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The Effect of Feeding Time Restriction During the Starter Period on Compensatory Growth and Thyroid Hormone Concentrations of Broiler Chickens

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Abstract: The objective of the study was to evaluate the effect of feeding time restriction during starter period on compensatory growth and thyroid hormone concentration of broiler chickens. Four hundred of 7 days-old unsexed broiler chicken of Ross commercial strain were used a completely randomized design with 4 treatments. The treatments were: broilers were fed *ad libitum* as control group (P-0); broilers had to feed during 15 h/d (07:00 to 10:00; 12:00 to 15:00; 17:00 to 20:00; 22:00 to 01:00; 03:00 to 06:00) from 7-21 d of age (P-1); broilers had free access to feed during 12 h/d (07:00 to 10:00; 13:00 to 16:00; 19:00 to 22:00; 01:00 to 04:00) from 7-21 d of age (P-2); broilers had free access to feed during 9 h/d (07:00 to 10:00; 15:00 to 18:00; 23:00 to 02:00) from 7-21 d of age (P-3). The treatments consisted of 5 replicates with 20 chicks per pen. Feed intake and body weight gain of feeding time restriction broiler (P-3, P-2 and P-1) was significantly lower than broiler fed *ad libitum* (P-0) during 7 to 21 d of age. During this period, feed conversion ratio of P-3 had better than P-0, P-1 and P-2. There were no significant difference among all treatments on feed intake, body weight gain and feed conversion ratio during realimentation period. There were significantly lower T_3 and T_4 of all feeding time restriction broiler than broiler fed *ad libitum*. However, T_3 and T_4 were normalized during realimentation period. It was concluded that feeding time restriction during starter period had compensatory growth phenomenon and similar body weight with control and thyroid hormones profile were normalized during realimentation period.

Key words: Broiler, compensatory growth, thyroid hormone, feeding time restriction

INTRODUCTION

The problems of raising broiler chickens in conventional open-sided house in tropical countries are constantly facing the challenge of excessive heat and humidity. This condition can have damaging effect on performance of broiler chickens. Al-Aqil *et al.* (2009) reported that raising birds in conventional open-sided houses under the hot, humid tropical environment depressed growth, feed intake and feed conversion ratio of broiler chickens. Metabolic heat production associated with feeding and digestion can be a significant contributor for the heat stress of broilers, particularly during hot hours of the day. For these reason, early feed restriction recommended to tackle this problems. Studies of Zulkifli *et al.* (2000) proposed that early age feed restriction appears to be beneficial in improving growth and survivability of female broiler chickens exposed to heat stress later in life.

Some variations of feed restriction including limiting the time of daily access to feed (Khetani *et al.*, 2009; Onbasilar *et al.*, 2009; Mohebodini *et al.*, 2009), removal of feed for up to 8 h a day or skip-a-day feeding, allowing birds to feed only once/h and feeding once every other day (Demir *et al.*, 2004; Khajali *et al.*, 2007; El-Fiky *et al.*, 2008; Benyi *et al.*, 2009, 2010; Boostani *et al.*, 2010; Saffar and Khajali, 2010), have been evaluated but

results have been conflicting (Navidshad *et al.*, 2006; Cornejo *et al.*, 2007; Khetani *et al.*, 2009; Ghazanfari *et al.*, 2010). However, later studies have shown that intermittent feeding through free access to feed during four periods of 2 h (0600-0800, 1200-1400, 1800-2000 and 2400-0200) from 7-21 d of age had lower on body weight gain than control but had no effect on weight gain during realimentation period from 22 to 42 d of age (Mohebodini *et al.*, 2009). Moreover, Banong and Hakim (2011) reported that fasting program up to 4 h daily (11:00-15:00) during 14 to 28 d of age had no effect on broiler performance. Such inconsistencies may relate to different feeding strategies applied which may affect the chick performance.

Feeding time restriction is a feed restriction schedule which chicks have daily free access to feed for 4 and 8 h/d in specific time. It is an alternative lower intensity of early feed restriction (Zhan *et al.*, 2007) and it is less stressful (Susbilla *et al.*, 2003). Such conditions may be possible due to broilers eat to their maximal physical capacity (Bokkers and Koene, 2003) during the feed availability. De Silva and Kalubowila (2012) found that when feed was offered after three hours of deprivation (13:00-16:00), broilers consumed higher amounts of feed (compensatory feed intake) within first two hours (16:00-18:00), compared to the feed intake of *ad libitum*

group during the same time period. Possibly, mild feed restriction strategies are more appropriate to achieve the beneficial effects of feed restriction without adverse effects on final body weight. Therefore, it is assumption that the feeding time restriction is not severe and it allows the recovery of body weight at market age.

