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Brown Produce Company
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NIOSH Investigators:
Steve Berardinelli, Jr., MS
Elizabeth Jennison, MD, MPH

I. SUMMARY

In September 1992, the Division of Respiratory Disease Studies (DRDS), National Institute for Occupational Safety and Health (NIOSH), received a request from the Occupational Safety and Health Administration (OSHA) for technical assistance in evaluating potential occupational asthma at the Brown Produce Company, a chicken egg processing facility in Farina, Illinois.

Brown Produce processes 2.0 million eggs a day into liquid egg products. Eggs are washed, cracked, and yolks separated from whites in a continuous operation. Employees are exposed to aerosolized egg proteins during the course of their work. Occupational asthma that develops from allergy to inhaled egg proteins has been previously reported by NIOSH in the egg processing industry.

An initial site visit and walk-through survey were conducted by NIOSH investigators on November 17, 1992. Environmental sampling was conducted on August 17-19, 1993. Personal breathing zone and area sampling was conducted for ammonia, carbon monoxide, halogens (chlorine and iodine), and egg protein. A medical survey was conducted on August 12-20, 1993, that consisted of a respiratory questionnaire, spirometry, serial peak flow measurements, and immunologic studies.

Environmental sampling revealed ammonia, carbon monoxide, and halogen levels were well below occupational exposure criteria. Egg protein concentrations measured in the workplace were above those previously reported by NIOSH in the egg processing industry. The medical survey demonstrated a high prevalence of respiratory symptoms and airway reactivity among employees of both the egg-transfer and egg-breaking rooms, with the prevalences being higher among breaking room employees. Among breaking room employees this study found the following symptom prevalences: 58% had chronic cough, 67% had chronic phlegm, and 50% had wheezing or whistling noises in the chest. Unlike previous NIOSH evaluations, this survey did not document IgE-mediated occupational asthma from egg protein exposure.

The high prevalence of respiratory symptoms and airway reactivity among employees of both the egg-transfer and egg-breaking rooms suggests that there is an ongoing respiratory health hazard at the Brown Produce Company. Although the levels of egg proteins measured during the environmental survey were above those previously reported by NIOSH in the egg processing industry and variable airflow obstruction was observed, this evaluation did not document an IgE-mediated response. Medical recommendations include medical evaluation of symptomatic workers, reassignment of workers with asthma related to workplace exposure to egg proteins, and avoidance of egg-derived vaccines (such as the influenza vaccine) by individuals with
IgE-mediated hypersensitivity to eggs.

Keywords: SIC 2017, poultry and egg processing, egg protein, egg dust, occupational asthma, aeroallergens, ammonia, halogen-based sanitizers, carbon monoxide

II. INTRODUCTION

In September 1992, the Division of Respiratory Disease Studies (DRDS), National Institute for Occupational Safety and Health (NIOSH), received a technical assistance request from the Occupational Safety and Health Administration (OSHA) to investigate employee concerns regarding the work environment at the Brown Produce Company in Farina, Illinois. The health complaints reported in the request included "asthma-like symptoms, difficulty breathing, wheezing and coughing, and excessive running of the nose."

OSHA had performed an inspection of Brown Produce Company on May 13, 1992. Employee interviews conducted by an OSHA inspector indicated that in the plant's egg transfer room, a substantial number of employees seemed to be affected by their work environment in terms of suffering "asthma-like" symptoms. An employee in the transfer room told the inspector that employees in other areas of the plant were suffering symptoms that were much worse.

A site-visit was conducted by a NIOSH occupational physician and industrial hygienist on November 17, 1992. A walk-through survey of the plant was conducted, additional information about the plant processes was collected, and employees were privately interviewed concerning their symptoms. The Log and Summary of Occupational Injuries and Illnesses (OSHA 200 logs) were reviewed for the past several years.

A medical survey was conducted on August 12-20, 1993. A health and symptoms questionnaire, spirometry, serial peak flow measurements, and immunologic studies were conducted. Employees who participated in the medical survey were notified of their individual medical findings in October 1993.

Environmental sampling was conducted on August 17-19, 1993. Personal breathing zone and area sampling was conducted for ammonia, carbon monoxide, halogen ions, and egg proteins.

III. BACKGROUND

Brown Produce Company is the establishment name of the Seger Egg Corporation. Brown Produce started operations in 1950. It processes two million eggs a day into pasteurized liquid or frozen egg white, egg yolk, and whole egg. All of the products produced by the plant carry the USDA inspection label, which means U. S. Department of Agriculture (USDA) inspectors check the plant for compliance under the Egg Products Inspection Act.[1]

The plant has been updated with new machinery over the years. The egg-breaking room is supplied with filtered, outside air in accordance with USDA guidelines in order to maintain the room under positive pressure.

There are approximately 60 employees at the plant. During the summer months an additional 10 employees (students) are hired. A handful of employees work on the second shift conducting scheduled maintenance and cleaning operations. Employees at the plant are not represented by a union. The plant quality control supervisor has the responsibility for the occupational safety and health programs (hazard communication program and hearing conservation) in the plant. No uniforms are required in the plant, but employees must wear hair nets and hearing protection (ear plugs). Safety glasses and dust masks are provided for the employees, but their use is not mandatory. No pre-placement physicals are required of new employees, and traumatic injuries are referred to a local clinic and hospital.

The workshift starts at 6:30 a.m., and employees work continually until lunch. At lunch, personnel operating the nine egg-washing and egg-breaking machines take a 30-minute break while the areas are cleaned. Fresh wash water and detergent are added to the machines, and the floors and surfaces are washed down and sprayed with a sanitizer. Equipment that transfers the liquid egg products is also disassembled and cleaned. The operators then report back to their workstations for the remainder of the workshift, which ends at 3:00 p.m. Occasionally if there is an egg surplus, an hour of overtime or Saturday work is required .

