Analysis of Current Feeding Practices of Distiller's Grains with Solubles in Livestock and Poultry Feed Relative to Land Use Credits Associated with Determining the Low Carbon Fuel Standard for Ethanol

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Introduction

The purpose of this report is to provide an independent, scientific evaluation of the information contained in two reports being used as references regarding the land use credit associated with the primary co-product, distiller's grains with solubles (DGS), generated from corn ethanol production. The intended use of this report is to support formal Renewable Fuels Association comments that will be submitted to the California Air Resources Board on the Low Carbon Fuel Standard. The information reviewed in this report was obtained from two sources: "Update of Distillers Grains Displacement Ratios for Corn Ethanol Life-Cycle Analysis" by Arora, Wu and Wang (2008) and Appendix C11 "Co-product Credit Analysis when Using Distiller's Grains Derived from Corn Ethanol Production" by the California Air Resources Board. It is critical that accurate, science-based information be used for government policy decisions. Therefore, the following report is a critique of the scientific validity of the information contained in these two references in order to provide the "current state of knowledge" relative to the use of ethanol co-products in livestock and poultry feeds.

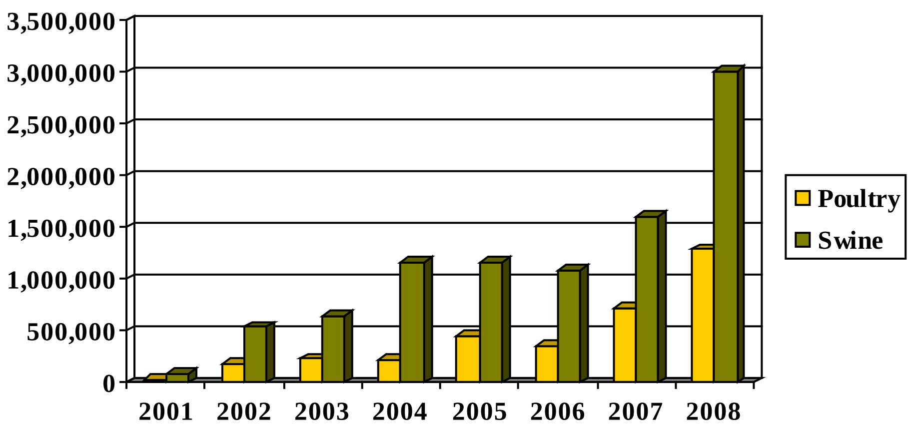
Review of Argonne National Laboratory Analysis (Arora et al., 2008)

The authors of this report correctly acknowledge that the addition of distillers grains with solubles to dairy, beef, and swine feeds has different effects on the amount of corn, soybean meal, and urea (which applies to dairy and beef diets only) that it partially replaces. Although dairy and beef cattle have historically been, and continue to be, the predominant consumers (80%) of DGS in animal agriculture, the amount being used in swine and poultry diets has been increasing over the past several years (Figure 1). In 2001, total annual estimated consumption of DGS was 89,000 MT for swine and 35,000 MT for poultry whereas in 2008, swine and poultry DGS consumption was about 3.0 and 1.3 million MT, respectively. This is a tremendous increase in DGS use over only an 8-year period and represents only 35 and 22% of the potential use in swine and poultry feed in the U.S., respectively (Cooper, 2006).

The percentage estimates of DGS consumed by various livestock and poultry species in 2008 are shown in Table 1. Dairy cattle consumed the greatest amount of DGS (9.0 million MT), followed by beef cattle (8.2 million MT), swine (3.0 million MT), and poultry (1.3 million MT), with the remaining 4.5 million MT being exported. As the amount of DGS production has increased, the estimated quantities of DGS consumed by all livestock and poultry sectors have also increased, and the estimated percentages of distribution of total DGS consumption have changed to include a higher percentage of total production in swine and poultry diets. Three primary factors that will affect further future market penetration in the various food animal sectors, and the percentage use of total DGS production are:

1. The price relationship between DGS and the ingredients it competes with in livestock and poultry diets (e.g. corn and soybean meal [all species], urea [cattle], and inorganic phosphate, fat, and synthetic amino acids [swine and poultry].
2. Availability of supply of the co-product as a feed ingredient.
3. Research focused on developing solutions for overcoming the barriers to increase DGS use in the livestock and poultry industries.

Figure 1. Estimated use of DGS in U.S. poultry and swine diets from 2001- 2008 (Metric Tonnes).



Source: S. Markham, CHS, Inc. (personal communication).

Therefore, when calculating land use credits due to DGS production and consumption, the usage in the swine and poultry sectors needs to be accurately estimated. Although the Arora et al (2008) report was the most comprehensive and objective analysis of the impact of DGS displacement ratios, the results are somewhat biased because it did not provide a thorough and accurate evaluation of the impact of DGS consumption in the swine and poultry industries.

