# Air quality in commercial turkey housing

J.J.R. FEDDES and Z.J. LICSKO

*Department of Animal Science, University of Alberta, Edmonton, AB, Canada T6G 2H1.* *Received 19 October 1992; accepted 31 March 1993.*

Feddes, J.J.R. and Licsko, Z.J. 1993. **Air quality in commercial turkey housing**. Can. Agric. Eng. **35**:147-150. Air quality was monitored in a typical brooder and grower turkey barn near Edmonton, AB. Ammonia, carbon dioxide, airborne dust, temperature, and ventilation rates were measured on a semi-hourly basis over a 24-h period during weeks 2, 3, 4, and 5 in the brooder barn and weeks 9, 10, 11, 12, 13, 14, and 15 in the grower barn. Both concentration and production rate data are reported. The levels of aerial contaminants were acceptable in the brooder barn and unacceptable in the grower barn.

La qualité de l'air à été mesurée dans un poulailler de démarrage et un poulailler de croissance pour dindons près d'Edmonton, AB. L'ammoniac, le bioxyde de carbone, la poussière de l'air, la température et les taux de ventilation ont été mesurés sur une base semi-horaire pendant 24-h durant les semaines 2, 3, 4, et 5 dans le poulailler de démarrage et durant les semaines 9, 10, 11, 12, 13, 14, et 15 dans la poulailler de croissance. Les données de concentration et de taux de production sont présentées. Les niveaux de contaminants aériens ont été acceptables dans le poulailler de croissance et inacceptables dans le poulailler de croissance.

## INTRODUCTION

Air quality in animal housing is a function of the concentration of ambient airborne contaminants. In turkey housing, aerial contaminants include gaseous compounds such as ammonia ($NH_3$), carbon dioxide ($CO_2$), and hydrogen sulphide ($H_2S$) as well as respirable airborne dust particles. Wolfe et al. (1968) focused their research on the effect of dust and $NH_3$ on turkeys and found no significant relationship between $NH_3$ levels and the occurrence of airsacculitis. However, they did find that the incidence of airsacculitis increased significantly with dust levels. Feed conversion rates were not affected by these $NH_3$ or dust levels.

Subsequent research has concentrated on the levels of bacterial and particulate concentrations (Jacobson and Jordon 1978). They found that humidity and bird activity affected the concentration of both these aerial contaminants; however, they could not relate the incidence of either bacterial or particulate concentrations to bird health. Increased ventilation rates, litter management, and humidity were suggested as control strategies for reducing bacterial and particulate concentrations.

More recent research reported on the concentration of aerosols and noxious gases under commercial conditions for turkey rearing (Janni et al. 1984, 1989). Additional research has focused on the causes of airsacculitis in male turkeys (Janni and Redig 1986). In a comparison of mortality differences on a seasonal basis, they found that high levels of *Aspergillus*, $NH_3$, dust, and aerosols were concurrent with high mortality rates among turkeys raised under commercial conditions.

Research also has attempted to correlate the clearance rate of Aspergillus spores with bird age and $NH_3$ concentration (Janni and Redig 1986; Mulhausen et al. 1987). Although spore clearance rate decreased with increasing bird age, there was no link to $NH_3$ concentrations. Final bird weights and bird mortality were not affected by the $NH_3$ concentrations in their study.

The objectives of this project were to obtain data on ambient levels and production rates of aerial contaminants found in commercial turkey housing throughout a growth cycle in a brooder and grower barn. The study was carried out concurrently with a study that compared direct and indirect calorimetric methods for determining bird heat production (Feddes and McDermott 1992).

## EXPERIMENTAL FACILITIES

This study was conducted at a commercial turkey facility approximately 150 km northwest of Edmonton, AB. A brooder and a grower barn were monitored between January and May of 1988. These two barns have been described elsewhere (Feddes and McDermott 1992). These barns were considered to be typical of turkey housing in that fresh bedding was provided after removal of the litter from the previous batch of turkeys and heating was provided to maintain acceptable ambient temperatures at recommended ventilation rates. Exchange air was introduced through continuous slot inlets and exhausted by wall mounted fans. Stocking density was that suggested by the industry. Birds were housed in the brooder barn (0.12 $m^2$/bird) from one day to 8 weeks and in the grower barn (0.43 $m^2$/bird) from 8 to 16 weeks of age. Table I shows the dates of each 24-h monitoring period, the number of birds, and their age in each barn.

