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The growth of the poultry processing industry was possible because of veterinary preventive medicine techniques and improvements in breeding, feed conversion, housing, and marketing practices. Increased production of broilers has caused an increase in the amount of airborne contaminants to which poultry processing workers (growers, catchers, and hangers) are exposed. The purposes of this research were to evaluate the exposures experienced by poultry processing workers in North Carolina and to recommend control measures for reducing exposures below levels considered to be safe. Exposure estimates were compared to 8-hour time-weighted average (TWA) limits of 10 mg/m^3 for total dust, 5 mg/m^3 for respirable dust, 10 ng/m^3 for bacterial endotoxin, and 25 ppm for ammonia with a STEL of 35 ppm.

Personal sampling at 22 North Carolina poultry farms involving 26 growers produced geometric mean 8-hour TWA concentrations of 11.6 mg/m^3 for inhalable dust, 0.60 mg/m^3 for respirable dust, 100 ng/m^3 for inhalable endotoxin, 3 ng/m^3 for respirable endotoxin, and 19 ppm for ammonia. Personal sampling of 36 chicken catchers produced geometric mean 8-hour TWA concentrations of 20.2 mg/m^3 for inhalable dust, 1.75 mg/m^3 for respirable dust, 250 ng/m^3 for inhalable endotoxin, 13 ng/m^3 for respirable endotoxin, and 6 ppm for ammonia. Personal sampling of six chicken hangers produced geometric mean 8-hour TWA concentrations of 17 mg/m^3 for inhalable dust and 830 ng/m^3 for inhalable endotoxin. These data suggest that North Carolina poultry growers, catchers, and hangers may be at risk of experiencing respiratory dysfunction. Until engineering and administrative control methods are developed, the use of National Institute for Occupational Safety and Health/Mine Safety and Health Administration (NIOSH/MSHA)-approved respiratory protection is likely the most practical and feasible method available for protecting poultry growers and catchers. Effective local exhaust ventilation systems should be used to protect the health of poultry hangers. Wetting chickens prior to shackling them, routine cleaning of cages and crates, and using NIOSH/MSHA-approved respiratory protection can supplement local exhaust ventilation. **Lenhart, S.W.; Morris, P.D.; Akin, R.E.; Olenchock, S.A.; Service, W.S.; Boone, W.P.: Organic Dust, Endotoxin, and Ammonia Exposures in the North Carolina Poultry Processing Industry. Appl. Occup. Environ. Hyg. 5:611–618; 1990.**

Introduction

Since about 1950, the American poultry industry has experienced a rapid and impressive growth, which is predicted to continue as overseas markets expand. Whereas 631 million broilers were produced nationally in 1950,[1] 5.2 billion broilers were produced in 1988, representing over 22 billion pounds of finished product.[2] North Carolina has shared in the growth of the poultry industry and ranked fourth in broiler production behind Arkansas, Georgia, and Alabama in 1988. Five hundred million broilers with a value of $713 million were produced in North Carolina in 1988.[2]

The tremendous growth of the poultry processing industry has been due in large measure to veterinary preventive medicine techniques which permit large flocks to be grown in a short period with little risk of losing an entire flock to the rapid spread of an avian disease. Improvements in breeding, feed conversion, housing, and marketing practices have also contributed to growth of the industry.[1] While a broiler of the 1950s consumed 13 pounds of feed in 13 weeks to reach a weight of 4 pounds, a broiler

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now attains the same weight in less than 7 weeks on less than 8 pounds of feed.

During the early years of the industry, poultry growers usually raised no more than 1000 broilers at a time. Now, 10,000–20,000 broilers are raised in a single chicken house, and many growers maintain four or more chicken houses. However, while the agricultural community has devoted a great deal of attention toward improving the overall health of poultry, the health of poultry workers has received less attention.

Background

Chicken growers, catchers, and hangers experience daily exposures to airborne contaminants in the poultry processing industry.

