African Journal of Biotechnology Vol. 8 (22), pp. 6470-6475, 16 November, 2009
Available online at http://www.academicjournals.org/AJB
ISSN 1684–5315 © 2009 Academic Journals

Full Length Research Paper

Effect of dietary dilution of energy and nutrients during different growing periods on compensatory growth of Ross broilers

S. Tooci[1], M. Shivazad[2]*, N. Eila[1] and A. Zarei[1]

[1]Animal Science Department, Islamic Azad University, Karaj branch, Karaj, Iran.
[2]Animal Science Department, University of Tehran, Karaj, Iran.

Accepted 9 October, 2009

A completely randomized design was conducted to evaluate the effect of dietary dilution of energy and nutrients during different growing periods on compensatory growth of Ross broilers. Four replicant pens were assigned per seven treatments. Chicks in each treatment received concentrated and diluted diets in different stages of growing periods (starter, grower and finisher). The diets were mainly based on maize and soybean meal and had constant ratio of metabolizable energy/nutrients. It was concluded that feed intake, feed conversion, production index, feed cost and metabolizable energy per weight gain of chicks receiving concentrated diets during all stages of growing periods were the same as the chicks receiving diluted diets during finisher period ($P > 0.05$). The amount of abdominal fat was significantly lower in chicks receiving diluted diets during finisher period ($P \leq 0.05$). Mortality percentage in chicks receiving concentrated diets during all stages of growing periods was significantly more than other treatments ($P \leq 0.05$). Based on the results of the experiment, diluted diets for finisher period of Ross broilers male chicks is suggested.

Key words: Ross broilers, concentrated diets, diluted diets, compensatory growth.

INTRODUCTION

Thanks to ever increasing trend of burgeoning population, we are facing with more demand of meat consumption. Here, poultry industry is of paramount importance. Since feed cost in poultry farming accounts for 70% of current expenditures and supplying dietary energy constitutes the highest feed cost (approx. 50-80% of feed cost), using concentrated diets in all stages of growing periods has resulted in increasing feed expenditures, moreover increasing abdominal fat wastes and heightening mortality rate.

The carried out experiments indicate that poultry feed intake rate strictly hinges on their required energy coupled with physical specification, however with dietary energy increase, poultry consumes more energy that lead to increase fat storing in their bodies (Robbins, 1981). Increasing dietary energy level will result in increase weight gain and also improvement of feed conversion (Araujo et al., 2005; Albuquerque et al., 2003) otherwise. There exists positive phonotype cohesion between rate of weight gain and substitution of fat in tissue (Jackson et al., 1982) and also experiments have shown that the best performance (higher rate of weight gain and lower FCR) is not always followed by the maximum economic output (Reginatto et al., 2000). Another researcher showed that broilers enjoy capability of compatibility with wide spectrum of diluted diets in finisher period in such a way that birds while consuming diluted diets, improve their energy intake productivity with reducing energy consumption (Leeson et al., 1996). In experiments on studying effect of dietary energy on performance of poultry, the necessity of existence of an appropriate proportion has been explained between energy and all diet nutrients (Leeson and Summers, 2001) that has been observed strictly in most experiments; but the discussion of palatability and its effect on feed intake is the issue that creates mistake at researches on effect of dietary energy level on performance of poultry, details of which have not been taken

*Corresponding author. E-mail: shivazad@ut.ac.ir. Tel: +989121150409. Fax: 982612246752.

Table 1. Experimental treatments.

Treatment	Starter diet (0 - 10 days)	Grower diet (11 - 28 days)	Finisher diet (29 - 42 days)
1	Concentrated Diet	Concentrated Diet	Concentrated Diet
2	Concentrated Diet	Diluted Diet	Diluted Diet
3	Diluted Diet	Concentrated Diet	Diluted Diet
4	Diluted Diet	Diluted Diet	Concentrated Diet
5	Diluted Diet	Concentrated Diet	Concentrated Diet
6	Concentrated Diet	Concentrated Diet	Diluted Diet
7	Concentrated Diet	Diluted Diet	Concentrated Diet

Table 2. Rations for all periods (%).