## EXPERIMENTAL PROCEDURES

An instrumentation and data acquisition system described by Feddes and McQuitty (1977) was used to monitor each barn. The system was housed in a mobile trailer and was isolated from the barn environment. The parameters monitored included: $NH_3$, $CO_2$, dust levels, relative humidity(RH), temperature, and ventilation rate. These parameters were measured twice an hour over a 24-h period during a week for each location. Ambient inside air temperatures in each barn were based on temperature measurements from thermistors (Fenwal Electronics, Framingham, MA) evenly spaced at bird height.

Air was drawn through plastic tubing to the mobile trailer from outside the barns and from the operating exhaust fan locations, the location being controlled by a set of sequenced solenoid activated valves, to the gas analyzers and a dewpoint hygrometer (Model 880, Cambridge Systems, Cambridge, MA).

Ammonia and $CO_2$ levels were recorded with the use of non-dispersive infrared gas analyzers (Beckman, LaHabra, CA). The accuracy of these instruments was checked at the start and at the end of each 24-h monitoring period by sampling calibration gases. Hydrogen sulphide levels were also checked periodically during each sampling period with the use of a hand held bellows-type detector and appropriate sampling tubes.

Dust levels were measured with the use of a forward-scattering optical particle counter (Climet Instruments, Redlands, CA). Samples were drawn 5 min of every hour during the 24-h run through a 6.35 mm ID tube to the dust sampler located in the mobile trailer. All dust samples were drawn from a single location at the centre of each barn at mid-height.

To measure the building ventilation rate, ducts with flow straighteners were located downstream from each operating ventilation fan (Jorgenson 1983). Flow rates from each variable-speed fan were determined from a fan voltage - air flow rate regression equation (Feddes and McDermott 1992). The voltage to the variable speed fans was recorded every four minutes. Air flow rates from single speed fans were determined from event recorders monitoring the time of operation. Airflow rates were measured manually two times during each run by measuring airspeeds at 25 points in each duct (Jorgenson 1983). These airflow rates, along with corresponding fan voltages, also were part of the data set used to establish the regression equations.

## ENVIRONMENTAL CONDITIONS

Outside air temperatures during the monitoring period ranged between -30°C and 13°C (Table I). Overall mean daily ventilation rates increased from 0.11 to 1.92 L/s per bird corresponding to the increase in age of the birds (Table II). Generally, ventilation rates were a constant minimum to maintain acceptable RH and aerial contaminant levels. In the grower barn, the mean daily ambient temperature ranged between 11°C and 15.8°C. The majority of the temperatures were well below 18°C as recommended by ASAE (1991). In the brooder barn, mean daily ambient temperatures ranged from 19.6°C to 33.8°C (Table I). Recommended inside RH values for poultry housing are a minimum of 50% and a maximum of 75% (ASAE 1991). Mean measured RH values ranged from 38 to 59% in the brooder barn and from 62 to 85% in the grower barn, the higher RH generally associated with lower ambient temperatures.

## RESULTS AND DISCUSSION

The mean $CO_2$ concentrations, as presented in Table II, were not great enough to be considered a health hazard to either birds or humans. They did not exceed the threshold limit value of 5000 ppm as recommended by ACGIH (1985). However, $CO_2$ is a good indicator of overall air quality. Concentrations of 2500 ppm are suggested as threshold levels in confinement buildings (Anonymous 1990). At 92 days, 24-h mean $CO_2$ levels reached 3616 ppm with a corresponding high $NH_3$ level of 28 ppm. The $CO_2$ production values ranged from 3.47 to 11.7 L/h per bird in the grower barn and 0.48 to 1.95 L/h per bird in the brooder barn. Carbon dioxide production rates for the turkey hens in the brooder barn were similar to that of broilers at the same age (Leonard et al. 1984).