Chicken Grower

A chicken grower is a farmer who owns one or more chicken houses and is contracted by a poultry processing company to raise their chickens. The company provides the chicks, veterinary services, and feed. A broiler reaches its processing weight in approximately 45 days; a farmer will raise four to six flocks per year. The tasks of a grower in a chicken house include cleaning drinkers, ensuring the continuous flow of water and feed, and collecting dead birds. Approximately 4000 poultry farmers in North Carolina work under contractual arrangements with poultry processing companies.(3) There are an estimated 40,000 poultry farmers nationwide, considering 10 percent of poultry production in the United States occurs in North Carolina.(2)

The floor of a chicken house is usually dirt-covered, with a layer of wood shavings commonly called litter. During the time between flocks, a fresh layer of litter is either applied over the existing layer, or applied after cakes of old litter are skimmed (with a rake attached to the back of a tractor) and removed from the house. Generally, litter is completely removed and replaced with clean material once every 12–18 months.

Litter in a chicken house serves as a reservoir for ammonia and other gases, and for organic dust that contains excrement, insect parts, microorganisms, and microbial toxins. The 1989–90 American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value Time-Weighted Average (TLV–TWA) concentration for ammonia was 25 ppm, and its Short-Term Exposure Limit (TLV–STEL) was 35 ppm.(4) The Occupational Safety and Health Administration's (OSHA) 8-hour Permissible Exposure Limit (PEL) for ammonia is a Transitional Limit of 50 ppm; OSHA established a 15-minute STEL of 35 ppm as a Final Rule limit.(5) The 1988–89 ACGIH TLV–TWA concentration applicable to organic dust was 10 mg/m^3 for Particulates Not Otherwise Classified (PNOC).(4) The OSHA PELs applicable to organic dust are 15 mg/m^3 for total dust of Particulates Not Otherwise Regulated and 5 mg/m^3 for the respirable fraction of Particulates Not Otherwise Regulated.(5) (The exposure limits applied here to organic dust might be inappropriate, since these "nuisance" dust concentrations are meant to be applied to dusts that do not produce significant disease or toxic effect.(4)) Guidelines for microorganisms and their toxins have been suggested for airborne molds, 10^7 cfu/m^3;(6) gram-negative bacteria, 10^3 cfu/m^3;(6) and endotoxin, 10 ng/m^3.(7,8)

Results of area sampling in three poultry houses in North Carolina have been published.(9) Dust sampling with open-face, three-piece, 37-mm cassettes connected to sampling pumps operated at a flow rate of 2 L/min produced an average concentration of 4.4 mg/m^3 for nine samples (range, 0.02–11 mg/m^3). Average endotoxin levels in these sam-

FIGURE 1. Chicken catchers collecting broilers.

ples were reported to range from 6.4 ng/mg to 16 ng/mg. Respirable dust sampling with a 10-mm nylon cyclone connected to a sampling pump operated at a flow rate of 1.7 L/min produced an average concentration of 0.24 mg/m^3 for nine samples (range, 0.02–0.62 mg/m^3). Ammonia levels in active areas of the houses, measured with the use of long-term detector tubes, averaged 25 ppm for four samples (range, 6–75 ppm).

Researchers who have evaluated the respiratory health of poultry farm workers have reported a higher incidence of respiratory symptoms associated with these workers than with control subjects,[10,11] significant decreases in Forced Expiratory Volume (FEV_1) over a work shift,[12,13] and pulmonary function values which were significantly lower than predicted.[10,14,15] While these results provide insight to the medical status of poultry farm workers, additional research should be conducted.

Chicken Catcher

A chicken catcher collects the birds by hand and places them into coops, cages, or crates for transportation by trailer truck to a processing plant once a flock of broilers is ready for processing.[16] Chicken catching is the occupation of approximately 800 workers in North Carolina and 8000 workers nationwide. Typically, a catching crew consists of a crew leader, four to eight catchers, and a loader operator who drives a fork lift tractor to move cages or pallets of crates from a chicken house to the trailer truck. Catchers are shown collecting chickens in Figure 1 and awaiting an opportunity to place birds in crates in Figure 2. Each catcher carriers from 8 to 15 chickens at a time.

Industrial hygienists from the Division of Occupational Safety and Health, North Carolina Department of Labor, conducted personal sampling on six catchers in February 1987, during a 7.5-hour work period. The 8-hour TWA concentrations of inhalable dust, defined as the concentration of dust collected by a closed-face, three-piece, 37-mm cassette connected to a sampling pump operated at a flow rate of 1.5 L/min, ranged from 15 to 20 mg/m^3. (The adjective "inhalable" is used here and throughout this article to define the mass of material collected by the sampling method. This was done in recognition of the distinction between the mass of material collected by this sampling method and the mass of material collected by both inspirable and thoracic particulate mass samplers, as defined by ACGIH.[4]) The geometric mean concentration was 17 mg/m^3 with a geometric standard deviation of 1.14. Each dust sample was analyzed for its endotoxin content, and 8-hour TWA concentrations ranged from 230 to 600 ng/m^3; the geometric mean concentration was 360 ng/m^3 with a geometric standard deviation of 1.4. The endotoxin content of the 24 dust samples collected by the compliance officers averaged 20 ± 8 ng/mg (range, 10–46 ng/mg).

