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STUDY OF AIR POLLUTANTS, PART (2): EFFECT OF VENTILATION RATES ON AMMONIA AND DUST EMISSIONS INSIDE POULTRY HOUSES

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ABSTRACT

The Experiment was carried out in the Poultry Farm of the Agricultural Experimental Station, College of Agriculture and Veterinary Medicine, AL-Qassim University, Saudi Arabia. The Experiment utilized a total of 3000 broiler chicken grown over a 42-d period. A factorial experiment of randomized block design (2 replicates x 4 minimum ventilation x 2 sexes) was used. Four minimum ventilation rates were used (0.2, 0.4, 0.6 and 0.8 CFM/Lb of live weight) was used. Individual body weights were recorded at hatch, 4 and 6 weeks of age. Feed and water were supplied ad libitum. Food consumption and mortality rate were recorded on a weekly basis. Ammonia and dust measurements were taken daily at the bird height at two locations in each room. Ventilation system had no significant effect on body weight, feed consumption, ammonia concentrations and inspirable dust concentrations at either 4 or 5 weeks or 6 weeks.

Keywords: Ammonia, Dust, Emission, Environment, Ventilation Rate, Model, Poultry Houses.

INTRODUCTION

Increased competition in the broiler industry emphasizes the continuing importance of productive efficiency. Within recent years, rapid strides in poultry nutrition and genetics have made more evident the need for a greater knowledge about the effects of environmental factors on poultry

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performance. Ventilation in the broilers house must remove moisture, allow the litter to dry, remove the carbon dioxide exhaled by the birds, and remove dust as well as ammonia from the faeces.

The air in floor housing systems for laying hens may be more polluted than in traditional cage systems, since gases are emitted from large exposed surfaces of manure and litter. From literature analysis, the ammonia emission from livestock buildings is highly correlated with ventilation rate and indoor temperature. These findings demonstrate the potentials of ammonia emission reduction by means of ventilation control strategies. In order to study odor and ammonia concentrations and emissions at different climatic conditions, a small scale poultry house (climate chamber) was equipped with a floor housing system. Both odor and ammonia emissions showed a significant increase with water vapor pressure. In the experiment, odor and ammonia emissions were more strongly correlated to water vapor pressure than to relative air humidity. The results suggest that control of temperature and humidity may decrease concentrations and emissions of odor and ammonia. One of these research works was **Nimmermark and Gustafsson (2005),** where they found from their experiments in the loose housing system for laying hens the following points:

• Ammonia concentrations sometimes exceeded hygienic threshold limit values and the concentration of 25 ppm is considered to be the highest tolerated concentration for poultry kept on litter in Sweden.

• Decrease of temperature and decrease of humidity decreased odor and ammonia concentrations and emissions.

• Water vapor pressure had a stronger correlation to odor and ammonia than relative humidity (RH). **Gay et al. (2006)** studied the ammonia (NH_3) emission data in four tom turkey houses (two grow out and two brooder) in Pennsylvania were monitored during winter 2003 and 2004. Data were collected during three 48-h periods for grow out houses and during two 48-h periods for brooder houses. Ammonia concentration was measured using electrochemical sensors in a portable monitoring unit; ventilation rate was determined using a fan assessment numeration system and fan run-time data. Mean NH_3 emission rates for the grow out house with used litter and the grow out house with new litter were 2.3 and 0.98 g $NH_3.d^{-1}.bird^{-1}$, respectively, for birds of ages 64 to 99 days. Daily variability in NH_3 emission rates from a single grow out house was relatively small compared to variability of NH_3 emission rates between houses due to litter management differences. The mean NH_3 emission rate for the grow out house with used litter, determined during this study was similar to the rate currently used by the U.S. Environmental Protection Agency. However, the NH_3 emission rate for the grow out house with new litter was 59% lower.

Ammonia emission rates determined during this study apply to only grow out houses with tom turkeys under cold weather minimum ventilation. **Nahm (2007)** had tried to reduce nitrogen (N) and ammonia emissions from poultry manure through the use of improved amino acid digestibilities and enzyme supplementation. Proper feed processing techniques, phase feeding and the minimization of feed and water waste can contribute to additional minor reductions in these emissions. Reductions in environmental pollution can be achieved through improved diet formulation based on available nutrients in the ingredients. Many feed manufacturers still use total amino acid content to formulate feeds. To meet amino acid requirements, crystalline amino acids are needed. The use of feather, meat and bone meal must not be overestimated or underestimated and the limiting amino acids. Meantime **Liang et al., (2003)** stated that ammonia and carbon dioxide concentration levels were collected bi-weekly from each house with portable monitoring units (PMUs).

There existed substantial seasonal variations in NH_3 emission from the layer houses. Specifically, daily mean NH_3 concentrations ranged from 1 to 7 ppm in the manure belt house and from 9 to 108 ppm in the high-rise house. The NH_3 emission rates averaged 6 mg/h-hen or 44 g/d-500kg over a 12-month monitoring period (February 2002 – March 2003) for the manure belt house and 44 mg/h-hen or 331 g/d-500kg over a 10-month monitoring period (February – November 2002) for the high-rise house. Ammonia emission rates are higher in summer than in winter, although NH_3 concentration may be much lower in summer. Using another technique **Liang et al., (2005)** carried out a research work to explore the ammonia (NH_3) emission rates (ER) of ten commercial layer houses (six high-rise or HR houses and four manure-belt or MB houses) with different manure handling or dietary schemes for one year in Iowa (IA) and Pennsylvania (PA). The field monitoring involved a total of 386 and 164 house-day measurements.

