Effect of litter oiling and ventilation rate on air quality, health, and performance of turkeys

J.J.R. FEDDES[1], K. TASCHUK[1], F.E. ROBINSON[1] and C. RIDDELL[2]

[1]Department of Agricultural, Food and Nutritional Science, University of Alberta, Edmonton, AB, Canada T6G 2P5; and Department of Veterinary Pathology, Western College of Veterinary Medicine, University of Saskatchewan, Saskatoon, SK, Canada S7N 0W0. *Received 20 August 1993; accepted 15 January 1995.*

Feddes, J.J.R., Taschuk, K., Robinson, F.E. and Riddell, C. 1995. **Effect of litter oiling and ventilation rate on air quality, health, and performance of turkeys.** Can. Agric. Eng. 37:057-062. An experiment was conducted with male heavy turkeys to study the effects of the application of canola oil to litter and ventilation rate, on health status and growth performance at 16 weeks of age. Litter oiling and increased ventilation rate significantly reduced the concentration of aerosol dust particles and the incidence of lung lesions. Overall, birds that developed lung lesions were those which had a fast rate of growth initially (8 to 12 weeks of age). Such birds later exhibited a relatively slow rate of growth (12 to 16 weeks of age). There would appear to be a negative relationship between the development of lung lesions and subsequent growth rate. Litter oiling offers a practical means of reducing dust in poultry housing.

Une expérience était conduite avec les dirdons pesant pour de étudier les effets de l'application de l'huile de canola á la litière, et la vitesse de ventilation sur la condition de santé et la performance de la croissance á 16 semaines d'âge. L'huilage de la litière et une vitesse de ventilation augmentée avaient redurent significativement la concentration des particules de la poussière aéroportée et l'incidence des lésions due poumon. Les dindons qui ont développés les lésions du poumon étaient seul qui avaient une croissance rapide initialement (8 á 12 semaines d'âge). Ces dindons avaient exhibités deniemment une croissance plus lent (12 á 16 semaines d'âge). Ca semble d'être un rapport négatif entre le développement des lésions du poumon et la croissance subséquent. L'huilage de la litière offert un moyen pratique de réduire la poussière dans la grange de volaille.

INTRODUCTION

Poultry raised under conditions of confinement housing can be subjected to a complex mixture of aerial contaminants comprised of airborne dust, viable micro-organisms, ammonia, carbon dioxide, and water vapour. Two routes can be followed to achieve a reduction in the level of aerial contamination in such housing. Firstly, an environment can be improved by diluting the aerial contaminants through ventilation to an acceptable concentration or secondly, by reducing the rate of release of such contaminants from the litter.

There is evidence that the well-being, productivity, and health of people and animals can be adversely affected by high levels of aerial contaminants (Wolfe et al. 1968; Janni et al. 1985; De Boer and Morrison 1988). Donham et al. (1988) have reported that respiratory function in stockpersons may be impaired due to high concentrations of airborne dust and ammonia. Nagaraja et al. (1983) reported on the adverse effects of ammonia concentrations of 10 and 40 ppm on tracheal tissues of turkeys. Excessive mucus production, matted cilia, and areas of deciliation in the tracheal tissues were detected after exposure to such conditions. Feddes et al. (1992a) found that turkeys housed from 12 to 20 weeks of age at a relatively low rate of ventilation (2.9 L/s per bird) exhibited lower body weights and a higher incidence of lung lesions than did turkeys that were subjected to a high (13.3 L/s per bird) ventilation rate. Feddes et al. (1992b) reported that the majority of the airborne dust particles in turkey housing is of fecal origin, with urates being the major contributor. The nitrogen content of the dust was found to be excessive and may be a contributing factor in the occurrence of lung lesions.

One potential method of suppressing dust production is the weekly application of canola oil to litter, since litter is considered to be a major source. Takai et al. (1993) reported using rapeseed oil to reduce dust levels in pig housing by 50-90%. The primary objective of the research reported here was to determine the effects of applying canola oil to litter and ventilation rate on air quality and the growth performance and health status of male heavy turkeys to 16 weeks of age. Air quality was evaluated in terms of the concentrations of ammonia and dust as well as relative humidity. Turkey performance and health were determined from body mass gain and feed efficiency data in addition to the incidence and severity of lung lesions. The study investigated the effects of the application of canola oil at ventilation rates typical of spring-fall, winter, and summer.

