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The Comparison of Early Feed Restriction and Meal Feeding on Performance, Carcass Characteristics and Blood Constituents of Broiler Chickens

H. Mohebodini, B. Dastar, M. Shams Sharg and S. Zerehdaran
Department of Animal Science,
Gorgan University of Agricultural Sciences and Natural Resources, Gorgan, Iran

Abstract: The present study was conducted to compare the effect of early feed restriction and meal feeding on performance, carcass characteristics and blood constituents of male broilers. Birds fed *ad libitum* for the 1st week post hatch. Feed restriction schedule was applied from 7-14 or 7-21 days of age. Chickens in treatment 1 fed *ad libitum* (AL) throughout the experiment. Birds in treatment 2 and 3 were subjected to Quantitative Feed Restriction based on Maintenance (QFRM) or 50% of Growth (QFRG) energy requirements. Birds in treatment 4 and 5 were subjected to quantitative feed restriction based on a meal feed schedule from 7-14 (MF 14) or 7-21 (MF 21) days of age. Five replicate groups of 12 broilers were allocated to each treatment. Results indicated that feed restriction reduced weight gain compared to AL or MF regimes ($p<0.05$) at the end of experiment. Broilers subjected to feed restriction regimes consumed less feed than either AL or MF ($p<0.05$). There were no significant differences between MF and AL groups for weight gain and feed intake. At the end of experiment, feed conversion was improved for birds in MF 14. The carcass weight of the control group significantly was higher than feed restricted groups, but was not statistically different from MF groups. Abdominal fat weight was not affected by feeding regimes. Blood constituents, such as triacylglycerol, cholesterol and LDH were affected by feeding regimes ($p<0.05$). The results of present experiment indicated that quantitative feed restriction from 7-14 days of age resulted to decrease performance and carcass weight in broiler chickens. Meal feeding from 7-14 or 7-21 days of age had no negative effect on the performance and carcass weights of broiler chickens. Lactate dehydrogenase activity was reduced in feed restriction and MF 21 broilers compare to AL broilers.

Key words: Feed restriction, meal feeding, performance, broiler chickens, carcass characteristics

INTRODUCTION

Now-a-days, broiler chickens have a very fast growth rate and generally are fed *ad libitum* throughout their rearing period. On this condition, body fat deposition and incidence of metabolic disorders such as ascites and Sudden Death Syndrome (SDS) may be increased. These undesirable conditions are closely related to high metabolic rate and higher nutrient intake due to increase of feed consumption. Feed restriction programs have been recommended to minimize these losses and improve production efficiency. Different methods of feed restriction programs are applied in practice such as reduced nutrients intake by means of diet dilution (Leeson *et al*., 1992; Camacho-Fernandez *et al*., 2002), appetite suppressant (Oyawoye and Krueger, 1990), limiting the time of the feed access as skip-a-day feeding (Khajali *et al*., 2007), meal feeding (Susbilla *et al*., 2003) or limiting quantity of feed offered to the birds daily (Lee and Leeson, 2001; Saleh *et al*., 2005; Ozcan *et al*., 2006; Ocak and Sivri, 2008).

Growth performance of broiler chickens is decreased during feed restriction period, because of limiting feed intake. However, conflicting results have been reported concerning the ability of chickens to achieve their losses body weight gain after refeeding *ad libitum*. It has been shown that chickens subjected to feed restriction have lower weight gain than those fed *ad libitum* at the end of experiment (Saleh *et al*., 2005; Ozcan *et al*., 2006; Petek, 2000; Camacho-Fernandez *et al*., 2002; Khajali *et al*., 2007; Leeson and Zubair, 1997). On the other hand, Tumova *et al*. (2002) compared the effect of feed allocation to 8 g/day/bird from 7-14 days of age or 6 g/day/bird from 7-11 days of age on the performance of broiler chickens. They concluded that feed restriction resulted in accelerated growth. There are

Corresponding Author: Hossein Mohebodini, Department of Animal Science,
Gorgan University of Agricultural Sciences and Natural Resources, Gorgan, Iran

some reports indicate that growth response of broiler chickens to feed restriction depends on severity of fed restriction period (Urdaneta-Rincon and Leeson, 2002; Lee and Leeson, 2001; Dozier *et al*., 2002).

