True Metabolizable Energy and Amino Acid Digestibility of Distillers Dried Grains with Solubles

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Primary Audience: Nutritionists, Researchers, Quality Control Personnel

SUMMARY

In recent years, policies encouraging the production of ethanol have stimulated an enormous increase in the production of distillers dried grains with solubles (DDGS). The form of the ingredient that is becoming increasingly available differs from that of previous decades in that it is derived almost entirely from corn and is dried under less severe conditions. Seventeen DDGS samples were obtained from 6 different plants in the midwestern United States from 2002 to 2004. Each sample was analyzed for TME_n, and 8 representative samples were analyzed for total and digestible amino acids (AA) by the precision-fed rooster assay using conventional or cecectomized Single Comb White Leghorn roosters, respectively. Color [lightness (L*), redness (a*), and yellowness (b*)] of each DDGS sample was measured with a Minolta Chroma Meter CR-300. The TME_n ranged from 2,490 to 3,190 kcal/kg (86% DM basis) and had a mean of 2,820 kcal/kg. Variation was noted among samples, presumably reflecting differences in the original corn composition, fermentation, and disposition of solubles. Considerable differences were observed among the true AA digestibilities of the DDGS samples. Most samples were golden in color, and true AA digestibility values were relatively consistent among these samples. The average total concentration and digestibility coefficients of several most limiting AA for the 8 DDGS samples were as follows: Lys, 0.71% (70); Met, 0.54% (87); cystine, 0.56% (74); Thr, 0.96% (75), Val, 1.33% (80), Ile, 0.97% (83); and Arg, 1.09% (84). Correlations were found among digestible Lys, Thr, Arg, His, and Trp and the yellowness (b*) and lightness (L*) of the DDGS samples. In general, DDGS samples that were more yellow and lighter in color had higher total and digestible AA levels. The variation in TME_n and AA digestibility observed among samples strongly indicated that confirmatory analyses should be conducted prior to using samples from a new supplier.

Key words: nitrogen-corrected true metabolizable energy, amino acid digestibility, distillers dried grains with solubles, protein, energy

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DESCRIPTION OF PROBLEM

Increased emphasis on ethanol production in the United States has and will continue to lead to significant increases in the production of distillers dried grains with solubles (**DDGS**). Currently in North America, approximately 5 million tonnes of DDGS are available to feed producers, and in 2006 it is estimated that there will be 7 million tonnes [1].

When considering the potential use of an ingredient such as DDGS, primary emphasis is

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Table 1. Proximate composition of distillers dried grains with solubles (DDGS; 86% DM basis)[1]

Sample	TME$_n$ (kcal/lb)	TME$_n$ (kcal/kg)	Crude protein (%)	Crude fat (%)	Crude fiber (%)	Ash (%)
1	1,450	3,190	29	9.9	6.1	4.0
2	1,320	2,904	30	9.8	5.7	4.3
3	1,319	2,902	30	10.2	5.3	4.6
4	1,353	2,978	28	—	—	—
5	1,335	2,936	28	—	—	—
6	1,281	2,819	26	10.6	5.1	5.4
7	1,389	3,056	26	9.6	6.8	4.3
8	1,272	2,799	26	9.8	7.4	4.2
9	1,149	2,526	24	4.2	6.3	3.9
10	1,277	2,808	29	9.8	6.9	4.4
11	1,132	2,490	25	2.5	7.0	—
12	1,195	2,629	25	9.8	7.8	4.0
13	1,258	2,768	28	9.8	8.1	4.4
14	1,250	2,748	27	10.5	7.4	4.7
15	1,199	2,638	28	10.1	7.1	4.6
16	1,305	2,870	23	8.0	6.0	4.6
17	1,304	2,869	27	7.1	5.9	4.9
Average[2]	1,282 ± 82	2,820 ± 181	27 ± 2	8.8 ± 2.3	6.6 ± 0.8	4.4 ± 0.4
Range[3]	1,132–1,450	2,490–3,190	23–30	2.5–10.6	5.1–8.1	3.9–5.4

