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Determination of the Energetic Value of Corn, Soybean Meal and Micronized Full Fat Soybean for Newly Hatched Chicks¹

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■ Keywords

Chicks, corn, metabolizable energy, micronized full fat soybean, soybean meal.

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ABSTRACT

There are some evidences described in the literature showing reduced energy metabolizability of ingredients for newly hatched chicks. Hence, a metabolism trial was carried out with the objective of determining the metabolizable energy of corn grain, soybean meal and micronized full fat soybean for newly hatched chicks. The method of total excreta collection was used in an experiment with 192 male chicks from one to seven days, distributed in a completely randomized design with four treatments and four replicates of twelve birds. Excreta were collected from four to seven days of age. The treatments included a reference diet, two test-diets consisting of 60% of the reference diet and 40% of the test ingredients: corn grain (CG) and soybean meal (SM), and one test-diet consisting of 80% of the reference diet and 20% of micronized full fat soybean (MFFS). The N-corrected apparent metabolizable energy (AMEn) and the metabolizability coefficient of gross energy (MCGE) of the ingredients determined for the chicks were respectively 3,213 kcal/kg and 81.6% for CG; 2,085 kcal/kg and 49.7% for SM and 4,068 kcal/kg and 74.8% for MFFS.

INTRODUCTION

The study of nutrition and metabolism of newly hatched broiler chicks has proven to be an interesting research area, which may allow the expression of the potential growth rate and meat production of birds by optimizing feed management. In the past decades, growth rates of broilers have increased and enabled to reach final bird weight earlier. Therefore, the dietary management of newly hatched chicks represents an important tool to improve broiler production indexes.

However, the immaturity of the digestive system of young chicks reduces its ability to absorb nutrients compared to older birds. According to Vieira & Moran Jr. (1999), the intestinal tract of birds is not completely able to digest dietary nutrients until two weeks of age.

During the early stages of broiler development, the ability of digesting carbohydrates and fat is decreased compared to other phases. Noy & Sklan (1995) showed that chicks at four days of age had reduced absorption rates of lipid and carbohydrate (85%) and protein (80%) when compared to older birds.

This lower nutrient utilization during early stages seems to result in decreased metabolizable energy (ME) values of the diets. Previous experiments showed that ME values are depressed between four and seven days of age of broilers (Murakami *et al.*, 1992; Sulistyanto *et al.*, 1998). Corless & Sell (1999) reported that dietary ME values obtained from birds with four, seven and 14 days old were lower than values calculated using the NRC (1994) tables.



The metabolizable energy values of corn-soybean based diets obtained for birds in the first, second and third week of age differed in about 200-250 kcal/kg when different ingredients for birds were evaluated (Mahagna *et al.*, 1988). However, ME values of wheat-soybean diets differed in 500-1,100 kcal/kg. This low metabolizability observed for wheat-soybean diets was due to higher digesta viscosity caused by the non-starch polysaccharide content of the ingredient. Nutrient digestibility is even more impaired when non-starch polysaccharides are associated to an immature enzymatic system.

Furthermore, the presence of oligosaccharides in soybean meal, such as raffinose and stachyose, is partially responsible for the reduction in the energy digestibility that is seen when considering this ingredient for birds (Leeson & Summers, 2001).

In birds, the ME value of a corn-soybean diet increases with age until 14 days, when it stabilizes. The reason for the observed increase in energy utilization using this type of diet is based on the increased utilization of starch from corn, fat from corn and supplemental fat, protein from corn and soybean and other carbohydrates from dietary components (Batal & Parsons, 2002). Therefore, even the usual components of broiler diets can have their utilization diminished during the first few days of age.

Dietary ingredients like soy protein concentrate and soy protein isolate are known to be better utilized by chicks when compared to ordinary soybean meal due to the removal of the oligosaccharide content. It is well established that these compounds act as anti-nutritional factors and reduce protein digestibility in birds (Parsons *et al.*, 2000).

The use of micronized full fat soybean in pre-starter broilers diets is an alternative for the use of soybean meal. This ingredient is produced using selected soybeans that are heated, dehulled, ground and micronized. The process results in a product with small particle size (between 30 and 300 μm) and completely free from hulls, which results in an increase of nutrient utilization by broilers (Goldflus, 2001).

The intake of pre-starter diet is low and corresponds to only 3.5% of total feed consumption, which justifies the use of high-quality ingredients in feed production (Penz Jr. & Vieira, 1998). In order that high-quality and expensive ingredients can be used in pre-starter diets, the evaluation of the actual capacity of ingredient utilization is critical for the formulation of efficient diets and for the improvement of nutrient utilization by young birds.

