.K. Heuermann could increase significantly if production is increased and larger amounts of heated oil and flavorings are required.

As there are no measurements of air concentrations of flavoring ingredients from August 2001 with the recipe of concern or the time prior to the installation of the local exhaust ventilation system, it is not possible to quantitatively determine how effective the local exhaust system is at reducing these concentrations. Smoke tubes were used to visualize the capture efficiency of the local ventilation system. While the system appeared to adequately capture air from its target locations, it is not possible to quantify these results.

In general, the concentrations of diacetyl and acetoin at B.K. Heuermann were noticeably higher on the third day of sampling (December 13, 2001) than on either of the previous two days. Further, it appears that the concentrations of diacetyl and acetoin are generally higher when the low-fat butter recipe is used than when the intense butter recipe is produced. The same low-fat butter recipe was being produced on December 12 and December 13. The higher concentration of diacetyl and acetoin on the third day of sampling (December 13) is probably attributed to the

longer production time. On December 12, microwave popcorn production was significantly delayed in the morning because the mixing tank was accidentally left cold overnight and the flavorings did not reach proper temperature until late morning. This was not a problem on December 13, so production was started much earlier.

During the December 2001 NIOSH visit, one worker was observed mixing flavoring ingredients. A NIOSH-approved half-mask with organic vapor cartridges and P100 filters was worn during flavoring mixing and salt sifting. The respirator was found to be in good shape, although it was stored in the plant beside the mixing tank. The worker stated that a conscientious effort was made to change respirator cartridges on a regular basis and to maintain a record of cartridge replacements. However, the changeout schedule is not based on any real exposure data or available computer models. The worker had not been fit tested and did not perform user seal checks when he donned the respirator.

Two workers usually worked to wash the 5-gallon flavoring buckets that were emptied each morning. They both consistently wore rubber gloves and aprons while washing the buckets. No respiratory protection was used during bucket washing.

Conclusions and Recommendations

Findings from our evaluation at B. K. Heuermann Popcorn, Inc. indicate exposures and health effects that are similar to what we have observed in other microwave popcorn plants. Current exposures may still pose risk. We recommend that you take the following steps to minimize the risk to workers in microwave popcorn production:

1. Enclose and isolate the mixing tank and salt shake-out box in a room that is walled off from the rest of the plant. Use ventilation to keep this room under negative air pressure and limit access to this room to only essential personnel. If possible, perform all handling and measuring of flavorings inside this room. Anyone entering this room should wear a respirator as discussed below.

2. Keep all containers of flavorings tightly sealed when not in use, including empty containers that are unwashed. Until a room for the mixing tank is built, weigh or measure all flavorings as far away from other workers in the plant as is feasible when preparing the oil mixture.

3. Identify options for adding flavorings to the mixing tank that eliminate the need to pour them from open containers or buckets. For example, a closed process that utilizes sealed flavoring-containers that are connected to the mixing tank through pipes or other suitable devices will decrease the potential for exposures.

4. Maintain the temperature of the heated oil mixture as low as the production process will allow, in order to minimize the amount of flavoring compounds that are emitted into the air. Keep the lid on the mixing tank closed as much as possible and continue to maintain the mixing tank under negative pressure with local exhaust ventilation.

5. Institute formal, mandatory respirator use and skin and eye protection for anyone preparing the oil and flavorings mixture, anyone measuring quantities of flavoring, and anyone looking into tanks that contain flavorings. Employees responsible for washing empty flavorings containers should also be included. Set up a written respiratory protection program that meets the requirements of the OSHA respiratory protection standard (29 CFR 1910.134). Workers need to have a medical evaluation for respirator use, fit testing for tight fitting respirators, and training on proper respirator use and maintenance and on the nature of the health hazard. The minimum protective respirator we recommend is a NIOSH-certified half-mask non-powered, air-purifying respirator with organic vapor cartridges and N95 particulate filters. A full facepiece respirator will provide respiratory and eye protection. Otherwise, use tight fitting goggles for eye protection taking care not to interfere with the seal of the respirator to the face. Since there is a lack of data surrounding the changeout schedule of the organic vapor cartridges, a very conservative changeout schedule should be in place. From what we have seen in other microwave popcorn plants, and given the fact that your plant only operates an average of eight days per month, changing the organic vapor cartridges each month is recommended. The N95 particulate filters should be changed whenever they become dirty or damaged, or when an increase in breathing resistance is noticed. Store the respirator away from the mixing area. It should be kept in a plastic bag to keep it clean and should be stored flat as to not deform the facepiece. Hanging the respirator should not be done during storage because hanging can deform the facepiece, stretch the straps, and make it difficult to get a good seal. **Workers should use a respirator at all times when handling open flavorings or looking into tanks of heated oil and flavorings.**