The high concentrations of inhalable dust and endotoxins measured during this compliance inspection, coupled with a lack of published information concerning the respiratory health of chicken catchers, suggested that a need for research existed in this area. Therefore, a cross-sectional epidemiologic study of respiratory symptoms and pulmonary function involving 59 North Carolina chicken catchers was conducted.[17] The results of the study suggested that catchers experience a high rate of acute symptoms and experience significantly higher rates for chronic phlegm and chronic wheezing than nonexposed blue-collar workers. The catchers evaluated had significant decrements over a workshift in Forced Vital Capacity (−2.2%) and FEV_1 (−3.4%), and there was suggestive evidence that they had decreased preshift pulmonary function compared to nonexposed blue-collar workers.

Chicken Hanger

A chicken hanger removes live birds one at a time from crates or a conveyor belt and hangs them upside down by their feet in W-shaped shackles. Chicken hanging is the occupation of approximately 400 workers in North Carolina and 4000 workers nationwide. A hanging crew consists of eight to ten workers standing in a hanging room or on an outdoor platform. Exposure estimates of inhalable dust in this environment have been reported as high as the levels experienced by catchers. The authors of a study that involved the collection of area samples of both inhalable and respirable dust over a 2-week period reported concentrations of inhalable dust ranging from 6 mg/m^3 to 24 mg/m^3.[18] Inhalable endotoxin concentrations ranged from 430 to 2150 ng/m^3. The endotoxin content of the 49 area samples collected during two weeks averaged 45 ± 18 ng/mg (range, 24–109 ng/mg). While inhalable dust was defined in the same manner as described previously, respirable dust was collected using a 10-mm Dorr–Oliver cyclone connected to a personal sampling pump operated at a flow rate of 1.7 L/min. Respirable dust concentrations ranged from 0.43 to 1.6 mg/m^3; respirable endotoxin concentrations ranged from 17 to 86 ng/m^3.

Personal sampling for inhalable dust involving six hangers was conducted during the same compliance inspection

FIGURE 2. Chicken catchers awaiting an opportunity to place broilers in crates for transportation to processing plant.

mentioned previously. The 8-hour TWA inhalable dust concentrations ranged from 10 to 24 mg/m^3; the geometric mean concentration was 17 mg/m^3 with a geometric standard deviation of 1.34. The 8-hour TWA inhalable endotoxin exposures ranged from 480 to 1260 ng/m^3; the geometric mean concentration was 830 ng/m^3 with a geometric standard deviation of 1.46. The average endotoxin content of the 33 dust samples collected by the compliance officers was 49 ± 18 ng/mg (range, 18–115 ng/mg).

Information has been published regarding the medical status of hangers; however, as with growers and catchers, additional research studies are needed. Pulmonary function testing of 23 hangers in Sweden conducted before and after a workshift resulted in significant decreases in Vital Capacity (−3.1%) and FEV_1 (−4.1%).[19]

Methods

Personal sampling was conducted with the assistance of 26 broiler growers[20] and 36 chicken catchers to estimate their exposures to inhalable and respirable dust, inhalable and respirable bacterial endotoxin, and ammonia vapor. Equipment for each inhalable dust sample consisted of a closed-face, three-piece, 37-mm cassette containing a tared, 5-μm pore size, polyvinyl chloride (PVC) filter and a cellulose supporting pad. Each cassette was connected by flexible tubing to a personal sampling pump operated at a flow rate of 1.5 L/min. The mass of dust collected on each filter was determined gravimetrically.

Equipment for each respirable dust sample consisted of a 10-mm, Dorr–Oliver nylon cyclone connected by flexible tubing to a personal sampling pump operated at a flow rate of 1.7 L/min. Respirable dust particles separated by the cyclone were collected on a tared, 5-μm pore size, PVC filter supported by a cellulose pad and contained in a closed-face, two-piece, 37-mm cassette. The mass of respirable dust collected on each filter was determined gravimetrically. Field blanks for both inhalable and respirable dust were submitted for each day of testing.

