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The Effects of Early Age Feed Restriction on Performance and Carcass Characteristics of Male Broiler Chickens

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Abstract: An experiment was conducted to evaluate the response of broiler chickens to degrees of diet dilution from 4-11 days of age. Broilers were fed conventional broiler diets from 0-4 and 11-42 days of age. From 4-11 days, birds were fed a commercial corn, wheat and soybean meal broiler starter, or the same diet in which major nutrients were replaced with 30, 40, or 50% ground rice hulls. Mineral and vitamin sources were not affected by diet dilution. Each of the 3 diluted diets together with an undiluted diet (control) was fed to 5 replicate floor pen groups of 60 male broilers. Diet dilution resulted in a significant ($p<0.05$) reduction in body weight at 11 days of age, although by 42 days there was complete recovery of retarded body weight with no change in overall efficiency of feed utilization. Diet dilution had no significant effect ($p>0.05$) on carcass characteristics at 42 days of age.

Key words: Feed restriction, diet dilution, broiler chicken, performance

INTRODUCTION

Birds subjected to early feed restriction for short periods show improvement of feed efficiency and reach a weight similar to that of birds fed *ad libitum* at the market age (Auckland and Morris, 1971; Plavnik *et al*., 1986; Plavnik and Hurwitz, 1991). Effects of feed restriction has been investigated to reduce the incidence of ascites (Tottori *et al*., 1997), sudden death syndrome (Blair *et al*., 1993; Gonzales *et al*., 1998) and skeletal abnormalities (Lee and Leeson, 2001) that are undesirable effects of full fed broiler chickens. These conditions are more prevalent in fast growing broilers that are fully fed. Broiler chickens fed *ad libitum* likely consume energy at two or three times greater than their maintenance needs (Boekholt *et al*., 1994) and so fat deposition is increased. This fact is of economical concern because fat is an undesirable and uneconomical product. To produce a leaner bird and reduce the unfavorable effects of fat on human health, there is interest in the poultry industry to reduce fat deposition in broiler carcasses. Results obtained from feed restriction programs to reduce the carcass fat content in broiler chickens have been inconsistent. Reduction in abdominal fat pad content has been noted by Plavnik and Hurwitz (1991), Jones and Farrell (1992) and Santoso *et al*. (1995). However, others have failed to confirm this effect (Yu *et al*., 1990; Fontana *et al*., 1993; Deaton, 1995; Zubair and Leeson, 1996). Such variability may relate to the vast range of techniques used to impose growth regulation, which may affect the bird's response to feed restriction.

The improvement in feed efficiency observed in feed restricted birds was attributed to reduced overall maintenance requirements caused by a transient decrease in basal metabolic rate of feed restricted birds (Zubair and Leeson, 1994) and is linked with a smaller body weight during early growth, leading to less energy needed for maintenance (Marks, 1991). Consequently, there is current interest in the use of feed restriction programs to modify bird growth patterns and decrease their maintenance requirements, which should improve feed efficiency. However, the improved feed efficiency during reelimination period can also be related to higher feed intake and to the hypertrophy of the gastrointestinal tract that occurs after the restriction period (Yu and Robinson, 1992; Zubair and Leeson, 1994).

Wilson and Osbourn (1960) conclude that compensatory growth following undernutrition was influenced by duration, timing and severity of feed restriction, together with re-feeding nutrition. Generally, it seems as though as the severity of undernutrition increases, complete growth correction becomes more unlikely (Plavnik *et al*., 1986; Yu and Robinson, 1992).

The most severe form of physical feed restriction is usually considered to be maintenance allowance, described by Plavnik and Hurwitz (1989) at 1.5 kcal ME/gBW$^{0.67}$/d. Unfortunately for very young birds, this means a very small quantity of feed is distributed daily and so this leads to the alternate concept of diet dilution. Leeson *et al*. (1991) and Jones and Farrell (1992) used 50-65% diet dilution with rice hulls from 4-11 day of age in order to retard early growth. This technique appeared to be successful and even though these birds ate more feed, adjustment was insufficient to normalize nutrient intake and so growth rate was reduced. Lee and Leeson (2001) reported that male broiler fed diets diluted up to 50 % with oat hulls from 7-14 days, caught up body weight by 8 week of age but had abdominal fat levels similar to control birds. Breast meat yield also, was decreased. In many of these physical feed restriction or diet dilution studies, there are reports of reduced body fat deposition, although this effect seems variable. The most consistent feature of all these studies, regardless of method of implementation, is improved feed efficiency.

