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Dried Corn Distillers Grains in Dairy Cattle Feeding
Part 2 – Nutrient Profiles, Variability and Key Impacts on Cattle

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While use of corn grain to produce ethanol is hardly a new process, corn whisky has been with us for a very long time, and spent distillers grains have been used as a cattle feed for an equally long time, what makes the recent situation different is simply the vast quantities of spent grains which are being created due to production of motor fuel ethanol, and the anticipated further increase of those quantities in the near future. It is estimated that from 5 million tonnes of spent corn distillers grains produced in the US during the 2001 crop year, there were about 44 million tons produced in 2012. Thus incorporation levels of distillers grains by-products into diets of most food animals will have to increase, both to utilize the distillers grains produced and as semi-substitutes for the corn grain which is no longer available at affordable prices.

Last issue I discussed the production and physical characteristics of some of the new DDG products. In this issue I address their nutrient profiles and variability.

Distillers Grains – Nutrient Analyses of the Products (Nutrient Levels)

Corn, wheat, barley and rye grains are not new feeds and they have long been utilized as human and animal feeds and, to a high degree, their nutritional attributes are well known in concept and detail. Thus the primary DDG by-products created by removing starch from grain due to its fermentation to ethanol creates, at its simplest, a de-starched grain which has the nutritional attributes one would expect of a de-starched grain. Thus the main DDG products are not 'new' feeds and should not be considered as such. What is 'new' about DDG as animal feedstuffs in a contemporary context is that, in contrast to the past where DDG products might comprise 2 or 3% of the dry weight of animal diets because there was not a lot of them available, animal producers are now interested in feeding DDG products at much higher levels due to their higher availability, but only if the costs of doing so are economically attractive.

Nutritional research of food animals has historically been driven, at least to some extent, by practicality and there are only a few cases where food animal nutritional research examined inclusion levels of nutrients, and ingredients, at levels which were not generally considered to be practical. Thus, of the small amount of research completed on the nutritional value of DDG products prior to ~1995, virtually none examined feeding DDG products at high dietary inclusion levels because that was not considered to be practically important. Nevertheless the nutritional attributes of the protein, fibre, non-structural carbohydrates and minerals in corn grain were generally well understood and so, in general, animal feeding industries moved quickly to utilize DDG products when they became available in high quantities in the early 2000's.

This high use of DDG products in food animal diets was facilitated by wide use of least cost linear programming (LP) as the basis of most major food animal diet formulation systems in most parts of the world. As LP's create a 'least cost' diet to meet a defined nutrient profile (the right hand side - RHS) based upon the nutrient profiles and costs of all available feedstuffs (the left hand side - LHS), any feedstuff with a known nutrient profile (relative to the defined RHS of the LP being used) will be considered for inclusion in the diet and will appear in the diet if it is cost effective. The RHS can contain minimum and/or maximum levels (constraints) of nutrients to be allowed into the diet, as well as minimum and/or maximum levels of ingredients to be allowed into the diet. As the confidence in nutrient requirements rises in the mind of the user, the number of ingredient constraints tends to decline, and the difference between their minimum and maximums tends to expand. However ingredient constraints, particularly the upper constraint, are often conservative when new feeds, or feeds available at substantially higher amounts, are suddenly available. Because there is a great deal that we do not know about the nutritional requirements of food animals, as well as the total nutritional value of individual feeds, uncertainty occurs in ration formulation - especially with new (or new to the user) feeds or when feeds are being fed at much higher levels than historically. Not until the LP user has ascertained that the upper feed constraint is not causing a problem with the animals will the upper constraint be raised and, if there is a feeling that it is causing a problem, then the upper constraint will be reduced.

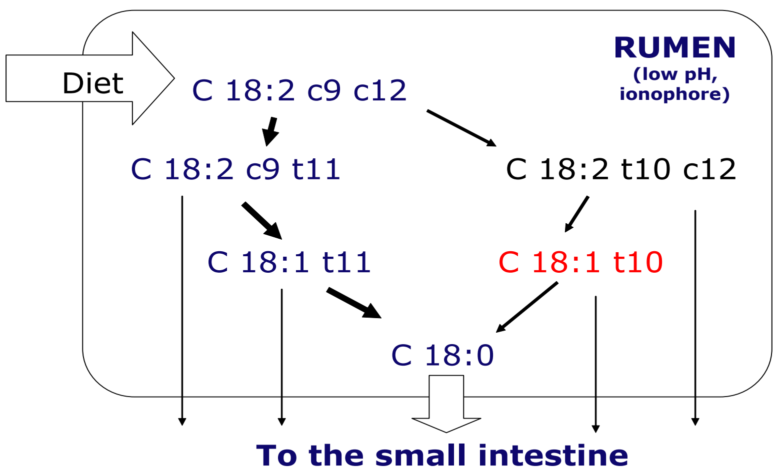
From a nutritional perspective, it is common to be more concerned about nutrients present at high levels in feeds, rather than low levels, since deficient (relative to animal needs) nutrients can generally be supplemented in other feeds or supplements, but they cannot be 'unsupplemented' if provided in excess of an animal need or human desire.

