Performance and hormonal profile in broiler chickens fed with different energy levels during post restriction period[1]

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Abstract – The aim of this work was to investigate the influence of diet energy level on performance and hormonal profiles of broilers during post restriction period. It was a split-plot experiment, and the main treatments were in a 2x2 factorial scheme. Birds were fed restricted to 30% of the *ad libitum* intake, from 7 to 14 days of age. After the restriction period, birds were fed *ad libitum* with diets containing low (2,900 kcal ME/kg) or high (3,200 kcal ME/kg) energy until 49 days of age. Broilers fed with high energy ration showed lower feed intake and better feed conversion and decreased carcass protein; however, abdominal fat pad, and total carcass fat were not affected by ration energy levels or feeding program. Neither diet energy level nor feed restriction program changed body weight at 49 days. The profile of insulin-like growth factor-1 (IGF-1) was reduced during the feed restriction period, but increased at refeeding period. Feeding program and ration energy level did not affect T_3, T_4 and growth hormone serum concentrations. Feed restriction at 30% of *ad libitum* intake is not enough to promote changes on carcass quality, related to fat deposition, and on metabolic hormone levels, except IGF-1 seric level that has rapid increase after feed restriction.

Index terms: carcass composition, weight gain, hormones, feeding level.

Desempenho e perfil hormonal de frangos alimentados com diferentes níveis energéticos após restrição alimentar

Resumo – O objetivo deste trabalho foi investigar o efeito do nível energético da dieta no desempenho e nos níveis hormonais após um período de restrição alimentar. O experimento foi em parcelas subdivididas, com os tratamentos principais em um esquema fatorial 2x2. O consumo de ração das aves foi reduzido em 30% em relação ao grupo controle, do 7º ao 14º dia de idade, sendo posteriormente alimentadas *ad libitum* com dietas contendo baixa (2.900 kcal EM/kg) ou alta energia (3.200 kcal EM/kg), até os 49 dias de idade. Aves alimentadas com o maior nível energético mostraram um menor consumo de ração, melhor conversão alimentar e decréscimo na quantidade de proteína da carcaça. A gordura abdominal e total da carcaça não foram afetadas pelo nível energético ou programa alimentar, assim como o peso corporal aos 49 dias de idade. Os níveis séricos do fator de crescimento tipo insulina-1 (FCI-1) foram reduzidos durante a restrição, mas aumentou com a realimentação. O programa alimentar e o nível energético não afetaram as concentrações de T_3, T_4 e hormônio de crescimento. A restrição alimentar em 30% do consumo *ad libitum* não é suficiente para promover alterações na qualidade da carcaça nem nas concentrações dos hormônios metabólicos, com exceção do FCI-1, que apresenta um rápido aumento após a restrição.

Termos para indexação: composição da carcaça, ganho de peso, hormônio, nível de alimentação.

Introduction

Birds with retarded growth due to undernutrition can achieve a growth rate higher than normal for chronological age after removal of the feed restriction (Plavnik & Hurwitz, 1985). This compensatory growth or catch up growth exhibited by restricted birds

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allows the recovery of body weight at slaughter age and sometimes a higher body weight than that of birds fed *ad libitum* (Plavnik & Hurwitz, 1990). However, the mechanisms responsible for this capacity have not yet been fully clarified. McMurtry et al. (1988) stated that changes in the weight gain composition, higher efficiency of energy utilization, and reduction in maintenance requirements, or a combination of these factors, contribute to the phenomenon of compensatory growth. However, other factors are related to total or partial compensatory gain as sex, qualitative or quantitative feed restriction, feed restriction severity, strain and broiler age (Yu & Robinson, 1992).

Although compensatory gain after feed restriction has been a subject of investigation, the hormonal profile involved in this process has not been often studied. In chickens, as well as other species, the animal metabolism is controlled by a variety of hormones that form a complex system which directly affects growth. Among hormones, growth hormone (GH), insulin like growth factor-1 (IGF-1), insulin, triiodothyronine (T_3) and thyroxine (T_4) have been reported to be involved in broiler growth control (Scanes et al., 1984). However, it should be emphasized that the final growth expression is the result of interactions between nutritional, environmental, and genetic factors interacting with endocrine secretions.

This study was carried out to investigate the influence of diet energy level on performance and hormonal profiles during post restriction period in broiler chickens.