MATERIALS AND METHODS

Facilities

Four environmental chambers located within a turkey barn at the University of Alberta's Edmonton Research Station were used to conduct the research. Each chamber was 3.4 x 4.0 x 2.4 m in size with a floor area of 13.6 m^2. Each chamber was ventilated by a variable speed exhaust fan to provide spring-fall, summer, and winter ventilation rates. A recirculation duct and counter balance continuous slot inlet ensured complete mixing of incoming air with the resident air (Fig. 1). A 60-W incandescent light bulb provided illumination (23 hours of light: 1 hour of dark). Two bell-type waterers and three conventional circular

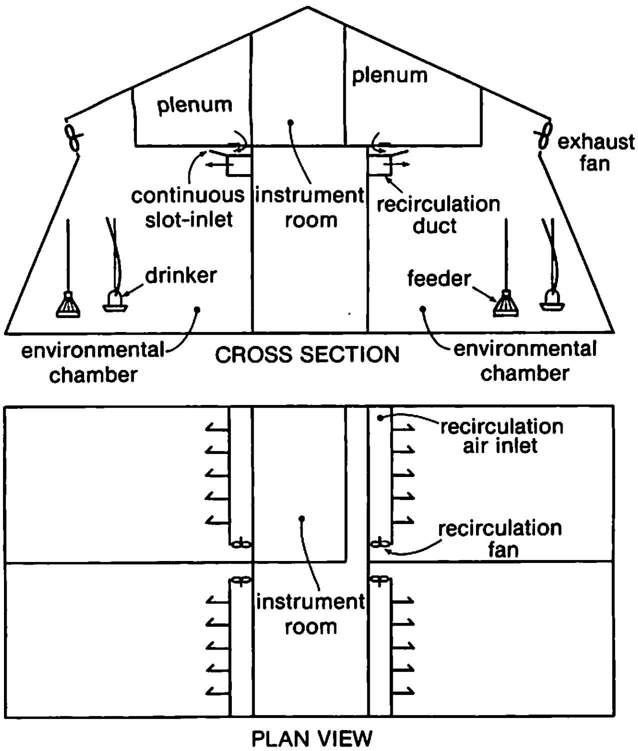

Fig. 1. Cross-section and plan view of the four environmental chambers.

feeders were suspended within each chamber.

The plenum was supplied with 1.65 m^3/s of outside fresh air which was heated by a natural gas furnace. A thermostat located in one of the chambers maintained a common set-point temperature for all four chambers. An 1.2 kW electrical heater was installed in each of the other rooms to ensure that the set-point temperature was maintained.

Air quality assessment

The environment of each chamber was monitored once per week for a 24-hour period. Measurements included: carbon dioxide, oxygen and ammonia concentrations, dry-bulb temperature, dewpoint, and dust concentration for particles of less and greater than 5µm. Measurements were taken in the plenum and in all four chambers. Ventilation rates were measured prior to each run by measuring air speeds in a discharge duct located downstream from each exhaust fan. Air velocities (± 0.2 m/s) were measured by a constant-temperature thermal anemometer (Velocicalc, TSI, St. Paul, MN). Dry-bulb temperatures (± 0.2°C) were measured with the use of thermistors (Fenwal Electronics, Framingham, MA). Dewpoints (± 1°C) were measured by a dewpoint hygrometer (General Eastern, Watertown, MA). Ammonia (± 5 ppm) and carbon dioxide (± 100 ppm) concentration were measured by non-dispersive infrared analyzers (Beckman Industrial, Model 880, La Habra, CA) while oxygen levels (±100 ppm) were measured by a paramagnetic oxygen analyzer (Servomex, Model 540A, Sussex, England). Oxygen concentrations were corrected for moisture content. Carbon dioxide, oxygen, and ammonia concentrations and dewpoints were measured alternately on a four-minute basis once each hour between the four chambers and the plenum. Gas samples were drawn to the analyzers via sample tubes connected to solenoid activated valves that were controlled by a datalogger. The tubes were connected to a vacuum pump downstream from each valve that delivered sample air to each analyzer at prescribed rates controlled by flow meters. The datalogger scanned the outputs from the analyzers as well as the thermistors prior to switching to the next sampling location. The datalogger was connected to an IBM-PC which recorded the temperatures and gas concentrations.