Meal feeding is a feed restriction schedule, which birds have daily free access to feed in specific times. In an early study, Feigenbaum *et al*. (1962) showed meal feeding led to decreased body weight gain and body fat percentage in broiler chickens. Razdan and Pettersson (1994) observed no effect of feeding once daily or three times (meal feeding) in feed restricted birds consumed the same quantity of feed during 4-21 days of age. There are some evidences regarding the effectiveness of meal feeding to reduce the prevalence of leg weakness (Su *et al*., 1999), blood triacylglycerol concentration (Razdan and Pettersson, 1994) and no adverse effect on the activity of proteolytic enzymes (Susbilla *et al*., 2003) in chickens.

There is a little information available concerning the effect of meal feeding on the performance and carcass composition of broiler chickens. Therefore, this experiment was conducted to compare the severity of feed restriction (energy allowance to support maintenance or 50% of the normal growth rate) and meal feeding on the performance and carcass composition of broiler chickens.

MATERIALS AND METHODS

Three hundred, 1 day old male broiler chickens (Ross 308) purchased from a local hatchery and transferred to a control environment poultry house. Broiler chickens randomly assigned to 25 floor pens with 12 birds pen^{-1} and reared for 42 days. The experiment was consisted of starter (0-21 days) and grower (22-42 days) periods according to the NRC (1994). A corn-soybean meal diet was formulated to meet NRC (1994) nutrient recommendations for each period (Table 1). Broiler chickens had free access to starter diet from 1-7 days of age. At 7 day, all birds were weighed after overnight fasting and randomly allotted to each of five experimental treatments. Birds in treatment 1 were fed *ad libitum* (AL) throughout the experiment period. Broilers in treatment 2 and 3 were subjected to Quantities Feed Restriction from 7-14 days of age based on Maintenance (QFRM) or 50% of Growth (QFRG) energy requirements, respectively. The following equation was used to calculate daily feed intake in QFRM treatment based on daily maintenance energy requirements (Plavnik and Hurwitz, 1990):

$$ME\ (kcal\ day^{-1}) = 1.5 \times BW\ 0.666$$

Where:

BW = Mean Body Weight (g) at day 7

Therefore, the QFRM chickens received daily 10 g feed per bird during restriction period. Daily feed intake in QFRG treatment was calculated based on energy requirement to support 50% of the normal growth rate according to the following equation reported by Ozcan *et al*. (2006):

$$ME\ (kcal\ day^{-1}) = 1.5 \times BW\ 0.666 + G \times GA$$

Where:

BW = Mean body weight (g) at 7th day

G = Energy requirement for 1 g of growth (2 kcal g^{-1})

GA = Growth allowance (15 g day^{-1})

Table 1: Composition of experimental diet (%)

Ingredients	Starter (0-21days)	Grower (21-42 days)
Corn	53.63	59.68
Soybean meal (44%CP)	38.64	32.49
Soybean oil	3.79	4.42
Limestone	1.29	1.27
Dicalcium phosphate	1.47	1.09
Vitamin-mineral mixture1	0.50	0.39
Salt	0.44	0.50
Salinomicin	0.05	0.05
DL-methionine	0.19	0.10
Total	100.00	100.00
Calculated chemical composition		
ME (kcal kg^{-1})	3000.00	3100.00
Crude protein (%)	21.56	19.14

Provided per kg of diet: vitamin A, 8,800 IU; vitamin D3, 3,300 IU; vitamin E, 40 IU; vitamin K3, 3.3 mg; thiamine, 4.0 mg; riboflavin, 8.0 mg; panthothenic acid, 15 mg; niacin, 50 mg; pyridoxine, 3.3 mg; choline, 600 mg; folic acid, 1 mg; biotin, 220 μg; vitamin B12, 12 μg; ethoxyquin, 120 mg; manganese, 70 mg; zinc, 70 mg; iron, 60 mg; copper, 10 mg; iodine, 1.0 mg and selenium, 0.3 mg

For treatment QFRG, birds received daily 15 g feed bird^{-1} during restriction period. For QFRM and QFRG treatments, the feed was provided once daily at 6 AM. Birds in treatments 4 and 5 were subjected to feed restriction based on a meal feeding schedule. These birds had free access to feed during four periods of 2 h (06:00-08:00, 12:00-14:00, 18:00- 20:00 and 00:00-02:00) from 7-14 days in treatment 4 (MF 14) and 7-21 days in treatment 5 (MF 21). Figure 1 shows the details of feed restriction regimens used. In all feed restriction treatments, birds had free access to feed after finishing the feed restriction period. The feeding schedules of experimental treatments are shown in Fig. 1. Water was available at all times and light was provided continuously throughout the experimental period. Birds were weighed and feed intake measured on a pen basis at the end of the starter (21 days) and grower (42 days) periods. At 35th day, four chickens from each pen (20 birds per treatment) were chosen randomly and their blood was collected from wing vein. Blood samples were centrifuged and plasma was collected. Plasma concentration of glucose, triglyceride, cholesterol and Lactate Dehydrogenase (LDH) were measured with an automated spectrophotometer using standard diagnostic kits. At end

