Investigation of relationship of chemical composition, viscosity, and metabolizable energy of distillers grains for poultry

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Executive summary

Thirteen samples of dried distiller's grains with solubles (DDGS) were collected from the Midwest region of the United States with an overall goal of the project to determine measurable characteristics of the DDGS for use in prediction of the energy value of various DDGS. To this end, DDGS was analyzed for chemical composition, and fed to turkeys for the determination of metabolizable energy, and viscosity. Correlations were determined among the various measures and a prediction equation was determined. One sample was dropped from the data set due to an extremely low energy value. The results of the project demonstrated that feeding a variety of different DDGS at a level of 15% did not increase intestinal viscosity in young turkey poults and therefore should not be associated with an increase in undesirable bacteria in the gut. A second outcome of the project was the determination of a relatively simple regression equation to predict DDGS apparent metabolizable energy value (AMEn) using crude protein (dry matter basis). Addition of other variables such as crude fat, viscosity, color and gross energy were not effective in enhancing the model fit. While crude fat content was correlated with gross energy content of the feed, it was not highly correlated with the AME content.

Introduction

Usage of corn distiller's grains with solubles (DDGS) in poultry diets is ultimately dependent on the economic value of the energy and nutrients that are provided by DDGS as compared to other ingredients. Protein and energy remain the most expensive components of poultry feed. Poultry in contrast to ruminant animals will extract less energy and protein from feed ingredients such as DDGS. Prediction of metabolizable energy content of DDGS based on chemical composition has not been very successful indicating the amount of energy derived from DDGS likely reflects a variety of influencing factors – diet levels, nutrient digestibility, gut environment, and interaction with other components in the feed at the gut level. Viscosity of intestinal contents has been used successfully to assess the feeding value of ingredients such as wheat, rye, and barley that contain high levels of a fiber component called non-starch polysaccharides. Increased viscosity can be associated with decreased nutrient digestibility in the gut and an association with non-desirable bacterial populations. Some initial data from DDGS use in broilers (Loar II et al., 2010) indicated that intestinal viscosity tended to increase with use of DDGS in the grower diet (P<.07). The overall goal of the project was to determine measurable characteristics of the DDGS for use in prediction of the energy value of various DDGS. To this end, DDGS was analyzed for chemical composition, and fed to turkeys for the determination of metabolizable energy, and viscosity. Correlations were determined among the various measures and a prediction equation was determined. The results of project demonstrated that feeding of a variety of different DDGS at a level of 15% did not increase intestinal viscosity in young turkey poults and therefore should not be associated with an increase in undesirable bacteria in the gut associated with necrotic enteritis. A second outcome of the project was the determination of a relatively simple regression equation to predict DDGS AME content using crude protein (dry matter basis). Addition of other variables such as crude fat, viscosity, color and gross energy were not effective in enhancing the model fit. While crude fat content was correlated with gross energy content of the feed, it was not highly correlated with the AME content.

Description of work performed

Test materials and chemical analyses

Thirteen samples of distiller's grains with solubles (DDGS) were obtained from poultry nutritionists within Minnesota with the goal of obtaining a wide range in nutrient content as possible. Each sample was analyzed for proximate components, gross energy, and color (CIE scale, L*, a*, b*). Crude protein was estimated from nitrogen determination through combustion (Leco). Each sample was assayed for apparent metabolizable energy (AMEn, corrected for nitrogen). A subset of samples was analyzed for metabolizable energy using the True Metabolizable Energy procedure (TMEn, corrected for nitrogen). All metabolizable energy assays were conducted with young turkeys. Viscosity determinations using a Brookfield Viscometer were conducted at the end of the AME assays.

Metabolizable energy assays

<u>Apparent metabolizable energy (AME).</u> Two AME trials were conducted in order to have sufficient replication (8 reps per DDGS source). In each trial, male turkey poults were reared on a common commercial starter diet to 10 days of age. On day 11, poults were weighed and sorted into cages (6 per cage) such that a similar body weight per cage was obtained. Poults were fed the test diets (basal plus 15% DDGs or dextrose) for an acclimation period of seven days. Test diets were prepared for each trial. Poults were then weighed again and test diets were weighed into the cage feeder for the 48 hr data collection period. At the end of the 48 hr assay, weights of poults and feed were measured; and excreta

was collected from each cage unit. Excreta was dried and ground. Samples of the test diets and excreta were for dry matter content, gross energy, and nitrogen. Excreta and diet analyses and feed intake were used to calculate AMEn of the diets and test DDGS samples as described by Rochell et al.

True metabolizable energy (TME). For the True Metabolizable Energy Assays, individually housed male turkeys (6-8 wks of age) were fasted and then fed DDGS. Excreta was collected 48 hrs post feeding. Excreta and the test DDGS were prepared and analyzed as described for the AME method. Six of the 13 DDGS samples were tested for TME determination.

