

INTERACTIVE EFFECT OF CAGE DENSITY AND DIETARY BLACK CUMIN LEVEL ON PRODUCTIVE EFFICIENCY IN BROILER CHICKENS

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Received July 17, 2014; Accepted January 08, 2015

ABSTRAK

Penelitian bertujuan untuk mengkaji pengaruh interaksi antara kepadatan kandang dan pemberian jintan hitam terhadap efisiensi produksi pada ayam broiler. Percobaan menggunakan 270 ayam broiler dengan berat badan awal $163,12 \pm 8.10$ g, dialokasikan dalam rancangan acak lengkap pola faktorial 3×3 . Faktor pertama, kepadatan kandang per m^2 yaitu, D1 = 8 ekor; D2 = 10 ekor, dan D3 = 12 ekor. Faktor kedua, level jintan hitam, yaitu B1 = 1%; B2 = 2%, dan B3 = 3%. Parameter konsumsi pakan, pertambahan bobot badan (PBB) dan konversi pakan (FCR) dihitung mingguan. Daya cerna protein, dan income over feed cost (IOFC) diukur pada akhir penelitian. Data dianalisis ragam, dan dilanjutkan dengan uji Duncan. Hasil penelitian menunjukkan bahwa tidak ada interaksi antara kepadatan kandang dan pemberian jintan hitam terhadap semua parameter. Konsumsi pakan dan FCR meningkat, tapi berat badan turun secara signifikan ($P < 0,05$) pada kepadatan 10 dan 12 ekor/ m^2 pada minggu 2 dan 3. IOFC menurun secara signifikan ($P < 0,05$) pada kepadatan kandang dari 10 dan 12 ekor/ m^2 dan efek pemberian 2% jintan hitam. Kesimpulan, peningkatan efisiensi produksi ayam broiler yang dipelihara pada kepadatan kandang 12 ekor/ m^2 dapat dicapai dengan pemberian 1% jintan hitam.

Kata kunci: kepadatan kandang, jintan hitam, edfisiensi produksi, ayam broiler

ABSTRACT

The present research was aimed to evaluate an interactive effect of cage density and level of dietary black cumin (BC) on productive efficiency of broiler chickens. A total of 270 broiler chickens (initial body weight of 163.12 ± 8.10 g) were allocated into a completely randomized design with a 3×3 factorial pattern. The first factor was the cage density (bird/ m^2) namely, D1 = 8; D2 = 10, and D3 = 12. The second factor was BC level (%), namely, B1 = 1; B2 = 2, and B3 = 3. Feed consumption, body weight gain (BWG), feed conversion ratio (FCR), protein digestibility, and income over feed cost (IOFC) were the parameters measured. Data were subjected to ANOVA and continued to Duncan test. No interaction between cage density and black cumin on all parameters was observed. Feed consumption and FCR were increased, but BWG was lowered significantly ($P < 0.05$) due to the cage densities of 10 and 12 birds/ m^2 on weeks 2 and 3. Protein digestibility was significantly increased by feeding 2 and 3% BC. IOFC decreased significantly ($P < 0.05$) when cage densities were 10 and 12 birds/ m^2 . In conclusion, the improvement of productive efficiency of broiler chicken reared at the cage density of 12 birds/ m^2 can be sufficiently achieved by feeding 1% black cumin.

Keywords: cage density, black cumin, productive efficiency, broiler chicken

INTRODUCTION

Broiler chickens are genetically designed to be able to grow fast and efficient in feed

utilization, but immune deficiency becomes very frequent problems. Overcoming such problems, broilers, especially in the tropical region, must be maintained on intensive systems. However,

intensive maintenance requires the provision of all needs of chickens, including housing and feeding managements, which bring about the production cost getting high, and the profit of the farmers gained small. Various ways have been sought to improve management efficiency, such as the increase in density cages, feed supplement administration with the purposes of improving the health and productive performance of the chicken.