[1]TME$_n$ determined with the precision-fed rooster assay with 10 conventional Single Comb White Leghorn roosters per sample.
[2]The average ± SD of 17 DDGS samples.
[3]Range of values observed for 17 DDGS samples.

placed on obtaining accurate information regarding metabolizable energy and amino acid (**AA**) composition. Although DDGS has been available as a feed ingredient for decades [2, 3, 4], it is not a completely homogenous ingredient. Fermentation residues from the beverage industry may be based on mixtures of several grains, and the DDGS becoming increasingly available today is usually from ethanol plants with corn as the only grain input. Most of the nutrient composition values currently cited for DDGS in standard tables of nutrient composition are from DDGS produced by the beverage industry, and the nutrient composition of DDGS from modern ethanol plants may differ. Because DDGS is becoming increasingly available as a feed ingredient and very limited nutritional information is available, this study was conducted to evaluate a representative sampling of current DDGS for those parameters of most interest to poultry industry nutritionists.

MATERIALS AND METHODS

Seventeen commercially produced DDGS samples were obtained from 6 different plants in the midwestern United States from 2002 to 2004. Each sample was evaluated for proximate composition [5, 6] and TME$_n$ [7, 8]. Eight samples were evaluated for AA composition and digestibility [9, 10]. Because darkness of soybean meal is used as a quick indicator of overprocessing, and thus decreased AA digestibility, color determinations were made on the 8 DDGS samples to determine whether darkness might also suggest reduced AA digestibility of DDGS. Color [lightness (**L***), redness (**a***), and yellowness (**b***)] was measured with a Minolta Chroma Meter CR-300 [11] using the average of 5 readings per sample. The data were analyzed using the GLM procedure of SAS [12] to determine the average and standard deviation of the samples. Correlations were applied to the total and digestible AA and color data using the GLM procedure of SAS [12] to determine if total and digestible Lys were correlated with color (L*, a*, b*). Regression analyses were applied to the proximate composition and TME$_n$ of DDGS using the GLM procedure of SAS [12] to determine the chemical components that best predicted the TME$_n$ of DDGS.

Table 2. Prediction equations for TME_n of distillers dried grains with solubles based on 1, 2, 3, or 4 variables (86% DM basis)

Variable (n)	Variable (%)	Prediction equation[1]	R^2
1	Fat	TME_n = 2439.4 + 43.2 (fat)	0.29
2	Fat, fiber	TME_n = 2957.1 + 43.8 (fat) − 79.1 (fiber)	0.43
3	Fat, fiber, protein	TME_n = 2582.3 + 36.7 (fat) − 72.4 (fiber) + 14.6 (protein)	0.44
4	Fat, fiber, protein, ash	TME_n = 2732.7 + 36.4 (fat) − 76.3 (fiber) + 14.5 (protein) − 26.2 (ash)	0.45

[1]Prediction equations are based of the values from 17 samples of distillers dried grains with solubles.

RESULTS AND DISCUSSION

Proximate composition and TME_n of all samples are presented in Table 1. For consistency, all values have been adjusted to an 86 % DM basis, this being representative of the DDGS samples evaluated in this study. Crude protein values ranged between 24 and 30% and average 27%, which was similar to the values (27.4, 27.5, and 26.9%) reported in the NRC [13] by Noll et al. [14] and by Cromwell et al. [15]. Substantial differences in fat were noted among samples, whereas crude fiber and ash were relatively constant. Nitrogen-corrected true metabolizable energy ranged from 2,490 to 3,190 kcal/kg and averaged 2,820 kcal/kg, which was very similar to the TME_n (2,864 kcal/kg) listed in the NRC [13] for DDGS on an 86% DM basis with 9% fat. Reports of the AME_n value of DDGS for layers state 2,770 and 2,750 kcal/kg for turkey poults and 2,880 kcal/kg for turkeys [16, 17, 18]. Equations with which to estimate the TME_n on the basis of proximate composition were developed based on 1, 2, 3, and 4 variables (Table 2). The best single indicator of TME_n was fat (R^2 = 0.29). The second, third, and fourth variables (fiber, protein, and ash) improved the accuracy of the TME_n prediction equation (R^2 = 0.43, 0.44, and 0.45, respectively). However, the relatively low R^2 obtained suggested that these prediction equations would serve only as a general guide.

