Effects of Different Minimal Ventilation Modes on Environmental Quality and Production Performance of Henhouse

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Abstract: In order to study the effects of minimum ventilation on the environmental quality and production performance of chicken coop in cold season, two different minimum ventilation risk control modes were tested, namely intermittent minimum ventilation mode and continuous minimum ventilation rate mode, and the changes of internal environmental quality and production performance of two kinds of chicken coop were compared. The results showed that the environmental quality of the continuous ventilated chicken house was better than that of the intermittent ventilated chicken house, and the temperature, relative humidity, ammonia and carbon dioxide concentrations were significantly lower than those of the intermittent ventilated chicken house ($P < 0.05$), and the environmental uniformity of the house was significantly better than that of the intermittent ventilated chicken house. At the same time, the laying rate and eggshell thickness of chickens were higher than intermittent ventilation chicken house. The results showed that the continuous minimum ventilation method had better environmental quality in cold season, and the performance and egg quality of chickens were significantly better than that of intermittent ventilation method.

1 INTRODUCTION

With the development of modern chicken industry, people pay more and more attention to chicken house environment. In the production of laying hens, feed, temperature, relative humidity, light, immunization program and many other factors jointly determine the performance and egg quality of laying hens, among which temperature accounts for 30%-40%. Temperature is an important environmental factor affecting the performance of laying hens. When the breeding environment temperature is higher or lower than the suitable range of chickens, it will affect the normal body metabolism, production performance continues to decline, induce the occurrence of disease, even death (Mueller 1959, Al-Saffar 2003, Zhao 2013). Therefore, in order to maintain the best performance and egg quality of laying hens, the ambient temperature must be controlled in a suitable range. But in winter, the chicken house warm and ventilation is contradictory, if not properly controlled, will seriously affect the production performance of chickens, serious will suffer from a

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variety of diseases, among which respiratory diseases are the most common.

Winter laying hens ventilation rate affect the inner temperature stability and air quality, which affect health and production performance of laying hens, in order to guarantee the henhouse environment temperature, most of the henhouse adopts the model of minimum ventilation rate, the required ventilation rate, ventilation mode mainly ruled out the foul air inside the henhouse, sufficient oxygen supply flock. Its value is usually designed and calculated based on the principle of carbon dioxide balance. The value of carbon dioxide determines the minimum ventilation volume and the ventilation heat consumption of the chicken house. In China, the minimum ventilation volume of laying hens in winter is usually the traditional empirical value and recommended value, and the minimum ventilation volume of laying hens in winter is relatively large. Intermittent ventilation is generally used in winter to solve the contradiction between ventilation and heat preservation, but intermittent ventilation will cause large temperature difference and temperature fluctuation in the house, which will affect the performance and health of laying hens. Wang Yang et al. summarized and analyzed the test data of NH_3 and CO_2 concentration in laying hens with different fecal cleaning methods by relevant scholars at home and abroad, and put forward suggestions on the value of CO_2 concentration in laying hens with modern conveyor belt fecal cleaning. Based on the balance principle of CO_2 concentration. In this paper, the minimum ventilation rate of laying houses under the risk control system of continuous ventilation in winter is set at 0.4 ~ 0.5 m^3/ (h•kg) (Wang 2017). Based on this value, intermittent minimum ventilation and continuous minimum ventilation tests were carried out in two laying hens with the same space and breeding scale, respectively, to compare the environmental quality of the two houses and the production performance during the test, so as to provide a certain reference for the accurate risk control system of chicken houses in cold season.

2 MATERIALS AND METHODS

2.1 The Henhouse

Two experimental chicken houses were located in Chengdu, Sichuan Province, China, and the test time was January 5, 2021, solstice, February 5, as shown in Figure 1. The size of the test hen house is 40m in length, 9.2m in width and 2.5m in height (ceiling height). the henhouse features two side-wall air intakes (or air intakes) for cooling the wet curtain in the summer, located at the front of the house. This hen house was provided with 2 side-wall air inlets (or referred as tunnel inlets) located at the front end of the house. 3 fans were installed at the end wall of the house, two are temperature control fans, and the middle one is time control fan. there were in total 32 side-wall windows as shown in Fig. 1. For the 2 air inlets and all side-wall windows, a bottom hinged flap mechanism was used to control the opening angle, enabling a control range from 0° (fully closed) to 90° (fully open).