The effort of improving productive efficiency via the increasing population of the chickens per unit area of the cage has been investigated previously by some researchers. Škrbić *et al.* (2009) reported that in higher stocking densities the profit per bird of chicken decreases, but total production of meat per unit of floor surface increases which results in higher profit. However, the high density cage had a negative effect on birds performance due to the chickens suffer more stress, and the conditions will be detrimental when oxidative stress activity of free radicals exceeds the antioxidant levels. Free radicals have the ability to easily attack the polyunsaturated fatty acids in the cell membrane called lipid peroxide (Sahin *et al.*, 2002). Feeding substances containing thymoquinone (TQ) as an antioxidant is one of the efforts to overcome the heat stress in tropical reared broilers. Antioxidant, such as thymoquinone (TQ), play an important role by changing the form of free radicals into the safely binding compound to stop the activity of lipid peroxides, thus, it could lowers suffering from stress and resistance to disease.

Thymoquinone (TQ) is an active component found in black cumin which serves as an antioxidant, anti-infection, anti-tumor and anti-inflammatory (Ragheb *et al.*, 2009). A study showed that the administration of black cumin containing thymoquinone (2-isopropyl-5-methylbenzo-1,4-quinone, $C_{10}H_{12}O_2$) as antioxidant can lead to significant improvements, the leukocyte count, hemoglobin and alanine aminotransferase (Al-Homidan *et al.*, 2002; Hermes *et al.*, 2011; Al-Zahrani *et al.*, 2012). Other studies showed that adverse effects, such as decreased leukocyte count, hemoglobin, spleen and bursa fabricius weights have been observed in very high cage density reared broilers (Haryono, 2009). Effect of heat stress due to cage density was too high had an impact on the blood hormone ACTH (adrenocorticotrophic hormone) and brought about the fall of the activity that affect the white blood cells (leukocytes) and an increase in lymphocytes (Siegel and Latimer, 1984; Virden

and Kidd, 2009; Kusnadi, 2009).

TQ can reduce the impact of heat stress by increasing antioxidant activity against the effects of free radicals, but there were few studies on the effects of stress due to the high cage density or high number of chickens per unit area of the cage. Rearing management of the chickens with high cage density, especially in the tropical region, is greatly possible to suffer stress and results poor growth or productive performance. The failure of achieving maximum production will be possible to be overcome by feeding feedstuff, such as black cumin, or other substances containing TQ. Feeding thymoquinone (TQ) derived from black cumin in the present study, is assumed to be a potent substance to avoid adverse effect of stress due to the high cage density, and finally improve health condition and productive performance. The purpose of this research was to improve the efficiency of broiler chicken productivity, through the management of the cage (cage density) and black cumin administration.

MATERIALS AND METHODS

Experimental Animal and Ration

Experimental animals of the present study were 270 birds of 8 days old broiler with an average initial body weight of 163.12 ± 8.10 g (CV = 0.50%). Prior to the feeding dietary treatment, from 1 to 7 days old the chickens were kept in a rice hull floored brooder cage, and fed a commercial diet with 23% crude protein and 2900 kcal/kg of metabolizable energy. Chickens at the age of 8 days were weighed and the uniform body weight were selected then allocated randomly into 27 units of experimental cage. Experimental diets (Table 1) were provided for 27 days, starting on day 8 and completed when the chickens were 35 days old. Feeding trial was divided into 2 periods, namely, from age of 8 to 21 days (a continuation of starter period) and from age of 22 to 35 days (finisher period).

Experimental Design, Parameters and Statistical Analysis

The present experiment was assigned in 3x3 factorial scheme of a completely randomized design with 3 replicates. The first factor was cage density (D), namely, normal density/D1 (8 birds/m²) moderate/D2 (10 birds/m²), and high/D3 (12 birds/m²). The second factor was the inclusion level of black cumin powder (B), namely 1%/kg

Table 1. Composition and Nutritional Content of Experimental Diet

Experimental Diet	Starter	Finisher
	(8 – 21 days)	(22 – 35 days)
	----- % -----	
Ingredient		
Yellow corn	53.00	55.00
Rice bran	13.00	16.00
Soybean meal	19.00	15.00
Fish meal	6.00	6.00
Meat bone meal	7.00	6.00
Cassava flour	2.00	2.00
Total	100,00	100.00
Nutritional content (calculated value, %)		
Metabolizable energy (kcal/kg)	2,929.89	2,937.86
Crude protein-	21.21	19.21
Ether extract	4.55	4.50
Crude fiber	6.09	6.21
Calcium -	1.25	1.28
Phosphorus	0.62	0.63
Methionine	0.39	0.37
Arginine	0.72	0.71
Lysine	1.35	1.23

ration (B1), 2% kg ration (B2), and 3%/ kg ration (B3).

