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THE EFFECT OF BROILER CHICKENS CLOSED-HOUSE FARM DENSITY ON MICROCLIMATE

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Abstract
The microclimate in broiler farms plays an important role in the bird's productivity. Productivity is influenced by a good housing environment to maximize production. This research was carried out to determine the effect of closed-house density on its microclimate to help industries optimize their maintenance and broiler chicken productivity. The research was conducted in March-April 2023 in Pinggirsari Village, Arjasari District, Bandung Regency. The total population of 52,500 broiler chickens of the Cobb CP 707 strain aged 15-32 days and data on their house temperature, humidity, CO_2 levels, and NH_3 levels were calculated on the farm. The researched farm was a closed house farm measuring 12 x 90 m^2, divided into six partitions measuring 12 x 15 m^2, with each partition equipped with a feeding area and nipple drinker, pan feeder, baby chick feeder, and digital thermometer. The results of the study showed that house density had a significant effect on temperature and levels of CO_2 and NH_3. House density had a significant influence on humidity during maintenance in the 4th and 5th weeks. The average house temperature, humidity, and CO_2 levels were 25.17–28.13°C, 70.41% - 82.24%, and 594.13–681.02 ppm, respectively. The 16 birds/m^2 density in a house provided the best microclimate and is still optimal in industrial-scale closed-house farms.
Keywords: broiler, house, density, microclimate, closed-house

PENGARUH KEPADATAN KANDANG AYAM BROILER CLOSE-HOUSE TERHADAP MIKROKLIMAT

Abstrak
Mikroklimat pada kandang ayam broiler berperan penting dalam produktivitasna. Produktivitas dipengaruhi oleh lingkungan kandang yang baik sehingga produksi akan maksimal. Penelitian ini dilakukan untuk mengetahui pengaruh kepadatan kandang close house terhadap iklim mikronya untuk membantu peternakan industri dalam mengoptimalkan manajemen dan produktivitas ayam broiler. Penelitian dilakukan pada bulan Maret-April 2023 di Desa Pinggirsari, Kecamatan Arjasari, Kabupaten Bandung. Jumlah populasi sampel ayam adalah sebanyak 52.500 ekor ayam broiler strain Cobb CP 707 usia 15-32 hari. Data suhu, kelembaban, kadar CO2, dan kadar NH3 diukur di dalam kandang. Kandang yang diteliti berupa kandang close house berukuran 12 x 90 m^2 yang dibagi menjadi enam partisi berukuran 12 x 15 m^2, dengan masing-masing partisi dilengkapi dengan tempat pakan dan tempat minum nipple, pan feeder, baby chick feeder, dan termometer digital. Hasil penelitian menunjukkan bahwa kepadatan kandang berpengaruh nyata terhadap suhu dan kadar CO_2 serta NH_3. Kepadatan kandang berpengaruh secara signifikan terhadap kelembaban selama pemeliharaan pada minggu ke-4 dan ke-5. Rata-rata suhu kandang, kelembaban, dan kadar CO_2 masing-masing adalah 25,17–28,13oC, 70,41% - 82,24%, dan 594,13–681,02 ppm. Kepadatan 16 ekor/m^2 dalam satu kandang menunjukkan mikroklimat terbaik dan optimal di peternakan close-house skala industri.
Kata kunci: ayam pedaging, kandang, kepadatan, iklim mikro, kandang tertutup

INTRODUCTION

Increasing house density is one way to increase the population while optimizing land conditions. The availability of land and the high cost of building closed-house farms are some of the factors that support the growth and development of broiler chicken commodities in Indonesia. One solution to the efficient use of farmland is the application of closed-house farms, which are considered to have great potential for labor and land efficiency. The climate change factors related to global warming are something that must also be taken into account, where extreme conditions with significant differences in day and night temperatures require us to start adapting maintenance technology, especially housing. Closed-house farms are an alternative use of technology that can be used to minimize extreme changes in the existing climate and in general, are more able to manipulate the microclimate in the house.

Livestock productivity is influenced by two main factors, namely genetics and the environment. Superior genetics alone are not enough to display good livestock productivity if environmental factors are uncomfortable for the birds. Livestock productivity can be influenced by any factor, especially the environmental factor. To get maximum productivity, livestock should be in a comfortable environment (comfort zone) (Nuriyasa & Puspany 2017). Likewise, a comfortable livestock or pen environment will not mean much if the livestock being kept do not have high genetic quality. Also explained by Nuriyasa & Puspany (2017), environmental factors can be categorized into two, namely the biotic environment (food, water, microbial development, and livestock social relations), and abiotic where the abiotic environment is the physicothermal condition of the livestock location which concerns the state of climate elements (microclimate).

