Advances in Bioresearch
Adv. Biores., Vol 6 (1) January 2015:90-95
©2015 Society of Education, India
Print ISSN 0976-4585; Online ISSN 2277-1573
Journal's URL:http://www.soeagra.com/abr.html
CODEN: ABRDC3
ICV 7.20 [Poland]

Advances in Bioresearch

ORIGINAL ARTICLE

The Effect of Quantitative Feed Restriction in Different Ages on Performance and Carcass Traits of Broilers Chicks

Mohammad Rokeshi and Masoud Jafari *
Department of Animal Science, Astara Branch, Islamic Azad University, Astara, Iran
*Corresponding author: E-mail: m.jafari@iau-astara.ac.ir

ABSTRACT
This experiment was conducted to investigate the effect of the physical limitations of feed in different ages on the performance, carcass characteristics and compensatory growth of broilers. Two hundred eighty day-old Ross 308 broiler chicks were used in a completely randomized design with 7 treatments, 4 replicates and 10 observations per each. The treatments consisted of SW, SW10, SW20, SW30, TW10, TW20 and TW30. The diet for SW treatment had no restriction [control], while those for treatments SW10, SW20 and SW30 were feed restricted to 90, 80, and 70%, respectively, of ad libitum intake of the control birds on the previous day, from 7-14 d and treatments TW10, TW20 and TW30 were feed restricted at same levels from 14-21 d, respectively. Feed intake [FI], daily weight gain [DWG], feed conversion ratio [FCR] were measured on days 1, 21 and 42 and final weight [FW], productive index [PI], feed cost [FC] and carcass characteristics were measured on day 42. Results indicated that FI, DWG and FCR were significantly affected by experimental treatments. In restricted diets FI decreased than that control diet [P <0.01]. DWG in restricted treatments was decreased and similar to control diet from 1-21d and 21-42d, respectively. FCR was improved in restricted diets than control diet [P <0.01] and was best in treatment SW30 than others from 1-42d. Between experimental diets, treatments SW20 and TW10 yielded FW similar to control diet. However, except treatments SW30 and TW30, other treatments improved PI than control diet [P <0.05]. In addition, FC was decreased in restricted diets than SW diet. As well as, there were no significant differences between treatment in carcass, thigh and pancreas percentage, however, breast, abdominal fat and gizzard weight were affected by experimental diets. Abdominal fat in restricted diets was decreased than control diet [P <0.01]. These results concluded that, quantitative restriction of feed decreased the feed cost and improved the productive parameters and carcass traits of broilers chicks.
Keywords: *broiler chicks, carcass traits, feed restriction*.

Received 02/10/2014 Accepted 11/12/2014

How to cite this article:
Mohammad R and Masoud J.The Effect of Quantitative Feed Restriction in Different Ages on Performance and Carcass Traits of Broilers Chicks. Adv. Biores. Vol 6 [1] January 2015: 90-95**.** DOI: 10.15515/abr.0976-4585.6.1.9095

INTRODUCTION

It is generally assumed that when birds eat more, they have greater body weights at market age. Barbato [1994] stated that the control mechanisms of feed intake post hatch are related to genetic selection for body weight. The improvement noted in market body weight has been attained due to an increased feed consumption, which is related to genetics [13] and supported by nutrition. This improvement in body-weight-for-age of modern broiler chickens, due to an increased growth rate and associated higher nutrient supply, has led to more frequent occurrences of metabolic and skeletal disorders [28], decrease of chicks immunity and their resistance against the diseases [16] and increased fat deposition [36]. Results of several studies show the topics of the issues [1, 8, 12, 23, 27, 30, 34].