Statistical Analyses

Data were analyzed statistically (analyses of variance) and correlations of measurements with AMEn were determined. Correlations and best subset regressions were determined using proximate components, gross energy, viscosity, and color. One sample was determined to be an outlier and was dropped from the final regression analyses.

Overall Results (all data presented on a dry matter (dm) basis)

Descriptive statistics were calculated and a summary of those results are given in Table 1. A large range in crude fat content of the samples was observed although only two of the 12 samples contained fat less than 8% (dry matter basis, dm). Crude protein content varied from 27 to 31%. Gross energy and AMEn averaged 5090 and 3079 kcal/kg, respectively. These values are respectively lower (5286 kcal/kg) and higher (2678 kcal/kg) than that presented by Rochell and co-authors using a data set of six DDGS samples and with AMEn determined in young broiler chickens.True metabolizable energy content averaged 3397 kcal/kg on a dry matter basis for six of the 12 samples. These values were higher than that found by Abe et al. (2003) for a set of 22 samples which averaged 3,208 kcal/kg on a dry matter basis.

One sample contained an extremely low AMEn content (1599 kcal/kg). The composition of this sample and bird performance during the feeding trial did not provide an explanation for the very poor AME value. Regression analyses indicated that it was an outlier and so it was dropped from the analyses. It remains an interesting sample regardless.

Correlations and best subset regressions were conducted with the goal of providing a prediction equation using measurements that could be conducted at the feed mill or ethanol plant to predict apparent metabolizable energy. Correlations (Pearson) are presented in Table 2. Only crude protein was significantly correlated with AMEn content of the DDGS (r=-.74). The negative correlation indicated that as crude protein increased, AMEn decreased. The lack of a correlation of AMEn with DDGS fat content was not totally unexpected. Batal and Dale (2006) noted a weak correlation of TME with crude fat (r^2=.29). Rochell et al (2011) also found no correlation of AMEn with crude fat.

The lack of a correlation of metabolizable energy and fat could be due to several things. Inherent variability of the AMEn determination, and the greater variability associated with fat determination as compared to nitrogen (protein) determination may have allowed the higher correlation with protein instead of fat. The composition of the fat in the DDGS may be another factor. Another reason could potentially be that there were insufficient numbers of DDGS samples with a low fat content included in the analyses. As indicated above only 2 of the 13 samples collected had fat contents less than 8%.

Best subset regression indicated that crude protein content on a dry matter basis was the best predictor of AMEn (adjusted r^2=.51, P <.001) (Figures 1 and 2). The predictive equation was AMEn on a dry matter basis (kcal/kg) = 12704-(332.4 x %CPdm). It should be noted that while a significant regression indicated a relationship exists between crude protein content and AMEn content, the r^2 of .51 indicates that crude protein content explains about 51% of the variability in AMEn response, meaning that other components or gut interactions are responsible for the remaining 49% variability in response. However, the predictive equation is relatively simple and most feed mills and ethanol plants are able to determine crude protein allowing for some adjustment in assigning the AMEn value to a particular lot of DDGS. Rochell and co-workers also developed a predictive equation that was stronger (r^2=.89) but it also required several different types of analyses.

Samples were also grouped by crude protein range and the analyzed content of AMEn, crude protein, and crude fat are presented (Table 3). One-way analysis of variance tested differences among determined AMEn as ranked by crude protein content indicated that DDGS with greater than 29% crude protein (dm) had reduced energy content as compared to samples with a lower protein content. For samples with a crude protein content of 28-29% had a similar AMEn of 3232 which is within the range of previously published or recommended values for DDGS of 3068-3238 kcal/kg dry matter or 2700-2850 kcal/kg as is basis for use in feed formulation.

Intestinal viscosity of turkeys fed test diets did not shift with addition of DDGS and was not correlated with any of the other measures. Viscosity averaged 2.2 cP and is relatively low compared to the feeding of dietary grains such as wheat and barley where viscosity will be in excess of 3 cP. High values are considered to be a negative in poultry feeding.

Conclusions

1. Previously reported concerns that poorer performance of DDGS was attributable to increased viscosity in the intestinal tract was not shown to be the case for young turkey poults fed diets containing different sources of DDGS in comparison to a control diet without DDGS.
2. Apparent metabolizable energy of the 12 samples of DDGS averaged 3,079 kcal/kg on a dry matter basis and varied from a low to high of 2267 to 3930.
3. The AMEn value of DDGS determined with young turkeys was only moderately correlated with crude protein content (dry matter basis) with a Pearson correlation value of -.74 such that AMEn decreased with increased crude protein content.
4. No other measures including crude fat were strongly correlated to AMEn.
5. AMEn could be partially predicted using crude protein content of the DDGS. The regression equation was AMEn on a dry matter basis (kcal/kg) = 12,704-(332.4 x %CP, dry matter basis) (r^2=.51). Such generated values for AMEn should be used carefully as crude protein content explains only 51% of the variability associated with AMEn of DDGS and the number of samples at the highest protein content was limited.

