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Atmospheric ammonia changes on different zone placement from the closed house inlet affecting broiler chicken performance in the rainy season

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Abstract. The applied study was conducted to evaluate the effect of different zone placements within the closed house on the performance of broilers during the rainy season. The treatments applied were as follows: zone 1 = chickens placed next to the inlet, zone 2 = chickens placed in $\frac{1}{4}$ length of the cage from the inlet, zone 3 = chickens placed in $\frac{1}{2}$ length of the cage from the inlet, and zone 4 = chickens placed in $\frac{3}{4}$ length of the cage from the inlet. Change of macroclimate outside the closed house, microclimate, and atmospheric ammonia inside the closed house were observed in each zone. The parameters observed were feed consumption, body weight gain (BWG), feed conversion ratio (FCR), performance index (PI), and income over feed cost (IOFC). Data were subjected to analysis of variance. Correlation analysis between heat stress index (HSI) or atmospheric ammonia on broiler performance was carried out. The results showed that a further distance of zone placement from the inlet is indicated by microclimate changes and an increasing average of atmospheric ammonia. There were significant decreases in feed consumption, BWG, PI, and IOFC start from the 2nd zone. FCR was significantly increased in the 3rd zone ($P \leq 0.05$). The increase of atmospheric ammonia at the further zone placement from the inlet negatively correlated, strong and significant with performance, while the HSI did not correlate strongly. In conclusion, the further zone placement from the inlet increased atmospheric ammonia and decreased broiler chicken performance in the rainy season.

1. Introduction

The changing seasons affect the management of broiler chickens. The rainy season is characterized by a rainfall with more than 150 mm/month, high humidity and relatively lower temperatures [1]. The condition affects the cage microclimate, so the litter becomes moist and contributes to the volatilization of ammonia. Ammonia is not directly produced by chickens, but by microbial activity through the breakdown of uric acid in the excreta. Increased production of ammonia is influenced by warm temperatures, pH (7.0-8.5), and litter humidity [2,3,4] where the condition is favorable for microbial to grow. Therefore, the rainy season is thought to result in a change of atmospheric ammonia levels in the cage.

Closed house equipped with ventilating controlled system, where the needs of temperature, humidity, and air velocity can be to minimize macroclimate interference, maximize microclimate based on broiler needs and removes harmful gases such as CO, CO₂, and NH₃ within the closed house cage [4]. However, closed house usage still leaves some problems, including temperature distribution,



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humidity, and uneven air velocity in certain zones [5]. Technically the zone inside the closed house is divided into four, where zone 1 starting from the inlet and zone 4 ends at the outlet (near exhaust fan). The division of the zone mostly aimed to distribute and arrange so that the chickens are not assembled in a particular zone, leveling feed and drinking water, facilitate the application of drug and vaccine programs, and harvesting process. The zone next to the inlet has a lower temperature than the further zone located from the inlet, this is due to the accumulation of heat from the zone next to the inlet [6]. The increased temperature and humidity in the zones further away from the inlet led to an increase in the volatilization of ammonia, so there was suspected an increase in atmospheric ammonia levels in the further zone of the inlet.

The high levels of atmospheric ammonia in the cage become one of the causes of broiler chickens experiencing damage to the respiratory tract, prone to disease, and decreased performance [7,8]. Lesion of the respiratory tract that causes heat loss via panting is ineffective, so that broiler chickens experience heat stress. This sustainable condition will have an impact of 4 the potential occurrence of oxidative stress. In general, atmospheric ammonia has a 28 ad impact on feed consumption, body weight, and feed conversion ratio of broiler chickens [9]. The results of the [10] study showed that increased atmospheric ammonia levels from 16 ppm to 39 ppm resulted in a decrease in feed consumption by 9.2%, weight loss of 6.6%, and increased feed conversion by 4.7%. Atmospheric ammonia can have a negative impact on broiler performance. Based on the conditions above the author suspected that there is a change of atmospheric ammonia level in different zone placement inside a closed house which potentially lowers broiler performance of chickens.

This research was 20 ducted in a commercial broiler closed house in Semarang (coastal region) in the rainy season. The study was conducted to evaluate the influence of different placement zone in the chicken closed house on the performance of broilers in the rainy season.