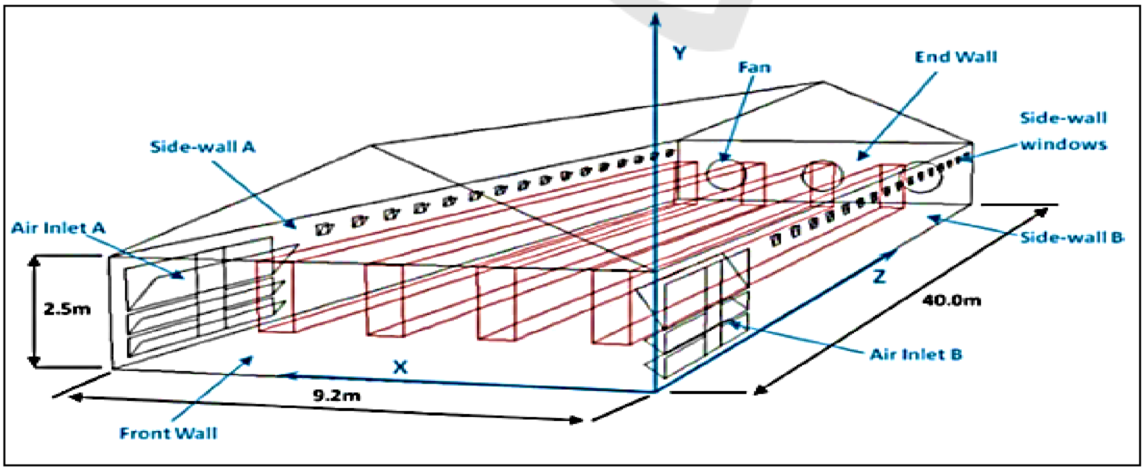

Figure 1: Schematic drawing of the henhouse.

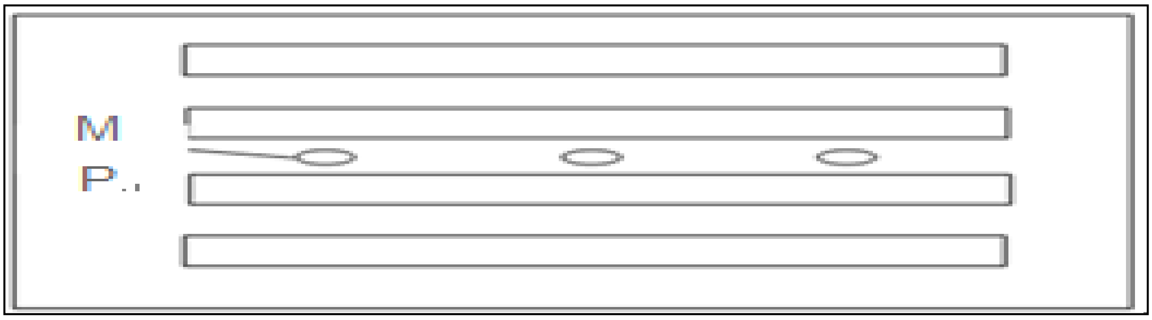

Figure 2: Schematic drawing of the measurement position.

The minimum ventilation volume was $0.5m^3$/(h•kg) in. The air flow direction of the two henhouses was air inlet through the side wall window and air outlet from the rear end fan. One of them adopts intermittent ventilation mode (IV). When it is turned on, the ventilation volume of the controlled frequency conversion fan is set to $150m^3$/min. The fan is set to 5 minutes for one cycle, and the cycle mode is 2 minutes for opening and 3 minutes for closing. The other one uses a time-controlled frequency conversion fan for continuous ventilation (CV), and the ventilation volume of the fan is set at $60m^3$/min.

2.2 Experiment Animal

During the experiment, 3000 broiler breeders with an average weight of 2.4kg were bred in both chicken houses. During the experiment, chickens were fed and managed strictly in accordance with the feeding management manual, and they were free to drink water and eat. Dietary composition and nutrient levels were shown in Table 1.

Table 1: Composition and nutrient levels of the basal diet (air-dry basis).