At the time of the walk-through survey, brief confidential interviews were conducted randomly with a total of nine employees, four from the egg-transfer room and five from the egg-breaking room. Two of the four individuals interviewed who worked in the transfer room reported that they had developed respiratory symptoms since beginning employment at Brown Produce. Both of these individuals used inhaled bronchodilator and said that their symptoms improved considerably on weekends. Three of the five individuals interviewed who worked in the breaking room reported respiratory symptoms. Only one had symptoms prior to working at this facility. Employees from both the transfer and breaking areas said they knew of individuals who had left work at Brown Produce because of respiratory problems.

Also during the walk-through survey, a brief questionnaire which asked about respiratory symptoms was left with management to be distributed to all employees 2 days later with their paychecks. Only six questionnaires were returned, and only one respondent reported respiratory symptoms. Only one respondent indicated willingness to participate in a NIOSH medical study of respiratory problems at Brown Produce. Of the individuals interviewed at the time of the walk-through, only one returned the questionnaire.

Approximately 1 month after the NIOSH walk-through survey, two persons filed additional complaints with OSHA regarding respiratory problems at Brown Produce. With the cooperation of the area OSHA office, NIOSH contacted both individuals. Both reported respiratory symptoms which they felt were associated with working at the facility.

IV. PROCESS DESCRIPTION

Chicken eggs from cage laying facilities are transported to the plant via semi-tractor trailer. Eggs come from a variety of sources. Eggs are brought in from surrounding states and as far away as Georgia. The eggs are unloaded from the trailer with electric powered forklifts and are put into a refrigerated in-shell storage area until they are ready to be processed.

The transfer room is where the eggs are transported from the in-shell refrigeration area to the egg washing machines. The company has nine egg-washing workstations with three standing employees per workstation. In addition to these 27 employees working in the transfer room, 4-5 material handlers transport the eggs from the storage area to the washing stations. The eggs are washed with a sodium hydroxide (NaOH) based detergent solution that is heated to 120°F. After washing and rinsing, the eggs are treated with a chlorine-based (sodium hypochlorite) sanitizer. OSHA had conducted personal air sampling in this area for these reagents (NaOH and chlorine) and all results were well under OSHA permissible exposure limits. One employee loads eggs from cardboard cartons (each carton holds 36 eggs in a 6x6 array) into the egg washing machine. The machine has suction cups that lift the eggs off the carton, transfers them into a conveyer system and through the washing solution. Another employee operates the machine that removes any unsuitable eggs and throws them into the inedible bucket. After the eggs move through the washing machine, they are conveyed to a candling station. The third employee is the candler who observes eggs that pass atop a lighted background and removes any eggs that appear unsuitable. The company has instituted administrative controls to prevent cumulative trauma (repetitive motion) disorders among the egg washing employees. Employees rotate among the three tasks every 15 minutes.

Once washed, the eggs pass directly into the breaking room through small openings in the wall via the conveyer. The breaking room is where the eggs are cracked and separated into whites or yolks, or left whole. There are nine breaking machine workstations in this area. One seated employee monitors the operation of the breaking machine. The only chemical reagent used in this area is an iodine-based hand cleanser. The eggs are broken mechanically and the contents fall into a semi-circular container. The egg white falls through a hole in the bottom of this container into a small pan, leaving the yolk behind. If the egg contents are "bloody" or the break was not clean, the operator trips the pan so that these eggs will not be transported to the storage vessel. The egg whites and yolks are transported by stainless steel piping to a storage tank. After a suitable quantity of egg has been collected, the egg products are pasteurized and then frozen in plastic buckets or cooled and put into tractor trailer tanker cars. Sometimes buyers request that additional ingredients be added to the egg product. Salt is added to the processed egg products that are used in mayonnaise production. Sugar is added to the egg product used in the bakery industry.

V. METHODS AND MATERIALS

A. Environmental

On August 17-19, 1993, air sampling was conducted in the egg-transfer room, the egg-breaking room, the boiler room, and the refrigeration mechanical room. Air sampling was focused on the most apparent agents in the workplace that could cause irritant respiratory symptoms or occupational asthma, namely, halogen ions from the sanitizing solutions, ammonia refrigerant, and protein aerosol from the egg products that the plant produces.

1. Ammonia

Area air samples for ammonia were collected in the refrigeration mechanical room. The plant has several warehouse freezers that use ammonia as the refrigerant. Full-shift time-weighted average (TWA) concentrations were measured using Dräger direct reading ammonia 10/a-D diffusion tubes. These tubes have a relative standard deviation of 15% (at 50 ppm).

2. Carbon Monoxide (CO)

An Interscan Series 4000 CO monitor (range: 0-100 ppm) equipped with a Metrosonics dl-714 data logger was utilized to collect real-time data over the work shift in the boiler room. Instrument zeroing and calibration was performed prior to use. The natural gas-fired boiler is the only source of combustion gas within the plant. The boiler room is an enclosed area, the area is accessed via two doors: (1) from the storage tank area and (2) from the tanker trailer loading garage. Both doors to the boiler are usually kept closed.

3. Halogens (Chlorine and Iodine)

Halogen-based sanitizers are used in the egg washing process. Area air samples for chlorine and iodine were collected by impinger in the transfer room near the egg-washing stations and in the breaking room near the egg-breaking machines. Impingers were filled with a sodium carbonate/sodium bicarbonate solution and sampled full-shift at 1.0 lpm. Impinger solution was analyzed using ion chromatography employing a combination of NIOSH methods 6005 and 7903 modified.[2,3] The modifications to method 7903 consisted of the collection of the samples in impingers and the conversion of chloride to chlorine for reporting purposes.