6. Discuss with your flavoring supplier the possibility of substituting powdered flavorings that release lower amounts of volatile organic compounds into the air than the flavorings that you currently use. Powdered flavorings that generate little dust when handled are preferable to ones that generate more airborne dust. If you make such a change in the flavorings that you use, workers should still use respirators when handling flavorings as discussed above.

7. Institute medical monitoring with spirometry twice a year for mixers and yearly for workers in microwave packaging to see if workers' lung function is remaining stable over time. New workers should have a baseline test before starting work. It is important to choose a health care provider that can assure high quality spirometry testing in order to compare test results over time. The provider should provide documentation that their spirometry technician has attended a NIOSH-certified spirometry course, and that routine calibrations of their spirometer are performed as recommended by the American Thoracic Society. If you are unable to locate a provider near your company that can provide such documentation, NIOSH can provide guidance to a provider of your choice.

This letter constitutes the final report for HHE 2001-0517. In accordance with Code of Federal Regulations, Title 42, Part 85, copies of this letter must be posted in a prominent place accessible

to the employees for a period of 30 calendar days. If you have any questions concerning this or any other occupational health issue, please contact us at (304) 285-5932.

Sincerely,

Richard Kanwal, MD, MPH
Medical Officer
Respiratory Disease Hazard Evaluation and
Technical Assistance Program
Field Studies Branch
Division of Respiratory Disease Studies

R. Kanwal for Stephen Martin

Stephen B. Martin, Jr.
Engineer (Occupational Safety and Health
Specialist)
Laboratory Research Branch
Division of Respiratory Disease Studies

cc:
OSHA, Region 7
Richard Hartle (HETAB)
Closeout File (HETA 2001-0517)

Table 1. Descriptions of Sampling Media and Associated Analyses used at B. K. Heuermann Popcorn, Inc.

Analyte	Method*	Collection Media	Analysis
Diacetyl and Acetoin	NIOSH 2557 draft	Tube, Solid Sorbent, Carbon Molecular Sieve (CMS)	Gas Chromatography with Flame Ionization Detection
Respirable Dust	NIOSH 0600	Filter, Polyvinyl Chloride, tared 37-mm, 5-µm with cyclone	Gravimetric Filter Weight
Total Dust	NIOSH 0500	Filter, Polyvinyl Chloride, tared 37-mm, 5-µm	Gravimetric Filter Weight
Volatile Organic Compounds (screening)	NIOSH 2549	Tube, Thermal Desorption (w/ graphitized carbon- and carbon molecular sieve sorbents)	Thermal Desorption with Gas Chromatography and Mass Spectrophotometry
Total Volatile Organic Compounds	NIOSH 1550 modified	Tube, Solid Sorbent, Coconut Shell Charcoal (CSC)	Gas Chromatography with Flame Ionization Detection
Particle Size Distribution	Cascade Impaction	Impactor w/ Polyvinyl Chloride substrate	Gravimetric Filter Weight
Acetic Acid	Colorimetric	Tube, Colorimetric Diffusion	Colorimetric Scale

*NIOSH methods are from the National Institute for Occupational Safety and Health Manual of Analytical Methods (4th Edition). Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 85-171-1710, 1986.

Table 2. Area Sampling Results from the industrial hygiene survey at B. K. Heuermann Popcorn, Inc.