Table 1. Estimated North American DGS usage rate by species (2008).

Species	% of total non-export[1]	Metric Tonnes
Dairy Cattle	42	9,025,800
Beef Cattle	38	8,166,200
Swine	14	3,008,600
Poultry	6	1,289,400
Exports	-	4,510,000[2]
Total	100	26,000,000[3]

[1] Source: S. Markham, CHS, Inc. (personal communication).
[2] Source: D. Keefe, U.S. Grains Council
[3] Source: Renewable Fuels Association www.ethanolrfa.org

In addition, the calculations for displacement ratios for DGS in the Arora et al. (2008) report only accounted for the amount of corn, soybean meal and urea replaced. While this is valid for calculating displacement ratios for cattle feeds, it does not fully account for partial replacement of other common ingredients used in swine and poultry diets such as inorganic phosphate, fat, synthetic amino acids, and salt.

2.1.1.2 DGS Inclusion in Feed and Animal Performance

Beef cattle

Arora et al. (2008) chose an excellent source of data and information for beef cattle using the review and meta-analysis by Klopfenstein et al. (2008) involving nine experiments to measure growth performance at DGS dietary inclusion levels up to 40%. Using these data for calculating feed ingredient displacement ratios for DGS in beef feedlot cattle diets is very appropriate.

Dairy cattle

Data from a recent study by Anderson et al. (2006) were used in the calculation of displacement ratios for DGS in lactating dairy cattle diets. The dietary inclusion rates of DGS in the Anderson et al. (2006) study represent the current range in feeding levels in the dairy industry, and the milk production and composition responses are consistent with other published studies. Although a more thorough review and summary of results from multiple studies should have been done, the data and assumptions used in their calculations are scientifically valid and representative of diet composition changes, as well as milk production levels and composition when feeding DGS diets to lactating dairy cows.

Swine

The analysis of DGS use in swine feeds was inadequately described by Arora et al. (2008) and was based on results from only a few select studies. It is more appropriate to use information from all of the published scientific studies to accurately characterize growth responses of growing swine fed diets containing DGS at levels of 10 to 30% of the diet. Stein and Shurson (2008) recently conducted a comprehensive literature review of results from all published studies and summarized growth performance responses for weanling pigs (Table 2) and grower-finisher pigs (Table 3). The majority of the studies conducted have shown no change in weanling pig and growing-finishing pig performance when DGS is included in the diet at levels up to 30% compared to feeding typical corn-soybean meal based diets. Although feed conversion (G:F) was improved in 50% of the weanling pig studies and 16% of the growing-finishing pig studies, indicating improved utilization of DGS diets compared to conventional corn-soybean meal diets, I chose to be conservative by assuming that feeding DGS diets results in no change in growth rate or efficiency of feed utilization. Therefore, when calculating displacement ratios for DGS, I did not give any credit for improvements in performance but rather focused on the amounts of common feed ingredients that DGS partially replaces (Table 4).

Currently, the industry average dietary inclusion rate of DGS in growing swine diets is 20%, which is double the assumption used in the Argonne report, and it has been as high as 40% for growing-finishing pigs when it has been priced substantially lower than the feeding value of corn, soybean meal, and inorganic phosphate. At a 20% dietary DGS inclusion rate, 400 lbs of DGS plus 6.4 lbs of calcium carbonate, and 2.8 lbs of synthetic amino acids replace 279.6 lbs of corn, 118 lbs of soybean meal, and 11.6 lbs of dicalcium phosphate per ton (2000 lbs) of complete feed (Table 4), resulting in a displacement ratio of 0.699 for corn, 0.295 for soybean meal, and 0.029 for dicalcium phosphate (Table 5). At the 30% dietary DGS inclusion rate the displacement ratios are 0.688 for corn, 0.307 for soybean meal, and 0.027 for dicalcium phosphate (Table 5).

Table 2. Effects of including corn distillers dried grains with solubles (DGS) in diets fed to weanling pigs[1]

Item	N	Response to dietary corn DGS		
		Increased	Reduced	Not changed
ADG	10	0	0	10
ADFI	10	0	2	8
G:F	10	5	0	5

[1]Data calculated from experiments by Whitney and Shurson (2004), Gaines et al. (2006), Linneen et al. (2006), Spencer et al. (2007), Barbosa et al. (2008), and Burkey et al. (2008).

Table 3. Effects of including corn distillers dried grains with solubles (DGS) in diets fed to growing-finishing pigs[1, 2]

Item	N	Response to dietary corn DGS		
		Increased	Reduced	Not changed
ADG	25	1	6	18
ADFI	23	2	6	15
G:F	25	4	5	16

[1] Data based on experiments published after 2000 and where a maximum of 30% DDGS was included in the diets.

