Misting and ventilation rate effects on air quality, and heavy tom turkey performance and health

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Four environmental chambers each initially housing 75 heavy tom turkeys were used to evaluate the effects of ventilation rate and misting of inlet air on airborne particle size distribution, ammonia concentrations and bird health and performance. The birds were reared according to commercial practise and were moved to the environmental chambers at 4 weeks of age. The chambers were either misted or non-misted and ventilated at winter (110 L/s) or summer (500 L/s) rates. Body mass, mortality, feed efficiency (feed/gain), airborne particle and ammonia concentrations along with relative humidity data were recorded. At weeks 12, 16 and 20, twenty-five birds were removed from each chamber for the purpose of scoring the severity of lesions in the lungs due to airborne particles. Increased air exchange resulted in increased bird body mass at 20 weeks (14.0 kg - summer rates, 13.3 kg - winter rates) and lower incidence of lung lesions (16% - summer rates, 36% - winter rates) whereas misting had no effect.

Quatre chambres d'environnement qui chacune logeait initialement 75 gros dindons étaient utilisées pour évaluer les effets de vitesse, de ventilation et l'embuage d'air frais, sur la distribution en grandeur des particules de poussière aéroportées, la concentration d'ammoniac et la santé et performance des oiseaux. Les oiseaux étaient élevés en accord avec la pratique commerciale et étaient déplacés aux chambres d'environnement à l'âge de 4 semaines. Les chambres étaient embuées ou non-embuées et ventilées à la vitesse de l'hiver (110 L/s) ou celle d'été (500 L/s). Le pesant, la mortalité, l'efficacité du fourrage (fourrage/gain), les concentrations des particules de poussière aéroportés et d'ammoniac, et l'humidité relative étaient enregistrés. A l'âge de 12, 16 et 20 semaines, 25 oiseaux étaient déménagés pour le dessein d'estimer la sévérité des lésions des poumons à cause de les particules de poussière aéroportées. L'augmentation en échange d'air resultait en l'augmentation du pesant des oiseaux à l'âge de 20 semaines (14.0 kg - vitesse d'été, 13.3 kg - vitesse d'hiver) et une incidence réduit des lesions des poumons (16% - vitesse d'été, 36% vitesse d'hiver). Embuage d'air frais avait aucun effet.

INTRODUCTION

Efficient production of animal products in total confinement housing requires that an ideal environment be both defined and achieved. In attaining such an environment, aerial contaminants generated within the confined space must be diluted to levels that will not affect the animals' performance and well-being. Such contaminants include: ammonia, carbon dioxide, water vapour, respirable dust and disease causing pathogens. High levels of aerial contaminants, especially dust have been suspected to contribute to losses through condemnation of carcasses due to air sacculitis at time of processing. Wolfe et al. (1968) investigated the effects of dust and ammonia on the occurrence of air sacculitis. Ammonia levels were not related to the occurrence of air sacculitis; however, the incidence of air sacculitis increased significantly with aerial dust concentration.

One method to reduce the level of airborne contamination in a poultry barn is to increase the rate of air exchange. Jacobson and Jordan (1978) could not relate poor bird health to the levels of bacteria and particulate matter that they imposed on the birds. However, they did find that bacterial and particulate concentrations were related to ventilation rates, litter management and humidity. Liao and Feddes (1989) found that ventilation exchange of air removed over 90% of the respirable dust.