Endotoxin analysis was performed on gravimetric dust samples, and inhalable and respirable endotoxin concentrations were calculated. After gravimetric analysis, each filter was placed aseptically into a separate screw-cap, sterile, nonpyrogenic plastic, 50-ml centrifuge tube and mailed to the National Institute for Occupational Safety and Health Laboratory in Morgantown, West Virginia. Each filter was extracted in 10 ml of sterile, nonpyrogenic water, and endotoxin analyses were performed in duplicate by the quantitative chromogenic *Limulus* amebocyte lysate test (QCL-1000; Whittaker Bioproducts, Walkersville, Maryland). Results were reported in terms of endotoxin units (EU) that were compared to the standard, EC-5. A conversion factor of 10 EU/ng was used.

Equipment for ammonia vapor sampling consisted of long-duration detector tubes (National Draeger reference number 67 28231) connected by flexible tubing to personal sampling pumps operated at flow rates ranging from 15 to 20 cc/min.

TABLE I. Summary of Exposure Concentrations of 26 North Carolina Broiler Growers

Exposure	Geometric Mean Concentration	Geometric Standard Deviation	Range of Concentrations
Inhalable dust	24.2 mg/m^3	1.56	12.9–78.2 mg/m^3
Inhalable endotoxin	210 ng/m^3	2.01	53–920 ng/m^3
Respirable dust	1.22 mg/m^3	1.66	0.41–3.77 mg/m^3
Respirable endotoxin	7 ng/m^3	2.11	2–23 ng/m^3
Ammonia	40 ppm	1.59	13–97 ppm

Note: Samples estimated exposure periods lasting from 15 minutes to 1.5 hours.

TABLE II. Summary of Projected 8-Hour Time-Weighted Average Exposure Concentrations of 26 North Carolina Broiler Growers

Exposure	Geometric Mean Concentration	Geometric Standard Deviation	Range of Concentrations
Inhalable dust	11.6 mg/m^3	2.07	2.30–35.0 mg/m^3
Inhalable endotoxin	100 ng/m^3	2.30	22–420 ng/m^3
Respirable dust	0.60 mg/m^3	1.88	0.15–1.88 mg/m^3
Respirable endotoxin	3 ng/m^3	2.24	1–12 ng/m^3
Ammonia	19 ppm	2.03	4–93 ppm

Results

The results of industrial hygiene sampling conducted at 22 North Carolina poultry farms to estimate the exposures of 26 broiler growers are summarized in Tables I and II. Twenty men and six women participated. The age of the chickens averaged 6 weeks (range, 5–10 weeks). Each grower wore three sampling trains (inhalable dust, respirable dust, and ammonia). Cassettes for inhalable dust sampling were replaced every 20–40 minutes to prevent overloading. Because a grower was sampled only during the first work period of a day, the majority of growers (14/26) wore only one cassette for inhalable dust. Only one cassette for respirable dust was necessary during each grower's sampling period. Also, each grower wore only one long-term detector tube for ammonia, with the exception of one grower who required two tubes because of his relatively high exposure.

A grower's time required inside chicken houses varies depending upon the number of birds being raised. Therefore, the mean concentrations presented in Table I represent exposure estimates obtained during sampling periods ranging from 15 minutes to 1.5 hours, which occurred always during a grower's first work period on the day of sampling. Several work periods can occur each day; the total time spent by the growers participating in this study ranged from 1 to 6 hours per day, 7 days per week. Because the poultry industry is growing rapidly, the exposure time of a grower in chicken houses is likely to increase as more houses are added to meet demand. Therefore, the mean values of Table I are presented chiefly as projections of possible full-shift exposures of the future.