[2]Data calculated from experiments by Gralapp et al. (2002), Fu et al. (2004), Cook et al. (2005), DeDecker et al. (2005), Whitney et al. (2006), McEwen (2006, 2008), Gaines et al. (2007ab); Gowans et al.(2007), Hinson et al. (2007), Jenkin et al. (2007), White et al. (2007), Widyaratne and Zijlstra (2007), Xu et al. (2007ab, 2008ab), Augspurger et al. (2008), Drescher et al. (2008), Duttlinger et al. (2008), Hill et al. (2008), Linneen et al. (2008), Stender and Honeyman (2008), Weimer et al. (2008), and Widmer et al. (2008).

Table 4. Partial replacement amounts of common feed ingredients with 20 or 30% DGS in typical swine grower diets.

Ingredient, %	**0% DGS**	**20% DGS**	**Difference**	**30% DGS**	**Difference**
Corn	81.30	67.32	-13.98	60.65	-20.65
Soybean meal, 46% CP	16.50	10.60	-5.90	7.30	-9.20
DGS	0.00	20.00	+20.00	30.00	+30.00
Dicalcium phosphate	0.82	0.24	-0.58	0.00	-0.82
Calcium carbonate	0.68	1.00	+0.32	1.13	+0.45
Salt	0.30	0.30	0.00	0.30	0.00
Synthetic amino acids	0.15	0.29	+0.14	0.37	+0.22
Vitamins and trace minerals	0.25	0.25	0.00	0.25	0.00
Total	100.00	100.00		100.00	

Table 5. Summary of co-product displacement ratios for swine when DGS is added at 20 and 30% dietary inclusion rates.

Dietary DGS Inclusion Rate	**Corn**	**Soybean meal**	**Dicalcium phosphate**
20%	0.699	0.295	0.029
30%	0.688	0.307	0.027

Poultry

Use of DGS in broiler, layer, and turkey diets was omitted from the analysis in the Argonne report (Arora et al., 2008). The authors cited that "poultry consumption was excluded because feed composition and performance data available for poultry were insufficient". While the

NASS-USDA (2007) survey did not include poultry data, other sources could have been used as a reference. Therefore, I elected to provide the following summary of DGS usage in broiler, layer, and turkey diets and calculate displacement ratios for common ingredients partially replaced in these diets, and include this information in the final composite displacement ratios for all food animal species.

Current dietary inclusion rates of DGS in broiler diets range from 3 to 15%, with an average of 5% (Dr. Amy Batal, 2009, personal communication). Commercial layer diets contain between 3 to 12% DGS, with an average dietary inclusion rate of 7% (Dr. Amy Batal, personal communication). For turkeys, typical dietary DGS use levels are 10%, but in 2008, levels of 20 to 30% DGS were used when feed prices were extremely high (Dr. Sally Noll, personal communication). Tables 6, 7, and 8 summarize the partial replacement rates of corn, soybean meal, and inorganic phosphate with DGS in broiler, layer, and turkey diets, respectively. The ranges in dietary DGS inclusion rates for broiler, layer, and turkeys used in this analysis result in no change in growth performance compared to feeding conventional corn-soybean meal based diets.

Table 6. Partial replacement amounts of common feed ingredients with 5 or 10% DGS in typical broiler grower diets.

Ingredient, %	**0% DGS**	**5% DGS**	**Difference**	**10% DGS**	**Difference**
Corn	64.87	61.81	-3.06	58.75	-6.12
Soybean meal, 49% CP	27.19	24.99	-2.20	22.79	-4.40
DGS	0.00	5.00	+5.00	10.00	+10.00
Poultry by-product	3.00	3.00	0.00	3.00	0.00
Defluorinated phos.	1.05	0.95	-0.10	0.85	-0.20
Calcium carbonate	0.59	0.68	+0.09	0.77	+0.18
Salt	0.39	0.38	-0.01	0.37	-0.02
Synthetic amino acids	0.32	0.36	+0.04	0.42	+0.10
Fat A-V Blend	2.26	2.49	+0.23	2.72	+0.46
Vitamins, trace minerals, and additives	0.33	0.34	+0.01	0.33	0.00
Total	100.00	100.00	100.00	100.00	100.00

At a 5% dietary DGS inclusion rate, 100 lbs of DGS plus 1.8 lbs of calcium carbonate, 0.80 lbs of synthetic amino acids, and 4.6 lbs of animal-vegetable blend fat replaces 61.2 lbs of corn, 44 lbs of soybean meal, and 2 lbs of defluorinated phosphate in one ton (2000 lbs) of complete feed, resulting in a displacement ratio of 0.612 for corn, 0.440 for soybean meal, and 0.020 for defluorinated phosphate. At the 10% dietary DGS inclusion rate the displacement ratios for corn, soybean meal, and defluorinated phosphate are the same as those at the 5% dietary inclusion level.

