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The effect of physical feed restriction during the starter period on broilers' performance

Somaia Mohamed Alkhair

Department of Animal Production, Faculty of Agricultural Sciences, Alzaeim Alazhari University, Sudan.

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An experiment was conducted in a completely randomized design to study the effect of physical feed restriction on broilers' performance during the starter period. Two hundred and forty one-day-old unsexed (Hubbard) broiler chicks were randomly distributed in six treatments; there were five replicates with eight chicks per a replicate. Treatment A: fed ad libitum (control). Restricted groups were restricted at selected percentages of the ad libitum intake of the full fed controls. The percentages were: B= 90%, C= 80%, D= 70%, E= 60% and F= 50%. Feed restriction was applied from 8-28 days of age. The experiment lasted for six weeks. Control birds showed significantly ($p<0.05$) higher body weight and carcass cuts weight than restricted ones. Feed conversion ratio was not affected by feed restriction regimen applied in the present study. Restricted birds failed to compensate for the loss in weight due to prolonged feed restriction period.

Key words: Broiler chicks, performance, physical feed restriction, starter period.

INTRODUCTION

Eating to full gut capacity was believed to guarantee maximum weight gain during the rearing period. So, to achieve this goal, management practices concerning broiler nutrition and welfare are thus established (NRC, 1994). Broilers also were genetically selected to gain more weight in shorter time with better feed conversion. These broiler strains are characterized by fast growth rates ((Netshipale et al., 2012) and over-consumption of feed (Mirshamsollahi, 2013). This led to increased mortality and culls due to ascites and skeletal abnormalities (Yagoub and Babiker, 2008; Tumova et al., 2002; Netshipale et al., 2012) and increased fat deposition (Yu and Robinson, 1992). As a result, management practices concerning feed and feeding have been changed to reduce the bad effects resulting from ad libitum feeding. Such practices aim to reduce the early growth rate of these modern strains. These practices include changing feed quantity and quality. Researches applied different early feed restriction programs to reduce growth rate. These programs may result in synchronizing the speed of growth of different body organs and decrease bad effects of rapid growth (Balog et al., 2000; Ozkan et al., 2006; Leeson and Summers, 2009), improve the efficiency of feed utilization and weight gain (Mahmood et al., 2007) and decrease the feed cost (Tolkamp et al., 2005; Zhan et al., 2007; Yang et al., 2009; Sahraei, 2012). Feed restriction means feeding chicks with a diet that does not meet the nutritional

E-mail: somaya4557@yahoo.com. Tel: 00966571316404.

Table 1. Composition of the experimental diets (%).

Ingredients (%)	Starter	Finisher
Sorghum	67.5	71.65
Groundnut cake	25	20
Super concentrate	5	5
Lime stone	1.7	1
Lysine	0.15	Not added
Methionine	0.2	Not added
Tallow	0.2	2
Anti mycotoxin	0	0.1
Salt	0.25	0.25
Total	100	100

Reference: calculations were based on The Nutrient Composition of Sudanese Animal Feeds (1999).

requirements for normal growth. It is achieved by limiting feeding time, or reducing amount of feed offered to the birds or changing the quality of feed by reducing protein or energy or both. Early feed restriction depends on compensatory growth phenomenon (Leeson and Zubair, 1996) in which restricted birds compensate for the weight loss during restriction period when feed restriction is over. The objective of the present study is to evaluate how six levels of physical feed restriction during the starter period influence broiler chicks' performance.