Feed consumption, body weight gain (BWG), and feed conversion ratio (FCR) were the parameters measured weekly. Protein digestibility was measured on day 35 using total collection method combined with indicator of chromic oxide (Suthama, 2003), and calculated with the formula of McDonald *et al.* (2002) as follow:

$$\text{Protein Digestibility} = \frac{[(\text{Protein Consumption} - \text{Protein Excreta}) / \text{Protein Consumption}] \times 100\%}{1}$$

Productive efficiency was measured according to income over feed cost (IOFC). Data were subjected to analysis of variance and continued to Duncan test to determine the difference between treatments mean (Steel and Torrie, 1991).

RESULTS AND DISCUSSION

Feeding black cumin at the levels of 1, 2 and

3% did not affect ($p>0.05$) weekly feed consumption. However, cage density significantly ($P<0.05$) affected feed consumption (Table 2) especially on week 3 the cage density of 12 birds/m² showed the highest value compared to both levels of density (8 and 10 birds/m²). The significant different of feed consumption was also found between the cage density of 8 and 10 birds/m². Abudabos *et al.* (2013) stated that feed intake is influenced by the density of the cage. The contradictory finding was reported by Kuan *et al.* (1990) that the average daily feed intake significantly reduced with the increase in stocking density, during the entire experimental period. It was found that birds on the lowest stocking density (0.095 m/bird) consistently consumed more amount of feed. However, in the following weeks, cage density had no effect on feed intake, indicated by the feed intake on weeks 4 and 5 were not significantly different due to various cage densities. This is because the chicken has

Table 2. Effect of Cage Density on Feed Consumption, Body Weight Gain and Feed Conversion Ratio of Broiler Chicken on Week 2 to 5

Parameter	Cage Density (bird/m ²)		
	8 (D1)	10 (D2)	12 (D3)
Week 2			
- Feed Consumption (g)	363.57	368.89	371.08
- Body weight gain (g)	273.88 ^a	272.81 ^a	259.15 ^b
- Feed Conversion Ratio	1.35	1.36	1.44
Week 3			
- Feed Consumption (g)	410.78 ^c	500.02 ^b	519.01 ^a
- Body weight gain (g)	416.16 ^a	382.18 ^b	384.25 ^b
- Feed Conversion Ratio	1.07 ^b	1.31 ^a	1.36 ^a
Week 4			
- Feed Consumption (g)	512.06	525.98	543.44
- Body weight gain (g)	367.60	374.99	372.89
- Feed Conversion Ratio	1.41	1.45	1.47
Week 5			
- Feed Consumption (g)	864.60	887.27	917.11
- Body weight gain (g)	327.76	318.78	321.84
- Feed Conversion Ratio	2.68	2.80	2.87

Values in the same raw followed by different superscript indicate significant difference (P<0.05)

been able to adapt to the unfavorable effects of density, i.e. heat stress. Chicken is homeo-thermic animals, which can adapt to the effects of environmental heat. Previous researcher (Škrbić *et al.*, 2009) confirmed that the effect of stocking density was primarily on body mass, and also on feed consumption and conversion. Similarly, Abudabos *et al.* (2013) also stated that there was negative effect of high stocking density in equal space of feeding per chicken on body mass. The present study demonstrated the exciting results because it was observed that chickens reared at the high cage density can adapt after week 4, and there was no significant effect on feed intake. There was a similarity to the finding of Kuan *et al.* (1990) that the chickens when they were kept in the cage density of 8, 10 and 12 birds/m², feed consumption was different on week 2, but no change in feed consumption on the following weeks (weeks 4 and 6). The fact supported the observed data of the present study that the birds

reared with the lowest stocking density were more flighty and active. Conversely, birds at the higher stocking densities were relatively less active and this behavioral physiology probably served to minimize heat loss and resulting lower caloric demand, and hence reduced appetite. Younger birds (week 2) started to be suffered due to the high cage density which was supported by the slightly decrease in feed consumption and significantly reduced body weight gain (Table 2). The clear negative response indicated by the increase in feed consumption and decrease in body weight gain were observed on week 3 with high cage density. Since feed consumption increased and body weight gain decreased, it caused higher feed conversion ratio. After week 3 and thereafter (week 4 and 5) cage density did not affect body weight gain. The chicken has been able to adjust their body physiologically to adapt to the change in environmental factors (i.e. cage density).