2. Methodology

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The research was conducted in a closed house with a capacity of 11,000 chickens with 29 length of 60 m and 12 m wide. Three hundred and sixty samples day old chicken (DOC) unsexed bro 12 with an average body weight of 44.8 ± 1.66 g allocated into the experimental model a complete randomized block design (CRBD) with 4 treatments and 6 groups (each consisting of 15 chickens) is reared for 28 days. The broiler was reared based on the standard broiler density during the brooding period up to finisher. In the brooding period, the chicken population was set to occupy the central portion of the house (360m²), then expanded gradually to find out the optimum capacity of the cage (720m²) at the age of 12 days until the finisher period (Figure 1. A and B). Placement zone as treatments applied are as follows: zone 1 = chicken placement at the position next to the inlet, zone 2 = placement of chickens at position $\frac{1}{4}$ of the cage length is measured from the inlet, zone 3 = The placement of chickens at the $\frac{1}{2}$ position of the cage length is measured from the inlet and zone 4 = placement of chickens at position $\frac{3}{4}$ of the cage length is measured from the inlet. The feed 22 provided was a complete feed with code S-10 (day to 0-21) and S-12 (day to 22-28) (Table 1). Feed and drinking water are given *ad libitum* during research.

Tabel 1. Nutritional Content of Experimental Diets

Nutrient Content	Content	
	S-10	S-12
Water Content (%)*	7.33	9.17
Ash (%)*	6.65	5.67
Crude Protein (%)*	22.97	22.38
Crude Fat (%)*	8.00	7.00
Crude Fiber (%)*	3.26	3.05
Ca (%)*	0.97	0.82
P (%)*	0.72	0.05

Metabolizable Energy (kcal/kg)** 3395 3328

*Proximate analysis result (2017)

**Values were obtained based on the formula according to Bolton as used by [11]

The atmospheric ammonia levels of each experimental unit are measured using the PT 804 ammonia gas meter, Dongguan Pince Tech-China. This study was carried out in the rainy season, routine macroclimate and microclimate data were also observed as support data related to atmospheric ammonia as presented in Table 2. The data retrieval is observed and evaluated at the end of the research cumulatively, including feed consumption, Body Weight Gain (BWG), Feed Conversion Ratio (FCR), Performance Index (PI), and Income Over Feed Cost (IOFC). PI calculations were performed based on the formula of [12]. The IOFC calculations are carried out based on the formula from [13]. The Heat Stress Index (HSI) value is calculated as supporting data to determine the level of stress in broiler chickens by summing the temperature in Fahrenheit (°F) and humidity (%) [14].

$$PI = \frac{\text{Weight(kg)} \times \text{liveability (\%)}}{\text{Age(day)} \times \text{FCR}} \times 100$$

$$IOFC = (\text{Weight (kg)} \times \text{Chicken Price/kg of Living Weights}) - (\sum \text{Feed Consumptions} \times \text{Feed Price/kg})$$

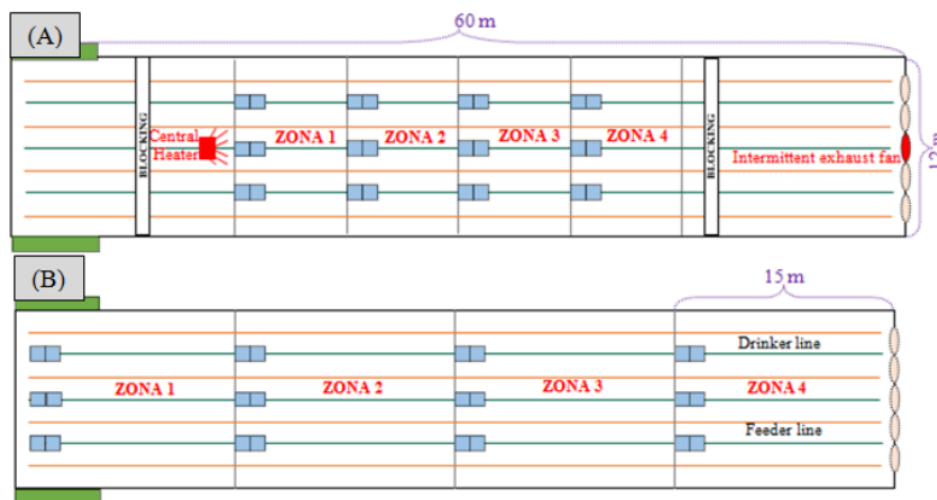
To find out the relationship between the Heat Stress Index (HSI) and the atmospheric ammonia with the broiler performance correlation analysis was conducted. The collected data were tabulated and analyzed based on analysis of variance (ANOVA). The data which showed significant influence ($P \leq 0.05$) would be tested further with the Duncan test.

