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Energy Values of Feed Ingredients for White Pekin Ducks

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Abstract: A modified true metabolizable energy bioassay was used to determine the nitrogen-corrected apparent (AMEn) and true (TMEn) metabolizable energy of various feed ingredients for ducks. In each of two experiments, which lasted 102 h with a 54-h excreta collection period following a 48-h period of feed withdrawal, six male White Pekin ducks were assigned to each of three test feed ingredients and dextrose. Dextrose-fed ducks were used for estimation of endogenous losses of energy and nitrogen. The test ingredients consisted of corn, bakery byproduct and wheat red dog in experiment 1 and corn, corn gluten meal and soybean meal in experiment 2. The AMEn and TMEn values of corn were similar in the first and second experiments at 3.322 and 3.358 and 3.289 and 3.528 kcal/g, respectively. The AMEn and TMEn values of corn were higher ($P < 0.05$) than those of wheat red dog (2.519 and 2.662 kcal/g), but lower ($P < 0.05$) than those of bakery byproduct (3.75 and 3.896 kcal/g). Corn gluten meal had the highest ($P < 0.05$) AMEn and TMEn values (3.695 and 3.934 kcal/g) among three feed ingredients. The AMEn and TMEn value of soybean meal (2.562 and 2.799 kcal/g) were lower ($P < 0.05$) than those of corn. The study provide new information on AMEn and TMEn values for bakery byproduct, corn, corn gluten meal, soybean meal and wheat red dog; and demonstrated that the energy values, for White Pekin ducks, of bakery byproduct and corn gluten meal are greater than those of corn or soybean meal.

Key words: Duck, feed ingredients, metabolizable energy, nitrogen correction

Introduction

Energy has always played a central economic function in the production of farm animals. Correctly establishing the relationship between the dietary metabolizable energy content and the amount of feed eaten is the critical for improving the precision of feed formulation. However, diet formulation for ducks often employ ME values for chickens, because there is relatively limited information on energy utilization in feed ingredients by ducks (Elkin, 1987). Bioavailable energy studies (Muztar *et al.*, 1977) showed that there are significant differences in the dietary requirements and energy utilization of ducks and chickens. The two species also exhibit differences in digestive physiology, body composition and growth rate (Siregar and Farrell, 1980), so the practical use of nutrient bioavailability data determined with chickens to formulate diets for ducks is questionable.

Corn and soybean meal are two of the most common feed ingredients used to formulate diets for poultry. Due to the low fiber content of the corn kernel and the high digestibility of its starch, the energy value of corn is generally used as a standard with which other energy sources are compared. Soybean meal is virtually devoid of starch, but has high protein content and has quite good amino acid profile (Pond and Manner, 1984). Bakery byproduct is a blend of various unsaleable products of the bakery industry including bread, chocolate, potato chips and snack foods. The ingredient is frequently included in poultry diets, primarily as an energy source, at levels up to and sometimes exceeding 6% (Dale, 1992). Corn gluten meal is a byproduct of the wet milling processes of corn for manufacture of high fructose corn syrup. After removing the energy yielding starch component and the germ, corn gluten meal has a high protein content (60%), which is very attractive where high nutrient density is required. Wheat red dog is inedible materials from flour manufacture and is the remaining product from extraction of flour. It is often included in wheat shorts and represents the very finest particles of bran, endosperm and germ and has a low (4%) fiber content (Leeson and Summers, 1997).

The objective of the present study was to determine the apparent and true metabolizable energy values of bakery byproduct, corn, corn gluten meal, soybean meal and wheat red dog used in duck diet formulation.

Materials and Methods

Diets and management of ducks: Twenty-four 8-wk-old male White Pekin ducks with an average weight 3.8 kg were used in each of two experiments. Birds were sorted according to initial weights and placed in individual cages (0.66 m × 0.66 m). The way ducks were assigned to the feed-deprived treatment (dextrose) and test feed ingredients ensured that initial weights were similar across treatments in each experiment. The cages were housed in an environmentally controlled room (25 ^{o}C). Fluorescent bulbs provided continuous 24 h lighting. Eighteen ducks were assigned to one of three dietary treatments (six ducks per diet). Six ducks were also assigned to a feed-deprived group that was fed dextrose for the estimation of endogenous losses of energy and nitrogen (Sibbald, 1979). The treatments were composed of three dietary groups and one feed-deprived group in each of two experiments. The test ingredients consisted of corn, corn gluten meal and soybean meal in experiment 1 and corn, bakery byproduct and wheat red dog in experiment 2.