The microclimate in a closed house farm is more manageable compared to an open house farm, well managed temperature, humidity, wind speed, oxygen requirements and ammonia levels in the house can increase the productivity of broiler chickens. Closed houses are a housing system that has the advantage of removing excess heat, water vapor, and hazardous gasses such as CO, CO_2, and NH_3 from the house, but on the other hand, it can provide oxygen needs for chickens (Prihandanu et al., 2015). Cobb-Vantress (2018) stated that good air changes in closed houses are one way to eliminate heat stress and reduce humidity in the house.

The microclimate in the farm has an important role because livestock productivity itself cannot be separated from environmental factors. Livestock productivity can be influenced by the environment, in which to get maximum productivity, livestock should be in their comfort environment zone (Nuriyasa & Puspany, 2017). On the other hand, no matter how good the livestock's genetics are, if they do not have comfortable environmental conditions, the performance and productivity of the livestock will never be optimal. Some parameters in regulating the microclimate in a house, are temperature, humidity, wind speed, litter condition, oxygen requirements, and maximum CO_2 and NH_3 gas concentration inside the farm. CO_2 and NH_3 gasses are some of the factors that influence productivity and stress levels, where carbon dioxide is produced from livestock respiration and manure. CO_2 production from livestock respiration is higher than from livestock manure, where the total carbon dioxide concentration may have a significant effect on animal health and performance. High concentrations create serious disturbances and reduce livestock yield levels (Karaman & Gokalp, 2017).

The environmental temperature was indicated as a potential factor influencing NH_3 emissions. On the other hand, temperature, pH, water content, carbon/nitrogen ratio, and oxygen content are considered factors that influence NH_3 loss in litter (Yao, et al., 2011). Swelum, et al. (2021) stated that the safe level at which chickens can receive emissions from NH_3 gas is 25 ppm. Low ventilation or high protein feeds are the main causes of long-term exposure of chickens to NH_3 levels higher than recommended (Swelum, et al., 2021). Vantress (2018) explained that good NH_3 is air with an NH_3 content below 10 ppm. When the concentration of NH_3 in the house exceeds normal levels, the cilia are paralyzed or damaged, and mucus cannot be removed from the mucosal surface of the trachea, exposing lung traps and air sacs to bacteria trapped in dust particles (Swelum, et al., 2021).

MATERIALS AND METHODS

The research was conducted in Pinggirsari Village, Arjasari sub-district, Bandung Regency. The research was carried out in March-April 2023. Sampling is done daily starting from chickens aged 15-32 days or during the 3rd week until harvest. Samples were taken at that time because CO_2 and NH_3 levels were only detected starting in the 3rd week. The farm used in this research is a closed house broiler farm measuring 12 x 90 m^2 divided into six partitions measuring 12 x 15 m^2, with each partition equipped with a feeding area and nipple drinker, fan feeder, baby chick feeder, and digital thermometer. The house was first washed using detergent and rinsed, then disinfected using 35% formaldehyde. After that, the floor was given lime powder, husks were added, then fumigation was carried out with 35% formaldehyde and force fumigant.

Microclimate measurements in the house were carried out every day during the maintenance period. In one day, measurements were taken three times, namely at 7 am, 13 noon and 10 pm. Sampling was carried out during the period, from 15 days to the completion of the harvest period, namely 32 days. Microclimate analysis in the farm included measuring temperature and humidity from an installed digital room thermometer and accurately using a Kestrel 3000. CO_2 measurements were carried out by keeping the measuring instrument at chicken level or about 30 cm from the floor. In research conducted by Wardah & Sihmawati (2020), measurements of CO_2 and NH_3 levels were carried out using the Ammonia Gas Detector smart sensor which was placed in the sample house for 2 minutes.

Measured Variables

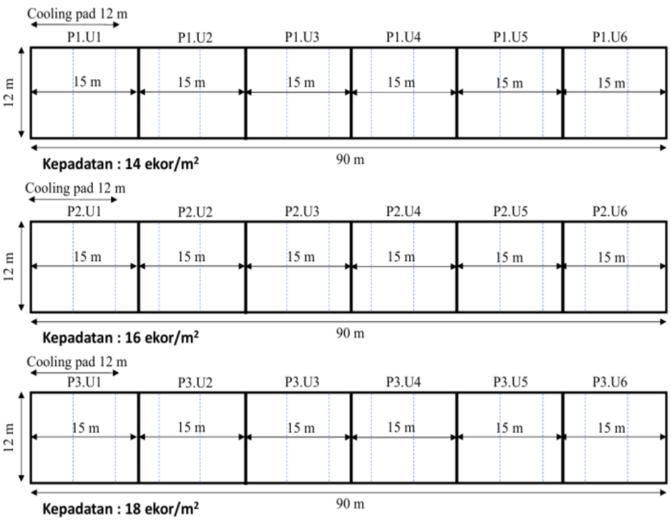
1. Temperature (℃)
   Temperature was obtained by looking at the actual temperature and humidity printed on a digital room thermometer, which is accurate using a Kestrel 3000 (Oktavia et al., 2021)
2. Humidity (%).
   Humidity was obtained by looking at the actual temperature and humidity printed on a digital room thermometer, which is accurate using a Kestrel 3000. (Oktavia et all., 2021)
3. Carbon Dioxide Level (ppm).
   Carbon dioxide level (CO_2) was obtained from measurements using the Smart Sensor AR8200 Carbon Dioxide Detector, to determine the CO_2 level in the house (Hasibuan et all, 2023).
4. Ammonia level (ppm).
   The Ammonia level (NH_3) was obtained from measurements using the Smart Sensor AR8500 Ammonia Gas Detector, to determine the NH_3 levels in the house (Hasibuan et all, 2023).