The ER showed considerable diurnal and seasonal variations. The annual mean ERs (g NH_3 hen^{-1} d^{-1}) and standard errors were 0.90 ±0.027 for IA-HR houses with standard diet, 0.81 ±0.02 for IA-HR houses with a nutritionally balanced 1% lower crude protein diet, 0.83 ±0.070 for PA-HR houses with standard diet, 0.054 ±0.0035 for IA-MB houses with daily manure removal, and 0.094 ±0.006 for PA-MB houses with twice a week manure removal. Mass balance of nitrogen (N) intake and output performed for IA-HR houses revealed a total N intake recovery of 94% to 101%, further verifying the certainty of the NH_3 ER measurements. Results of the study contribute to the U.S. national inventory on NH_3 emissions from animal feeding operations, particularly laying hen facilities as affected by housing type, manure handling scheme, crude protein content of the diet, and geographical location.

Xin et al. (2003) mentioned that ammonia level is measured with electro-chemical sensors that undergo cyclic purging to avoid sensor saturation. Building ventilation rate is directly measured by calibrating the airflow rates of fans in-situ with a Fan Assessment Numeration System (FANS) device and recording of fans runtime, or indirectly calculated using the CO_2 balance method based on the latest metabolic rate information for the modern birds (W-36 laying hens). Comparative tests were conducted between the PMU and a chemiluminescence NH_3 analyzer in a field emission laboratory (FEL) and there were no significant differences between the two measurement methods (P=0.33). On the other hand **Metin et al., (2007)** studied the heat balance status of laying hen houses in regions with continental climate. The material consists of 45 laying hen houses from 27 commercial farms selected from the survey area where continental climate prevails.

These laying hen houses differ from each other with respect to capacity, planning system and materials used in construction. First observations were conducted on the size and dimensions of laying hen houses as well as construction materials used, insulation, heat loss factors, ventilation capacity, ground space per hen and total size of laying hen house in order to assess the sufficiency of heat balance. These models give heat conduction coefficients that will prevent moisture concentration and ensure heat balance under continental climate conditions and suggest different sets of materials that can be used on walls and roofs. In research area, minimum ventilation capacities are determined as 0.72m^3/h hen for carbon dioxide balance and according to outdoor temperature, as 0.83–1.20m^3/h hen for water vapor balance. Heat loss factors are calculated to be between 0.10 and 0.15 Kcal/1Ch hen. They believe that these suggestions will greatly facilitate the work of project engineers in the design of laying hen houses in regions and areas with continental climate. **Lim et al., (2003)** stated that the particulate matter (PM) was measured in the ventilation exhaust air of a caged layer house using three tapered element oscillating microbalances (TEOMs).

Diurnal patterns of PM concentration and emission were observed during 6 days in June 2002. The average daily mean (±95% c.i.) concentrations and emissions were 39±8.0, 518±74, and 1887±563 .g/m^3 and 1.1±0.3, 16±3.4, and 63±15 g/d-AU for PM2.5, PM10, and total suspended particulates (TSP), respectively. Daytime (lights on) PM2.5, PM10, and TSP concentrations were 151, 108, and 136% higher ($P<0.05$) than at night. Emissions peaked during the day when birds were most active and ventilation rates were the highest. Wide diurnal variations in PM concentration and ventilation were observed. PM emission was correlated to ventilation, ambient and exhaust temperatures and relative humidity ($P<0.05$). **Metin et al., (2005)** research conditions were, the indoor and outdoor temperatures 25.3 °C and 20.2 °C, respectively, maximum total heat conduction coefficients were calculated to be between 1.38 and 1.73 Kcal/m^2 °C h. According to the features of area and housing, for providing heat balance, total heat conduction coefficients requirements were calculated to be between 0.62 and 2.08 Kcal/m^2 °C h for walls, 0.33 and 1.62 Kcal/m^2 °C h for roofs. In research area, minimum ventilation capacities are determined as 0.72 m^3/h hen for carbon dioxide balance and, according to outdoor temperature, as 0.83–1.20 m^3/h hen for water vapor balance. Heat loss factors are calculated to be between 0.10 and 0.15 Kcal/°C h hen. These suggestions will greatly facilitate the work of project engineers in the design of laying hen houses in regions and areas with continental climate. Also **Walker et al. (2003)** conducted a research work was present one year of ambient ammonia (NH_3) and some other gases in three sites in the Coastal Plain region of North Carolina. The three sites, Clinton, Kinston, and Morehead Cities all of them are located in counties.

The results shown that the total NH_3 emission densities were 5827, 2768, and 389 kg NH_3 km^{-2} yr^{-1}, respectively. The ammonia (NH_3) concentrations were highest during the summer at all sites, with summer-to-winter concentration ratios of 2.40, 5.70, and 1.69 at Clinton, Kinston, and Morehead City, respectively. NH_3 concentrations were higher at night at the Clinton site, during the day at the Kinston site, and day vs. night concentrations were similar at the Morehead City site. This study shows that agricultural NH_3 emissions influence local ambient concentrations of NH_3 and particulate matter (PM) 2.5 agreed with the same interest. In the same area of interest of ammonia emission, **Gates et al., (2007)** using recently published baseline ammonia emissions data for U.S. broiler chicken housing, we present a method of estimating their contribution to an annual ammonia budget that is different from that used by USEPA. Emission rate increases in a linear relationship with flock age from near zero at the start of the flock to a maximum at the end of the flock, 28–65 days later.