Dust concentrations were measured by an aerodynamic particle sizer (TSI, St. Paul, MN). Sample tubes from the four chambers and the plenum were connected to a ball valve assembly which was controlled by an I/O board connected to an IBM personal computer. Each sampling location was sampled 4 min/h. Prior to switching sampling locations, the dust concentrations were recorded. All equipment was housed in a laboratory located in the plenum directly above the chambers (Fig. 1).

Stocks and management

Male Hybrid-strain tom turkeys were obtained commercially and were raised to 8 weeks of age in another environmentally-controlled turkey brooding facility. At 8 weeks of age, the birds were wing-banded and randomly assigned to one of the four chambers described above. Initially, each chamber housed 75 turkeys with a stocking density of 5.5 birds/m^2. The birds had *ad libitum* access to feed and water throughout the experiment. Commercial-type turkey starter and grower diets were fed in mash form in accordance with National Research Council requirements (National Research Council 1984).

The birds were individually weighed at 8, 12, and 16 weeks of age. Feed consumption was recorded for the intervals of 8 to 12 weeks and 12 to 16 weeks. At 12, 13, 14, and 15 weeks of age, five or six birds were removed from each pen to maintain a similar bird mass in each pen throughout these weeks of the experiment. Hence, at 16 weeks of age, there were approximately 50 birds in each pen at a stocking density of 3.7 birds per m^2. The mass of these birds and the mass of all mortality were taken into account in the calculation of feed efficiency.

At 16 weeks of age all remaining birds were shipped to a commercial abattoir. During processing, all lungs were removed, identified as to bird of origin by wing band number, and stored on ice pending examination for the incidence of lung lesions as described previously (Feddes et al. 1992a). The experiment consisted of two treatments (oiled and untreated litter) and three ventilation rates (summer, winter, and spring-fall) representative of the range normally used in Western Canada. Two flocks of birds were used in the experiment utilizing the rooms two times. The chambers housing the first flock were ventilated at spring-fall rates. From 8 to 12 weeks of age, the ventilation rate was 4.8 L/s per bird and increased to 6.7 L/s per bird during weeks 13 to 16, due to increased bird mass. For the second flock, two chambers were ventilated at summer rates while the remaining two were ventilated at winter rates. From 8 to 12 weeks of age

Table I. Mean values recorded for ammonia, dust particle concentration, temperature, relative humidity, ventilation rate, and moisture production for male heavy turkeys subjected to oiled versus untreated litter and three rates of ventilation

Parameter	Age (weeks)	U-W	U-SF	U-S	O-W	O-SF	O-S
NH_3 (ppm)	9-12	14	16	6	12	15	6
	13-16	14	11	4	14	11	4
NH_3 (mL/h per bird)	9-12	136	85	146	109	83	151
	13-16	134	118	132	127	115	133
Dust concentration (particles/mL)							
<5μm	9-12	39	18	13	5	5	3
	13-16	42	49	14	7	13	3
>5μm	9-12	1	3	1	1	1	1
	13-16	3	3	1	1	1	1
Temperature (°C)	9-12	20.1	19.4	18.0	18.5	20.0	18.6
	13-16	20.3	21.1	18.4	20.6	21.0	18.4
RH (%)	9-12	42	26	29	42	25	28
	13-16	54	31	38	56	31	37
Ventilation rate (L/s per bird)							
	9-12	2.8	4.8	7.2	2.7	4.7	7.3
	13-16	2.7	6.8	9.7	2.7	6.7	9.6
Moisture production (mL/h per bird)							
	9-12	41.1	25.6	37.2	35.1	26.0	39.7
	13-16	48.9	47.3	49.5	51.8	48.8	48.0

U-W = Untreated Litter Winter Vent
U-SF = Untreated Litter Spring-Fall (2 rooms)
U-S = Untreated Litter Summer Vent
O-W = Oiled Litter Winter Vent
O-SF = Oiled Litter Spring-Fall (2 rooms)
O-S = Oiled Litter Summer Vent

these rates were 2.7 and 7.3 L/s per bird, respectively, while from 12 to 16 weeks these rates were 2.7 and 9.7 L/s per bird, respectively. Ventilation rates were increased during the 13 to 16 week period since air contaminant production increases with age (Agriculture Canada 1988). However, the winter ventilation rates remained unchanged since the rates for the 8 to 12 week period could not be set at 1.5 L/s per bird as recommended by industry. At 16 weeks of age, on the last day of the experiment, the temperature in each of the four chambers was increased to 29°C over a period of approximately 1 hour to monitor respiratory competency. The number of birds that were noticeably gasping was determined in each of the chambers in two 5-minute observation periods immediately prior to the temperature reaching 29°C.