A major nutrient in DDG products which is present at high levels relative to animal needs, and has subsequent negative environmental impacts (although not on animal performance), is phosphorous (P). For example, conventional DDGS contains 0.70-0.84% of DM as P, which means that a 10% dietary DM inclusion of DDGS in a dairy lactation diet would meet 20-25% of their total P requirement of ~0.34% of DM. As P excretions from dairy cattle are limited by regulations in many areas of the world, thus requiring an upper constraint on P levels in the diets to limit P excretions in manure, this creates a limitation on the amount of DDGS which can be included in the ration, especially if other high P feeds are more cost effective and/or low P feeds are available.

Another nutrient which can be a problem due to its high level in corn based DDG by-products, especially to lactating ruminants, is corn oil. Present in conventional DDGS at about 11% of DM, a 10% dietary inclusion of DDGS in a dairy lactation diet would deliver a little over 1% of dietary DM as corn oil, or about 0.7% of diet DM as C18:2 and C18:3 fatty acids. When fed at high levels to lactating cows, especially diets which create a low rumen pH, the C18:2 t10 c12 in the diet can spill over to a rumen bacterial pathway which converts it to C18:2 t10 c12 and then, via C18:1 t10, to C18:0 (see the Figure). C18:2 t10 c12 and C18:1 t10 inhibit milk fat synthesis at high levels, and both can appear in milk.

As many dairy producers are paid on the basis of milk fat production, such an event is highly undesirable. While the high levels of corn oil in corn based DDGS products can be advantageous in diets with low fat levels, where the C18:0 which escapes the rumen can be an effective energy source, they can push lactating cows into a milk fat depression when fed at high levels and/or in concert with other plant product feeds which also contain high levels of C18:2 and C18:3 fatty acids, a milk fat depression which does not occur if the fats are supplemented as saturated fatty acids.

Hydrogenation of C18:2 c9 t12 in the rumen.



In contrast to P and corn oil, a nutrient which is present at levels too low to support the nutritional needs of lactating animals, particularly high producing lactating dairy cows, is lysine. For example, in cows producing ~105 lb/d of milk and eating 62 lb/d of a diet containing 10% of dry weight as DDGS, the DDGS would meet ~16% of the crude protein (CP) needs of the cows, but only about 4% of their absorbable lysine requirement. If the diet also contains other corn protein sources, such as corn silage, corn grain, corn gluten feed or corn gluten meal, the ability of the cows to maintain production will be inhibited due to an absorbable lysine deficit.

While DDG products contain numerous other nutrients which can be utilized by farm animals, there are none which are likely to be a problem by negatively impacting animal performance. In addition, DDG products, similar to the grains from which they are derived, are very low in native secondary metabolites (*i.e.,* anti-nutrients) which could negatively impact animal performance. However as most mold derived toxins survive the ethanol fermentation process, grains with high levels of mycotoxins will lead to DDG products with higher mycotoxin levels.

Distillers Grains – Nutrient Analyses of the Products (Nutrient Variability)

Nutrient levels in feedstuffs are never exactly the same among production processes, among facilities with the same production process, within production facilities, among loads and even within loads. In addition, what is claimed to be 'nutrient variability' may partly be variation introduced by sampling it and/or analysis of the nutrients. Thus heterogeneous feeds and analytes with higher analytical variation will tend to have more measured 'variation', even when there may be very low real variation. In general, homogeneous feeds such as grains and protein meals based upon single source materials will have lower variability than heterogenous materials, such as pomaces, pulps and forages, which are based upon multi-source materials. From a diet formulation perspective, variability in ingredient profiles of feeds is seldom directly considered, although it may be considered indirectly by fixing lower ingredient inclusion constraints of feeds which are known by experience to be more variable. In this context the DDG by-products, in general, would not be considered to be feedstuffs with a likelihood to have high nutrient variability since few of the risk factors for variability exist. For example, in general, the grain source is consistent and the processes used to ferment its starch to ethanol are large scale and highly automated. In addition the drying process is generally tightly controlled to prevent heat damage which will reduce its fiscal value. As all DDG by-products have a fine particle size, they tend to flow smoothly and mix easily making it relatively simple to collect a representative sample and, if this sample requires sub-sampling at a laboratory before grinding prior to chemical analysis, its small particle size creates little chance of non-representative sub-samples. However it is clear that DDG production facilities use slightly different processes to create DDGS, WDGS, HPDDGS and LFDDGS, which will lead to differences among production facilities in the nutrient profiles of their DDG by-products.

Based upon samples of various feeds collected from commercial dairy farms throughout the California, the variability of DDGS is similar to other protein sources such as canola meal (see the Table) and, with only one exception, the co-efficient of variation (CV) for its organic nutrients is <10%. In contrast, a group of DDGS samples collected from a single DDGS production facility had substantially lower nutrient CV's than the DDGS collected from the commercial dairy farms which represented numerous production facilities and were collected over a 3 year period. However, in general, DDGS is a feedstuff with low variation in its nutritionally important nutrients, and its upper constraint in diet formulation should not be impacted to a substantive extent by this variation.