Research Methods and Data Analysis

The research was carried out experimentally. The design used was a Randomized Block Design with 3 house density treatments and 6 replications on the same floor. The treatments in this study were:

1. P1 = Density of 14 individuals/m ^{2} or 15,000 heads
2. P2 = Density of 16 individuals/m ^{2} or 17,500 heads
3. P3 = Density of 18 individuals/m ^{2} or 20,000 heads

Figure 1. Treatment Layout



Note: The data was analyzed using the Variance Test Method and then to see the differences between treatments, a further test was carried out using the Duncan Test Method (Gaspersz, 1995).

RESULTS AND DISCUSSION

House Microclimate

Temperature in the House

House density had a significant effect on its temperature ($P<0.05$). The average temperature in this study ranged from 25.17 ^{o}– 28.13 ^{o}C. The temperature of the P3 house at weeks 3, 4, and 5 was higher than that of P1 and P2. This was caused by the density of P3 being higher than the other treatments (18 birds/m^2).

A larger population causes the density in the house to be higher so that the temperature in the house increases due to the process of releasing more body heat from the chickens. As explained by Nurfaizin et al, (2014), overcrowded density has negative effects of increasing temperature and humidity in the house. In the third week, the temperature for all treatments ranged from 27.15 – 28.13 ^{o} C. This is in line with Cobb Vantress (2021) which states that the optimum temperature for 3-week-old chickens is 28 ^{o}C. In the fourth week, the house temperature in P3 was 25.73 ^{o}C. Cobb Vantress (2021) reports that the optimum temperature for 4-week-old chickens is 26 ^{o}C. The broiler chickens in adulthood require a cooler temperature so the temperature in the house is lower than the third and fourth weeks.

It is known that in the fourth week, P2 and P3 experienced temperatures above the standard required for chickens because they were 25 days old for P2 and 24 days old for P3 or when the density in the house was 21 kg/m^2. A decrease in the actual temperature in the house was seen again at the age of 26 days after thinning or reducing the population by 30%. As the chicken population decreases, CO_2 output will decrease, resulting in lower coop temperatures. In line with Karaman and Gokalp (2017), CO_2 production originating from livestock respiration is higher than from livestock manure.

Humidity in the House

Based on the results obtained, house density did not have a significant effect on house humidity in the third week but had a significant effect in the fourth and fifth weeks ($P<0.05$). House humidity in this study ranged from 70.41% - 82.24%. In the fourth week, P2 and P3 experienced humidity above the standard required for chickens because at the age of 25 days for P2 and 24 days for P3 or when the density in the house was 21 kg/m^2. Cobb Vantress (2021) explains that the ideal humidity is below the range of 60 – 65%, in other words, the humidity at the research location is higher than recommended. This allows the chickens to experience stress which results in a decrease in the performance of the broiler chickens.

Overcrowding in houses can lead to the accumulation of heat and water vapor, which contributes to increased humidity. According to Nurfaizin et al, (2014) overcrowded farm has a negative effect of increasing temperature and humidity in the farm. According to He et al., (2018) when the ambient temperature is too high, the gastric emptying time and intestinal peristalsis of livestock are prolonged and weakened, thereby reducing digestive function which results in appetite inhibition. This is directly proportional to data on feed consumption and body weight growth which are below company standards.

CO_2 Concentration in the Farm

House density had a significant effect on CO_2 levels in the house ($P<0.05$). The average CO_2 levels in this study ranged from 594.13 ppm – 681.02 ppm. This result is within the CO_2 standard according to Cobb Vantress (2021), namely below 3000 ppm. The results showed that the CO_2 concentration of P1 at weeks 3,4 and 5 was better than P2 and P3. This is caused by a smaller chicken population compared to other treatments. A lower population will result in a lower livestock respiration frequency per individual.