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4. Total and Respirable Protein

Personal (breathing zone) samples were collected on 37mm glass fiber filters, with a flowrate of 2.0 lpm and were analyzed for total protein using the Micro-Kjeldahl method (EPA method 351.2). The respirable fraction was obtained using standard 10mm nylon cyclones with a flowrate of 1.7 lpm. Full-shift sampling was conducted on the employees in the transfer room operating the egg-washing stations and on the employees in the egg-breaking room.

5. Aeroallergens

Personal (breathing zone) samples were collected on 37mm Teflon® (polytetra-flouroethylene or PTFE) filters, with a flowrate of 2.0 lpm and were analyzed for egg aeroallergens. Ovalbumin, ovomucoid, and lysozyme were quantitated by an indirect competitive enzyme-linked immunosorbent assay (ELISA) from the eluates obtained by the extraction of the filters.[4] Full-shift sampling was conducted on the employees in the transfer room operating the egg-washing stations and on the employees in the egg-breaking room.

B. Medical

All current employees were invited to participate in the medical survey conducted August 12-20, 1994, which consisted of a health questionnaire, serial peak flow testing, spirometry, and immunologic testing. Cross-shift spirometry was performed on the first day of the work week, and single session spirometry was performed on the last day of the work week.

1. OSHA 200 Logs

OSHA 200 logs for the facility were reviewed for the years 1990, 1991, 1992, and through the time of medical survey in August 1993. OSHA 200 logs were reviewed to determine company trends and potential cases of respiratory illness.

2. Health Questionnaire

The presence of respiratory symptoms and nasal, eye, and skin irritation were assessed by questionnaire. Chronic cough was defined as cough occurring on most days of the week for at least 3 months of the year. Chronic phlegm was defined similarly. Grade I dyspnea was defined as shortness of breath when hurrying on level ground or walking up a slight hill. Grade II dyspnea was defined as shortness of breath while walking on level ground with people of one's own age, and Grade III was defined as having to stop for breath when walking at one's own pace on level ground. Individuals who currently smoke cigarettes were defined as current smokers. Individuals who have smoked five or more packs of cigarettes during their entire life, but do not currently use cigarettes, were classified as ex-smokers.

3. Spirometry

Spirometry was performed using a dry rolling-seal spirometer interfaced to a dedicated computer. At least five maximal expiratory maneuvers were recorded for each participant. All values were corrected to BTPS (body temperature, ambient pressure, saturated with water vapor). The largest forced vital capacity (FVC), and forced expiratory volume in one second (FEV_1) were the parameters selected for analysis, regardless of the curves on which they occurred. Testing procedures conformed to the American Thoracic Society's recommendations for spirometry.(5) Predicted values were calculated using the Knudson reference equations.(6) Predicted values for blacks were determined by multiplying the value predicted by the Knudson equation by 0.85.(7) Test results were compared to the 95th percentile lower limit of normal (LLN) values obtained from Knudson's reference equations to identify participants with abnormal spirometry patterns of obstruction and restriction.(6) By definition five percent of a normal, non-smoking population would be expected to have predicted values that fall below the LLN, while 95% will have predicted values above this value.

Using this comparison, obstructive and restrictive patterns are defined as:

Obstruction: Observed ratio of FEV_1/FVC % below the LLN.
Restriction: Observed FVC below the LLN.

The criteria for interpretation of the level of severity for obstruction and restriction, as assessed by spirometry, is based on the NIOSH classification scheme (available upon request from the Division of Respiratory Disease Studies). For those persons with values below the LLN, the criteria are:

	OBSTRUCTION (FEV_1/FVC x 100)	RESTRICTION (% Predicted FVC)
Mild	>60	>65
Moderate	≥45 to ≤60	≥51 to ≤65
Severe	<45	<51

A cross-shift decline in FEV_1 of 10% or greater was considered to be evidence of work-related airways obstruction.

4. Serial Peak Flow Measurements

All study participants were given log sheets and instructed in the use of the Mini-Wright Peak Flow Meter on the first day of the medical survey. Participants were asked to record: (a) flow results from three blows every 2 hours while awake for 8 consecutive days, and (b) the presence of symptoms and use of medication during the preceding 2 hours.

Peak flow records from each worker were considered adequate for a given day if they contained peak flow results from at least three recording times that spanned at least 8 hours that day. If adequate records from a minimum of 4 of the 8 survey days were present, the data were considered usable for further analyses.

From each peak flow recording time, only the largest of the three recorded values was used for calculations and subsequent interpretation. For each worker, an overall mean peak flow was calculated, using the largest value from all available recording times. For each survey day with valid results, a daily mean was calculated from the best values on that day. Diurnal variation in peak flow was calculated as the difference between the daily maximum and minimum best values for the survey day divided by the daily mean. Overall variation in peak flow was calculated as the difference between the maximum and minimum best values for the entire survey, divided by the overall mean. Overall variation of ≥20% is suggestive of increased airway responsiveness.[8] If mean peak flow is lower on work days compared to days away from work, or variation ≥20% is seen on work days and absent on days off work, a relationship between airflow changes and workplace exposures is suggested.

5. Immunologic Testing

Two immunologic tests were performed on venous blood. The first measured total immunoglobulin-E (IgE), a nonspecific indicator of an individual's tendency to exhibit allergic responses. Total IgE levels were determined by the paper radioimmunosorbent test (PRIST) using a commercially available assay (Pharmacia Diagnostics, Piscataway, New Jersey), following the manufacturer's recommendations for the use of appropriate controls and reference reagents. Individuals who are atopic (have allergies) usually have IgE levels that are greater than 100 kU/l.[9] For comparison, the geometric mean for IgE in the NIOSH DRDS lab is 33.8 kU/l.

The second immunologic test was a radioallergosorbent test (RAST) for specific reactivity to hen's egg white. This was performed using a commercially available assay kit (Pharmacia Diagnostics, Piscataway, New Jersey). The assay was performed according to the manufacturer's recommendations and included reference and control sera. This test is scored from zero to four, with a zero score indicating the absence of specific antibodies to hen's egg white. Scores of one or two are considered to be "low positive;" they indicate exposure to hen's egg white, but not necessarily an allergy. Scores of three or four are more likely to be associated with allergic symptoms.

