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AGE EFFECT ON THE ENDOGENOUS AND METABOLIC LOSSES IN INDUSTRIAL AND FREE-RANGE BROILER CHICKENS

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ABSTRACT

The objective of this study was to determine the endogenous and metabolic losses in industrial and free-range broiler chickens at different age rates. In the first experiment, 140 broiler chickens distributed in an entirely randomized design with four treatments and five replications were used. In the second experiment, 120 birds of both sexes from Embrapa 041 free-range strain were distributed into three treatments and five replications following the same design. In both experiments the treatments consisted in the average ages of the birds. The ages in the first experiment were 5, 15, 25 and 35 days of age, and in the second experiment the average ages adopted were 15, 45 and 75 days of age. The experimental period was of 72 hours of fasting, being the first 24 hours for digestive tract cleaning and the last 48 hours for total collection of the endogenous and metabolic losses. The contents of dry matter, nitrogen and gross energy from birds` endogenous and metabolic losses were determined. When relating losses per bird and bird weight, different interpretations were obtained for the same variable. The equations obtained to industrial and free-range broiler chicken revealed that those birds had different behaviors during metabolic fecal excretion and endogenous urinary excretion. The losses diminished according to age advance.

KEYWORDS: fasting birds, total collection method, metabolic fecal energy, endogenous urinary energy.

RESUMO

EFEITO DA IDADE SOBRE AS PERDAS ENDÓGENAS E METABÓLICAS DE FRANGOS DE CORTE INDUSTRIAL E CAIPIRA

Objetivou-se determinar as perdas endógenas e metabólicas em frangos de corte industrial e caipira em diferentes idades. No experimento 1, utilizou-se 140 pintos de corte industrial, distribuídos num delineamento inteiramente casualizado, com quatro tratamentos e cinco repetições. No segundo experimento, foram utilizadas 120 aves de sexo misto, da linhagem caipira Embrapa 041, distribuídas em três tratamentos e cinco repetições distribuídas num mesmo delineamento. Em ambos os experimentos os tratamentos consistiram nas idades médias das aves. Para o experimento 1 as idades foram: 5; 15; 25 e 35 dias de idade e experimento 2, as idades médias adotadas foram 15, 45 e 75 dias de idade. O período experimental foi de 72 horas de jejum, sendo as primeiras 24 horas para limpeza do trato digestivo e as últimas 48 horas de coleta total das perdas endógenas e metabólicas. Foram determinados os teores de matéria seca, nitrogênio e energia bruta das perdas endógenas e metabólicas das aves. Ao se relacionar as perdas, por ave e peso da ave diferentes interpretações foram obtidas para mesma variável. As equações obtidas para frango industrial e caipira revelaram essas aves tiveram comportamentos diferentes na excreção fecal metabólica e urinária endógena. As perdas diminuíram com o avanço da idade.

PALAVRAS-CHAVE: aves em jejum; método de coleta total; energia fecal metabólica; energia urinária endógena.

INTRODUCTION

Researchers have been studying the metabolic and endogenous losses and their effects on the determination of the energy values of feeding for birds for over three decades. During this period, the concept and standardization of methodologies were improved in order to increase the accuracy in determining actual energy utilized by animals.

Conceptually, the undigested residues and metabolic fraction formed by bile, digestive secretions and cells derived from intestinal mucosa are found in feces of birds not cecectomized to microbial action. Food residues non-absorbed and eliminated without being catabolized, joined with endogenous fraction, which is the product of the catabolism of tissues, predominate in urinary fraction (SIBBALD & PRICE, 1978; SIBBALD, 1981a; SILVA et al., 2006).

The system of apparent metabolizable energy (AME) presumes that all excreted energy comes from food, which is not true. Motivated by this premise, SIBBALD (1976) proposed the correction of endogenous and metabolic losses in the values of AME, suggesting that the true metabolizable energy system (TME) is the one which best represents food energy.

This author stated that the metabolic and endogenous fractions present in the excreta of birds under ad libitum regimen are similar to the fractions collected from birds submitted to fasting. This statement is also not true, and it has motivated theoretical discussions among researchers.

Therefore, in literature, there are reports that the TME system expresses more accurately the energy content of birds feeding, when compared to the AME system (SIBBALD, 1976; DALE & FULLER, 1982; BORGES et al., 2003). However, this assumption has not been confirmed in some studies of animal performance, such as FREITAS et al. (2006), who detected increased feed intake, weight gain and better feed conversion with AME system.

Currently, it is known that among the factors that affect the intensity of endogenous and metabolic losses in poultry are the methodology applied, the diet, genetics, the category (BORGES et al., 2003) and, for industrial chicken, the age, as recently discovered (SILVA et al., 2006). Therefore, the goal of this research was to determine the effect of age on endogenous and metabolic losses in industrial and free-range broilers.

MATERIAL AND METHODS

Two experiments were carried out: one with industrial and another one with free-range broiler chicken. The first experiment was conducted at the Department of Animal Science, Universidade Federal Rural de Pernambuco (UFRPE) with 140 male, one-day-old, Cobb broiler chicks. The chicks were distributed into a completely randomized design with four treatments and five replicates.