The objective of the present study was, to study the broiler chicken's response to a 4-11 day period of feed restriction imposed through diet dilution with up to 50% rice hulls as an indigestible material.

MATERIALS AND METHODS

Two hundred forty day old male broiler chicks of Ross commercial strain were randomly assigned to 1 of 4 treatment groups. Each treatment consisted of 5 replicates of 12 birds each and placed in a (1×1 m) floor pen. The experiment was a completely randomized design. All birds were fed *ad libitum* from 0-4 and 11-42 days of age using conventional starter and grower diets (Table 1), formulated to meet the nutrient requirements according to the NRC (1994). Lighting was provided 23 h day^{-1}. Room temperature was maintained at 32°C in d one and then gradually reduced according to standard brooding practices to reach 18°C on day 42. The experimental diets were formulated using maize, wheat, fish meal and soybean meal, as main ingredients (Table 1). Diet dilution was achieved by substitution of major nutrients with 30, 40 and 50% ground rice hulls. Four dietary treatments including: One control (with no diet dilution) and three restricted groups which their diet was diluted with 30, 40 and 50% ground rice hulls from 4-11 days of age. The percentage of mineral and vitamin sources was not affected by diet dilution. After this period, chicks were fed with a regular starter and grower diets up to 42 days of age (Table 1). All diets were formulated to meet the nutrient requirements according to NRC (1994).

Table 1: Composition of experimental diets (as-fed basis)

Ingredient (%)	0-21 day	21-42 day
Corn ground	53.0	40.0
Wheat ground	12.25	35.5
Soybean meal	26.0	19.5
Fish meal	5.0	2.2
Oyster shell	1.43	1.43
Monocalcium phosphate	1.12	0.7
DL-Methionine	0.07	0.025
Mineral Premix[1]	0.3	0.3
Vitamin Premix[2]	0.3	0.3
Common Salt	0.33	0.23
Calculated analyses		
CP	20.82	18.12
ME (kcal kg^{-1})	2900	2900
Calcium	0.92	0.82
Available phosphorus	0.47	0.32
Arginine	1.37	1.13
Lysine	1.21	0.92
Methionine	0.46	0.34
Met+Cys	0.81	0.68

[1]Mineral mix supplied the following per kg of diet: Cu, 25 mg; Fe, 125 mg; Mn, 100 mg, Se, 0.5 mg; Zn, 300 mg; Mg, 250 mg; Co, 0.5 mg; I, 2.5 mg; Cholin chloride, 2500 mg, [2]Vitamin mix supplied the following per kg of diet: vitamin A, 5000 IU, vitamin D_3, 2500 IU; vitamin E, 100 IU; vitamin K_3, 15 mg; vitamin B_1, 12.5 mg, vitamin B_2, 40 mg; vitamin B_6, 7.5 mg; vitamin B_9, 3 mg; vitamin B_{12}, 0.1 mg

During the experiment, live body weight, body weight gain, feed intake and feed conversion ratio were measured weekly and pen basis till end of the experiment. One bird close to pen average weight was selected and organ and abdominal fat pad weighs were determined at 42 days of age. After 12 h feed withdrawal, the selected birds were slaughtered and processed. Viscera were manually removed and the abdominal fat pad and other carcass parts were weighed. Daily mortality was recorded throughout the experiment.

Statistical analysis: Data were analyzed as a completely randomized design using the GLM procedure of SAS (1991) (SAS Inst. Inc., Cary, NC). The pen of chicks served as the experimental unit. Means were compared using Duncan's new multiple range test (Steel and Torrie, 1980). The level of significance was reported at $p<0.05$.

