South Dakota State University
Open PRAIRIE: Open Public Research Access Institutional Repository and Information Exchange

South Dakota Beef Report, 2004 | Animal Science Reports

2004

Composition and Nutritive Value of Corn Co-Products from Dry Milling Ethanol Plants

Simone M. Holt
South Dakota State University

Robbi H. Pritchard
South Dakota State University

Recommended Citation

Holt, Simone M. and Pritchard, Robbi H., "Composition and Nutritive Value of Corn Co-Products from Dry Milling Ethanol Plants" (2004). *South Dakota Beef Report, 2004.* Paper 2.
http://openprairie.sdstate.edu/sd_beefreport_2004/2

Composition and Nutritive Value of Corn Co-products From Dry Milling Ethanol Plants

Simone M. Holt[1] and Robbi H. Pritchard[2,3]
Department of Animal and Range Sciences

BEEF 2004 – 01

Introduction

The South Dakota ethanol industry is rapidly expanding. As a direct result of this expansion it is expected that in excess of 500,000 tons of corn co-products will be available to livestock enterprises annually as a feed source. Processing methods are, in general terms, similar among dry milling ethanol plants. However, newer technology and small deviations of methods can alter the nutritive value of the co-products. Subsequently, diet formulations using general nutritive values may be inaccurate and cause production inefficiencies.

The objective of this research project was to characterize the composition and nutritive value of corn co-products produced from several dry milling ethanol plants in the upper Midwest.

Materials and Methods

Four regional dry milling ethanol plants were used in this study. Samples were collected during March, April and May 2002. Each plant was sampled four times per day over four consecutive days. Sampling times were approximately 0800, 1100, 1300 and 1700 h.
The type of co-product sampled from individual ethanol plants depended on products being produced during the sampling period (Table 1).

Samples were collected such that each sample was representative of co-product received by producers. To achieve this, in most instances, co-products were sampled from the transport carrier instead of the production stream or storage facilities.

During each 4 d sampling period, samples were refrigerated at each plant. At the conclusion of the sampling period, samples were then transported to the South Dakota State University Ruminant Nutrition Laboratory for processing and analyses.

Proximate analysis, with the exception of the soluble samples, was assayed as individual samples. The four samples of solubles collected on a given day from each plant were combined to form a single composite sample for each of the four days. Composite soluble samples for each plant, and a similar composite of Wet Distiller's Grains with solubles (WDGS) and Dry Distiller's Grains with solubles (DDGS) were assayed for mineral concentrations at Oscar E. Olson Biochemistry Laboratories, South Dakota State University. Laboratory assays performed on all samples are presented in Table 2.

Soluble samples were lyophilized using a commercial freeze drier (Labonco Lyph Lock 12, Labonco Corporation, Kansas City, MO). NDF, ADF and ADIN assays were not determined on the soluble samples.

ADIN was determined only on DDGS and WDGS from two plants where fiber results suggested possible differences in heat damage to the co-product. These samples were composited for each plant by day. Levels of ADIN were reported on a crude protein basis (ADIN-CP) and as a proportion (%) of the total crude protein in the sample (ADFIP).

Statistical analyses were conducted using the GLM procedures of SAS (1999) with day and plant included as the independent variables in the model. Treatment means were compared using least significant differences ($P < 0.05$). Across plants, variability was tested for homogeneity of variance. Within plant variation was evaluated by univariate analysis (SAS, 1999).

---

[1] Post Doctorate
[2] Professor
[3] The authors thank the SD Corn Utilization Council for their financial support of this research.

Results and Discussion

Mean nutrient compositions of traditional co-products assayed across all plants are presented in Table 3 and compared to NRC tabular values. Corn is generally the commodity that is replaced when corn co-products are added to a diet.

Cracked corn grain has smaller standard deviations for most components than the DDGS and WDGS sampled during this study (Table 3). These results suggest that diet formulation consistency may be an issue when using these products.

