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Effect of broiler chicken age on ileal digestibility of corn germ meal

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ABSTRACT. The objective of this research study was to evaluate the effect of age on the apparent ileal digestibility coefficient of nutrients, gross energy and digestible energy of corn germ meal for broilers. Four digestibility trials were conducted using 280 broilers (Cobb 500) distributed in a completely randomized design with two treatments and five replications, repeated at four ages (10, 20, 30 and 40 days). The number of birds used in the tests was 10, 8, 6 and 4 birds per experimental unit at the different ages. The results were analyzed considering as dependent variable the apparent ileal digestibility of dry matter, crude protein, ether extract and gross energy, digestible dry matter, digestible crude protein, lipid and digestible energy; and ages (10, 20, 30 and 40 days) as the independent variable. The results for the variables showed that bird age exerted influence only in the ileal digestibility of dry matter and gross energy. The digestible energy of corn germ meal increased by about 13 kcal kg^{-1} day^{-1} up to the evaluated age (40 days).

Keywords: corn coproducts, digestible energy, fat, ileum, partial collection.

Efeito da idade de frangos de corte sobre a digestibilidade ileal do gérmen integral de milho

RESUMO. Objetivou-se com esta pesquisa avaliar o efeito da idade sobre os coeficientes de digestibilidade ileal aparente dos nutrientes, da energia bruta e os valores de energia digestível do gérmen integral de milho para frangos de corte. Quatro ensaios de digestibilidade foram realizados com 280 aves de corte (Cobb 500) distribuídas em um delineamento experimental inteiramente casualizado, com quatro tratamentos e cinco repetições. Os tratamentos avaliados consistiram das diferentes idades das aves: 10, 20, 30 e 40 dias. A quantidade de aves utilizadas nos ensaios foram: dez, oito, seis e quatro em cada unidade experimental, nas diferentes idades avaliadas, respectivamente. Os resultados foram analisados considerando-se como variável dependente a digestibilidade ileal aparente da matéria seca, da proteína bruta, do extrato etéreo e da energia bruta, matéria seca digestível, proteína bruta digestível, extrato etéreo digestível e energia digestível e como variável independente as idades (10, 20, 30 e 40 dias). Os resultados obtidos para as variáveis analisadas revelaram que a idade da ave exerceu influência apenas nos coeficientes de digestibilidade ileal da matéria seca e da energia bruta. A energia digestível do gérmen integral de milho aumentou cerca de 13 kcal kg^{-1} dia^{-1} até a idade avaliada (40 dias).

Palavras-chave: coprodutos do milho, energia digestível, gordura, íleo, coleta parcial.

Introduction

Corn stands out among the most frequently used energy-rich foods in the diets of non-ruminants for its energy content and amino acid profile. A significant fraction of worldwide corn production is destined for processing industries in order to make products for human consumption and co-products for animal feeding.

Corn grain can be processed in two ways: dry and wet. The latter modality results in technologically superior products, such as corn gluten feed 21 (fiber portion of corn grains), corn gluten feed 60 (protein portion of corn grains), starch and corn germ meal through the degermination of corn grains, according to the Corn Refiners Association (2010).

In Brazil, Abimilho (2010) estimates that corn intake from wet processing nears 1,500,000 tons, assuming that 13% of that total is corn germ (EMBRAPA, 1991); nearly 195,000 tons of corn germ meal have been produced from processing, which could be another alternative to minimize the inclusion of traditional energy sources such in feeds for non-ruminants, as corn, oil or fat, justified by the crude protein and fat content - 8.96 to 10.9% of protein (BRITO et al., 2005; RODRIGUES et al., 2001; ROSTAGNO et al., 2005) and 3 to 19.37% of fat (BRITO et al., 2005; ROSTAGNO, 2001, ROSTAGNO et al., 2005).

Digestibility studies are necessary, particularly when improvements in performance and profitability are desired. These improvements can be obtained by adjusting diet formulation, considering the effect of bird age in the digestibility of nutrients and energy of the feeds.

Regarding to corn germ, this effect is 23.16 kcal kg^{-1} day^{-1} for metabolizable energy (LIMA, 2008). In practice, this adjustment can result in more rational use of ingredients, because considers the effects of physiological maturity of birds.