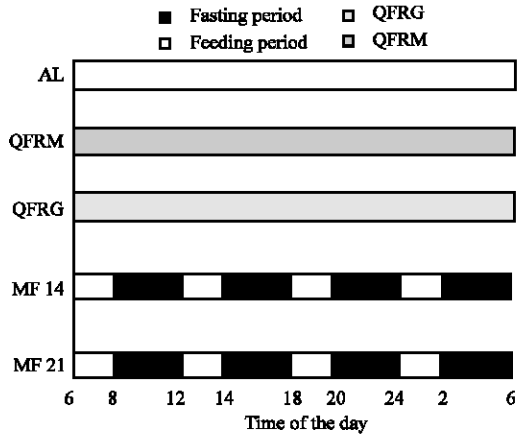

Fig. 1: Diagram of feed restriction regimes. AL = *ad libitum* feeding, QFRM: Feed Restriction (provide daily Maintenance energy requirement) from 7-14 days, QFRG: Feed Restriction (support 50% of the normal Growth rate) from 7-14 days, MF 14 = Meal feeding from 7-14 days, MF 21 = Meal feeding from 7-21 days

of experiment, two weight closest to the mean pen weight were killed and carcass characteristics were recorded as described by Perreault and Leeson (1992).

Statistical analysis: Data were analyzed in a completely randomized design using the GLM procedure of SAS software. The significant differences between treatment means were determined by Duncan's multiple rang test with a probability level 0.05 ($p<0.05$). Percentage data were transformed to arcsine square root before analysis. All data are presented as natural numbers.

RESULTS AND DISCUSSION

Growth performance: The effects of feed restriction for 7 days on performance of broiler chickens are shown in Table 2. The AL and MF 14 treatments had significantly higher weight gain than other treatments during the starter period ($p<0.05$). Feed restriction resulted to significant decrease of feed intake compared to birds fed AL at this period ($p<0.05$). No significant differences were found between treatments for feed conversion ratio. These finding indicated feed restriction resulted in decrease of feed intake in the starter period and subsequently in reduce of weight gain. However, MF 14 birds had lower feed intake than AL birds, but no significant decrease was observed for weight gain. The inability of MF 21 and QFR birds to achieve compensatory gain at 21 days was expected. Because MF 21 birds fed periodically 8 h daily and QFR birds were only 7 days in realimentation period. Such inability to achieve compensatory growth immediately following realimentation has been reported by other researchers Lee and Leeson (2001), Leeson and Zubair (1997) and Dozier *et al.* (2002). Zubair and Leeson (1994) also, reported that >3 weeks lasted for restricted birds to achieve complete recovery of growth performance.

During the grower period (22-42 days), there was not significant difference between birds fed AL and others subjected to feed restriction for weight gain and feed conversion ratio. The lowest feed intake was related to QFRM birds and was significantly different compared to those fed AL ($p<0.05$). Therefore, it seems all feed restricted birds with equal or lower feed intake than AL birds are able to recover completely after feeding *ad libitum*. In accordance with the results, Dozier *et al.* (2002) also reported, the feed restricted birds showed greater gain than AL birds during their realimentation period. This improvement in body weight gain may be related to decrease of energy required for maintenance in feed restricted birds (Yu and Robinson, 1992).