Conclusions

The rapid increase in use of grains for ethanol production since 2001 in the Midwestern USA, and other parts of the world, is primarily based on corn, wheat and barley grains which are nutritionally very well known human and animal feeds. Thus it is clear that their main by-product, DDG byproducts, are not 'new' feeds and should be considered, in general, to be de-starched grains when used in diet formulation. While DDG by-products have a long history as feeds for farm animals, it is the vast quantity of DDG by-products, expected to have reached 44 million tons in the USA in 2012, and the desire to include them in farm animal diets at much higher levels than in the past, which is new. In this context, DDG by-products contain nutrient profiles consistent with their base grain and ethanol fermentation production processes, and those nutrients have relatively low variation relative to other similar feeds.

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Nutrient levels and variation of several in distillers dried grains with solubles (DDGS) and several other feedstuffs.

	DM	OM	Fat	CP	SolCP	ADICP	NDF	dNDF	ADF	NEl	Ca	P	Mg	K	S	Na	Cl	Fe	Mn	Zn	Cu	Mo
	%	% DM			% CP		% DM	% NDF	% DM	Mcal/kg DM	% DM							ppm DM				
Canola Pellets (38% CP, solvent, various sources)																						
Mean	89.6	91.8	3.1	41.2	31.5	31.5	27.1	55.3	19.0	1.70	0.85	1.23	0.60	1.51	0.76	0.06	0.11	259	62	70	5	2.7
CV (%)	1.7	0.5	15.5	4.7	15.2	15.2	8.3	16.0	10.9	3.2	15.6	24.6	8.0	8.3	13.6	62.9	55.6	19.1	10.7	12.7	51.9	39.3
Corn (grain, flaked, various sources)																						
Mean	87.4	99.0	3.6	9.0	21.7	9.4	11.0	71.2	4.0	2.19	0.02	0.24	0.09	0.33	0.11	0.01	0.11	41	6	21	2	1.2
CV (%)	0.6	0.1	13.1	3.6	14.7	25.5	7.9	5.6	8.4	1.3	77.9	14.8	18.8	19.2	18.2	0.0	56.8	40.0	25.7	18.4	92.6	29.8
Cotton (seed, upland with lint, various sources)																						
Mean	92.7	95.9	22.1	23.6	27.1	6.5	52.3	41.4	40.0	2.14	0.20	0.72	0.37	1.16	0.27	0.03	0.11	126	20	43	11	2.1
CV (%)	0.7	0.1	5.347	3.187	6.1	15.6	4.5	27.9	5.1	8.2	29.5	17.3	14.2	10.2	4.9	74.7	46.6	89.6	52.3	29.3	32.9	40.4
Distillers Grains (dehy/corn/w solubles; various sources)																						
Mean	90.3	95.1	11.5	30.1	15.7	26.4	34.7	76.2	20.1	1.93	0.12	0.90	0.35	1.08	0.58	0.12	0.22	180	38	69	4	2.0
CV (%)	0.4	0.2	5.5	1.4	10.4	47.8	3.6	10.0	6.4	7.5	86.6	14.8	23.1	21.5	24.4	72.9	60.0	26.8	49.3	18.5	81.9	46.0
Distillers Grains (dehy/corn/w solubles; single facility)																						
Mean	88.2	95.4	11.9	30.7	17.5	8.2	28.1	77.4	14.4	2.19	0.02	0.70	0.30	0.94	0.59	0.144	0.15	73	15	109	5	0.7
CV (%)	0.3	0.1	1.9	1.3	2.8	8.8	2.7	0.6	2.2	0.5	9.2	2.5	1.9	1.6	8.0	14.8	3.5	3.0	3.5	14.4	5.7	9.9
Soybean (48% CP, solvent, various sources)																						
Mean	91.3	92.4	1.2	52.3	18.1	2.0	9.8	79.7	6.7	1.96	0.51	0.80	0.32	2.41	0.42	0.01	0.06	199	44	59	18	5.0
CV (%)	0.6	0.2	21.2	1.1	9.9	35.3	7.9	5.1	10.4	1.5	29.5	15.1	30.3	27.1	39.7	43.3	11.3	28.9	11.2	14.4	36.5	45.1
Wheat (millrun/midds, various sources)																						
Mean	91.2	94.7	4.0	19.1	40.6	3.4	38.5	51.2	12.6	1.64	0.16	1.12	0.37	1.06	0.18	0.01	0.13	170	131	88	11	2.4
CV (%)	0.7	0.1	10.2	2.5	4.8	37.5	3.0	3.6	3.5	2.4	29.5	15.1	30.3	27.1	39.7	43.3	11.3	28.9	11.2	14.4	36.5	45.1

DM, dry matter; OM, organic matter; CP, crude protein; SolCP, buffer soluble CP; ADICP, CP insoluble in acid detergent; NDF, neutral detergent fibre; dNDF, NDF digested *in vitro* for 30 h; ADF, acid detergent fibre; NE_l, net energy for lactation.