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APPARENT ILEAL NITROGEN DIGESTIBILITY AND APPARENT METABOLIZABLE ENERGY CORRECTED TO ZERO NITROGEN IN BROILER CHICKENS FED TEXTURED DIETS AND FEED RESTRICTED AT DIFFERENT AGES

Determinación de la digestibilidad ileal aparente del nitrógeno y de la energía metabolizable aparente corregida a cero nitrógeno en pollos de engorde alimentados con dietas molidas y sujetos a restricción alimenticia a diferentes edades

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ABSTRACT

Two experiments were carried out to evaluate the apparent nitrogen digestibility and the apparent metabolizable energy in broiler chickens fed textured diets and feed restricted**.** Chicks in experiment 1 were housed in an electrically heated brooder battery and fed *ad libitum* or feed-restricted to 90% of birds fed *ad libitum* intake of previous day. Chromic oxide was used as a marker. Birds at 15 d of age were killed and the ileal digesta collected for nitrogen digestibility and AMEn. The apparent nitrogen digestibility was no significantly different ($P > 0.05$) between *ad libitum* (78.9%) and feed-restricted (79.3%) broilers at 15 days of age. There was no difference ($P > 0.05$) for the apparent metabolizable energy corrected to zero nitrogen (AMEn) between treatments. Chicks in the second experiment were housed in batteries or cages depending on age of the bird. Birds were fed with diets pelleted, mashed or pelleted but feed-restricted to 90% of *ad libitum* intake. Excreta was collected and wrapped in aluminum foil trays over 72 h, and dried at 65°C. Samples were assay for gross energy and nitrogen evaluations. The AMEn was significantly different ($P < 0.01$) among chicks fed crumble (3061 Kcal/kg), mash (2994 Kcal/kg), or feed restricted to 90% of ad *libitum* crumble intake (3087 Kcal/kg). In broiler chickens at 28 and 48 days of age, there were no significant differences ($P > 0.05$) in the AMEn when fed crumble (3355 and 3357 Kcal/kg), mash (3344 and 3348 Kcal/kg) or feed restricted (3332 and 3356 Kcal/kg) to 90% of *ad libitum* texture diets intake respectively. It was concluded that mild feed restriction does not influence ileal nitrogen digestibility or AMEn in young broilers. Texture of diets only affected ($P < 0.05$) the AMEn at early age of birds.

Key words: Broilers, nitrogen, digestibility, AME, feed restriction.

RESUMEN

Dos experimentos se llevaron a cabo con la finalidad de evaluar la digestibilidad ileal aparente del nitrógeno (DIAN) y la energía metabolizable aparente corregida a cero nitrógeno (AMEn) en pollos de engorde alimentados con diferentes tamaños de partículas de dietas y sujetos a restricción alimenticia. Los pollitos en el experimento 1 fueron alimentados *ad libitum* o sujetos a una restricción alimenticia del 10%. Los pollitos a los 15 días de edad se sacrificaron y se recolectó la digesta ileal para evaluaciones de la DIAN y de la AMEn. La digestibilidad ileal aparente del nitrógeno y la AMEn no fueron significativamente diferentes ($P > 0,05$) entre pollitos de 15 días de edad alimentados *ad libitum* (78,9% y 3238 Kcal/kg) y sujetos a una restricción alimenticia del 10% (79,3% y 3220 Kcal/kg) respectivamente. Las aves en el segundo experimento fueron alimentados con dietas peletizadas, molidas o restringidos con un 10% del consumo de las aves alimentadas *ad libitum* con dietas peletizadas. La excreta fue recolectada en papel de aluminio por 72 h y secadas a 65°C. La AMEn fue significativamente diferente ($P < 0,01$) entre pollitos alimentados con dietas peletizadas y luego partidas (3061 Kcal/kg), molidas (2994 Kcal/kg) o sujetos a restricción alimenticia (3087 Kcal/kg). En pollos de engorde a los 28 y 48 días de edad, no se encon-

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tró diferencia significativa (P > 0,05) entre las diferentes dietas utilizadas. Existe un indicio de un aumento en la AMEn debido al peletizado, sin embargo el efecto no es mayor. Se concluye que la restricción alimenticia leve no influyó la DIAN o la AMEn en pollos jóvenes. El tamaño de la partícula afectó únicamente la AMEn a temprana edad (P < 0,05) pero no tuvo ningún efecto (P > 0,05) a los 28 o 48 días de edad del ave.