Date	Job Description	Sampling Time (min)	Ketones[¥] Diacetyl ppm	Diacetyl mg/m³	Acetoin ppm	Acetoin mg/m³	Total VOCs[§,¥] (mg/m³)	Acetic Acid (ppm)	Total Dust (mg/m³)	Respirable Dust (mg/m³)	Comment	Recipe Running
11 Dec 2001	Ambient	417	<0.01	<0.03	<0.01	<0.03	<0.29	ND	0.05	0.04		Intense Butter
11 Dec 2001	Catcher (Packer)	406	0.62	2.17	0.68	2.46	~0.39	ND	0.08	0.03		Intense Butter
12 Dec 2001	Catcher (Packer)	452	0.69	2.43	0.70	2.52	<0.27	ND	0.06	0.02		Low-Fat Butter
13 Dec 2001	Catcher (Packer)	320	0.59	2.06	0.57	2.06	<0.38	ND	0.10	0.04		Low-Fat Butter
11 Dec 2001	Machine Operator	413	0.73	2.57	0.78	2.81	~0.39	ND	0.09	0.04		Intense Butter
12 Dec 2001	Machine Operator	457	0.65	2.28	0.66	2.36	<0.26	ND	0.07	0.02		Low-Fat Butter
13 Dec 2001	Machine Operator	423	1.18	4.16	1.27	4.59	~0.33	ND	0.12	0.03		Low-Fat Butter
11 Dec 2001	Mixer	453	0.39	1.37	0.42	1.50	~0.44	ND	0.18	0.02		Intense Butter
12 Dec 2001	Mixer	552	0.52	1.85	0.50	1.81	<0.22	ND	0.12	0.03	A	Low-Fat Butter
12 Dec 2001	Mixer	194	0.25	0.89	0.24	0.86	<0.21	ND	0.26	0.03	B	Low-Fat Butter
13 Dec 2001	Mixer	455	0.99	3.47	0.94	3.38	<0.26	ND	0.27	0.06	C	Low-Fat Butter
13 Dec 2001	Mixer	72	0.39	1.39	0.46	1.67	<1.67	ND	NS	NS	D	Low-Fat Butter
11 Dec 2001	Palletizer (Stacker)	410	0.44	1.56	0.46	1.66	~0.44	ND	0.08	0.03		Intense Butter
12 Dec 2001	Palletizer (Stacker)	447	0.55	1.92	0.48	1.74	<0.27	ND	0.08	0.03		Low-Fat Butter
13 Dec 2001	Palletizer (Stacker)	425	0.91	3.20	0.86	3.11	~0.42	ND	0.16	0.04		Low-Fat Butter
12 Dec 2001	R&D Testing	439	~0.01	~0.04	<0.01	<0.03	~0.91	NS	0.76	0.47	E	NA

[¥]Values shown with a less than symbol (<) were below the limit of detection for the particular analysis. The value shown after the < is the limit of detection for that sample (actual concentration was less than the value listed, possibly even zero). Values shown with a tilde (~) represent an approximate concentration. The compound was detected in the sample at concentrations above the limit of detection but below the minimum quantifiable concentration.

[§]Analysis excluded the contribution of diacetyl and acetoin. To get total VOCs including diacetyl and acetoin, add diacetyl and acetoin concentrations listed (in mg/m³) to this value.

ppm = parts per million parts air

mg/m³ = milligrams per cubic meter of air

ND = not detectable (acetic acid sampling done by colorimetric method and no noticeable color changes were observed)

NS = no sample taken

NA = not applicable

A = Included 194 minutes of flavorings mixing

B = Sample taken during flavorings mixing only

C = Included 72 minutes of flavorings mixing and salt sifting

D = Sample taken during flavorings mixing and salt sifting only

E = Facility in separate building from microwave packaging line, popped corn with hot oil only (no flavorings)

Table 3. Personal Sampling Results from the industrial hygiene survey at B. K. Heuermann Popcorn, Inc.