Component	Starter		Grower		Finisher	
	Conce.	Dilu.	Conce.	Dilu.	Conce.	Dilu.
Corn, Grain	40.28	33.99	51.78	39.27	60.37	45.06
Soybean Meal	36 .50	30.87	33.43	25.01	18.11	8.54
CanolaMeal	10.48	10.48	2.80	2.80	10.00	10.00
Wheat Bran	0.00	10.02	0.00	19.12	0.00	25.62
Canola Oil	5.00	5.00	5.00	5.00	4.50	4.50
Anchovy Meal	4.00	4.00	3.36	3.36	3.36	3.36
Inert	0.00	2.28	0.00	1.95	0.07	0.00
Oyster Shells	1.27	1.27	1.27	1.30	1.23	1.30
DCP	1.36	1.05	1.29	0.76	1.30	0.63
Mineral Premix	0.3	0.3	0.3	0.3	0.3	0.3
Vitamin Premix	0.3	0.3	0.3	0.3	0.3	0.3
DL-Methionine	0.25	0.23	0.21	0.17	0.15	0.12
Common Salt	0.25	0.22	0.27	0.21	0.28	0.20
L-Lysine	0.00	0.00	0.00	0.00	0.03	0.08

Conce. = Concentrated diet, and Dilu. = diluted diet.

into consideration in most experiments. At this experiment, the rate of fat and fish meal has been taken into consideration equally in concentrated and diluted diets of each growing period, aimed at removing effect of palatability on rate of feed intake in various diets. Also, diet formulation has been based on digestible amino acids of feed, aimed at removing problems as a result of consuming low-energy feed with the adaptability of low digestion of amino acids.

MATERIALS AND METHODS

The experiment was carried out within the statistical design of Complete Random Design (CRD) and includes seven treatments, containing effect of seven various modes of using concentrated and diluted diets in various growing periods on performance of chicks (Table 1). Composition of the rations for all three periods is listed in Table 2.

Each treatment includes four replications and in each repetition, five chicks were placed. The experiment was carried out in cold battery and a number of 140 day-old Ross male chicks, after weighing, were distributed randomly in 28 pens. Hence, one observation existed for each studied attributes per each test operation unit. Characteristics of weight gain, feed intake, feed conversion, production index and proportion of abdominal fat per live weight and also mortality rate were studied. In the same direction, consumable metabolizable energy was estimated per Kg live weight. Moreover, feeding cost was also estimated per live weight as well. The data obtained at the research was analyzed and studied through the application of SAS (Statistical Analysis System) software package system. Accordingly, Duncan averages comparison test was carried out for all studied factors with error level of alpha = 0.05%. It should be noted that mortality rate was studied in the form of none parametric and test of Analysis of Variance and Wilcoxon Scores were used with the aim of comparing effect of treatments.

The starter period include age of chicks up by their 10 days. Age of chicks from 11 to 28 days is defined as grower period while finisher period is defined to their 29 to 42 days.

Concentrated diets are meant to the diets which have been formulated with metabolizable energy level as recommended at Ross broiler male chicks catalogue which are 3010, 3150 and 3200 kilo calories per kilo gram diet, for starter, grower and finisher periods respectively. Diluted diets are meant to the diets which have been formulated with 2800 kilo calories metabolizable energy level/kg. Although diluted diets differed from concentrated diets (recommended at Ross catalogue) in terms of energy level, protein and other nutrients; proportion of energy kept fixed to all nutrients

Table 3. Comparision of average of treatments with Duncan test (average ± standard error).