MATERIALS AND METHODS

Experimental birds

Two hundred and forty 1-day-old (Hubbard) broiler chicks were tested for performance in this experiment. The birds were reared as one group for one week (adaptation period). At day 8 of their age, these chicks were weighed and distributed amongst cages so that the mean body weight in each cage and their variations were nearly identical. Then they were allotted randomly to six treatment groups such that each treatment received five replicates with eight chicks per a replicate. Each replicate was kept in a separate pen measuring 1 × 1 m^2. The chicks in group A were fed *ad libitum* and served as control. The birds in groups B, C, D, E and F were kept on a feed restriction program from 8-28 days. The chicks were restricted at selected percentages of the *ad libitum* intake of the full fed controls. The birds were kept under similar management conditions like space, light, and vaccination in an open-sided poultry house up to the age of six weeks. Fresh and clean water was available *ad libitum* during the experimental period. The experiment was carried out at the Animal Production Research Center, Khartoum North, Sudan.

Restriction program

Broiler chicks were restricted at selected percentages of the *ad libitum* intake of the previous 24 h feed consumption of full fed controls (X% multiplied by amount of feed intake of controls at the previous 24 h); (A) ad libitum feeding; (B) 90% of ad libitum; (C) 80% of ad libitum; (D) 70% of ad libitum; (E) 60% of ad libitum; (F) 50% of ad libitum. The amount of feed is daily calculated and offered to the chicks. At the end of the week the left overs are weighted and feed intake is calculated.

Experimental diets

All birds received the same pre-starter diet to 7-days of age. They received the starter diets to 28 days old, and the finisher diet from 29 to 42 days old (Tables 1 and 2). All diets were formulated to meet the nutrient requirements per NRC (1994) with sorghum and groundnut cake.

Data collection

Feed intake, body weight, weight gain were recorded weekly. Then, feed conversion ratio is calculated for all treatments. The data were collected in group basis. At day 42 after feed was withheld for 12 h, ten birds from each treatment were selected for carcass and carcass cut weights.

Statistical analysis

In this experiment, birds were assigned to the six dietary treatment groups following a completely randomized design (CRD). The experimental units were replicate cage means. All data were analyzed using the One- Way ANOVA procedure for analysis of variance. Significant differences among treatments were identified at 5% level by Duncan's Multiple Range Tests (1955).

RESULTS

Effect of physical feed restriction during 8-14 days-old

The results of the effect of physical feed restriction on performance during 8-14 days old are presented in Tables 2 and 3. The results showed that full fed birds had significantly higher ($p<0.05$) body weight, weight gain and feed intake than restricted ones. Among restricted birds, 90% fed birds consumed more feed and gained more weight ($p<0.05$) than the other restricted groups. Feed

Table 2. Calculated nutrients and determined analysis of the experimental diets.

Ingredients	Starter	Finisher
ME (kcal/kg)	2951	3121
Crude protein (%)	23	21
Crude fiber (%)	4.4	4.01
Ether extract (%)	3.81	5.54
Methionine (%)	0.54	0.59
Lysine (%)	1.27	1.01
Ca (%)	1.34	1.10
Available phosphorus (%)	0.55	0.53
Determined analysis		
ME (kcal/kg)	3086	2995
Dry matter (%)	94.10	92.20
Ash (%)	8.93	5.01
Crude protein (%)	21.92	16.81
Ether extract (%)	3.2	3.8
Crude fiber (%)	4.4	4.00

Composition of the super concentrate: ME =2300 kcal/ kg, CP =37%, EE = 4.5%, CF =7.5%, Ca=6.0, P=6.5, Lysine=11.0, Methionine =4.2.

restriction regimes used in the present study had no effect on feed conversion ratio except for 60% fed birds which showed the poorest feed conversion ratio ($p<0.05$).

Effect of physical feed restriction during 15-21 days-old

The results of the effect of physical feed restriction on performance during 15-21 days old are presented in Tables 2 and 3. Control birds showed significantly higher ($p<0.05$) body weight than restricted ones. Comparing restricted birds, the differences in body weight were significant ($p<0.05$) and the 90% fed birds were the heaviest. During this week, the differences in weight gain and feed intake of control and 90% fed birds were not significant. The effect of feed restriction on feed conversion ratio was not significant ($p<0.05$) between full fed and restricted birds and amongst the restricted ones.