2 Tabel 2. The macroclimate and microclimate condition during the research

Macroclimate	Value			
Temperature (°C) ¹⁾	25.15 ± 1.89			
Relative Humidity (%) ¹⁾	91.36 ± 7.67			
Air Velocity (m/s) ¹⁾	1.49 ± 0.67			
Monthly Rainfall (mm) ¹⁾	499,60 ± 16,60			
Sun Radiation (W/m ²) ¹⁾	107.81 ± 55,42			
Microclimate	Zone 1	Zone 2	Zone 3	Zone 4
Temperature (°C)	28.53	29.01	29.65	29.88
Relative Humidity (%)	83.41	83.37	82.18	82.21
Air Velocity (m/s)	0.79	0.47	0.45	0.48
Atmospheric ammonia (ppm) ²⁾	1.57	3.17	5.13	6.22
Heat Stress Index	168.98	169.85	169.61	169.93

¹⁾Based on automatic weather station of the Diponegoro University (2017)

²⁾ [6]



(A): brooder period; (B): finisher period

Figure 1. Zone placement settings in closed house

3. Results and discussion

The data showed that the influence of different placement zones in the closed house to the broiler chicken performance in the rainy season are presented in Table 3, and the analysis of the correlation between the atmospheric ammonia and HSI to the broiler of chicken performance are provided in Table 4. As presented in Table 2, there is a change in atmospheric ammonia, the further distance from closed house inlet the higher atmospheric ammonia level, while the value of HSI which representing broiler stress level due to temperature and humidity changes are relatively the same.

Significant reductions in the amount of feed consumption began to occur in the 2nd placement zone and continued to decline in 3rd and 4th zone. This decline in feed consumption followed with the same pattern for the BWG, PI, and IOFC, while the significant increase in FCR begins to occur in the 3rd placement zone ($P \leq 0.05$).

Table 3. Performance of broiler chickens and income over feed cost (IOFC)

Parameter	Zone 1	Zone 2	Zone 3	Zone 4	P	SE
Feed Consumptions (g/bird)	2404.50 ^a	2310.50 ^b	2197.83 ^c	2181.83 ^c	0.00	25.16
Body Weight Gain (BWG) (g/bird)	1647.58 ^a	1551.52 ^b	1441.23 ^c	1397.68 ^c	0.00	19.01
Feed Conversion Ratio (FCR)	1.46 ^c	1.49 ^c	1.53 ^b	1.56 ^a	0.00	0.01
Performance Index (PI)	414.50 ^a	383.17 ^b	348.00 ^c	330.33 ^c	0.00	6.30
Income Over Feed Cost (IOFC) (IDR/bird)	9890.50 ^a	9168.70 ^b	8532.20 ^c	8073.30 ^d	0.00	150.52

Table 4. Correlation between atmospheric ammonia, HSI, and the parameter observed

Parameter	Correlation coefficient (r)	
	Atmospheric ammonia	HSI
Feed Consumptions (g/bird)	-0,86**	-0,46*
Body Weight Gain (BWG) (g/bird)	-0,92**	-0,46*
Feed Conversion Ratio (FCR)	0,78**	0,36
Performance Index (PI)	-0,90**	-0,44*

Income Over Feed Cost (IOFC) (IDR/bird)	-0,86**	-0,46*
*Significant correlation to the 5%		
**Significant correlation to the 1%		

Based on the correlation analysis results between the atmospheric ammonia and the HSI on performance suggested that even the ideal condition of closed house microclimate achieved, the atmospheric ammonia problem is one of the major contributing factors that able to decrease chicken broiler performance.

The increase in the atmospheric ammonia levels in further zone placement from the inlet has a negative, strong, and significant correlation with performance ($r > 0.5$), which demonstrates a very strong relationship [15], and even HSI has a fairly strong relationship and significantly to the performance, the value of the correlation coefficient is still less than 50%, while the FCR parameter does not indicate a significant correlation ($r < 0.5$). Based on our research, we suggest that the effect of atmospheric changes due to zone placement inside a closed house is more detrimental to broiler performance than microclimates.

The changing seasons affect the changing conditions of microclimate and atmospheric ammonia levels inside the closed house. The results of the research [6] in the rainy season showed that the atmospheric ammonia levels in the closed house were 3.5% higher than the research results of [16] conducted in the dry season of the same cage. This condition is suspected to affect broiler performance.