Controversy of compensatory growth phenomenon during realimentation period showed inconsistency result. These differences showed that growth is still a complex phenomenon due to the physiological aspects involved such as the role of thyroid hormones triiodothyronine (T_3) and thyroxine (T_4) as the controlling metabolism are not widely disclosed. In chickens, the metabolism is controlled by a variety of hormones that form a complex system directly affecting growth. Previous researches in chickens showed that feed restriction modified the levels of hormones T_3 and T_4 that modulate energy metabolism and growth (Buyse *et al.*, 2000; Decuypere *et al.*, 2005; Zhan *et al.*, 2007). However, it is not clear whether feeding time restriction can reduce thyroid hormone concentration during realimentation period. The objective of the study was designed to investigate the effect of feeding time restriction during starter period on compensatory growth and thyroid hormone concentration of broiler chickens.

MATERIALS AND METHODS

Chickens, feed and housing: A total of 400 unsexed Ross broiler chicks bought from commercial hatchery (PT Super Unggas Jaya Tbk, Lampung, Indonesia), were used in the study. All chicks were fed commercial standard broiler starter crumble (21% CP) and finisher pellet (19% CP) diets from 1 to 21 and 22 to 42 days, respectively. The commercial feed purchased from Poultry Shop (manufacture by PT Cheil Jedang Superfeed, Serang-Banten Indonesia). Water was available at all times. The chicks were reared under continuous lighting during experimental period (5 weeks). All the chicks were reared in a conventional open-sided house with natural cyclic temperatures (minimum, 20°C; maximum, 34°C). The chicks were assigned to 20 floor pens with 20 chicks/pen (1xwxh; 2x1.5x0.75 m).

Treatments and experimental design: Broiler chickens had free access to feed from 1 to 6 d of age. On 7 d, all birds were weighed and randomly allotted to each of four treatments. The treatments were: broilers were fed *ad libitum* as control group (P-0); broilers had to feed during 15 h/d (07:00 to 10:00; 12:00 to 15:00; 17:00 to 20:00; 22:00 to 01:00; 03:00 to 06:00) from 7-21 d of age (P-1); broilers had free access to feed during 12 h/d (07:00 to 10:00; 13:00 to 16:00; 19:00 to 22:00; 01:00 to 04:00) from 7-21 d of age (P-2); broilers had free access to feed during 9 h/d (07:00 to 10:00; 15:00 to 18:00; 23:00 to 02:00) from 7-21 d of age (P-3). The treatments were

arranged in a completely randomized design with 5 replications. All data were analyzed based on ANOVA and the significant differences between treatment means were determined by Duncan's multiple range test. All statements of significance are based on testing at $p < 0.05$. (Steel and Torrie, 1991).

Performance, blood sampling and variables measure:

Body weight gain and feed intake were measured weekly. On d 21 (end feed restriction) and 35 (end realimentation period), blood samples were collected from a brachial vein of 2 chicks randomly selected birds from each pen using disposable syringe (± 3 ml/chick). The blood samples were collected directly into test tube with anticoagulant Ethylene Diamine Tetra acetic Acid (EDTA). Thereafter, the blood samples were centrifuged at 3000 rpm for 5 minutes and plasma was harvested and kept frozen at -30°C until analyzed. Hormone analyses (T_3 and T_4) on the plasma samples were performed by Radio Immuno Assay (RIA). It is a solid phase monoclonal antibody and radiolabel using ^{125}I (Izotop, Institute of Isotopes Co Ltd, Budapest, Hungaria). The range of standard to made curve standard of T_3 concentration from 0.1 to 100 nmol/dl. T_3 concentration was analyzed directly in the plasma with a volume 100 μl . The range of standard to made curve standard of T_4 concentration from 10 to 1000 nmol/dl. T_4 concentration was analyzed directly in the plasma with a volume 25 μl . Each sample was in duplicate determination and radioactivity T_3 and T_4 were counted by gamma counter.

RESULTS

Feed intake and growth performance: The responses of feed intake and growth performance of broilers to early feeding time restriction is as presented in Table 1. Feed intake of feeding time restriction broiler (P-3, P-2 and P-1) was lower ($p < 0.05$) than broiler fed *ad libitum* (P-0) during feed restriction from 7 to 21 d of age. Among the group feeding time restriction, feed intake of P-3 was lower ($p < 0.05$) than P-2 and P-1. During realimentation period from 21 to 35 d of age, feed intake of all feeding time restriction broiler were not significantly differences than P-0. Body weight gain and body weight of feeding time restriction broiler (P-3, P-2 and P-1) was lower ($p < 0.05$) than broiler fed *ad libitum* (P-0) during 7 to 21 d of age. Among the group feeding time restriction, body weight gain and body weight of P-3 were lower ($p < 0.05$) than P-2 and P-1. During realimentation period, growth rate of all feeding time restriction was no significantly differences than broiler fed *ad libitum* from 21 to 35 d of age. Because there was no statistical difference among the final body weight at 35 d of age, near full compensatory growth was achieved. Feed conversion ratio of P-3 was lower ($p < 0.05$) than P-0, P-1 and P-2

