Composition and Nutritive Value of Corn Fractions and Ethanol Co-products Resulting from a New Dry-milling Process

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Composition and Nutritive Value of Corn Fractions and Ethanol Co-products Resulting from a New Dry-milling Process[1]

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BEEF 2005 - 12

Summary

The development of a new dry-milling process for the production of corn ethanol has resulted in new feedstuffs. This process fractionates the corn kernel prior to fermentation. Pre-fermentation fractions include bran, germ, and endosperm. Post-fermentation fractions include dried distillers grains (DDG) and condensed distiller solubles (syrup). Proximate analysis was conducted on these fractions along with the parent corn sample. Equations were used to predict TDN and undegradable intake protein (UIP). These feeds differ substantially from historical dried distiller's grains with solubles (DDGS). Feeding experiments will be necessary to confirm the results of the predicted feed values.

Introduction

A dry-milling process that involves fractioning the corn kernel prior to fermentation in the course of ethanol production results in three fractions: bran, germ, and endosperm. Currently, only the endosperm fraction is fermented for ethanol production. Post-fermentation products include dried distillers grains (DDG) and condensed distiller solubles (syrup). These fractions, along with the parent corn sample, were used to determine nutrient values.

Materials and Methods

Four fermentation runs were used in this study. Samples were collected June 16-20, 2004. Ethanol plant personnel collected samples from each fermentation run, for each fraction, over a period of 10 h. Sampling occurred every 2 h. At the end of each sampling period, samples were frozen at the plant. These samples were transported to South Dakota State University Ruminant Nutrition Laboratory for processing and analyses.

Samples were allowed to thaw in a refrigerator. Solid samples were composited by fraction for each fermentation run by collecting equal weights (as-is basis) and mixing for 2 min in a bowl-type mixer. The liquid samples were composited by collecting equal volume and mixing for 2 min in a high-speed blender.

Dry matters were determined on all solid fractions by drying at 60°C until no further water loss occurred. Dry matters of the liquid fractions were determined by freezing samples at -80°C and lyophilizing them. Corn, germ, bran, and DDG samples were then ground to pass through a 1 mm screen.

Proximate analysis was performed on each composite sample. The DDG, germ, and bran fractions were subjected to a crude protein fractionation assay as outlined by Licitra et al. (1996) to predict percent undegradable intake protein (UIP). Mineral concentrations of all samples were determined by inductively coupled plasma spectrophotometry (Olsen Biochemistry Labs, SDSU).

The TDN values were calculated using a model for forages and concentrates ($TDN=(TD_{cp}xCP)+((EE-1)x2.25)+[(0.98x(100-NDF_n-CP-ash-(EE-1)-1)]+0.75x\{(NDF_n-Lig)x[1-(Lig/NDF_n)^{0.667}]\}-7$; Weiss et al., 1992). The UIP values were estimated using Dairy Cattle NRC (2001) equation for calculating rumen undegradable protein. Rate of digestion (K_d; B_1=150, B_2=6, B_3=0.5%/h) and rate of passage (K_p=2.5%/h) of CP fractions were taken from dried distiller's grains with solubles (DDGS) values published in Beef Cattle NRC (2000).

[1] This study funded in part by the U.S. Department of Energy.
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Results and Discussion

Research conducted on four regional ethanol plants reported CP, NDF, and fat of DDGS to be 33.3%, 42.7%, and 13.1%, respectively (Holt and Pritchard, 2004). Because only endosperm was fermented, the new DDG was higher in CP, and lower in NDF and fat than conventional DDGS. Germ was a dry, flowable, relatively high fat, and high TDN feedstuff. Bran provides a primary source of NDF with TDN and CP content comparable to corn. Syrup was a liquid feed source that could be used to condition diets while adding CP and fat.

Bran-cake, currently being used to market the bran and syrup fractions, is combined in a 1:1 mix on a wet basis (78% bran, 22% syrup, DMB). Bran-cake composition suggests it could be fed much the same way as corn gluten feed. Based upon our analyses, bran-cake would be 58% DM, 30% NDF, 12% CP, 38% UIP, 7.5% EE, 3% OM, 0.5% P, and 90% TDN.

Phosphorus was also a consideration when evaluating this fractionation process. TDN:P ratios on corn, germ, bran, and bran-cake were 293, 78, 209, and 180, respectively. The CP:P ratios on conventional DDGS and new DDG were 36 and 97, respectively. The TDN:P and CP:P are important considerations for farm operations where manure application is controlled by soil and manure P levels. Producers that feed new DDG as a CP source instead of conventional DDGS will lower their dietary P input.

Implications

New DDG will be used exclusively as a CP supplement as opposed to conventional DDGS being used as a protein and energy supplement. New DDG allows operations to use a product with similar particle size and density to conventional DDGS, but is higher in CP and lower in EE and P.

Germ can be used as a protein and energy supplement to replace concentrates (corn and SBM) in feedlot and dairy diets. This product could allow producers to add a dry, solid form of fat to diets, increasing the caloric density of the diet. Producers that use germ as an energy source should consider their farm-feedlot P balance since the addition of germ to diets will increase the amount of P accumulation in the manure.