The treatments consisted of four average ages of broilers (5, 15, 25 and 35 days of age), with respectively ten, eight, six and four birds per experimental plot. The average weights of birds at the beginning of the trial period were 83.28 g (T1), 434.10 g (T2), 1004.80 g (T3) and 2310.60 g (T4). The birds were selected by weight, searching for maximum uniformity, and housed in metabolism cages equipped with heating system in the first week of life and collecting trays under the floor.

Initially, the birds were transferred to the batteries (1.00 x 0.50 x 0.50 m) at 1, 10, 20 and 30 days of age, according to a period of four days of adaptation to the facilities. The birds were kept fasting from 4, 14, 24 and 34 days for a period of 24 hours to empty the digestive tract and then for another 48 hours for collecting the material, resulting in the average experimental ages at the 5th (T1), 15th (T2), 25th (T3) and 35th day of age (T4), as previously reported.

The birds used were discarded after each experiment. Thus, of a total of 240, other birds were selected for each age and were housed on the first day of life in boxes with 100 watts incandescent lamps for heating during the first two weeks of life. Wood shavings were used as bedding. The birds were fed a diet based on corn and soybean meal, formulated to meet the nutritional requirements at different ages, according to ROSTAGNO et al .(2005).

During the experiment, after fasting for 24 hours in each age group, residues (endogenous and metabolic material) excreted by the birds for a period of 48 hours were collected twice a day. Then, the material collected from each experimental plot was prepared and frozen at -20°C.

At the end of the experiment, the material was thawed, homogenized, sampled, weighed and pre-dried in a forced air oven set at 55°C for 72 hours. At the end of the pre-drying phase, feces were ground in a knife mill, equipped with 1 mm sieve for determination of dry matter, nitrogen and gross energy, following the methodology described by SILVA & QUEIROZ (2002).

Metabolic fecal and endogenous urinary dry matter (mfDM + euDM), metabolic fecal and endogenous urinary nitrogen (mfN + euN) and metabolic fecal and endogenous urinary energy (mfE + euE), as well as endogenous and metabolic losses of dry matter and nitrogen were calculated after analysis

The second experiment was conducted at the Small Animals Experimental Station (EEPAC), belonging to UFRPE, in Carpina, state of Pernambuco. A total of 120 birds (Embrapa 041 strain of both sexes) were used. The birds were distributed into a completely randomized design with three treatments and five replications. The average ages of free-range chicken were considered as parameters for the treatments: 15, 45 and 75 days of age, using ten, eight and six birds per age experimental plot, half of each sex.

The birds were transferred to the batteries (1.00 x 0.50 x 0.50 m) on the 10th, 40th and 70th day of age with a period of 4 days of adaptation to the facilities. The birds were fasted on the 14th, 44th and 74th day for 24 hours to clear the entire digestive tract. Then, they fasted for more 48 hours for material collection, resulting in average experimental ages of 14 (T1,) 45 (T2) and 75 days (T3).

In the pre-experimental period, birds were reared in conventional warehouse with ad libitum supply of food and water. The feed was based on corn and soybean meal, formulated according to the nutritional requirements for different ages, as recommended to the strain (Table 1).

Table 1. Percentage composition and nutritional values of feeding

Ingredients	Industrial broiler chicken				Free-range broiler chicken		
	Pre-starter	initial	Growth	Final	initial	growth	Final
Corn grain	56.650	59.657	62.557	66.556	61.625	66.300	70.300
Soybean meal 45%	36.768	34.227	30.618	26.779	31.905	26.270	22.090
Wheat meal	-	-	-	-	2.548	3.611	4.104
Soybean oil	2.048	2.183	3.097	3.120	-	-	-
Dicalcium phosphate	1.943	1.798	1.653	1.506	1.910	1.750	1.495
Limestone	0.939	0.894	0.851	0.807	1.128	1.259	1.311
Salt	0.517	0.492	0.469	0.442	0.508	0.457	0.418
DL-methionine 99%	0.445	0.250	0.240	0.230	0.086	0.093	0.082
L-Lysine HCl	0.400	0.219	0.235	0.280	-	-	-
Vitamin Supplement	0.1001	0.1001	0.1001	0.100[1]	0.1002	0.0802	0.0402
Mineral Supplement 2	0.0503	0.0503	0.0503	0.0503	0.0504	0.0504	0.0504
Anticoccidial	0.050	0.050	0.050	0.050	0.050	0.050	0.050
Zinc Bacitracin 15%	0.040	0.040	0.040	0.040	0.040	0.040	0.040
Choline chloride 60%	0.050	0.040	0.040	0.040	0.050	0.040	0.020
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
AMEn Mcal / kg	2.960	3.000	3.100	3.150	2.850	2.900	2.950
Crude protein	22.11	20.79	19.41	18.03	20.00	18.00	16.50
Lysine,%	1.503	1.263	1.183	1.121	1.044	0.904	0.800
Total Met + Cystine,%	1.067	0.897	0.852	0.807	0.724	0.681	0.633
Total methionine,%	0.728	0.568	0.540	0.512	0.400	0.380	0.350
Threonine total,%	0.836	0.800	0.745	0.690	0.770	0.690	0.630
Calcium,%	0.942	0.884	0.824	0.763	1.000	1.000	0.950
Available phosphorus,%	0.471	0.442	0.411	0.380	0.468	0.436	0.386
Sodium,%	0.224	0.214	0.205	0.194	0.220	0.200	0.190

