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Level of Ammonia, Dust, Production Performance, and Egg Quality of Laying Hens on Cage and Litter System in Tropical Area

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Abstract

High ambient temperature in tropical during rearing period of laying hens cause high level of stress and low productivity. Stress level of laying hens also influenced by the housing system. In Indonesia, most of rearing system of commercial laying hens were cage system (individual cage). So the aim of this study was to evaluate the influence of the housing system (cage and litter) toward the quality of air, production performance, and egg quality of laying hens. A number of 36 laying hens, 30 weeks old were used. They were placed at 2 small closed houses (30^{o}C). The first house was designed as cage system and the second as litter system. Each of it sized 2x2 m^{2}, and it was filled 18 laying hens. This study used completely randomized design. Data of production performance was analyzed by t-test. Data of air quality and egg quality were descriptively analyzed. Ammonia and PM2.5 level in cage system were lower than litter system. Production performances of laying hens in cage system were higher, with the value of feed conversion ratio was 2.20, and it was better significant than litter system (2.61). Thick and percentage of eggshell in cage system were lower than litter system. There was no dirty egg in cage system but it was 16.67% in litter system. It can be concluded that the rearing of commercial laying hens at 30^{o}C in cage system produced higher air quality, production performance, and egg quality than litter system.

Keywords: Housing system; ammonia; PM2.5; production performance; egg quality.

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1. Introduction

According [1], stated that the Egg needs of Indonesian people in 2014 was 1,159,549 ton, and it increased by 5.53% from the previous year. To meet this needs, population of laying hen in Indonesia is very large. In 2013, the population was 147.2 million, and it increased by 6.17% from 2012. Therefore the commercial laying hen was one of potential poultries in Indonesia.

Environmental factor which has great impact on the productivity of the laying hen is temperature. The comfortable temperature (thermoneutral zone) for laying hen is 20-24°C [8]. In this temperature range, laying hen will not produces much body heat, so the use of energy becomes more efficient. The temperature change will be responded quickly by chicken.

The environmental temperature in Indonesia, especially during the daytime (30-34°C), is above of chicken comfortable temperature. This is a major constraint in rearing of laying hen. At high temperature, the laying hen releases the body heat through panting. Respiratory rate of laying hen can increase up to 200 times/minute [17].

One of the physiological characteristic of chicken is the high of metabolic rate. It looks from the high of O2 consumption and of CO2 production. Both of them from chicken nearly twice of other livestock (cow, sheep, horse, and pig) [9].

Combination of these factors (the high of ambient temperatures with physiological characteristics) cause process of digestion and absorption disorders, which in turn produce watery feces. It caused relative humidity in house of chickens increase [16]. This condition can increase the intensity of bacteria to decompose the feces. An increase of decomposition process can lead to increased production of ammonia gas and another gases, and it can cause air pollution in house of chicken.

A decrease of air quality in house of laying hen also influences to the productivity, such as the occurrence a decrease of body resistance, egg production, and egg quality that produced by laying hens. Beside that, an increase of these gases contributing to air pollution in environment around the farm [24].

Most of the laying hen in Indonesia was reared in cage system especially individual cage. So far, it is unknown the impact of environmental temperature in tropical area toward air quality due to rearing of laying hen in cage and litter system, and its association with production performance and egg quality. Base on these condition, so the aim of this study was to evaluate the level of ammonia, dust, production performance, and egg quality that produced by laying hen from rearing on cage and litter in tropical area.

2. Materials and Methods

2.1 Animal Experiments and Rearing

The study was conducted in field laboratory of Poultry Division, Faculty of Animal Science, Bogor Agricultural University. It used 36 laying hens Lohmann strain, 30 weeks aged. The average of body weight of laying hens were 1.89 ± 0.09 kg. 2 small closed houses were used. Each of it measuring 2x2 m^2, and it was equiped with heater and blower as temperature control. The temperature in the house of laying hen was set on 30^{o}C.