**Table I. Summary of environmental conditions for turkeys in the brooder and grower barn.**

| Date | No. of birds | Age (days) | ..........Temperature (°C).......... Outside | Range | Ambient | Range | Relative humidity (%) Ambient | Range |
|---|---|---|---|---|---|---|---|---|
| | | | | Brooder Barn | | | | |
| 88-02-17 | 4692 | 16 | -0.3 | -5/6 | 27.2 | 26/28 | 38 | 35/43 |
| 88-02-22 | 4665 | 21 | -12.0 | -20/-5 | 24.5 | 22/26 | 46 | 42/52 |
| 88-03-01 | 4616 | 29 | -2.7 | -8/6 | 22.2 | 20/25 | 66 | 55/90 |
| 88-03-08 | 4595 | 36 | 6.4 | 2/13 | 23.0 | 21/26 | 59 | 51/68 |
| | | | | Grower Barn | | | | |
| 88-01-12 | 2710 | 64 | -18.0 | -23/-8 | 14.0 | 12/17 | 68 | 60/79 |
| 88-01-18 | 2692 | 70 | -12.2 | -17/-2 | 12.1 | 09/16 | 63 | 54/72 |
| 88-01-25 | 2673 | 77 | - 1.4 | -10/4 | 12.8 | 08/18 | 70 | 57/77 |
| 88-02-01 | 2658 | 84 | -18.0 | -22/-17 | 11.0 | 06/16 | 81 | 59/92 |
| 88-02-09 | 2636 | 92 | -23.8 | -30/-17 | 13.2 | 12/16 | 85 | 66/90 |
| 88-02-16 | 2610 | 99 | 1.4 | - 2/5 | 15.8 | 12/20 | 62 | 54/68 |
| 88-02-23 | 2575 | 106 | - 9.1 | -16/8 | 11.3 | 08/14 | 73 | 54/87 |
| 88-02-26 | 2560 | Marketed | | | | | | |

**Table II. Daily means data for the gases and dust monitored in the two barns.**

| Age (days) | Ventilation L/(s.bird) | Concentration | | Dust particles/mL | | Production | |
|---|---|---|---|---|---|---|---|
| | | $CO_2$ ppm | $NH_3$ ppm | <5µm | >5µm | $CO_2$ L/(s.bird) | $NH_3$ mL/(m$^2$ of bldg/h) |
| | | | | Brooder Barn | | | |
| 16 | 0.11 | 1558 | - | 17 | 0.6 | 0.48 | - |
| 21 | 0.16 | 2542 | 1 | 18 | 0.3 | 1.26 | 5 |
| 29 | 0.20 | 2514 | 1 | 4 | 0.1 | 1.56 | 6 |
| 36 | 0.38 | 1772 | 3 | - | - | 1.95 | 34 |
| | | | | Grower Barn | | | |
| 64 | 0.43 | 2594 | 11 | 32 | 4 | 3.47 | 40 |
| 70 | 0.80 | 1880 | 10 | 34 | 4 | 4.41 | 67 |
| 77 | 1.54 | 1584 | 8 | 35 | 3 | 6.84 | 103 |
| 84 | 0.95 | 2681 | 20 | 49 | 31 | 7.97 | 158 |
| 92 | 0.84 | 3616 | 28 | 41 | 21 | 9.88 | 194 |
| 99 | 1.92 | 1858 | 15 | 45 | 4 | 10.4 | 235 |
| 106 | 1.85 | 2113 | - | 50 | 3 | 11.7 | - |

### Ammonia

Ammonia concentration and production rates are presented in Table II. Mean 24-h $NH_3$ levels exceeded 25 ppm at 92 days of age and exceeded 10 ppm during most of the monitoring periods in the grower barn. In the brooder barn, $NH_3$ concentrations were low since dry litter was maintained by the floor heating. Levels of 10 ppm of $NH_3$ are suggested as exposure threshold in swine buildings for swine health (Anonymous 1990). Moulsley (1977) found that concentrations as low as 20 ppm increased the susceptibility of chickens to Newcastle disease. Ammonia production reached a maximum of 235 mL/h per m$^2$ of building floor area at 99 days of age.

### Hydrogen sulphide

The presence of hydrogen sulphide in each barn was checked during each monitoring period, but no more than trace amounts (<1 ppm) were ever detected.