Bran-cake composition suggests it could be fed much like corn gluten feed in finishing and dairy diets to provide energy without adding starch.

Feeding experiments will be necessary to confirm the results of predicted feed values reported in this paper.

References

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Tables

Table 1. Type and description of samples taken from new dry-mill ethanol procedure

Fraction	Description
Corn	Parent corn sample taken prior to fractionation
Bran	Seed coat of corn kernel
Germ	Reproductive fraction of corn kernel
Endosperm	Starch fraction of corn kernel
DDG	Solid residue from fermentation of endosperm
Syrup	Liquid residue from fermentation of endosperm

Table 2. Laboratory assays

Assay	Method
Dry Matter (DM)	60°C oven, AOAC Official Method 4.1.03
Crude Protein (CP)	Kjeldahl Method, AOAC Official Method 954.01
Neutral Detergent Fiber (NDF)	Goering, H.K. and P.J. Van Soest. 1970. in:Forage Fiver Analyses. (USDA, Agric. Handbk. No. 379 Jacket No. 389-598)
Acid Detergent Fiber (ADF)	Goering, H.K. and P.J. Van Soest. 1970. In:Forage Fiver Analyses. (USDA, Agric. Handbk. No. 379 Jacket No. 389-598)
CP Fractionation	Licitra et al. 1996. In: Anim. Feed Sci. Technol. 57:347–358
Ash	500°C Muffle Furnace, AOAC Official Method 942.05
Ether Extract	Soxhlet Fat Extraction methods, AOAC
Lignin	H_2SO_4 Lignin, AOAC Official Method 973.18
Minerals	Inductively coupled plasma spectrophotometry, AOAC official method 985.01 and 999.10

Table 3. Composition of new dry-milling process co-products

	Corn		Bran		Germ		Endosperm		DDG		Syrup	
Item	Mean [c]	cv	Mean	cv	Mean	cv	Mean	cv	Mean	cv	Mean	cv
DM, %	92.0	0.2	90.1	0.1	91.3	0.1	89.6	0.2	89.1	1.5	25.5	1.0
GE, Mcal/kg	4.18	0.2	4.48	1.4	4.99	0.7	3.82	0.1	4.62	0.6	4.98	0.9
TDN, % [a]	--	--	87.8	1.9	103.2	1.7	--	--	84.2	1.6	99.7	1.4
NDF, %	10.8	6.9	38.1	4.5	17.8	6.6	4.2	11.7	23.8	1.9	--	--
ADF, %	2.4	4.5	9.3	5.1	5.6	9.7	1.1	6.4	8.4	14.8	--	--
Lignin, %	--	--	0.6	5.8	1.0	26.4	--	--	1.5	40.5	--	--
CP, %	8.4	1.8	9.4	2.5	14.5	0.9	7.8	2.0	42.5	0.4	20.6	5.1
UIP, % of CP [b]	--	--	40.9	1.1	34.1	1.5	--	--	41.0	2.0	--	--
EE, %	3.9	1.1	5.7	18.0	18.1	5.3	--	--	2.6	23.5	14.0	7.8
Ash, %	1.3	2.9	2.1	2.8	5.5	3.1	0.7	3.0	2.1	10.2	7.3	1.7

[a] Values are predicted using Weiss' equation. (Anim. Feed Sci. Technol. 39:95) Note: No liquid feeds were used to derive this equation (syrup).

[b] Values are predicted using Dairy Cattle NRC equation for ruminally undegraded feed CP (RUP).

[c] Values represent means of four different fermentation runs.

Table 4. Mineral composition of new dry-milling process co-products

	Corn		Bran		Germ		Endosperm		DDG		Syrup	
Item	Mean [a]	cv	Mean	cv	Mean	cv	Mean	cv	Mean	cv	Mean	cv
Ca, %	--		0.02	14.5	0.02	2.3	--		0.01	8.4	0.03	7.9
P, %	0.28	5.2	0.42	6.7	1.33	4.5	0.14	2.6	0.44	3.3	0.97	2.8
Mg, %	0.12	3.3	0.18	6.0	0.55	2.3	0.06	2.0	0.14	3.6	0.44	2.2
K, %	0.39	3.1	0.62	4.4	1.37	3.4	0.23	2.0	0.49	0.6	1.7	1.2
Na, %	--		--		--		--		0.12	12.9	0.41	9.7
S, %	0.13	2.5	0.13	2.7	0.20	1.1	0.1	1.8	0.83	4.9	0.79	2.5
Cu, ppm	--		3.94	7.6	12	9.7	--		--		4.6	14.3
Fe, ppm	84	2.9	94	7.3	117	2.7	53	10.2	127	6.7	174	7.2
Mn, ppm	5	1.9	13	2.7	24	1.7	2	4.9	8	6.2	19	1.5
Zn, ppm	21	2.0	38	5.2	93	3.1	9	2.1	42	4.8	59	6.7
Mo, ppm	0	27.5	1	2.3	2	9.9	0	12.6	1	2.9	2	4.5

[a] Values represent means of four different fermentation runs.