[1]Warranty levels per kg of product: Vit.A 6,000,000UI; Vit.D3 1,000,000UI; Vit.E 10,000 mg; Vit. B12 6,000 mcg; Vit. K3 1,000; Niacin 10,000 mg; Pyridoxine 800 mg; Riboflavin 2.000 mg; Thiamine 600 mg; Biotin 30 mg; Calcium Pantothenate 8.000 mg, Selenium 400 mg. [2] Quantity /kg of ration: : Vit.A 11,000 UI.; Vit. D3 2,000 UI; Vit. E 16 UI; Folic Acid 0.4 mg; Calcium Pantothenate 10.0 mg; Biotin 0.06 mg; Niacin 35 mg; Pyridoxine 2.0 mg; Riboflavin 4.5 mg; Thiamin 1.2 mg; Vit. B12 16.0 mg; Vit. K3 1.5 mg; Selenium 0.25 mg; Antioxidant 30 mg. [3] Warranty levels per kg of product: Copper: 18,000 mg; Zinc: 120,000 mg; Iodine: 2,000 mg; Iron: 60,000 mg; Manganese: 120,000 mg. 4 Quantity / kg of ration: Copper 9.0 mg; Zinc 60.0 mg; Manganese 60.0 mg; Iron 30.0 mg; Iodine 1.0 mg.

The animal selection was based on the weight of the birds, seeking uniformity of the plot. The average weights of the chicks were: 0.273, 0.921 and 2.047 g at ages 15, 45 and 75 respectively. Water was provided ad libitum in both experiments throughout the whole experimental period. The collection, manipulation and analysis of excreted material, and the calculations of the parameters were the same ones as described in the first experiment.

The following dependent variables were analyzed: metabolic and endogenous losses of dry matter, nitrogen and gross energy, at different ages, expressed in different unit systems. The results were submitted to regression analysis, using SISVAR computer software, version 4.6 (FERREIRA, 2003).

RESULTS AND DISCUSSION

The chemical composition of metabolic and endogenous losses of industrial and free-range broiler chickens is presented in Table 2. The results showed that the highest concentrations of dry matter was observed after 25 days of age, and the lowest concentrations were found in birds with an average age of five days. Unlike the dry matter (DM), gross energy (GE) of the endogenous and metabolic losses showed no changes at different ages and the analysis of nitrogen (N) had the lowest level at 25 days of age, with no significant differences among the other ages.

The metabolic and endogenous losses of free-range broilers had the highest concentrations of dry matter and gross energy at 45 days of age; at this age, the concentration of nitrogen, showed the lowest level, with no differences between the equidistant ages (15 and 75 days). Factors associated with fasting conditions, age, body composition, genotype and physiological status of the bird are reported (SIBBALD, 1981b; SILVA et al., 2006) as constraints on the chemical composition of the endogenous and metabolic losses. Thus, the chemical composition must be related to other variables in order to be properly contextualized and conclusively and consistently interpreted regarding what happens with the bird in state of fasting and prolonged fasting.

Table 2. Mean chemical and energy composition of metabolic and endogenous losses, expressed on dry matter basis

Constituent	Industrial broiler				CV %	Free-range broiler			CV %
	5	15	25	35		15	45	75	
	(days)					(days)			
DM	19.20 c	23.63 b	31.27 a	31.76 a	10.5	17.51 c	34.50 a	24.17 b	13.3
N	21.06 a	21.16 a	15.60 b	21.28 a	7.8	19.29 a	15.49 b	19.34 a	9.3
GE (kcal /g)	3.549 a	3.358 a	3.658 a	3.290 a	6.8	3.248 c	3.496 a	3.376bc	2.7

[a, b, c] Means followed by same letter in the line, differ statistically by Student Newman-Keuls test at 5% probability. CV, coefficient of variation%

The relation between the metabolic fecal and the endogenous urinary dry matter with the excretion volume per plot and per bird, and with the weight of the bird, reveals that there are differences among the ages ($p \leq 0.01$); however, the results show opposite behaviors depending on the system in which it is expressed (Table 3).

On the other hand, the relation with the weight of the bird showed an opposite result. Thus, birds with an average age of five days excreted an amount equivalent to 8% of their weight. These differences were canceled from the 15th day of life on and at 35 days the losses correspond to just over a tenth of their body weight.

The adjustment of the metabolism to the different physiological conditions is achieved due to the process which comprises the metabolic regulation; therefore, 12 hours after the meal, the post-absorptive state starts, afterwards, glycogen degradation, muscle proteolysis and lipolysis occur subsequently, and are responsible for maintaining the energy input in the body (MALHEIROS, 2006).

Table 3. Means and standard errors, regression equation, probability, and coefficient of variation for the values of metabolic fecal and urinary endogenous dry matter losses of industrial broilers at different ages

Age (days)	Metabolic fecal and urinary endogenous dry matter			
	(gDM / bird)	(gDM / kgBW)	(% BW)	(gDM / kgBW $^{0.75}$)
5	6.00 d	72.38 a	8.76 a	69.05 a
15	10.73 c	24.74 b	0.71 b	33.76 b
25	15.10 b	15.02 bc	0.25 b	23.54 bc
35	23.29 a	10.09 c	0.11 b	17.58 c
Mean	13.78 ± 0.62	30.56 ± 3.96	2.46 ± 0.53	35.98 ± 3.79
RE[1]	$\hat{Y}$ = 2.530+0.563X	$\hat{Y}$ = 69.877-1.967X	$\hat{Y}$ = 7.743-0.264X	$\hat{Y}$ = 68.903-1.646X
R^2, %	97.62	79.09	65.68	85.12
P[2]	0.0001	0.0001	0.0001	0.0001
CV[3]	10.19	29.03	47.97	23.57

[a, b, c, d] Means followed by different letter in the column differ statistically by Student Newman-Keuls test at 1% probability.
[1] Regression Equation
[2] Probability
[3] Coefficient of variation,%

During fasting, glucagon is favored in the insulin/glucagon relation, and glycogenolysis is intensified. In prolonged fasting, the glycemic index is maintained by gluconeogenesis and this pathway is related to the significant losses of muscle mass and adipose tissue which occur with fasting (NELSON & COX, 2000).