However, the use of high-quality and expensive ingredients in the composition of pre-starter diets is extremely dependent on precise evaluation of the utilization capacity of the standard ingredients, such as corn and soybean meal. The knowledge of these values would allow nutritionists to produce efficient diets that improve nutrient utilization by young birds.

The objective of this work was to determine the metabolizable energy value and the metabolizability coefficient of gross energy for corn, soybean meal and micronized full fat soybean for newly hatched broiler chicks.

MATERIAL AND METHODS

A metabolism assay was conducted in an environmentally controlled room at the Department of Animal Science, ESALQ/USP, Piracicaba/SP, Brazil. One hundred and ninety-two AgRoss male broiler chicks with one day of age were distributed in a completely randomized design with four treatments and four replicates of 12 birds per cage. The birds were raised on battery cages with automatic heating and a tray under the screen floor to collect excreta.

The treatments included a reference diet (Table 1) formulated to meet nutritional requirements of birds in the early stages (Rostagno *et al.*, 2000) and three test diets. Two of the test diets were composed of 60% of the reference diet and 40% of the tested ingredient (corn or soybean meal). In the third test diet, 20% of the reference diet was substituted for micronized full fat soybean meal.

Birds were fed the experimental diets from one to three days of age, corresponding to an adaptation period. Total excreta collection method was then performed for four consecutive days. Feed intake and excreta production were recorded daily. Iron oxide was added to the experimental diets to dye the excreta and establish the start and the end of the collection period.

The produced excreta were collected twice a day, identified and stored in a freezer until analysis. After thawing and homogenization, representative samples of each replicate were dried in an oven at 55°C for 72 hours and ground. Samples of dietary ingredients, experimental diets and excreta were analyzed for dry matter, nitrogen, total fat and gross energy.



Table 1 - Composition and calculated analysis of the reference diet.

Ingredients	%
Corn	57.30
Soybean meal	36.75
Dicalcium phosphate	1.89
Limestone	1.00
Salt	0.50
DL-Methionine	0.21
L-Lysine.HCl	0.18
Choline-Cl 60%	0.05
Vegetable oil	1.92
Vitamin mix ¹	0.10
Mineral mix ²	0.10
Calculated values	
Metabolizable energy, kcal/kg	2,950
Crude protein, %	21.92
Methionine, %	0.54
Methionine + Cystine, %	0.93
Lysine, %	1.31
Available phosphorus, %	0.47
Calcium, %	0.99

1 - Levels per kg of diet: vitamin A, 10,000 IU; vitamin D₃, 2,000 IU; vitamin E, 12.5 mg; vitamin K₃, 2.5 mg; thiamin, 2.4 mg; riboflavin, 6.0 mg; pyridoxine, 3.2 mg; vitamin B₁₂, 0.012 mg; folic acid, 1.0 mg; pantothenic acid, 12.5 mg; niacin, 30 mg; selenium, 0.2 mg; BHT, 15 mg. 2 - Levels per kg of diet: manganese, 65 mg; copper, 12 mg; zinc, 50 mg; iron, 40 mg; iodine, 1 mg.

The N-corrected apparent metabolizable energy (AME_n) was calculated based on data obtained from analysis of experimental diets and excreta, as suggested by Matterson *et al.* (1965). AME_n was calculated for each test ingredient based on energy values obtained for the experimental diets using the following formula:

$$\text{AMEn ing.} = \frac{\text{AMEn ref.} + (\text{AMEn test} - \text{AMEn ref.})}{(\% \text{ replacement} / 100)}$$

Where:

AMEn: calculated N-corrected apparent metabolizable energy (kcal/kg);
ing.: test ingredient;
ref.: reference diet;
test: basal diet + test ingredient;
% replacement: substitution level of basal diet for the test ingredient.

The metabolizability coefficient of gross energy (MCGE) was calculated based on gross energy (GE) and apparent metabolizable energy values (MCGE = AME_n/GE x 100).

The MCGE ingredient data were evaluated using General Linear Model Procedure (SAS Institute, 1996) and means were compared by the Tukey's test.

RESULTS AND DISCUSSION

The values of dry matter (DM), gross energy (GE), crude protein (CP) and total fat (TF) of the studied ingredients (corn, soybean meal and micronized full fat soybean) are presented in Table 2. The nutrient composition for the test ingredients found in the present study are in agreement with the composition reported in nutritional tables.

The calculated AME_n and MCGE values for corn, soybean meal and micronized full fat soybean are shown in Table 3, as well as comparative data found in the literature.

Table 2 - Results of dry matter (DM), gross energy (GE), crude protein (CP) and total fat (TF) for corn, soybean meal and micronized full fat soybean*.

	Corn	Soybean	Micronized full fat soybean
DM (%)	89.92	91.67	98.35
GE (kcal/kg)	3,943	4,197	5,438
CP (%)	9.26	47.52	41.70
TF (%)	4.63	1.80	23.12

* As-fed basis.