3.1. Feed Consumption

The increase in atmospheric ammonia potentially damaging the respiratory tract of broiler chickens especially in the parabronchi. The research results of [17;18] showed that elevated levels of atmospheric ammonia resulted in the occurrence of respiratory tract problems especially parabronchi by 80%. The occurrence of tissue thickening reached 2 times thus narrowing the air capillaries. This may affect heat loss inefficiencies and increased body temperature [10]. As homeotherm animals broiler will perform thermoregulation mechanism and reduce heat production [19], so that technically broiler chickens in this research will perform thermoregulation by lowering the amount of the feed consumption.

3.2. Body Weight Gain and FCR

Broiler chickens have a characteristic of rapid growth, so the need for oxygen also increases rapidly during its growth to support the metabolism process [20]. Previous research conducted by Isroli [21] showed that the average oxygen consumption of broiler chickens on starter phase is 7.63-10.48/hour with a metabolic rate of 866.64-1324.30cal/kg^{0.75}/hour. The higher oxygen consumption will be followed by higher metabolism rate. When fresh air from the outside enters the closed house through the inlet, the broiler placed in the zone near the inlet receives cleaner air with higher oxygen levels. Air shift due to negative pressure and the slowing of air velocity in the further zone from the inlet are contributed to the increased of atmospheric ammonia accumulations in the further placement zones of the inlet (Table 2), this condition substantially worsen the air quality on 3rd and 4th zone which is further from the inlet.

Presumably, lower oxygen availability in 3rd and 4th zone was suspected caused by two things, the first is lower air velocity in the further zone from the inlet causing fresh air volume in smaller quantities. Second, the utilization of oxygen by the chicken population placed in the placement zone near the inlet reducing the availability of oxygen level in the further placement zone from the inlet. This is according to the opinion of [22] that the decrease of air exchange velocity inside a closed house increases the concentration of atmospheric ammonia so that the broiler chicken has a smaller chance of oxygen uptake. Decreased uptake oxygen of chicken placement on the further zone from the inlet suspected of decreasing metabolic rate.

Thermoregulation inefficiency as has been described above was suspected to have an impact on the decline of Triiodothyronine hormones [23,24], which affects the decrease in protein metabolism. The results of the [6] study indicate that an increase in ammonia affects the decline in meat protein mass to the total deposition of protein in broiler chickens. As explained above that decreased oxygen consumption and thermoregulation failure will have an impact on the decrease in metabolic rate, thus the placement further zone from the inlet will undergo a reduction in body weight gain and feed efficiency which is represented with an increase in the FCR value.

3.3. Performance Index (PI)

The performance index is used as a universal index to evaluate broiler performance. The value of PI acquired in this study decreased with the further placement distance from the inlet. It was suspected because of the change of atmospheric ammonia. The change in air quality due to an increase of atmospheric ammonia decline of the feed consumption, body weight gain, and efficiency of feed, thus PI value obtained also decreased. According to [8] that high atmospheric ammonia levels resulted in a significant decline in performance (BWG, FCR, and PI). Good performance is supported by several factors, such as DOC quality, good health condition, feed condition, and optimal microclimate which comfort for growth [25].

Based on our observations and studies, an increase in the atmospheric ammonia levels that occurred in the placement further zone from the closed house inlet at least occurred because of the following: The negative accumulative impact on the further zone from the inlet, greater volatilization opportunities of ammonia and the increased nitrogen output of the excreta due to higher levels of stress contribute to the decrease of broiler performance index. So in principle, the implications of zone changes are the change in distance function and cage volume. Therefore, the author proposed the concept of spatial change of atmospheric ammonia in different placement zones in a closed house. The increased spatial atmospheric ammonia on the further zone from the inlet has negative effects on the PI of broiler chickens and further towards the IOFC.

3.4. Income over feed cost (IOFC)

IOFC is the benchmark for the successful reared of broiler chickens based on economic calculations. This value is derived from the difference between the selling price of chicken (live bird) and the purchase price of feed consumed, greater profit achieved with higher IOFC. The decrease percentage of profit difference in each zone compared to zone 1 are as follows: zone 2 is 7.3%, zone 3 is 13.7% and zone 4 is 18.4% lower than zone 1. The sharper decrease rate of IOFC is presumed to correspond to the higher level of energy allocation shifting for maintenance due to thermoregulation inefficiency. Chickens placed on the zone further from the inlet will allocate a higher portion of the feed energy for maintenance than for growth. The decrease in performance due to the atmospheric ammonia in a closed has an impact on the economic decline [26].

4. Conclusion

Increased atmospheric ammonia in the placement zone further from the inlet decreased the performance of broiler chicken in the rainy season.

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