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Impact of Feeding Byproducts on Nutrient Management

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This NebGuide presents the effects of feeding byproducts in beef feedlot diets as they relate to nutrient management, and gives recommendations designed for managing dietary phosphorus and nitrogen.

When distillers grains plus solubles (DGS) is fed as an energy source, dietary nitrogen (N) and phosphorus (P) exceed nutritional requirements. In distillers grains (DGS) production from corn, starch is fermented into alcohol and CO_2. This concentrates the remaining nutrients by about three times. As a result, DGS contains about 32 percent crude protein (CP) and 0.85 percent P (*Table I*). Nutrient variation of byproducts does, however, exist from plant to plant and even within a given ethanol plant. Excess N and P fed are excreted on the pen surface. Since P is not volatilized, the majority of P excreted remains in the manure. Excess N fed when DGS is included as an energy source has the potential of being volatilized from the pen surface.

Table I. Nutrient composition of common feedlot ingredients (% of DM).

Feedstuff[1]	*% DM*	*% CP*	*% P*
DRC	86.0	9.0	0.32
WCGF	44.7	19.5	0.66
Sweet Bran	60.0	24.0	0.99
DDGS	90.4	33.9	0.81
MDGS	46.2	30.6	0.84
WDGS	34.9	31.0	0.84
CCDS	32.5	23.5	1.72
Steep	49.4	35.1	1.92

[1]DRC=dry rolled corn, WCGF=wet corn gluten feed, Sweet Bran is Cargill wet corn gluten feed, DDGS=dry distillers grains plus solubles, MDGS=modified distillers grains plus solubles, WDGS=wet distillers grains plus solubles, CCDS=condensed corn distillers solubles (corn syrup), Steep = steep liquor from wet milling plants.

As DGS increases in the diet, nutrient intake increases. However, cattle retain similar amounts of nutrients and as a result, nutrient excretion increases. Nutrient mass balance from two different feeding periods are shown in *Table II* when DGS were fed to calves or yearlings at 15 or 30 percent of the diet dry-matter. Nutrient excretion is calculated by subtracting the amount of nutrient retention from the amount of intake. The excreted nutrient is the amount of nutrient in the manure, runoff, and what may leach into the soil. Since P is not volatilized, as WDGS inclusion increases in the diet, manure P also increases. This amount is a direct reflection of the amount of byproducts in the diet. Unlike P, a portion of N is volatilized and unavailable for crop uptake. The amount of N volatilized increases with increasing levels of DGS. However, manure N:P ratios remain similar.

Nitrogen volatilization is greater in the summer than in the winter. About 50 percent of N is lost via volatilization in the winter, and about 70 percent is lost in the summer due to effects of temperature and moisture.

Table II. Effect of dietary treatment on nutrient mass balance.

	WINTER[a]			*SUMMER*[b]		
Dietary Treatment[c]	*CON*	*15*	*30*	*CON*	*15*	*30*
N intake	69.4	79.8	98.4	63.8	78.3	94.6
N retention[d]	12.2	12.7	13.0	10.1	10.9	10.8
N excretion[e]	57.1	67.1	85.3	53.6	67.3	83.9
N Run-off	1.03	1.18	1.72	19.8	21.3	22.1
Manure N	25.2	24.0	38.1	2.6	1.9	3.4
N lost[f]	30.9	42.0	45.5	31.2	44.1	58.4
N loss, %	55.1	63.8	55.0	58.1	65.6	69.6
P intake	11.5	14.4	17.2	11.4	13.5	16.0
P retention[c]	3.0	3.1	3.2	3.1	3.3	3.3
P excretion[d]	8.6	11.3	14.0	8.3	10.2	12.7
Manure P	8.4	9.0	14.4	7.2	6.3	7.2
Run-off P	0.5	0.3	0.4	1.0	0.7	0.7
Manure N:P ratio	3.06	2.81	2.65	3.06	4.03	3.95

[a]Values are expressed as lb/steer over 167-day feeding period.
[b]Values are expressed as lb/steer over 133-day feeding period.
[c]CON=Control corn-based diet with no WDGS, 15=15% WDGS (DM basis), 30=30% WDGS (DM basis).
[d]Calculated using NRC (1996) net energy, protein, and phosphorus equations.
[e]Excretion=Intake-Retention.
[f]Calculated as nutrient excretion minus manure nutrient.

Recommendations to consider when feeding byproducts.