Because broiler production is a 7-day-a-week job, projected 8-hour TWA concentrations were determined. This

TABLE III. Summary of Exposure Concentrations for Six North Carolina Chicken Catching Crews

Exposure	Geometric Mean Concentration	Geometric Standard Deviation	Range of Concentrations
Inhalable dust (n = 17)	30.6 mg/m³	1.92	10.8–92.4 mg/m³
Inhalable endotoxin (n = 17)	380 ng/m³	2.54	51–1360 ng/m³
Respirable dust (n = 19)	2.34 mg/m³	1.79	0.93–5.60 mg/m³
Respirable endotoxin (n = 18)	17 ng/m³	2.25	3–75 ng/m³
Ammonia (n = 16)	10 ppm	1.8	5–30 ppm

Note: Samples estimated exposure periods lasting from 3.5 to 9 hours.

was done by multiplying each exposure concentration for a sampling period by the ratio of a grower's estimate of the total hours spent daily in broiler houses times 7 days, to a 40-hour workweek. For example, if a grower estimated that he averaged 4 hours per day in his broiler houses, and his inhalable dust concentration for a sampling period of 1 hour was 20 mg/m³, then his 8-hour TWA concentration equals 28 hours (4 hours/day × 7 days) divided by 40 hours per workweek times 20 mg/m³, or 14 mg/m³.

The geometric mean concentrations of 11.6 mg/m³ for inhalable dust and 100 ng/m³ for inhalable endotoxin presented in Table II exceed the 1988–1989 ACGIH TLV–TWA of 10 mg/m³ for PNOC[4] and the suggested exposure limit of 10 ng/m³ for endotoxin.[7,8] Seventy-three percent (19/26) of the inhalable dust concentrations equaled or exceeded 10 mg/m³. All 26 inhalable endotoxin concentrations exceeded 10 ng/m³. The endotoxin content of these 26 dust samples averaged 11 ± 6 ng/mg (range, 3–25 ng/mg). In contrast to the relatively high inhalable dust concentrations achieved, the ratio of respirable dust to inhalable dust was low for the 26 pairs of samples: averaging 5 percent and ranging from 2 to 13 percent. None of the 8-hour TWA respirable dust concentrations exceeded 5 mg/m³. One of the 8-hour TWA ammonia concentrations exceeded the OSHA PEL of 50 ppm,[5] and 42 percent (11/26) exceeded the ACGIH TLV–TWA of 25 ppm.[4] Sampling was not conducted specifically to evaluate short-term exposures to ammonia. However, the potential for exceeding the ACGIH TLV–STEL and the OSHA 15-minute STEL of 35 ppm is apparent, since 73 percent (19/26) of the ammonia concentrations representing the exposures experienced during each grower's first work period of the day of sampling exceeded 35 ppm.

The results of industrial hygiene sampling during chicken catching are summarized in Tables III and IV. Each of the six crews from two companies consisted of six to ten men. The six workshifts lasted an average of 6 hours and ranged from 3.5 to 9 hours. An average of 34,000 ± 9,000 birds were caught per shift. All of the chickens were approximately 7 weeks old. Most catchers wore only one sampling train (either inhalable dust or respirable dust). Sampling train assignment was done randomly. Three randomly selected catchers from each crew also wore a sampling train to evaluate exposures to ammonia. Cassettes for inhalable dust sampling were replaced every 30–90 minutes to prevent overloading. Therefore, depending upon the duration of a workshift, a series of four to seven cassettes were worn by a catcher. Regardless of the duration of a workshift, most cassettes for respirable dust were replaced once at the middle of the shift. Exceptions were the 3.5-hour shift (one cassette per worker) and the 9-hour shift (three cassettes per worker). One to two long-term detector tubes for ammonia were worn by each of the three selected catchers from each crew.

The geometric mean concentrations of 20.2 mg/m³ for inhalable dust and 250 ng/m³ for inhalable endotoxin presented in Table IV exceed the 1988–89 ACGIH TLV–TWA of 10 mg/m³ for PNOC[4] and the suggested exposure limit of 10 ng/m³ for endotoxin.[7,8] Eighty-eight percent (15/17) of the inhalable dust exposure estimates equaled or exceeded 10 mg/m³. All 17 inhalable endotoxin exposure estimates exceeded 10 ng/m³. The endotoxin content of the 38 samples collected for this phase of the study averaged 14 ± 10 ng/mg (range, 4–51 ng/mg). Respirable dust concentrations were less than one-tenth of the inhalable dust concentrations, which is similar to the results reported for the growers. As with the growers, none of the 8-hour TWA respirable dust concentrations exceeded 5 mg/m³. Two of the sixteen 8-hour TWA ammonia concentrations equaled or exceeded the ACGIH TLV–TWA of

TABLE IV. Summary of 8-Hour Time-Weighted Average Exposure Concentrations for Six North Carolina Chicken Catching Crews