The average, low, and high total AA concentrations and digestibility coefficients are listed in Table 3. The digestibility coefficient of all AA averaged 81.7% across all samples. The digestibility was lowest for Lys, Cys, and Thr (69.6, 73.9, and 74.5%, respectively), which agrees with work by Ergul et al. [19]. Digestible Lys averaged 0.51% and ranged from 0.18 to 0.66. Ergul et al. [19] reported a digestible Lys average for DDGS of 0.53% based on 22 samples, and the range in Lys digestibility was not as great (0.38 to 0.65%). Some decrease in the digestibility of the AA because of drying would be expected, especially for certain AA such as Lys. Limited previous research results suggest that Lys digestibility of DDGS is lower than that of its substrate corn (81%, NRC [13]), presumably reflecting a slight lowering in digestibility because of drying. Lysine digestibility coefficient estimates determined with chick growth studies have been reported at 66% [20] and 80% [21] and range from 71 to 93% [22]. Lysine digestibility values for DDGS determined with cecectomized White Leghorn roosters have been reported at 82% [20] and 75% [21], which is higher than the average Lys digestibility value noted previously (69.6%). It was confirmed that dark DDGS has a lower Lys digestibility than golden DDGS [15, 19].

The effect of color (L* and b*) on total and digestibility Lys is presented in Table 4. Many of the samples (samples 1 to 4) were light in color and typical of that produced by many new DDGS plants. The light samples (1 to 4) had levels of total and digestible Lys of 0.79 and 0.60, respectively. The intermediate samples (5 and 6) had somewhat reduced levels of total and digestible Lys, but this decrease was not severe. However, the darker samples (7 and 8) had extremely low levels of total and digestible Lys. This finding indicates that a significant amount of Lys was destroyed during processing. In addition, much of the Lys that was not destroyed had become biologically unavailable. Thus, the level of digestible Lys in sample 8 was only one-third of that in the light sample 1. As is the case with soybean meal, other AA were not as severely affected as Lys by the excessive heating.

Table 3. Total and digestible amino acid (AA) composition (%) of 8 distillers dried grains with solubles (DDGS; as-fed basis) samples

	Average[1] (%)		Low[2] (%)		High[2] (%)	
AA	Concentration	Digestibility[3]	Concentration	Digestibility[3]	Concentration	Digestibility[3]
Asp	1.75 ± 0.20	74.8 ± 7.8	1.49	59.4	2.04	83.4
Thr	0.96 ± 0.06	74.5 ± 6.0	0.85	63.6	1.05	82.6
Ser	1.09 ± 0.07	81.9 ± 4.3	0.97	73.7	1.16	86.2
Glu	3.49 ± 0.24	83.3 ± 3.3	3.36	78.3	3.80	87.3
Pro	1.99 ± 0.10	83.5 ± 4.1	1.86	75.1	2.09	87.8
Ala	1.78 ± 0.07	82.8 ± 2.2	1.69	79.7	1.86	85.2
Cys	0.56 ± 0.04	73.9 ± 9.7	0.50	62.6	0.62	87.6
Val	1.33 ± 0.07	79.5 ± 3.2	1.23	74.8	1.44	83.1
Met	0.54 ± 0.06	86.8 ± 3.4	0.46	83.0	0.61	90.5
Ile	0.97 ± 0.06	83.3 ± 4.9	0.90	80.7	1.03	92.9
Leu	3.05 ± 0.14	88.6 ± 2.0	2.84	85.1	3.21	91.7
Tyr	0.96 ± 0.09	87.9 ± 3.2	0.81	82.0	1.05	91.4
Phe	1.31 ± 0.04	87.5 ± 3.3	1.26	81.5	1.36	91.7
His	0.69 ± 0.06	84.1 ± 5.7	0.56	76.3	0.74	89.3
Lys	0.71 ± 0.16	69.6 ± 11.5	0.39	45.8	0.86	77.8
Arg	1.09 ± 0.16	84.1 ± 6.6	0.75	73.4	1.25	90.9
Trp	0.20 ± 0.05	82.8 ± 5.1	0.13	75.7	0.28	89.3