Table 7. Partial replacement amounts of common feed ingredients with 5 or 10% DGS in typical layer diets (peak egg production).

Ingredient, %	0% DGS	5% DGS	Difference	10% DGS	Difference
Corn	58.64	55.60	-3.04	52.56	-6.08
Soybean meal, 49% CP	26.53	24.34	-2.19	22.14	-4.39
DGS	0.00	5.00	+5.00	10.00	+10.00
Defluorinated phos.	2.26	2.16	-0.10	2.06	-0.20
Calcium carbonate	8.92	9.01	+0.09	9.10	+0.18
Salt	0.19	0.18	-0.01	0.17	-0.02
Synthetic amino acids	0.22	0.26	+0.04	0.30	+0.08
Fat A-V Blend	2.90	3.12	+0.22	3.34	+0.44
Vitamins, trace minerals, and additives	0.34	0.33	-0.01	0.33	-0.01
Total	100.00	100.00		100.00	

Similar to broiler diets, at a 5% dietary DDGS inclusion rate in layer diets, 100 lbs of DDGS plus 1.8 lbs of calcium carbonate, 0.80 lbs of synthetic amino acids, and 4.4 lbs of animal-vegetable blend fat replaces 60.8 lbs of corn, 43.8 lbs of soybean meal, and 2 lbs of defluorinated phosphate per ton (2000 lbs) of complete feed, resulting in a displacement ratio of 0.608 for corn, 0.438 for soybean meal, and 0.020 for defluorinated phosphate. At the 10% dietary DDGS inclusion rate, the displacement ratios for corn, soybean meal, and defluorinated phosphate are the same as those for the 5% dietary inclusion level.

Table 8. Partial replacement amounts of common feed ingredients with 10 or 20% DDGS in typical turkey grower diets (11-14 week old tom, or 8-11 week old hen).

Ingredient, %	0% DGS	10% DGS	Difference	20% DGS	Difference
Corn	59.57	54.10	-5.47	48.62	-10.95
Soybean meal, 46% CP	28.68	24.08	-4.60	19.47	-9.21
DGS	0.00	10.00	+10.00	20.00	+20.00
Dicalcium phosphate	0.95	0.69	-0.26	0.43	-0.41
Calcium carbonate	0.72	0.91	+0.19	1.09	+0.37
Salt	0.23	0.19	-0.04	0.15	-0.08
Synthetic amino acids	0.31	0.37	+0.06	0.39	+0.08
Animal fat	5.03	5.22	+0.19	5.41	+0.38
Vitamins, trace minerals, and additives	4.51	4.44		4.44	
Total	100.00	100.00		100.00	

In turkey diets, a 10% dietary DGS inclusion rate results in adding 200 lbs of DGS plus 3.8 lbs of calcium carbonate, 1.20 lbs of synthetic amino acids, and 3.8 lbs of animal fat to replace 109.4 lbs of corn, 92 lbs of soybean meal, 5.2 lbs of defluorinated phosphate, and 0.80 lbs of salt per ton (2000 lbs) of complete feed, resulting in a displacement ratio of 0.547 for corn, 0.460 for soybean meal, 0.026 for dicalcium phosphate, and 0.004 for salt. At the 20% dietary DGS inclusion rate, the displacement ratios for all of these ingredients are the same as the 10% DGS dietary level.

Table 9 shows a summary of DGS displacement ratios for broilers, layers, and turkeys. Since these values are similar, I chose to average them to obtain a composite ratio for corn, soybean meal, and phosphate for the overall displacement ratio calculations for poultry shown in Table 10. These values are the same at DGS inclusion rates up to 20% which exceeds current average dietary inclusion rates of 5% for broilers, 7% for layers, and 10% for turkeys.

Table 9. Summary of DGS displacement ratios for poultry.

Species	Corn	Soybean meal	Phosphate
Broilers	0.612	0.440	0.020
Layers	0.608	0.438	0.020
Turkeys	0.547	0.460	0.026
Average	**0.589**	**0.446**	**0.022**

2.1.2 Step 2: Characterize U.S. Distillers Grains Consumption by Animal Type

The Argonne report referred to the NASS-USDA survey published in 2007 as a source of DGS consumption data by species. However, this survey was conducted before the record high corn and soybean meal prices occurred in 2008, and therefore, the dietary inclusion rates for various species reported in this survey are conservative, especially for swine based on current diet usage rates in 2008-2009. Usage estimates of DGS in poultry diets was not included in this survey.