Janni et al. (1985) investigated the causes of air sacculitis in male turkeys. They found that high aerial concentrations of Aspergillus spores, ammonia, dust and aerosols were concurrent with high mortality rates among turkeys raised under commercial conditions. Members of the Aspergillus species, like some bacterial and viral infections, are opportunists. These fungi take advantage of birds whose immunological defenses have been weakened by other health problems or situations (Marsh et al. 1979), and causes further weakening or even death. As turkeys may be more susceptible to Aspergillosis than other poultry, work has been done to characterize the conditions and causes of infection (Richard et al. 1984; Mulhausen et al. 1987). The aerosols in the turkey environment appear to be the major factor in predisposing the birds to infections. Feddes et al. (1989) reported that the majority of dust particles in turkey housing are of fecal origin but that urates are also a major airborne contaminant. Feddes et al. (1990) found that barns with the highest airborne urate concentrations had the most problems with air sacculitis condemnations at the time of slaughter. Barns with high air sacculitis condemnations had very low numbers of Aspergillus spores present in the ambient air suggesting that greater numbers of Aspergillus spores are required to bring about air sacculitis condemnations.

A second potential method of suppressing the level of airborne particulate matter is through the misting of incoming air. A relative humidity of greater than 60% in environmentally controlled rooms housing chickens has been found to significantly reduce the small particles (<5.0 µm), but increases the number of larger particles (Stroh et al. 1978). Misting wets the litter directly or indirectly as a result of high relative humidities (Scarborough et al. 1988). This reduces particulate generation from the litter.

The objective of this investigation was to determine the effects of a summer and winter ventilation rate along with misting on air quality and turkey growth performance and health from 4 to 20 weeks of age. Air quality was evaluated in terms of ammonia, dust concentrations and relative humidity while turkey performance and health were determined from body mass, feed efficiency data and the incidence and severity of lesions in lungs, respectively.

EXPERIMENTAL FACILITIES AND PROCEDURES

Four environmental rooms were constructed within an existing turkey barn at the Poultry Research Centre of the University of Alberta's Edmonton Research Station. Each room had a floor area of 13.6 m^2 and a height of 2.4m (Fig. 1). Each room contained an exhaust fan for maintenance of air quality and one for temperature control, a recirculation duct, a counter balance continuous slot inlet, incandescent lighting, three manual poultry feeders, two bell-type turkey drinkers, and a 1.5 kW electric heater.

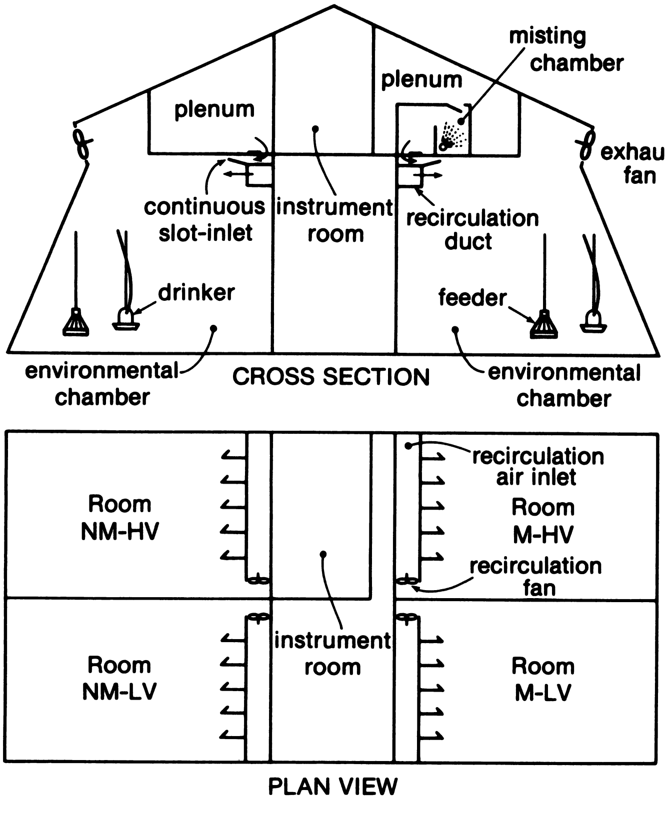

Fig. 1. Cross-section and plan view of environmental chambers.