Palabras clave: Pollos de engorde, AME, nitrógeno, digestibilidad, restricción alimenticia.

INTRODUCTION

The use of feed restriction programs in broiler chickens has been considered as a means of improving feed conversion. However, it is necessary to determine if mild feed restriction has an effect on AMEn (Apparent Metabolizable Energy corrected to zero nitrogen retention). Some workers have reported that restricting feed intake between 30 and 90% of *ad libitum* intake does not affect AME (Apparent Metabolizable Energy) [3, 7] while others have reported variable diet AME related to intake [6, 9, 19, 20]. It is known that both fecal and urinary energy losses depend on the amount of feed consumed, so affecting AME values. In addition, it is generally accepted that feed intake levels affect classical AME values because at low feed intake endogenous losses represent a higher amount of energy voided in the excreta, so affecting AME.

Dietary metabolizable energy is also affected by factors such as age [1, 2], and the method used for evaluation [4]. It is known that age of bird affects digestive enzyme activities and associated availability of nutrients [11, 13, 14]. Gous [5] suggested that in feed-restricted birds the availability of amino acids might be increased due to an improved absorption. Effects of feeding regimen on the activity of digestive enzymes have also been studied [12, 16]. Increased synthesis of digestive enzymes at times of feed restriction was observed [12]. It was stated [16] that the feeding regimen affected the activities of proteolytic enzymes, and that the activity of trypsin enzyme was higher in intermittent rather than *ad libitum* fed birds. Related to this, an improved amino acid digestibility may occur in feed restricted chicks.

In order to determine if mild feed-restriction affects nitrogen digestibility in young broilers at 15 days of age, and if mild feed restriction or pelleting of diet influence AMEn at different broiler ages two experiments were carried out.

MATERIALS AND METHODS

Experiment 1

Two hundred and forty one day-old male broiler chickens of a commercial strain were randomly allocated to one of two treatments of 120 chicks each. Each treatment consisted of twelve replicates of 10 birds each. Chicks were housed in an electrically heated brooder battery and were given water *ad libitum.* Lighting was provided 23h/day. All birds were fed on *ad libitum* basis to 5 d of age using a conventional starter diet (Diet 1, TABLE I), formulated to meet the nutrient requirements according to the NRC [15]. Chromic oxide was added to the diet at a level of approximately 0.4% as a marker for determining ileal digestibility. Chicks were fed *ad libitum* or feed-restricted from d 9 to d 15 to 90% *ad libitum* intake determined from observations on the control birds of the previous day.

At 15 d of age, 5 birds per replicate, selected at random, were killed by cervical dislocation, the body cavity opened and the digestive tract immediately removed. Ileal digesta were carefully removed by washing with distilled water and gentle pressure from the terminal ileum (15 cm) adjacent to the ileocecal junction. Digesta was pooled for the five chicks, from each replicate and oven-dried at 65°C for 72 h (Hotpack, Philadelphia, PA 19154, USA), and then allowed to come to equilibrium with atmospheric moisture for 3 days. Digesta was ground in a commercial blender (Waring Products Division, New Hortford, CT 06057-0000, USA). Nitrogen determination was assessed in both feed and ileal digesta using a Leco nitrogen analyzer (Leco Instruments, Stock Port, Cheshire, SK7 5DA, UK). Gross energy of feed and ileal digesta was assayed by the complete combustion of the samples in a C5003 ika adiabatic bomb calorimeter (GMBIT and CO. KG D-79219, Staufen, Germany). Chromiun content of the diet and digesta were analyzed using the method described by Williams et al. [22].

Statistical analysis

The experiment was arranged as a complete randomized design with replicate as the experimental unit. All variables were subjected to *t*- test procedure analysis [21].

Experiment 2

Experiment 2.1. One hundred and twenty day-old male broiler chickens of a commercial strain were randomly allocated to one of three treatments of 40 chicks each. Each treatment consisted of eight replicates of 5 birds each, located in an electrically heated battery brooder. Chicks in treatment 1 were fed *ad libitum* crumble-pelleted diets (Diet 2, TABLE I), formulated to meet the NRC [15] nutritional recommendations. Chicks in treatment 2 were fed a mash starter diet (Diet 2, TABLE I), or chicks in treatment 3 were fed the same crumble starter diet but were feed-restricted to 90% of *ad libitum* intake determinations for crumble *ad libitum* (treatment 1) fed chicks of previous day (Diet 1, TABLE I). All diets were formulated to meet nutrient requirements according to the NRC [15]. Battery brooder temperature was controlled according to standard practices. Water was offered *ad libitum* for all treatments and lighting was provided 23 h/day. All birds had a period of adaptation of 4 d prior to starting the excreta collection. Excreta was collected from 4-6 d of age and accumulated in aluminum foil trays over 72 h. During the excreta collection feathers, scales