Market weight of chickens raised for meat varies from ‘‘broilers’’ weighing about 2 kg to ‘‘roasters’’ weighing about 3 kg. Uncertainty in baseline emissions estimates is used so that inventory estimates are provided with error estimates. The method also incorporates the condition of litter that birds are raised upon and the varying market weight of birds grown. Results suggest that a 10% uncertainty in annual emission rate is expected for the market weight categories of broilers, heavy broilers, and roasters. A 27–47% reduction in annual housing emission rate is predicted if new rather than built-up litter were used for every flock. The estimating method can be adapted to other meat bird building emissions and future ammonia emission strategies, with suitable insertion of an age-dependent emission factor or slope into a predictive model equation. **Vranken et al., (2003)** studied climate control settings, such as optimal temperature, proportional band, minimal and maximal ventilation rate were optimized as a function of outdoor temperature and animal weight, in order to reduce ammonia emission from mechanically ventilated pig and poultry houses by appropriate ventilation rate control. Simulation on new ventilation control settings showed a possible reduction of NH_3- emission of 8% on yearly bases. Such reduction strategies without any additional costs highly increase the economical potentials of pig farms in contrast to feeding and building strategies that mostly do not suffice on their own to satisfy the new environmental.

In poultry houses which have insufficient ventilation, **Missohou et al., (1995)** found that growth rate was low, mean 7-week body weight was only 1240 g and the mortality rate was 9% during brooding and 6% during the growing period. It is obvious, therefore, that ventilation does influence broiler performance, but this is through its effect on other environmental factors, such as temperature, humidity, ammonia and dust levels., However, **Vranken et al., (2003)** studied climate control settings, such as optimal temperature, proportional band, minimal and maximal ventilation rate were optimized as a function of outdoor temperature and animal weight, in order to reduce ammonia emission from mechanically ventilated pig and poultry houses by appropriate ventilation rate control. Simulation on new ventilation control settings showed a possible reduction of NH_3-emission of 8% on yearly bases.

MATERIAL AND METHODS

The experiment was carried out in the Poultry Farm of the Agricultural Experimental Station, College of Agriculture and Veterinary Medicine, AL-Qassim University, Saudi Arabia. The Experiment utilized a total of 3000 Hybro broiler chickens grown over a 42-d period. A factorial experiment of randomized block design (2 replicates X 4 minimum ventilation x 2 sexes) was used. Four minimum ventilation rates were used (0.2, 0.4, 0.6 and 0.8 CFM/Lb). Birds were fed a commercial diet. Starter crumbs were fed from hatch to 28 days containing 22.0 CP % and providing 12.6 MJ ME/kg diet, then switched to finisher diet from 28 to 42 day containing 18.0% CP and 13.4MJ ME/kg diet. Individual body weights were recorded at hatch, 4 and 6 weeks of age. The feed offered to each pen was recorded daily. Feed and water were supplied ad libitum. Food consumption and mortality rate were recorded on a weekly basis. Ammonia and dust measurements were taken daily at the bird height at two locations in each room.

Ammonia Production

Ammonia production was measured using air sampling pump (Model AP 5) .The setup consisted of a head vacuum pump which pulls the polluted air sample through a glass tube containing indicator reagents which are sensitive to ammonia. The ammonia and carbon dioxide concentrations, indicated by the color change of the material inside the tube, could be determined from the scale on the side of that tube. Two tubes were used during the experiment: 0.2 - 20 ppm (No.105 SD) and 5 - 260 ppm (No.105 SC) for ammonia.

Considering that the amount of ammonia desorbed from the litter mixture into the house air is directly proportional to the following; the concentration of the ammonia in broiler litter, interfacial area of exposure, duration of desorption, temperature and atmospheric pressure. Therefore the emitting amount of the ammonia could be estimated by **Raymond (1997)** as a function of the change in the ammonia concentration in the litter mix AMc, throughout certain time Δt, considering that the total area of the interfacial surface of the litter is Ag, θ is the air temperature ($^{\circ}$C) therefore.

$$\mathbf{AM_e = K\ A_g\ F_c\ \Delta t} \qquad \mathbf{(1)}$$

Where $\mathbf{AM_e}$ is the amount of emitted ammonia from the budding pasture; $\mathbf{A_g}$ is the total ground area of budding; $\mathbf{\Delta t}$ is duration of the desorption from the entire surface; **K** is desorption constant at a given temperature and pressure per unit area and time.

$$F_c = \frac{[NH_3]}{[NH_3]+[NH_4]} = \frac{10^{pH}}{10^{pH} + K_b/K_w} \quad \textbf{(2)}$$

Since K_b/K_w increase by increasing temperature therefore, mathematically the relation between both value K_b/K_w and temperature as the following,

$$K_b/K_w = [-3.4 Log_e(0.024\theta)]x10^9 \quad \textbf{(3)}$$

where θ is the temperature in °C.

Inspirable dust

Inspirable dust levels were measured with air sampling pumps (Model VORTEX Standard 2), which ran for 24 hours, they were attached to Casella total dust sampling heads (Model T 13087) (SKC Ltd. WIMBORINE. DORSET) containing Whatman GF/4 20-50 mm glass microfibre filters, which retained all particles larger than 1.6 µm. The sampling head was located approximately 0.5 m above the floor in the middle of the broiler rooms. Fresh and used filter papers were kept in desiccators for at least 24 hours before weighing. The difference between the weight of the filter paper with and without dust (before and after sampling) was transformed to give dust levels in mg/m^3.