Date	Job Description	Sampling Time (min)	Ketones[¥]				Comment	Recipe Running
			Diacetyl		Acetoin			
			ppm	mg/m³	ppm	mg/m³		
11 Dec 2001	Catcher (Packer)	479	0.50	1.75	0.54	1.96		Intense Butter
11 Dec 2001	Catcher (Packer)	483	0.33	1.16	0.41	1.49		Intense Butter
11 Dec 2001	Catcher (Packer)	481	0.19	0.67	0.20	0.71		Intense Butter
12 Dec 2001	Catcher (Packer)	455	0.36	1.27	0.60	2.15		Low-Fat Butter
12 Dec 2001	Catcher (Packer)	364	0.61	2.14	0.66	2.36		Low-Fat Butter
13 Dec 2001	Catcher (Packer)	455	0.59	2.07	0.76	2.73		Low-Fat Butter
13 Dec 2001	Catcher (Packer)	449	0.52	1.83	0.43	1.56		Low-Fat Butter
11 Dec 2001	Machine Operator	489	0.39	1.39	0.49	1.76		Intense Butter
12 Dec 2001	Machine Operator	571	0.42	1.47	0.42	1.51	A	Low-Fat Butter
13 Dec 2001	Machine Operator	510	0.76	2.67	0.70	2.51	B	Low-Fat Butter
12 Dec 2001	Mixer	205	0.55	1.95	0.44	1.59	C	Low-Fat Butter
13 Dec 2001	Mixer	75	1.14	4.00	0.89	3.20	D	Low-Fat Butter
11 Dec 2001	Palletizer (Stacker)	487	0.26	0.90	0.43	1.56		Intense Butter
11 Dec 2001	Palletizer (Stacker)	479	0.45	1.59	0.46	1.67		Intense Butter
12 Dec 2001	Palletizer (Stacker)	457	0.47	1.66	0.46	1.66		Low-Fat Butter
12 Dec 2001	Palletizer (Stacker)	457	0.15	0.53	0.49	1.75		Low-Fat Butter
12 Dec 2001	Palletizer (Stacker)	454	0.50	1.76	0.51	1.85		Low-Fat Butter
13 Dec 2001	Palletizer (Stacker)	248	0.96	3.39	1.05	3.79		Low-Fat Butter
13 Dec 2001	Palletizer (Stacker)	444	0.74	2.61	0.74	2.66		Low-Fat Butter
13 Dec 2001	Palletizer (Stacker)	446	0.52	1.84	0.71	2.56		Low-Fat Butter
12 Dec 2001	R&D Tester	435	~0.01	~0.05	<0.01	<0.03	E	NA
12 Dec 2001	R&D Tester	431	~0.01	~0.05	<0.01	<0.03	E	NA
12 Dec 2001	R&D Tester	429	~0.01	~0.05	<0.01	<0.03	E	NA

[¥]Values shown with a less than symbol (<) were below the limit of detection for the particular analysis. The value shown after the < is the limit of detection for that sample (actual concentration was less than the value listed, possibly even zero). Values shown with a tilde (~) represent an approximate concentration. The compound was detected in the sample at concentrations above the limit of detection but below the minimum quantifiable concentration.

ppm = parts per million parts air

mg/m³ = milligrams per cubic meter of air

NA = not applicable

A = Included flavorings mixing

B = Included flavorings mixing and salt sifting

C = Sample taken during flavorings mixing only

D = Sample taken during flavorings mixing and salt sifting only

E = Facility in separate building from microwave packaging line, popped corn with hot oil only (no flavorings)