VI. EVALUATION CRITERIA AND TOXICOLOGY

A. Egg Allergy

NIOSH has conducted several health hazard evaluations at egg processing facilities.[10-14] These sites all processed chicken eggs into various products, including powdered whole egg, powdered yolk, and liquid whites. Immunoglobulin E (IgE)-mediated occupational asthma associated with exposure to airborne egg proteins was demonstrated in all evaluations. Employees with bronchial lability were identified by assessing variability in their peak expiratory flow rates. Several workers were identified who had positive skin prick test reactions to egg allergens or specific IgE to egg allergens, including whole egg, egg white, ovomucoid, and ovalbumin. In addition, immunoglobulinG (IgG)- to lysozyme, whole egg, and conalbumin was present in egg-exposed workers.

Hen's egg white contains approximately 40 different proteins. The major allergens, ovalbumin, ovomucoid, and ovotransferrin are among the 13 proteins which have been found to induce specific IgE antibodies in egg-allergic individuals. Proteins that cross-react with hen's egg white proteins have been demonstrated in hen's egg yolk. All allergens detected in hen's egg white are water soluble.[15]

Patients with egg allergy have significantly higher total IgE levels than do atopic individuals who do not have egg allergy. In allergic individuals, inhalation of egg proteins can produce allergic rhinitis and conjunctivitis, as well as bronchial asthma. In a group of individuals with documented egg allergy, the most common symptoms after ingesting eggs were itching or exacerbation of atopic dermatitis (49%), bronchial asthma (26%), urticaria (26%), and vomiting (25%). Other symptoms were angioedema (14%), rhinitis/conjunctivitis (14%), and laryngeal edema (2%).[16] The term food allergy is restricted to reactions induced by the ingestion of a food for which an immunological pathogenesis can be demonstrated. Food sensitivity is used as a broader term for all abnormal reactions following the ingestion of a food.[17] Sensitization, as measured by skin prick testing, may be present even in individuals who are able to consume the sensitizing food without symptoms.[18] In a group of patients with clinical symptoms of egg allergy, 96% had a positive RAST to egg-specific antigens, compared to 25% of a group of individuals who had allergies to other foods. The RAST findings correlated well with the results of skin prick testing.[18]

B. Environmental Evaluation Criteria

To assess the hazards posed by workplace exposures, NIOSH investigators use a variety of environmental evaluation criteria. These criteria suggest exposure levels which most workers may be exposed for a working lifetime without experiencing adverse health effects. However, because of wide variation in individual susceptibility, some workers may experience occupational illness even if exposures are maintained below these limits. The evaluation criteria do not take into account individual hypersensitivity, pre-existing medical conditions, or possible interactions with other work place agents, medications being taken by the worker, or environmental conditions.

The primary sources of evaluation criteria for the workplace are: NIOSH Criteria Documents and Recommended Exposure Limits (RELs),[19] the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs),[20] and the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs).[21] The objective of these criteria for chemical agents is to establish levels of inhalation exposure to which the vast majority of workers may be exposed without experiencing adverse health effects.

Occupational health criteria are established based on the available scientific information provided by industrial experience, animal or human experimental data, or epidemiologic studies. Differences between the NIOSH RELs, OSHA PELs, and ACGIH TLVs may exist because of different philosophies and interpretations of technical information. It should be noted that RELs and TLVs are guidelines, whereas PELs are standards which are legally enforceable. OSHA PELs are required to take into account the technical and economical feasibility of controlling exposures in various industries where the agents are present. The NIOSH RELs are primarily based upon the prevention of occupational disease without assessing the economic feasibility of the affected industries and as such tend to be conservative. A Court of Appeals decision vacated the OSHA 1989 Air Contaminants Standard in *AFL-CIO v OSHA*, 965F.2d 962 (11th cir., 1992); and OSHA is now enforcing the previous 1971 standards (listed as Transitional Limits in 29 CFR 1910.1000, Table Z-1-A).[20] However, some states which have OSHA-approved State Plans continue to enforce the more protective 1989 limits. NIOSH encourages employers to use the 1989 limits or the RELs, whichever are lower.

Evaluation criteria for chemical substances are usually based on the average personal breathing zone exposure to the airborne substance over an entire 8- to 10-hour workday, expressed as a time-weighted average (TWA). Personal exposures are usually expressed in parts per million (ppm), milligrams per cubic meter (mg/m^3), or micrograms per cubic meter ($\mu g/m^3$). To supplement the 8-hr TWA where there are recognized adverse effects from short-term exposures, some substances have a short-term exposure limit (STEL) for 15-minute peak periods; or a ceiling limit, which is not to be exceeded at any time. Additionally, some chemicals have a "skin" notation to indicate that the substance may be absorbed through direct contact of the material with the skin and mucous membranes.

It is important to note that not all workers will be protected from adverse health effects if their exposures are maintained below these occupational health exposure criteria. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, previous exposures, and/or a hypersensitivity (allergy). In addition, some hazardous substances may act in combination with other work place exposures, or with medications or personal habits of the worker (such as smoking, etc.) to produce health effects even if the occupational exposures are controlled to the limit set by the evaluation criterion. These combined effects are often not considered by the chemical specific evaluation criteria. Furthermore, many substances are appreciably absorbed by direct contact with the skin and thus potentially increase the overall exposure and biologic response beyond that expected from inhalation alone. Finally, evaluation criteria may change over time as new information on the toxic effects of an agent become available. Because of these reasons, it is prudent for an employer to maintain worker exposures well below established occupational health criteria.