In practical terms, the relationship between basal metabolism and metabolic weight of the bird allows a more coherent explanation and interpretation of the physiological events which occur in the bird, especially when comparing the metabolic rate of animals with different body weight and composition (BLAXTER, 1989).

The gram of metabolic fecal and endogenous urinary dry matter (mfDM + euDM) excreted per bird increased linearly with the advance of age $\hat{Y}$ = 2.530+0.563X, R2 = 97.62 (Figure 1A). On the contrary, it showed an opposite behaviour when mfDM + euDM excretion was related with the metabolic weight of the bird. In this case, excretion decreased about 1.646 g / day, according to the equation $\hat{Y}$ = 68.903-1.646X, R2 = 85.12 (Figure 1B).

At this phase, differences in the chemical constituents of the body of the bird are remarkable (SILVA et al., 2006), and these factors are responsible for the differences shown, since body composition is closely related to the expression and intensity of metabolic and endogenous losses, according to the authors previously mentioned.

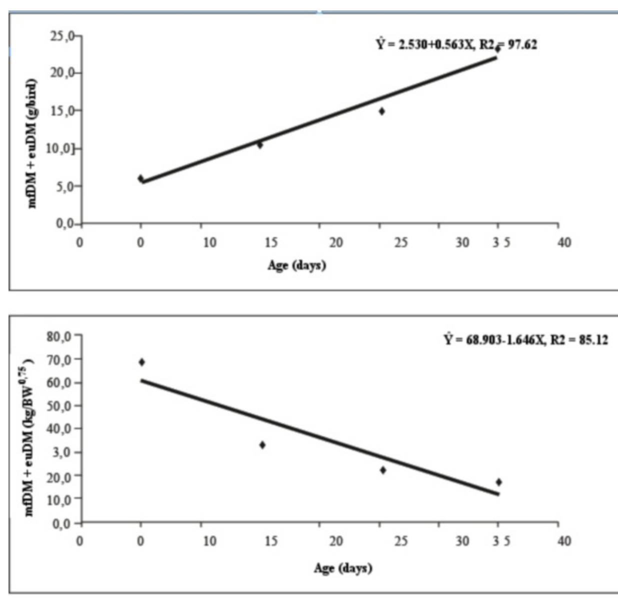

Figure 1. Effect of age on metabolical fecal and endogenous urinary dry matter losses (mfDM + euDM) in industrial broilers (A) expressed per bird and (B) expressed in metabolic weight.

Significant differences were observed at the initial phase of slow-growing birds, where the excretion of mfDM + euDM per bird was approximately 2.4 times smaller than the excretion in the subsequent phases, growing and finishing, (Table 4). At the initial phase, by comparison, 4.25 g of dry matter results in difference in the amount excreted between industrial broilers and free-range broilers, and, in a percentage relation, industrial broilers lose in the same collection period about 70 % more than the free-range broilers.

Table 4. Means and standard errors, regression equation, probability, and coefficient of variation for the values of metabolic fecal and urinary endogenous dry matter losses of free-range broilers at different ages

Age (days)	Metabolic fecal and urinary endogenous dry matter			
	(gDM / bird)	(gDM / kgBW)	(% BW)	(gDM / kgBW $^{0.75)}$
15	1.75 b	6.41 a	0.23 a	8.24 a
45	4.32 a	4.69 b	0.06 b	7.72 a
75	4.03 a	1.97 c	0.02 c	3.69 b
Mean	3.37 ± 0.24	4.35 ± 0.23	0.10 ±0.007	6.55 ±0.339
RE[1]	Ŷ = 1.675+0.037X	Ŷ = 7.65-0.071X	Ŷ = 0.27-0.003X	Ŷ = 9.93-0.073X
R^2, %	65.79	98.33	89.40	83.35
P[2]	0.0001	0.0001	0.0001	0.0001
CV[3]	15.70	12.01	16.17	11.60

[a, b, c, d] Means followed by different letter in the column differ statistically by Student Newman-Keuls test at 1% probability.
[1] Regression Equation
[2] Probability
[3] Coefficient of variation,%

Both industrial and free-range broilers showed an opposite behavior when the variable gram of dry matter was related with body weight and metabolic weight. Unlike the previous system (gDM / bird), systems gDM / kgBW, %BW, and gDM/kgBW 0.75 showed differences ($p<0.01$) among the experimental ages. For the system gDM / kgBW, a decrease about 27% was verified between the 15th and 45th days of age. This percentage increased between the subsequent ages (45 and 75 days of age) approaching 58% reduction, until 1.97 gDM / kgBW was achieved at the last evaluated age.