Characteristics	Treatments						
	1	2	3	4	5	6	7
Weight gain (gr)	2254.83^{a} ±14.50	1745.80^{b} ±88.95	1859.80^{b} ±75.04	1934.60^{b} ±54.52	1930.55^{b} ±97.79	1822.85^{b} ±51.51	1807.13^{b} ±62.90
Feed intake (gr)	4149.90^{a} ±163.07	4247.00^{a} ±90.13	4105.15^{a} ±106.32	4032.98^{a} ±116.20	4009.03^{a} ±117.60	3839.90^{a} ±214.93	4093.68^{a} ±135.58
Feed conversion	1.84^{c} ±0.07	2.44^{a} ±0.09	2.21^{ab} ±0.11	2.08^{bc} ±0.05	2.08^{bc} ±0.09	2.10^{bc} ±0.06	2.26^{ab} ±0.04
Production index	248.00^{a} ±28.46	163.47^{b} ±18.07	202.52^{ab} ±18.72	211.05^{ab} ±17.88	186.82^{b} ±9.46	226.45^{ab} ±2.07	181.27^{b} ±15.13
Production index based on corpes weight	170.25^{a} ±10.73	108.50^{c} ±10.98	139.00^{bc} ±9.60	142.25^{ab} ±9.37	128.75^{bc} ±4.71	168.75^{a} ±10.66	123.25^{bc} ±9.59
Abdominal fat per live weight (%)	2.44^{a} ±0.11	1.84^{ab} ±0.17	2.24^{a} ±0.27	1.87^{ab} ±0.20	1.86^{ab} ±0.36	1.37^{b} ±0.31	2.02^{ab} ±0.11
Metabolizable energy per Kg live weight	5970.03^{b} ±233.73	6931.38^{a} ±274.56	6511.25^{ab} ±337.42	6387.50^{ab} ±203.55	6825^{a} ±279.94	6104.75^{b} ±165.61	6979.75^{a} ±163.70
Feed cost per live weight (dollar)	0.813^{bc} ±0.031	0.895^{abc} ±0.035	0.849^{abc} ±0.044	0.846^{abc} ±0.027	0.909^{ab} ±0.037	0.798^{c} ±0.019	0.926^{a} ±0.022

Different alphabetic words referred as existence of significant difference between treatments ≤ 0.05).
Similar alphabetic words referred as lack of significant difference between treatments (P > 0.05).

like standard diets.

Nutritional proposals existing at Ross catalogue is regarded as reference for determining chicks' nutrients requirements.

RESULTS AND DISCUSSION

Weight gain

Results of the experiment showed that the average weight gain of first treatment was significantly (P ≤ 0.01) more than other treatments (Table 3).

With due observance to the results gained at Table 3, chicks at first treatment had received concentrated diet in all stages of growing periods with significant difference, had better weight gain performance as compared with other treatments. Researchers have announced that chicks' weight gain is strictly affected with dietary energy density in a way that concentrated diets will cause high growth as compared with diluted diets. Therefore, it is expected that in case of dilution of diet in each starter, grower and finisher period, weight gain is reduced significantly and will cause prolongation of rearing period. These results accord with reports of many researches (Leeson et al., 1996; Donaldson, 1985; Jackson et al., 1982; Lott et al., 1992; Hussein et al., 1996; Holsheimer and Veerkamp, 1992); but on the other hand, studies have shown that there exists positive phonotype cohesion between growth rate and fat substitution at tissue (Jackson et al., 1982). We should bear in mind that more growth is not always synonymous with maximum economic performance (Reginatto et al., 2000) and it should be noted that application of concentrated diets will follow feed expenditures increase as well (Jackson et al., 1982).

During growing periods, chicks, thanks to their genetic potential, tries to reach their weight in conventional way with feed consumption increase. There are reasons that shows appetite is regarded as the first factor which directly affects growth rate of chicks in such a way that more appetite of chicks is lead to more weight gain, so weight gain is directly affected by dietary energy rate, genetic potential and other factors (Olumu and Offiong, 1980).