1. Ammonia

   Ammonia is a severe irritant of the eyes, respiratory tract, and skin. It may cause coughing, burning and tearing of the eyes, runny nose, chest pain, cessation of respiration, and death. Symptoms may be delayed in onset. Exposure of the eyes to high gas concentrations may produce temporary blindness and severe eye damage. Exposure of the skin to high concentrations of the gas may cause burning and blistering. Repeated exposure to ammonia gas may cause chronic irritation of the eyes and upper respiratory tract.[22] Tolerance to usually irritating concentrations of ammonia may be acquired by adaption, a phenomenon frequently observed among workers who were previously affected by exposure; no data are available on concentrations that are irritating to workers who are regularly exposed to ammonia and who presumable have a higher irritation threshold. Vapor concentrations of 10,000 ppm are mildly irritating to moist skin, while 30,000 ppm or greater causes a stinging sensation and may produce skin burns and blisters.

The NIOSH REL for ammonia is 25 ppm for a 10-hour TWA and a STEL of 35 ppm. ACGIH has set limits of 25 ppm as an 8-hour TWA and a STEL of 35 ppm. The OSHA PEL for ammonia is 50 ppm for an 8-hour TWA.

2. Carbon Monoxide

Carbon monoxide is a colorless, odorless, tasteless gas, slightly lighter than air. It is produced whenever incomplete combustion of carbon-containing compounds occurs. Major sources of exposure to CO are engine exhaust, tobacco smoke, and inadequately vented combustion products from appliances and heaters that use natural gas, propane, kerosene, or similar fuels. On inhalation, CO acts as a metabolic asphyxiant, causing a decrease in the amount of oxygen delivered to the body's tissues. CO combines with hemoglobin (the oxygen carrier in the blood) to form carboxyhemoglobin (CO-Hb), which reduces the oxygen-carrying capacity of the blood. The initial symptoms of CO poisoning may include headache, dizziness, drowsiness, and nausea. These initial symptoms may advance to vomiting, loss of consciousness, and collapse if prolonged or high exposures are encountered. Coma and death may occur if high exposures continue.[22-25]

The NIOSH REL for CO is 35 ppm for an 8-hour TWA exposure, with a ceiling limit of 200 ppm which should not be exceeded for any length of time. The NIOSH REL of 35 ppm is designed to protect workers from health effects associated with CO-Hb levels in excess of 5%.[24] The OSHA PEL for CO is 50 ppm for an 8-hour TWA exposure. The ACGIH recommends an 8-hour TWA TLV of 25 ppm. ACGIH has also proposed a biological exposure index (BEI) of <8% CO-Hb in blood at the end of a work shift.

3. Halogens (Chlorine and Iodine)

Exposure to chlorine gas can cause coughing, shortness of breath, and itching or burning eyes, nose, and throat. Iodine vapor is an irritant and is corrosive. Exposure to iodine vapor leads to excessive flow of tears (epiphora), tightness in the chest, sore throat and headache.

The NIOSH REL for chlorine gas is a 0.5 ppm ceiling limit which should not be exceeded for any length of time. The current OSHA PEL for chlorine is a 1 ppm ceiling limit. The ACGIH TLV is 0.5 ppm TWA with a 1 ppm STEL.

The NIOSH REL, OSHA PEL, and ACGIH TLV for iodine vapor are all a 0.1 ppm ceiling limit which should not be exceeded for any length of time.

4. Protein Dust and Aeroallergens

There are no occupational exposure standards or recommendations specific for egg protein aerosols. Exposure to egg protein may lead to sensitization. Allergic reactions may develop in sensitized individuals subsequently exposed to egg protein. Sensitized individuals may react to allergens at low concentrations, and the response may be dose related. Previous studies at egg processing facilities conducted by NIOSH have reported the following maximum aeroallergen levels: 360 $\mu g/m^3$ ovalbumin, 351 $\mu g/m^3$ ovomucoid, and 672 $\mu g/m^3$ lysozyme.[11-13]

A previous study of exposure to egg-breaking employees found airborne concentrations of 50.0 $\mu g/m^3$ ovalbumin, 10.70 $\mu g/m^3$ ovomucoid, and 2.00 $\mu g/m^3$ lysozyme.[26] These levels were considered by the investigators to be extraordinarily high when compared with other occupations or aerollergenic proteins. This study also showed that employees can bring aeroallergens home via work clothes.

VII. RESULTS AND DISCUSSION

A. Environmental

1. Ammonia

Results of ammonia sampling in the refrigeration mechanical room indicted that 9-hour TWA measurements were well below occupational exposure criteria. On August 17, 1993, the average of three measurements (range: 2.2-5.4 ppm) was 3.2 ppm TWA; on August 18, 1993, the average of four measurements (range 2.2-5.6 ppm) was 3.9 ppm TWA; and on August 19, 1993, the average of four measurements (range: 2.3-5.7 ppm) was 3.1 ppm TWA.

2. Carbon Monoxide

Results of real-time CO sampling in the boiler room (see Graphs 1-3) indicated that CO concentrations were well below occupational exposure criteria. Graph 1 is a plot of CO levels versus time on August 17, 1993; measurements ranged from

1.7-43.6 ppm with a 9-hour TWA of 2.6 ppm. Graph 2 displays the CO concentrations on August 18, 1993; measurements ranged from 0-65.3 ppm with a 1.1 ppm TWA. Graph 3 displays the CO concentrations on August 19, 1993;measurements ranged from 0-12.0 ppm with a 0.4 ppm TWA.

3. Halogens (Chlorine And Iodine)

Chlorine gas was detected in 6 of 14 area samples. Chlorine concentration ranged from below the limit of detection to 0.01 ppm TWA. In the transfer room, chlorine was detected on three samples and ranged from .003 - .01 ppm. In the breaking room, chlorine was detected on three samples and ranged from .005 - .01 ppm. The analytical limit of detection (LOD) for the chlorine analysis was 4 µg/sample, which equates to a minimum detectable concentration (MDC) of 0.003 ppm, assuming a sampling volume of 480 liters. Chlorine exposures were well below occupational exposure criteria.

