



Growth Performance and Carcass of Two Different Strains of Broilers Subjected to Different Feed Restriction Methods

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ABSTRAK

Tujuan penelitian ini adalah untuk menganalisis apakah ada perbedaan performa pertumbuhan pada dua strain ayam berbeda yang diberi pakan komersial dengan metode *ad libitum* atau terbatas. Sebanyak 216 ekor DOC ayam broiler dialokasikan pada 6 perlakuan dengan 6 ulangan dan ada 6 ekor/ulangan. Percobaan menggunakan rancangan acak lengkap pola faktorial 2x3, yaitu 2 strain, dan 3 cara pemberian pakan, 1) *ad libitum* sesuai pedoman Cobb 500 sebagai kontrol, 2) pembatasan kuantitas (45% dari konsumsi harian *ad libitum*), 3) pembatasan waktu (pakan diberikan 10 jam/hari). Pembatasan pakan pada umur 8–21 hari, kemudian ayam diberi pakan *ad libitum* sampai umur 35 hari. Hasil penelitian menunjukkan bahwa terdapat interaksi yang nyata ($P < 0,05$) antara strain ayam dan metode pembatasan pakan terhadap bobot badan, konsumsi ransum, konversi ransum, lemak abdominal, karkas, dan potongan primal karkas. Performa pertumbuhan dan karkas ayam strain A dan B yang diberi pembatasan kuantitas pakan dapat setara dengan pemberian secara *ad-libitum*. Konversi ransum dan lemak abdominal pada strain A dan B yang diberi pembatasan pakan nyata ($P < 0,05$) lebih rendah dari pada pemberian pakan secara *ad libitum*. Kesimpulan, pembatasan pakan secara kuantitas dapat diterapkan pada strain A dan B untuk memperbaiki konversi ransum dan mengurangi lemak abdominal.

ABSTRACT

The study aimed to analyze if there is a difference in the growth performance of two different strains that were fed commercial diets with either *ad libitum* or restricted methods. Two hundred sixteen (216) broiler chicks were allocated to 6 treatments with 6 replicates of 6 chicks/replicate. The experiment used a factorial design 2x3 with 2 strains, and 3 feeding methods, as follows: 1) *ad libitum* defined in Cobb 500 guidelines as control, 2) quantity restriction (45% of the daily *ad libitum* consumption), 3) time restriction (standard feed offered for 10h/d). Chicks were exposed to feed restriction from 8-21d. Then, the chickens were fed *ad libitum* until 35 days of age. The results showed that there was a significant interaction ($P < 0.05$) between strains and feed restriction methods on body weight, feed consumption, feed conversion, abdominal fat, carcass, and carcass primal cuts. The growth performance and

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carcass of chicken strains A and B that were given feed quantity restrictions were equivalent to ad-libitum feeding. The feed conversion and abdominal fat in strains A and B that were given feed restrictions were significantly ($P < 0.05$) lower than those given ad libitum feeding. In conclusion, feed restriction in quantity can be applied to strains A and B to improve feed conversion and reduce abdominal fat.

1. Introduction

Genetic improvements of modern broiler chickens now have led to a very fast growth rate. However, this growth rate is accompanied by increased body fat deposition, high mortality, ascites, and lameness (Blois, *et al.*, 2019; Ebeid *et al.*, 2022). These situations most commonly occur with broilers that consume feed ad libitum. Thus, feed restriction has been proposed to reduce these problems.

The methods of feed restriction have been evaluated in several ways, including limiting the amount of time chickens can access food in a given day (Bordin *et al.*, 2021; Tumova *et al.*, 2022), removing food for up to 8 hours at a time or skip a day feeding, and feeding only once every other day (Boostani *et al.*, 2010; Saffar and Khajali, 2010). However, results have been inconsistent (Khetani *et al.*, 2009; Ghazanfari *et al.*, 2010). These variations occur because many factors influence compensatory gains, such as restriction type applied, the age of application, severity, and genetic factors, such as strain. Different strains of broiler chickens may have different body characteristics that will lead to different growth and carcass yields.