Table 1: Body weight gain, feed intake and feed conversion ratio in broiler chicken subjected to feeding time restriction

Performance	Treatments			
	P-0	P-1	P-2	P-3
Body weight (g/chick)				
7 d	115.31±4.77	115.81±2.05	115.71±4.39	115.66±3.90
21 d	776.58±8.17 ^a	760.23±4.24 ^b	749.04±5.33 ^c	724.38±10.14 ^d
35 d	1854.52±13.55	1854.84±55.19	1810.42±13.47	1817.99±32.58
Body weight gain (g/chick)				
7 to 21 d	661.26±8.45 ^a	644.42±4.67 ^b	633.32±5.90 ^c	608.72±9.37 ^d
21 to 35 d	1077.95±14.41	1094.61±52.39	1061.39±17.15	1093.62±23.74
7 to 35 d	1739.21±14.02	1709.03±55.44	1694.71±12.23	1702.34±31.77
Feed intake (g/chick)				
7 to 21 d	893.57±6.40 ^a	876.24±8.80 ^b	854.13±17.36 ^c	801.90±10.69 ^d
21 to 35 d	1880.36±59.98	1892.13±60.24	1864.82±94.08	1923.58±37.82
7 to 35 d	2773.93±62.39	2768.37±67.20	2718.96±102.31	2725.48±41.62
Feed conversion ratio (g:g)				
7 to 21 d	1.35±0.02 ^a	1.36±0.02 ^a	1.35±0.02 ^a	1.32±0.01 ^b
21 to 35 d	1.74±0.04	1.73±0.07	1.76±0.09	1.76±0.05
7 to 35 d	1.60±0.03	1.59±0.04	1.60±0.06	1.60±0.03

^{a,b,c,d}Mean within a row with no common superscripts differ at p<0.05.

Broiler chicks fed *ad libitum* (P-0); broilers had to feed during 15 h/d (07:00 to 10:00; 12:00 to 15:00; 17:00 to 20:00; 22:00 to 01:00; 03:00 to 06:00) from 7-21 d of age (P-1); broilers had free access to feed during 12 h/d (07:00 to 10:00; 13:00 to 16:00; 19:00 to 22:00; 01:00 to 04:00) from 7-21 d of age (P-2); broilers had free access to feed during 9 h/d (07:00 to 10:00; 15:00 to 18:00; 23:00 to 02:00) from 7-21 d of age (P-3)

Table 2: The concentrations of triiodothyronine (T₃) and thyroxine (T₄) in the plasma of broilers chicken subjected to feeding time restriction

Thyroid hormones	Treatments			
	P-0	P-1	P-2	P-3
Triiodothyronine; T ₃ (nmol/l)				
21 d	1.34±0.09 ^a	1.17±0.03 ^b	1.01±0.09 ^c	0.94±0.09 ^c
35 d	0.89±0.21	0.78±0.07	0.95±0.13	0.93±0.13
Thyroxine; T ₄ (µg/dl)				
21 d	5.67±0.69 ^a	5.02±0.23 ^b	3.92±0.31 ^c	3.72±0.28 ^c
35 d	5.43±0.45	5.66±0.69	5.53±0.19	5.40±0.17

^{a,b,c}Mean within a row with no common superscripts differ at p<0.05.

Broiler chicks fed *ad libitum* (P-0); broilers had to feed during 15 h/d (07:00 to 10:00; 12:00 to 15:00; 17:00 to 20:00; 22:00 to 01:00; 03:00 to 06:00) from 7-21 d of age (P-1); broilers had free access to feed during 12 h/d (07:00 to 10:00; 13:00 to 16:00; 19:00 to 22:00; 01:00 to 04:00) from 7-21 d of age (P-2); broilers had free access to feed during 9 h/d (07:00 to 10:00; 15:00 to 18:00; 23:00 to 02:00) from 7-21 d of age (P-3)

during 7 to 21 d of age. However, there was no significant difference among all the treatments on feed conversion ratio during 21 to 35 d of age.

Thyroid hormones profile: Effect of feeding time restriction on thyroid hormones concentration was presented in Table 2. Hormone T₃ and T₄ concentrations of feed restricted broilers (P-3, P-2 and P-1) had significantly lower (p<0.05) than those *ad libitum* broilers (P-0) at 21 d of age. There were no differences among P-2 and P-3 on T₃ and T₄ concentrations during this period. At the end period of realimentation (35 d of age), T₃ and T₄ concentrations in all feed restricted broilers were no differences than those *ad libitum* broilers.