Feed intake

Results of the experiment (Table 3) did not show difference between treatments significantly (P > 0.05). In 1982, Scott and colleague announced that animals such as poultry eat feedstuff with the aim of energy requirements. Therefore, feed intake should be increased upon reduction of dietary energy, aimed at meeting energy requirement. It should be noted that diluted diets have less density and with considering that feed intake was equal in numerical terms in all diets and effect of reduction of dietary energy has not been significant on feed intake, it seems that the chicks in treatments which have received diluted diet, physical trend has been occurred before supplying required energy, details of which has caused lack of increase in feed intake and consequently has caused growth reduction. These results accord with the results of other researches which have been carried out in this field (Leeson et al., 1996; Scott and Young,

1982; NRC, 1994).

On the other hand, researches carried out by Sunder et al. (1988) proved reverse relation of increasing volume of alimentary system with dietary energy level. Therefore, intake of diluted diet in starter and growth periods creates this possibility for the poultry that could meet energy requirement at the finisher period through feed intake increase; In other words, intake of diluted diets increases energy intake efficiency (Leeson et al., 1996).

Therefore, it seems that, although volume of alimentary system is mostly been increased at the finisher period, increasing feed energy level at the finisher period caused lack of increasing feed intake, for, chicks have improved their energy consumption productivity at grower period. Since their need of energy is increased even at the finisher period, increasing energy level at finisher diets along with boosting productivity in energy intake causes lack of significant increase on feed intake at the finisher period (Leeson and Summers, 2001). Hence, as mentioned above, results of the experiment are accorded with most of the carried out researches.

Feed conversion

With due observance to the results of test, as shown at Table 3, there exists significant difference between treatments ($P \leq 0.01$). It should be noted that first treatment (1.84), fourth (2.08) and sixth (2.10) enjoy the highest feed conversion while second treatment (2.44), third (2.21) and seventh (2.26) enjoyed the worst feed conversion. Since first treatment had received concentrated diet at all growing periods, it had not any significant difference with fourth, fifth and sixth treatment in terms of feed conversion, it seems that dietary energy reduction has not caused change in performance of feed efficiency during some stages of growing periods. Other researches announced that birds improve their energy intake while consuming diluted diets (Leeson et al., 1996; Scott and Young, 1982).

With studying feed intake rate and weight gain of treatments, it seems that more weight gain of first treatment, as compared with other treatments, is related to the full-energy feed intake at all stages of growing periods, moreover feed cost is cost dearly (Jackson et al.,1982), according to the various experiment this weight gain can not be necessarily followed up with maximum economic performance (Reginatto et al., 2000) and on the other hand, fat storage hike can be observed (Jackson et al., 1982).

Production index

As observed at results of the experiment (Table 3), there exists significant difference between treatments ($P \leq 0.05$) in a way that first treatment (248.00), third (202.52), fourth (211.05) and sixth (226.45) had the highest production index while second treatment (163.47), fifth (186.82) and seventh (181.27) had the lowest production index.

With the aim of explaining and clarifying performance of chicks strictly and while considering stored abdominal fat, production index was calculated based on weight of corpse and results were studied and analyzed. With a glance to comparing average of treatments with Duncan test (Table 3), existence of significant difference becomes clear between treatments ($P \leq 0.01$). First treatment (170.25) and sixth treatment (168.75) had the highest production index while second treatment (108.5) had the lowest production index. Third treatment (139), fifth treatment (128.75) and seventh treatment (123.25) had the average level of production index. It should be noted that fourth treatment (142.25) did not show significant difference with first and sixth treatments.

Since production index criteria, in addition to chicks' weight gain, involves feed conversion and also mortality rate, it is regarded as the best and appropriate criteria for determination of the best possible mode of using both concentrated and diluted diets in growing Ross broilers. According to results of the experiment production index of chicks receiving concentrated diets during all stages of growing periods (first treatment) were the same as the chicks receiving diluted diets during finisher period (sixth treatment) statistically ($P > 0.05$), so that with exertion of concentrated diet in the starter and grower periods and then application of diluted diet at the finisher period, while attaining to the growing objectives (less mortality rate, acceptable weight and appropriate feed conversion), improving economic productivity was accessed through inexpensiveness of diet. Studying production index confirms this claim based on corpse weight.