Most research on feed restriction and compensatory growth was done 2 decades ago, but genetic companies continue to increase broiler growth potential (Zuidhof *et al.*, 2014). Therefore, some of the outcomes of older literature may not be applicable today. Recent literature shows that feeding 70% of ad libitum in week 2 might be beneficial to reduce fat pad, but later feed restriction in week 3 may reduce breast muscle weight at broiler processing age (Van der Klein, *et al.*, 2017). According to Novet *et al.* (2009), feed restrictions of 50% and 25% did not affect FCR, whereas restrictions of 50% decreased body weight at 42 days. According to Van der Klein *et al.* (2017), by day 35, the broiler's body weight, feed conversion ratio, and fat pad did not significantly change after receiving a 30% feed restriction therapy. The effects of moderate levels of feed limitation during the grower stage are still unknown. Therefore, the purpose of this study was to examine the effects of 45% feed restriction and a skip day feeding during the

grower period (8–21 days) on the growth performance and carcass of two commercial broiler strains.

2. Materials and Method

2.1. Birds' management and housing

Two commercial broiler strains (strain A and strain B) were used in this research. All birds were weighed individually after they arrived from the poultry shop, the average initial weight of chicks was 44 ± 1.27 g/chick. At the start of the experiment (8d) the average weight of chicks was 175 ± 1.85 g/chick. The selection and allocation procedure was such that the mean group weights were the same and contained a similar range of body weights; birds with extremely low or high body weights were discarded as were sick birds. Mortality was recorded daily and the weight of dead birds was recorded. The trial was carried out in a poultry cage on the university campus for 5 weeks. Chicks were vaccinated at the hatchery for Newcastle disease. From day-old chicks to 35 days of age were housed in experimental cages. The cage temperatures were between 33°C and 35°C on day 1 and were lowered stepwise to 27°C by week 1. Clean and dry rice husks as bedding were spread on the floor of the cage approximately 5 to 7 cm. Additional bedding was added to cages if needed.

2.2. Broilers diet

Chickens were provided with a commercial starter diet (CP511) until 3 weeks of age. Then, from 3 to 5 weeks of age, all chickens were given commercial finisher diets (CP512). Feed and water were provided ad libitum which were adequate to meet their nutritional requirements according to age. The diets were formulated according to the needs of chickens recommended by SNI (2015). The composition of starter and finisher diets can be seen in Table 1.

Table 1. Nutrition composition of broiler starter and finisher diet

Nutrition (%)	Starter diet	Finisher diet
EM (Kkal/kg)	3000	3100
Crude protein (%)	20,00	19,00
Crude fat (%)	5.00	5.00
Crude fibre (%)	5.00	6.00
Ca (%)	0,80-1,10	0,80-1,10
P (%)	0,50	0,45

Source : SNI (2015)

2.3. Experimental design

Two hundred sixteen (216) broiler chicks were allocated to 6 treatments with 6 replicates of 6 chicks/replicate. The experiment method used a completely randomized design, factorial arrangement 3x2 to analyze the interaction between treatments. The treatment were 3 feeding methods, and 2 strains of broiler (broiler strain A and strain B). The three feeding methods were as follows: P1 = ad libitum consumption defined in Cobb 500 guidelines, as a control; P2 = quantity restriction (45% of the daily ad libitum consumption defined in Cobb 500 guidelines); and P3= time restriction (feed offered for 10h/d). The research was terminated at 35 days of age. Chicks were exposed to feed restriction from 8 to 21 days of age. Following the restriction period, the chickens were fed ad libitum. Chickens from each strain were standardized to a similar weight.

2.4. Data collection

Feed intake and weight gain were recorded weekly. Weekly weight gain is computed as follows: body weight at the end of the week minus body weight at the beginning of the week. Feed intake was calculated using the formula: Feed issued (g) + feed added – Feed residue (g). The feed conversion ratio (FCR) was determined by dividing feed intake by the body weight gain of the birds over the experimental period. At day 35 after 8h of feed withdrawal, two average chickens from each replicate were individually weighed, slaughtered, bled, de-feathered, and eviscerated. Carcass weight is obtained by weighing the weight of the chicken after slaughter and subtracting the blood, feathers, head, legs, and viscera organs. Carcass weight and weight of individual cuts (breast, leg quarter, wings, and abdominal fat) were recorded. The breast (pectoralis major and minor) includes the skin and sternum. The leg quarter comprises thighs and drumsticks. The yields of carcass cuts were evaluated relative to the live body weight (BW) of sacrificed birds at 35 d and expressed as percentages (Soeparno. 2009).