Iodine was not detected on any of the 14 area samples. The LOD for the iodine analysis was 6 µg/sample, which equates to a MDC of 0.001 ppm, assuming a sampling volume of 480 liters. Iodine concentrations were well below occupational exposure criteria.

4. Total Protein.

Worker protein aerosol exposures were determined by the Micro-Kjeldahl method. Table 1 displays total protein personal exposures for 12 samples collected. Total protein exposure ranged from below the limit of detection to 765 µg/m^3. The LOD for the protein analysis was 0.007 mg/filter, which equates to a MDC of 7 µg/m^3, assuming a sampling volume of 960 liters. Total protein exposures in the breaking room were on average more than eight times those in the transfer room.(27) Worker exposure to respirable protein is displayed in Table 2. Protein concentrations ranged from 8.8 to 74.4 µg/m^3 with 9 samples collected. Average respirable protein was twice as high in the breaking room.

5. Aeroallergens

Egg lysozyme, ovomucoid, and ovalbumin levels were quantitated in the eluates obtained by extraction of 12 filters used to collect samples in worker breathing zones. The MDC for these ELISA assays is approximately 1 µg/m^3. Blank samples were negative for elutable protein. Table 3 displays the personal aeroallergen exposures for the transfer and breaking rooms. Ovalbumin concentrations ranged from 81- 5259 µg/m^3, ovomucoid concentrations ranged from

22 - >973 µg/m^3, and lysozyme concentrations ranged from 3 - 97 µg/m^3. The relatively large quantities of ovalbumin relative to those of ovomucoid and lysozyme reflect the relative amounts of these proteins found in whole eggs. A direct relationship between the relative amount of the three egg proteins was observed in all but one sample (ovalbumin > ovomucoid > lysozyme). Average concentrations for all aeroallergens were higher in the breaking room. These ovalbumin and ovomucoid levels are the highest yet reported in the literature for an egg processing facility.

B. Medical

1. OSHA 200 Log Review

Review of company OSHA 200 logs since 1990 revealed no reported respiratory conditions. Muscularoskeletal and eye injuries, lacerations, and soft tissue infections were reported.

2. Evaluation of Current Employees

There were 57 employees who worked performing egg processing jobs at Brown Produce Company. The questionnaire was completed by 31 (54%) of the employees. Spirometry was performed by 28 (49%) of the workers and 26 (46%) of the workers used peak flow meters for at least part of the study period. Immunologic testing was performed on 27 (47%) of the workers. Women comprised 67% of the eligible workforce and 81% of the participants. Parti-cipants ranged from 18 to 65 years of age, with a median age of 37 years. The prevalence of current cigarette smoking was 23%. Current smokers had smoked a median of 21.5 years, and 86% of them reported smoking one or more packs of cigarettes per day. Sixteen percent of workers reported that they were former smokers. These individuals had smoked a median of 7 years, and all reported smoking one or more packs per day. The remaining 61% of workers reported that they had never smoked.

The median employment tenure at Brown Produce was 7 years, with a range of 3 months to 35 years. Of those surveyed, 45% worked in the transfer room, 39% worked in the breaking room, and 16% worked in other areas of the plant. Four individuals had prior occupational exposure to shell (whole, unbroken) eggs, and two had worked in other facilities that produced liquid egg products.

Fifteen individuals reported that they had a history of atopy, defined as having hay fever or allergies to foods, metals, medicines, animals, dust, or chemicals. These diagnoses had been confirmed by a physician for five individuals. Only one individual reported having experienced rhinitis or nasal congestion after eating eggs. Six reported a history of abdominal cramps after eating eggs, and five of these six reported ever having diarrhea after eating eggs. No worker reported cough, chest tightness, wheezing, shortness of breath, vomiting or rash after eating eggs. Four individuals report that they no longer eat eggs, one because eggs cause diarrhea and cramps, and two because they find eggs unappealing since working with them. The fourth person did not give a reason.

Respiratory symptoms were common among workers in both the transfer room and the breaking room (see Table 4), although symptom prevalences were generally higher among breaking room employees. Differences between the groups were noted in the reported prevalence of chronic cough (transfer room: 36%, breaking room: 58%), chronic phlegm (transfer room: 43%, breaking room: 67%), and wheezing or whistling noises in the chest (transfer room: 21%, breaking room: 50%).

Baseline spirometry results are displayed in see Table 5. All of these individuals had spirometry that was within normal limits for their age, height, and sex. Although the mean percent predicted FVC and FEV_1 for transfer room workers appear to be higher than those for breaking room workers, these differences were not statistically significant. Two individuals, both breaking room employees, had cross-shift declines in FEV_1 that were greater than 10%, suggestive of work-related airways obstruction.

Peak flow results are displayed in Table 6. For 4 (15%) of the 26 participants, the data were not interpretable, generally because of an insufficient number of days of recording. Eleven workers had $\geq$20% variation in peak flow over the recording period. The 11 individuals who worked in the breaking room were more likely to have peak flow variability of $\geq$20% than were the 11 working in the transfer room (64% versus 36%). There was no relationship between peak flow variability and cigarette smoking history. Although it is not always possible with occupational asthma to demonstrate a work-related pattern of peak flow variability, one such individual was identified. This individual, a breaking room employee, has had asthma since childhood, but reported that it has not worsened since beginning work at Brown Produce. This individual also had a cross-shift decline in FEV_1 of 18%.

Total IgE and RAST scores were available for 27 workers. The IgE counts ranged from 3.31 kU/l to 2789.27 kU/l, with a median of 25.13 kU/l. Atopic individuals usually have total IgE levels greater than 100 kU/l. Only one individual had an IgE level greater than 100 kU/l. Three workers had low positive RAST scores; one had a RAST score of "one," and two had RAST scores of "two." The individuals with the low positive RAST scores did not report symptoms on the questionnaire.