Effect of physical feed restriction during 22-28 days-old

The results of the effect of physical feed restriction on performance during 22-28 days old are presented in Tables 2 and 3. At 28 days- old (the end of the restriction period), there were no significant differences in body weight between full fed and restricted birds ($p<0.05$). There was no significant difference ($p<0.05$) in weight gain between full fed and 90%, 70% and 60% fed birds. Control birds consumed significantly ($p<0.05$) more feed than restricted birds. The best feed conversion ratio was shown by 90% fed birds. There were no significant differences in feed conversion ratio among full fed, 80 and 60% fed birds.

Effect of physical feed restriction on carcass and cut weights

The results of the effect of physical feed restriction on carcass and cuts weights are presented in Table 4. The differences in carcass weight, breast, drumstick and wings weight between full fed and restricted birds were significant ($p<0.05$). Restricted birds showed different breast, drumstick and wing weights.

Effect of physical feed restriction on overall performance (8-42 day old)

The results of the effect of feed restriction on performance during 8-42 days old are presented in Table 5. Different feed restriction regimes used in this study resulted in significantly ($p<0.05$) lighter body weight of restricted birds than full fed ones. Among restricted birds, 90 and 80% fed birds showed the same weight ($p<0.05$). Full fed birds gained significantly ($p<0.05$) more weight than restricted birds, but the difference in weight gain among restricted birds was not significant. Full fed and 90% fed birds consumed the same ($p<0.05$) amount of feed. There were no significant differences in feed intake among 80, 70 and 60% fed birds. The group fed 50% diet

Table 3. Effect of feed restriction on body weight and weight gain (g).

Parameter	Treatment					
	A	B	C	DE		F
Bird age (days)			**Body weight (g/b)**			
8- 14	337.5±15.31^{a}	244.0±25.08^{b}	205.0±11.18^{bc}	241.25±33.54^{b}	165.0±78.76^{c}	202.5±9.48^{bc}
15- 21	650.25±31.87^{a}	530.25±45.98^{b}	431.5±25.39^{cd}	459.25±50.25^{c}	403.75±25.62^{ed}	361.5±22.03e
22- 28	611.8±464.1	882.8±61.28	745.00±38.78	796.2±59.29	724.00±34.52	675.00±15.98
Bird age (days)			**Weight gain (g/b)**			
8- 14	200.0±15.31^{a}	114.0±14.24^{b}	67.5±11.18^{c}	103.75±33.54^{b}	67.5±14.25^{c}	65.0±9.48^{c}
15- 21	312.75±23.39^{a}	286.25±42.4^{a}	226.5±20.34^{b}	218.0±29.43^{b}	198.8±14.18^{b}	159.0±18.08^{c}
22- 28	333.6±16.29^{ab}	352.6±41.37^{a}	313.8±15.99^{b}	337.00±20.29^{ab}	320.2±35.49^{ab}	313.8±14.69^{b}

Means within a row with different super scripts differ significantly ($p<0.05$). Feed conversion ratio (gram feed intake/gram weight gain). A= 100%, B=90%, C=80%, D=70%, E=60%, F= 50%. Values are means ± Standard deviation.

Table 4. Effect of feed restriction on feed intake and feed conversion ratio (g).

Parameter	Treatment					
	A	B	C	D	E	F
Bird age (days)			**Feed intake (g/b)**			
8- 14	308.95±29.25^{a}	204.80±17.58^{b}	129.5±23.48^{c}	177.68±14.72^{b}	141.85±23.56^{c}	123.27±20.09^{c}
15- 21	577.0±63.7^{a}	577.96±138.1^{a}	460.42±38.95^{b}	426.29±76.81^{b}	408.78±86.37^{b}	296.6±20.84^{c}
22- 28	603.2±35.55^{a}	542.6±37.58^{b}	541.8±23.27^{b}	548.4±19.86^{b}	536.2±29.92^{b}	519.8±17.40^{b}
Bird age (days)			**Feed conversion ratio (g/b)**			
8- 14	1.55±0.14^{b}	1.76±0.06^{b}	1.92±0.19^{ab}	1.85±0.51^{ab}	2.14±0.37^{a}	1.9±0.17^{ab}
15- 21	1.86±0.11	2.00±0.29	2.02±0.11	1.95±0.19	2.05±0.39	2.05±0.11
22- 28	1.81±0.09^{a}	1.55±0.15^{c}	1.73±0.05^{ab}	1.63±0.10^{bc}	1.69±0.14^{ab}	1.66±0.07^{bc}