Table 3 - Calculated values and standard deviation of N-corrected apparent metabolizable energy (AME_n) and metabolizability coefficient of gross energy (MCGE) for corn, soybean meal and micronized full fat soybean.

Ingredients	Calculated AMEn (kcal/kg ¹)	MCGE (%)	Literature AMEn ² (kcal/kg ¹)
Corn	3,213±31	81.60±0.78 ^a	3,360
Soybean meal	2,085±45	49.67±1.07 ^c	2,385
Micronized full fat soybean	4,068±78	74.81±1.38 ^b	3,950

a, b, c - Means in the same column with no common letters are different by Tukey's test (p<0.01) - Coefficient of variation = 1.61%
1 - as-fed basis. 2 - NRC (1994) and Rostagno *et al.* (2000).

AME_n values in the present study for young chicks were 150 and 300 kcal/kg lower than average values indicated in the literature for corn (3,360 kcal/kg) and for soybean meal (2,385 kcal/kg), respectively (NRC, 1994; Rostagno *et al.*, 2000). However, micronized full fat soybean AME_n was similar with values previously reported in the literature (4,068 and 3,950 kcal/kg). It should be noted that the reference values for AME_n found in literature for those ingredients were determined using older birds.



Sulistyanto *et al.* (1998) analyzed metabolizability of corn and wheat in broiler chicks aged one, three and 10 days and found that the energy values of these ingredients increased with age, although no significant differences were seen.

The results of AME_n reported by Café *et al.* (1993) for micronized full fat soybean using broiler chicks from 13 to 23 days-old are only 108 kcal/kg higher (4,176 kcal/kg) than the value determined in this study (4,068 kcal/kg).

The MCGE values obtained in the present study for the three ingredients were statistically different ($p < 0.01$). Corn was considered the most efficient ingredient on energy utilization followed by micronized full fat soybean and the least efficient was soybean meal. In agreement with Sulistyanto *et al.* (1999), corn also demonstrated better energy utilization for young birds compared to other carbohydrate sources like wheat and sorghum.

The calculated values of MCGE obtained from the nutritional data for older birds found in the Brazilian tables (Rostagno *et al.*, 2000) were compared to those determined in this study using young chicks. It was noted that the ability of the younger birds to metabolize energy was similar for micronized full fat soybean (75.3% *vs.* 74.81%), lower for corn (85.7% *vs.* 81.6%) and even lower for soybean meal (60.7% *vs.* 49.7%).

The depressed values of AME_n and MCGE found in this study for corn and soybean meal are probably related to the intrinsic characteristics of the feed ingredients and to the reduced digestion and absorption ability of young birds due to their immature digestive system. This demonstrates that metabolic aspects of young broiler chicks can regulate energy utilization of dietary ingredients.

Nevertheless, similar values observed for AME_n and MCGE for micronized full fat soybean emphasize the importance of an effective quality control and normalization of micronized full fat soybean production, including the complete removal of hulls to insure the efficient utilization of the ingredients by young chicks.

Pupa (2000) did not observe significant differences between MCGE for micronized full fat soybean when fed to swine at 22 days (76.7%) or at 33 days of age (80.0%).

The results reported in the present study confirm previous results described by Mahagna *et al.* (1988). Those authors associated the degree of energy metabolizability of soybean meal measured for young broilers with the increase of viscosity caused by this ingredient on the intestinal digesta. This fact can

further reduce the ingredient digestibility when associated to an immature enzymatic system.

An accurate determination of AME_n of corn and soybean meal for newly hatched broiler chicks corroborate the study of alternative ingredients with focus on appropriate and precise diet formulation. On the other hand, the results showed herein and in previous reports (Nir, 1998) suggest that AME_n of feed ingredients described in the literature are overestimated for newly hatched chicks.

The reference diet produced for this experiment was formulated to achieve 2,950 kcal/kg but the diet actually offered 2,800 kcal/kg, based on the determined AME_n for corn and soybean meal. Therefore, when diets are formulated using alternative ingredients and energy contents that were calculated based on experiments with newly hatched chicks, it must be considered that the reference diet may not contain the expected energetic concentration.

CONCLUSIONS

N-corrected apparent metabolizable energy values (as-fed) and metabolizability coefficient were 3,213 kcal/kg and 81.6%; 2,085 kcal/kg and 49.7%, and 4,068 kcal/kg and 74.8% for corn, soybean meal and micronized full fat soybean, respectively.

The differences between calculated values obtained in this study and literature data indicate a deficiency on digestive and absorptive processes of birds from one to seven days of age and emphasize the importance of the study of ingredients for this phase with the objective of optimizing diet formulation.

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