Excreta collection: The collection methodology utilized in the experiments followed the methods detailed by Adeola *et al.* (1997). Approximately one week before the start of each experiment, ducks were fitted with modified plastic retainer lids from a Playtex™ bottle set. The ducks were placed head first supine into a restraint box. Ducks received injections of 4 ml of 2% lidocaine hydrochloride around the vent to desensitize the area. Feathers around the vent were removed and a continuous suture was used to secure a retainer ring (from a Playtex™ bottle set) to the vent area. The plastic bottle of the nurser set was measured and cut to a length of 3 cm below the threads on the bottle and Whirl-Pak bags inserted into the top of the bottle, so that the edges of the bags hung over the threads of the bottle. The bottle and Whirl-pak bag were then screwed onto the modified retainer ring attached to the duck thus completing the collection apparatus.

Feeding procedures: The metabolizable energy assay used in the present experiment was patterned after the procedures developed by Sibbald (1976) and integrated the modifications described by McNab and Blair (1988). In preliminary experiments, many ducks were observed to regurgitate generous portion of the test ingredient when 50 g was tube-fed at one time. Thus, the feeding procedure was modified such that the test ingredients were fed in two equal portions, 6 h apart and extend excreta collection from a total 48 h to 54 h. All test ingredients were ground through a 0.5 mm screen prior to feeding.

Forty-eight hours prior to feeding the test ingredients, feed was withdrawn from all ducks. At 24 h and 30 h after feed was removed, each duck was tube-fed a dextrose solution (25 g/100 ml water). Twenty-five grams of each test ingredient was mixed with 100 ml of water and tube fed to ducks at 48 h and 54 h after feed was withdrawn. Ducks assigned to the feed-deprived group for estimation of endogenous losses were tube-fed 25 g of dextrose with 100 ml of water at 48 h and 54 h after feed was withdrawn. All ducks were fitted with their respective collection apparatus at the time of first feeding of the test ingredients. The Whirl-Pak bags containing excreta were changed within the first 6 h after placement and every 12 h thereafter during the 54 h collection period. More details of these experimental protocols were published in Table 1 of King *et al.* (2000). Purdue University Animal Care and Use Committee approved all the feeding and collection protocols used in the experiments.

Table 1. Analysis of the test ingredients[1, 2]

Item	Dry matter %.	Gross energy kcal/g.	Crude protein N x 6.25,%.
Experiment 1			
Corn	88.54	3.944	7.06
Bakery byproduct	91.57	4.276	10.74
Wheat red dog	90.06	4.106	16.61
Experiment 2			
Corn	88.54	3.944	7.06
Corn gluten meal	92.26	5.033	53.93
Soybean meal	89.92	4.190	44.81

[1]Samples were analyzed in duplicate. [2]Values are means of the samples analyzed for each material.

Chemical analysis: Collected excreta were immediately stored at -20 °C. At the completion of the experiment, all samples were thawed, transferred to aluminum pans and placed in an oven at 55 °C for 96 h. After drying, excreta samples were ground through a 0.5 mm screen prior to analysis. Dry matter was determined by drying the samples at 110 °C for 24 h. Nitrogen determination was by the combustion method with LECO model FP-2000 Nitrogen Analyzer (LECO, St. Joseph, MI, USA). The energy contents of the feedstuffs and excreta samples were determined by bomb calorimeter with benzoic acid as the standard (Parr, Moline, IL, USA).

Calculations and statistical analysis: The apparent metabolizable energy (AME), nitrogen-corrected apparent metabolizable energy (AMEn), true metabolizable energy (TME) and nitrogen-corrected true metabolizable energy (TMEn) were calculated as follows:

$$\text{AME} = (\text{EI} - \text{EO})/\text{FI}$$

$$\text{AMEn} = \text{AME} - (34.39 \times \text{ANR}/\text{FI})$$

$$\text{TME} = \text{AME} + (\text{FEL}/\text{FI})$$

$$\text{TMEn} = \text{TME} - (34.39 \times \text{ANR}/\text{FI}) - (34.39 \times \text{FNL}/\text{FI})$$

Where EI is gross energy intake; EO is gross energy output; FI is the intake of the feedstuffs (50 g); ANR is apparent nitrogen retention; FEL is fasting energy loss from the feed-deprived ducks and FNL is fasting nitrogen loss (g). Nitrogen retained in tissues can be catabolized to yield energy containing excretory compounds that contribute to fasting energy loss, therefore the gross energy excreted was corrected to zero nitrogen balance using a factor of 8.22 kcal/g (Hill and Anderson, 1958). All experimental data were subjected to GLM procedure of SAS (2002). appropriate for a randomized complete block design with 2 df for feed ingredients, 5 df for blocks and 10 df for the error term. Means were compared by using the least significant difference tests.