Means within a row with different super scripts differ significantly ($p<0.05$). Feed conversion ratio (gram feed intake/gram weight gain). A= 100%, B=90%, C=80%, D=70%, E=60%, F= 50%. Values are means ± Standard deviation.

consumed the lowest amount of feed. There were no significant ($p<0.05$) differences in feed conversion ratio between control and the other restricted groups except 50% fed group which had the poorest performance.

DISCUSSION

Performance at 14 days- old

At this early age, restricted birds' performance was inferior to control birds. That might be due to the inability of the young birds to adapt to feed restriction. This inability of adaptation was evident in the performance of birds subjected to severe (60% and 50%) and mild (80%) levels of restriction.

Table 5. Effect of physical feed restriction on carcass weight (g).

Treatment	Carcass	Breast	Thigh	Drumstick	Wings
A	1310.000±60.21^{a}	390.70±27.03^{a}	198.40±16.29^{a}	189.20±26.34^{a}	147.80±5.76^{a}
B	1130.000±71.59^{b}	306.60±33.25^{b}	206.20±9.88^{a}	153.20±12.05^{bc}	134.60±10.97^{b}
C	1087.600±81.13^{b}	323.00±13.22^{b}	192.50±52.56^{ab}	148.00±4.08^{bc}	135.25±2.06^{b}
D	1090.000±195.74^{b}	279.75±16.80b^{c}	194.50±15.42^{ab}	126.00±4.76^{d}	113.50±6.14^{c}
E	1045.000±54.20^{b}	276.80±27.98b^{c}	164.80±7.53^{b}	160.20±13.44^{b}	126.00±8.94^{b}
F	1077.000±31.84^{b}	233.00±56.47^{c}	178.00±5.00^{ab}	137.40±8.17^{cd}	124.20±4.60^{bc}

Means within a column with different super scripts differ significantly ($p<0.05$), A= 100%, B=90%, C=80%, D=70%, E=60%, F= 50%, Values are means ± Standard deviation.

Restricted birds had significantly ($p<0.05$) lower body weight than full fed ones. This result agrees with the findings of Mohebodini et al. (2009). The results of the present study showed that full fed birds gained higher weight than restricted ones. This result agrees with what reported by Jang et al. (2009) and Acheampong-Boateng et al. (2012). Reduced feed intake of restricted birds agrees with the findings of Santoso (2002) who found that feed intake was lower during feed restriction. It also follows the findings of Leeson et al. (1999), Jang et al. (2009), Mohebodini et al. (2009), Toghyani et al. (2014) and Dissanayake and David (2017). It seemed that longer duration and more severe feed restriction would significantly reduce feed intake (Santoso, 2002). That is clear in feed consumed by 90% fed birds in comparison to the restricted birds except for 80% fed ones. The reduced feed intake of restricted birds in this study does not follow the findings of Acheampong-Boateng et al. (2012). The results of the effect of feed restriction on feed conversion ratio in this study showed no effect of feed restriction on the ability of restricted birds to utilize nutrients at this age. This result does not follow the findings of Shariatmadari and Hosseni (2001) who found that the feed conversion efficiency of the birds subjected to early feed restriction was better than the control group. The results also do not follow the findings of Urdaneta-Rincon and Leeson (2002), but agrees with Lippens et al. (2000) and Yussefi et al. (2001) and Jang et al. (2009) who found that feed restriction did not affect feed conversion ratio.