Ventilation

Ventilation, air condition and heating in each of the 6 rooms was controlled by a Dicam FSC2.2M master unit (Farm Energy and Control Services Ltd. (FARMEX), Pingewood, Reading RG 30 3VR). The unit contains an integrate processor, process times and serial parts. Each room had a dedicated temperature sensor leading to the Dicam unit. The unit controlled the temperature to preset limits, and inducted preset minimum ventilation rates, which were increased during the age of the bird. Routine adjustments to the individual room requirements were carried out on a daily basis by reconfiguring the system at the Master unit

Models of statistical analysis

Data were analyzed using the GLM procedure of SAS program (SAS, 1996). Growth traits of body weights and daily gains in weight were analyzed using the following linear model:

$$\mathbf{Y_{ijklm} = \mu + R_i + A_j + B_k + C_l + AB_{jk} + AC_{jl} + BC_{kl} + ABC_{jkl} + e_{ijklm}} \quad \textbf{(Model 1)} \quad \textbf{(4)}$$

Where Y_{ijklm} is the observation on the ijklmth chick; μ is the overall mean; R_i is the effect of ith replicate; A_j is the effect of jth type of litter; B_k is the effect of kth stocking density; C_l is the effect of lth sex; AB_{jk}, AC_{jl} and BC_{kl} is the effect of two-order interactions; ABC_{jkl} is the effect of three-order interaction; and e_{ijkl} is the random deviation particular to the mth chick, **NID** (**0**, $\sigma^2 e$). Polluters (ammonia, carbon dioxide and dust concentrations) were analyzed for each week separately using the following linear model:

$$\mathbf{Y_{ijkl} = \mu + R_i + A_j + B_k + AB_{jk} + e_{ijkl}} \quad \textbf{(Model 2)} \qquad \textbf{(5)}$$

Where Y_{ijkl} is the observation on the ijklth polluter, and e_{ijkl} is the random deviation particular to the lth polluter, **NID** (**0**, $\sigma^2 e$). All other symbols of this model are defined in model (1). Data of feed consumption and conversion were analyzed using the following linear model:

$$\mathbf{Y_{ijkl} = \mu + R_i + A_j + B_k + AB_{jk} + e_{ijkl}} \quad \textbf{(Model 3)} \qquad \textbf{(6)}$$

Where Y_{ijkl} is the observation on the ijklth feeding group and e_{ijkl} is the random deviation particular to the lth feeding group, **NID** (**0**, $\sigma^2 e$). All other symbols of this model are defined in model (1).

RESULTS AND DISCUSSION

Maximum and minimum ventilation rates setting based on 0.2 and 0.4 CFM/LB are illustrated in Table (1) for whole birds age period (63 days). Timer setting intervals varied between 1.1 and 60 minutes. Measurements are taken and calculations were performed every three days.

As shown in Table (1), ventilation rates ranged between 15.28 and 893.69 M^3/h/360 BIRDS (9-526.32 CFM/360 BIRDS) for first experiment (0.2 CFM/LB and Timer Settings of 13 sec). Whereas, the required time per hour ranged between 12.23 and 714.95 sec. The same trend was noticed in the second experiment (0.4 CFM/LB and Timer Settings of 26 sec). Where ventilation rates ranged between 30.56 and 1787.38 M^3/h/ 360 BIRDS (18-1052.64 CFM/ 360 BIRDS). Meanwhile, the time required per hour ranged between 24.46 and 1439.9 sec.

Table (2) illustrates maximum and minimum ventilation rates setting based on 0.6 and 0.8 CFM/LB for whole birds age period (63 days). As well, timer setting intervals varied between 1.1 and 60 minutes and ventilation rates ranged between 45.84 and 1787.38 M^3/h/360 BIRDS (27-1578.96 CFM/ 360 BIRDS) for third experiment (0.6 CFM/LB and Timer Settings of 39 sec). Additionally, the required time per hour ranged between 36.69 and 2144.82 sec. Similar tendency can be observed in the fourth experiment (0.8 CFM/LB and Timer Settings of 52 sec). Whereas ventilation rates ranged between 61.12 and 3574.76 M^3/h/360 BIRDS (36-2105.28 CFM/ 360 BIRDS). While, the time required for every hour ranged between 48.92 and 2859.8 sec.

Table 1. Maximum & Minimum Ventilation Rate Settings Based on 0.2 and 0.4 CFM/LB.