A plenum located above the rooms was the source of fresh air to the four rooms. This plenum was supplied by a natural gas furnace with a capacity of 1.65 m^3/s. The thermostat of the furnace was located in the room requiring the coolest incoming air of the four rooms (Room 2). If the ambient temperature in the other rooms was lower than the setpoint temperature, then the 1.5 kW heaters would operate to maintain the setpoint temperature.

To evaluate the effect of ventilation rate and misting on turkey performance and air quality, the ventilation and misting treatments were set up as shown in Table I. Misting was provided continuously by spray nozzles (Micromist, Baumac International, Mentone, CA) connected to a high pressure water pipe located along the length of the misting chamber. The length of the chamber was that of the continuous-slot inlet for each environmental room. Inlet air was introduced into each of the two rooms via the misting chamber (Fig. 1). Mist was introduced at a pressure of 3450 kPa. Excess mist not mixing with the inlet air drained from the chamber.

Table I: Experimental Design

Room	Ventilation (L/s)	Misting
1 non misted-low ventilation (NM-LV)	110	No
2 non misted-high ventilation (NM-HV)	500	No
3 misted-high ventilation (M-HV)	500	Yes
4 misted-low ventilation (M-LV)	110	Yes

Day-old heavy tom turkeys (Hybrid strain) were obtained commercially and raised to 4 weeks of age in a different facility, using typical industry conditions. The birds were wingbanded and were transferred to the environmental chambers and housed in groups of 75 birds per chamber at a stocking rate of 5.5 birds/m^2. Typical commercial-type turkey rations were fed in a mash form. Feed consumption was recorded throughout the experiment.

All birds were individually weighed at weeks 4, 6, 9, 10 and 12. At 12 weeks of age, the number of turkeys in each room was reduced to 50 (stocking density of 3.7 birds/m^2). The removed birds were taken to a local slaughter plant for processing. At sixteen weeks, all birds were again individually weighed and the number of turkeys in each room was reduced to 25 (stocking density of 1.8 birds/m^2). The removed birds were shipped for processing and lung lesion scoring. The remaining birds were weighed and slaughtered at 20 weeks of age.

At processing, all lungs were removed and identified as to bird of origin. A blind procedure was used to examine all lungs for lesions. Each lung was cut transversely with four cuts through the center of the major lobes between rib indentations. Each section was examined visually for lesions of consolidation and bronchitis. Each bird was given a score based on the severity of lesions in its lungs based on the following criteria:

0 - No visible lesions.
1 - Minor consolidation of parenchyma or small yellow nodules.

2 - Consolidation of parenchyma and small yellow nodules or plaques in bronchi.
3 - Severe consolidation of parenchyma and large yellow plugs in bronchi.

A severity index was established by averaging the lung scores of birds having lung lesions in each treatment.

Blood samples were collected randomly from 20 birds at 20 weeks of age. Sera harvested from these blood samples were tested for antibodies to *Mycoplasma meleagridis*, *synoviae*, and *gallisepticum* by the serum plate test, to influenza virus by the agar gel diffusion test and to Newcastle disease virus by the enzyme linked immunoabsorbent assay.

The data for body mass and lung lesion score were subjected to one-way ANOVA and treatment means were separated using Duncan's Multiple Range test using SAS for Personal Computers (Joyner et al. 1985). All percentage data were transformed to arc sines prior to analyses. Significance was assessed at the 0.05 level.

The environment of the four rooms was monitored once each week for a 24-h period. Measurements included room and plenum temperatures, dewpoint, and ammonia concentrations. Dust concentrations were measured for particle sizes greater and less than 5 µm. Ventilation rates were measured prior to each run by measuring air speeds in a discharge duct located downstream from each fan (Jorgenson 1983). Air velocities were measured by constant - temperature thermal anemometer (Velocicalc, TSI, St. Paul, MN).

Dry-bulb temperatures were measured by thermistors (Fenwal Electronics, Framingham, MA). Dewpoints was measured by a dewpoint hygrometer (General Eastern, Watertown, MA). Ammonia was measured by a non-dispersive infrared analyzer (Beckman Industrial, La Habra, CA) that was zeroed with nitrogen gas and spanned with a certified gas specific to the instrument.