Nutrient composition of Modified dry distiller's grains, Blended dry distiller's grains and Solubles are presented in Table 4. Although the Modified and Blended DGS products are produced by different processes they are often considered interchangeable feed sources. Based upon this survey, the Modified product was much lower in CP and fiber and much higher in fat than the Blended product. Variability in proximate composition was much greater with the Modified DGS.

Dry matter content of Soluble samples were approximately 7 percentage points lower than most plants suggested (Table 4). This deviation would alter the value of solubles by 25 to 30%.

A small amount of variation in dry matter content was reported in DDGS between plants ($P < 0.05$; Table 5). Greater differences were observed between plants for dry matter content of WDGS ($P < 0.05$). The amount of solubles that is utilized in these products from plant to plant, in particular WDGS, may be a potential cause of the variation that exists.

A significant day effect within plant was reported for crude fat content for Plant C, and neutral detergent fiber for Plant D (Table 6). While these differences between days were statistically significant, the magnitude of change was of little biological consequence. The resultant low variation in composition within a day reflects good manufacturing controls in the plants sampled in this study.

Neutral detergent fiber content differed ($P < 0.05$) among all plants (Table 6), and was lowest for Plant B (37.3%) and highest for Plant C (49.3%). Heat damage of co-products was proposed as a possible explanation for the differences in NDF since there was no apparent dilution of CP or fat associated with differences in NDF.

Acid detergent insoluble nitrogen (ADIN) assays were conducted on DDGS and WDGS composites for Plants B and C to ascertain if heat damage would explain differences in the NDF content (Table 7). ADIN is the nitrogen remaining in the ADF residue. While some occurs naturally in all plant material, it is generally considered to be an estimate of heat damage occurring during storage or processing (Goering and Van Soest, 1970) and would contribute to the NDF residue mass. The ADIN content from DDGS and WDGS did not differ ($P > 0.05$) when expressed as a proportion of DM (ADIN-CP) or as a proportion of total crude protein (ADFIP). Similar ADFIP content for both these co-products indicates that both plants were able to dry distiller's grains without causing the Malliard reactions that reduce crude protein availability. A possible explanation is that there are differences in starch content of the co-products from these two plants.

Composite samples of DDGS, WDGS and Solubles were assayed for selected mineral concentrations and compared to NRC tabular values (Table 8). In general, for the DDGS samples, the mineral concentrations were lower than those reported by the NRC. Iron concentrations, on average, were only approximately 22% of those reported by the NRC. Sodium and sulfur levels in DDGS were highly variable.

Similar to what was observed for DDGS, mineral concentrations for WDGS as a whole were lower than the NRC tabular values. Iron levels were variable between plants, ranging from approximately 21 to 153% of those reported in the NRC. Although concentrations of phosphorus were lower (5.7-20.0%) than reported values (NRC, 2000), variation existed between plants.

Sodium and potassium levels were also highly variable and in some instances differed substantially from NRC values. Mineral content of solubles tended to be closer to tabular values although substantial variations were present. These deviations were sufficient to be of critical importance if feeding solubles to cattle.

Conclusion

Deviations in composition of ethanol co-products from tabular values can be partially explained by recent advances in technology that have improved the fermentation process and reduced residual starch. As a consequence, remaining nutrient and non-nutrient components in the co-products have increased. However, this did not apply to the minerals evaluated. As the renewable fuels industry continues to expand and develop new technologies, it is important to understand these changes and their impact on livestock industries. Monitoring these changes will need to continue at some level to assure efficient utilization of these co-products as livestock feeds.

Tables

Table 1. Type of corn by-products samples

Product Type	Description
DDGS	Dry distiller's grains with solubles
Modified DGS	Dry distiller's grains with additional solubles added back to the original product (MDGS)
Blended DGS	Dry distiller's grains with solubles are blended with Wet distiller's grains with solubles (BDGS)
WDGS	Wet distiller's grains with solubles
Solubles	Concentrated solubles that remain after post-fermentation separations.