Each of houses were filled in 18 laying hens. In first house, laying hen was placed on cage system. The size of cage (individual cage) was 35x45x50 cm^3. In the second house, laying hen was placed on litter system. Every houses of laying hen was equipped with light bulb (75 Watt), feed and water. As material of litter was rice husks.

The feed was commercial feed for laying hen that contain 14-17% of crude protein, and 2850 kcal/kg of metabolizable energy. It was presented in Table 1. Every day, 120 g/hen of feed were given for laying hens. The water was given *ad libitum*. The rearing was carried out for six weeks.

Table 1: Nutrient content of commercial feed of laying hens

Nutrient	Content
Metabolizable energy (kcal/kg)	2 850
Kadar air (%)	13.0
Crude protein (%)	17.0
Crude fiber (%)	6.0
Fat (%)	3.0
Ca (%)	3.0-4.2
P (%)	0.6-1.0

Source : PT Gold Coin Indonesia.

2.2 Measurement of Laying Hens Performance and Eggs Quality

Every day, recording and weighing of egg were done. Every week, feed weighing and calculated of feed conversion ratio (FCR) were done.

$$FCR = \frac{\text{Feed consumption/hen/week (g)}}{\text{Egg production/hen/week (g)}}$$

Every week end, the quality of egg that produced by laying hen was analyzed consisted of: eggshell thickness, eggshell weight, eggshell wholeness, percentage of eggshell dirty, and value of Haugh Unit (HU).

$$HU = 100 \log (H + 7.57 - 1.7 W^{0.37})$$

HU = value of Haugh Unit

H = high of egg weight /albumen (mm)

W = egg weight (g/egg) [12].

2.3 The Assay of Ammonia and Dust Level

The assay of ammonia level and dust (Total Suspended Particulate/TSP and Particulate Measured/PM2.5) were done in Laboratory of Aquatic Environment, Department of Aquaculture, Faculty of Fisheries and Marine Science, Bogor Agricultural University. Air sample for ammonia level analysis was obtained with catch of air from house of laying hens, using impinger with ammonia adsorbent 10 ml. The assay method that was used according to the guidelines of SNI 19-7117.6-2005 [3].

Air sample for dust analysis was obtained through catch of air from house of laying hens, using holder. The method based on the guidelines of SNI 17-7058-2004 [2]. Taking of air sample from house of laying hen was done at the end of 6^{th} week.

2.4 Data Analysis

This study used completely randomized design. As a treatment was housing system (cage and litter). Each of treatment was repeated 18 times. Data of production performances of laying hens were analyzed by t-test [18]. Data of air quality and egg quality were descriptively analyzed.

3. Results

This research was done in August until mid-October, to coincide with the end of dry season period. The laying hen was placed in small closed house system. Temperature in laying hens house was set on 30oC with using heater. The observation of temperature and air humidity in laying hen house was done every day, using digital thermo hygrometer at 06.00, 13.00, and 24.00.

Base on the result of daily recording during the study, it was obtained that temperature and air humidity in laying hen house was fluctuating. The result of it was presented in Table 2. It was caused by effect of environmental temperature in out of the house of laying hens which also fluctuates. The temperature range (in morning, noon, and night) was outside of the comfort zone for laying hen, according to [8].

Table 2: The range of temperature and air humidity in the laying hen house during the study

Variable	Housing system	
	Cage	Litter
Temperature (ºC)	28.10 - 31.50	28.00 - 30.25
Air humidity (%)	87.50 - 92.30	88.63 - 92.00

3.1 Air Quality

The assay of air quality in this study included level of ammonia and dust. Level of dust distinguished in the TSP and PM2.5. The result of assay of air quality was presented in Table 3.