Currently, the most commonly used methodology for feed evaluation is the total excreta collection in growing broilers (15 to 25 days old). This method has contributed significantly to nutritional requirements tables. However, the partial collection of ileal digesta can, in theory, shows digestibility coefficient values more precise due the elimination of the microbial fermentation's effects from food residue that reach to the large intestine, particularly the nitrogenous derivative (FAN et al., 1995). It also cancels out some adverse effects relative to estimates of digestibility of nutrients and energy, such as: food intake, contamination from feathers, scaling and loss of feces during collection (SAKOMURA; ROSTAGNO, 2007).

Thus, this research study had as purpose to evaluate the effect of age in the apparent ileal digestibility coefficient of nutrients, crude energy and digestible energy of corn germ meal for broilers.

Material and methods

The present study was performed at the Aviculture Sector of the Animal Science Department belonging to the Federal Rural University of Pernambuco (DZ-UFRPE). In order to evaluate the effect of age in the ileal digestibility of corn germ meal, 280 Cobb 500 broilers were used, distributed in an entirely randomized design, with four treatments and five replications. Treatments consisted of the different bird ages, namely: 10, 20, 30 and 40 days, totaling four digestibility trials.

One trial was conducted at each age, using two feeds: one reference feed (Table 1) made with corn and soybean meal, with composition and nutritional requirements obtained from Rostagno et al. (2005); and a test feed, obtained from 60% reference feed + 40% corn germ meal, containing 95.42% of requirements for dry matter, 10.38% of crude protein, 56.48% of ether extract, 5.35% of crude fiber and 5.00% of mineral matter, and 7,039 kcal kg^{-1} of gross energy. The birds used in each trial were: 100, 80, 60 and 40. Each experimental unit consisted of ten, eight, six and four birds.

Table 1. Percent and nutritional composition of the experimental diets.

Ingredients	Feed composition (%)			
	1 to 10 days old	10 to 20 days old	20 to 30 days old	30 to 40 days old
Corn grain	56.660	59.657	62.557	66.556
Soybean meal 45%	36.768	34.227	30.618	26.779
Soybean oil	2.048	2.183	3.097	3.120
Dicalcium phosphate	1.943	1.798	1.653	1.506
Limestone	0.939	0.894	0.851	0.807
Salt	0.517	0.492	0.469	0.442
DL-Methionine 99%	0.445	0.250	0.240	0.230
L-Lysine HCl 78%	0.400	0.219	0.235	0.280
Vitamin supplement [1]	0.100	0.100	0.100	0.100
Mineral supplement [2]	0.050	0.050	0.050	0.050
Salinomycin sodium	0.050	0.050	0.050	0.050
Bacitracin zinc	0.040	0.040	0.040	0.040
Choline chloride 60%	0.040	0.040	0.040	0.040
Total	100.00	100.00	100.00	100.00
Nutritional composition				
EMAn, Mcal kg^{-1}	2.960	3.000	3.100	3.150
Crude protein, %	22.110	20.790	19.410	18.030
Digestible lysine, %	1.503	1.263	1.183	1.121
Digestible Met+Cis, %	1.067	0.897	0.852	0.807
Digestible threonine,%	0.836	0.800	0.745	0.690
Digestible tryptophan, %	0.268	0.254	0.234	0.213
Fat, %	4.70	4.90	5.85	5.95
Calcium, %	0.942	0.884	0.824	0.763
Available phosphorus, %	0.471	0.442	0.411	0.380
Potassium, %	0.831	0.793	0.736	0.676
Sodium, %	0.224	0.214	0.205	0.194
Crude fiber, %	2.969	2.388	2.740	2.600

[1]Vitamin A: 6,000.000 IU; Vitamin D_3: 1,000.000 IU; Vitamin E: 10,000 mg; Vitamin B_{12}: 6,000 mg; Vitamin K_3: 1,000 mg; Niacin: 10,000 mg; Pyridoxine: 8,000 mg; Riboflavin: 2,000 mg; Thiamin: 600 mg; Biotin: 30 mg; Calcium Pantothenate: 8,000 mg; Folic Acid: 550 mg; Antioxidant: 5,000 mg. [2]Guaranteed levels per kg of product: Iron: 60,000 mg; Copper: 13,000 mg; Manganese: 120,000 mg; Zinc: 100,000 mg; Iodine: 2,500 mg; Selenium: 500 mg.