Feed restriction programs have shown the potential to reduce the incidence of ascites [15, 35] and sudden death syndrome [SDS] [4, 11]. These conditions are more commonly observed in fast growing broilers that are fully fed. Improvement in feed efficiency noted with the use of feed restriction programs is due to reduced overall maintenance requirements. This reduction seems to be due to a decrease in basal metabolic rate of feed restricted birds [40] and is related to smaller body weight during early growth, leading to less energy needed for maintenance [22]. Broiler chickens fed *ad libitum* likely consume energy and protein at two or three times greater than their maintenance needs [5], and so fat deposition is increased. This fact is of economical concern because fat represents an undesirable and

uneconomical product. To reduce of carcass fat and their unfavorable effects 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 some studies [14, 19, 26, 31]. However, others researches have failed to confirm this effect [9, 7, 37, 39]. Such inconsistency may relate to different feeding strategies applied [as age of restriction or severity of restriction], which may affect the bird's response to feed restriction. 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. Therefore, the aim the study was to investigate the affects of severity of feed restriction of in different age on performance and carcass traits of broiler chicks.

MATERIALS AND METHODS

Bird Management and Dietary Treatments

In this experiment two hundred eighty day-old Ross 308 broiler chicks with similar initial weight [45 ± 2g] were used. Chicks were randomly divided into seven groups of 28 cages [cage dimensions: 100 cm width × 100cm long × 90 cm height]. Four replicate pens of 10 birds per pen were allocated for each dietary treatment group. Control birds [*ad libitum*] and feed-restricted birds received the starter diet from 1 to 10 d, grower diet from 10 to 24 d, and finisher diet from 24 to 42 d of age. All birds were fed *ad libitum* to 7 d of age using a starter diet [Table 1], according to nutrient requirements of broilers chicks as given by Ross 308 Broiler Management Guide [27]. At 7 day of age, all chicks in the seven treatments received four different diets [Table 1]. The treatments consisted of SW, SW10, SW20, SW30, TW10, TW20 and TW30. The diet for SW treatment had no restriction [control], while those for treatments SW10, SW20 and SW30 were feed restricted to 90, 80, and 70%, respectively, of *ad libitum* intake of the control birds on the previous day, from 7-14 d and treatments TW10, TW20 and TW30 were feed restricted to 90, 80, and 70%, respectively, of *ad libitum* intake of the control birds on the previous day from 14-21 d. During the experimental period, conventional management procedures were employed, natural and artificial light was provided for 23 h per day, ambient temperature was controlled and birds were watered *ad libitum*.

Table 1. Ingredients and nutrient composition of diets

Ingredient and composition	Experimental diets		
	Starter 0- 10d	Grower 10- 24d	Finisher 24- 42d
Corn	56.15	57.12	60.26
Soybean meal [44% CP]	32.60	33.05	30.57
Fish meal	4.00	2.00	0.00
Soybean oil	3.09	3.97	5.00
Dicalcium phosphate	1.44	1.35	1.54
Oyster shells	1.26	1.04	1.08
Vitamin Premix[1]	0.25	0.25	0.25
Mineral Premix [2]	0.25	0.25	0.25
DL-Methionine	0.3	0.27	0.23
Hcl -Lysine	0.05	0.11	0.22
Threonine	0.11	0.04	0.04
Salt	0.25	0.20	0.20
Sodium bicarbonate	0.20	0.30	0.30
Against coccidiosis	0.05	0.05	0.05
Calculated composition			
AMEn [kcal/kg]	3025	3100	3200
Crude protein [%]	22.00	21.00	19.00
Lysine [%]	1.43	1.11	1.09
Methionine + Cystine [%]	1.07	0.948	0.86
Threonine [%]	0.94	0.83	0.74
Tryptophan [%]	0.24	0.29	0.26
Calcium [%]	1.05	0.87	0.85
Available Phosphorus [%]	0.50	0.44	0.42
Sodium [%]	0.18	0.18	0.18

[1] Vitamin supplements per kg: Vitamin A, 360000 IU. Vitamin D3, 800000 IU. Vitamin B6, 1176 mg. Vitamin E, 14400 mg. Vitamin B9, 400 mg. Vitamin K3, 800 mg. Vitamin E, Vitamin B12, 6 mg. Vitamin B1,710 mg. Vitamin H2, 2640 mg. Choline chloride, 10000 mg, niacin,11880mg. [2] mineral supplement per kg: Manganese, 39,680 mg. Iodine, 397mg. Selenium, 80 mg. Zinc, 33880 mg. Cu, 4000 mg.