AGE (days)	Timer Setting intervals (min.)	**0.2 CFM/LB. (Timer Settings of 13 sec)**			**0.4 CFM/LB. (Timer Settings of 26 sec)**		
		Time Req. in (sec) per hour	Vent. Rates M^3/h/ 360 BIRDS	Vent. Rates CFM/ 360 BIRDS	Time Req. in (sec) per hour	Vent. Rates M^3/h/ 360 BIRDS	Vent. Rates CFM/ 360 BIRDS
0-3	60 min	12.23	15.282	9	24.46	30.564	18
3-6	30 min	25	31.175	18.36	50	62.35	36.72
6-9	16 min	49.88	62.35	36.72	99.76	124.7	73.44
9-12	9 min	87	108.80	64.08	174	217.6	128.16
12-15	6.3 min	124.21	155.27	91.44	248.42	310.54	182.88
15-18	4.8 min	160.4	200.50	118.08	320.8	401.0	236.16
18-21	4 min	197.57	246.96	145.44	395.14	493.92	290.88
21-24	3.32 min	234.73	293.41	172.80	469.46	586.82	345.6
24-27	2.87 min	271.90	339.87	200.16	543.8	679.74	400.32
27-30	2.52 min	309.10	386.33	227.52	618.2	772.66	455.04
30-33	2.52 min	345.25	431.56	254.16	690.5	863.12	508.32
33-36	2 min	382.40	478.02	281.52	764.8	956.04	563.04
36-39	1.86 min	419.58	524.48	308.88	839.16	1048.96	617.76
39-42	1.71 min	456.75	570.94	336.24	913.5	1141.88	672.48
42-45	1.58 min	493.90	617.39	363.60	987.8	1234.78	727.20
45-48	1.47 min	530.10	662.63	390.24	1060.2	1325.26	780.48
48-51	1.35 min	576.25	709.08	417.60	1152.5	1418.16	835.2
51-54	1.29 min	604.43	755.54	444.96	1208.86	1511.08	889.92
54-57	1.22 min	641.59	801.99	472.32	1283.18	1603.99	944.64
57-60	1.14 min	678.80	848.46	499.68	1357.6	1696.92	999.36
60-63	1.1 min	714.95	893.69	526.32	1429.9	1787.38	1052.64

Table 2. Maximum & Minimum Ventilation Rate Settings Based on 0.6 and 0.8 CFM/LB.

AGE (days)	Timer Setting intervals (min.)	**0.6 CFM/LB. (Timer Settings of 39 sec)**			**0.8 CFM/LB. (Timer Settings of 52 sec)**		
		Time Req. in (sec) per hour	Vent. Rates M^3/ h/360 BIRDS	Vent. Rates CFM/ 360 BIRDS	Time Req. in (sec) per hour	Vent. Rates M^3/h/ 360 BIRDS	Vent. Rates CFM/ 360 BIRDS
0-3	60 min	36.69	45.846	27	48.92	61.128	36
3-6	30 min	75	93.525	55.08	100	124.7	73.44
6-9	16 min	149.64	187.05	110.16	199.52	249.4	146.88
9-12	9 min	261	326.4	192.24	348	435.2	256.32
12-15	6.3 min	372.63	465.81	274.32	496.84	621.8	365.76
15-18	4.8 min	481.2	601.5	354.24	641.6	802	472.32
18-21	4 min	592.71	740.88	436.32	790.2	987.84	581.76
21-24	3.32 min	704.19	880.23	518.4	938.92	1173.63	691.2
24-27	2.87 min	815.7	1019.16	600.48	1087.6	1359.48	800.64
27-30	2.52 min	927.3	1158.99	682.56	1236.4	1545.32	910.08
30-33	2.52 min	1035.75	1434.06	762.48	1381	1726.24	1016.64
33-36	2 min	1147.2	1573.44	844.56	1529.6	1912.08	1126.08
36-39	1.86 min	1258.74	1712.82	926.64	1678.32	2097.92	1235.52
39-42	1.71 min	1370.25	1852.17	1008.72	1827	2283.76	1344.96
42-45	1.58 min	1481.7	1987.89	1090.8	1975.6	2469.56	1454.4
45-48	1.47 min	1590.3	2127.24	1170.72	2102.4	2650.52	1560.96
48-51	1.35 min	1728.75	2266.62	1252.8	2305	2836.32	1670.4
51-54	1.29 min	1813.29	2405.97	1334.88	2417.72	3022.16	1799.84
54-57	1.22 min	1924.77	2545.38	1416.96	2566.36	3207.96	1889.28
57-60	1.14 min	2036.4	2681.07	1499.04	2715.2	3393.84	1998.72
60-63	1.1 min	2144.82	1787.38	1578.96	2859.8	3574.76	2105.28

Maximum ventilation rates are drawn for the four experiments (0.2, 0.4, 0.6 and 0.8 CFM/LB) as illustrated if Figure (1). Maximum ventilation rates ranged between 61.12 to 3574.76 m^3/h/360 Birds for (0.8 CFM/LB), 45.84 to 2823.99 m^3/h/360 Birds for (0.6 CFM/LB), 30.56 to 1787.38 m^3/h/360 Birds for (0.4 CFM/LB) and 15.28 to 893.38 m^3/h/360 Birds for (0.2 CFM/LB), respectively.