Dietary inclusion of black cumin until 3% did not affect body weight gain of broiler chicken (Table 2). The result of this study was not consistent with that of Khan *et al.* (2012) who reported that dietary inclusion of black cumin had variable effects on chicken performance and indicated that birds fed dietary black cumin of 2.5 or 5.0% had significantly greater body weight gain than that fed with 1.25% black cumin diet and the negative control. Same result was found by Amada and Radman (2013) that the average daily weight gain (g/bird/d) significantly ($p < 0.05$) increased only for birds received 2.5% black cumin compared to control (without black cumin) birds. Ashayerzadeh *et al.* (2009) compared the feeding effects of black cumin, garlic, wild mint and control groups, and showed that body weight gain significantly increased in group of feeding black cumin than others. Since no significant effect was found due to the inclusion of black cumin until 3% in the present study, thus, it provides the meaning that feeding black cumin did not support growth of broiler chicken, although the health status increased. The result implies that the inclusion of 1% black cumin in the diet can be categorized as enough level because further inclusions did not improve weight gain.

Cage density was found to have significant ($P < 0.05$) effect on body weight gain (Table 2). Body weight gain significantly ($P < 0.05$) decreased to be the lower value on week 2 due to cage density (12 birds/m²), and the value was still lower as compared to that of low density on week 3, but it was the same to that of medium density. However, on week 4 and 5 cage density did not affect body weight gain. This is because the chicken has been able to adjust to environmental

condition (density of the cage) thereafter. Amada and Radman (2013) demonstrated their study results that there were no significant ($p > 0.05$) differences in the body weight gain of 12 weeks old indigenous chicken due to the effect of different densities (among 4, 5 and 6 birds/m²). These results suggest that the positive exerting effect of active substance of black cumin brought about the chickens become stronger and more susceptible to unfavorable condition. It has been reported previously (Kusnadi and Djulardi, 2011; Tamzil *et al.*, 2013, and Ali *et al.*, 2014) that the health and maintenance of the chicken at various cage densities could be improved by dietary inclusion of black cumin on weeks 3. This biological process of adaptation went to be stable until the completion of the study since there was no effect on those of chickens on week 5 of observation. Ansari *et al.* (2008) stated that supplementary feeding effect of natural additives such black cumin powder could improve the performance of broiler chickens. The improved body weight gain was supported by the value of protein digestibility was not changed when measured at the end of the experiment (Table 3). Protein digestibility, the parameter is closely related to final output such as body weight gain, was maintained at the same value due to cage density, but it was increased significantly by the dietary inclusion of black cumin at higher levels (Table 3). Result of the present study was in agreement with the report of Nasir and Grashorn (2010) that cumin powder containing an active substance, such as thymoquinone, dithymoquinone, thymol and carvacrol, can improved the digestibility and absorption of nutrients by stimulating digestive enzymes. The chemical constituents of plant-derived feedstuff

Table 3. Effect of Cage Density and Black Cumin on Protein Digestibility

Cage Density(bird/m ²)	Level of Black Cumin (%/kg)			Average
	1 (B1)	2 (B2)	3 (B3)	
	----- % -----			
8 (D1)	73.78	73.62	74.86	74.09
10 (D2)	72.80	72.15	73.51	72.82
12 (D3)	70.17	75.31	75.02	73.50
Average	72.25 ^b	73.69 ^a	74.46 ^a	

Mean values in the column followed by different superscript indicate significant difference ($P < 0.05$)