Almost half (48%) of the participants in this study reported that they were atopic. This is consistent with previous population studies in which 14-50% of subjects reported allergic rhinitis, and skin testing indicated that 20-53% of the general population had a positive reaction to at least one common environmental antigen.[28] However, only one participant in the study had an IgE level greater than 100 kU/l, the level usually associated with atopy. Three individuals had low positive RAST scores of "one" or "two," indicative of exposure to hen's egg white, but not necessarily allergy.

One worker reported having experienced rhinitis or nasal congestion after eating eggs, symptoms which suggest the presence of an egg allergy; however, this individual had a RAST score of "zero." This individual also reported work-related chest tightness, but had normal peak flow variability and had no cross-shift decrease in FEV_1. Six workers reported abdominal cramps after eating eggs and five of these six reported diarrhea; these symptoms are more consistent with a food intolerance rather than a true allergy.

Employees in the breaking room had a higher prevalence of respiratory symptoms such as chronic cough, chronic phlegm, and wheezing or whistling noises in the chest than did transfer room employees. Breaking room employees were also more likely to have peak flow variability of $\geq$20% than were those working in the transfer room, but only one of them had a work-related pattern. This employee, and one other who had a cross-shift decline in FEV_1 greater than 10% were both breaking room employees. Breaking room employees thus appear to be at increased risk for respiratory symptoms and airway reactivity than are employees in the transfer room.

VIII. CONCLUSIONS AND RECOMMENDATIONS

The low participation rate notwithstanding, the high prevalence of respiratory symptoms and airways reactivity among employees of both the transfer room and the breaking room suggests that there is an ongoing respiratory health hazard at the Brown Produce Company. The levels of egg aeroallergens measured during this survey were more than adequate to induce sensitization and occupational respiratory disease.[29] Based on the air sampling results and medical findings breaking room employees appear to be at increased risk for respiratory symptoms and airways reactivity relative to employees in the transfer room. In contrast to previous NIOSH evaluations of egg processing facilities,[10-13] this survey did not document an IgE-mediated response from egg protein exposure. The following recommendations are made to safeguard employee occupational safety and health:

1. Occupational exposures can be controlled by the application of a number of well-known principles, including engineering controls, work practices, and personal protective equipment. These principles may be applied at or near the exposure source, to the general workplace environment, or at the point of occupational exposure to individuals. Controls applied at the exposure source, including engineering controls (materials substitution, process or equipment modification, isolation or automation, local exhaust ventilation) and work practices, are the preferred and most effective means of control. Controls which may be applied to hazards that have escaped into the workplace environment include dilution ventilation, dust suppression, and housekeeping. Control measures may also be applied near individual workers, including the use of isolated control rooms, isolation booths, fresh-air showers, improved work practices, and personal protective equipment.

   Sometimes, a combination of the above control measures may be required to provide worker protection. Process and workplace monitoring devices, personal exposure monitoring, and medical monitoring are important mechanisms for providing feedback concerning effectiveness of the controls in use. Ongoing monitoring and maintenance of controls to insure proper use and operating conditions, and the education and commit-ment of both workers and management to occupational health are also important components of a complete, effective control program.

   These principles of control apply to all situations, but their optimal application varies from case to case. A discussion of probable exposure sources, with the application of the above principles are discussed below for each processing area:

   Transfer Room: Mist escapes from the freshly washed eggs, from the conveyor entrance and the exit of the washer. Since this wash water is contaminated by broken eggs and is recirculated , this mist may be an important source of exposure to egg protein. The adjacent breaking room must me maintained under positive pressure. Therefore, any mist generated during egg breaking, passes through the transfer/breaking room windows into the transfer room. The control strategy addresses the two major aerosol sources (the egg washing machines, and air flow from the egg breaking room). Although the egg washing machines are connected directly to a roof mounted fan, egg aerosol mist should be controlled from the front and rear of the egg conveyor by exhaust hoods. Exhaust hoods should also be installed over the transfer/breaking room windows. This would also assist in keeping the breaking room under positive pressure.

   Breaking Room: The control strategy for the breaking room involves three elements: (1) minimizing the generation of egg-containing aerosol, (2) containing the escape of the generated aerosol, and (3) diluting any aerosol that may escape. The egg breaking machines should be enclosed and provided with local exhaust ventilation to contain the generated protein mist.

2. Workers who develop episodic wheezing, shortness of breath, chest tightness, or other symptoms compatible with asthma should be evaluated for occupational asthma.

3. Workers with asthma related to workplace exposure to egg proteins should be offered work assignments that will minimize their inhalational exposure to egg proteins. Workers would have less incentive to conceal work-related health problems or to continue working in areas of potential exposure if, after job transfer, they retained all wages and benefits associated with their previous job.

4. Persons with documented IgE-mediated hypersensitivity to eggs, including those who have had occupational asthma or other allergic responses from exposure to egg protein, may be at risk for reactions from influenza vaccine. Such individuals should consult a physician for appropriate evaluation to assist in determining whether vaccination may proceed or should be deferred.[30] Similar recommendations apply to yellow fever vaccine, which is also derived from eggs.

5. OSHA 200 logs indicated numerous preventable occupational injuries. Occupational eye injuries are easily preventable with safety glasses, and there use should be made mandatory. Employees should wear safety shoes with non-slip tread to prevent slips and falls since the workplace floor can become slippery with broken eggs.