### Airborne dust

Respirable (<5µm) dust particle concentrations ranged from 32 to 50 particles/mL in the grower barn and between 4 and 18 particles/mL in the brooder barn. The mean stocking densities of the birds were 7 and 17 kg of bird/m$^2$ for the brooder and grower barn, respectively. As suggested by Webster (1990) and Stroh et al. (1978), stocking density appears to be a significant contributor towards dust concentrations. Donham suggested 25 particles/mL of respirable dust as a threshold level (Anonymous 1990). Therefore, air quality appears to be acceptable within the brooder barn, whereas dust levels in the grower barn are almost twice that suggested.

## CONCLUSIONS

The following conclusions can be drawn:

1) The levels of aerial contaminants in the brooder barn were acceptable.
2) Air quality in the grower barn was not acceptable. Ammonia and respirable dust concentrations were higher than those suggested (10 ppm $NH_3$ and 25 particles/mL respirable dust).

## ACKNOWLEDGEMENTS

The authors acknowledge the financial support of the Alberta Agricultural Research Institute and NSERC. The cooperation of producer, Mr. Clarence Olthius, and the assistance in the collection and compilation of data by D. Travis, technician, and K. McDermott, graduate student, from the Department of Agricultural Engineering, University of Alberta, is also gratefully acknowledged.

## REFERENCES

ACGIH. 1985. Threshold limit values for chemical substances in work air adopted by ACGIH for 1984. American Conference of Governmental Industrial Hygienists, Cincinnati, OH.

Anonymous. 1990. Your health - The risks of confinement. Blue Print series for Top Managers. National Hog Farmer. Webb Division, Intertec Publishing Corp., Minneapolis, MN.

ASAE. 1991. ASAE Standards. St. Joseph, MI: ASAE.

Feddes, J.J.R. and K. McDermott. 1992. Turkey heat production measured directly and indirectly under commercial-scale conditions. *Canadian Agricultural Engineering* 34:258-264.

Feddes, J.J.R. and J.B. McQuitty. 1977. Data acquisition system for measuring environmental variables within confinement animal units. *Canadian Agricultural Engineering* 19(2):75-77.

Jacobson, L.D. and K.A. Jordan. 1978. Aerosol concentration in a turkey barn environment. *Transactions of the ASAE* 21(2):325-328.

Janni, K.A. and P.T. Redig. 1986. Factors affecting the occurrence of aspergillosis in turkeys. ASAE Paper No. 86-4533. St. Joseph, MI: ASAE.

Janni, K.A., P.T. Redig and J.A. Newman. 1989. Effects of dust and ammonia on turkeys. ASAE Paper No. 89-4022. St. Joseph, MI: ASAE.

Janni, K.A., P.T. Redig, J.A. Newman and J.R. Mulhausen. 1984. Respirable aerosol concentrations in turkey grower buildings. ASAE Paper No. 84-4522. St. Joseph, MI: ASAE.

Jorgenson, R. 1983. *Fan Engineering*, 8th ed. Buffalo Forage Company, Buffalo, NY.

Leonard, J.J., J.J.R. Feddes and J.B. McQuitty. 1984. Air quality in commercial broiler housing. *Canadian Agricultural Engineering* 26(1):65-71.

Moulsley, L.J. 1977. A comparison between winter and summer concentrations of ammonia and carbon dioxide in the atmosphere of 2 broiler houses. Sectional Note, SN/EN/23/10003. National Institute of Agricultural Engineering, Silsoe, UK.

Mulhausen, J.R., C.E. McJilton, P.T. Redig and K.A. Janni. 1987. Aspergillus and other human respiratory disease agents in turkey confinement houses. *American Industrial Hygiene Association Journal* 48(11):894-899.

Stroh, R.C., J.E. Dixon, C.F. Peterson, E.A. Sauter, J.F. Parkinson and E.E. Steel. 1978. Environmental effects upon poultry house aerosols. ASAE Paper No. 78-4510. St Joseph, MI: ASAE.

Webster, A.J. 1990. Housing and respiratory disease in farm animals. *Outlook on Agriculture* 19(1):31-35.

Wolfe, R.R., D.P. Anderson, F.L. Cherms and W.E. Roper. 1986. Effect of dust and ammonia air contamination on turkey response. *Transactions of the ASAE* 11(4):515-518.