Table 3: Level of ammonia and dust (TSP and PM2.5) in cage and litter system

Variable	Housing system	
	Cage	Litter
NH_3 (ppm)	1.06 ± 0.08	1.12 ± 0.13
TSP (µg/Nm^3)	0.15 ± 0.03	0.16 ± 0.04
PM2.5 (µg/Nm^3)	4.00 ± 0.20	27.00 ± 0.63

3.2 Performance of Production

Production performance of laying hen in this study consisted of feed consumption, henday production, egg weight and feed conversion ratio.

The achievement of production performances in this study were presented in Table 4.

Table 4: The average of feed consumption, hen day production, egg weight, and feed conversion ratio of laying hens in the cage and litter system

Variable	Housing system	
	Cage	Litter
Feed consumption (g/hen/day)	116.85 ± 8.46	120.00 ± 0.00
Henday production (%)	87.70 ± 1.40a	86.45 ± 2.90a
Egg weight (g/egg)	60.44 ± 0.72a	53.25 ± 1.65b
Feed conversion ratio	2.20 ± 0.32a	2.61 ± 0.22b

Note : different letters in the same line indicated statistically differences ($p > 0.05$)

3.3 Egg Quality

Egg quality in this study was presented in Table 5.

Egg quality that was observed included the value of Haugh Unit (HU), eggshell thickness, percentage of eggshell weight, eggshell wholeness, and percentage of egg dirty.

Table 5: Egg quality of laying hens that produced during 6 weeks in cage and litter system

Variable	Housing system	
	Cage	Litter
Haugh Unit	76.70 ± 2.60	73.90 ± 3,80
Eggshell thickness (mm)	0.40 ± 0.06	0.42 ± 0.04
Eggshell weight (%)	11.94 ± 0.65	14.25 ± 0.80
Eggshell wholeness (%)	100.00	100.00
Eggshell dirty (%)	0.00	16.67

4. Discussion

4.1 Air Quality

Ammonia gas is a gas that is colorless and soluble in water. This gas was resulted by microbe, by way of decomposition of nitrogen compounds of feces. Ammonia has no ionic charge, so that can be released to atmosphere in gas form. Ammonia is a main pollutan, especially in chickens farms [7].

Level of ammonia in cage slightly lower than litter system. This result was caused by the air humidity in litter system slightly higher than cage system. This is accordance with statement of [25], that level of ammonia was very affected by the type of laying hens house (litter or cage), housing management as such setting ventilation and humidity.

Nevertheless, the production of ammonia gas from decomposition of feces of laying hens that reared in this both housing system was be on the safe limit. According [10, 21, 20], concentration of ammonia gas at ≥ 5 ppm was harmful threshold for chicken. Ammonia level from laying hen house in this study (1.06-1.12 ppm) was higher than the research result [23], which was stated that ammonia level from broiler house in the same area during 5 weeks rearing was 0.54 ppm.

Level of total suspended particulate (TSP) in cage and litter system were almost the same, but the level of particulated measured (PM2.5) was very different. PM2.5 is particle of dust which has diameter 2.5 µm. PM2.5 in litter system (27 µg/Nm^3) was six times greater than in cage system (4 µg/Nm^3). In litter system, chicken can move and activity with free on a pedestal of litter (rice husk). The friction of rice husk which continues over time, lead to high production of dust which has small diameter in litter system. PM2.5 is particle of dust which is small diameter that very harmful, because it can enter into respiratory system on human and animal, include the laying hens [15].

The high of PM2.5 level in litter system indicated that chance of the occurrence of disease infection that was caused by respiratory disorder on laying hen was high. The observation result during this study was ontained that laying hens showed the symptom of chronic respiratory disease (CRD) infection from cage system was

12%, and from litter system was 31%. CRD clinical symptoms that often appear in the chicken farm was started with come out clear liquid, sneezing, coughing, snoring and conjunctivitis [14].