2.1.3 Step 3: Characterize Life Cycle of Animals

The information provided in the Argonne report for beef and dairy cattle is valid and adequately accounts for improved growth performance of feedlot beef cattle and improvements in milk production in lactating dairy cattle. Because growth performance of swine, broilers, layers, and turkeys are unchanged with typical dietary inclusion rates of DGS as previously described, no adjustments in displacement ratios for DGS are needed like those for cattle. This was accurately represented for swine in the Argonne report, although the authors used a 10% dietary DGS inclusion rate where I have used displacement ratios assuming a 20% DGS dietary inclusion rate for swine. The Argonne report did not include calculations for displacement ratios for poultry, however, they will be used in the final displacement ratio calculations presented here.

2.1.4 Step 4: Results - Displacement Ratio of Distillers Grains

The final composite DGS ratio results are presented in Table 10. By adding the proportional amounts of each ingredient that is decreased or increased as a result of using DGS in the diets, while accounting for market share for each species, 1 kg or 1 lb of DGS can displace 1.244 kg or lbs of other dietary ingredients to achieve the same level of performance (or improved performance as with cattle). This displacement ratio is slightly lower, but similar to the value of 1.271 kg obtained in the Arora et al. (2008) report which had limited information on swine dietary DGS usage and expected growth performance results, and DGS usage in poultry diets was not included.

In my analysis, the overall displacement ratio for corn and soybean meal was 1.229 compared to the Argonne calculation of 1.28. The reason for this slightly lower value was that the corn displacement value (0.895) was slightly lower in my analysis compared to the value (0.955) calculated in the Arora et al. (2008) report. However, the soybean meal displacement ratio was higher (0.334 vs. 0.291) value in Argonne report. This indicates that 27% of the corn and soybean meal displacement value is soybean meal compared to 24% in the Argonne report. Most of this change can be explained by the greater proportion of soybean meal displaced (and less corn) in swine and poultry diets, with the remaining contribution coming mostly from savings in phosphate supplementation.

Table 10. Summary of DGS displacement ratio by species and overall DGS displacement ratio[1].

Parameter	Dairy	Beef	Swine (20%)	Poultry	Overall Ratio (kg/kg DGS)
Market share, %	42	38	14	6	100
Corn	0.731	1.196	0.699	0.589	0.895
Soybean meal	0.633	-	0.295	0.446	0.334
Urea	-	0.056	-	-	0.021
Synthetic amino acids	-	-	+0.140	+0.073	(0.024)
Fat	-	-	-	+0.363	(0.022)
Inorganic phosphate	-	-	0.580	0.220	0.094
Calcium carbonate	-	-	+0.320	+0.183	(0.056)
Salt	-	-	-	0.027	0.002
Total	**1.364**	**1.252**	**1.114**	**0.663**	**1.244**

[1]Values designated with + indicate additions to maintain equivalent dietary nutrient levels when DGS is added to diets for swine and poultry and values in ( ) indicate subtractions from the overall composite ratio.

Review and Critique of Appendix C11 Co-product Credit Analysis when Using Distiller's Grains Derived from Corn Ethanol Production (CARB)

The authors of this Appendix acknowledge that when DGS displaces traditional feed ingredients such as corn and soybean meal, it reduces green house gas emissions and becomes a life-cycle carbon intensity credit for corn ethanol. However, they criticize the Argonne National Laboratory report (Arora et al., 2008) as having insufficient justification for adopting the DGS displacement value in this report. I strongly disagree. In the preceding analysis of this report, I have noted the areas of insufficient information and have made calculations to be more reflective of actual DGS use among the major livestock and poultry species that consume it. Although this Appendix of the CARB report attempts to describe some of the challenges of using DGS in livestock and poultry feeds, it does not accurately represent factual information for making informed decisions on the impact of feeding DGS on land use credits. The following is a summary of critical evaluation of the incorrect information and improper context of statements in this Appendix.

In this Appendix, the California Air Resources Board (CARB) indicated that their staff conducted an extensive literature review to determine the likelihood that significant quantities of traditional feed ingredients will be replaced by DGS. The accuracy of this statement is highly questionable because they vaguely reference a limited number of sources of information, and no list of publications or other sources of information are provided at the end of the Appendix. Furthermore, the most striking point of the information in this Appendix is that they question whether the barriers to DGS use will be overcome to allow it to be used in livestock and poultry feeds in a significant way. **The fact is, ALL of the growing supply of DGS has been, and continues to be used in livestock and poultry feeds both domestically and in the export market**. Although the barriers they have identified are realistic, their impact is more on further market penetration and use in the various livestock and poultry sectors than on the ethanol industry's ability to market the quantities of DGS currently being produced. Variability in nutrient content along with handling, storage and transportation are challenges that have, to some degree, limited market penetration of DGS use for some species. However, under competitive market price conditions, DGS will continue to be fully utilized in livestock and poultry feeds.

