Variation in Composition of Distillers Wet Grains with Solubles[1]

Robert M. Kaiser[2]
University of Wisconsin-Extension

Summary

Due to this country's nearly insatiable appetite for ethanol, an ever increasing supply of distillers co-products will be available and will likely continue to displace other feedstuffs in livestock diets. Nutrition consultants and livestock producers critically evaluate feed costs as they represent the largest single variable cost of production. Distillers dried grains with solubles (DDGS) and distillers wet grains with solubles (DWGS) typically possess moderate to high variability in nutrient composition. Costs associated with this variation include over supplementation to avoid deficiencies or decreased animal performance because of insufficient nutrients. To evaluate the variation in DWGS a field research study was conducted. Fifty-one samples of DWGS were collected by ten nutrition consultants from client livestock operations, representing three ethanol plants. Samples were analyzed at the University of Wisconsin Soil and Forage Analysis Laboratory via wet chemistry for CP, EE, NDF, NDF-CP, NDF-D, P, Ca, K, Mg and ash. Sample DM was determined, NFC values calculated and NIR spectra recorded. Prepared samples from the Marshfield lab were sent to the UW-Madison Department of Dairy Science lab for fatty acid profile and comparative ether extract analysis. Means, SD and ranges for these parameters are reported in Tables 1, 2, and 3. The second phase of this study will be to determine if an NIR calibration set for DWGS is feasible.

Introduction

Political momentum for increased production of renewable fuels like ethanol and biodiesel is evident nationally and in major grain and soybean producing states. Similar legislation introduced in the Senate and the House, if approved, will establish a Renewable Fuels Standard (RFS) of 8 billion gallons by 2012. The U.S. produced 3.4 billion gallons of ethanol in 2004 via dry and wet mill technology. This represents more than a doubling of ethanol production in four years and production is expected to top 4 billion gallons this year. Currently there are 83 ethanol plants in operation and 15 new plants under construction. Most ethanol plants built in the past ten years employ dry mill technology and dry mills generate about seventy-five percent of the total ethanol volume. In addition to ethanol, dry mills produce distillers grains and carbon dioxide using corn and grain sorghum as primary feed stocks. With increasing demand for ethanol a home must be found for the growing quantities of distillers grains.

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[2] Contact at: Room 249, Animal Sciences Building, 1675 Observatory Drive, University of Wisconsin, Madison, WI 53706, Email: robert.kaiser@ces.uwex.edu (608) 263-9411, FAX (608) 263-9412,

Presently, ethanol dry mills produce the equivalent of 7.3 million metric tons of DDGS annually, and the U.S. exports about one million metric tons. With other nations also ramping up ethanol production (world ethanol production rose nearly 11 billion gallons in 2004) it may be challenging to increase U.S. exports of DDGS. Over eighty-five percent of U.S. fed distillers grains are consumed by dairy and beef cattle and incorporation of this feed into swine and poultry diets is increasing. While our national livestock base is sufficient to make use of all available distillers grains, other feed ingredients now included in diets, must be displaced. With increasing supplies and relatively stable exports it is evident livestock producers are supplementing animal diets with distillers grains.

Utilizing dry mill technology, ethanol is removed through distillation and the whole stillage is run through centrifuges where grain particles or cake are separated from dissolved solids. The dissolved solids, which are carried in the thin stillage, are then concentrated into syrup through multiple effect evaporators. The syrup may be sold as condensed distillers solubles or dried as such to become distillers dried solubles. Most of the syrup or solubles however are combined with the cake to become DDGS or DWGS and offered for sale to feed manufactures/ handlers or directly to livestock producers. Marketing of wet distillers grains usually occurs within 150 miles of ethanol plants because of transportation costs associated with the movement of water. The Renewable Fuels Association estimates that twenty to twenty-five percent of the nationally utilized supply of distillers grains is sold wet. Ethanol plants without drying equipment usually market only DWGS.

Materials and Methods

With financial support from the Wisconsin Corn Promotion Board, a field research study was initiated to develop a data base (mean, standard deviation and range) of locally produced DWGS through a common laboratory and to determine the feasibility of creating a near infra-red reflectance (NIR) calibration set for DWGS. The assistance of ten nutrition consultants was solicited to obtain samples of DWGS according to a written protocol from the following ethanol plants: Ace Ethanol, Stanley; Adkins Energy, Lena; Badger State Ethanol, Monroe; and Utica Energy, Oshkosh. Subsequent to the start of the study, Ace Ethanol began drying all distillers co-products, therefore no samples were obtained from this plant.