Material and Methods

A total of 400 female broiler chickens of Cobb-500 strain were allocated in environmentally controlled rooms at Setor de Avicultura, FCAV/Unesp, Jaboticabal, Brazil, between July and August in 2000. Ambient temperature was maintained at thermoneutrality according to birds age, that were reared in pens on litter floor (8 cm of wood shavings and population density of 10 birds/m^2) up to 49 days of age. At day 7, chicks were assigned to one of two feeding groups: *ad libitum* (AL) or feed restricted (FR), and two different energy levels (high and low) with four replications of 25 birds per treatment. Feed restriction was applied during the second week (7 to 14 days) when birds were restricted to 30% of *ad libitum* intake. After the feed restriction period, the birds were fed *ad libitum* until the end of the experiment (49 days). Feed was continuously available to the animals of the *ad libitum* group. The diets used in the experiment were based on corn and soybean meal (Table 1). Feed intake and body weight were recorded weekly. Light was provided for 23 hours throughout the experimental period.

Blood samples of 12 birds per treatment (each bird being considered one replication) were collected between 2 pm and 4 pm from the wing veins, using sterile and heparinized syringes, on days 14, 18, 22, 26, 30 and 49. After collection, tubes containing blood were kept at room temperature for two hours and then transferred to a refrigerator and kept overnight at 4°C, centrifuged at 3,000 rpm/15 min. Serum was obtained and stored at -20°C until analysis.

Quantification of insulin, growth hormone (GH) and insulin-like growth factor-1 (IGF-1) were performed by radioimmunoassay. Insulin level was measured using the commercial kit 'Coat a Count Insulin' (Diagnostic Products Corporation). GH was determined by homologue radioimmunoassay procedure described by Berghman et al. (1988) and validated to birds plasma sample and IGF-1 level was determined according to Huybrechts et al. (1985). The levels of triiodothyronine (T_3) and thyroxine (T_4) were measured by enzymatic immunoassay using commercial kits Stratus (DADE International Incorporation in immunofluorescense apparatus BAXTER STRATUS II).

Table 1. Composition and calculated analysis of experimental diets offered to broiler chickens from 1 to 49 days of age.

Variable	Starter diet (1 to 21 days of age)		Growing diet (22 to 49 days of age)	
	Low energy	High energy	Low energy	High energy
Maize (%)	56.12	48.85	63.05	55.79
Soybean meal (%)	37.41	38.85	31.69	33.09
Soybean oil (%)	1.47	7.30	0.26	6.12
Vitamin and mineral mix(1)	5.00	5.00	5.00	5.00
	Calculated analysis			
Protein (%)	22.00	23.00	20.00	20.00
Metabolizable energy (kcal/kg)	2,900	3,200	2,900	3,200
Metionine + cystine (%)	0.70	0.70	0.65	0.64
Lysine (%)	1.22	1.24	1.07	1.09
Calcium (%)	1.03	1.03	1.01	1.01
Available phosphorus (%)	0.46	0.45	0.45	0.45

(1)Vitamin and mineral mix/kg: Vitamin A, 176,000 IU; Vitamin D3, 40,000 IU; Vitamin E, 500 mg; Vitamin K3, 100 mg; Vitamin B1, 36 mg; Vitamin B2, 200 mg; Vitamin B6, 50 mg; Vitamin B12, 560 mg; niacin, 700 mg; biotin, 3 mg; pantotenic acid, 500 mg; folic acid, 30 mg; choline chloride, 20 mg; Fe, 1,100 mg; Cu, 300 mg; Mn, 1,800 mg; Zinc, 1,200 mg; I, 24 mg; Se, 3 mg; metionine, 20 g; Ca, 176 g; P, 68 g; Na, 23 g; Cl, 36 g; growth promoter, 2 g; coccidiostatic, 10 g; BHT, 1 g.

At 14, 28, 42 and 49 days of age, 12 birds per treatment were weighed and slaughtered by cervical dislocation for carcass composition analysis (protein and fat) after two hours of fasting. The abdominal fat pad (fat around the cloaca and abdominal muscles) was removed and weighed, and again added to the carcass. The carcasses were then ground with an industrial meat grinder, and dried in a forced-air oven at 55ºC during 72 hours. The carcasses were homogenized and samples were collected for protein and total fat determinations. All analysis were performed in duplicates, according to the procedures of Association of Official Analytical Chemists (1990).

The experiment was performed in a split-plot design with main plots as the combination of two feeding program (*ad libitum* and restricted) and two ration energy levels (low: 2,900, high: 3,200 kcal ME/kg) and age as secondary plots. Data were subjected to statistical analysis using the General Linear Model procedure (GLM) of SAS (SAS Institute, 2000), and means were compared by Tukey's test at 5% of probability.

Results and Discussion

Birds that were fed with high energy level had a lower ($p<0.01$) feed conversion and lower ($p<0.05$) feed intake; however, no significant difference ($p>0.05$) in final body weight was found between the birds fed with different energy levels (Table 2). The feeding program did not affect any of the performance parameters and there was no significant interaction ($p>0.05$) among treatments. The great variability of data shown in the literature regarding early feed restriction in broilers seems to be related to several factors, i.e., severity and duration of feed restriction, broiler age, refeeding period (Lippens et al., 2000) and energy level. Coon et al. (1981) comparing the performance of male and female broilers fed on low or high energy rations during 56 days, found a significant improvement in the feed conversion using a diet with high energy level. Zorrila et al. (1993) observed a linear increase in body weight gain increasing the energy levels. The present work also provides evidence that a high energy diet improves feed consumption and results in a better feed conversion during post restriction period, compared to a lower energy level.