TABLE I
PERCENTAGE DIET COMPOSITION

Ingredients	Starter	Grower	Finisher	Starter
	Diet 1	Diet 2	Diet 3	Diet 4
Soybean meal (48%)	36.12	30.49	25.49	36.12
Yellow corn	56.87	61.68	66.58	56.72
Animal-Vegetable fat	2.74	3.76	3.93	2.74
Limestone	1.79	1.61	1.61	1.79
Dicalcium phosphate	1.06	1.04	0.99	1.06
Salt	0.313	0.31	0.31	0.31
Vitamin-mineral premix	1.00	1.00	1.00	1.00
DL-Methionine	0.107	0.11	0.09	0.107
Chromiun oxide				0.4
Calculated analysis				
ME (kcal/kg)	3050	3150	3190	3036
Crude protein (%)	22.31	20.0	18.0	22.79
Lysine (%)	1.27	1.10	0.948	1.27
Methionine + cystine (%)	0.82	0.74	0.64	0.82
Calcium (%)	1.00	0.92	0.90	1.03
Available phosphorus (%)	0.42	0.40	0.38	0.419

Supplied per kilogram of diet: vitamin A: 8,800 IU (retinyl palmitate); cholecalciferol: 3,300IU; vitamin E: 40 IU (dL-α-tocopheryl acetate); rifoflavin: 8.0 mg; biotin: 0.22 mg; thiamin: 4 mg; pantothenic acid: 15.0 mg; vitamin B_{12}: 12 μg; niacin: 50 mg; choline: 600 mg; vitamin K: 3.3 mg; folic acid: 1.0 mg; ethoxyquin: 120 mg; manganase: 70 mg; zinc: 70 mg; copper: 10 mg; iron: 60 mg and selenium: 0.3 mg.

and spilled feed were removed from the excreta and the split feed was weighed. At the end of the collection period, the excreta was wrapped in foil and dried at 65 C for 72 h in a forced-air oven (Hotpack, Philadelphia, PA 19154, USA). Samples were assay for gross energy and nitrogen as described in Experiment 1. AME was calculated according to Leeson *et al.* [10]. Correction for nitrogen excretion was determined using 8.22 Kcal/g nitrogen as described by Hill and Anderson [7].

Experiment 2.2. Seventy-two 21 d old male broiler chickens of a commercial strain were randomly allocated to one of three treatments of 24 birds each. Each treatment consisted of eight replicates of 3 birds each, located in a grower battery. Chicks were fed *ad libitum* pelleted grower diet (Diet 3, TABLE I). Chicks were fed a mash grower diet (Diet 3, TABLE I) *ad libitum*, or chicks were fed pellets but feed-restricted to 90% of *ad libitum* intake determinations for *ad libitum* fed pellest birds of previous day. Excreta was collected from 26 - 28 d of age. Subsequently the experiment followed the same procedure as described for experiment 2.1

Experiment 2.3. Twenty-four 42 d old male broiler chickens of a commercial strain were randomly allocated to one of three treatments of 8 birds each. Each treatment consisted of eight replicates of 1 bird each, located in individually cages. Birds were placed in alternate cages so as to prevent feed contamination. Chicks were fed a pelleted finisher diet (Diet 4, TABLE I), or chicks were fed pellets and were feed-restricted to 90% of *ad libitum* intake determinations for *ad libitum* fed pellet chicks of previous day. Excreta was collected from 47-49 d of age. Subsequently sampling and analysis procedure were as described in experiment 2.1.

Statistical analysis

The experiments were arranged as a complete randomized design with replicate as the experimental unit. All variables were analyzed by one way of ANOVA [21].

RESULTS

Experiment 1

Apparent ileal nitrogen digestibility and apparent metabolizable energy (AMEn) values are shown in TABLE II. There was no difference (P > 0.05) between *ad libitum* and fed-restricted broilers at 15 days of age for either apparent nitrogen digestibility or apparent metabolizable energy corrected to zero nitrogen (AMEn).