Performance at 21 days- old

The results of the present study showed higher body weight and weight gain of control birds in comparison to restricted birds. The increased severity of feed restriction caused lower body weight. This result agrees with the findings of Mohebodini et al. (2009) and Vargas et al. (1999) who reported that the body weight and weight gain reduced in higher levels of feed restriction. Santoso (2002) reported that the level of feed restriction significantly influenced the body weight. This result agrees with the findings of Jalal and Zakaria (2012) who found that *ad libitum* fed birds showed higher body weight and gained more weight than the restricted groups. El-Moniary et al. (2010) got different results. They found that 70% of fed birds had higher body weight and gained more weight than full fed birds at 21 days old. The present study showed that at 21 days old, 90% fed chicks consumed more feed than the control and other restricted groups, while other restricted groups consumed lesser quantities than full fed birds. This agrees with Santoso (2002), Mohebodini et al. (2009) and Acheampong-Boateng et al. (2012) who found that feed intake of restricted birds was lower during feed restriction. Dissanayake and David (2017) also reported that feed intake deceased with the severity of feed restriction. The effect of feed restriction on feed conversion ratio was not significant ($p<0.05$) between full fed and restricted birds. Full-fed and 90% fed birds had superior feed conversion ratio, which indicates a good ability of these birds to utilize nutrients. This result agrees with the findings of El-Moniary et al. (2010).

Performance at 28 days old (the end of restriction period)

Even though there were no significant differences in body weight between full fed and restricted birds ($p<0.05$), restricted birds showed higher body weight than control ones. This result does not agree with Butzen et al. (2013) who found lower body weight of restricted birds at the end of the restriction period. The results of Jang et al. (2009), Mohebodini et al. (2009) and Acheampong-Boateng et al. (2012) go in the same line with the present study. Feed intake of restricted birds was significantly ($p<0.05$) lower than that of full fed birds. This result agrees with Leeson et al. (1999), Santoso (2002) and Dissanayake and David (2017) but disagrees with Leeson et al. (1991) and Mahmood and Mehmood (2007) who reported that restricted birds consume more feed than full fed birds. The results of the present study also do not follow the findings of Lippens et al. (2000) who found no significant difference in feed intake between

Table 6. Effect of physical feed restriction on overall performance (8-42 day old) (g).

Treatment	Body weight	Weight gain	Feed intake	*FCR
A	1725.00±106.07^{a}	1588.00±106.13^{a}	2943.40±159.19^{a}	1.85600±0.09^{ab}
B	1585.00±96.18^{b}	1454.60±96.76^{b}	2851.40±191.50^{ab}	1.96600±0.16^{a}
C	1525.00±107.53^{b}	1388.00±107.53^{b}	2554.00±162.47^{c}	1.84800±0.15^{ab}
D	1378.00±101.16^{c}	1335.20±77.31^{b}	2676.20±96.85^{bc}	2. 00800±0.11^{a}
E	1474.00±57.60^{bc}	1337.00±57.60^{b}	2595.00±114.98^{c}	1.94200±0.09^{a}
F	1485.00±60.21^{bc}	1348.00±60.21^{b}	2335.20±123.90^{d}	1.73200±0.04^{b}

Means within a column with different super scripts differ significantly ($p<0.05$), *FCR= feed conversion ratio (gram feed intake/gram weight gain), A= 100%, B=90%, C=80%, D=70%, E=60%, F= 50%,Values are means ± Standard deviation.

restricted and full-fed birds. The significant difference in feed intake combined with the same body weight of full fed and restricted birds reflects the improvement of feed conversion ratio of restricted birds due to restriction regime used in the present study. Similar results were reported by Vargas et al. (1999), Urdaneta-Rincon and Leeson (2002), Saleh et al. (2005), Ozkan et al. (2006) and Yagoub and Babiker (2008).