Feed restriction could also affect the feed intake following restriction period, feed conversion efficiency and body weight (Plavnik & Hurwitz, 1991). The present work did not show any effect of quantitative early feed restriction on broiler performance. Thus, even though the level of early feed restriction is an important factor influencing the broilers response, early feed restriction at 30% of *ad libitum* intake was not able to influence broiler performance parameters at market age (49 days).

As to carcass composition, broiler total and abdominal fat were not affected by ration energy level; however, birds fed with high energy level (3,200 kcal ME/kg) had lower body protein content when compared to the birds fed with low energy level (2,900 kcal ME/kg) (Table 3). There was a decrease ($p<0.01$) in carcass protein percentage and an increase in fat pad and total body fat as broilers

Table 2. Means for the effects of feeding program, diet energy level and age on feed intake, body weight gain and feed conversion of broiler chickens[(1)].

Treatment	Feed intake (g/bird)	Body weight (g/bird)	Feed conversion (g/g)
Feeding program			
Ad libitum	1,332±270a	541±86a	1.91±0.10a
Feed restricted	1,266±269a	549±95a	1.91±0.09a
Energy level			
Low energy	1,361±287a	518±92a	2.03±0.08a
High energy	1,237±250b	572±89a	1.79±0.10b
Age (days)			
7-14	203±12d	124±9d	1.67±0.05b
15-21	429±9c	271±11c	1.60±0.05b
22-28	725±17b	429±14b	1.70±0.06b
29-49	3,840±124a	1,409±39a	2.66±0.11a

[(1)]For each variable, means in the column followed by the same letter do not differ significantly by the Tukey's test at 5% of probability; values represent mean±standard deviations.

Table 3. Means for the effects of feeding program, ratio energy level and age on protein, ether extract and abdominal fat content of broiler chickens[(1)].

Treatment	Protein (%)	Total fat (%)	Abdominal fat (g)
Feeding program			
Ad libitum	41.93±0.77a	32.61±0.97a	28.48±2.80a
Feed restricted	41.16±0.64a	32.68±1.06a	26.76±2.89a
Energy level			
Low energy	42.65±0.62a	31.68±1.04a	28.74±2.75a
High energy	40.44±0.79b	32.68±1.00a	26.43±2.96a
Age (days)			
14	46.33±0.51a	23.75±0.59c	-
28	42.44±0.79b	32.76±0.51b	10.99±0.37c
42	37.54±0.68c	38.31±0.77a	34.98±2.44b
49	36.85±0.67c	37.22±1.26a	47.72±2.94a

[(1)]For each variable, means in the column followed by the same letter do not differ significantly by Tukey's test at 5% of probability; values represent mean±standard deviations.

growth. Feeding program did not affect ($p>0.05$) broilers carcass protein, total fat and abdominal fat pad, and no significant ($p>0.05$) interactions were verified among treatments.

A controversial aspect of feed restriction programs has been the inconsistent effect on carcass fat deposition. Summers et al. (1990) and Jones & Farrell (1992) did not find changes in carcass composition of birds after feed restriction conditions; however, Plavnik & Hurwitz (1985, 1989) and Plavnik et al. (1986) reported a decrease in fat pad on birds restricted from 6 to 12 days of age, without adverse effects on growth. The same effect of restriction on the amount of carcass fat was found by Sugeta et al. (2002), but with lower body weight gain in relation to the *ad libitum* birds, perhaps due to the restriction severity (70% of the *ad libitum* feed intake). Fontana et al. (1992) reported a larger abdominal fat deposition in the carcass of restricted birds after refeeding. According to Evans (1977), fat pad is more directly influenced by nutrition than total carcass fat. The present data showed that early feed restriction and energy level did not reduce carcass fat and fat pad content at 49 days of age. Probably, this finding is related to a high fat deposition on broiler adipose tissue observed during refeeding period. Furlan (1996) also verified high fat deposition (abdominal and carcass) one week after refeeding.

Serum concentrations of hormones were significantly ($p<0.01$) affected by birds age (Table 4). There were no significant effects of feeding program and energy levels on T_3, T_4 and GH serum concentrations; however, a significant feeding program x broilers age interaction was observed in IGF-1 and insulin serum levels. The interaction analysis showed that feeding program significantly ($p<0.01$) reduced the IGF-1 serum level in approximately 44% at the end of the feed restriction period, compared to birds fed *ad libitum* (Table 5). After four days of *ad libitum* feed intake (refeeding), IGF-1 returned to normal levels, not differently ($p>0.05$) from that observed in the *ad libitum* birds

Table 4. Means for the effects of feeding program, energy level and age on seric levels of triiodothyronine (T_3), thyroxine (T_4), insulin, insulin-like growth factor (IGF-1) and growth hormone (GH) of broiler chickens[(1)].