The effect of free-range broilers age on metabolic fecal and endogenous urinary dry matter can be clearly seen in Figure 2 (A and B), especially when relating mfDM + euDM with kilogram of metabolic weight; in this sense, excretion per bird decreased 0.073 g per day until the last experimental age (Figure 2B), rather than the excretion gram/bird system (Figure 2A), which showed significant increase up to 45 days of age. Between this age and the subsequent the differences were not verified by the average test and regression analysis showed the model (Ŷ = 1.675 +0.037 X, R2 = 65.79) with a considerable degree of dispersion, compared to the previously announced model for industrial broilers.

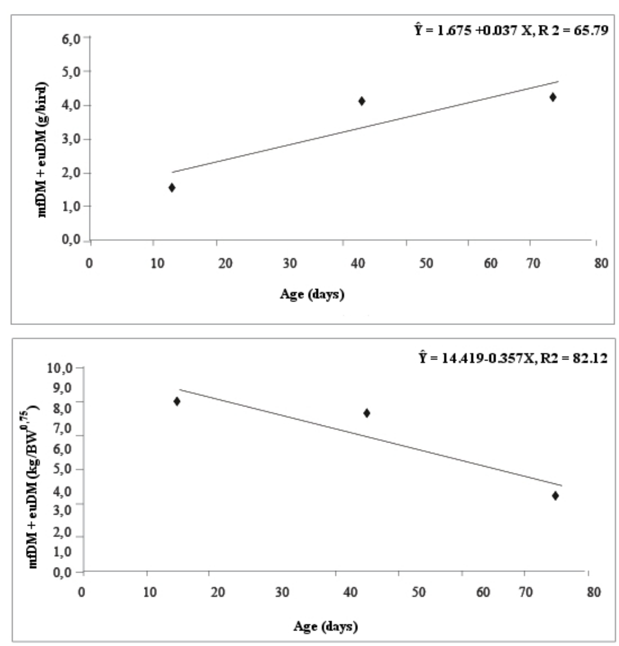

Figure 2. Effect of age on metabolical fecal and endogenous urinary dry matter losses (mfDM + euDM) in free-range broilers (A) expressed per bird and (B) expressed in metabolic weight.

This significant increase until the 45th day of age may be related to the physiological age of the bird, that is, at this age the growth rate begins to decrease significantly (inflection point of the line) and leads to a decrease in the metabolic rate of the bird. Growth assays with chicks in this category and genetic group were performed by SANTOS et al. (2005). These authors, by applying Gompertz equation, found that the point of change of the patter of acceleration in the curve, i.e. the point of inflection, where the bird reaches the highest rate of growth around the 46th day of life, shows intense metabolic activity.

This physiological state may have influenced this significant increase observed at this age (45 days) and after this period, i.e. at the subsequent phase, there were no great changes in metabolic and endogenous excretion of dry matter per bird observed in the current experiment.

Table 5 presents the data on metabolic and endogenous nitrogen (mfN + euN) assessed in industrial broilers at different ages. The data obtained suggest that the major differences in the excretion of mfN + euN are located at equidistant ages, five and 35 days of age, regardless of how it is being expressed, thus, the bird increases its excretion of 1.112 g per day.

Table 5. Means and standard errors, regression equation, probability, and coefficient of variation for the values of metabolic fecal and urinary endogenous nitrogen losses of industrial broilers at different ages

Age (days)	Metabolic fecal and urinary endogenous nitrogen			
	(gN / bird)	(gN / kgBW)	(% BW)	(gN / $kgBW^{0.75}$)
	1.26 c	15.22 a	1.52 a	14.52 a
5	2.26 b	5.21 b	0.52 b	7.11 b
15	2.38 b	2.36 b	0.24 b	3.70 c
25	4.96 c	2.15 b	0.21 b	3.75 c
35	2.72 ± 0.17	6.23 ± 0.85	0.62 ±0.08	7.27 ± 0.83
Mean	$\hat{Y}$ = 0.475+0.112X	$\hat{Y}$ = 14.645-0.420X	$\hat{Y}$ = 1.467-0.042X	$\hat{Y}$ = 14.419-0.357X
RE[1]	84.02	77.94	78.02	82.12
R^2, %	0.0001	0.0001	0.0001	0.0001
P[2]	14.39	30.62	30.72	25.66
CV[3]				

[a, b, c, d] Means followed by different letter in the column differ statistically by Student Newman-Keuls test at 1% probability.

[1] Regression Equation

[2] Probability

[3] Coefficient of variation,%

This information regarding body weight indicates that, proportionally, the greatest loss occurs during the pre-starter phase and after this period there is a reduction approximately of 0.42 g per day. Thus, the endogenous and metabolic nitrogen assessed in the excretion of broilers at 15 days of age decreases about 66% compared to the youngest age. Then, from 15 to 25 days of age, the reduction decreases to 54% and tends to stabilize between 25 and 35 days of age, reaching 12.5% reduction.

Nitrogen losses in the digestive tract have motivated studies for a long time. The secretion of endogenous nitrogen in the digestive tract of rats was investigated by the researchers TWOMBLY & MEYER (1961), by means of short-term trials. In this trial, the authors observed that as the percentage of dietary protein increased, the nitrogen content increased 0.0459 g according to the equation ($\hat{Y}$ = 1.31 + 0.0459 X). The researchers estimated that, for the maximum level of protein in the diet at the end of 12 hours of feeding, about 2.228 grams of nitrogen were secreted by the secretory epithelium of the digestive tract. By extrapolating to zero intake of protein, for a protein-free diet, TWOMBLY & MEYER (1961) found around 1.31 grams of nitrogen in the feces of these animals.