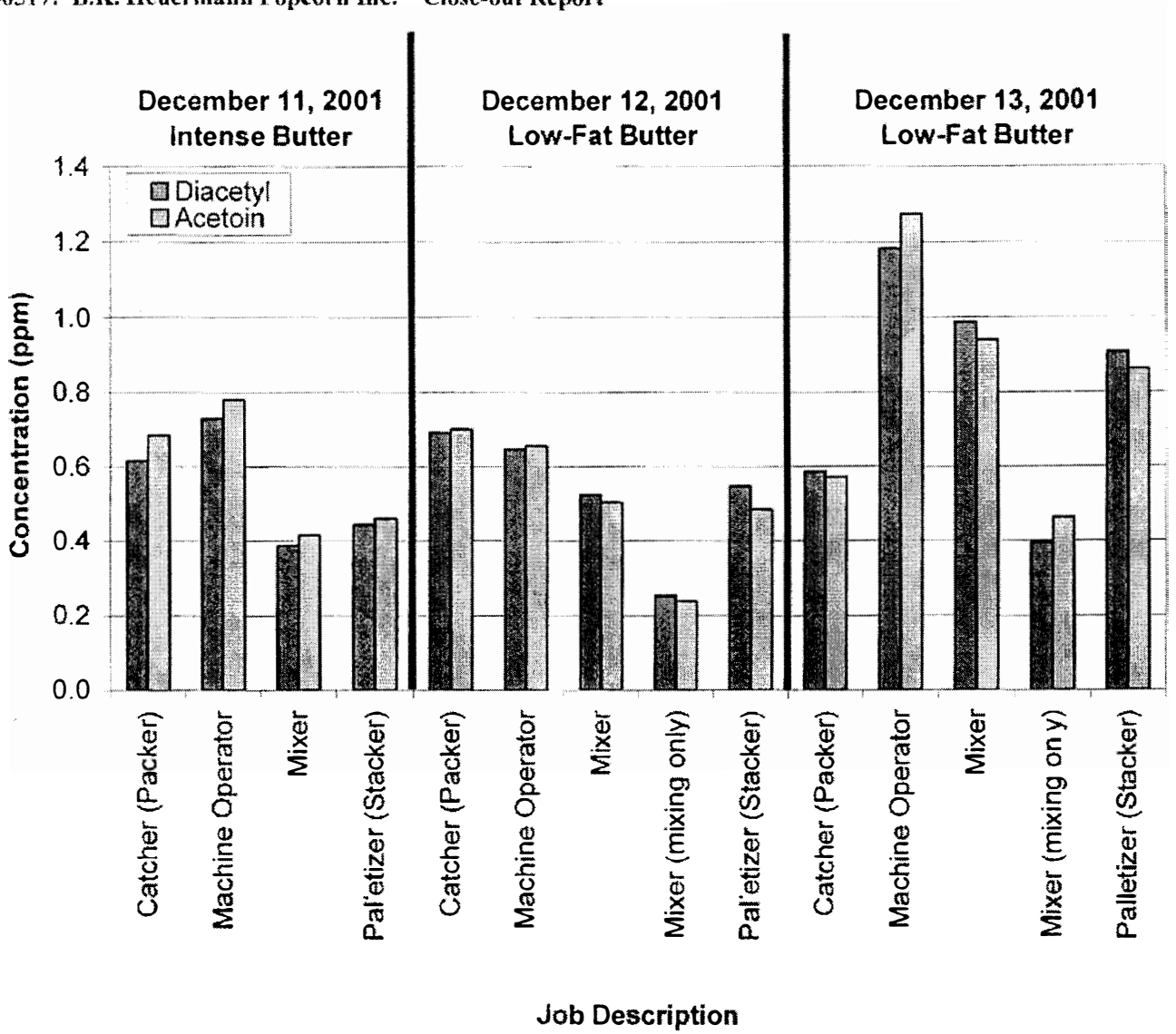