Future research needs

The decrease in apparent metabolizable energy content of the DDGS products with protein in excess of 29% crude protein should be examined further because of the substantial decrease in metabolizable energy with a percentage unit change in crude protein level. Likewise with the move towards production of a de-oiled DDGS product, emphasis on utilization of energy by poultry should move toward the use of the extracted crude oil and improving energy extracted from the DDGS such as through the use of enzymes.

Table 1. Descriptive statistics summary of tested DDGS samples (N=12).

Values reported on a **dry matter basis** where appropriate.

		Range	
Measurement	Mean	Low	High
Dry matter, %	91.75	87.9	93.8
Crude protein, %	28.96	27.1	30.8
Crude fat, %	11.94	5.94	15
Ash, %	5.26	4.16	6.17
Gross energy, kcal/kg	5090	4831	5294
Apparent metabolizable energy , kcal/kg	3079	2267	3930
True metabolizable energy, kcal/kg[1]	3397	3190	3632
Intestinal Viscosity, cP	2.2	1.81	2.89
Color			
L*	64.3	61.2	68.3
a*	4.9	3.5	11
b*	33.8	29.3	41.1

1. N=6

Table 2. Correlation (r) of the determined AMEn (dry matter basis) with DDGS characteristics

Characteristic	r	P-value
Dry matter	-0.01	NS
Crude protein	-0.74	0.006
Crude fat	0.31	NS
Ash	-0.14	NS
Gross energy	0.24	NS
Intestinal Viscosity	0.12	NS
Color		
L*	0.24	NS
a*	-0.08	NS
b*	0.17	NS

NS=not significant

Table 3. AMEn of dried distillers grains with solubles categorized by crude protein content

Range	Number	Average Analyzed (dm basis)			Predicted
Cr. Protein, dm	of samples	Cr. Protein	Crude fat	AMEn	AMEn, dm
%		%	%	kcal/kg	kcal/kg
27-27.9	3	27.7[d]	14.0	3441[a]	3506
28-28.9	3	28.5[c]	11.0	3232[a]	3232
29-29.9	4	29.5[b]	12.4	2862[b]	2905
30-30.1	2	30.5[a]	9.2	2738[b]	2554
P-value	--	0.0001	ns	0.0001	--

[a,b] Means with different superscripts are statistically different (P<.05)

Figure 1. Scatter plot of determined apparent metabolizable energy (AMEn) of distillers dried grains with solubles (DDGS) vs. crude protein content. All values on a dry matter basis (dm).

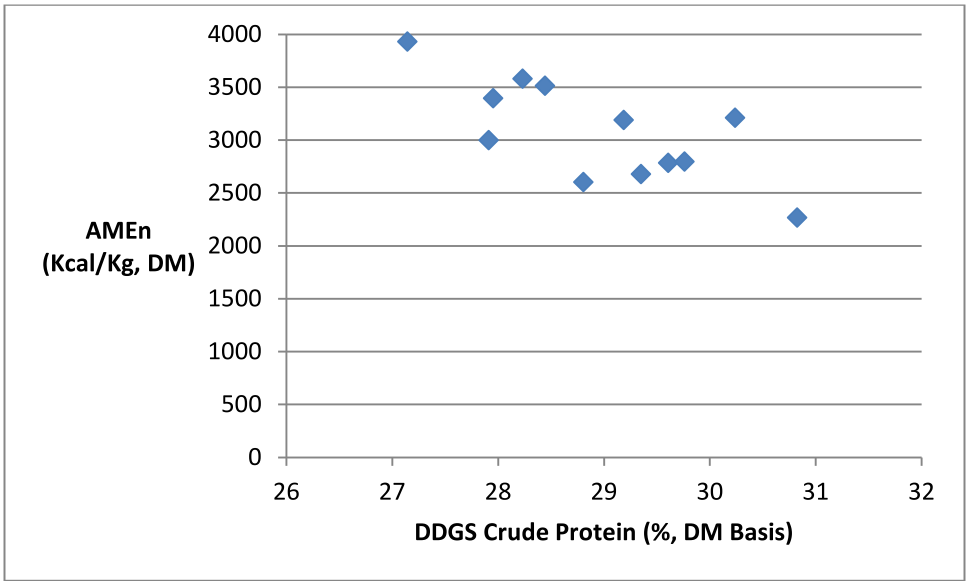

Figure 2. Scatter plot of predicted apparent metabolizable energy (AMEn) of distillers dried grains with solubles (DDGS) vs. crude protein content. All values on a dry matter basis (dm).