RESULTS

Diet dilution during 4-11 days of age had a significant effect ($p<0.05$) on body weight gain over this period (Table 2). As the diet was diluted with increasing proportions of rice hulls, there was a corresponding reduction in body weight gain of the birds ($p<0.05$). With 30, 40 and 50% diet dilution, weight gain of the birds from 4-11 days of age was reduced by 9, 17 and 36%, respectively. Weight gain from 11-21 days was significantly ($p<0.05$) lower than control group. Over the entire 0-21 days starter period, weight gain was not affected by 30% diet dilution, although the birds subjected to higher levels of diet dilution showed significantly lower weight gain. During growing period, prior diet dilution had no effect on weight gain and seems compensatory growth completed the performance.

Table 2: Effect of diet dilution on body weight gain of male broiler chickens (g bird^{-1})

Diet dilution (%)	0-4	4-11	11-21	0-21	21-35	35-42	0-42
0 (Control)	50	156^{a}	365^{a}	572^{a}	750	380	1702
30	51	143^{b}	364^{a}	558^{ab}	717	422	1697
40	50	130^{c}	350^{ab}	530^{b}	731	410	1671
50	52	100^{d}	340^{b}	492^{c}	750	425	1667
SD	3	6	14	18	41	51	42

[a-c] Means within each column with no common superscripts are significantly different ($p<0.05$)

Table 3: Effect of diet dilution on feed intake of male broiler chickens (g $bird^{-1}$)

Diet dilution (%)	0-4	4-11	11-21	0-21	21-35	35-42	0-42
0 (Control)	56	242^{d}	639^{a}	892^{c}	1688^{a}	1034	3387
30	57	279^{c}	615^{ab}	932^{bc}	1577^{ab}	1051	3377
40	56	306^{b}	578^{b}	943^{b}	1535^{ab}	1066	3359
50	59	320^{a}	551^{c}	1008^{a}	1425^{b}	1079	3451
SD	04	11	15	20	50	35	90

a-d Means within each column with no common superscripts are significantly different ($p<0.05$)

Table 4: Effect of diet dilution on feed efficiency of male broiler chickens (g $bird^{-1}$)

Diet dilution (%)	0-4	4-11	11-21	0-21	21-35	35-42	0-42
0 (Control)	1.11	1.55^{d}	1.75^{a}	1.56^{a}	2.25	2.72	1.99
30	1.12	1.95^{c}	1.69^{ab}	1.67^{b}	2.20	2.49	1.99
40	1.11	2.35^{b}	1.65^{ab}	1.78^{c}	2.10	2.60	2.01
50	1.13	3.20^{a}	1.62^{b}	2.05^{d}	1.90	2.54	2.07
SD	0.05	0.08	0.10	0.15	0.16	0.25	0.12

a-d Means within each column with no common superscripts are significantly different ($p<0.05$)

Table 5: Effect of diet dilution on carcass characteristics of male broiler chickens at 42 days of age (% of carcass weight)

Diet dilution (%)	Wings	Tights	Breast	Abdominal fat pad
0 (Control)	8.1	20.4	18.9	3.38
30	8.3	20.7	19.1	3.21
40	8.5	20.2	18.7	3.25
50	8.2	19.9	18.8	3.13
Standard error	0.21	0.35	0.41	0.26

During diet dilution period (4-11 days), birds subjected to diluted diet consumed significantly more feed to maintain nutrient intake. As shown in Table 3, increasing degrees of diet dilution resulted in graded increases in feed consumption ($p<0.05$). During the 11-21 days period, when all birds was offered regular starter diet, the birds previously subjected to 40 and 50% rice hulls in their diets ate less feed than control group ($p<0.05$). Forty and fifty percent dilution treatments over the entire 0-21 days resulted in significantly more feed than control group. However, during periods of 35-42 days and during the entire 0-42 days, there were no significant differences among the treatments.

As shown in Table 4, increasing degrees of diet dilution resulted in graded increases in feed efficiency ($p<0.05$) during 4-11 days of age. During the 11-21 days period the birds previously subjected to 50% diluted diet had significantly better feed efficiency ($p<0.05$) in compare to control group. Over the entire 0-21 days, increasing levels of diet dilution resulted in graded increases in feed efficiency. However, during periods of 35-42 and whole experimental period, there were no significant differences among the treatments.

Carcass characteristics of the birds at 42 days of age were not affected by diet dilution (Table 5).