There are several additional technical errors in the CARB Appendix C11.

1. In Table C-11-1, they do not reference the source of the information in the table, generalize ranges in digestibility and availability across species, and do not define "availability". Data in this table are being used to argue that variability in nutrient content will determine the **feasibility** of displacing traditional feeds with DGS. It is not a

question of feasibility, but rather a question of managing variability and appropriately valuing and determining nutrient loading values of the source of DGS being fed.

2. Livestock **ARE** able to digest a much higher percentage of the protein (amino acid fraction) than the 16.8 to 28.8% that was indicated. Wet and dry DGS contains about 55% ruminally undegradable protein, and the crude protein digestibility of DGS for swine ranges from 58 to 71%. If protein digestibility were as low as indicated in this Appendix, there would be much lower levels of soybean meal or urea replaced in animal feeds by DGS than is currently done.

3. Yes, DGS is low in lysine content relative to the nutrient requirements of pigs and poultry. That is why **diets for swine and poultry** are supplemented with synthetic lysine and other amino acids to make up for low levels of lysine and a few other amino acids. Supplemental synthetic amino acids are generally not used in cattle diets.

4. High sulfur content of DGS can be a concern in cattle diets in geographic areas where sulfur content of water, forages and other feed ingredients are also high, and a high dietary inclusion rate (40%) of DGS with high sulfur content is fed. However, this has not limited DGS use in cattle feeds (38% of total DGS production is fed to beef feedlot cattle). Historically, there have been a few cases of polioencephalamalacia that have occurred in beef feedlots when high amounts of DGS containing high levels of sulfur have been fed along with high sulfur content of other feed ingredients.

5. The phosphorus content and digestibility in DGS is high (65 to 90%) for all species. This provides a significant nutritional advantage for DGS in swine and poultry diets because it allows for a significant reduction in the need for supplemental inorganic phosphate to meet the animals phosphorus requirement while substantially reducing diet cost. Furthermore, using DGS to displace corn and soybean meal, which have much lower phosphorus content and digestibility, can substantially reduce the amount of phosphorus excreted in manure.

6. Hogs do not get urinary calculi, but it can occur in ruminants. It is essential to add supplemental calcium to diets containing DGS because it is very low in calcium compared to phosphorus, and the proper calcium:phosphorus ratio must be maintained to insure optimal health and growth performance of all food animal species.

7. Lactating dairy cow diets high in fat do not cause milk to contain an unacceptably high fat content. Feeding high fat diets to lactating dairy cows actually can depress milk fat content. That is why dairy cattle feeds should not contain more than about 20% DGS to avoid potential milk fat depression.

8. While it is true that fine particle size of complete feeds can increase the incidence of gastric ulcers in swine, particle size of DGS often exceeds 700-800 microns and only represents a maximum of 20 to 30% of the diet. Particle size of corn and soybean meal has a greater effect on overall diet particle size than most sources of DGS.

9. DDGS is a preferred energy and protein source for cattle because the fermentable carbohydrate (fiber) in DDGS reduces the risk of rumen acidosis compared to feeding corn which has a very rapidly fermentable carbohydrate (starch) that can increase the risk of acidosis.

10. Handling of some sources of dried DGS and transportation costs of wet DGS are challenges but they have not prevented widespread use of DGS in livestock and poultry feeds domestically or in the export market.

11. Livestock producers depend on their nutritionists to help them use diets containing DGS to obtain the best performance at the lowest cost. The majority of animal nutritionists in the feed industry have extensive knowledge of the benefits and limitations of feeding DGS to various livestock and poultry species. Lack of knowledge may have limited DGS use several years ago, but not today.

12. Exports of DGS increased 91% in 2008 from 2.36 million MT to 4.51 MT. There is no doubt that the efforts of U.S. Grains Council have been extremely effective in increasing the export market for DGS.

13. The conclusions in this Appendix are not realistic or valid. The staff who compiled and wrote this Appendix have demonstrated great incompetence in their understanding of the use of DGS in animal feeds.

In summary, the Arora et al. (2008) report slightly overestimated the DGS displacement ratio by not accurately accounting for the contributions consumed by swine and poultry. Based on current estimates for market share for each species and a revised composite DGS displacement ratio, 1 kg or 1 lb of DGS can displace 1.244 kg or lbs of other dietary ingredients to achieve the same level of performance (or improved as with cattle), which is slightly lower, but similar to the value of 1.271 kg obtained in the Arora et al. (2008) report. The information contained in the CARB Appendix does not appear to acknowledge that **all** of the 26 million tonnes of DGS produced in 2008 **was** consumed by livestock and poultry, and inaccurately describes the nature of the challenges for increased use of DGS in livestock and poultry feeding in the future. The information contained in the CARB Appendix C11 is misleading and has no value in establishing land use credits for current DGS production and use.