A total of fifty-one samples were collected by nutrition consultants from their dairy and livestock client operations from May of 2004 through January of 2005. Samples were analyzed at the University of Wisconsin Soil and Forage Analysis Laboratory (Marshfield, WI) via wet chemistry for crude protein (CP), ether extract (EE), neutral detergent fiber (NDF), crude protein-bound NDF (NDF-CP), NDF digestibility (NDF-D), phosphorous (P), calcium (Ca), potassium (K), magnesium (Mg) and ash. Sample dry matter (DM) was determined, non-fiber carbohydrate (NFC) values were calculated and NIR spectra recorded. Prepared samples from the Marshfield lab were sent to the UW-Madison Department of

Dairy Science lab for fatty acid profile analysis via gas chromatography and comparative ether extract analysis using an alternate assay.

Tables 1, 2 and 3 list analytical means, standard deviations and minimum and maximum values for organic parameters, fatty acid profiles and inorganic parameters by total population of samples (n=51) and ethanol plant, respectively. Each table is comprised of two blocks and organized for easy observation and comparison of values within (upper portion) and across (lower portion) the total population of samples and samples representing each ethanol plant. Values included in upper and lower blocks are identical, just organized differently for viewing convenience.

Nutrient Composition of Distillers Grains with Solubles

Important factors to consider when evaluating any feedstuff for inclusion in livestock diets are nutrient composition and variability. As with many co-product feeds, nutrient composition of distillers grains with solubles is influenced by multiple variables and its variability exceeds that of the whole grain from which it is produced. An excellent discussion of this topic is covered by William P. Weiss, OARDC, in a paper entitled *"Randomness Rules: Living with Variation in the Nutrient Composition of Concentrate Feeds.*" A tutorial on the interpretation of relevant statistics is presented and practical diet formulation recommendations offered for concentrate feeds with low, moderate and high degrees of variation in nutrient composition.

Due to differences in dry mill production processes, both within and across ethanol production facilities, DDGS and DWGS typically possess moderate to high variability in nutrient composition. Listed in Table 4 are nutrient means and standard deviations of distillers grains with solubles from seven data sets (NRC, 2001; Kaiser unpublished; Robinson, 2005; Hardy et al. 1998; DePeters et al. 2000; Belyea et al.1989; and Spiehs et al., 2002). DDGS and DWGS are priced competitively compared to average available nutrients and are usually considered bargain feeds. However, dietary inclusion rate is often limited because of product variation and/or negative experiences by nutrition consultants using these feeds in client rations. Distillers co-product variation therefore represents inherent costs and challenges for both ethanol and livestock industries.

In recognition of livestock industry concerns, select ethanol plant interests are striving to minimize variability and/or assure consistency of their commodity feeds. Broin Companies, for example, produces a certified all-corn DDGS at sixteen of its' ethanol production facilities in Iowa, Minnesota, South Dakota, Missouri, and Michigan. Their product is marketed under the trade name of Dakota Gold Enhanced Distillers Products™ and according to Kip Karges of Dakota Gold Marketing (personal communication), Broin Companies is committed to an immense quality control effort for their premium brand DDGS. A comparison of standard deviation values in Table 4 suggests techniques applied by Broin Companies have successfully reduced variation in their Dakota Gold™ brand DDGS.

Options available to dry mill ethanol plant interests wishing to differentiate or add value to their distillers co-products include various combinations of: segregation (cake and solubles sold independently, discard of off-spec product); standardization (constant cake to solubles ratio, in-plant testing and blending of batches, particle size uniformity); and/or integration (adding a preservative to DWGS during warm weather months, adding porcine blood meal to DDGS to increase lysine content). For the livestock industry, economic value of a feedstuff is based primarily on its nutritive value and nutritional requirements are species specific. An informal poll of Wisconsin dairy nutrition consultants indicates a mixed review of DWGS use in dairy diets. A majority of consultants indicate they recommend DWGS use to appropriate clients. A sizable minority however, indicate they will only include DWGS in dairy diets when the client insists. Quality control issues, variation in nutrient composition and metabolic disorders were reasons most often cited for negative experiences with DWGS by dairy consultants. With typical lactating cow diet inclusion rates of 8 to 12 percent (DM basis), the ethanol industry can ill-afford a reputation that may limit utilization by this segment of the livestock base.