Data collected by CHUNG & BAKER (1992) using adult roosters revealed that the loss of metabolic fecal and endogenous urinary nitrogen (mfN + euN) was close to 0.944 g per bird. Recent data on fasting birds published by SILVA et al. (2006) showed that an industrial broiler chick on the seventh day of life loses an average of 0.61 g of mfN + euN; the same chicken at 37 days increases the this excretion about 3.5 times. This increase proportion is similar to the values obtained in this study.

Nevertheless, absolute numbers reported in this study at different ages were higher than the ones reported by SILVA et al. (2006). This is based on methodological aspects, regarding the age and weight of the bird submitted to experimental fasting.

The values of nitrogen losses by free-range boilers are presented in Table 6. Nitrogen excretion increased with the advancement of age in a proportion of 0.007 grams per day, with the largest increase from 15 to 45 days of age.The difference in excretion between 15 and 45 days of age was 1.97 times – this increase is expected because the length of the intestine increases considerably in this period, as verified by FIGUEIREDO et al. (2002).

SANTOS et al. (2005) verified that the intestines weight of the animal in fasting corresponds to about 3.35% in free range broilers and 3.8% in industrial broilers. In relative numbers, this difference is narrow, but in absolute numbers, industrial broilers have a greater surface area for occurrences of intestinal cell desquamation. This characteristic accentuated the differences in results, while the average value for broiler chickens was about 4.6 times higher than those obtained for free-range birds.

Table 6. Means and standard errors, regression equation, probability, and coefficient of variation for the values of metabolic fecal and urinary endogenous nitrogen losses of free-range broilers at different ages

Age (days)	Metabolic fecal and urinary endogenous nitrogen			
	(gN / bird)	(gN / kgBW)	(% BW)	(gN / kgBW $^{0.75}$)
15	0.34 b	1.23 a	0.12 a	1.58 a
45	0.67 a	0.73 b	0.07 b	1.20 b
75	0.78 a	0.38 c	0.04 c	0.71 c
Mean	0.59 ± 0.55	0.78 ± 0.049	0.08 ± 0.005	1.16 ± 0.077
RE[1]	$\hat{Y}$ = 0.267+0.007X	$\hat{Y}$ = 1.41-0.013X	$\hat{Y}$ = 0.139-0.0013X	$\hat{Y}$ = 1.81-0.014X
R^2, %	92.05	98.76	98.42	99.64
P[2]	0.001	0.0001	0.0001	0.077
CV[3]	20.52	14.09	14.62	14.81

[a, b, c, d] Means followed by different letter in the column differ statistically by Student Newman-Keuls test at 1% probability.
[1] Regression Equation
[2] Probability
[3] Coefficient of variation,%

In order to meet body needs with the advancement of age to develop and improve the digestive--absorptive capacity, the growth of the intestines, requires the occurrence of changes in the epithelium, especially in jejunum and ileum, as regards the number and volume of enterocytes (MORAN JUNIOR, 1985; UNI et al., 1995). These phenomena result in daily desquamation which, added to the intestinal flora and the mobilization of body reserves to meet the maintenance requirement during the fasting period, may have affected directly the amount of nitrogen present in the endogenous and metabolic losses, which is more intense in the industrial broiler.

In prolonged fasting, the level of amino acid circulating in the bloodstream is high; they are directed to hepatic tissue cells, where they undergo complete oxidation or might be converted to glucose and ketone bodies (BROSNAN, 2000; MALHEIROS, 2006). At this time, the amino acid alanine plays an essential role as an important substrate for gluconeogenesis (STRAYER, 1995; NELSON & COX, 2000). According to these researchers, muscle tissue proteins are used for this purpose, but for a short period, because it tends to be preserved, since its reserve is limited.

Therefore, the mobilization of reserves is the main source for hepatic glucose synthesis during periods of prolonged fasting; amino acids are the priority precursors, which come mainly from skeletal muscle. At other moments, the mobilization of glycerol from fat reserves, triglycerides from adipose tissue and lactate from erythrocytes, which are the devices used by the animal´s metabolism during the data collection using this methodology with fasting birds.

Birds under ad libitum regimen use metabolic artifices different from ones the previously described, thus, endogenous and metabolic losses tend to be different, since the nitrogen present in urine (in fed birds) did not come from the mobilization of reserves, but from the catabolism of the diet amino acids.

This kind of information, according to WARPECHOWSKI et al. (2006), has been discussed regarding the true metabolizable energy system, since the endogenous and metabolic nitrogen loss is assessed in the calculation of true nitrogen balance. Therefore, the balance is directly influenced by the method used for collecting data, and consequently for metabolizable energy values.

Tables 7 and 8 present the metabolic fecal and endogenous urinary dry energy losses (mfE+euE) in industrial and free-range broilers in relation to age. The metabolic fecal and endogenous urinary energy excretion per plot proved to be different only in pre--starter phase, with no more change in stages thereafter, according to statistical analysis. However, it is prudent to note that the high coefficient of variation caused a minimal significant difference superior to 43 kcal at the other ages.