4.2 Performance of Production

In this study, all of laying hens were given the same feed, and the nutrient content of it was in accordance with the need of laying hens [13], but the average of feed that was consumed by laying hens in individual cage was lower than in litter system. It was because the laying hens that was reared on litter system showed a higher motion intensity, so they needed higher of energy.

Although the average of feed that was consumed by laying hen in individual cage was lower, but the percentage of henday production was not significant different than litter system. Beside that, laying hens which was used in this study from the same strain, so genetically they have the same high production potential.

The average of egg weight that was produced by laying hens in the cage system (60.44 g/egg), higher significant than egg weight from litter system (53.25 g/egg). Laying hens in litter system utilize partly of energy from feed greater than cage system, so the energy for egg production is reduced. It can decrease egg production and egg weight that produced [6].

Statistically, the value of feed conversion ratio of laying hens that reared in the cage system (2.20), lower significant than litter system (2.61). It means that laying hens that reared on high temperature (30^{o}C) in the cage system more efficient in convert the feed into egg than litter system.

4.3 Egg Quality

Haugh Unit (HU) value reflect the quality of egg interior. HU value of egg is constitute correlation between egg weight with high of albumen. This study obtain the HU value of egg that was produced by laying hens in cage system was higher than litter system. Nevertheless, base on standard of [4], both of them included in the same quality (AA), because their HU value $\geq$ 72.

The temperature range during this study in the cage system was higher than litter system. It caused the average of eggshell thickness and the percentage of eggshell weight that produced by laying hens in the cage system were lower than litter system [22]. High temperature in cage system cause the rate of metabolism of laying hen was higher. As a result of it was body heat loss through panting. The increase in panting intensity of laying hens in the cage system cause the decrease of CO_2 concentration in blood [26]. The lower of CO_2 concentration of blood, caused the forming process of $CaCO_3$ was disturbed. $CaCO_3$ is main component of eggshell. This condition caused the eggshell was more thin [19].

From this study not found cracked egg and broken egg. Chance the occurrence of cracked/broken egg in the litter system higher than cage system, but it can overcome with improved of management [11]. During observation in this research, collection of egg was done 3 time/day (at morning, at noon, and at aafternoon). It caused all of eggs that produced in the litter system were not found the cracked/broken egg.

The percentage of dirty egg from litter system was found as much as 16.67%. The criteria of dirty egg base on [22], is if ≥ 1/8 part of the whole surface of egg shell was dirty. All of eggs that produced in cage system were clean. The effort to reduce of dirty egg level from litter system, can do with add the nest in these house.

4.4 General Discussion

The summary of this result research was that rearing of laying hens at high housing temperature in tropical area (30ºC) in cage system produced better air quality. Besides that, it also produced better feed efficiency, and higher egg quality (HU value and percentage of clean egg) than litter system.

Laying hens that rearing in litter system can express their normal behavior, however in cage system, they cannot. It caused due to their limited space to move free. Rearing of laying hens in individual cage, just like make their position as biological factories to change feed become egg with high efficiency. In terms of animal welfare, rearing of laying hens in cage system (individual cage) is a violation.

Therefore, in order to be safer, it was recommended to reare laying hen in litter system. To increase the air quality, performance of production, and egg quality can be done by increase the rearing management. Placing the nest, controlling the house of temperature and air humidity in the rearing environment in tropical area get close to the condition of thermoneutral zone, were the actions that can be done [5].

Laying hen that was reared in cage system (individual cage), in order to be safer, so size of cage should be enlarged, so it can be placed 3-4 hens/cage. Besides that, the cage material and the form of cage should be modified, so laying hen can express their normal behavior.

Limitations of this study is the implementation of the air arrests is difficult because this study using open house cage so the bias is high with the surrounding environment. To measure air quality and performance, it is necessary to use close house system with all good management.

5. Conclusion

Rearing of laying hen at high housing temperature (30ºC) in closed house with cage system produced better air quality, higher performance, more efficient, and higher egg quality than those at litter system.

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