While considering meager numerical difference of production index of sixth treatment with first treatment (which had no significant difference in statistical term), we can grasp out that meager and less numerical difference, when production index is measured based on corpse weight, is turned as less once again. Therefore, we can reach to a conclusion that some of surplus weight and also production index of chicks in first treatment is related to the waste of corpse (abdominal fat and entrails). It is obvious that partial increase of energy level of diluted diet as much as 2800 kilo calorie or partial increase in growing periods within application of diluted diet at finisher period, will result in heightening production index of sixth treatment than first treatment.

Abdominal fat percentage per weight gain

Thanks to the results of experiment shown at Table 3, it is observed that significant difference was perceived among treatments ($P \leq 0.05$) in such a way that first treatment (2.44%) and third treatment (2.24%) had

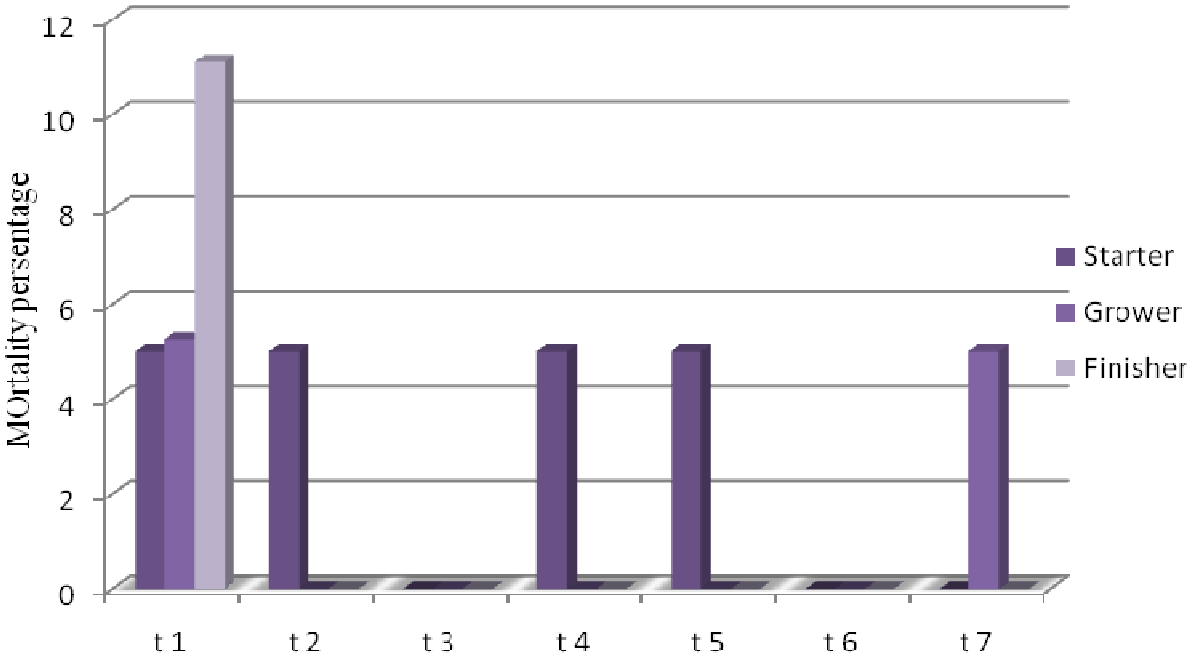

Figure 1. Mortality percentage in experiment.

highest percentage of abdominal fat and sixth treatment (1.37%) had lowest percentage of abdominal fat. Other treatments were located between these two categories.

The results of this study showed that percentage of abdominal far is affected with dietary energy level and also with exertion of diluted and concentrated diets, details of which are accorded with the result of other researches carried out in this regard. For this reason, in 1990, Waldroup and his colleagues announced that dietary energy level affects abdominal fat weight. The data announced on abdominal fat as compared with body weight, they explained abdominal fat increase in all cases is due to dietary energy level increase (Maiorka et al., 2005; Farell et al., 1999; Rostagno et al., 1995).