Throughout, the overall period (7-42 days), the QFRM and QFRG treatments had significantly lower weight gain and feed intake than other treatments ($p<0.05$). These birds had about 11.6 and 10.7% less body weight gain and also, consumed 11.3 and 6.6% less feed, respectively. These finding showed that the severity of feed restriction in QFRM and QFRG treatments were high and so these birds were unable to attain compensatory growth at 42 days. In agreement with the results, Saleh *et al.* (2005) found no evidence of compensatory gain in birds were fed based on daily maintenance energy requirement during restricted period from 7-14 days. In contrast with the finding, Tumova *et al.* (2002) reported birds were fed daily 8 g feed from 7-14 days able to show accelerated growth at 42 days. In the present experiment, birds were fed based on meal feeding schedules (MF 14 and MF 21) were able to attain body weight gain similar to those birds fed AL. The feed conversion ratio was significantly lower for MF 14 than for QFRG ($p<0.05$), but there were no significant differences between other treatments. Little information is available about the effect of meal feeding on the performance of broiler chickens. Razdan and Pettersson (1994) found no significant differences for body weight gain in birds fed daily once or three times (meal pattern) in equal interval time when received the same quantity of chickens from each pen (10 birds treatment^{-1}) with bodyfeed. In experiment conducted by Su *et al.* (1999), birds fed based on meal feeding schedule in two, three or four meals per day from 5-35 days. Birds in all groups fed *ad libitum* 240 min daily. Meal feeding resulted to decrease of body weight gain in compared to AL feeding. Also, birds were received fever meals per day had significantly lower weight gain at 28 and 35 days.

Table 2: Broiler performance in relation to feed restriction

	Starter period (7-21days)			Grower period (22-42 days)			Overall period (7-42 days)		
Treatments	Body weight gain (g)	Feed intake (g)	Feed conversion ratio	Body weight gain (g)	Feed intake (g)	Feed conversion ratio	Body weight gain (g)	Feed intake (g)	Feed conversion ratio
AL	495.3a	736.9a	1.49	1589.20	3337.6ab	2.10	2084.8a	4074.5a	1.95ab
MF 14	473.1a	632.4b	1.34	1599.70	3369.2ab	2.11	2072.8a	4001.6a	1.93b
MF 21	436.3b	629.6b	1.44	1621.20	3435.8a	2.12	2057.5a	4065.3a	1.98ab
QFRG	357.2c	558.2b	1.56	1503.80	3248.4bc	2.16	1861.0b	3806.6b	2.05a
QFRM	314.9d	460.9c	1.47	1527.80	3151.8c	2.06	1842.8b	3612.7c	1.96ab
SEM	9.55	30.21	0.07	40.05	52.84	0.03	48.53	61.99	0.03

a,b: Means within a column with no common superscripts differ significantly ($p<0.05$), AL = *ad libitum* feeding; MF 14 = Meal feeding from 7-14 days; MF 21 = Meal feeding from 7-21 days; FRM = Feed Restriction (provide daily maintenance energy requirement) from 7-14 days, FRG = Feed Restriction (support 50% of the normal Growth rate) from 7-14 days

Table 3: Carcass characteristics of broilers at 42 days of age subjected to different methods of feed restriction

	Carcass weigh		Breast weight		Thigh weight		Abdominal fat weight	
Treatment 1	g	Live weightg (%)	g	Live weight (%)	g	Live weight (%)	g	Live weight (%)
AL	1515.90a	61.19	544.00a	21.18	450.2a	18.09	27.34	1.09
MF14	1521.20a	60.33	538.94a	21.32	456.5a	18.13	26.79	1.05
MF21	1475.91a	60.41	513.71ab	20.95	445.5a	18.26	28.59	1.18
QFRG	1262.19b	59.34	433.52c	20.35	387.1b	18.24	23.83	1.12
QFRM	1303.77b	59.58	454.87bc	20.74	391.4b	17.92	25.85	1.29
SEM	60.53	1.06	29.30	0.64	18.70	0.52	4.27	0.17

a,b: Means within a column with no common superscripts differ significantly ($p<0.05$), AL = *ad libitum* feeding; MF 14 = Meal Feeding from 7-14 days; MF 21 = Meal Feeding from 7-21 days; QFRM = Feed Restriction (provide daily maintenance energy requirement) from 7-14 days; QFRG = Feed Restriction (support 50% of the normal growth rate) from 7-14 days