Dewpoint and ammonia concentrations were measured alternately between the four rooms and the plenum on a 4-minute basis. Gas samples were drawn via sample lines to the analyzers. Each sample line was connected to a solenoid-activated valve that was controlled by a data logger.

Downstream from each valve, the lines were connected to a vacuum pump. The pump delivered sample air to each analyzer at prescribed rates. Each location was sampled 4 minutes every hour. The data logger scanned the outputs from the analyzers prior to switching to the next sampling location.

Dust concentrations were measured by a dust particle sizer (TSI, St. Paul, MN). Sample lines from the four rooms and the plenum were connected to pinch valves that were controlled by an I/O board connected to an IBM-PC computer. Each sampling location was sampled for 5 minutes per hour. Prior to switching valves, the dust concentrations were recorded and the data collected were stored on an IBM-PC computer. This computer also received input from the data logger that recorded the temperatures and gas concentrations.

RESULTS AND DISCUSSION

The mean values of the measured environmental parameters are tabulated in Table II. These values are averages of 24-h data measured on a weekly basis from week 9 to week 20.

The NM-HV chamber had the lowest mean NH_3 concen-

Table II: Mean experimental values for environmental parameters based on 12 weekly measurements.

		Treatment			
	Age	NM - LV	NM - HV	M - LV	M - HV
NH_3 (ppm)	9 - 12 wks	39	14	20	34
	13 - 16 wks	12	5	26	13
	17 - 20 wks	8	2	23	10
	9 - 20 wks	20	7	23	19
NH_3 (L/h)	9 - 20 wks	8	13	9	34
Airborne Particulate (part/mL) <5(>5) µm	9 - 12 wks	227(1)	117(2)	350(3)	452(1)
	13 - 16 wks	107(1)	154(1)	273(4)	183(1)
	17 - 20 wks	216(5)	88(2)	262(3)	500(4)
	9 - 20 wks	183(2)	120(2)	295(3)	378(2)
Drybulb Temperature (°C)		20	20	20	18
Relative Humidity (%)		53	34	75	68
Ventilation Rate (L/s)		110	500	110	500

tration. This was due to the dry litter observed in the room. The litter in the other rooms was observed to have a wetter surface. Misting at both ventilation rates resulted in higher ammonia and relative humidity values. It is interesting to note that overall ammonia concentration decreased by 13 ppm and 4 ppm for the non-misting and misting treatments, respectively when increasing ventilation from winter to summer rates. Although the litter in the NM-HV room appeared dry, it produced more NH_3 than the NM-LV and the M-LV rooms (13 L/h vs 8 L/h and 9 L/h) (Table II). Higher concentrations appear to be suppressing production. The ammonia concentrations varied directly with the relative humidity and moisture content of the litter.

The mean temperature for the 16-week growth period was 20°C except for the M-HV treatment. The 2°C decrease in temperature was a result of the large quantity of sensible heat lost to evaporization of the water droplets introduced during misting.

Airborne particle measurements during the 12-week period indicate that the misting and ventilation rate had no effect on the concentration of large particles (>5µm). In the misted rooms, the particle counts (<5µm) were the highest (Table II), and the particle counts were lowest in the high ventilation rooms. The high particle counts in the misted rooms were not expected. Upon closer inspection, all the particles were found to be water vapour droplets since the counts immediately downstream from the misting unit were very similar to those in the room. In a humid environment, water droplets do not change to molecular size very quickly. Misting, however, did reduce the concentration of respirable particles (<5µm).

Selected data pertaining to bird performance are presented in Table III. The average bird mass values are shown at weeks 4 and 20. At week 4, the masses of the birds in the four chambers are similar, while they differ at all successive weighings with the exception of the 16 week data. However at week 20, the turkeys in the M-LV room had lower body mass values than did the birds in the two high ventilation rate rooms.