Results

The use of physical restraint and local anesthetic during attachment of the retainer rings minimized stress and discomfort. The procedure was done under the most hygienic condition possible and no infection or cellulitis was observed after surgical attachment of the retainer rings. During the experiments, ducks adjusted very well to the collection apparatus and there was no appearance of any discomfort or impaired mobility. The average initial weights for ducks in experiments 1 and 2 were 3.82 and 3.81 kg, respectively; and average final weights after the 102-h experiment were 3.41 and 3.46 kg, respectively. Ducks attained initial weight (pre-experiment average weight of 3.82 or 3.81 kg) within 5 d of being returned to full feed following each experiment. The dry matter, gross energy and crude protein contents of the five test ingredients are shown in Table 1. The nutrient content of corn was the same in the two experiments because the same batch of corn was used in both studies. Corn gluten meal in experiment 2 had the highest gross energy (5.033 kcal/g) and crude protein (53.93%) and those values for corn were lowest in the two experiments. Fasting losses of energy and nitrogen are summarized in Table 2. Mean energy losses for feed-deprived birds were similar during the 54-h collection period in both experiments. However, the mean endogenous nitrogen loss in first experiment was numerically higher than that in the second experiment (1,015 vs. 614 mg/bird/54 h).

Table 2: Fasting losses of nitrogen[1] and energy[2] for feed-deprived ducks

Item	Mean	SD	Range
Experiment 1			
Fasting losses of nitrogen	1,015	457	628 to 1,719
Energy	16.88	3.85	13.50 to 23.58
n	6		
Experiment 2			
Fasting losses of nitrogen	614	603	335 to 1,844
Energy	14.57	8.16	8.98 to 30.85
n	6		

[1] Milligrams per duck per 54 h. [2] Kilocalories per duck per 54 h.

Table 3 presents a summary of the nitrogen and energy balance of birds. For experiment 1, nitrogen retention was higher ($P < 0.05$) in ducks fed wheat red dog than in those fed corn. The highest output of energy (92.99 kcal. was observed for the birds fed wheat red dog ($P < 0.05$) and was about 36% of their energy intake, as compared with 17 and 13% for the birds fed corn and bakery byproduct, respectively. Because nitrogen outputs were greater than nitrogen intakes, birds fed corn and bakery byproduct had negative nitrogen balances during the 54 h collection periods. For experiment 2, the apparent nitrogen retention approximately reflected nitrogen intake. Birds fed corn gluten meal and soybean meal were observed to have similar ($P > 0.05$) nitrogen output and apparent nitrogen retention, which were significantly higher ($P < 0.05$) than those in the group fed corn. Birds fed corn were also observed to have the lowest energy intake and energy output ($P < 0.05$). Although the highest energy intake was observed in birds fed corn gluten meal (293.7 kcal), birds fed soybean meal had the highest ($P < 0.05$) energy output (80.8 kcal), which accounted for about 30% of energy intake.

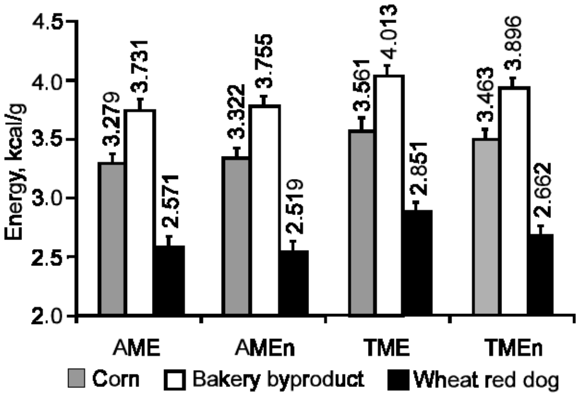

Fig. 1: The apparent metabolizable energy (AME), nitrogen-corrected apparent metabolizable energy (AMEn), true metabolizable energy (TME) and nitrogen-corrected true metabolizable energy (TMEn), of corn, bakery byproduct and wheat red dog for White Pekin ducks in Experiment 1. Values represent means of 6 ducks per ingredient with standard deviations of 0.106 kcal/g for AME or TME and 0.050 kcal/g for AMEn or TMEn. Bakery byproduct was greater ($P < 0.05$) than corn and corn was greater ($P < 0.05$) than wheat red dog.