Table 2. Laboratory assays

Assay	Method
Dry Matter (DM)	100° C oven, AOAC Official Method 034.01
Crude Protein (CP)	Kjeldahl Method, AOAC Official Method 954.01
Neutral Detergent Fiber (NDF)	Analysis on samples dried at 55° C. Goering, H.K. and P. J. Van Soest 1970. In: Forage Fiber Analyses. (USDA, Agric. Handbk. No. 379 Jacket No. 387-598)
Acid Detergent Fiber (ADF)	Analysis on samples dried at 55° C. Goering, H. K. and P. J. Van Soest. 1970. In: Forage Fiber Analyses. (USDA, Agric. Handbk. No. 379 Jacket No. 387-598)
Acid Detergent Insoluble Nitrogen (ADIN)	NFTA 1993. Forage Analyses Procedure - Method 6.
Ash (ASH)	600° C Muffle Furnace, AOAC Official Method 942.05
Ether Extract – Crude Fat (FAT)	Soxhlet Fat Extraction Methods, AOAC
Minerals Iron (Fe), Magnesium(Mg), Phosphorus (P), Potassium (K), Sodium (Na), Sulfur (S)	Flame Atomic Absorption, AOAC Official Method 965.09A

Table 3. Comparison of NRC[a] tabular values of cracked corn grain, dry distiller's grain with solubles (DDGS) and wet distiller's grain with solubles (WDGS) to values determined during this study

	Cracked corn grain		DDGS			WDGS		
Item, %	NRC	Std dev	NRC	Study	Std dev	NRC	Study	Std dev
DM	90	0.88	91	90.0	1.08	25	31.4	2.12
CP	9.8	1.06	29.5	33.3	2.78	29.7	35.5	1.37
NDF	10.8	3.57	46	42.7	5.17	40	42.3	6.34
ADF	3.3	1.83	n/a	13.2	2.51	n/a	12.1	2.46
Ash	1.5	0.33	5.2	4.1	0.28	5.2	3.8	0.63
Fat	4.1	0.64	10.3	13.1	1.95	9.9	12.1	1.39

[a]NRC Beef Cattle (Update 2000).

Table 4. Mean nutrient composition of modified DDGS, blended DDGS and solubles

	Modified DDGS		Blended DDGS		Solubles	
Item, %	Mean	Std dev	Mean	Std dev	Mean	Std dev
DM	58.9	2.79	50.5	0.75	23.4	2.87
CP	29.7	1.44	36.4	0.07	19.8	2.54
NDF	34.9	2.03	49.1	0.34		
ADF	10.9	1.87	14.6	0.22		
Ash	5.3	0.42	3.6	0.03	9.5	0.99
Fat	16.7	1.24	10.6	0.17	32.1	1.90

Table 5. Nutrient composition of DDGS and WDGS by plant

Dry Distiller's Grain with Solubles

Item, %	Plant A	Plant B	Plant C	Plant D	SEM
DM	90.91^{a}	89.80^{bc}	90.48^{ab}	89.39^{c}	0.260
CP	33.16^{b}	34.03^{b}	36.71^{a}	30.68^{c}	0.513
NDF	40.29^{c}	37.34^{d}	48.91^{a}	45.30^{b}	0.720
ADF	14.04^{b}	10.94^{c}	16.00^{a}	12.85^{b}	0.476
ASH	4.20^{a}	4.23^{a}	3.88^{b}	4.08^{ab}	0.074
FAT	13.52^{a}	13.39^{a}	10.35^{b}	14.20^{a}	0.401

Wet Distiller's Grain with Solubles

Item, %	Plant A	Plant B	Plant C	SEM
DM	36.48^{a}	32.86^{b}	29.52^{c}	0.277
CP	36.18^{a}	34.39^{b}	36.58^{a}	0.246
NDF	46.44^{a}	36.10^{b}	48.18^{a}	0.511
ADF	16.93^{a}	9.81^{c}	14.05^{b}	0.263
ASH	2.75^{b}	4.23^{a}	3.47^{ab}	0.153
FAT	12.49^{ab}	13.12^{a}	11.04^{b}	0.298

^{abc} Means within a row without common superscripts differ ($P < 0.05$).