Performance and carcass traits

Chicks were weighed at 1, 21 and 42 d of age and feed intake [FI, g] was determined at 21 and 42 d of age. At the end of experiment, two birds per replicate were randomly selected for carcass measurements. All chicks were fasted for approximately 8 h and then individually weighted, sacrificed, de-feathered and eviscerated. Whole carcass, breast, thigh, gizzard, pancreas and abdominal fat were weighted. Daily Feed intake [DFI, g], average daily gain [ADG, g], final body weight [FBW, g], feed efficiency [FCR, g feed/g weight gain], productive index [PI] and carcass weight and organs were also calculated. Data from DFI and ADG were adjusted for mortality and carcass weight and parts calculated as percentage of BW. PI at 42 days of age calculated according to the formula:

PI= [[average weight of bird at slaughter × Viability] / age at slaughter × FCR] × 100

Where: Viability= 100 - mortality

Statistical analyses

Data from chick assay was subjected to GLM for completely randomized designs using by SAS [32]. Statistical significance of differences among treatments was assessed by using the Duncan's test. Independent comparisons were also used between all treatment groups.

RESULTS AND DISCUSSION

Growth performance

The results for performance of broiler chicks are presented in Table 2. Daily feed intake [DFI] of birds was significantly different between treatments [P < 0.01]. DFI differed commensurate with the goal of the restriction program and was highest in birds fed *ad libitum* diet and decreased in restricted diets at all age. Also, independent comparisons for DFI showed that there was significant difference between control diet and restricted diets.

Body weight gain [BWG] of birds was decreased from 1-21d, but compensate after restriction period [21-42d]. Compensatory growth after restriction period was also explained by independent comparisons at 21-42d [table 2]. The reduction in BWG depended on the level of feed restriction applied, with the smallest BWG noted in treatment TW30. However BWG in treatments SW20 and TW10 was similar to control diet from 1-42d. Other researchers showed that compensatory growth was occurred after restriction [2, 25, 33, 40].

Final body weight [Table 3] followed the same pattern as for BWG. Body weights of birds at 42 d were significantly different for most treatments [P < 0.01], and birds fed *ad libitum* were heavier at all ages. Treatments SW20 and TW10 was similar body weight to control diet. Feed-restricted birds in these treatments were able to attain normal market body weight at 42 d of age, which suggests that growth compensation occurred. This finding may result from the fact that proportionally more nutrients are used for growth rather than for maintenance [19]. The age and severity of the feed restriction used in these treatments allowed birds to attain market body weight for age. The energy to support accelerated growth may come from a reduction in the overall maintenance energy needs [36] or from a decrease in needs for basal metabolic rate as previously observed in feed-restricted birds [40]. The results have also reported by other studies [2, 16, 17, 21, 25, 33]. As well as, Palo et al [1995] reported that body weight in feed-restricted birds was similar to that chicks fed *ad libitum*.

Table 2. The effect of quantitative feed restriction on performance of broiler chicks

Treatment	Daily feed intake [g/bird/day]			Average daily gain [g/bird/day]			Feed conversion ratio [g/g]		
	1-21d	21-42d	1-42d	1-21d	21-42d	1-42d	1-21d	21-42d	1-42d
SW	49.69^{a}	158.65^{a}	104.17^{a}	35.00^{a}	84.56^{a}	59.76^{a}	1.42^{a}	1.88^{a}	1.74^{a}
SW10	48.19^{b}	146.93^{b}	97.56^{bc}	35.17^{a}	81.19^{b}	57.16^{c}	1.37^{bc}	1.81^{b}	1.68^{b}
SW20	46.76^{d}	150.24^{b}	98.50^{b}	34.36^{b}	84.31^{a}	59.35^{ab}	1.36^{cd}	1.78^{bc}	1.66^{bc}
SW30	45.29^{e}	148.83^{b}	96.91^{bcd}	33.77^{bc}	84.29^{a}	58.93^{b}	1.34^{d}	1.77^{c}	1.65^{c}
TW10	47.52^{c}	149.95^{b}	98.45^{b}	33.57^{c}	85.00^{a}	59.29^{ab}	1.42^{a}	1.76^{c}	1.66^{bc}
TW20	44.64^{f}	148.31^{b}	96.49^{cd}	32.19^{d}	83.93^{a}	58.04^{c}	1.39^{b}	1.7^{7c}	1.66^{bc}
TW30	41.81^{g}	148.79^{b}	95.29^{d}	31.90^{d}	82.43^{b}	57.20^{d}	1.31^{e}	1.80^{bc}	1.67^{bc}
SEM	0.465	0.767	0.544	0.238	0.295	0.176	0.007	0.008	0.0006
P value	**	**	**	**	**	**	**	**	**
Independent comparisons[2]	P value								
1	**	**	**	**	NS	**	**	**	**
2	**	NS	NS	**	NS	**	*	NS	NS
3	**	NS	NS	**	NS	NS	*	NS	NS
4	**	NS	**	**	NS	**	**	NS	NS
5	**	NS	*	**	NS	**	**	NS	NS