2.5. Statistical analysis

The data obtained were analyzed statistically using analysis of variance with the help of SPSS software version 32 according to a Completely Randomized Design with a 3x2 factorial pattern with 6 replications. If there are differences between treatments, continue with Duncan's multiple range test, the significant level was set at $P < 0.05$.

3. Result and Discussion

The effect of feed restriction, strain, and their interaction on growth performance of broiler chickens is given in Table 2.

Table 2. The effect of feed restriction, strain, and their interaction on the growth performance of broiler chickens

Treatment	Body weight (g)			Feed intake (g)			Feed conversion ratio		
	0-14d	15-35d	0-35d	0-14d	15-35d	0-35d	0-14d	15-35d	0-35d
Feed restriction									
P1	364.8 ^a	1712.7 ^a	2077.5 ^a	533.6 ^a	2962.7 ^a	3496.3 ^a	1.46 ^a	1.73 ^a	1.68 ^a
P2	356.8 ^a	1703.7 ^a	2060.5 ^a	434.3 ^b	2906.1 ^a	3340.4 ^a	1.22 ^b	1.71 ^a	1.62 ^b
P3	357.2 ^a	1551.7 ^b	1908.86 ^a	430.9 ^b	2696.8 ^b	3126.8 ^b	1.19 ^b	1.68 ^a	1.59 ^b
P-value	0.067	0.002	0.104	0.004	0.002	0.004	0.00	0.137	0.002
Strain									
A	362.87 ^a	1680.8 ^a	2043.67 ^a	466.4 ^a	2877.8 ^a	3309.6 ^a	1.30 ^a	1.71 ^a	1.62 ^a
B	356.33 ^a	1631.3 ^a	1987.43 ^a	466.1 ^a	2866.5 ^a	3332.7 ^a	1.35 ^a	1.76 ^a	1.65 ^a
P-value	0.346	0.213	0.233	0.411	0.672	0.331	0.231	0.324	0.11
Interaction between feed restriction and strain									
P1A	369.70 ^a	1724.3 ^a	2094.0 ^a	534.3 ^a	3018.7 ^a	3553.0 ^a	1.45 ^a	1.75 ^a	1.65 ^b
P1B	359.90 ^a	1701.1 ^a	2061.0 ^a	532.9 ^a	3010.4 ^a	3543.3 ^a	1.48 ^a	1.77 ^a	1.72 ^a
P2A	358.88 ^a	1718.0 ^a	2076.9 ^a	434.8 ^b	2912.3 ^a	3347.1 ^a	1.21 ^a	1.70 ^a	1.61 ^b
P2B	354.77 ^a	1689.4 ^a	2043.8 ^a	433.9 ^b	2899.8 ^a	3333.7 ^a	1.22 ^a	1.72 ^a	1.63 ^b
P3A	360.02 ^a	1600.1 ^a	1960.12 ^b	430.22 ^b	2702.5 ^b	3132.7 ^b	1.19 ^a	1.69 ^a	1.60 ^b
P3B	354.33 ^a	1603.2 ^b	1957.5 ^b	431.66 ^b	2689.9 ^b	3121.1 ^b	1.19 ^a	1.79 ^a	1.59 ^b
P-value	0.067	0.002	0.004	0.004	0.002	0.003	0.112	0.244	0.002

Means followed by the same superscripts in each row and each parameter are not significantly different at the 5% level

3.1. The effect of feed restriction and strain and their interaction on body weight gain of broiler

There was an interaction between strain and feed restriction methods on body weight gain. Feed restriction by time given to strain A (P3A) or strain B (P3B) was significantly lower ($P < 0.05$) from restricted by quantity in body weight of broilers strain A (P2A) and B (P2B). Feed restriction by quantity can be given to strain A or strain B without affecting body weight gain. This study showed that chickens given the quantity restriction method were able to compensate for the weight lost during the restriction program. This study shows that weight loss during early feed restriction in chickens can be compensated by 21 to 35 days of the refeeding period. A delayed fast growth on 8-21 days enabled the restricted chickens to catch up with growth. However, in the time restriction method, both strain A (P3A) and B (P3B) were unable to reach an acceptable body weight at the end of the rearing period.