Experiment 2

Apparent Metabolizable Energy corrected to zero nitrogen in broiler chickens as affected by diet texture and feed restriction at different ages is shown in TABLE III. There were significant differences (P < 0.01) in AMEn at 5 d among chicks

TABLE II
APARENT ILEAL NITROGEN DIGESTIBILITY AND AMEn RELATED TO FEED RESTRICTION IN BROILERS OF 15 DAYS OF AGE, EXPERIMENT 1

Treatment	App Ileal N Digestibility (%)	AMEn (Kcal/kg)
Ad libitum	[a]78.95 ± 38.8	[a]3238 ± 0.13
Feed Restricted	[a]79.30 ± 39.3	[a]3220 ± 0.16

[a]Means ± Std Error. AMEn= Apparent metabolizable energy corrected to zero nitrogen. App Ileal N Digestibility= Apparent ileal nitrogen digestibility.

TABLE III
AMEn IN BROILER CHICKENS FED TEXTURED DIETS AND FEED RESTRICTED, EXPERIMENT 2

Treatment Diets	AMEn (Kcal/kg)		
	Day 5	Day 28	Day 48
Textured	3061[a] ± 14.96	3355[a] ± 9.13	3357[a] ± 16.37
Mash	2994[b] ± 14.96	3344[a] ± 9.13	3348[a] ± 13.46
90% Textured	3087[a] ± 14.96	3332[a] ± 9.13	3356[a] ± 14.72

[a-b]Means with different superscript differ significantly ($P < 0.01$). AMEn = Apparent metabolizable energy corrected to zero nitrogen. Means ± std error.

fed crumble, mash, or feed restricted to 90% of *ad libitum* crumble intake respectively (TABLE III). It was observed that chicks fed pelleted and mash had 0.8 and 3% reduced AMEn respectively, compared to feed restricted broilers. No significant differences ($P > 0.05$) were obtained in AMEn of grower or finisher diets whether fed as pellets, mash, or feed-restricted to 90% of *ad libitum* intake respectively (TABLE III).

DISCUSSION

The objective of these experiments was to determine if mild feed restriction program affects nitrogen digestibility and AMEn in broiler chickens at different ages. Restricting the intake of young broiler chickens to 90% of *ad libitum* intake did not affect apparent ileal nitrogen digestibility. This result is contrary to the results of Gous [5] who suggested that feed-restriction improves amino acid availability. In this experiment amino acid digestibility was not determine because apparent ileal nitrogen digestibility was not affected. However, it is necessary to establish if chicks subjected to a more severe feed restriction program do influence the nitrogen and/or amino acid digestibility.

AMEn values among birds feed-restricted to 90% of *ad libitum* intake and *ad libitum* fed broiler chickens were not different at any age measured. These results are in accord with the observations of Bourdillon et al. [3] and Hill and Anderson [7] but contrary to Potter et al. [17], whom observed a slightly increase in the ME of the diet at reduced feed intake. Increased fat digestibility has been reported in growing chicks when their feed intake is reduced [8]. However, Zelenka [23] suggested that AMEn decreased with increasing feed intake, and this is due to a variation in *ad libitum* feed intake. It may be that no differences in AMEn between chicks fed *ad libitum* and feed-restricted to 90% of *ad libitum* intake may have occurred because the degree of feed restriction used was not severe enough. There was a significant effect on AMEn related to age of the chicks, with increasing AMEn levels in older chicks. These results are in agreement with the observations of Bartov [2] and Zelenka [23]. The increased AMEn values in older chicks occurred because age of birds noticeably affects growth of digestive organs and production of digestive enzymes, and therefore the availability of nutrients [11], and /or due to the different diets given exerts an effect. Regardless of intake level AMEn values for crumble were significantly higher than for mash at 5 d old chicks. Although AMEn values of grower and finisher diets were not significantly different at 28 and 48 days of age regardless of texture, pelleted diets always showed higher values than those fed as mash. This may occur due to increased digestibility of starch since pelleting causes gelatinization [18], resulting in greater diet AME values.

CONCLUSION

There is an indication of improved AMEn due to texturing diets for young birds, but not for older birds fed grower or finisher rations. Mild feed restriction does not affect AMEn of the diet fed at any age, indicating that the level of feed restriction applied did not reduce AMEn. It is concluded that mild feed restriction did not improve ileal nitrogen digestibility in young chicks, therefore amino acid digestibility is likely not to be improved.

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