The equation models generated for industrial strain were linear, whereas free-range broilers were suited to quadratic models. The fmE + euE verified for each free-range broiler presented as maximum value 15.7 kcal at 57 days of age, according to the model $\hat{Y}$ = -2.79 +0.65 X-0, 0057X2. Maximum excretion of free-range broilers was inferior to the lowest value obtained for industrial broilers, which increased 1.86 kcal per day with age, according to regression analysis.

The true metabolizable energy (TME) is obtained by the difference between consumed energy (consE) and excreted energy (excE), corrected for metabolic fecal and endogenous urinary energy (mfE + euE). Thus, the formula is: TME = consE - excE - mfDM+euDM, assuming, then, constant feed intake and excretion, varying only the value of the mfE + euE at five days (208 kcal) and the average (308 kcal) between 15 and 35 days of age. In the calculation of TME, one may speculate that the adoption of the average 308 kcal /plot can overestimate metabolizibility ration for chicks at five days of age by more than 8%, considering only the source of variation mfE + euE for industrial broiler chicks.

This is due to the fact that, at low intake levels, losses are proportionately larger and result in a decrease in the estimated values for apparent metabolizable energy (AME) and corrected apparente metabolizable energy (AMEn), according to LIMA et al. (1989).

SILVA et al. (2006) pointed out that effects derived from the low intake by experimental birds are more pronounced when using the feeding methodoly recommended by SIBBALD (1976). Results of experiments conducted by LIMA et al. (1989) showed values significantly different when compared to the values of AME vs TME and TMEn vs AMEn, showing the effects of endogenous and metabolic losses at low levels of intake. For normal intake levels, the metabolic and endogenous losses are small in relation to the excretion of energy from food, and it tends to show little influence on the values of AME and AMEn (LIMA et al., 1989).

Although some studies have shown that mathematically there is no difference in metabolizable energy values using the traditional method of total collection from birds in an ad libitum regimen, the nature of the excreted compounds and the metabolic profile of fasting birds are different from those submitted to feeding. Thus, the correction made in the values of TME with information on metabolic and endogenous losses of fasting birds does not represent the real energy value of the food. Besides these aspects, they also differ regarding age and metabolic weight, whether industrial or free-range broiler.

Table 7. Means and standard errors, regression equation, probability, and coefficient of variation for the values of metabolic fecal and urinary endogenous energy losses of industrial broilers at different ages

Age (days)	Metabolic fecal and urinary endogenous energy		
	(kcal/bird)	(kcal/kgBW)	(kcal/kgBW$^{0.75}$)
5	20.87 d	251.65 a	240.07 a
15	36.04 c	83.11 b	113.41 b
25	55.22 b	54.93 c	86.09 c
35	76.54 a	33.15 c	57.78 d
Mean	47.17 ± 1.92	105.71 ± 9.22	124.34 ± 8.81
RE[1]	$\hat{Y}$ = 9.93+1.86X	$\hat{Y}$ = 242.5-6.8X	$\hat{Y}$ = 239.1-5.74X
R^2, %	99.45	78.82	84.94
P[2]	0.0001	0.0001	0.0001
CV[3]	9.14	19.51	15.85

[a, b, c, d] Means followed by different letter in the column differ statistically by Student Newman-Keuls test at 1% probability.
[1] Regression Equation
[2] Probability
[3] Coefficient of variation,%

Table 8. Means and standard errors, regression equation, probability, and coefficient of variation for the values of metabolic fecal and urinary endogenous energy losses of free-range broilers at different ages

Age (days)	Metabolic fecal and urinary endogenous energy		
	(kcal/ave)	(kcal/kgBW)	(kcal/kgBW^{0,75})
15	5.67 b	20.77 a	26.70 a
45	15.09 a	16.40 b	27.01 a
75	13.63 a	6.66 c	12.47 b
Média	11.47 ± 0.83	14.61 ± 0.71	22.06 ± 1.07
ER[1]	$\hat{Y}$ = -2.79+0.65X-0.0057X2	$\hat{Y}$ = 25.08-0.227X	$\hat{Y}$ = 32.62-0.229X
R^2	99.29	95.42	73.41
P[2]	0.0001	0.0001	0.0001
CV[3]	16.17	10.90	10.91

[a, b, c, d] Means followed by different letter in the column differ statistically by Student Newman-Keuls test at 1% probability.
[1] Regression Equation
[2] Probability
[3] Coefficient of variation,%

CONCLUSION

The metabolic and endogenous losses of industrial and free-range broilers decreased with age advancement, being more pronounced for industrial broilers.

REFERENCES

BLAXTER, K. **Energy metabolism in animals and man**. Cambridge: Cambridge University Press, 1989. 336 p.

BORGES, F. M. O.; ROSTAGNO, H. S.; SAAD, C. E. P.; RODRIGUEZ, N. M.; TEIXEIRA, E. A.; LARA, L. B.; MENDES, W. S., ARAÚJO, V. L. Comparação de métodos de avaliação dos valores energéticos do grão de trigo e seus subprodutos para frangos de corte. **Arquivo Brasileiro Medicina Veterinária e Zootecnia**, v. 55, n. 6, p. 710-721, 2003.

BROSNAN, .J. T. Glutamate, at the interface between amino acid and carbohydrate metabolism. **Journal of Nutrition**, v. 130, n. 4, p. 988S-990S, 2000.