The body weight of strain B that was given time restriction feeding (P3B=1857.55g/b) was significantly lower than strain B chickens fed ad libitum (P1B =

2061g/b). Conversely, Novel *et al.*, (2009) and Lee and Leeson (2001) showed that body weight reached slightly higher values than those of ad libitum-fed chickens.

Feed restriction by quantity was not significantly different ($P>0.05$) from ad libitum in the body weight of broilers. But, feed restriction by time significantly ($P<0.05$) decreased chickens' body weight. At 15-35 days of age, broiler given time restriction feeding resulted in lower body weight ($P_3=1551.7$ g) than ad libitum method ($P_1=1712.7$ g). Feed restriction programs by time reduced the initial growth rate and affected the final weight. The lowest final weight was found in broiler fed time restriction (1908.86g), followed by quantity restriction (2060.5g). This was also found by Dozier *et al.*, (2003) and Butzen *et al.*, (2015) that time restriction (feed offered 8h/d) slows down broiler growth in the early stages.

The initial body weight (1-14d) of strain A (357.6g/b) was not significantly different ($P>0.05$) from the body weight gain of strain B (342.3g/b). Also, during the whole period of research (1–35d) body weight gain of strain A (2038.4 g/b) broiler was not significantly ($P>0.05$) different from strain B (1973.5 g/b). Both strains A and B were selected for higher body weight and faster growth. This study shows that different strains did not provide different growth, even though each strain has different characteristic growth patterns. Generally, studies comparing different strains of broiler found that strain affects performance. Vargas *et al.* (2020) reported that two different strains of broiler have significantly different weight gain, feed intake, and feed conversion ratio. Orso *et al.*, (2019) demonstrated inconsistency in compensatory growth due to genetic factors. Changes in broiler chicken genetics over the last 30 years are reflected in the growth performance. Numerous bird strains with different phenotypic characteristics are now being marketed as a result of these alterations. Breed-specific variations in broiler strains' growth performance metrics are typically caused by variations in the genetic composition of various breeds (Nangsuay *et al.*, 2017)

3.2. The effect of feed restriction and strain and their interaction on feed intake of broiler

The effect of feed restriction and strain on feed intake of broiler is given in Table 2. There was an interaction between strain and restriction methods on feed intake. At 1–35 d, the feed intake of both strain A and B subjected to time restriction feeding (P_3A and P_3B) was significantly ($P>0.05$) lower than the feed intake of chicken subjected to

quantity restriction feeding (P2A and P2B). This research shows that quantity feed restriction for a short period followed by refeeding results in catch-up growth that is accompanied by an increase in feed intake. Agree with Zhan *et al.* (2007) who reported that feed restriction increases feed intake. Another result from Jahanpour *et al.*, (2015) found that birds fed 75 % of the advised daily feed intake for 14 days were heavier than the control group.

The amount of feed intake after the restriction period can be related to the hypertrophy of the gastrointestinal tract that occurs after the quantity restriction period. Sahraei (2012) found that the restricted-refed broiler chickens exhibited a relative expansion of their digestive organs, particularly their gizzard, crop, pancreas, and liver, which all contribute to boosting feed intake and support compensatory growth. Sahraei (2012) also found when compared to the *ad libitum* method, broiler chicks on restricted feed exhibited a higher feed intake to body weight. Therefore, increased feed intake to body weight; and the corresponding changes in the digestive system appear to be significant contributors to any growth compensation.