Carcass composition: Effects of feed restriction on carcass composition are shown in Table 3. The weight of carcass, breast and thigh weights in QFRM and QFRG chickens were significantly lower than those fed AL ($p<0.05$). These finding was expected, because body weight of QFRM and QFRG treatments at 42 days of age were significantly lower than AL treatment. However, there were no significant differences between weight of carcass composition in broiler chickens fed AL and those fed meal feeding schedules (MF 14 and MF 21). When, weight of carcass compositions calculated as a percentage of live body weight, no significant differences found between relative carcass compositions in different treatments. The effects of QFRM and QFRG treatments on carcass composition are in agreement with the evidences have been reported by some researches (Camacho-Fernandez *et al*., 2002; Saleh *et al*., 2005; Ocak and Sivri, 2008; Novel *et al*., 2009). However, Urdaneta-Rincon and Leeson (2002) reported that quantitative feed restriction to 95, 90 or 80% of *ad libitum* resulted to decrease of absolute values of carcass and breast weight and also, breast meat weight when, expressed as a percentage of carcass weight. The reason for these similarities may be related to ability of meal feeding treatments to achieve compensatory growth. Lee and Leeson (2001) reported there was no loss of meat yield, when feed restricted birds able to achieve compensatory growth during realimentation period. Feed restriction programs considered as a means of reducing the incidence of metabolic disorders and fat deposition in broiler chickens. However, conflicting results have been reported about the effect of feed restriction programs on the abdominal fat content. In the present experiment, no significant differences were found between birds subjected to feed restriction and AL. These findings, similar to results of others, show no significant differences between abdominal fat content in restricted and unrestricted birds (Petek, 2000; Lee and Leeson, 2001; Urdaneta-Rinconand and Leeson, 2002; Dozier *et al*., 2002; Saleh *et al*., 2005; Ozcan *et al*., 2006; Khajali *et al*., 2007; Novel *et al*., 2009). In contrast, some evidences indicate that feed restriction lowers absolute or relative weight of abdominal fat in broiler chickens (Leeson and Zubair, 1997; Ocak and Sivri, 2008).

Biochemical parameters: Effect of feed restriction on blood parameters are shown in Table 4. No significant differences were observed between the concentration of serum glucose between feed restriction and AL birds. The LDH enzyme activity of all feed restricted treatments were significantly lower than those fed AL ($p<0.05$). Imaeda (1999) reported that LDH activity is a critical index of SDS incidence in broiler chickens and begin to rise at a time when, a weak disturbance of the cardiovascular system occurs before death due to SDS. Broilers have more body weight gain are most susceptible to incidence of metabolic disorders such as SDS, because of high metabolic rate (Julian, 2005).

Table 4: Effect of feeding regimes on blood constituents of broilers

Treatments	Glucose (mg dL^{-1})	Lactate dehydro-genase (IU L^{-1})	Cholesterol (mg dL^{-1})	Triacylglycerol (mg dL^{-1})
AL	204.6	542.8a	118.2ab	104.8c
MF14	203.6	459.8ab	112.6b	109.4abc
MF21	208.4	434.0b	119.6ab	106.4bc
QFRG	208.8	415.0b	129.0a	116.2a
QFRM	216.2	415.0b	126.6a	112.8ab
SEM	7.12	31.75	4.33	2.22

a,b: Means within a column with no common superscripts differ significantly ($p<0.05$), AL = *ad libitum* feeding; MF 14 = Meal Feeding from 7-14 days; MF 21 = Meal feeding from 7-21 days; QFRM = Feed restriction (provide daily maintenance energy requirement) from 7- 14 days; QFRG = Feed Restriction (support 50% of the normal growth rate) from 7-14 days

In the present experiment, feed restriction resulted to decrease of body weight gain and therefore, the lower LDH activity in feed restricted birds was expected. Birds were fed based on maintenance (QFRM) or growth (QFRG) energy requirements had significantly higher cholesterol concentration than those were fed by meal feeding schedule for 7 days (MF 14). The concentration of triacylglycerol of QFRM and QFRG treatments were significantly higher than AL treatment ($p<0.05$). These finding indicated that the QFRM and QFRG treatments which, subjected to more feed restriction severity, generally led to increase lipid concentration. In accordance with our results, Razdan and Pettersson (1994) reported the higher triacylglycerol concentrations for chickens received restricted diets compared with chickens fed AL.

CONCLUSION

Feed restriction has been proposed to minimize metabolic disorders and may be improved production efficiency. However, birds were subjected to quantitative feed restriction for 1 week on maintenance or 50% of growth energy requirements, unable to achieved compensatory growth. Meal feeding regimes (MF 14 and MF 21) decreased rapid early growth, while achieving similar final body weight gain and meat recovery compared with birds fed *ad libitum*. Carcass weight was depressed by feed restriction treatments (QFRM and QFRG), but not meal feeding regimes. Abdominal fat as absolute body weight was not significantly influenced by each of treatments.

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