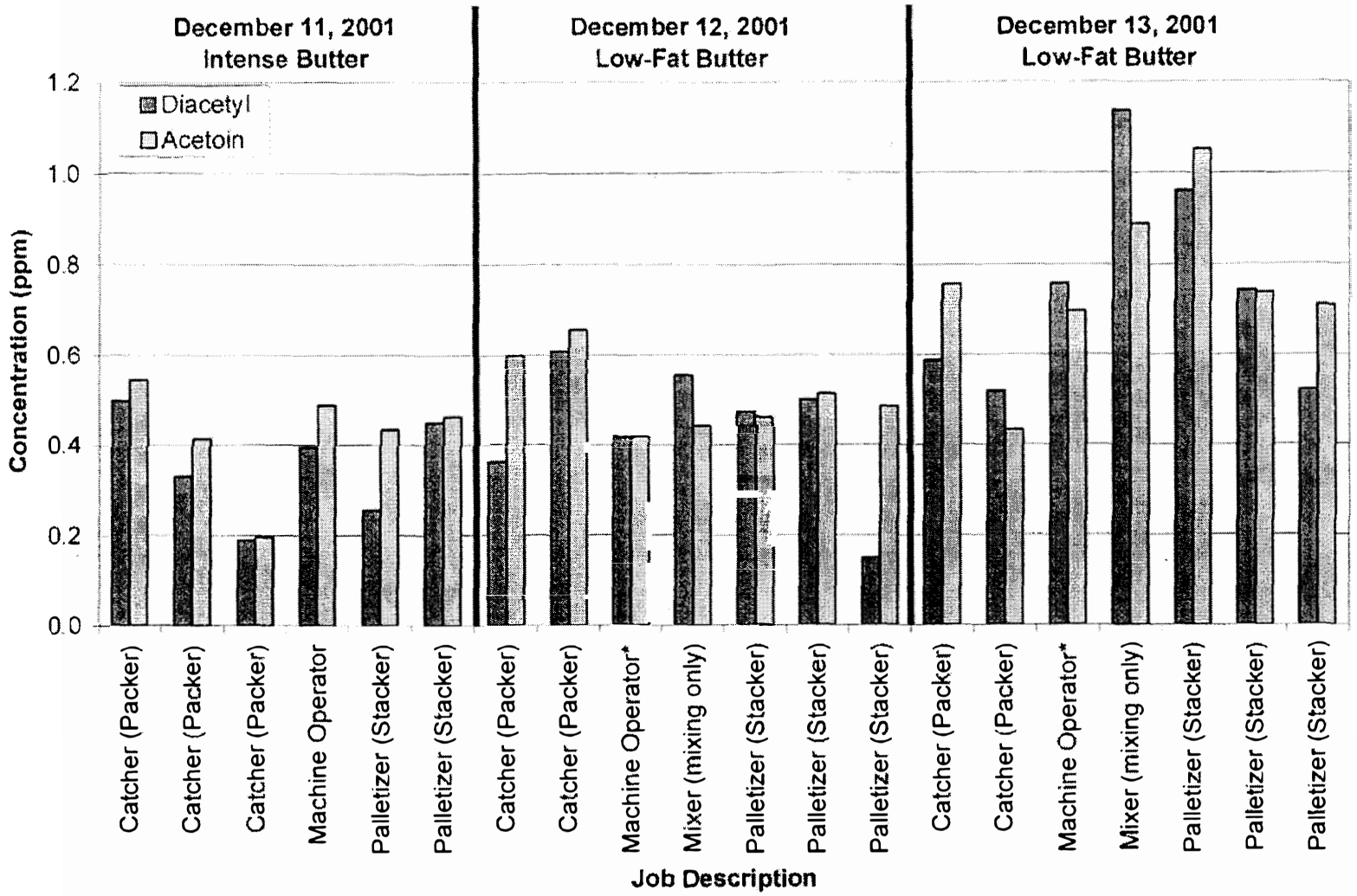