Different strains of broiler did not give different feed intake significantly ($P>0.05$). During the whole period of study (0-35d), the feed intake of strain A was 3344.3g and strain B was 3329.5g. The similarity of feed intake of both strains A and B could be due to the similar characteristics of these two genotypes in terms of growth performance and development of their digestive organ.

3.3. The effect of feed restriction and strain and their interaction on FCR

The effect of feed restriction and strain on feed conversion ratio is shown in Table 2. It can be seen that there was an interaction ($P<0.05$) between feed restriction and strain on FCR. Strain A and B subjected to restriction feeding (both quantity and time restriction method) was significantly ($P<0.05$) better FCR than *ad libitum* method. Weight gain and feed intake of broiler fed restricted by quantity positively correlated with the FCR. The FCR of broilers subjected to quantity restriction feeding was 1.61, while in FCR of broilers fed *ad libitum* was 1.70. Both strains A and B did not provide significant differences ($P>0.05$) in FCR. It has been demonstrated that early feed restriction, especially between 8 and 12 days of life, is a workable way to improve FCR. Feed restriction can result in leaner body mass, as the body prefers protein and water deposition

over fat, which is more effective at turning feed into meat. Birds can compensate for early feed restriction by consuming more feed and growing faster later in their cycle, which could result in a final weight that is comparable to or better than ad libitum feeding.

3.4. The effect of feed restriction and strain and their interaction on carcass

The effect of feed restriction and strain on carcass, breast weight, and abdominal weight are given in Table 3.

Table 3. The effect of feed restriction, strain, and their interaction on carcass performance of broiler chickens

	Carcass (g)	Breast (g)	Legs (g)	Wings (g)	Abdominal fat (g)
Feed restriction					
P1	1421.17 ^a	419.24 ^a	383.67 ^a	95.93 ^a	17.67 ^a
P2	1414.99 ^a	410.48 ^a	381.93 ^a	91.88 ^a	11.43 ^b
P3	1204.34 ^b	347.22 ^b	325.08 ^a	72.34 ^b	10.81 ^b
P-value	0.003	0.003	0.146	0.002	0.002
Strain					
A	1354.1 ^a	418.94 ^a	365.49 ^a	86.03 ^a	13.99 ^a
B	1339.57 ^a	365.68 ^a	361.62 ^a	87.39 ^a	12.61 ^a
P-value	0.476	0.654	0.201	0.114	0.233
Interaction					
P1A	1424.23 ^a	441.44 ^a	384.48 ^a	99.68 ^a	18.15 ^a
P1B	1418.12 ^a	397.04 ^a	382.86 ^a	92.17 ^a	17.18 ^a
P2A	1428.85 ^a	442.68 ^a	385.56 ^a	85.68 ^a	12.67 ^b
P2B	1401.14 ^a	378.27 ^a	378.27 ^a	98.07 ^a	10.19 ^b
P3A	1209.23 ^b	372.70 ^a	326.43 ^a	72.74 ^b	11.16 ^b
P3B	1199.45 ^b	321.74 ^b	323.73 ^a	71.94 ^b	10.45 ^b
P-value	0.001	0.004	0.127	0.004	0.002

Means followed by the same superscripts in each row and each parameter is not significantly different at the 5% level

A significant interaction ($P < 0.05$) was observed between feed restriction and strain on carcass weight (Table 3). Strain B subjected to the time restriction feeding method had significantly ($P < 0.05$) lower carcass weight than other treatments. Quantity restriction and ad libitum method did not give significant ($P > 0.05$) difference in carcass weight of both strain A and B. This is because the final weights of broiler-fed quantity restriction and chickens fed ad libitum were not significantly different ($P > 0.05$). However, the carcass weight of broilers subjected to time restriction feeding was significantly lower

($P < 0.05$) than the other group. Some reports show an effect of feed restriction concerning reducing carcass weights at slaughter (Leeson and Summers, 2001), whereas others show no effect or even show an increase in carcass weight (Elia *et al.*, 2012; Mirshamsollah, 2013). Jahanpour *et al.*, (2015) found that birds fed 75 % of the advised daily feed intake for 14 days had heavier carcasses ($P < 0.05$) than those in the control group.