Carcass and cuts weight

Feed restriction procedure applied in this study clearly affected carcass and cuts weight (Table 4). Full-fed birds had the heaviest carcass and cuts weight. This result agrees with Vargas et al. (1999), Lippens et al. (2000), Urdaneta-Rincon and Leeson (2002) and Mohebodini et al. (2009), who found that carcass and cuts weight were depressed by feed restriction. Different results have been reported by Jalal and Zakaria (2012). They reported no significant differences were observed in carcass yield. Mirshamsollah (2013) found that feed restriction did not affect carcass cuts weight. Jahanpour et al. (2015) found that feed restriction did not affect breast weight. Tumova et al. (2002) and Jahanpour et al. (2015) found increased carcass weights of restricted birds compared to the control ones.

Overall performance

The results of the present study showed that restricted birds do not compensate for the loss in body weight (Tables 5 and 6). This result agrees with Fontana et al. (1992) who reported that broilers subjected to early feed restriction commencing at 4 days of age had significantly lower mean final body weight than control for all durations. The result of the present study also follows the findings of Santoso et al. (1995) who reported that restricted birds at 50% had lower body weight than control ones at 56 days old, Ramlah et al. (1996) who concluded no compensatory gain in restricted groups when providing 75% or restricted to 50% and Lanhui et al. (2011) who reported that feed restriction for 70 and/or 80% decreased body weight significantly compared to full fed birds. Jang et al. (2009) reported the same result after 85 and 70% physical feed restriction at 35 days old. The significant ($p<0.05$) difference in body weight between full fed and restricted birds reflected that the restriction was severe enough, that it did not allow for complete recovery at 42 days of age. This result indicated no compensatory growth occurred at this age. Past studies showed complete compensatory growth at 42 days of age after one week of feed restriction. Zubair and Leeson (1996) found complete compensatory growth when 50% was used, while Kumar et al. (1997) used 60%. Lippens et al. (2002) found that compensatory growth was substantial at 42 days old when 80% physical feed restriction was used.

Deaton (1995) applied 90, 80 and 60% levels and found complete compensatory growth at 41 days old. Bally et al. (1992) found that complete compensatory growth can be achieved in just 39 days after 6 days of feed restriction during the first 18 days of age. Many authors reported complete compensatory growth after longer re-feeding periods. Jones and Farrell (1992) reported that restricted birds showed body weight equivalent to that of control ones at 48 days old, Plavnik and Balnave (1992) at 47 days, Santoso et al. (1995) at 56 days, Attia et al. (1998) at 49 days, Santoso (2002) at 56 days, and Ozkan et al. (2006) at 56 days old.

According to study of Zubair and Leeson (1996), most weight loss during early feed restriction in birds can be normally compensated by 20 to 25 days of the re-feeding period. This indicates that mild feed restriction followed by long re-feeding period (6 weeks) allows restricted birds to compensate for the loss in body weight. That may be the reason for the failure of restricted birds in the present study to compensate for the loss in body weight. The results of this study showed significant differences ($p>0.05$) in weight gain, feed intake and feed conversion ratio between full fed and restricted birds. Comparing restricted birds, 80, 70, 60 and 50% fed birds consumed lesser amounts of feed but gained significantly ($p>0.05$) same weight. This indicated improvement in feed conversion ratio.

Conclusion

Early feed restriction depends on compensatory growth phenomena, in which restricted animals compensate for the weight loss during restriction period when feed restriction is over depending on duration of feed restriction and age of restriction. According to the study of Zubair and Leeson (1996), most weight loss during early feed restriction in birds can be normally compensated by 20 to 25 d of the re-alimentation period. The severity and prolonged period of feed restriction as well as the short re-feeding period (13 days) caused the restricted birds not to recover the loss of body weight due to feed restriction. It could be concluded that the severity and duration of feed restriction program applied in this study required a longer re-feeding period to allow complete compensatory growth.

CONFLICT OF INTERESTS

The author has not declared any conflict of interests.

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