Nutrient Digestibility of High Protein Corn Distillers Dried Grains and Corn Germ

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ABSTRACT

Sectors of the ethanol industry are starting to use a new bio-refining production technology which separates the corn into three fractions: fiber, germ and endosperm, prior to ethanol production. These fractions are then converted into new co-products, high protein distillers dried grains (HP-DDG), corn germ, and bran. Studies were conducted to determine the nutritional parameters of these new co-products. A chick experiment was conducted to determine the phosphorus (P) bioavailability based on tibia ash. In addition, conventional and cecectomzied precision-fed rooster assays were conducted to determine TME_N and amino acid digestibility. For the chick assay, a P-deficient corn-soybean meal diet containing 0.13% non-phytate P was supplemented with 0, 0.05, 0.10, and 0.15% from KH_2PO_4 or 7 and 14% DDGS, HP-DDG, and corn germ. Cobb 500 chicks were fed the experimental diets to 18 d of age and bioavailability of P was estimated using the slope-ratio method where tibia ash was repressed on P intake. The total P content and P bioavailability of the DDGS, HP-DDG, and corn germ were 0.77 and 60, 0.35 and 47, and 1.18 and 31%, respectively. The average protein, fiber, and fat % for DDGS was 27, 7, and 10, for HP-DDG 44, 7, and 3, for corn germ 15.5, 4.5, and 17, and for bran 11.6, 4.5, 7.8. The average TME_N was 2,879, 2,846, 3,204, and 2,912 kcal/kg (as-fed basis) for the DDGS, HP-DDG, corn germ, and bran, respectively. Bran had a higher TME_N value than expected, which is likely due to the high fat content, addition of the solubles. Total concentration and percent availability, of lysine for the DDGS, HP-DDG, corn germ, and bran was 0.94 (75), 1.16 (74), 0.83 (86) and 0.43% (68%), respectively. The total lysine as a % of CP was 3% for the conventional DDGS and only 2% for the HP-DDG, however these products had a similar TME_N. New bio-refining techniques result in co-products that have unique nutritional qualities compared to conventional DDGS. Thus, confirmatory analyses should be conducted prior to utilizing these new co-products of ethanol production.

INTRODUCTION

In recent years, policies encouraging the production of ethanol have stimulated an enormous increase in the production of distiller's dried grain with solubles (DDGS). Until recently, the majority of the dry-grind ethanol plants use unmodified corn (or other cereal grains) to produce ethanol and some type of distillers dried grains (DDG). However, many plants are implementing a modified dry milling process as the first step in the ethanol facility. The whole corn is milled into several fractions; corn germ, bran and the endosperm which is used for ethanol fermentation. Ethanol facilities are implementing this modified dry milling process because it increases ethanol yield. However, what is not so obvious is how these changes affect the nutrient quality of the resultant co-product. The two main resultant products are corn germ and a high protein distillers dried grains (HP-DDG), which is the product after the fermentation of the endosperm to ethanol. The corn germ fraction is high in fat and phosphorus, and has a more desirable amino acid profile. The DDG product has a very high protein level (which is why it is often called high protein DDG) and lower levels of fat and phosphorus, because it does not contain the syrup that would normally be added back to the DDG.

When considering the potential use of a feed ingredient such as HP-DDG and corn germ, primary emphasis is placed on obtaining accurate information regarding metabolizable energy, phosphorus availability and amino acid composition and digestibility. As these by-products from ethanol plants promise to become increasingly available feed ingredients studies were conducted to determine the TME_N, phosphorus availability and amino acid digestibility of a number of HP-DDG and corn germ products currently available to the feed industry.

MATERIALS AND METHODS

Distillers dried grains with solubles (DDGS), high protein distillers dried grains (HP-DDG) and corn germ samples were obtained from at least seven different fuel ethanol plants in the Midwest from 2005 to 2007. Each sample was analyzed for TME_N and for true amino acid digestibility by the "precision-fed rooster assay" as described by Sibbald (1976, 1979). Ten conventional and six cecectomized Single Comb White Leghorn roosters were fasted for 24 h and then crop intubated with 35 g of each sample. Feces were collected for a 48 h period, dried, and weighed. The dried samples were then ground and sent for analysis.

An experiment was conducted to assess the bioavailability of phosphorus in DDGS, HP-DDG, and corn germ. Chicks were fed a standard starter diet from 0 to 7 days of age. The chicks were fasted overnight and at 8 days of age 8 replications of 8 chicks were each fed the twelve experimental diets. Dietary treatments were: 1) Corn- soybean meal basal with 0.13% available phosphorus, 2) Basal + 0.05% P from KH_2PO_4, 3) Basal + 0.10% P from KH_2PO_4, 4) Basal + 0.10% P from KH_2PO_4 5) Basal + 7% HP-DDG, 6) Basal + 14% HP-DDG, 7) Basal + 7% DDGS, 8) Basal + 15% DDGS, 9) Basal + 7% corn germ, and 10) Basal + 14% corn germ. The basal diet was adequate in all nutrients except P and HP-DDG and DDGS were added at the expense of cornstarch. The chicks were fed the experimental diets from 8 to 20 days of age. At the end of the experiment tibias were collected from each chick. The tibias were fat extracted and ashed. The % tibia ash was calculated and multiple regression was used to determine the relative P bioavailability.