While considering results simultaneously gained from studying corpse fat percentage and also production index, since sixth treatment had received diluted diet at the finisher period not only did not show difference with first treatment significantly in terms of production index but also it had less corpse abdominal fat rate that can be considered as positive privilege in terms of quality of corpse, therefore applying diluted diet at the finisher period stage of growing Ross male broilers can be recommended. This affair has also resulted in improving economic efficiency through diminishing the cost price of diet as well.

It should be noted that abdominal fat increase has numerous side effects and wastes in economically point of view, because, abdominal fat is completely thrown away by consumers and while slaughtering, some part of fat will enter sewage systems and consequently, disposal of sewage contaminated with fat will create problem for slaughterhouses. On the other hand, high existence of abdominal fat indicates surplus energy intake and existence of such fat is not appropriate economically for producer, for, it causes reduction of feed efficiency coupled with increasing feed cost price.

Mortality percentage

According to the results gained in this regard, the first treatment which had received concentrated diet recommended at catalogue, had more mortality percentage in all stages of growing periods even at the finisher period had significant difference ($P \leq 0.05$) of the highest mortality percentage as compared with other treatments (Figure 1). The said issue is probably related to intake of concentrated diet and pertinent problem such as Ascites and Sudden Death Syndrome (SDS).

Based on the researches made in this regard, concentrated diets cause high weight increase among chicks while this high weight increase enjoys cardiac side effects and deficiencies, details of which will increase mortality rate (Ferket and Gernat, 2006).

Metabolically energy per weight gain

The results of experiment shown at Table 3, indicates significant difference among treatments ($P \leq 0.05$). The first treatment (5970.03 Kcal/Kg) and sixth treatment (6104.75 Kcal/Kg) had the best metabolizable energy intake rate per each kg of live weight while second treatment

(6931.38 Kcal/Kg), fifth treatment (6825 Kcal/Kg) and seventh treatment (6979.75 Kcal/Kg) had the highest metabolism energy intake rate per each kg of their live weight. Other treatments include third treatment (6511.25 Kcal/Kg) and fourth treatment (6387.50 Kcal/Kg) had average performance.

With the aim of more precise clarification of comparison of effects of treatments, metabolizable energy intake rate was calculated per each kg of their live weight and the data gained in this regard were studied and analyzed. According to the results gained at this research, sixth treatment, which had received diluted diet at the finisher period, showed the best performance without showing significant difference with first treatment in terms of metabolizable energy intake rate per each kg of their live weight. Therefore, with considering better production index, quality of appropriate corpse, meager mortality rate and finally, less rate of metabolizable energy intake, it is recommended that diet at the finisher period should be diluted for Ross male broilers.

Feed cost per weight gain

With comparison of average of treatments with Duncan test, shown at Table 3, it became clear that there exists significant difference between treatments ($P \leq 0.05$. Sixth treatment with feed cost of 0.798 dollars per each kg weight gain had the lowest amount and seventh treatment with feed cost of 0.926 dollars per each kg weight gain had the highest rate. After sixth treatment, the first treatment with 0.813 dollars feed cost per each kg of weight gain, showed the lowest rate.

Other treatments including second treatment (0.895 $), third treatment (0.849 $) and fourth treatment (0.846 $) had the average extent. It should be noted that fifth treatment (0.909 dollars) after seventh treatment had the most expensive feed cost per each kg of weight gain.

In poultry industry like other industries, more efforts were taken to gain the highest profit with diminishing production cost. In the same direction, major part of cost in poultry farming industry spends for procurement of feedstock as well. On the other hand, the highest feed cost is related to providing energy resources in diet and the amount of poultry feed intake varied with energy level in diet. Results of this research accord with other researches carried out in this regard. Researchers recommended using diluted diets for minimizing cost of each weight gain unit (Jackson et al., 1982).