Literature Cited

Augspurger, N. R., G. I. Petersen, J. D. Spencer, and E. N. Parr. 2008. Alternating dietary inclusion of corn distilelrs dried grains with solubles (DDGS) did not impact growth performance of finishing pigs. J. Anim. Sci. 86(Suppl. 1):523. (Abstr.)

Barbosa, F. F., S. S. Dritz, M. D. Tokach, J. M. DeRouchy, R. D. Goodband, and J. L. Nelsen. 2008. Use of distillers dried grains with solubles and soybean hulls in nursery pig diets. J. Anim. Sci. 86(Suppl. 1):446. (Abstr.)

Burkey, T. E., P. S. Miller, R. Moreno, S. S. Shepherd, and E. E. Carney. 2008. Effects of increasing levels of distillers dried grains with solubles (DDGS) on growth performance of weanling pigs. J. Anim. Sci. 86(Suppl. 2):50. (Abstr)

Cook, D., N. Paton, and M. Gibson. 2005. Effect of dietary level of distillers dried grains with solubles (DDGS) on growth performance, mortality, and carcass characteristics of grow-finish barrows and gilts. J. Anim. Sci. 83(Suppl. 1): 335. (Abstr.)

Cooper, G. 2006. A brief, encouraging look at theoretical distiller's grains markets. Distillers Grains Quarterly, First Quarter, p.14-17.

DeDecker, J. M., M. Ellis, B. F. Wolter, J. Spencer, D. M. Webel, C. R. Bertelsen, and B. A. Peterson. 2005. Effects of dietary level of distiller dried grains with solubles and fat on the growth performance of growing pigs. J. Anim. Sci. 83(Suppl. 2):79. (Abstr.)

Drescher, A. J., L. J. Johnston, G. C. Shurson, and J. Goihl. 2008. Use of 20% dried distillers grains with solubles (DDGS) and high amounts of synthetic amino acids to replace soybean meal in grower-finisher swine diets. J. Anim. Sci. 86(Suppl. 2):28. (Abstr.)

Duttlinger, A. W., M. D. Tokach, S. S. Dritz, J. M. DeRouchy, J. L. Goodband, R. D. Goodband, and H. J. Prusa. 2008. Effectsof increasing dietary glycerol and dried distillers grains with solubles on growth performance of finishing pigs. J. Anim. Sci. 86(Suppl. 1):607. (Abstr.)

Fu, S. X., M. Johnston, R. W. Fent, D. C. Kendall, J. L. Usry, R. D. Boyd, and G. L. Allee. 2004. Effect of corn distiller's dried grains with solubles (DDGS) on growth, carcass characteristics, and fecal volume in growing finishing pigs. J. Anim. Sci. 82 (Suppl. 2):80. (Abstr.)

Gaines, A. M., J. D. Spencer, G. I. Petersen, N. R. Augspurger, and S. J. Kitt. 2007b. Effect of corn distillers dried grains with solubles (DDGS) withdrawal program on growth performance and carcass yield in grow-finish pigs. J. Anim. Sci. 85 (Suppl. 1):438. (Abstr.)

Gaines, A., B. Ratliff, P. Srichana, and G. Allee. 2006. Use of corn distiller's dried grains and solubles in late nursery pig diets. J. Anim. Sci. 84 (Suppl. 2):120. (Abstr.)

Gatlin, L. A., M. T. See, D. K. Larick, X. Lin, and J. Odle. 2002. Conjugated linoleic acid in combination with supplemental dietary fat alters pork fat quality. J. Nutr. 132:3105-3112.

Gowans, J., M. Callaahan, A. Yusupov, N. Campbell, and M. Young. 2007. Determination of the impact of feeding increasing levels of corn dried distillers grains on performance of growing-finishing pigs reared under commercial conditions. Adv. Pork Prod. 18:A-22. (Abstr.)

Hill, G. M., J. E. Link, D. O. Liptrap, M. A. Giesemann, M. J. Dawes, J. A. Snedegar, N. M. Bello, and R. J. Tempelman. 2008a. Withdrawal of distillers dried grains with solubles (DDGS) prior to slaughter in finishing pigs. J. Anim. Sci. 86(Suppl. 2):52. (Abstr.)

Hinson, R. G. Allee, G. Grinstead, B. Corrigan, and J. Less. 2007. Effect of amino acid program (low vs. High) and dried distillers grains with solubles (DDGS) on finishing pig performance and carcass characteristics. J. Anim. Sci. 85(Suppl. 1):437. (Abstr.)