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X. AUTHORSHIP AND ACKNOWLEDGMENTS

Evaluation Conducted and Report Prepared by:	Steve Berardinelli, Jr., MS Elizabeth Jennison, MD, MPH
Medical, Statistical, and Industrial Hygiene Assistance:	Toni Bledsoe Immunology Section Laboratory Investigations Branch Division of Respiratory Disease Studies
	Brian Day Statistics Section Epidemiological Investigations Branch Division of Respiratory Disease Studies
	Elizabeth Knutti, RN Michael Lyman, RN, MPH Chris Piacitelli Mark Ryan Betsy Viola Ray Petsko Clinical Investigations Branch Division of Respiratory Disease Studies
	Sylvia Saltzstien Summer Intern Clinical Investigations Branch Division of Respiratory Disease Studies
Originating Office:	Respiratory Disease Hazard Evaluations and Technical Assistance Program Clinical Investigations Branch Division of Respiratory Disease Studies 1095 Willowdale Road Morgantown, West Virginia 26505-2888 (304) 285-5711

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1. Seger Egg Corporation / Brown Produce Company
2. OSHA, Region V, Belleville District Office
3. USDA, Poultry Division

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

Table 1. Total Protein Personal Exposures
Brown Produce Company
Farina, Illinois
August 17, 1993
HETA 92-0354

Location	**Employee Task**	**Total Protein ($\mu g/m^3$)**
Transfer Room	Egg Washer Loader	73.2
	Egg Washer Machine Operator	43.8
	Egg Washer Loader - Canning	ND*
	Egg Washer Machine Operator	ND*
	Egg Washer Machine Operator	52.8
Average = 38.4 $\mu g/m^3$	Egg Washer Operator - Candling	51.7
	Egg Washer Loading	47.6
Breaking Room	Egg Breaking Machine Operator	268.6
	Egg Breaking Machine Operator	764.7
	Egg Breaking Machine Operator	389.1
Average = 338.5 $\mu g/m^3$	Egg Breaking Machine Operator	107.8
	Egg Breaking - Churning - Cleaning	162.5

* Not Detected

Table 2. Respirable Total Protein Personal Exposures
Brown Produce Company
Farina, Illinois
August 18, 1993
HETA 92-0354

Location	Employee Task	Respirable Protein (µg/m^3)
Transfer Room	Egg Washer Loader	9.8
	Egg Washer Machine Operator	23.0
Average = 17.4 µg/m^3	Egg Washer Loader - Canning	11.0
	Egg Washer Machine Operator	25.9
Breaking Room	Egg Breaking Machine Operator	25.2
	Egg Breaking Machine Operator	22.4
	Egg Breaking Machine Operator	49.2
Average = 36.0 µg/m^3	Egg Breaking Machine Operator	74.4
	Egg Breaking - Churning - Cleaning	8.8

Table 3. Aeroallergen Personal Exposures
Brown Produce Company
Farina, Illinois
August 19, 1993
HETA 92-0354

Location	**Employee Task**	**Ovalbumin ($\mu g/m^3$)**	**Ovomucoid ($\mu g/m^3$)**	**Lysozyme ($\mu g/m^3$)**
Transfer Room	Candling - Canning Area	81	22	3
	Washer Operator	940	270	12
	Washer Loader	893	344	27
	Washer Operator	1382	136	81
	Washer Operator	1887	326	34
	Washer Operator	950	233	18
	Average	**1022**	**222**	**29**
Breaking Room	Breaking Machine Operator	1144	194	3
	Breaking Machine Operator	5259	973	97
	Churning Operator	2232	240	13
	Breaking Machine Operator	3277	599	94
	Breaking Machine Operator	1389	457	5
	Breaking Machine Operator	1807	322	13
	Average	**2518**	**462**	**38**

Table 4. Prevalence of Respiratory Symptoms and
Nasal, Eye, and Skin Irritation by Work Area
Brown Produce Company
Farina, Illinois
August 12-20, 1993
HETA 92-0354

RESPIRATORY and IRRITANT SYMPTOMS	WORK AREA			
	TRANSFER ROOM		BREAKING ROOM	
	Number of Participants = 14		Number of Participants = 12	
	YES	(%)	YES	(%)
Chronic Cough	5	36%	7	58%
Chronic Phlegm	6	43%	8	67%
Chronic Shortness of Breath:				
> Grade I	2	14%	1	8%
> Grade II	1	7%	3	25%
> Grade III	1	7%	2	17%
Chest Tightness	5	36%	5	42%
Wheezing or Whistling Noises in Chest	3	21%	6	50%
Attacks of Shortness of Breath with Wheeze	4	29%	5	42%
Nasal Irritation	10	71%	10	83%
Eye Irritation	6	43%	6	50%
Skin Irritation	4	29%	6	50%

Table 5. Baseline Spirometry by Work Area
Brown Produce Company
Farina, Illinois
August 12-20, 1993
HETA 92-0354

BASELINE SPIROMETRY	WORK AREA	
	TRANSFER ROOM Number of Participants = 14	BREAKING ROOM Number of Participants = 10
	Mean ± SD	Mean ± SD
FVC (liters)	3.83 ± 0.68	4.04 ± 1.12
Percent Predicted FVC [a]	110.8 ± 16.49	105.4 ± 8.89
FEV_1 (liters)	3.12 ± 0.59	3.27 ± 1.07
Percent Predicted FEV_1 [b]	106.8 ± 15.03	100.4 ± 8.05
FEV_1/FVC Ratio	81.44 ± 6.40	80.07 ± 6.32

(a) Wilcoxon 2-sample test significance = 0.44 (not significant)
(b) Wilcoxon 2-sample test significance = 0.56 (not significant)

Table 6. Peak Flow Measurements
Brown Produce Company
Farina, Illinois
August 12-20, 1993
HETA 92-0354

% PEAK FLOW MAX-MIN / MEAN	WORK AREA	
	TRANSFER ROOM	BREAKING ROOM
	Number of Participants = 11	Number of Participants = 11
<20%	7 (64%)	4 (36%)
≥20%	4 (36%)	7 (64%)