Table 6. Mean daily NDF, ADF and FAT composition of dry distiller's grains with solubles

NDF

Day	Plant A	Plant B	Plant C	Plant D
1	40.55	36.37	50.84	48.78^{a}
2	39.09	38.61	48.35	45.66^{b}
3	42.95	36.89	47.3	44.64^{bc}
4	39.87	37.48	49.65	42.12^{c}
Mean	40.29^{x}	37.34^{w}	48.91^{z}	45.3^{y}
EMS	5.895	6.872	7.129	3.158

ADF

Day	Plant A	Plant B	Plant C	Plant D
1	14.36	10.87	16.61	13.94
2	15.19	10.34	16.11	13.38
3	12.36	11.08	15.65	11.19
4	14.49	11.45	14.91	12.89
Mean	14.17^{x}	10.94^{w}	16.1^{y}	12.85^{x}
EMS	2.136	1.537	2.148	5.905

FAT

Day	Plant A	Plant B	Plant C	Plant D
1	12.8	13.21	11.03^{a}	13.76
2	14.32	13.56	10.76^{a}	14.54
3	14.29	14.4	9.58^{ab}	14.29
4	13.46	12.41	8.47^{b}	14.22
Mean	13.46^{x}	13.39^{x}	10.41^{w}	14.2^{w}
EMS	0.672	3.922	0.439	2.304

^{a,b,c} Day means within plant without common superscripts differ ($P < 0.05$).

^{w,x,y,z} Plant means without common superscripts differ ($P < 0.05$).

Table 7. Acid detergent insoluble nitrogen (%) for dry distiller's grain with solubles and wet distiller's grain with solubles.

Dry Distiller's Grain with Solubles

	Plant B			Plant C		
Day	CP	ADIN-CP[a]	ADFIP[b]	CP	ADIN-CP[a]	ADFIP[b]
1	34.1	4.1	12.1	35.0	3.2	9.1
2	33.4	3.2	9.6	36.3	2.5	6.9
3	34.8	3.6	10.2	41.3	3.6	8.6
4	33.9	2.8	8.3	34.7	n/a	n/a
Mean	34.0	3.4	10.1	36.6	3.0	8.2

Wet Distiller's Grain with Solubles

	Plant B			Plant C		
Day	CP	ADIN-CP[a]	ADFIP[b]	CP	ADIN-CP[a]	ADFIP[b]
1	33.7	3.8	11.1	36.3	6.0	16.5
2	34.3	2.7	7.9	37.5	3.3	8.8
3	34.9	2.8	7.9	36.4	2.9	8.0
4	34.7	3.1	9.0	36.1	3.3	9.0
Mean	34.4	3.1	9.0	36.6	3.9	10.6

[a] Acid detergent insoluble nitrogen expressed as crude protein, %.

[b] Acid detergent insoluble N as a percentage of total N.

Table 8. Selected mineral concentrations for DDGS, WDGS and solubles composited by plant

DDGS

	NRC	Plant A	Plant B	Plant C	Plant D
Iron, ppm	560	110	154	130	102
Magnesium, %	0.33	0.32	0.32	0.259	0.317
Phosphorus, %	0.83	0.722	0.778	0.664	0.783
Potassium, %	1.07	0.938	0.986	0.76	0.947
Sodium, %	0.24	0.172	0.0545	0.214	0.138
Sulfur, %	0.4	0.504	0.368	0.353	0.692

WDGS

	NRC	Plant A	Plant B	Plant C
Iron, ppm	560	118	660	857
Magnesium, %	0.65	0.204	0.311	0.2
Phosphorus, %	1.4	0.484	0.754	0.53
Potassium, %	1.83	0.412	0.933	0.54
Sodium, %	0.24	0.041	0.054	0.162
Sulfur, %	0.4	0.394	0.36	0.376

SOLUBLES

	Plant A	Plant B	Plant C	Plant D
Iron, ppm	105	212	249	143
Magnesium, %	0.71	0.639	0.774	0.759
Phosphorus, %	1.49	1.42	1.65	1.58
Potassium, %	2.5	2	2.28	2.3
Sodium, %	0.302	0.118	0.692	0.436
Sulfur, %	0.337	0.254	0.32	1.15