- Do not supplement phosphorus in the diet.
- Reduce N intake by utilizing the metabolizable protein (MP) system.
- Nutrient Management Plan should reflect dietary nutrients.
- Increase carbon on the pen surface.
- Increase pen cleaning frequency.
- Manure stockpile or composting.
- Apply manure as a fertilizer on a 4-year P basis.

Do not supplement Phosphorus in the diet.

Phosphorus requirements for calf-feds and yearlings are 0.16 percent and 0.14 percent of diet dry-matter, respectively. Most common feedlot diets exceed these requirements. Corn is about 0.32 percent P, which is well above dietary P requirement. In a common diet where DGS is fed at a 40 percent inclusion level the resulting diet will contain about 0.55 percent P; this is more than three times the animal requirement for growth. Supplementing mineral P in finishing diets is unnecessary, and results in economic costs and possibly environmental challenges.

Reducing N Intake by Utilizing the Metabolizable Protein System.

The metabolizable protein (MP) system presented in the 1996 Nutrient Requirements of Beef Cattle (NRC) allows us to more accurately formulate feedlot diets so that requirements are met but protein (N) is not oversupplied, reducing N excretion and losses. Protein requirements change during the feeding period as body weight increases. When diets are formulated to not exceed degradable intake protein (DIP) and undegradable intake protein (UIP) requirements, N intake is reduced by 19 percent; this led to a 32.5 percent decrease in the amount of N volatilized.

Nutrient Management Plan should reflect dietary nutrients.

As byproducts increase in the diet, management planning issues should address:

- *Greater land requirements.* Increasing dietary nutrients by including high levels of byproducts in the diet increases the land required in nutrient management plans. For instance, a 0.55 percent P diet, in which WDGS is included at 40 percent of the diet DM, would increase the land requirement for P-based application by about 90 percent, compared to a 0.30 percent P diet with no byproducts are fed for P-based application. Land required for P-based applications typically increases by a factor of about four over N-based applications.

- *Greater travel distances and time requirements for manure distribution increase labor and equipment needs.* Nutrient Management Plans should account for additional labor and equipment requirements when byproducts are added to the diet. Land application based on a one-year P-basis increases land, expenses, and time needed for application compared to applying manure on a N-basis.

- *Greater need for management practices that minimize soil erosion and runoff for fields receiving higher P-content manures.* Over-application of P increases P runoff from fields and can cause eutrophication. Eutrophication enhances undesirable algae growth in lakes and streams creating a bloom that depletes oxygen levels in the water that may lead to fish kills. The best way to minimize problems is with routine soil testing to avoid soil P build-up due to over-application of P.

Table III illustrates the value, cost, and net return of manure from a corn-based diet compared to one containing DGS, during the summer and winter at three different rates of N volatilization. Manure from cattle fed DGS diets have greater nutrient concentrations and also greater economic value ($5-8/head compared to corn-based diets). Even though there is greater labor, machinery, and operating costs associated with DGS diets, net returns were about $5/head greater. Manure is more valuable when less N is volatilized. The most valuable manure in this scenario is from steers fed a DGS diet when only 20 percent of N is lost via volatilization.

Table III. Manure Economics: Comparing corn-based and 40% DGS diets with either 70, 50, or 20% N loss and applying manure on an annual N basis.

	*Manure Value**	*Spreading Cost**	*Net Value**
Summer (70% N Loss)			
Corn (13.0% CP; 0.3% P)	$12.42	$ 7.22	$ 5.20
DGS (18.2% CP; 0.5% P)	$17.86	$ 8.40	$ 9.46
Winter (50% N Loss)			
Corn (13.0% CP; 0.3% P)	$14.78	$ 8.98	$ 5.80
DGS (18.2% CP; 0.5% P)	$21.34	$10.92	$10.42
Reduced N Loss (20% N Loss)			
Corn (13.0% CP; 0.3% P)	$18.34	$11.36	$ 6.98
DGS (18.2% CP; 0.5% P)	$26.58	$14.46	$12.12

*Values expressed as $/head.
Assumptions: 5,000 head feedlot; 750-1,300 lb steer; 23 lb DMI; 144 DOF; 100 head/pen; open lot; winter; 80 acre fields; 50 percent in crops; 50/50 corn and soybean; corn yield = 120 bu/acre; soybean yield = 35 bu/acre; $0.40/lb N; $0.27/lb P_2O_5; $0.20/lb K_2O.

Increase carbon on the pen surface.