Figure 1. Area Sampling Results for Diacetyl and Acetoin at B. K. Heuermann Popcorn, Inc.



*Machine operator samples include morning mixing on December 12 and December 13

Figure 2. Personal Sampling Results for Diacetyl and Acetoin at B. K. Heuermann Popcorn, Inc.

DEPARTMENT OF HEALTH & HUMAN SERVICES

Public Health Service

Centers for Disease Control
and Prevention (CDC)
National Institute for Occupational
Safety and Health - ALOSH
1095 Willowdale Road
Morgantown, WV 26505-2888

April 19, 2002
HETA 2001-0517
Interim Report I

Mr. Keith Heuermann
B.K. Heuermann Popcorn, Inc.
504 W US Hwy 34
Phillips, Nebraska 68865

Dear Mr. Heuermann:

The purpose of this letter is to provide interim findings and recommendations resulting from a National Institute for Occupational Safety and Health (NIOSH) health hazard evaluation (HHE) conducted at B.K. Heuermann Popcorn, Inc. NIOSH received a request from management on August 28, 2001, to evaluate work processes and exposures occurring during the packaging of microwave popcorn. This request was motivated in part by the fact that several workers experienced eye injuries and cough while using a new flavoring in August 2001. One of these workers was found to have fixed airways obstruction on evaluation by a pulmonologist. NIOSH has investigated the occurrence of fixed airways obstruction in workers exposed to flavorings at a microwave popcorn plant in Missouri and in workers of a plant that manufactures flavorings. Those investigations and animal studies conducted at NIOSH have shown that exposure to vapors from flavorings may lead to lung disease under some working conditions. The ingredient(s) in flavorings that are responsible for this risk, and exposure levels that are considered to be safe, are still not known.

NIOSH investigators visited your plant on September 27, 2001, to perform an initial walkthrough and to interview management and workers. Several workers participated in interviews and spirometric lung function testing during that visit. Those who participated were individually notified of their test results by letters sent to them in October 2001. Some workers reported symptoms of mucous membrane irritation (sneezing, burning eyes) and coughing occurring occasionally prior to August 2001. Others reported those symptoms only in relation to the use of the new flavoring in August 2001. Spirometry testing revealed that three of the workers had mild or borderline airways obstruction. Exposure was a likely factor in the previously mentioned worker with fixed airways obstruction which improved significantly after medical treatment and cessation of exposure to flavorings. Whether or not the minimal lung function abnormalities in the other workers can be attributed to flavoring exposure is unknown.

A NIOSH industrial hygiene survey was conducted from December 11 to December 13, 2001. The air concentrations of diacetyl and acetoin, two ingredients in butter flavoring, were measured as markers of exposure. During these measurements, a recently installed local exhaust ventilation system for the mixing tank and packaging machine was in operation. There was no general dilution ventilation of the building. All external building doors were closed, and an axial

wall fan that was present was not in use. Preliminary results from an analysis of the air sampling data shows that the average concentrations of these compounds in the air ranged from 0.1 to 1.1 parts per million parts air (ppm). Most of the measured concentrations were between 0.4 and 0.8 ppm. At this time, required or recommended exposure limits for these compounds have not been established by the Occupational Safety and Health Administration (OSHA), the American Conference of Governmental Industrial Hygienists (ACGIH), or NIOSH. It is also not clear what role, if any, these compounds may have in the development of lung disease in workers exposed to butter flavorings.

One way to attempt to determine if present levels of exposure may pose risk is to compare these exposures to those that have been associated with lung health effects in other plants. As previously mentioned, NIOSH has investigated the occurrence of fixed airways obstruction in workers of another microwave popcorn plant located in Missouri. The following table contains the concentrations of diacetyl and acetoin measured at B.K. Heuermann in December 2001 and at the Missouri plant in November 2000. Quality control workers at the Missouri plant heat approximately 80-100 bags of microwave popcorn in microwave ovens in a small enclosed room per 8 hour shift.

Table 1: Ranges of diacetyl and acetoin concentrations and exposures at a microwave popcorn plant in Missouri (November 2000) and at B.K. Heuermann (December 2001).

	BKH Diacetyl	Missouri Diacetyl	BKH Acetoin	Missouri Acetoin
Oil Mixer	0.6 - 1.1 ppm	2.3 - 97.9 ppm	0.4 - 0.9 ppm	0.08 - 12.2 ppm
Machine Operators, Packers, Stackers	0.1 - 1.0 ppm	0.3 - 6.8 ppm	0.2 - 1.0 ppm	ND - 1.5 ppm
Quality Control		0.3 - 0.9 ppm		ND

*The BKH ranges are from personal samples while the Missouri ranges are from area samples.
*ND=less than the detection limit, approximately 0.02 ppm.