Ingredients (%)	
Corn	64
Soybean meal	16
rapeseed meal	3
wheat bran	4
corn gluten meal	3.5
Limestone	7.5
CaHpO4	0.8
NaCl	0.3
Premix1)	0.9
Total	100.0
Nutrient levels2)	
Metabolizable energy/(MJ/Kg)	11.33
Crude Protein	16
Calcium	3.1
Available Phosphorus	0.42
Lysine	0.84
Methionine	0.4

1) Premix Provided the following Per kg of diets: VA 12500 IU, VD 2500 IU, VE 30 IU, VK3 1.8 mg, VB12 12 ug, biotin 0.2mg, choline 600 mg, Fe 80 mg, Cu 8 mg, Mn 90 mg, Zn 72 mg, I 0.9 mg, Se 0.27 mg.
2) Calculated values.

2.3 Instrumentation

A portable multi-function high-resolution air velocity meter (Model 9545, TSI, MN) was used to measure the indoor air velocity, air temperature and relative humidity. Meanwhile, a compound gas detector (GT-2000) is used to measure CO2 and NH3 concentrations in the chicken house. eggshell thickness, egg weight, albumen height, yolk color and Haugh unit were measured using a thickness gauge (PEACOCK P-1) and egg quality tester (ORKA Egg Analyzer EA-01).

2.4 Measurements

Respectively using automatic detection equipment, daily record two hen house within 24 hours of temperature, relative humidity, concentration of carbon dioxide and ammonia, the measurement location is shown in Figure 2. At the same time, the egg production rate of each chicken house was recorded, and randomly selected 200 eggs do experiments henhouse each egg quality, including egg weight, eggshell thickness, albumen height, egg yolk color and hartz units. EXCEL2010 software was used to build a monitoring database, and the data of environmental parameters, egg production rate and egg quality were calculated as the daily statistical mean, and the environmental parameters and egg quality were expressed as the mean ± standard deviation. SPSS 20 was used for one-way ANOVA, LSD was used for multiple comparisons, and pair correlation analysis.

3 RESULTS

3.1 Environmental Quality

Two henhouse environment quality parameter statistics after the results are shown in Table 2, and (IV) the temperature and relative humidity of hen house (CV) is significantly higher than the henhouse, evenness is 5.23 ℃ and 1.25 ℃ respectively, (IV) the henhouse evenness is poorer, intermittent opening and closing, the main reason for the henhouse fan fan opens, inner temperature to produce, make the inner temperature difference, Similarly, the relative humidity in the house will also plummet; (IV) The concentration of carbon dioxide and ammonia gas in the chicken house was also significantly higher than that in the (CV) chicken house, in which the concentration of carbon dioxide was much higher than the standard requirements and the uniformity was as high as 1058.57 mg/m3. Since carbon dioxide mainly came from the respiration of the chickens, intermittent ventilation would also cause the accumulation of carbon dioxide in the house. Ammonia mainly comes from the decomposition of excreta of chickens, and ammonia will also accumulate in intermittent ventilation mode.

3.2 Production Performance

According to Table 3, the laying rate in (CV) house was significantly higher than that in (IV) house ($P < 0.05$), while in egg quality, the eggshell thickness in (CV) house was significantly higher than that in (IV) house ($P < 0.05$). Egg weight in (CV) house was higher than that in (IV) house, but the difference was not significant ($P > 0.05$), albumen height in (CV) house was lower than that in (IV) house, but the difference was not significant ($P > 0.05$), yolk color and Haugh unit were also not significant ($P > 0.05$).

Table 2: Average value and average value of environmental quality parameters of two chicken houses.

Ventilation form	Temperature (℃)		Relative humidity (%)		CO_2 (mg/m^3)		NH_3 (mg/m^3)	
	M±SD	UNIF	M±SD	UNIF	M±SD	UNIF	M±SD	UNIF
IV	23.87*±2.38	6.23	55.42*±5.18	5.29	2155.82*±568.45	1058.57	1.88*±0.39	2.18
CV	20.42±0.98	2.25	50.60±3.52	4.66	1309.09±63.88	89.26	0.28±0.03	0.08

Note: 1. UNIF is the absolute value of the difference between the highest value and the lowest value at different time or at different measurement points in the analysis of environmental parameters.2. The data with same or no superscript star(*) indicates significance (p<0.05) in a list.

Table 3: Laying rate and egg quality.

Ventilation form	LR (%)	ST (μm)	EW (g)	AH (mm)	YC	HU
IV	63.32	37.63±2.38	60.14±4.22	5.71±0.89	6.37±1.38	73.46±5.83
CV	68.11*	38. 20±3.22*	60.67±3.02	5.65±0.67	6.46±1.55	74.83±7.01

Note: 1.LR, laying rate; ST, shell thickness; EW, egg weight; AH, albumen height; YC, yolk color; HU, Haugh unit.2. The data with same or no superscript star(*) indicates significance (p＜0.05) in a list.