The birds were fed with the rations according to the respective phase, and received the experimental feeds with added 0.5% of indicator chromium oxide (Cr_2O_3) at seven, 17, 27 and 37 days old, adjusting to the diet and metabolic cages for three days. At the 10, 20, 30 and 40th day of age, all birds were slaughter through cervical dislocation.

A few hours before being slaughter, the broilers were stimulated to intake the feed in order to maximize ileal content at the time of collection. Following the sacrifice, abdominal incisions were made to expose the small intestine and separate the ileum. The sampling of the ileal segment of the intestine was standardized, taking as basis for collection the region between 30 mm before the ileocecocolic junction and 30 mm after Meckel's diverticulum, in order to avoid contamination of the cecal and jejunal flow, respectively, and adjust to individual variability in the intestinal tract length of birds.

Following the incision of the ileal segment, the digesta of each bird in the same experimental unit was delicately removed using pliers, and then

placed in a labeled plastic container and stored in a freezer at -20°C. Next, the content of each sample was homogenized, pre-dried at 55ºC, ground to 1 mm screen, and analyzed for levels of dry matter, crude protein, ether extract, gross energy and chromium oxide concentration, according to the methodologies proposed by Silva and Queiroz (2002).

The formulas described by Sakomura and Rostagno (2007) were applied to calculate the concentrations of chromium oxide present in the digesta and in the diet, as well as the indigestibility factor. Some calculations were made to isolate the apparent ileal digestibility coefficients of dry matter (AIDCDM), crude protein (AIDCCP), ether extract (AIDCEE) and gross energy (AIDCGE) of corn germ meal, using the formulas proposed by Matterson et al. (1965).

The data were submitted initially to analysis to verify the normalcy of errors and homogeneity of variance by tests of Cramer-von Mises and Brown and Forsythe's, respectively. Once the presuppositions were satisfied in relation to data, it was submitted to analysis of variance according to the following statistical model: $Y_{ij} = \mu + Age_i + e_{ij}$; in which Y_{ij} is the value observed with the *i*th age of the bird; μ is the overall mean effect; Age_i is the effect of the *i*th age of the bird; e_{ij} is the casual effect, experimental error. The fitted models were simple linear, quadratic polynomial and broken line. The dependent variables under consideration were the apparent ileal digestibility coefficient of: dry matter, crude protein, ether extract, gross energy and values of digestible of: dry matter, crude protein, ether extract and energy. The independent variables were the ages (10, 20, 30 and 40 days).

Specifically, the broken line (BL) mathematical model adopted was described by Siqueira et al. (2009), according to the equation: $\hat{Y}_i = L + U (R - Age_i) + e_i$, $i = 1,2...n1, n1+1,...,n$; in which $(R - Age) = 0$ for $i \geq n1 + 1$, n1 is the number of observations up to the breaking point, n is the number of observation pairs, $\hat{Y}_i$ is the value estimated for the *i*th age of the bird, Age_i is bird age, L is the estimated value at the plateau, U is the slope of the line, R is the bird age estimated by the break point, and e_i is the error between the observed value and the value estimated by the equation.

The statistical analyses were analyzed by SAS (2009) computer software, version 9.1, using procedures PROC GLM for the continuous linear models and PROC NLIN to fit the broken line and linear models. The selection of models to explain the behavior of variables was based on the significance of each equation parameter and on the coefficient of determination.

Results and discussion

The assumptions of normality of the errors and homoscedasticity of variance were tested and satisfied. Table 2 features the means and standard deviation of the apparent ileal digestibility coefficients of dry matter (AIDCDM), crude protein (AIDCCP), ether extract (AIDCEE) and gross energy (AIDCGE), based on dry matter and natural matter. The results indicated that age influenced the apparent ileal digestibility of dry matter (AIDCDM), in which the model that best fit the data was the Linear Response Plateau. The model estimated that AIDCDM stabilized from the 16th day of age, as can be seen in Figure 1.

Although the model provided a good fit, there is a possibility of the digestibility coefficient have been overestimated for the first evaluated age. A similar answer was observed by Garcia et al. (2007), who determined the ileal digestibility for chicken between seven and 21 days old, and did not find differences for most analyzed variables.