Treatment	T_3 (ng/mL)	T_4 (ng/mL)	Insulin (μIU/mL)	IGF-1 (ng/mL)	GH (ng/mL)
Feeding program					
Ad libitum	1.43±0.07a	9.68±0.43a	3.54±0.17a	28.95±1.03a	103.50±8.72a
Feed restricted	1.46±0.08a	9.22±0.48a	3.25±0.14a	27.23±1.05a	118.65±8.00a
Energy level					
Low energy	1.40±0.06a	9.73±0.47a	3.38±0.16a	27.13±1.03a	118.48±8.53a
High energy	1.18±0.09a	9.14±0.44a	3.43±0.16a	29.08±1.04a	103.80±8.19a
Age (days)					
14	1.18±0.15cd	6.61±0.63	4.11±0.28a	20.69±2.26b	193.88±16.28a
18	1.24±0.11cd	7.81±0.85	2.35±0.22b	22.32±1.52b	113.34±10.57b
22	1.31±0.10bcd	5.93±0.64	3.91±0.22a	24.66±1.35a	154.50±15.24ab
26	0.96±0.08d	10.13±0.79	2.59±0.18b	40.24±1.90a	111.66±11.61b
30	1.83±0.20ab	8.61±0.51	1.93±0.22b	37.36±1.86b	151.78±18.32ab
42	1.98±0.12a	11.91±0.59	3.75±0.33a	26.72±0.97b	27.20±2.75c
49	1.63±0.09abc	13.65±0.71	4.71±0.29a	24.37±1.01b	29.10±5.36c

(1)For each variable, means in the column followed by the same letter do not differ significantly by Tukey's test at 5% of probability; values represent mean±standard deviations.

Table 5. Interactions between feed program and age on seric levels of insulin and insulin-like growth factor-1 (IGF-1) of broiler chickens[(1)].

Feeding program	Age (days)						
	14	18	22	26	30	42	49
				Insulin (μIU/mL)			
Ad libitum	4.03±0.45AB	2.34±0.27C	4.09±0.40AB	2.62±0.25BC	1.56±0.29C	4.56±0.47Aa	4.95±0.42A
Feed restricted	4.19±0.35AB	2.37±0.35D	3.73±0.23ABC	2.56±0.27CD	2.32±0.31CD	2.86±0.35BCDb	4.45±0.39A
				IGF-1 (ng/mL)			
Ad libitum	26.56±3.93BCa	24.50±2.24C	26.21±1.96BC	38.78±2.32A	35.64±3.06AB	26.53±1.40BC	23.21±1.54C
Feed restricted	14.82±1.19Cb	20.03±1.96BC	23.19±1.86B	41.95±3.16A	39.28±1.96A	26.90±1.38B	25.43±1.34B

(1)For each variable, means followed by the same small letter within a column and by the same capital letter within a row do not differ significantly by Tukey's test at 5% of probability; values represent mean±standard deviations.

until the end of the experimental period. Insulin serum level was lower ($p<0.05$) for feed restricted birds only at 42 days of age when compared to *ad libitum* fed broilers (Table 5).

Changes in the IGF-1 plasma level by different nutritional status have been described in mammals and birds. Generally, there is a fall in the concentration of this growth factor due to protein and energy restriction (Kita et al., 1996; McMurtry et al., 1997). In the present work broiler chickens also reduce IGF-1 plasma level due to feed restriction, and increase it after refeeding period (Table 5). Schew et al. (1996) submitted quails to feed restriction and reported that when feed was provided *ad libitum*, there was a reestablishment of the IGF-1 plasma concentration in levels above than those found in the control birds. Fasting is associated not only with reduced plasma IGF-1 concentration but also with elevated plasma GH levels (Morishita et al., 1993). McMurtry et al. (1988) and Buyse et al. (1996) reported that restricted broiler showed high GH plasma concentration during compensatory growth than non-restricted ones.

Insulin serum concentrations did not decrease during feed restriction. Similarly, McMurtry et al. (1988) did not observe changes in the plasma insulin concentration in broiler chickens submitted to feed restriction. These findings suggest that the level of restriction used was not severe enough to elicit any physiological changes in the serum insulin level.

Conclusions

1. A high energy diet improve feed consumption and results in a better feed conversion during post restriction period when compared to a lower energy level.
2. Feed restriction at 30% of *ad libitum* intake is not enough to promote changes in carcass quality and on metabolic hormones levels, except IGF-1 seric level that has rapid increase after feed restriction.

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