4 DISCUSSIONS

4.1 Environmental Quality Analysis of Different Ventilation Modes

Among the environmental parameters of chicken house, temperature is the most significant factor affecting the health and production performance of chickens. Compared with other animals, chicken has a higher temperature, thicker feathers and no sweat glands. Its body temperature can only be dissipated by epidermal evaporation and respiration, and its regulation ability is particularly weak. It is generally believed that the appropriate temperature of laying hens is 13-23℃, and the critical temperature is 0-30 ℃ (Hu 2004). Generally, heavy varieties are cold and heat tolerant, while light varieties are the opposite (An 2004). Therefore, in the production of laying hens, to maintain the best performance and quality of laying hens, the environmental temperature must be controlled within the appropriate range. In winter, the insulation and ventilation of chicken coop are contradictory to each other. It is necessary not only to maintain the appropriate temperature in winter, but also to control the air quality in the coop. The minimum ventilation mode is the best method to solve this problem at present. In this experiment, two control modes of intermittent ventilation and continuous ventilation were compared, and the results showed that under the two ventilation modes, except the carbon dioxide concentration of intermittent ventilation, other indoor environmental parameters were in a relatively suitable range. But sheds (IV) temperature, relative humidity, concentration of carbon dioxide and ammonia concentration (CV) is significantly higher than the henhouse, significant difference ($p < 0.05$), continuous ventilation mode of environment parameters is better than that of intermittent ventilation mode, especially the uniformity is far better than the intermittent ventilation mode, under the condition of guarantee optimum temperature, the inner environment to stability of the continuous ventilation mode is stronger, Small fluctuation; However, the intermittent ventilation mode has poor uniformity, especially the temperature and carbon dioxide concentration. When the fan is turned on, the chickens will suffer a sudden drop in temperature, which will produce certain stress effect on the chickens.

4.2 Effects of Chicken House Environment on Production Performance and Egg Quality

Different environmental quality can affect the performance and egg quality of laying hens. In this experiment, the overall production performance and egg quality of (CV) chicken house were better than that of (IV) chicken house. Among them, the laying rate of (CV) house was better than that of (IV) house, and the difference was significant ($P < 0.05$). In terms of egg quality, there was no significant difference except eggshell thickness. Compared with the environmental quality of the chicken house, both temperature and relative humidity are within the suitable range of laying hens. It can be seen that temperature and relative humidity have little influence on production performance and laying performance. The main difference lies in the uniformity of harmful gas concentration and environmental quality. Research shows that in the high concentration of ammonia environment, chicken feed intake, reduce the egg production performance, egg quality, rate is negatively related to the inner ammonia concentration, at the same time, when the inner elevated co2 concentration, laying hens production performance degradation, feed conversion rate is negatively related to the concentration of carbon dioxide, ammonia, The experimental results are consistent with those of Reece et al (Reece 1980), When carbon dioxide levels reach 2% to 3 %, eggshell thinning occurs in flocks. Due to the intermittent ventilation conditions, the chickens are intermittently affected by sudden temperature changes, always under the cold and hot stress response, will cause the chicken immunity decline, it is very likely to induce some environmental bacteria disease outbreak.

5 CONCLUSIONS

In the present study, the minimum ventilation volume designed with 0.5 $m^3/(h•kg)$ as the calculation parameter in winter can not only ensure the temperature requirements of the chicken coop, but also better achieve the environmental quality control target. However, this experiment showed that adopting different risk control time model would cause different environmental quality in the barn, and also affect the production performance and egg quality of the chickens. By comparing two different control modes, we found that usually takes 5 minutes as a cycle of intermittent risk control system mode, can cause environmental quality variation within the hen house increased, especially the concentration of harmful gases such as carbon dioxide and ammonia is much higher than continue with wind model, in terms of production performance, rate and shell thickness were also affected. And adopting continuous ventilation mode of the henhouse, although slightly below intermittent ventilation mode, but still control within the scope of a more comfortable, more important is effectively exhaust the harmful gas of inner, inner environment parameter to less volatile, reduces the stress reaction of chickens, significantly improve the rate and egg quality, therefore, in the cold season, The minimum ventilation mode with continuous ventilation is better than the intermittent ventilation mode. However, in this study, the comparison of energy consumption and efficiency between the two control modes was not made.

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