DISCUSSION

The present study showed that feeding time restriction decreased feed intake and body weight gain for 14 d

feed restriction. Our findings suggest that feeding time restriction reduced feed intake and growth rate. These may be due to limiting availability of feed for chicks during feed restriction to supply energy and nutrient for support optimal tissues growth. Some factors that may influence growth rate of broiler during feed restriction such as limiting intake of nutrients and energy for tissues growth (Hornick *et al.*, 2000), decreasing thyroxin concentration (Hassanabadi and Moghaddam, 2006; Rajman *et al.*, 2006) and decreasing enzyme activity of protein digestion (Susbilla *et al.*, 2003). These results were agreement with Mohebodini *et al.* (2009) have found that intermittent feeding through free access to feed during four periods of 2 h (06:00-08:00, 12:00-14:00, 18:00-20:00 and 24:00-02:00) from 7-21 d of age had lower feed intake (629.6 vs 736.9 g) and body weight gain (436.3 vs 495.3 g) than control. Similar observation reported that broilers were fed to meal feeding with feeding times from 08:00-12:00 h and

13:00-17:00 h during 5 to 11 d of age (Saffar and Khajali, 2010) or 08:00-12:00 h and 16:00-20:00 h during 7 to 21 d of age (Azis *et al.*, 2011) had lower feed intake and body weight gain.

Assumption that feeding time restriction can reduce feed intake and growth rate during realimentation period is not exhibited. Our results show that chickens which have been deprived during certain times of the day for longer period were able to compensate growth during realimentation period and reached the market weight equal to those fed *ad libitum*. However, restricted feeding did not result in a decrease in feed intake. Gous and Cherry (2004) reported that a period of slow growth for chickens subjected to early feed restriction is usually followed by a period of rapid growth when the chicken approaches the final stages of its growth. The fast rate of body weight gain compensates for the delayed growth that occurred during the first week realimentation period. These results are consistent with previous reports (Lippens *et al.*, 2002; Dozier *et al.*, 2002; Teimouri *et al.*, 2005; Rezaei *et al.*, 2006; Zhan *et al.*, 2007; Mohebodini *et al.*, 2009; Saffar and Khajali, 2010).

Stress induced by feed restrictions may reflect in dramatic change plasma thyroid hormones. Some studies in chickens showed that the feed restriction may modified the concentration of hormones that modulate energy metabolism and growth, such as hormone T₃ and T₄ (Decuypere *et al.*, 2005; Zhan *et al.*, 2007). In the present study, during the feeding time restriction period, there was a lower concentration of thyroid hormones in feed restricted broilers. This result was in agreement with the previous study of Zhan *et al.* (2007) that the concentration of hormones T₃ (1.7 vs 2.1 ng/ml) and T₄ (55.3 vs 60.5 ng/ml) in feed withdrawal for 4 h/d (14:00 to 18:00) from 1 to 21 d of age were lower than the control. This fact in line with growth performance of broilers declined during the feeding time restriction. This might be caused by the low basal metabolism and thus allows the organism to spare energy by decreasing basal metabolism (Hornick *et al.*, 2000). Therefore, it was supposedly that metabolic rate decreased during feed restriction causes hormonal activity associated with energy metabolism and growth declined.

During realimentation period, there were not significant differences between all treatments concerning the thyroid hormones concentration. These findings indicate that T₄ and T₃ concentrations of the feed restricted broiler were normalized and remain as the value of *ad libitum* broilers during realimentation period. Zhan *et al.* (2007) reported that the concentration of T₃ (1.1 vs 1.0 ng/ml) and T₄ (63.3 vs 65.7 ng/ml) in feed withdrawal for 4 h/d (14:00 to 18:00) from 1 to 21 d of age were not differences than the control during the period of realimentation from 21 to 62 d of age. It suggests that degree of feed restrictions applied was not severe because there was a very fast adaptive response with small and transient alterations in T₃ and T₄

concentrations during the period of realimentation. This might be caused by increased activity of the enzyme deiodinase type III (D3) during the realimentation period would recover concentrations of T₃ hormone (Darras *et al.*, 2000; Gyorffy *et al.*, 2009).

Conclusion: Based upon findings of the study, feeding time restriction with free access to feed during 9 h/d (07:00 to 10:00; 15:00 to 18:00; 23:00 to 02:00) during starter period had compensatory growth phenomenon and similar body weight with control and profile of thyroid hormones (T₃ and T₄) were normalized during realimentation period.

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