Strain does not have a significant effect ($P > 0.05$) on carcass weight. The carcass weight of strain A (1354.1 g) and strain B (1339.57 g) did not give a significant difference ($P > 0.05$). It was expected because the two chicken strains used in this research were the result of crossing superior chickens through strict selection for good body conformation growth, thus producing carcasses that were not significantly different. Carcass weight indicates selection for a rapid growth rate.

3.5. The effect of feed restriction and strain and their interaction on carcass primal cuts

The breast weight of chicken fed quantitative restriction was significantly lower than the ad libitum feeding method ($P < 0.05$). The highest breast weight (1421.17 g) was obtained by chickens fed ad libitum. Consistent with carcass weight assessment, the breast weight of broilers fed ad libitum was higher compared with birds fed quantitative restriction. Different from Tumova *et al.* (2022) who reported an increase in breast muscle weight after a feed restriction regime. The difference could be due to that this study did not differentiate the sex of the chicken. This may be what causes the difference in the chicken carcass cuts. According to Butzen *et al.* (2015), males are more capable of depositing nutrients than females due to their greater growth potential, and these disparities become more noticeable as they age. Males exhibit higher protein deposition rates up to 28 to 35 days, whereas females have maximal deposition rates up to 21 to 28 days (Butzen *et al.*, 2015).

The size and function of the digestive tract may also be impacted by feed restriction, which could have an impact on the absorption of nutrients necessary for the growth of the whole carcass as well as its component components (breast, legs, and wings). According to Saffar and Kajali (2010), the internal organ weight of restricted birds is lower than that of the control group. Orso *et al.*, (2019), in contrast, discovered that the relative weight of the organs of the digestive system during the restriction phase was typically higher than in the control group.

There was no significant effect ($P>0.05$) of strain on breast weight. The breast weight of strain A (418.94 g) and strain B (365.68 g) did not give a significant difference. This could be due that the body weights of strain A and strain B were not different significantly. The results of this study indicate that strains that do not differ significantly in their body weight may also not be significantly different in other body characteristics.

3.6. The effect of feed restriction and strain and their interaction on abdominal fat weight

It can be seen in Table 3 that the abdominal fat of broiler fed ad libitum was significantly ($P<0.05$) higher than the abdominal fat of broiler fed restricted diet. This result may be related to the energy and crude protein intakes being lower in the quantity and time restriction groups. According to Yang *et al.*, (2010), feed restriction lowers abdominal fat by increasing fatty acid oxidation and preventing hepatic lipogenesis. According to Ghazanfari *et al.*, (2010), broiler body fat production and fat storage occur in two stages. Initially, the rate of fat cell multiplication is dominating; later, fat storage becomes increasingly noticeable until the third week of life, when the rate of fat storage takes over. Thus, the reduced rate of lipocyte proliferation may account for the potential for feed limitation to lower body fat weight (Tan and Ohtani, 2000).

Wu *et al.* (2012) found that feed restriction lowered the body fat content by decreasing the hepatic activity of enzymes. Tan and Othani (2000) confirmed that quantitative feed restriction decreased the activities of the main lipogenic enzymes in the livers of White Pekin ducks. Sahraei (2012) stated that broilers will consume more than two to three times their maintenance needs if feed is provided ad libitum; and some of the dietary energy is wasted as abdominal fat instead of being used to produce edible parts of meat. Zhan *et al* (2007) found that feed restriction did not appear to decrease the number of abdominal fat cells. Yang *et al.*, (2010), on the other hand, demonstrated that at 42 days of age, the number of lipocytes in the abdominal fat of the restricted chicks reduced, but the size of the cells remained the same as in the control. According to Wu *et al.* (2012), feed efficiency and abdominal fat were unchanged by skip-a-day feeding for 14 or 28 days during the starter and grower periods.

4. Conclusion

The growth and carcass performance of chickens subjected to quantity restriction feeding (45% of the daily ad libitum consumption in two weeks) can compete with the performance of chickens fed ad libitum, but implementing time restriction feeding (10h/d) improve feed conversion ratio and reduce abdominal fat in modern chicken strains.

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