Results

The initial phase of this Wisconsin Corn Promotion Board sponsored field research study has been completed with the development of a data base of DWGS analytical values. Study results indicate:

- substantial variation in DWGS composition, both within and across ethanol production facilities; however, variation is similar to that of other data sets
- precision of select laboratory assays – NDF-CP, NDF-D and EE – on DWGS is challenging
- alternate ether extract assays (acid hydrolysis, Marshfield; Soxhlet, UW) yield significantly different DWGS ether extract values
- fatty acid profile analysis of DWGS (C16:0 palmitic acid, 14%; C18:0 stearic acid, 2%; C18:1 oleic acid, 25%; and C18:2 linoleic acid, 54%) is consistent with the composition of corn oil

The second phase of this study will be to determine the feasibility of an NIR calibration set for DWGS.

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Table 1. Organic nutrient composition of DWGS by total population and ethanol plant.

Organized for ***Within*** *population or plant comparisons*

	DM	CP	EE Mars	EE UW	FA	NDF	NDF-CP	NDF-D	NFC
	%	% DM						% NDF	% DM
Population (n=51)	35.6	26.7	10.6	16.4	13.2	30.2	8.9	59.0	35.8
SD	7.4	1.6	1.0	1.2	0.8	2.9	3.4	6.4	5.0
Min Value	28.0	23.0	7.8	13.7	11.4	24.7	3.0	39.5	24.2
Max Value	53.2	29.0	13.0	19.0	15.5	39.7	15.9	74.9	45.9
Plant 1 (n= 9)	32.6	27.5	10.6	16.0	12.7	31.4	6.7	59.4	31.5
SD1	0.9	1.6	0.9	1.1	0.8	2.0	3.2	5.6	4.4
Min Value 1	31.4	24.2	9.1	14.5	11.4	28.7	3.7	52.7	24.2
Max Value 1	33.7	29.0	11.7	18.0	14.2	34.9	13.4	71.7	37.3
Plant 2 (n=11)	49.3	25.6	10.9	17.5	13.8	30.4	5.9	55.9	32.8
SD2	2.3	1.5	1.0	0.8	0.9	3.1	2.5	8.6	4.3
Min Value 2	44.9	23.5	9.6	16.5	12.3	26.6	3.0	39.5	26.8
Max Value 2	53.2	27.2	13.0	19.0	15.5	36.3	11.2	67.6	38.6
Plant 3 (n=31)	31.6	26.8	10.5	16.1	13.2	29.7	10.5	59.9	38.1
SD3	1.2	1.5	1.0	1.2	0.5	3.1	2.6	5.7	4.0
Min Value 3	28.0	23.0	7.8	13.7	12.1	24.7	7.1	48.3	27.9
Max Value 3	33.9	28.6	12.0	18.2	14.7	39.7	15.9	74.9	45.9

Organized for ***Across*** *population or plant comparisons*

Population (n=51)	35.6	26.7	10.6	16.4	13.2	30.2	8.9	59.0	35.8
Plant 1 (n= 9)	32.6	27.5	10.6	16.0	12.7	31.4	6.7	59.4	31.5
Plant 2 (n=11)	49.3	25.6	10.9	17.5	13.8	30.4	5.9	55.9	32.8
Plant 3 (n=31)	31.6	26.8	10.5	16.1	13.2	29.7	10.5	59.9	38.1
SD	7.4	1.6	1.0	1.2	0.8	2.9	3.4	6.4	5.0
SD1	0.9	1.6	0.9	1.1	0.8	2.0	3.2	5.6	4.4
SD2	2.3	1.5	1.0	0.8	0.9	3.1	2.5	8.6	4.3
SD3	1.2	1.5	1.0	1.2	0.5	3.1	2.6	5.7	4.0
Min Value	28.0	23.0	7.8	13.7	11.4	24.7	3.0	39.5	24.2
Min Value 1	31.4	24.2	9.1	14.5	11.4	28.7	3.7	52.7	24.2
Min Value 2	44.9	23.5	9.6	16.5	12.3	26.6	3.0	39.5	26.8
Min Value 3	28.0	23.0	7.8	13.7	12.1	24.7	7.1	48.3	27.9
Max Value	53.2	29.0	13.0	19.0	15.5	39.7	15.9	74.9	45.9
Max Value 1	33.7	29.0	11.7	18.0	14.2	34.9	13.4	71.7	37.3
Max Value 2	53.2	27.2	13.0	19.0	15.5	36.3	11.2	67.6	38.6
Max Value 3	33.9	28.6	12.0	18.2	14.7	39.7	15.9	74.9	45.9

DM = dry matter, CP = crude protein, EE Mars = ether extract Marshfield lab, EE UW = ether extract UW-Madison Dairy Science lab, FA = fatty acids, NDF = neutral detergent fiber, NDF-CP = CP bound NDF, NDF-D = NDF digestibility, NFC = non-fiber carbohydrates.