DISCUSSION

Many researchers have used diet dilution as an alternative method of feed restriction because of the advantage of attaining a more consistent growth pattern within a flock. Diets are mixed with a non-digestible ingredient such as fiber and so reduce nutrient density. In the present study, compensatory growth following diet dilution was complete by 42 days. However, levels of nutrient density affected recovery time. Leeson *et al.* (1991) showed complete compensatory growth in male and female broilers at 42 days of age where growth was limited from 4-11 days due to a diluted diet containing up to 55% of rice hulls as a non-digestible ingredient. In addition, there was no significant difference in the overall efficiency of feed utilization, although during the diluted period birds increased their feed consumption in an attempt to maintain their energy intake.

Osbourn and Wilson (1960) stated that increased appetite following refeeding is largely responsible for any improved growth and feed conversion ratio. In the present study, there was not any increased feed consumption immediately after undernutrition. Although, birds increased their feed intake when the diluted diet was offered, they were not able to gain normal energy intake.

Jones and Farrell (1992) applied diet dilution to broilers by including 60 or 65% of rice hulls to a commercial starter diet from 4-7 days of age, showing complete compensatory growth at 48 days of age. These results are in agreement with those of Zubair and Leeson (1994), who reported no difference in body weight at either 42 or 49 days when birds were fed a 50% oat-hull diluted diet for 6 days. In another trial, Leeson *et al.* (1992) offered birds a conventional finisher diet diluted up to 50% with a 50:50 mixture of sand:oat hulls from 35-49 days of age and showed no significant difference in body weight at 49 days or breast weight at 42 or 49 days of age.

The use of diluted diets relies upon the fact that broiler chickens eat close to their physical intake capacity (Newcombe and Summers, 1984). Leeson *et al.* (1992) reported somewhat unexpected growth and feed intake with diet dilution during the finisher period. This might have occurred because broilers obtained energy from supposedly non-digestible ingredients (Leeson *et al.*, 1992) or that the oat hull dilution improved the nutrient availability (Leeson and Zubair, 1997), such that birds acquired more energy than anticipated for growth. Moreover, Leeson *et al.* (1992) reported that broilers during the finisher period altered their feed intake according to the energy density of the diet. These results are in agreement with those of Zubair and Leeson (1994), where birds receiving a 50% oat hull-diluted diet increased their feed intake. This trend to increased feed intake when feeding a diluted diet seems to be the bird's attempt to maintain its nutrient intake and suggests that modem broilers do, in fact, adjust intake in response to variable diet nutrient density. These findings are at variance with the previously described report of Newcombe and Summers (1984).

Another response noted with broilers undergoing a period of feed restriction is reduced carcass fat at 42-56 days (Plavnik and Hurwitz, 1985, 1988, 1989). Thus, Plavnik and Hurwitz (1985, 1988, 1989) cited substantial reductions in the size of the abdominal fat pad of broilers that was not influenced by nutrition during realimentation. Early diet dilution, may reduce adipocyte hyperplasia. Cherry *et al.* (1984) concluded that although hyperplasia proceeds during periods of nutrient restriction, the adipocytes remain smaller.

Similarly Rosebrough *et al.* (1986) observed reductions in both liver size and lipogenesis in 12-day-old birds subjected to feed restriction from 6-12 days. However, there is some suggestion of increased lipogenesis and greater fat accumulation following refeeding. Thus, Rosebrough *et al.* (1986) indicated an 80× increase in lipogenic activity 2 days after refeeding, whereas Osbourn and Wilson (1960) indicated 6-24% more fat in birds after refeeding depending upon the method of feed restriction used. Differences in abdominal fat deposition may relate to degree of energy restriction. The results regarding to carcass characteristics at the present study are in accord with reports of Yu *et al.* (1990), Fontana *et al.* (1993), Deaton (1995) and Zubair and Leeson (1996) who failed to observe significant effects of feed restriction on carcass characteristics and abdominal fat pad size.

Generally, the broiler chicken completed their growth after early feed restriction at the present study and early feed restriction had no significant effect on carcass characteristics. Economic benefits of the feed restriction will depend on the severity, methods of implementation and duration of feed restriction.

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