[1] SW = no restriction [control]; SW10, SW20 and SW30= feed restriction at levels of 90, 80 and 70% of *ad libitum* intake of the control birds on the previous day from 7-14d, respectively; TW10, TW20 and TW30= feed restriction at levels of 90, 80 and 70% of *ad libitum* intake of the control birds on the previous day from14-21d, respectively.
[2] 1= control vs. other treatments, 2= treatments SW10, SW20 and SW30 vs. treatments TW10, TW20 and TW30 [second wk vs. third wk], 3= treatments SW10 and TW10 vs. SW20 and TW20, 4= treatments SW10 and TW10 vs. SW30 and TW30, 5= treatments SW20 and TW20 vs. SW30 and TW30.
[a–g] Means within a column with no common superscript differ significantly [* = P< 0.05, ** = P< 0.01].
SEM = standard error of means, NS = not significant.

Table 3. Effect of quantitative feed restriction on body weight, productive index [PI] and carcass traits of broilers

Treatment	Quantitative traits			Carcass traits [%] [3]					
	Final body weight [g]	PI	Feed cost [RLS]	Carcass	Thigh	Breasts	Gizzard	Pancreas	Abdominal Fat
SW	2510.0[a]	342.98[bc]	30712[a]	68.91	21.49	31.26[a]	1.67[a]	0.085	1.79[a]
SW10	2442.5[c]	346.68[ab]	29524[b]	63.23	21.51	30.19[ab]	1.65[ab]	0.085	1.56[b]
SW20	2492.5[a]	357.54[a]	29216[bc]	70.09	21.32	30.13[ab]	1.36[c]	0.098	1.34[cd]
SW30	2475.0[b]	340.08[c]	28952[c]	68.45	20.99	28.85[bc]	1.44[bc]	0.080	1.25[d]
TW10	2490[ab]	356.09[ab]	29304[bc]	67.98	20.31	28.54[bc]	1.56[abc]	0.078	1.44[bc]
TW20	2437.5[c]	349.12[a]	2926[bc]	68.80	20.23	28.71[bc]	1.41[cd]	0.083	1.25[d]
TW30	2402.5[d]	335.43[c]	29348[bc]	67.06	21.14	27.46[c]	1.78[a]	0.085	1.06[e]
SEM	7.39	2. 06	11.29	0.46	0.24	0.34	0.36	0.003	0.045
P value	**	*	**	NS	NS	*	**	NS	**
Independent comparisons[2]	P Value								
1	**	NS	**	NS	NS	NS	NS	NS	**
2	**	NS	NS	NS	NS	*	NS	NS	**
3	NS	NS	NS	NS	NS	NS	NS	NS	**
4	**	**	NS	NS	NS	NS	NS	NS	**
5	**	**	NS	NS	NS	**	**	NS	**