CHUNG, T. K.; BAKER, D. H. Apparent and true amino acid digestibility of a crystalline amino acid mixture and of casein: comparison of values obtained with ileal-cannlated pigs and cecectomized cockerels. **Journal Animal Science**, v. 70, n. 12, p. 3.781-3.790, 1992.

DALE, N. M.; FULLER, H. L. Applicability of the metabolizable energy system in practical feed formulation. **Poultry Science**, v. 61, n. 2, p. 351-356, 1982.

FERREIRA, D. F. Programa SISVAR. **Sistema de análise de variância**. Versão 4.6. Lavras: Universidade Federal de Lavras, 2003.

FIGUEIREDO, E. P. A.; ROSA, O. S.; OMM, E. R.; BOFF, J. A.; BASSI, L. Peso e tamanho dos órgãos de diferentes linhagens de frangos de corte. **Revista Brasileira de Ciência Avícola**, v. 4, supl. 4, p. 95, 2002.

FREITAS, E. R.; SAKOMURA, N. K.; EZEQUIEL, J. M. B.; NEME, R.; MENDONÇA, M. O. Energia metabolizável de alimentos na formulação de ração para frangos de corte. **Pesquisa Agropecuária Brasileira**, v. 41, n. 1, p. 107-115, 2006.

LIMA, L. I.; SILVA, J. D. da.; ROSTAGNO, S. H. TARFURI, M. L. Composição química e valores energéticos de alguns alimentos determinados com pintos e galos, utilizando duas metodologias. **Revista Brasileira de Zootecnia**, v. 18, n. 6, p. 546-556, 1989.

MALHEIROS, S. V. P. Integração metabólica nos períodos pós-prandial e de jejum. **Revista Brasileira de Ensino de Bioquímica e Biologia Molecular**. Disponível em: <http://www.bdc.ib.unicamp.br/rbebbm/>. Acesso em: 22 jul. 2008.

MORAN JR. E. T. Digestion and absorption of carbohydrates in fowl and events through perinatal development. **Journal of Nutrition**, v. 115, n. 5, p. 665-674, 1985.

NELSON, D. L.; COX, M. M.; **Lehninger, principles of biochemistry**. 3. ed. Worths Publishers: New York, 2000. p. 949.

ROSTAGNO, H. S.; ALBINO, L. F. T.; DONZELE, J. L.; GOMES, P. C.; OLIVEIRA, R. F. M.; LOPES, D. C.; FERREIRA, A. S.; BARRETO, S. L. T. **Tabelas brasileiras para aves e suínos (Composição de alimentos e exigências nutricionais)**. 2. ed. Viçosa: Edutira UFV, 2005. 186 p.

SANTOS A. L. dos.; SAKOMURA, N. K.; FREITAS, E. R.; FORTES, C. M. L. S.; CARRILHO, E. N. V. M.; FERNANDES, J. B. K. Estudo do crescimento, desempenho, rendimento de carcaça e qualidade de carne de três linhagens de frango de corte. **Revista Brasileira de Zootecnia**, v. 34, n. 5, p. 1.589-1.598, 2005.

SIBBALD, I. R. The true metabolizable energy values of several feedstuffs measured with roosters, laying hens, turkeys and broiler hens. **Poultry Science**, v. 55, n. 4, p. 1.459-1.463, 1976.

SIBBALD, I. R. Metabolic plus endogenous energy and nitrogen loses of adult cockerels the correction used in the bioassay for true metabolizable energy. **Poultry Science**, v. 60, n. 4, p. 805-811, 1981a.

SIBBALD, I. R. Metabolic plus endogenous energy excretion by fowl. **Poultry Science**, v. 60, n. 12, p. 2.672-2.677, 1981b.

SIBBALD, I. R.; PRICE, K. The metabolic and endogenous energy losses of adult roosters. **Poultry Science**, v. 57, n. 2, p. 556-557, 1978.

SILVA, D. J.; QUEIROZ, A. C. **Análise de alimentos (métodos químicos e biológicos)**. 3. ed. Viçosa: Editora UFV, 2002. 235 p.

SILVA, E. P.; RABELLO, C. B. V.; LIRA, R. C.; FARIAS FILHO, R. V.; ALBUQUERQUE, C. S.; SILVA, da. T. Estimativas das perdas endógenas e metabólicas em frangos de corte. **Revista Brasileira de Ciências Agrárias**, v. 1, n. único, p. 115-121, 2006.

STRAYER, L. **Biochemistry**. 4. ed. New York: W.H. Freeman, 1995.

TWOMBLY, J.; MEYER, J. H. Endogenous nitrogen secretions into the digestive tract. **Journal of Nutrition**, v. 74, n. 4, p. 453-460, 1961.

UNI, Z.; NOY, Y.; SKLAN, D. Post-hatch changes in morphology and function of the small intestine in heavy and light strain chicks. **Poultry Science**, v. 74, n. 10, p. 1.622-1.629, 1995.

WARPECHOWSKI, M. B.; KESSLER, A. M. POPHAL, S.; EBERT, A.; RIBEIRO, A. M. L. Digestibilidade ideal verdadeira da proteína em frangos de corte sob dietas com diferentes níveis de proteína bruta. **Acta Scientiarum Animal Science**, v. 28, n. 3, p. 281-287, 2006.

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