Table 2. Fatty acid composition of DWGS by total population and ethanol plant.

*Organized for **Within** population or plant comparisons*

	FA	**C8 to C15**	**C16**	**C18:0**	**C18:1**	**C18:2**	**C18:3**	**C20 to C24**	**NA**
	% DM	----------------------			% of total fatty acids	--------------------------------			
Population (n=51)	13.2	0.2	14.2	2.1	25.0	53.9	1.5	0.8	2.4
SD	0.8	0.2	0.3	0.1	0.9	1.2	0.1	0.1	0.7
Min Value	11.4	0.1	13.5	1.9	21.8	51.8	1.3	0.4	1.3
Max Value	15.5	0.9	14.8	2.2	26.1	58.0	1.9	1.1	4.5
Plant 1 (n= 9)	12.7	0.2	14.2	2.1	24.7	54.5	1.4	0.7	2.2
SD 1	0.8	0.0	0.2	0.1	0.5	1.2	0.1	0.1	0.9
Min Value 1	11.4	0.1	13.8	2.0	23.7	52.6	1.4	0.5	1.3
Max Value 1	14.2	0.2	14.5	2.2	25.3	56.5	1.6	0.9	3.7
Plant 2 (n=11)	13.8	0.3	13.9	2.1	24.4	55.1	1.5	0.8	1.9
SD 2	0.9	0.2	0.2	0.1	1.5	1.4	0.1	0.1	0.3
Min Value 2	12.3	0.1	13.5	2.0	21.8	53.4	1.3	0.6	1.5
Max Value 2	15.5	0.6	14.2	2.2	26.1	58.0	1.7	1.0	2.5
Plant 3 (n=31)	13.2	0.2	14.3	2.0	25.3	53.3	1.5	0.8	2.5
SD 3	0.5	0.2	0.3	0.0	0.6	0.7	0.1	0.1	0.6
Min Value 3	12.1	0.1	13.8	1.9	23.4	51.8	1.4	0.4	1.6
Max Value 3	14.7	0.9	14.8	2.1	26.0	55.2	1.9	1.1	4.5

*Organized for **Across** population or plant comparisons*

Population (n=51)	13.2	0.2	14.2	2.1	25.0	53.9	1.5	0.8	2.4
Plant 1 (n= 9)	12.7	0.2	14.2	2.1	24.7	54.5	1.4	0.7	2.2
Plant 2 (n=11)	13.8	0.3	13.9	2.1	24.4	55.1	1.5	0.8	1.9
Plant 3 (n=31)	13.2	0.2	14.3	2.0	25.3	53.3	1.5	0.8	2.5
SD	0.8	0.2	0.3	0.1	0.9	1.2	0.1	0.1	0.7
SD 1	0.8	0.0	0.2	0.1	0.5	1.2	0.1	0.1	0.9
SD 2	0.9	0.2	0.2	0.1	1.5	1.4	0.1	0.1	0.3
SD 3	0.5	0.2	0.3	0.0	0.6	0.7	0.1	0.1	0.6
Min Value	11.4	0.1	13.5	1.9	21.8	51.8	1.3	0.4	1.3
Min Value 1	11.4	0.1	13.8	2.0	23.7	52.6	1.4	0.5	1.3
Min Value 2	12.3	0.1	13.5	2.0	21.8	53.4	1.3	0.6	1.5
Min Value 3	12.1	0.1	13.8	1.9	23.4	51.8	1.4	0.4	1.6
Max Value	15.5	0.9	14.8	2.2	26.1	58.0	1.9	1.1	4.5
Max Value 1	14.2	0.2	14.5	2.2	25.3	56.5	1.6	0.9	3.7
Max Value 2	15.5	0.6	14.2	2.2	26.1	58.0	1.7	1.0	2.5
Max Value 3	14.7	0.9	14.8	2.1	26.0	55.2	1.9	1.1	4.5

Table 3. Inorganic nutrient composition of DWGS by total population and ethanol plant.