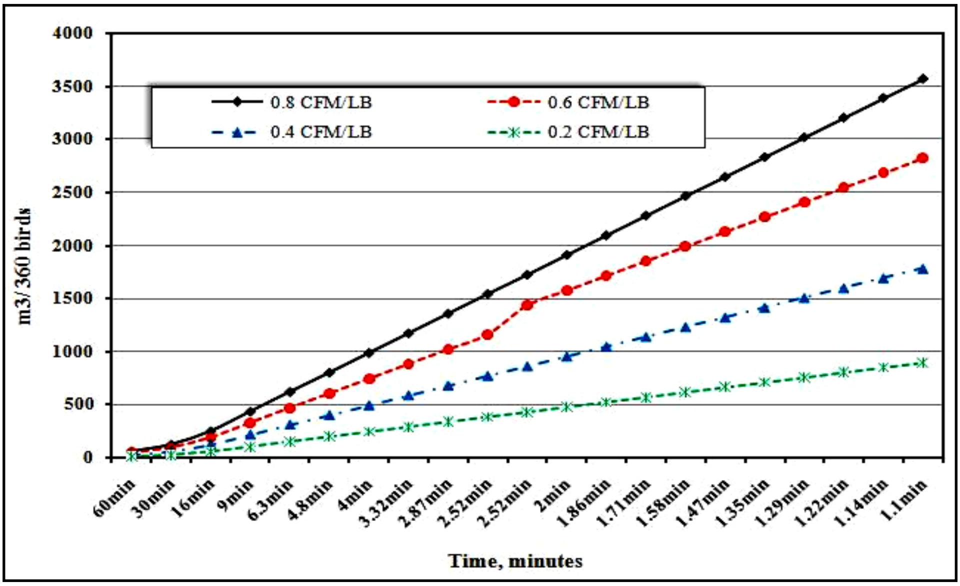

Fig.(1). Maximum ventilation rates 0.2, 0.4, 0.6 and 0.8 CFM/LB.

Time required in seconds for every hour under minimum ventilation rate used in the four experiments is shown in Figure (2). This time is used every hour to maintain minimum ventilation rates conditions and ranged between, (12.23 - 714.95 sec.), (24.46 and 1439.9 sec.), (36.69 and 2144.82 sec.) and (48.92 and 2859.8 sec.) for (0.2, 0.4, 0.6 and 0.8 CFM/LB) respectively.

Fig. (3) illustrates minimum and maximum ammonia emissions (ppm) in opposition to minimum and maximum ventilation rates (m^3/B.h). From Fig. (3) it can be noticed that ammonia emission (ppm) ranged between 0.7 ppm (at 10 days, age) and 14.26 ppm (at 53 days, age) under minimum ventilation rates. Moreover, this emission fluctuated between 5.13 ppm (at 13 days, age) and 15.65 ppm (at 43 days, age) under maximum ventilation rates conditions.

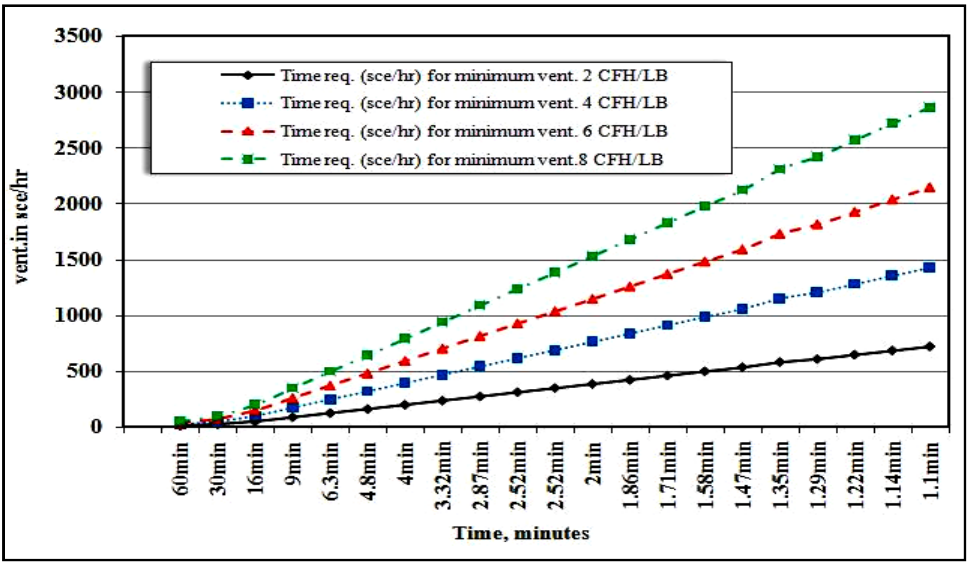

Fig. (2). Time required in seconds for every hour under minimum vent.

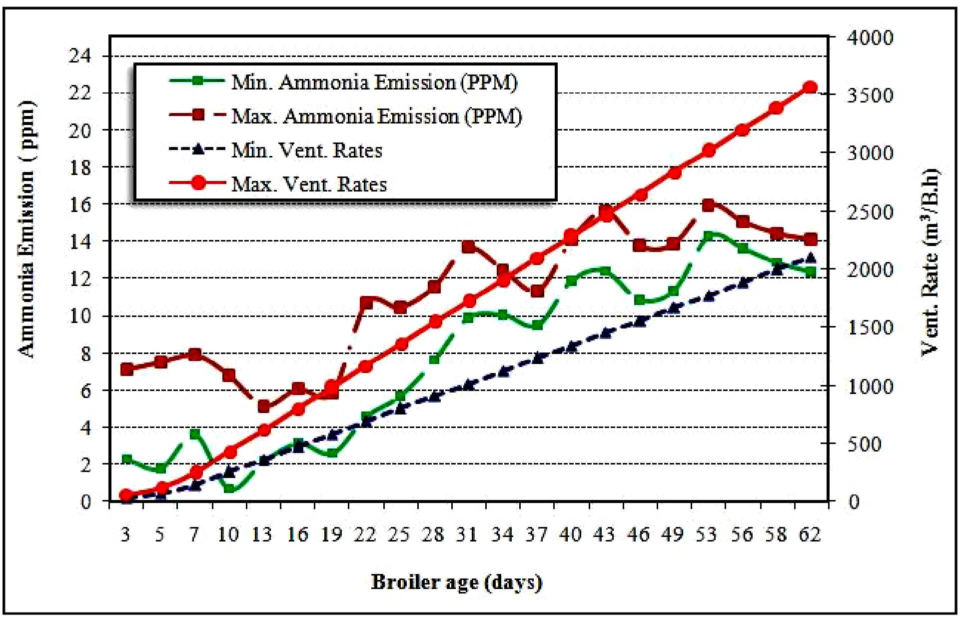

Fig. (3). Min. and maximum ammonia emission (ppm) in opposition to minimum and maximum ventilation rates (m^3/B.h).