Conclusions

The results of this experiment indicate that diluting diet at the finisher period enjoys the most appropriate economic performance while considering better production index, quality of appropriate corpse, meager mortality rate and intake metabolizable energy per each kg of its live weight. Also, feed cost is remarkably reduced per each kg of their live weight. Generally, using diluted diets at the finisher period will result in reduction of abdominal fat percentage and consequently improvement of quality of corpse, details of which will reduce chicks' mortality rate due to cardiac disorders.

REFERENCES

Albuquerque R, Faria DE, Junqueira OM, Salvador D, Rizzo MF (2003). Effects of energy level in finisher diets and slaughter age of on the performance and carcass yield in broiler chickens. Bras. Cienc. Avic. 5: 2.

Araujo LF, Junqueira OM, Araujo CSS, Barbosa LCGS, Stringhini JH (2005). Energy and lysine for broilers from 44 to 55 days of age. Bras. Cienc . Avic. 7: 11.4.

Donaldson WE (1985). Lipogenesis and body fat in chicks: Effect of calorie-protein ratio and dietary fat. Poult. Sci. 64: 1199-1204.

Farell DJ, Mannion PF, Maldonado RAP (1999). A comparison of total and digestible amino acid in diets for broilers and layers. Anim. Feed Sci. Technol. 82: 131-142.

Ferket PR, Gernat AG (2006). Factors that affect feed intake meat birds. Poult. Sci. 5(10): 905-911.

Holsheimer JP, Veerkamp CH (1992). Effect of dietary energy, protein. and lysine content on performance and yields of two strains of male broiler chicks. Poult. Sci. 71: 872-879.

Hussein AS, Cantor AH, Pescatore AJ, Johnson TH (1996). Effect of dietary protein and energy levels on pullet development. Poult. Sci. 75: 973-978.

Jackson S, Summers JD, Leeson S (1982). Effect of dietary protein and energy on broiler performance and production costs. Poult. Sci. 61: 2232-2240.

Leeson S, Summers JD (2001). Scoot's Nutrition of the Chicken. University Book. Guelph, Canada.

Leeson S, Caston L, Summers JD (1996). Broiler response to dietary energy. Poult. Sci. 75: 529-535.

Lott BD, Day EJ, Deaton JW, May JD (1992). The effect of temperature, dietary energy level and corn particle size on broiler performance. Poult. Sci. 71: 618-624.

Maiorka A, Dahlke F, Penz AM (2005). Diets formulated on total or digestible amino acid basis with different energy levels and physical form on broiler performance. Rev. Bras. Cienc. Avic. 7: 47-50.

NRC (National Research Council) (1994). Nutrient requirements of poultry. 9th. rev. ed. National Academy Press, Washington, D.C.

Olumu JM, Offiong SA (1980). The effects of different protein and energy levels and time of change from starter to finisher ration on the performance of broiler chickens in the topics. Poult. Sci. 59: 828-835.

Reginatto MF, Ribeiro AM, Penz AM (2000). Effect of energy, energy: protein ratio and growing phase on the performance and carcass composition of broilers. Rev. Bras. Cienc. Avic. 3: 229-237.

Robbins KR (1981). Effects of sex, breed, dietary energy level, energy source, and calorie: protein ratio on performance and energy utilization by broiler chicks. Poult. Sci. 62: 837-845.

Rostagno HS, Pupa JM, Pack M (1995). Diet formulation for broilers based on total versus digestible amino acids. J. Appl. Poult. Res. 4: 293-299.

SAS Institute. SAS® (Statistical Analysis System) (1998). User's Guide: Statistics. Cary, NC: SAS Institute Inc.

Scott ML, Young RJ (1982). Nutrition of the chicken. M.L. Scott and Assoc. Itacha, N.Y.

Sunder GS, Sadagopan VR, Maitra DN (1988). Influence of varying dietary protein and energy levels on the performance of purebred broiler chicks. Indian J. Poult. Sci. 23: 72-78.

Waldroup PW, Tidwell NM, Izat AL (1990). The effect of energy and amino acid levels on performance and carcass quality of male and female broilers grown separately. Poult. Sci. 69: 1513 -1521.