Exposure	Geometric Mean Concentration	Geometric Standard Deviation	Range of Concentrations
Inhalable dust (n = 17)	20.2 mg/m³	1.67	5.74–39.8 mg/m³
Inhalable endotoxin (n = 17)	250 ng/m³	2.53	27–700 ng/m³
Respirable dust (n = 19)	1.75 mg/m³	1.70	0.55–4.18 mg/m³
Respirable endotoxin (n = 18)	13 ng/m³	2.11	3–34 ng/m³
Ammonia (n = 16)	6 ppm	2.3	2–26 ppm

25 ppm,[4] and none exceeded the OSHA PEL of 50 ppm.[5] The potential for ammonia exposures to exceed the ACGIH TLV–STEL and the OSHA 15-minute STEL of 35 ppm during chicken catching was not evaluated.

Four catching crews worked at night under low light conditions, and two crews worked entirely during the day. Concentration estimates of both inhalable and respirable dust showed marked differences between these two groups. Day crews had a geometric mean concentration of inhalable dust during their work shifts of 61 mg/m^3 with a geometric standard deviation of 1.3, based upon seven workers' results. By comparison, night crews had a geometric mean concentration of 19 mg/m^3 with a geometric standard deviation of 1.3, based upon ten workers' results. The geometric mean concentration of respirable dust for day crews was 4.3 mg/m^3 with a geometric standard deviation of 1.2 ($n=7$), versus 1.6 mg/m^3 with a geometric standard deviation of 1.5 ($n=12$) for night crews.

Discussion and Recommendations

Exposures to organic dust, endotoxin, and ammonia experienced by workers in the poultry processing industry present an important respiratory health risk which should be reduced by the implementation of protective measures. Engineering and administrative measures for reducing the exposures of chicken growers and catchers are presented next along with guidance regarding respirator selection. While this article has been concerned primarily with the respiratory health risks of chicken growers and catchers, this section concludes with suggested methods for protecting chicken hangers.

Poultry houses are long, narrow buildings with widths from 9 m (30 ft) to 11 m (36 ft) and lengths from 60 m (200 ft) to 120 m (400 ft). Curtains made of heavy cloth line the length of both sides. They are kept up (closed) during cold months to conserve heat and are lowered (opened) when ambient temperatures are warmer. Exhaust fans are also located along the sides of chicken houses, as components of a system intended primarily for maintaining acceptable temperatures in the houses as the chickens grow. While these fans may provide some reduction in the exposure of humans to organic dust and ammonia, there might be too few fans for this purpose. Installation of additional fans might be too costly for some growers, and their value as a protective measure remains to be evaluated.

In a previous study of three North Carolina poultry houses, results of area sampling produced a mean concentration of 4.4 mg/m^3 for total dust.[9] Respirable dust and ammonia concentrations averaged 0.24 mg/m^3 and 25 ppm, respectively.[9] The personal samples from the present study showed much larger exposure estimates with geometric mean concentrations determined for the period of sampling of 24.2 mg/m^3 for inhalable dust, 1.22 mg/m^3 for respirable dust, and 40 ppm for ammonia. While the differences between the results of these two studies might be related to differences between sample sizes and sampling methods, it is more likely that the differences are related to the season of the year during which the studies were conducted. The ambient temperatures reported during the previous study[9] were so warm that the doors and curtains of the houses were open and fans operated continually.

Weather conditions during the sampling periods of the present study were such that the doors and curtains of the houses were never opened. Growers reported that opening the curtains manually was time consuming and that heating expenses were too high. Replacing manual systems of adjusting the curtains of a chicken house with automated systems might serve to encourage growers to increase natural ventilation when they need to enter their houses.

Research has been conducted on the use of technical binding agents for controlling ammonia concentrations in chicken houses.[21] Researchers concluded after laboratory and field studies that peat was the best litter for decreasing ammonia concentrations. Chickens exposed to controlled levels of 20 to 50 ppm of ammonia in laboratory experiments have demonstrated reduced feed efficiency, pulmonary congestion and edema, hemorrhage, ciliary loss, and increased goblet cell numbers in the nasal and tracheal epithelium.[22–24] Therefore, reducing ammonia concentrations to which growers are exposed in poultry houses might also help to improve the health of chickens.