Jenkin, S., S. Carter, J. Bundy, M. Lachmann, J. Hancock, and N. Cole. 2007. Determination of P-bioavailability in corn and sorghum distillers dried grains with solubles for growing pigs. J. Anim. Sci. 85(Suppl. 2):113. (Abstr.)

Linneen, S. K., M. U. Steidiger, M. D. Tokach, J. M. DeRouchy, R. D. Goodband, S. S. Dritz, and J. L. Nelssen. 2006. Effects of dried distillers grain with solubles on nursery pig performance. Page 100–102 in Kansas State Univ. Swine Day Report. Kansas State Univ. Manhattan.

Linneen, S. K., J. M. DeRouchy, S. S. Dritz, R. D. Goodband, M. D. Tokach, and J. L. Nelssen. 2008. Effects of dried distillers grains with solubles on growing and finishing pig performance in a commercial environment. J. Anim. Sci. 86:1579-1587.

McEwen, P. 2008. Canadian experience with feeding DDGS. Page 115-120 in Proc. 8^{th} London swine conf. London, Ca, April 1-2, 2008.

McEwen, P. L. 2006. The effects of distillers dreid grains with solubles inclusion rate and gender on pig growth performance. Can. J. Anim. Sci. 86:594. (Abstr.)

Spencer, J. D., G. I. Petersen, A. M. Gaines, and N. R. Augsburger. 2007. Evaluation of different strategies for supplementing distillers dried grains with solubles (DDGS) to nursery pig diets. J. Anim. Sci. 85(Suppl. 2):96-97.(Abstr.)

Stender, D., and M. S. Honeyman. 2008. Feeding pelleted DDGS-based diets fo finishing pigs in deep-bedded hoop barns. J. Anim. Sci. 86(Suppl. 2):50. (Abstr.)

Weimer, D., J. Stevens, A. Schinckel, M. Latour, and B. Richert. 2008. Effects of feeding increasing levels of distillers dried grains with solubles to grow-finish pigs on growth performance and carcass quality. J. Anim. Sci. 86(Suppl. 2):51. (Abstr.)

White, H., B. Richert, S. Radcliffe, A. Schinckel, and M. Latour. 2007. Distillers dried grains decreases bacon lean and increases fat iodine values (IV) and the ratio og n6:n3 but conjugated linoleic acids partially recovers fat quality. J. Anim. Sci. 85(Suppl. 2):78. (Abstr.)

Whitney, M. H., and G. C. Shurson. 2004. Growth performance of nursery pigs fed diets containing increasing levels of corn distillers dried grains with solubles originating from a modern Midwestern ethanol plant. J. Anim. Sci. 82:122-128.

Whitney, M. H., G. C. Shurson, L. J. Johnson, D. M. Wulf, and B. C. Shanks. 2006a. Growth performance and carcass characteristics of grower-finisher pigs fed high-quality corn distillers dried grain with solubles originating from a modern Midwestern ethanol plant. J. Anim. Sci. 84:3356-3363.

Widmer, M. R., L. M. McGinnis, D. M. Wulf, and H. H. Stein. 2008. Effects of feeding distillers dried grains with solubles, high-protein distillers dried grains, and corn germ to growing-finishing pigs on pig performance, carcass quality, and the palatability of pork. J. Anim. Sci. 86:1819-1831.

Widyaratne, G. P., and R. T. Zijlstra. 2007. Nutritional value of wheat and corn distillers dried grain with solubles: Digestibility and digestible contents of energy, amino acids and phosphorus, nutrient excretion and growth performance of grower-finisher pigs. Can. J. Anim. Sci. 87:103-114.

Xu, G., S. K. Baidoo, L. J. Johnston, J. E. Cannon, and G. C. Shurson. 2007a. Effects of adding increasing levels of corn dried distillers grains with solubles (DDGS) to corn-soybean meal diets on growth performance and pork quality of growing-finishing pigs. J. Anim. Sci. 85(Suppl. 2):76. (Abstr.)

Xu, G., G. C. Shurson, E. Hubly, B. Miller, and B. de Rodas. 2007b. Effects of feeding corn-soybean meal diets containing 10% distillers dried grains with solubles (DDGS) on pork fat quality of growing-finishing pigs under commercial production conditions. J. Anim. Sci. 85(Suppl. 2):113. (Abstr.)

Xu, G., S. K. Baidoo, L. J. Johnston, J. E. Cannon, D. Bibus, and G. C. Shurson. 2008. Effects of dietary corn dried distillers grains with solubles (DDGS) and DDGS withdrawal intervals, on pig growth performance, carcass traits, and fat quality. J. Anim. Sci. 86(Suppl. 2):52. (Abstr.