*Organized for **Within** population or plant comparisons*

		P	Ca	K	Mg	Ash Mars	Ash UW
				% DM			
Population	(n=51)	0.9	0.1	1.2	0.3	5.7	4.5
	SD	0.2	0.1	0.1	0.0	1.5	0.4
	Min Value	0.5	0.0	1.0	0.3	2.9	3.9
	Max Value	1.2	0.5	1.5	0.4	8.8	5.5
Plant 1	(n= 9)	0.8	0.1	1.1	0.3	5.7	4.4
	SD 1	0.2	0.1	0.1	0.0	2.0	0.3
	Min Value 1	0.5	0.0	1.0	0.3	3.0	4.1
	Max Value 1	1.0	0.2	1.3	0.4	8.2	5.0
Plant 2	(n=11)	0.9	0.0	1.3	0.4	6.3	5.2
	SD 2	0.2	0.0	0.1	0.0	1.3	0.2
	Min Value 2	0.6	0.0	1.2	0.3	4.1	4.8
	Max Value 2	1.2	0.1	1.5	0.4	8.2	5.5
Plant 3	(n=31)	0.9	0.1	1.1	0.3	5.4	4.3
	SD 3	0.1	0.1	0.1	0.0	1.5	0.2
	Min Value 3	0.6	0.0	1.0	0.3	2.9	3.9
	Max Value 3	1.1	0.5	1.4	0.4	8.8	4.7

*Organized for **Across** population or plant comparisons*

Population	(n=51)	0.9	0.1	1.2	0.3	5.7	4.5
Plant 1	(n= 9)	0.8	0.1	1.1	0.3	5.7	4.4
Plant 2	(n=11)	0.9	0.0	1.3	0.4	6.3	5.2
Plant 3	(n=31)	0.9	0.1	1.1	0.3	5.4	4.3
SD		0.2	0.1	0.1	0.0	1.5	0.4
SD 1		0.2	0.1	0.1	0.0	2.0	0.3
SD 2		0.2	0.0	0.1	0.0	1.3	0.2
SD 3		0.1	0.1	0.1	0.0	1.5	0.2
Min Value		0.5	0.0	1.0	0.3	2.9	3.9
Min Value 1		0.5	0.0	1.0	0.3	3.0	4.1
Min Value 2		0.6	0.0	1.2	0.3	4.1	4.8
Min Value 3		0.6	0.0	1.0	0.3	2.9	3.9
Max Value		1.2	0.5	1.5	0.4	8.8	5.5
Max Value 1		1.0	0.2	1.3	0.4	8.2	5.0
Max Value 2		1.2	0.1	1.5	0.4	8.2	5.5
Max Value 3		1.1	0.5	1.4	0.4	8.8	4.7

Ash Mars = ash values determined at Marshfield lab, Ash UW = ash values determined at UW-Madison Dairy Science lab

Table 4. Nutrient means and standard deviations of distillers grains with solubles from seven data sets.

	DM	SD	**CP**	SD	**EE**	SD	**EE UW**	SD	**NDF**	SD	**NDF-D**	SD
NRC, DDGS	90.2	1.8	29.7	3.3	10.0	3.4			38.8	7.8		
Kaiser, DWGS	35.8	1.5	26.6	1.6	10.5	1.0	16.4	1.2	30.1	3.0	59.0	6.4
Robinson, DDGS	90.1	1.6	30.1	2.6	11.5	3.5			33.7	4.7	76.2	7.6
Robinson, Dakota Gold™	88.2	0.9	30.7	1.2	11.9	0.7			28.1	2.4	77.5	1.5
Hardy, DDGS	92.7	1.0	30.1	1.5	10.5	1.2			48.8	3.2		
DePeters, DDGS			31.2	0.6	13.0	1.3			35.6	8.2		
Belyea, DDGS			30.6	1.4	7.4	0.9			33.0	1.5		
Spiehs, DDGS	89.0	1.1	30.2	1.0	10.9	0.5			42.0	4.3		

	P	SD	**Ca**	SD	**K**	SD	**Mg**	SD	**Ash**	SD	**Ash UW**	SD
NRC, DDGS	0.8	0.1	0.2	0.1	1.1	0.2	0.3	0.1	5.2	1.1		
Kaiser, DWGS	0.9	0.2	0.1	0.1	1.2	0.1	0.4	0.0	5.6	1.5	4.5	0.4
Robinson, DDGS	0.9	0.1	0.1	0.0	1.0	0.2	0.3	0.1	4.9	0.8		
Robinson, Dakota Gold™	0.7	0.1	0.0	0.0	0.9	0.1	0.3	0.0	4.6	0.2		
Hardy, DDGS									4.3	0.6		
DePeters, DDGS	0.8	0.0	0.1	0.0	1.0	0.1	0.4	0.0	4.7	0.3		
Belyea, DDGS	0.7	0.0	0.0	0.0	0.9	0.1	0.3	0.0	3.1	0.3		
Spiehs, DDGS	0.9	0.1	0.1	0.0	0.9	0.1	0.3	0.0	5.8	0.5		