Table 2. Mean apparent ileal digestibility coefficients of dry matter (AIDCDM), crude protein (AIDCCP), ether extract (AIDCEE) and gross energy (AIDCGE) of corn germ meal.

Age	AIDCDM	AIDCCP	AIDCEE	AIDCGE	AIDCDM	AIDCCP	AIDCEE	AIDCGE
(days)	based on dry matter (%)				based on natural matter (%)			
10	95.8 ± 0.5	91.2 ± 0.8	87.8 ± 0.9	79.6 ± 1.2	90.5 ± 0.5	86.1 ± 0.8	82.9 ± 0.9	75.1 ± 1.1
20	94.2 ± 0.6	90.5 ± 1.1	91.5 ± 1.3	80.7 ± 0.9	88.9 ± 0.6	85.5 ± 1.0	86.4 ± 1.2	76.2 ± 0.9
30	94.3 ± 0.9	87.9 ± 1.1	86.8 ± 2.7	80.3 ± 1.9	89.0 ± 0.8	83.0 ± 1.0	82.0 ± 2.0	77.8 ± 2.3
40	95.4 ± 0.8	92.8 ± 0.9	91.5 ± 1.5	85.5 ± 0.2	90.1 ± 0.8	87.7 ± 0.9	86.4 ± 1.5	80.8 ± 0.1
Mean ± SE	95.0 ± 0.2	90.8 ± 0.5	89.5 ± 0.6	81.2 ± 0.6	89.7 ± 0.2	85.8 ± 0.5	84.5 ± 0.6	77.1 ± 0.6
F	6.45	0.36	1.11	18.90	6.42	0.36	1.11	37.56
P	0.0212	0.5581	0.3096	0.0008	0.0214	0.5582	0.3087	<0.0001
CV, %	1.07	2.13	3.00	2.05	1.07	2.13	3.00	1.65
RE	[1]BL	NS	NS	[2]Linear	[3]BL	NS	NS	[4]Linear
R^2 (%)	82.50	-	-	59.25	82.23	-	-	72.28

Mean ± standard error; CV: Coefficient of variation; RE: regression equation; P: Probability; R^2: Coefficient of determination; [1]BL: 94.6557 + 0.1940(15.9699 - Age); [2]BL: 89.3736 + 0.1832*(15.9518 - Age); [3]Linear: $\hat{Y}$ = 77.458 + 0.166*(Age); [4]Linear: $\hat{Y}$ = 73.136 + 0.157*(Age).

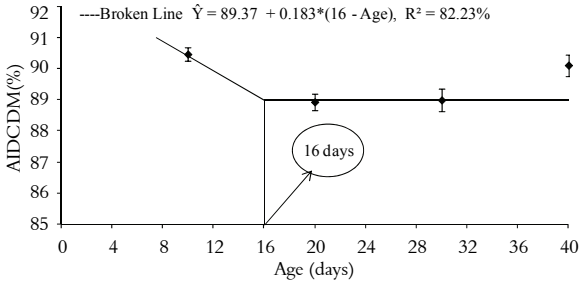

Figure 1. Apparent ileal digestibility coefficients of dry matter (AIDCDM), expressed in natural matter (♦ observed).

Birds with normal intake patterns have a characteristic gastrointestinal flow dynamic, and the indictors present in the diets assume a similar condition in order to obtain an accurate estimate. However, it is known that birds feature has different intake pattern when submitted the different diets. Garcia et al. (2007) justified that reduced feed intake can affect the dynamic equilibrium and the accuracy of the estimate of nutrients' digestibility coefficient.

The digestibility coefficients of protein and ether extract of corn germ meal were not influenced by bird age. An increase was expected in the digestibility coefficients of the nutritional components at advanced ages. This effect was observed only in the apparent digestibility coefficient of gross energy. The model shows each day over the broiler increase 0.179% in the digestibility coefficient of the energy.

The absence of effect in the digestibility coefficients of protein and ether extract can be justified because of the experimental period applied. According to Batal and Parsons (2002), greater increases are observed in the first ten days of age. These authors estimated, using the broken line model (LRP), that the digestibility coefficients of some nutritional components of the feeds stabilized at ten days old.

In the same study, Batal and Parsons (2002) further establish that feed composition directly interferes with digestibility. In that study, the researchers compared a purified diet (dextrose-casein) to a practical diet (corn and soybean meal), and observed increased digestibility of protein fraction components for the practical diet in two- to 21-day-old of broiler chicks; however, the same was not observed for the purified diet.