The area concentrations for diacetyl at the Missouri plant for oil mixers, machine operators, packers, and stackers were higher than personal exposures at B.K. Heuermann. Acetoin exposures at B.K. Heuermann were similar to the Missouri acetoin concentrations for machine operators, packers, stackers. Missouri oil mixers were exposed to higher acetoin concentrations. Most of the workers with affected lung function in the Missouri plant worked in oil mixing, machine operating, packing, and stacking, and quality control. While the diacetyl exposures for the quality control workers in Missouri were similar to exposures measured at B.K. Heuermann, the high heat involved in the microwave process may mean that the quality control workers are exposed to compounds that B.K. Heuermann workers are not exposed to.

What can be inferred from this comparison is limited for several reasons. Flavorings are complex mixtures of dozens of ingredients, many of which have irritant properties which may contribute to the development of lung disease. The effects of these ingredients may be additive,

such that exposures to concentrations of compounds which would not cause harm as a sole exposure, may be harmful if combined with exposures to low levels of other compounds. Diacetyl and acetoin are just two of several compounds in butter flavorings which may affect lung function. The fact that some flavorings used at one plant were not used at the other may also complicate a comparison of the data, as the compounds in the mixtures may be different. Workers at the Missouri plant may have been at more risk because they work 20 or more days a month, while those at B.K. Heuermann work fewer than 10 days a month on average in microwave popcorn production.

The above air sampling data imply that exposures to certain flavoring ingredients at B.K. Heuermann in December 2001 were lower than they were at the Missouri plant in November 2000. Whether they are low enough to prevent effects on lung function is still unknown. Safe levels of exposure for most flavoring ingredients have not yet been established. Previous levels of exposure at this plant likely caused respiratory effects in one worker and may have affected others. As there are no measurements of air concentrations of flavoring ingredients from the time prior to the installation of the local exhaust ventilation system, it is not possible to quantitatively determine how effective the local exhaust system is at reducing these concentrations.

Based on the preceding discussion, our current recommendations follow:

1. Any worker mixing oil, salt, and flavorings should continue to use respiratory protection, with the minimum protection being a non-powered one half face piece respirator with organic vapor cartridges and P100 filters.

2. Empty but unwashed flavoring containers should be kept closed with tight fitting lids.

3. All microwave popcorn production workers (any one who works in the room where the oil is mixed and the popcorn is packaged) should have lung function testing with spirometry every six months. Repeated testing with spirometry will detect if excessive changes in lung function are occurring over time, which may indicate that work exposures are still too high. New workers should be tested prior to beginning production work. Workers with lung disease should have guidance from a physician regarding the possible risk of worsening lung function from exposure to flavoring vapors. Workers who report respiratory symptoms should be referred for medical evaluation, including spirometry. It is important to choose a health care provider that can assure high quality spirometry testing in order to compare test results over time. The provider should provide documentation that their spirometry technician has attended a NIOSH certified spirometry course, and that routine calibrations of their spirometer are performed as recommended by the American Thoracic Society. If you are unable to locate a provider near your company that can provide such documentation, NIOSH can provide guidance to a provider that you select.

4. If spirometry testing reveals excessive changes in lung function occurring in workers over the next one to two years, request an evaluation by a ventilation expert to identify additional mechanisms for local exhaust of the mixing tank, and general dilution ventilation of the room where production occurs. To decrease exposures, you may want to use the wall fan you already have. NIOSH can perform additional air sampling to document the effects of any ventilation changes that you make.

5. Maintain the temperature of the heated oil mixture as low as the production process will allow in order to decrease the amounts of flavoring compounds that are emitted into the air.

This letter contains preliminary results from the industrial hygiene data analysis. Final results will be reported to you when remaining analyses are completed. Please feel free to contact us if you have any questions.

Sincerely,

Richard S. Kanwal, MD, MPH
Respiratory Disease Hazard Evaluation and
Technical Assistance Program
Field Studies Branch
Division of Respiratory Disease Studies

Stephen Martin
Engineer
Laboratory Research Branch
Division of Respiratory Disease Studies