Few occupations can match the physical demands and undesirable working conditions experienced by a chicken catcher. Because of high employee turnover, increasing worldwide demand for poultry products, and expenses associated with catching chickens by hand, the use of automated equipment for catching and cooping chickens is probably inevitable. An Irish firm developed the first such mechanized system designed to catch and coop chickens.[25] The device resembles a street sweeper with two outriggers which, according to the company's advertisement, "rotate slowly to encourage the chickens to step onto a slightly inclined conveyor fitted with perches." The conveyor leads to a four-tiered cage, which is a component of the system. While the use of automated catching and caging equipment requires fewer workers, a benefit is a reduction in the number of catchers at risk of overexposure to organic dust and ammonia.

Use of a large diameter, gasoline engine-driven fan capable of being transported from farm to farm on the same trailer as the loader operator's fork lift tractor was reported in the agricultural literature.[26] The fan is described as being able to exhaust dust-laden air out the end door of a chicken house and is moved occasionally ahead of the catchers as they proceed through the house. The protective value of this method is unknown, but it is obviously not applicable to those chicken houses without an end door.

Interestingly, the findings of this study suggest that chicken catchers who work at night experience less exposure to both inhalable and respirable dust than catchers who work during the day. The differences in exposures might be because the birds are much less active at night and, consequently, generate less airborne dust. Therefore, it might be appropriate to limit chicken catching to nighttime hours whenever possible.

While improved engineering and administrative control measures for chicken houses are under consideration, the use of NIOSH/MSHA-approved respiratory protection is apparently the most practical and feasible method available for protecting chicken growers and catchers. After exposure estimates have been determined for contaminants in an occupational environment, a respirator selection process begins by objectively determining the level of protection necessary. This is usually done by dividing the highest 8-hour TWA exposure estimate of a contaminant by the contaminant's exposure limit. Then, a class of respiratory protection is selected with an assigned protection factor equal to or exceeding the needed level of protection.

If respirator selection for chicken growers and catchers was based upon the highest 8-hour TWA respirable dust concentration reported here, then no respirator would be necessary, since the highest 8-hour TWA respirable dust concentration (4.18 mg/m^3) was less than the OSHA PEL of 5 mg/m^3. Alternatively, respirator selection based upon the results of inhalable dust sampling and the ACGIH TLV–TWA of 10 mg/m^3 for PNOC produces a minimum required level of protection of 4 (39.8 mg/m^3 ÷ 10 mg/m^3). This suggests that any NIOSH/MSHA-approved respirator would be acceptable. However, respirator selection based upon the highest 8-hour TWA inhalable endotoxin concentration (700 ng/m^3) and a suggested exposure limit of 10 ng/m^3 produces a required level of protection of 70.

A full facepiece respirator with high efficiency filters is recommended for use by chicken growers and catchers. This class of respiratory protection is recognized generally as having an assigned protection factor of 50.[27] While this value is less than the calculated level of protection required, a full facepiece respirator should provide adequate respiratory protection if it is worn and used properly. A full facepiece respirator has the additional benefit of providing eye protection against irritating substances such as ammonia and particulates. Because ammonia concentrations can be excessive in chicken houses, the use of combination cartridges for both particulate and ammonia might be necessary. Without convincing evidence for their necessity, other types of respiratory protection with assigned protection factors equal to or higher than 50, (e.g., powered air-purifying respirators with tight-fitting facepieces, supplied air respirators, and self-contained breathing apparatuses) might be impractical and/or too expensive to be considered currently by chicken growers and chicken catchers.

As with any other type of respirator with a facepiece, a good face-to-facepiece seal is essential for the protection of a respirator user's health. Growing chickens can be a family business which oftentimes involves a farmer's children. Special care should be taken to ensure that respirators used by children fit properly. Simultaneous in-mask and lapel sampling should be performed on a sample population of chicken growers or catchers to ensure that the class of respiratory protection recommended here is indeed sufficient to protect them during all conditions of use.

In contrast to the mobility of the chicken grower and the chicken catcher, chicken hangers are stationary throughout a workshift. Therefore, effective local exhaust ventilation can be used to control their dust exposures. There are also two other measures seldom used for dust control but which might reduce the amount of dust generated during the chicken hanging process. These methods are 1) wetting chickens with a water spray either in their crates or while on the conveyor belt just before they enter the hanging area and 2) thorough and frequent removal of all dirt and excrement from crates before more birds are placed in them. Both of these methods might also extend the shelf-life of the finished chicken product, since it has been known for several years that there is a relationship between shelf-life and the cleanliness of the birds when they arrive at the receiving area of the processing plant.[28,29]

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