[1] SW = no restriction [control]; SW10, SW20 and SW30= feed restriction at levels of 90, 80 and 70% of *ad libitum* intake of the control birds on the previous day from 7-14d, respectively; TW10, TW20 and TW30= feed restriction at levels of 90, 80 and 70% of *ad libitum* intake of the control birds on the previous day from14-21d, respectively.
[2] 1= control vs. other treatments, 2= treatments SW10, SW20 and SW30 vs. treatments TW10, TW20 and TW30 [second wk vs. third wk], 3= treatments SW10 and TW10 vs. SW20 and TW20, 4= treatments SW10 and TW10 vs. SW30 and TW30, 5= treatments SW20 and TW20 vs. SW30 and TW30.
[3]Carcass traits calculated as a proportion of weight to live weight.
[a–e] Means within a column with no common superscript differ significantly [* = P< 0.05, ** = P< 0.01].
SEM = standard error of means, NS = not significant.

Feed conversion ratio [FCR] was significantly different [P < 0.01] among control and feed-restricted treatments. FCR significantly improved in feed-restricted birds compared to chicks fed *ad libitum*. This difference also showed by independent comparison at all age for FCR in comparison control diet vs. restricted diets. Similar results have been reported by other research [6, 7, 20, 21]. The improvement in FCR noted with the use of age or severity of feed restriction was likely due to reduced maintenance requirements. This finding perhaps relates to a decrease in basal metabolic rate [40] associated with a smaller body weight during early growth.

Productive index in feed-restricted birds improved [P < 0.05] than birds fed *ad libitum*. Except treatments SW30 and TW30, other treatments improved PI than control diet. Improvement in PI was due to improvement in feed efficiency of feed-restricted birds. These findings agree with results obtained by Palo et al, [1995] and Plavnik and Hurwitz, [1985]. As well as, feed cost in restricted diets was decreased than control diet. These results were also reported by other researchers [33, 38].

Carcass traits

The results for carcass characteristics and organ as a percentage of the live body weight of treatments are presented in table 3. No significant differences were observed among treatments for carcass, thighs and pancreas weight. However, there were significant differences across treatments in breast, gizzard and abdominal fat pad weight [P < 0.05]. Control-fed birds had the highest [P < 0.05] abdominal fat pad weight and a progressive reduction in abdominal fat pad was noted with increasing age or severity of feed

restriction. As well as, gizzard weight was decreased in feed-restricted birds compared to chicks fed *ad libitum*. Moreover, Breast meat as a percentage of the body weight was reduced in feed- restricted birds [Table 3].

Abdominal fat deposition was significantly affected by the implementation of feed restriction, confirming the results of other studies [14, 26, 31]. However, others have failed to confirm this effect [9, 7, 37, 39]. Such inconsistency may relate to different feeding strategies applied, which may affect the bird's response to feed restriction. The fact that there was significant reduction in abdominal fat deposition in this experiment suggests that severity or age of restriction [restriction at second or third week] applied in this study, significantly reduce abdominal fat content.

Breast weight in restricted diets was reduced. This finding suggests that feed restriction specifically reduced breast muscle growth [10, 18] and that this effect again depends on the age or level of feed restriction. It is also possible that reduction in breast meat yield in feed-restricted birds might be due to lowering amino acid intake linked with decreasing energy levels. Finally, the smaller gizzards observed in feed-restricted chicks as compared with gizzards of chicks fed *ad libitum* was due to high feed intake in control birds. This result is a consequence of the increased grinding activity of the gizzard in high level of feed intake.

CONCLUSION

It is concluded that feed restriction slows the early growth of broilers and improved the performance parameters. It seems, implementation of feed restriction at an earlier period [7-14d] resulted in more beneficial productive parameters than did feed restriction starting at a later period [14-21 d]. Our results showed that, by increasing the age of bird's severity of feed restriction should be decreased. Thus, feed restriction at level of 80% and 90% *ad libitum* feed intake from 7-14d and 14-21, respectively, allowed birds to achieve complete growth compensation. Moreover, with increasing level of feed restriction, abdominal fat pad weight was decreased. Therefore, application of feed restriction up to 80% *ad libitum* feed intake at second week or 90% *ad libitum* feed intake at third week of age, in broiler chickens is suggested due to the improved response observed in birds in relation to feed conversion and productive index.

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