The body mass and lung lesion score data were subjected to one-way ANOVA and treatment means were separated using Duncan's Multiple Range test (SAS Institute 1989). All percentage data were transformed to arc sines prior to analyses. Significance was assessed at the 0.05 level.

For each flock of birds, canola oil was sprayed on a weekly basis with a hand sprayer directly onto the litter in two of the chambers (Table I). The quantity of oil was calculated on the basis of fresh litter volume, such that the oil content of the litter was approximately 2% by litter volume or a weekly application of approximately 2 L of canola oil per pen (0.15 L/m^2).

RESULTS AND DISCUSSION

The mean values of the environmental data for the two flocks are the means of the 24-h data measured one day each week from 9 to 16 weeks of age. The mean heat production for weeks 9 to 12 was 117 kJ/h per bird and that from 13 to 16 weeks of age was 203 kJ/h per bird. The mean carbon dioxide production rate for the four chambers during weeks 9 to 12

Table II. Body mass gain (mean ± SEM), feed conversion efficiency (per pen), incidence of mortality (%), and incidence of lung lesions (%) of male heavy turkeys in response to applications of canola oil to litter

	Non-Oiled			Oiled		
Ventilation rate	Winter	Spring/Fall	Summer	Winter	Spring/Fall	Summer
Body mass gain (kg)						
Weeks 8 to 16	7.58±.09	7.34 ± 0.06	7.67 ± 0.07	7.61 ± 0.07	7.32 ± 0.06	7.63 ± 0.09
Feed conversion (feed/gain)						
Weeks 8 to 16	4.10	4.00	4.25	4.2	3.82	4.13
Incidence of mortality (%)						
Weeks 8 to 16	5.4	0.7	4.0	1.3	2.7	2.7
Incidence of severe lung lesions (%)						
Week 16	23.4	10.9	6.9	8.9	6.9	2.1
Incidence of gasping(%)						
Week 16	45.1		6.9	9.8		13.7

and 13 to 16 was 5.8 and 9.9 L /h per bird, respectively. These heat and carbon dioxide values agreed with those reported by Feddes and McDermott (1992) and Feddes and Liscko (1993).

Ammonia concentrations were very similar between the oiled and non-oiled treatments suggesting that the oil had a negligible effect on ammonia volatilization from the litter (Table I). The mean concentrations for the winter and spring-fall ventilation rate treatment was 13 ppm while that for the summer ventilation rate treatment was 5 ppm. Even though, ammonia concentrations for the summer ventilation rate were low, ammonia production was higher than the winter and spring-fall ventilation rates. Perhaps the higher air velocities near the litter were able to strip more ammonia from the litter. The ammonia production did not increase consistently from one period to the next because litter was removed when its wetness was thought to impose uncomfortable conditions to the birds.

The level of dust was the only environmental parameter measured that was affected by the addition of canola oil to the litter (Table I). The respirable dust (<5 μm) levels in the non-oiled chambers (29 particles/mL) were on average, five-fold higher than the oiled chambers (6 particles/mL). The concentration of particles that were larger than 5 μm was negligible for both treatments. These data indicate that the addition of oil to litter had a significant effect on reducing dust concentration. The addition of canola oil to the litter in each of the two chambers did not affect the cleanliness of the birds plumage. The birds in the oiled chambers had a brownish tinge on the feathers similar to that of the birds in the non-oiled chambers.

Ventilation rate also has an effect on dust concentration. The summer ventilation rate reduced the dust levels greatly over that by the spring-fall and winter ventilation rates in the non-oiled treatment. Particle concentrations ranged from 40 particles/mL in the untreated litter-winter ventilation rate (U-W) treatment to 3 particles/mL in the oiled litter-summer ventilation rate (O-S) treatment. Dust levels did not increase during the second period except for the spring-fall ventilation rate treatment. When considering both ammonia and dust levels, the U-W and untreated litter-spring/fall ventilation rate (U-SF) treatments had the worst environment while the preferred environment was the O-S treatment. In the presence of respirable dust, ammonia sticks to the dust particles that are able to penetrate the lung tissue (Donham et al. 1988).