Fig. (4) points up average dust emission rate (mg/m^3) opposed to minimum and maximum ventilation rates (m^3/B.h). Dust emission rate ranged between 1.89 - 5.625 mg/m^3 under minimum ventilation rates and between 1.35 - 3.75 mg/m^3 for maximum ventilation rates. Furthermore, it can be reported that dust emission changed between its minimum value of 1.881 mg/m^3 (at 34 days, age) and 5.909 mg/m^3 (at 58 days, age) under minimum ventilation rates. What is more, this emission fluctuated between 0.99 mg/m^3 (at 34 days, age) and 4.46 mg/m^3 (at 25 days, age) under maximum ventilation rates.

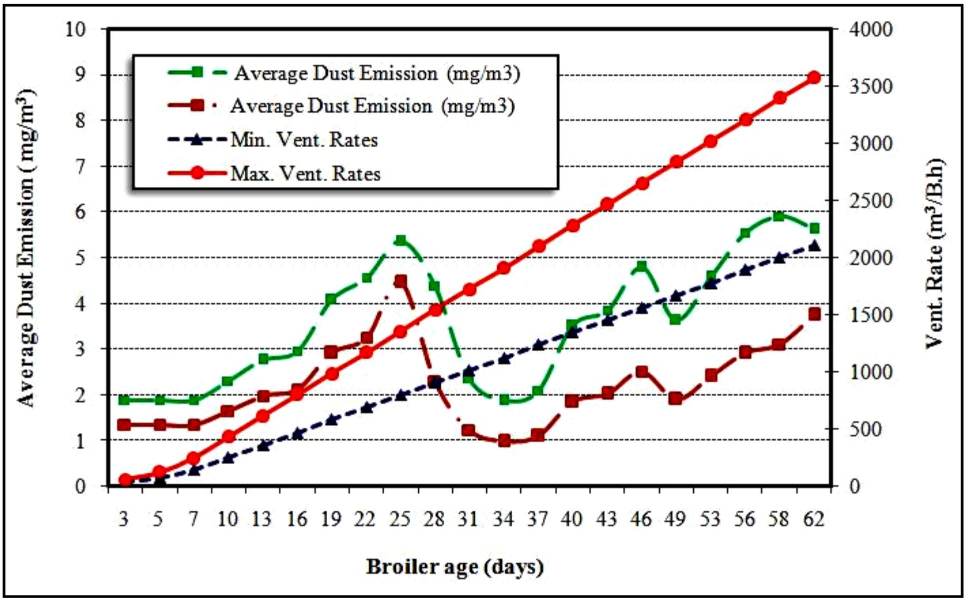

Fig. (4). Average dust emission rate (mg/m^3) vs. minimum and maximum ventilation rates (m^3/B.h).

Statistical analysis for collected results from four experiments was carried out and displayed in Tables (3,4 and 5), respectively. At the same time, Table (3) demonstrates Least Square Means and their standard errors (SE) for ammonia concentration (ppm) and inspirable dust concentrations (mg/m^2) as affected by ventilation system. Also, Table (4), illustrates Least Square Means and their standard errors (SE) for broiler body weights (g) and daily weight gains (g) as affected by ventilation system. Finally, Finally, Table (5) shows Least Square Means and their standard errors (SE) for daily feed consumption (g) and feed conversion ratio (g) as affected by ventilation systems.

Table (3). Least square means and their standard errors (SE) for ammonia concentration (ppm) and Inspirable dust concentrations (mg/m^2) as affected by ventilation system.

Vent. System, CFM/ LB	**Ammonia concentration (ppm)**			**Inspirable dust concentrations (mg/m^2)**		
	Age, Weeks			Age, Weeks		
	3-4	4-5	5-6	3-4	4-5	5-6
0.2	13.70 ± 1.14 [a]	14.00 ± 0.95[a]	16.50 ± 1.19[a]	5.33 ± 0.51[a]	5.20 ± 0.28[a]	4.00 ± 0.33[a]
0.4	10.60 ± 1.14[a]	13.10 ± 0.95 [a]	15.62 ± 1.19 [a]	5.50 ± 0.51 [a]	4.90 ± 0.28[a]	4.32 ± 0.30 [a]
0.6	11.60 ± 1.14 [a]	12.00 ± 0.95[a]	13.75 ± 1.19 [a]	5.60 ± 0.51[a]	4.10 ± 0.28 [a]	3.00 ± 0.01[a]
0.8	11.40 ± 1.14 [a]	12.40 ± 0.95 [a]	13.00 ± 1.19[a]	4.16 ± 0.51[a]	5.50 ± 028[a]	3.33 ± 0.33[a]

Means within columns with no common letters are significantly different (P<0.05).

Table (4). Least square means and their standard errors (SE) for broiler body weights (g) and daily weight gains (g) as affected by ventilation system.