Feed efficiency values for the period from 4 to 20 weeks are seen to be similar except for treatment M-HV. The higher feed/gain ratio seen in this chamber of birds was attributed to the lower room temperature of 18°C. The lower feed efficiency occurred at this temperature even though these birds had the highest body mass at time of slaughter. The birds with the highest feed efficiency had the lowest body mass at time of slaughter.

Table III: Body mass, mortality and feed efficiency of heavy tom turkeys in response to environmental treatment.

		NM - LV	NM - HV	M - LV	M - HV
		Average body mass (kg)			
	Week 4	0.93	0.93	0.92	0.93
	Week 6	2.04^{ab}	2.11^{a}	2.01^{b}	2.05^{ab}
	Week 9	4.63^{a}	4.54^{ab}	4.47^{b}	4.52^{ab}
	Week 10	5.59^{a}	5.43^{b}	5.33^{b}	5.43^{b}
	Week 12	7.07^{a}	7.13^{a}	6.74^{b}	6.98^{b}
	Week 16	10.39	10.37	10.20	10.43
	Week 20	13.49^{ab}	13.98^{a}	13.06^{b}	14.09^{a}
Mortality (# of birds)		2	3	3	4
Feed/Gain ratio	(Weeks 4 -20)	2.96	2.97	2.90	3.08

[a,b]Means within a row with different superscripts are significantly different ($P<0.05$).

Table IV: Incidence and severity of lung lesions at different ages and densities.

	NM - LV	NM - HV	M - LV	M - HV	Density (kg/m^2)
12 weeks	13^{A} $(0.13)^{B}$	9 (0.09)	21 (0.21)	13 (0.13)	38.5
16 weeks	64 $(1.00)^{a}$	12 $(0.12)^{b}$	41 $(0.79)^{a}$	16 $(0.16)^{b}$	38.0
20 weeks	36 (0.52)	28 (0.28)	37 (0.50)	20 (0.33)	25.1
Average	38 (0.56)	16 (0.17)	33 (0.50)	16 (0.21)	

[A]Incidence of lungs with lesions (%)

[B]Severity index

[a,b]Means within a row with different superscripts are significantly different ($P<0.05$).

The percentages of turkeys with lung lesions and the associated lesion severity scores of these birds are presented in Table IV. The results indicate that the ventilation rates affected the incidence of lung lesions. This effect of ventilation rate is supported by Liao and Feddes (1989) who found that the exchange air can remove a significant percentage of the airborne particulate. As ventilation rate increases, lesions decrease along with respirable dust concentrations. Misting increased particle concentration and did not markedly reduce the incidence of lesions suggesting that the respirable airborne water droplets may be carriers of ammonia and other contaminants.

The incidence and severity of lung lesions in the low ventilated rooms were greater at 16 weeks than at 20 weeks suggesting that some lesions may heal. Although the dust levels did not decrease during the four-week period, this decrease in lesions may be a result of reducing the bird density by 13 kg/m^2 during the last four weeks. Webster (1990) suggests that a ten-fold increase in ventilation is only two-thirds as effective as halving stocking density in reducing the challenge from infectious organisms. This may explain the reduction in lesions as a result of decreasing the stocking density. In the high ventilation rate chambers, the number of birds with lesions increased perhaps as a result of being heavier and utilizing more air. Serological tests were negative indicating that the birds were free of most of the common pathogens causing respiratory disease in turkeys in the Canadian prairies.

CONCLUSIONS

The following conclusions are drawn from this study:

1) Ventilation rate had a significant effect on bird health. The incidence and severity of lung lesions is higher when birds are ventilated at winter rates. At winter and summer ventilation rates, 36 and 16 percent of the birds had lesions in their lungs, respectively.

2) Misting did not have a significant effect on bird health.

3) Bird body masses at 20 weeks were the highest in the high ventilation rate treatment at 14.0 kg as compared to 13.3 kg in the low ventilation rate treatment.

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