CO_2 production originating from livestock respiration is higher than from livestock manure (Karaman and Gokalp, 2017). The relatively low CO_2 results in this study were a result of good litter management by the company standards. At the initial litter preparation, the husk thickness was 5-8 cm, at the age of 0-14 days the husks were turned, then at the age of 3 weeks until harvest, new husks were added by spreading. This is in line with Calvet et al. (2011), which states that CO_2 levels depend on litter management. It was further explained that the type of litter and the use of new litter from the beginning of the rearing period will reduce microbial activity so that it will reduce CO_2 levels until the end of the rearing period.

NH_3 Concentration in the Farm

Farm density had a significant effect on NH_3 levels ($P<0.05$). NH_3 P1 levels in week 3 were lower than in other weeks, which could be caused by the condition of the husks being still good. NH_3 levels in weeks 4 and 5 were higher than in week 3 which could be caused by higher humidity, which ranged from 79.18% - 82.24%.

According to Garces et. al., (2013) husks can absorb NH_3 and reduce humidity in the house. High humidity causes the husk to become damp so that it can increase bacterial activity to decompose feces which results in increasing NH_3 concentration levels. This is in line with the opinion of Ritz et al., (2009) who stated that damp or wet husks are the cause of NH_3 emission.

The measurement results show that the NH_3 levels in this study are below the NH_3 standard in broiler chicken houses. Cobb Vantress (2021) states that NH_3 levels in the house should be below 10 ppm. Ammonia concentrations above 10 ppm can impact feed consumption, chicken growth, and mortality (Naseem and Annie, 2018). NH_3 levels in chicken coops are produced by chemical and microbial degradation of uric acid excreted by chickens (Bittman and Mikkelsen, 2009).

Table 1. The average temperature in houses with different densities.

Treatment	P1	P2	P3
Week 3 (ºC)	27.15 ± 0.19^a	27.56 ± 0.22^a	28.13±0.18^b
Week 4 (ºC)	25.73 ± 0.15^a	26.29±0.18^b	26.70 ± 0.23^b
Week 5 (ºC)	25.17 ± 0.39^a	25.76±0.18a^b	26.34 ± 0.13^b

Description: Numbers in the same column followed by different letters are significantly different at the 5% test level (Duncan's multiple interval test).
P1: Houses with a density of 14 birds/m ^{2}
P2: House with a density of 16 individuals/m ^{2}
P3: House with a density of 18 individuals/m ^{2}

Table 2. Average humidity in houses with different densities.

Treatment	P1	P2	P3
Week 3 (%)	70.94 ± 0.35	70.95±0.12	70.41 ± 1.59
Week 4 (%)	80.75±0.16^a	81.19 ± 0.45^a	82.24±0.42^b
Week 5 (%)	77.81 ± 0.42^b	79.15±0.61^b	79.72±0.40^b

Description: Numbers in the same column followed by different letters are significantly different at the 5% test level (Duncan's multiple interval test).
P1: Houses with a density of 14 birds/m^2
P2: House with a density of 16 individuals/m^2
P3: Houses with a density of 18 individuals/m^2

Table 3. Average CO_2 in houses with different densities.

Treatment	P1	P2	P3
Week 3 (ppm)	636.61±49.05^a	681.02±40.51^b	776.03±92.85^b
Week 4 (ppm)	591.91±26.54^a	597.08±18.43^a	632.45±20.68^b
Week 5 (ppm)	594.68±25.10^a	594.13±13.23^a	630.96±14.72^b

Description: Numbers in the same column followed by different letters are significantly different at the 5% test level (Duncan's multiple interval test).
P1: Houses with a density of 14 birds/m^2
P2: House with a density of 16 individuals/m^2
P3: House with a density of 18 individuals/m^2

Table 4. Average NH_3 in houses with different densities.

Treatment	P1	P2	P3
Week 3 (ppm)	2.99 ± 0.66^a	3.52 ± 0.58^b	3.88 ± 0.51^b
Week 4 (ppm)	4.14 ± 0.69^{ab}	3.86 ± 0.27^a	4.35 ± 0.86^b
Week 5 (ppm)	3.59 ± 0.67^{ab}	3.56 ± 0.32^a	4.04 ± 0.46^b

Description: Numbers in the same column followed by different letters are significantly different at the 5% test level (Duncan's multiple interval test).
P1: Houses with a density of 14 birds/m^2
P2: Houses with a density of 16 individuals/m^2
P3: Houses with a density of 18 individuals/m^2

CONCLUSION

House density had a significant effect on temperature and levels of CO_2 and NH_3. Humidity had a significant effect during maintenance on house density in the 4th and 5th weeks. The average temperature of the farm was 25.17–28.13 ^{o}C, with an average humidity of 70.41-82.24%, and CO_2 levels of 594.13–681.02 ppm. The density of chickens in a house of 16 birds/m^2 provided the best house microclimate and is still optimal in industrial-scale closed-house farms.

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