Vent. System, CFM/ LB	**Body weight (g)**		**Daily weight gain (g)**		
	Age, Weeks		Age, Weeks		
	4	6	0-4	4-6	4-6
0.2	983 ± 11.77[a]	1909 ± 22.09[a]	33.57 ± 0.65[b]	66.15 ± 1.17[a]	44.43 ± 0.52[a]
0.4	1024 ± 11.40 [a]	1949 ± 21.68 [a]	35.75 ± 0.57 [a]	66.08 ± 1.15[a]	45.37 ± 0.51 [a]
0.6	1011 ± 11.35[a]	1911 ± 21.42[a]	34.57 ± 0.54[a]	64.29 ± 1.14 [a]	44.49 ± 0.51[a]
0.8	1000 ± 11.37 [a]	1931 ± 21.85[a]	34.20 ± 0.54[b]	66.40 ± 1.15[a]	44.97 ± 0.48[a]

Means within columns with no common letters are significantly different (P<0.05).

Table (5). Least square means and their standard errors (SE) for daily feed consumption (g) and feed conversion ratio (g) as affected by ventilation systems.

Vent. System, CFM/ LB	Daily feed consumption (g)			Feed conversion ratio (g)		
	Age, Weeks			Age, Weeks		
	DFC0-4	DFC4-6	DFC0-6	DFR0-4	DFR4-6	DFR4-6
0.2	55.40 ± 0.17 [a]	121.30 ± 4.29[a]	77.90 ± 1.49[a]	1.57 ± 0.02[a]	2.14 ± 0.04[a]	1.83 ± 0.01[a]
0.4	55.20 ± 0.17[a]	116.35 ± 4.29 [a]	75.95 ± 1.49 [a]	1.55 ± 0.02 [a]	2.05 ± 0.04[a]	1.78 ± 0.01 [a]
0.6	54.95 ± 0.17 [a]	116.35 ± 4.29[a]	75.95 ± 1.49 [a]	1.54 ± 0.02[a]	2.06 ± 0.04 [a]	1.78 ± 0.01[a]
0.8	55.70 ± 0.17 [a]	122.80 ± 4.29 [a]	78.70 ± 1.49[a]	1.53 ± 0.02[a]	2.08 ± 0.04[a]	1.80 ± 0.01[a]

Means within columns with no common letters are significantly different (P<0.05).

The mean ammonia concentrations in the atmosphere for weeks of 4, 5, and 6 respectively, are presented in Table (3). In all cases, ammonia concentration was seen to greatly increase towards the end of the trial, but there were no significant differences in ammonia concentrations produced under the various ventilation systems of the experimental treatments. Table (3) shows that the rooms at 0.2 CFM/LB had slightly higher mean ammonia concentrations throughout weeks 3 to 6 than the rooms at 0.4, 0.6 and 0.8 CFM/LM, although the means were not significantly different. Ventilation system had no significant effect on inspirable dust concentrations at either 4 or 5 weeks or 6 weeks, (Table.3).

The mean body weight of the broilers from weeks 4 to 6 is shown in Table (4). Ventilation systems had no significant effect on body weights and daily weights gain over weeks 4 to 6 as illustrated in Table (4). The feed conversion ratios can be calculated when feed consumption and weight gain are known. That is: daily feed conversion ratio = daily feed consumption / daily weight gain. The resulting conversion ratios and daily feed consumption are shown in Table (5). There were no significant effects of any of the environmental factors. Indeed the feed conversion ratios were identical or very similar over the 6 week period at the four levels of ventilation system (Table - 5). It was very obvious that there are significant differences.

CONCLUSION

Under conditions of this requirement, ventilation system had no significant effect on body weight, feed consumption, ammonia concentrations and inspirable dust concentrations at either 4 or 5 weeks or 6 weeks.

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الملخص العربي

دراسة الملوثات الهوائية ، جزء (٢): تأثير معدلات التهوية على انبعاث الأمونيا والغبارِ داخل بيوتِ الدواجنِ

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أجريت هذه التجربة في مزرعة دواجن في محطة الأبحاث الزراعية ، كلية الزراعة والطب البيطري ، جامعة القصيم ، المملكة العربية السعودية. وقد استخدم فى هذه التجربة قطيع من دجاج التسمين بعدد ٣٠٠٠ طائر والتى تم تربيتها لفترة ٤٢ يوم. حيث تم تصميم التجربة بمكررين لأربعة معدلات تهوية لجنسين من الطيور وكانت معدلات التهوية الأربعة على النحو الاتى : ٠,٢ – ٠,٤ – ٠,٦- ٠,٨ قدم مكعب / دقيقة/ رطل. وقد تم تسجيل أوزان الطيور بشكل فردى عند أعمار ٤, ٥ , ٦ أسابيع. كذلك تم حساب معدلات التغذية وإضافة المياه وتم حساب معدلات استهلاك الغذاء ومعدلات الوفيات أسبوعيا. وتم اخذ قياسات الأمونيا والغبار يوميا وعند مستويات الطائر فى موقعين مختلفين لكل تجربة. وقد أظهرت نتائج التجربة أن نظام التهوية لم يكن له تأثير يذكر على وزن الجسم أو معدل التحويل الغذائى أو تركيز الأمونيا والغبار المتطاير لكل من الأعمار ٤ , ٥ , ٦ أسابيع وذلك فى ظروف التجربة.

الكلمات الدالة: الأمونيا- غبار - انبعاث – بيئة – معدل تهوية– نموذج - بيوت الدواجن.

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