Adding carbon (C) to the pen surface may increase the C:N ratio of feedlot manure, which may trap more N. Increasing C on the pen surface can be achieved by feeding diets that are less digestible or by adding C (i.e. bedding) to the pen surface. Feeding a less digestible energy source increases the amount of organic matter (OM) on the pen surface, and that increases the amount of N recovered in the manure. These diets may consist of higher roughage, gluten feed, or corn bran inclusion levels. The consequences of feeding a less digestible energy source are reduced animal performance and increased manure on the pen surface.

Increase pen cleaning frequency.

Increasing pen cleaning frequency reduces the total N loss to the environment. Based upon research at the University of Nebraska–Lincoln, manure N from pens that are cleaned monthly nearly doubles compared to cleaning pens once at the end of the feeding period. Monthly cleaning reduced the total N loss to the environment by an average of 14 percent.

Table IV. Comparing manure economics from a DGS diet with 50% N losses (Winter) when spread on 1-year nitrogen, 1-year phosphorus, or 4-year phosphorus basis.

	Manure Economics 50% N loss, WDGS Diet				
	$/head			*Acres/head*	
	Value	*Spreading Cost*	*Net*	*Total Land*	*Single Year*
1-Year N-Based	$21.34	$10.92	$10.42	0.19	0.19
1-Year P-Based	$21.34	$29.04	- $7.70	0.79	0.79
4-Year P-Based	$21.34	$11.76	$9.58	0.80	0.20

Assumptions: 5,000 head feedlot; 750-1,300 lb steer; 23 lb DMI; 144 DOF; 100 head/pen; open lot; winter; 80 acre fields; 50 percent in crops; 50/50 corn and soybean; corn yield = 120 bu/acre; soybean yield = 35 bu/acre; $0.40/lb N; $0.27/lb P_2O_5; $0.20/lb K_2O.

When pens from cattle fed a high inclusion DGS diet are cleaned monthly, manure N increases and the amount of N lost via volatilization decreases. When manure is allowed to collect on pen surfaces during the entire feeding period, more N is exposed to the environment and volatilization increases.

Stockpile vs. Composting Manure

Stockpiled manure appears to have greater value as a fertilizer compared with composted manure. Stockpiling manure results in greater total N recovered in manure, which can be available for crop uptake. Dry matter losses and moisture content are similar between the two methods, depending on management and initial manure nutrient concentration. If the total mass hauled to the field is not different among the two methods, the added costs for management, labor, land, and equipment needed for composting may not be offset by decreased transportation cost to the field. When these factors are coupled with nutrient loss, anaerobic stockpiling of feedlot manure may be more economically favorable compared with composting in some situations. The amount of moisture in the manure has a large impact on the storage or management method.

Apply Manure as a Fertilizer on a 4-Year Phosphorus Basis.

If manure is applied every year to the same ground on an N basis, P is being over applied by three to six times. The amount of land required for annual P-based applications typically increases by a factor of about four compared with N-based applications. *Table IV* illustrates that manure from cattle fed a WDGS diet in the winter would require about 0.19 acres/head if applied on an annual N basis, compared to 0.80 acres/head on an annual P basis. Land, expenses, and time needed for application increases when manure is applied annually on a P-basis compared to N-basis, at $29.04 and $10.92, respectively.

Applying manure on an annual N basis can pose environmental problems if excess P is not accounted for. Applying manure on an annual P basis is expensive and unnecessary. *Table IV* shows that the cost of applying P annually is the most expensive at $29.04/head, resulting in a net return of -$7.70/head. It also requires the greatest amount of land to spread (0.79 acres/head). When applying manure on an annual P basis crop N requirements will not be met, resulting in extra costs to cover the same ground with more N. Additionally, applying P annually is unnecessary, because multiple years of crop P requirements can be applied in a single application and will be available to crops in following years.

Phosphorus should be applied on a 4-year basis, which provides for multiple years of P in a single application. Applying on a 4-year P basis also meets crop requirements for N for the equivalent of one year. The following three years N should be applied without P followed by manure application again after four years. By implementing this method, manure nutrient potential is maximized and crop P requirements are met without being exceeded. This is a more cost-efficient method.

As byproducts become more commonly used in feedlot diets, the amount of N and P intake increases, as does the amount of N and P excreted by the animal. However, if these nutrients are managed effectively through the feedlot, producers can diminish costs associated with supplementing P and reduce N lost via volatilization, as well as benefit from utilizing manure as fertilizer.

Additional information can be found in UNL Extension publication G2250, *Managing Manure Phosphorus from Feedlots;* G2252, *Beef Feedlot Nitrogen Management;* and RP190, *Impact of Feeding Distillers Grains on Nutrient Planning for Beef Cattle Systems.*

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Index: Beef
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