[1]The average ± SD amino acid concentration and digestible amino acid (%) values of 8 DDGS samples.
[2]The low and high amino acid concentrations and digestibility (%) levels observed in 8 DDGS samples.
[3]Determined with 5 cecectomized Single Comb White Leghorn roosters per sample.

Correlations ($P < 0.01$) were found between digestible Lys, Thr, Arg, His, and Trp and L* values (r = 0.87, 0.53, 0.71, 0.84, and 0.72, respectively) and b* values (r = 0.96, 0.76, 0.87, 0.88, and 0.77, respectively) but not with a* values. More lightness (L* = 60.3) and more yellowness (b* = 25.9) were associated with a product averaging 0.66% digestible Lys (76.8% digestibility, 0.86% total Lys), whereas darker (L* = 50.4) and less yellow (b* = 7.41) samples were associated with a product averaging 0.18% digestible Lys (45.8% digestibility, 0.39% total Lys). Lighter color (L* = 60.3) and more yellow color (b* = 25.9) were associated with a product averaging 0.74% digestible Thr (75.5% digestibility, 0.98% total Thr), whereas darker (L* = 50.4) and less yellow (b* = 7.41) color was associated with a product averaging 0.59% digestible Thr (69.5% digestibility, 0.85% total Thr). These results agree with those of Ergul et al. [19] in which a correlation was found between digestible Lys, Cys, and Thr

Table 4. Total and digestible Lys composition (%) and the color of 8 distillers dried grains with solubles samples (as-fed basis)

	Color[1]			Total Lys concentration	Lys digestibility[2]	Digestible Lys
Sample	L*	b*	a*	(%)	(%)	(%)
1	62.9	28.4	7.6	0.86	76.8	0.66
2	61.5	26.6	6.1	0.85	75.3	0.64
3	57.4	21.3	5.8	0.79	77.8	0.61
4	57.5	20.5	6.9	0.82	72.1	0.59
5	51.2	13.9	5.7	0.67	77.1	0.52
6	49.5	11.2	4.1	0.64	73.8	0.47
7	48.0	8.82	4.3	0.64	58.3	0.37
8	47.9	9.3	4.4	0.39	45.8	0.18

[1]Color [lightness (L*), redness (a*), and yellowness (b*)] was measured with a Minolta Chroma Meter CR-300 [11].
[2]Amino acid digestibility coefficients as determined with the precision-fed cecectomized rooster assay with 5 Single Comb White Leghorn roosters per sample.

and L* values and b* values but again not with a* values. Ergul et al. [19] concluded that a DDGS sample with lighter (L* 53.8) and more yellow (b* 42.8) color is associated with a product averaging 0.65% digestible Lys, whereas darker (L* 41.8) and less yellow (b* 32.9) color was associated with a product averaging 0.38% digestible Lys.

CONCLUSIONS AND APPLICATIONS

1. Metabolizable energy (TME_n) of DDGS ranged from 2,490 to 3,190 kcal/kg (86% DM basis) and had a mean of 2,820 kcal/kg.
2. In general, the average AA concentration level and digestibility (%) in DDGS was satisfactory for poultry feeding and was only slightly lower than that of corn.
3. Darker DDGS samples may have lower AA digestibility (especially Lys) than lighter DDGS samples.
4. Color measurement (with a Minolta Color Meter) may be a quick and reliable method of estimating the AA quality of DDGS when used as a feed ingredient in poultry diets.
5. The variation in TME_n and AA digestibility observed among DDGS samples indicated that confirmatory analyses should be conducted prior to utilizing samples from a new supplier.

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