SUMMARY

1. The metabolizable energy (TME_N) of HP-DDG ranged from 2,667 to 3,282 kcal/kg, with a mean of 2,846 kcal/kg.
   a. This is not dramatically different than the average TME_N of DDGS (2,800 kcal/kg), but is surprising since the fat level is almost a third lower.
2. The metabolizable energy (TME_N) of corn germ ranged from 2,911 – 3,681 kcal/kg, with a mean of 3,204 kcal/kg.
   a. Corn germ is a good source of energy.
3. The total lysine concentration (amino acid digestibility coefficient) of DDGS, HP-DDG, and corn germ was 0.94 (74.9), 1.16 (74.3), and 0.83% (85.7%), respectively.
4. The phosphorus relative bio-availability of DDGS, HP-DDG, and corn germ was 60.4, 46.9, and 31.5, respectively.

CONCLUSIONS

1. Due to increased emphasis on ethanol production, there has and will continue to be significant amounts of by-products from ethanol production available to the feed industry.

2. Due to the variation in the nutrient content of the various by-products it is important that confirmatory analysis be conducted prior to utilizing a new by-product from a new plant/supplier.

Proximate composition of distillers dried grains with solubles, high protein distillers dried grains, and corn germ

	TME_N, kcal/kg	DM	Crude Protein	Fat	Crude Fiber	Ash
	Distillers dried grains with solubles[1]					
Average	2879	11.02	27.2	10.2	7.82	5.01
Range	2720 – 3000	8.3 – 14.9	27.1 – 27.9	9.98 – 10.4	7.3 – 8.2	4.36 – 5.65
	High protein distillers dried grains[2]					
	TME_N, kcal/kg	DM	Crude Protein	Fat	Crude Fiber	Ash
Average	2846	9.10	43.8	2.69	7.17	3.24
Range	2667 - 3282	7.1 – 11.5	42.2 – 45.9	1.89 – 3.65	6.98 – 7.42	1.32 – 8.4
	Corn germ[3]					
	TME_N, kcal/kg	DM	Crude Protein	Fat	Crude Fiber	Ash
Average	3204	9.07	15.0	17.4	5.37	8.06
Range	2911 – 3681	7.0 – 12.2	13.1 – 15.7	16.3 – 18.3	4.1 – 6.3	5.6 – 6.1

[1] Average of 5 samples for the distillers dried grains with solubles, [2] Average of 7 samples for the high protein distillers dried grains, [3] Average of 7 samples for the corn germ

The phosphorus bio-availability of distillers dried grains with solubles (DDGS), high protein distillers dried grains (HP-DDG) and corn germ

Treatments	Weight gain (grams/chick)	Tibia Ash (%)	Relative Bioavailability (%)
Corn-SBM basal diet (0.12% available P)	426[e]	29.1[de]	
Basal + 0.05% P from KH_2PO_4	477[cd]	29.6[cde]	
Basal + 0.10% P from KH_2PO_4	514[abc]	33.3[b]	
Basal + 0.15% P from KH_2PO_4	528[ab]	35.1[a]	
Basal + 7% HP-DDG	453[de]	28.5[c]	
Basal + 14% HP-DDG	483[cd]	29.4[cde]	46.9
Basal + 7% DDGS	470[d]	29.8[cde]	
Basal + 14% DDGS	520[abc]	31.1[c]	60.4
Basal + 7% Corn Germ	494[bcd]	29.4[cde]	
Basal + 14% Corn Germ	521[bcd]	30.6[cd]	31.4
Pooled SEM	13.93	0.598	

Total Phosphorus levels, KH_2PO_4 = 0.228%; HP-DDGS = 0.35%; DDGS-BPX = 0.72%, DDGS = 0.77%, Corn Germ = 1.18%

Average total and amino acid (AA) digestibility coefficients (%) of distiller's dried grains with solubles (DDGS), high protein distillers dried grains (HP-DDG), and corn germ (as-fed basis)

	DDGS		HP-DDG		Corn germ	
Amino Acid (AA)	AA concentration	AA digestibility	AA concentration	AA digestibility	AA Concentration	AA digestibility
Aspartic Acid	1.61	73.3	2.71	83.7	1.18	82.3
Threonine	1.00	74.9	1.57	81.7	0.54	75.9
Serine	1.14	83.1	2.05	87.1	0.63	80.1
Glutamic Acid	3.41	85.1	7.76	92.5	1.98	86.6
Proline	1.96	85.3	3.71	91.9	0.91	86.2
Alanine	1.83	85.6	3.34	91.3	0.92	84.0
Cysteine	0.50	72.2	0.85	84.4	0.31	80.3
Valine	1.37	82.1	2.14	87.3	0.73	82.1
Methionine	0.53	86.0	0.95	91.8	0.27	85.9
Isoleucine	1.07	82.0	1.77	87.5	0.46	80.0
Leucine	3.08	89.8	6.12	93.9	1.06	84.3
Tyrosine	1.18	88.0	1.91	91.5	0.42	79.8
Phenylalanine	1.37	86.3	2.37	91.1	0.59	83.2
Histidine	0.78	85.9	1.15	89.4	0.44	90.9
Lysine	0.94	74.9	1.16	74.3	0.83	85.7
Arginine	1.20	87.8	1.54	87.6	1.15	91.4
Tryptophan	0.18	82.8	0.20	80.2	0.13	87.6

[1] The values are averages of 6 distiller's dried grains with solubles, 6 high protein distiller dried grains, and 6 corn germ samples.