Thus, the findings in the present study suggest that the protein fraction and fatty acids present in corn germ meal are arranged in a structure is easily degradable by the enzyme systems, as there was an effect of bird age.

The overall mean of the digestibility coefficients of crude protein and ether extract of the ages were 90.8 and 89.5%, respectively. For these same variables, Rostagno et al. (2005) report values of 88.2 and 84.0%.

Table 3 presents the values of digestible dry matter, digestible protein, digestible ether extract and digestible energy of corn germ meal. The absence of effect in the values of the digestibility of crude protein and ether extract were due of the results from ileal digestibility coefficients these nutrients.

Table 3. Means values of digestible dry matter (DDM), digestible crude protein (DCP), digestible ether extract (DEE) and digestible energy (DE).

Age	DDM	DCP	DEE	DE
(days)		(%)		Kcal g^{-1}
10	85.4 ± 0.5	8.9 ± 0.1	46.8 ± 0.5	5,288 ± 0,079
20	83.9 ± 0.6	8.9 ± 0.1	48.8 ± 0.7	5,365 ± 0,062
30	84.0 ± 0.8	8.6 ± 0.1	46.3 ± 1.2	5,473 ± 0,160
40	85.1 ± 0.8	9.1 ± 0.1	48.8 ± 0.8	5,684 ± 0,011
*Mean ± SE	84.66 ± 0.2	8.90 ± 0.05	47.72 ± 0.4	5,425 ± 0,041
F	6.43	0.38	1.11	37.45
CV, %	1.07	2.13	3.00	1,65
ER	[1]BL	NS	NS	[2]Linear
R^2	82.34	-	-	72.23
P	0.0213	0.5483	0.3088	<0.0001

Mean ± standard error; CV: Coefficient of variation; RE: regression equation; P: Probability; SE: Standard error; [1]BL: Ŷ= 84.3886 + 0.1731 (16 - Age); [2]Linear: Ŷ= 5.148+0.013*(Age).

The digestible energy of corn germ meal increased by 13 kcal kg^{-1} d^{-1} until the age of 40 days (Figure 2). This result reveals a 396 kcal energy increase in the same kilogram of feed. This energy gain can be attributed to the enhanced use of the carbohydrates contained in the feed, given that the digestibility of crude protein and ether extract did not change as age advanced, leaving only the carbohydrate fraction to make up the entire organic matter of the feed.

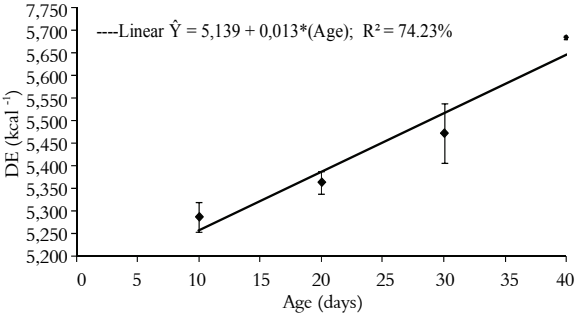

Figure 2. Effect of age on digestible energy (DE) of corn germ meal, expressed in natural matter.

Indirectly, it can be inferred that the energy increase was due to the carbohydrates present in the feed. This hypothesis is founded on physiological events that affect birds around the second week of life. According to Obst and Diamond (1992), a temporary increase in glucose uptake can be observed in that period, as a result of the change from lipid metabolism to carbohydrate metabolism, due to the depletion of yolk reserves.

Lima (2008) evaluated the effect of age on the use of metabolizable energy of corn germ meal in five- to

35-day-old birds, and estimated the daily increase at 26 kcal kg^{-1}, which was higher than that found in the present work. These results differ with regard to the methodological nature in which they were collected, as those authors used the total feces collection method.

Overall, age influenced the energy digestibility of corn germ meal; nevertheless, it is evident that the wide range of points covered may have been one of the factors for not obtaining more expressive results in the other analyzed variables. Studies of that nature are essential.

Conclusion

The age of broiler chickens influenced only the digestibility coefficient of energy; thus, the additive effect of age on the digestible energy of corn germ meal was estimated at 13 kcal kg^{-1} day^{-1}.

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