The AME, AMEn, TME and TMEn values of five test ingredients are shown in Fig. 1 and 2. As a standard with which other energy sources are compared, corn was measured to have similar metabolizable energy values in the two experiments. For experiment 1, the AME values were similar for the three test ingredients - corn, bakery byproduct and wheat red dog ($P > 0.05$). However, when AME was corrected to zero nitrogen retention, the AMEn values were significantly different ($P < 0.05$) for the three test ingredients. Bakery byproduct was observed to have the highest AMEn value (3.755 kcal/g) and wheat red dog had the lowest (2.519 kcal/g). Because birds in the groups fed corn and bakery byproduct were in negative nitrogen balance during the experimental period, their AMEn values were greater than the AME values. Nitrogen correction of the TME for the three test ingredients resulted in a 3 to 7% reduction

Table 3: Nitrogen and energy balances of ducks

Item	Nitrogen intake	Nitrogen output	Nitrogen retention	Energy intake	Energy output	n
		g			kcal	
Experiment 1						
Corn	0.68	0.99	-0.32^{a}	236.6	39.88^{a}	6
Bakery byproduct	1.03	1.19	-0.16^{a,b}	256.7	32.7^{a}	6
Wheat red dog	1.59	1.22	0.38^{b}	247.1	91.99^{b}	6
SD	---	0.51	0.51	---	6.34	---
Experiment 2						
Corn	0.68	0.43^{a}	0.25^{a}	236.6^{a}	38.24^{a}	6
Corn gluten meal	5.18	2.64^{b}	2.39^{b}	293.7^{c}	59.43^{b}	6
Soybean meal	4.30	2.24^{b}	2.06^{b}	251.4^{b}	80.8^{c}	6
SD	---	0.39	0.47	11.94	4.47	---

^{a,b,c}Means in the same column and experiment with no common superscript differ significantly $P < 0.05$.

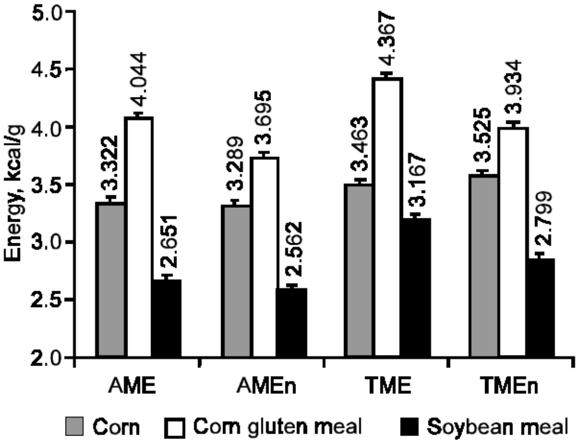

Fig. 2: The apparent metabolizable energy (AME), nitrogen-corrected apparent metabolizable energy (AMEn), true metabolizable energy (TME) and nitrogen-corrected true metabolizable energy (TMEn), of corn, corn gluten meal and soybean meal for White Pekin ducks in Experiment 2. Values represent means of 6 ducks per ingredient with standard deviations of 0.059 kcal/g for AME or TME and 0.041 kcal/g for AMEn or TMEn. Corn gluten meal was greater ($P < 0.05$) than corn and corn was greater ($P < 0.05$) than soybean meal.

in the TME values. The TME and TMEn values for bakery byproduct were significantly higher than those for corn or wheat red dog ($P < 0.05$). Wheat red dog was observed to have the lowest TME and TMEn: 2.851 and 2.662 kcal/g, respectively. The AME and TME values for corn gluten meal were highest ($P < 0.05$), followed by corn. In agreement with the results of experiment 1, nitrogen correction of the TME for the three test ingredients results in a 3 to 11% reduction in the TME values. The AME, AMEn, TME and TMEn values for soybean meal were observed to be significantly less ($P < 0.05$) than those for corn or corn gluten meal.

Discussion

The method of collecting excreta is a consideration in digestion and balance studies. The excreta collection method with trays placed under cages is not appropriate for ducks because ducks consume much greater quantities of water than chickens (Siregar and Farrell, 1980) and produce a highly liquid excreta. The consequence of excreta with high water content is dry matter loss due to splatter from contact of forcefully ejected excreta with trays. The surgical collection method (Adeola *et al.*, 1997) employed in the current study was observed to minimize excreta losses and excreta contamination by feed, dander, or feather.