(black cumin) used in the present study might exert its improving effect on the digestive enzymes. Protein digestibility improvement of the birds fed black cumin (*Nigella sativa*) may probably be due to the fact that ethyl ether extracts of the seed can inhibit growth of intestinal pathogenic bacteria such as *S. aureus* and *E. coli*. The decrease in the growth of pathogenic bacteria population could improved nutrients utilization by the host as reported by Hanafy and Hatem (1991) and Jamilah *et al.* (2013). When the load of these bacteria in the intestine is low, birds may absorb more nutrients, thus it lead to the improvement in body weight gain. It was reported that phytogetic substances are usually supposed to improve performance of birds by stimulating secretion of digestive enzymes leading to enhanced nutrient digestion and absorption (Vidanarachchi *et al.*, 2005; Recoquillay, 2006 and Levic *et al.*, 2008). Furthermore, the presence of active ingredients and phenolic compounds can reduce numbers of intestinal pathogens, thus nutrient loss is minimized and performance of the birds can be improved. Both effects may result better intestinal health and may lead to more protein deposition into body tissues.

Feed consumption increased and, on the other hand, body weight gain decreased significantly ($P<0.05$) on week 3, thus it caused the increase in feed conversion ratio (Table 2). Medium and high densities significantly ($P<0.05$) increased feed conversion to be higher than low density. This phenomenon provides the meaning that the higher density brought about the lower nutrients utilization efficiency, especially at the early stage of life (weeks 2 and 3), although protein digestibility was the same (Table 3). The

results at early age or at starter period (weeks 2 and 3) can be well understood that when the chickens could not adapted to unfavorable environment, such as suffering heat due to cage density, and the level of body resistance decreased (Kusnadi and Djulardi, 2011; Tamzil *et al.*, 2013 and Ali *et al.*, 2014) and in efficiency nutrient utilization (Saputra *et al.*, 2013). However, on the contrary, the physiological condition of the chickens can be assumed to be gradually adapted to the cage density since feed consumption and body weight gain on weeks 4 and 5 were recovered to be the same value although it kept at the high cage density. This phenomenon can be explained by the dietary inclusion of black cumin containing active substance, called thymoquinone, can act slowly according to the increasing age of the chickens (finisher period). The fact supported the mechanism was indicated by the improved protein digestibility (Table 3) due to feeding effect of black cumin, especially the higher inclusion levels (2 and 3%). Similar result was reported by Kuan *et al.* (1990) that feed conversion of birds at the three higher levels of stocking densities (15, 17 and 21 birds/m²) were significantly better than that of the birds at the lowest one. It is interesting that feed conversion, however, started to reduce at the end of the fourth week. By the end of the sixth week of the experiment, feed conversion of birds at the medium and high density was similar to those of two higher cage densities. Results of previous researches (Škrbić *et al.*, 2009) confirmed that the effect of stocking density was not only primarily on body mass, but also conversion of feed.

Income over feed cost (IOFC) to be the important consideration in maintaining broiler to achieve productive efficiency. The change in

Table 4. Effect of Cage Density and Black Cumin on Income over Feed Cost

Cage Density (bird/m ²)	Level of Black Cumin (%/kg)			Average
	1(B1)	2 (B2)	3 (B3)	
----- IDR -----				
8 (D1)	11,724	10,343	10,214	10,760 ^a
10 (D2)	10,234	8,318	9,884	9,479 ^b
12 (D3)	10,767	8,556	7,491	8,938 ^b
Average	10,908 ^a	9,072 ^b	9,196 ^{ab}	

Mean values in the same column and raw followed by different superscript indicate significant difference ($P<0.05$)

performance of the birds is closely related to the income over feed cost (IOFC). High cage density significantly ($P < 0.05$) lowered the value of IOFC. There was no interaction between cage density and feeding level of black cumin on IOFC (Table 4). However, IOFC value of the birds kept in the low cage density (8 birds/m²) was found to be the highest (IDR 10,761) compared to that in high density (12 birds/m²). According to Škrbić *et al.* (2009) that the negative effect of high cage density reduced body mass, and finally decreasing IOFC due to the low selling value of chicken.

CONCLUSION

The improvement of productive efficiency of broiler chicken kept at the cage density of 12 birds/m² can be sufficiently achieved by feeding 1% black cumin, although on the first 2 or 3 weeks needs the physiological adaptation to balance the body to the cage temperature.

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