The mean temperature for all periods and treatments was 19.5°C, while the relative humidity was 32 and 41% for the 9-12 and 13-16 wk periods, respectively (Table I). The increase in relative humidity was due to the increased water vapour production during the 13-16 wk periods. As shown in Table I, the water vapour production increased from 34 to 49 mL/h per bird). The addition of canola oil did not change the water vapour production rate (41.6 mL/h per bird per treatment). Relative humidity in the summer ventilated chambers was approximately 15% lower than that in the winter ventilation chambers.

There were no significant differences in bird body masses between treatments (Table II). The turkeys gained 7.62 kg over the 8-week period. The feed conversion of the birds in the treatments also was not different (Table II). The mean feed conversion of the 8-week study period was 4.17 kg of feed per 1.0 kg of gain. The incidence of mortality during the experiment was low, ranging from 1.3% to 5.3%. Mortality was 4.7% and 2% in the untreated treatments and oiled treatments, respectively. The incidence of lung lesions differed considerably among treatments (Table II). In the U-W treatment, 23.4% of the birds had severe lesions, compared to only 2.1% of the O-S birds. The incidence of severe lung lesions appeared to be related to respiratory competency as measured by the incidence of gasping at elevated temperatures. When chamber temperatures were raised from 20 to

Table III. Body mass gains (mean ± SEM) from 8 to 16 weeks of age of a second flock of male heavy turkeys with no evidence of lung lesions and with moderate or severe lung lesions

	Lesion severity		
	No lesions n=112	Moderate lesions n=57	Severe lesions n=17
Body mass gain (kg)			
Weeks 8 to 12	3.83 ± 0.03^b	3.86 ± 0.05^b	4.06 ± 0.10^a
Weeks 12 to 16	3.77 ± 0.04	3.78 ± 0.07	3.49 ± 0.14
Weeks 8 to 16	7.60 ± 0.05	7.64 ± 0.07	7.55 ± 0.12

^{a,b}Means within a row with different superscripts are significantly different ($P < .05$)

29°C over 1 hour at 16 weeks of age, 45% of the U-W birds exhibited gasping, while the incidence of gasping was less than 15% in the other four treatments. No data are available for the spring/fall treatment.

The body mass data of the birds in all treatments were pooled to determine the relationship between mass gain and severity of lesions (Table III). The mass gain data indicated that the fastest growing birds during weeks 8 to 12 had developed severe lung lesions at time of slaughter and showed the lowest mean mass gain of 3.49 kg during weeks 12 to 16. The similar mass gains over the entire 8 week study period suggests that birds with lung lesions are affected in terms of health rather than growth performance. It is suggested that birds exhibiting an early fast growth (8 to 12 weeks) would have a higher requirement for oxygen, and hence would also be inhaling more dust than would the slower growing pen mates. These birds would then exhibit reduced rates of growth due to impairment of the air:blood barrier resulting from the lung damage caused by the dust. However, birds that grew slower during the period from 8 to 12 weeks, eventually also increased their oxygen demand, and they too developed lung lesions, so that by 16 weeks of age, all birds, the early fast growing and the early slow growing, developed lesions. Both ventilation rate and litter condition contributed to the condition of the birds lungs.

CONCLUSIONS

The following conclusions can be drawn from this study:

1. The application of canola oil to litter reduces the concentration of airborne respirable dust particles in housing for heavy turkeys.
2. There is no evidence that litter oiling or ventilation rate influence heat and carbon dioxide production of the birds or production of ammonia or moisture.
3. Increased rates of ventilation reduce the concentration of respirable dust particles.
4. The addition of canola oil and increasing the ventilation rate did not affect body mass gain but reduced the incidence of lung lesions.
5. Individual birds that exhibited severe lung lesions were those birds that had fast rates of gain initially. Such afflicted birds showed reduced growth rates during the later stages of production. Hence there would appear to be a negative relationship between the development of lung lesions and growth rate in heavy turkeys.

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