The basic assumption in the TME bioassay is that the relationship between energy intake and excreta energy output is linear and that the intercept value gives endogenous energy loss (EEL) at no food intake. In a study with cockerels, Sibbald and Morse (1982) reported a mean intercept of 32.7 kcal which is identical to the mean energy of 32.3 kcal voided by feed-deprived birds during a 60 h collection period, but almost twice the mean fasting losses of energy (15.5 kcal) for ducks in the present study. These differences may be related to species and different collection periods. The mean EEL of feed-deprived ducks in the present study are similar with the EEL reported by Adeola *et al.* (1997) for ducks and McNab and Blair (1988) for cockerels. The endogenous nitrogen loss reported by Mohamed *et al.* (1984) were 760 and 660 mg/bird/24 h for ducklings and chickens, respectively, which are close the endogenous nitrogen loss for feed-deprived ducks in experiment 2. However, the fasting nitrogen loss in experiment 1 was higher than the value reported by Mohamed *et al.* (1984) and Ragland *et al.* (1997) for ducklings. It is reasonable that fasting losses of nitrogen are an approximate and will vary from time to time and from bird to bird (McNab and Blair, 1988).

The AME, AMEn, TME and TMEn values of corn are in agreement with previous results determined in ducks (Adeola *et al*., 1997; King *et al*., 1997; Ragland *et al*., 1997; Hong *et al*., 2002). However, the AME and TME values of corn for ducks were lower than observations by Sibblad (1976) for roosters. After nitrogen correction, the TMEn values paralleled those for cockerels reported by NRC (1994). Correction of TME for nitrogen also resulted in a 3% reduction in TME values of corn in both experiments, an observation similar to the 2 to 4% reduction reported by McNab and Blair (1988) for cockerels.

Bakery byproduct is a promising energy feed ingredient with a potential for improving the cost efficiency of feed for ducks. In the present study, TMEn value of bakery byproduct was observed to exceed that of corn by about 0.432 kcal/g. Damron *et al*. (1965) reported that bakery byproduct could be included at a level of 10% in broilers diets without adversely affecting performance. The study of Dale *et al*. (1990) showed that bakery byproduct could replace up to 20% corn in a high-energy finishing diet without reducing meat quality or growth performance. It should be noted that a major problem with bakery byproduct is its poor handing characteristics when fat content exceeds 13-14%.

Ducks appear to use energy in bakery byproduct more efficiently than chickens. Sugden (1974) pointed out that differences in energy metabolism do exist between birds within poultry species and across poultry species. The study of Mohamed *et al*. (1984) showed that duckling ME value was slightly greater than that of chickens when fed on a high fiber diet. However, the bakery byproduct used in the current study had low crude fiber contents (1.2%). Dean (1978) reported that ducks are better than chickens in handling very low energy diets. Ducks are able to extract sufficient energy for near normal weight gain with pelleted diets ranging from as low as 9.2 to as high 3.298 kcal of ME/g of diet, provided the diet is balanced with amino acids, minerals and vitamins. When compared with values published by NRC (1994), the TMEn value of wheat red dog is similar to that listed for cockerels, but the value for bakery byproduct is about 10% higher than that of NRC (1994). The energy value of wheat red dog in the present study is similar to that observed for ducks by Hong *et al*. (2002).

Corn gluten meal used in the present study was observed to have a higher TMEn value than soybean meal (3.934 vs. 2.799 kcal/g). The TMEn values of corn gluten meal and soybean meal in the present study were observed to be 3 and 10%, respectively, higher than those listed in the NRC (1994) for cockerels. It seems that ducks can metabolize energy in high protein feed ingredients more efficiently than chickens. Dean (1972) reported that ducklings have exceptional capacity to overcome a growth depression due to protein deficiency and achieve normal weight at market age. The conclusion was supported by Baeza and Leclercq (1998) whose studies showed that reducing crude protein had little or no effect on food conversion efficiency and fatness in Muscovy ducklings, unlike the observed situation in broiler chickens.

The present study provided new information about the energy utilization by ducks on bakery byproduct, corn, corn gluten meal, soybean meal and wheat red dog; and demonstrated that the energy values of bakery byproduct and corn gluten meal are greater than those of corn or soybean meal. Further improvement of the accuracy of duck diet formulation requires more studies with a wider variety of feedstuffs.

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