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Matt K. Luebbe
University of Nebraska - Lincoln, mluebbe2@unl.edu

Galen E. Erickson
University of Nebraska-Lincoln, gerickson4@unl.edu

Terry J. Klopfenstein
University of Nebraska-Lincoln, tklopfenstein1@unl.edu

Matthew A. Greenquist
University of Nebraska-Lincoln, mgreenquist2@unl.edu

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Nutrient Mass Balance and Performance of Feedlot Cattle Fed Wet Distillers Grains

Matt K. Luebbe
Galen E. Erickson
Terry J. Klopfenstein
Matt A. Greenquist[1]

Summary

Two experiments were conducted to evaluate effects of three dietary inclusions (0%, 15%, and 30%, DM basis) of wet distillers grain plus solubles (WDGS) on feedlot performance and nutrient mass balance in open feedlots. Replacing corn with WDGS increased ADG response and HCW in both experiments. Feeding WDGS balanced for MP (15%) or in excess of requirements (30%) resulted in more OM in the manure but only more manure N in the winter experiment. Percentage N loss was not different among WDGS level but the amount of N lost was increased when WDGS were fed due to greater N excretion compared with cattle fed the control diet. Increasing dietary P with WDGS resulted in more phosphorus in the manure.

Introduction

Improving the C:N ratio of feedlot manure by increasing roughage levels or using a less digestible NDF source reduces the amount of nitrogen lost to volatilization. Corn bran with steep inclusion (wet corn gluten feed) was effective in reducing N losses in the winter as well as maintaining cattle performance (*2005 Nebraska Beef Report*, pp. 54-56). Wet distillers grains with solubles (WDGS) improves cattle performance and is moderate in neutral detergent fiber content (35% to 30% NDF). The NDF may trap more N in the manure but WDGS have levels of CP (30% to 35%) which may not be trapped by the additional OM in the manure. The objectives of this study were to evaluate effects of WDGS level on steer performance and nutrient mass balance.

Procedure

Cattle Performance

Two experiments were conducted using 96 steers each, calves (649 ± 73 lb BW) were fed 167 days from November to May (WINTER) and yearlings (820 ± 54 lb BW) fed 133 days from May to October (SUMMER) to evaluate wet distillers grains with solubles (WDGS) level on N and P balance in open feedlots. Steers were blocked by BW, stratified within block and assigned randomly to pen (8 steers/pen). Dietary treatments consisted of 0%, 15%, and 30% dietary inclusion of WDGS (DM basis) replacing corn (CON, 15WDGS, and 30WDGS, respectively). Traditional WDGS (32% DM) was fed in the WINTER and modified WDGS (48% DM) was fed in the SUMMER experiment. Basal diets for both experiments consisted of high-moisture and dry-rolled corn fed at a 1:1 ratio, 7.5% alfalfa hay, 5% molasses, and 5% supplement (DM basis). Corn gluten meal (65% CP) was included in the CON diet at 3.5% for 90 days for WINTER steers and 2.0% for 60 days for SUMMER steers to meet the metabolizable requirement of those calves. Cattle were adapted to finishing diets over a 21-day period with the corn blend replacing alfalfa hay. The CON and 15WDGS diets were balanced for MP using the 1996 NRC while the 30WDGS was in excess of requirements. Crude protein concentrations were 13.1%, 13.9%, and 17.0% for CON, 15WDGS, and 30WDGS, respectively in the WINTER and 13.0%, 13.8%, and 16.9%, in the SUMMER. Dietary P concentrations were 0.33%, 0.43%, and 0.48%, for CON, 15WDGS, and 30WDGS (respectively) in the WINTER and 0.34%, 0.39%, and 0.46% in the SUMMER. Rumensin, Tylan and Thiamine were fed at 320, 90, and 130 mg/head/day (respectively) in both experiments.

Steers in the WINTER experiment were implanted on d1 with Synovex Calf (Fort Dodge Animal Health, Overland Park, Kan.) followed by Revelor-S (Intervet Inc., Somerville, N.J.) on day 67. Steers in the SUMMER experiment were implanted once on day 1 with Revelor-S. Steers were slaughtered on day 167 (WINTER) and day 133 (SUMMER) at a commercial abattoir (Greater Omaha, Omaha, Neb.). Hot carcass weight and liver scores were recorded on day of slaughter. Fat thickness and LM area were measured after a 48-hour chill and USDA called marbling score was recorded. Final BW, ADG, and feed efficiency were calculated based on hot carcass weights adjusted to a common dressing percentage of 63.

Nutrient Balance

Nutrient mass balance experiments were conducted using 12 open feedlot pens with retention ponds to collect runoff. When rainfall occurred, runoff collected in the retention ponds was drained and quantified using an air bubble flow meter (ISCO, Lincoln, Neb.). Before placing cattle in pens, 16 soil core samples (6 inch depth) were taken from each pen in both experiments. After cattle were removed from the pens, manure was piled on a cement apron and sampled (n = 30) for nutrient analysis while being loaded. Manure was weighed before it was hauled to the University of Nebraska compost yard. Manure was freeze-dried for nutrient analysis and oven dried for DM removal calculation. After manure was removed, additional soil core samples were taken from each pen.

Ingredients were sampled monthly and feed refusals were analyzed to determine nutrient intake using a weighted composite on a pen basis. Retained steer N and P were calculated using the energy, protein, and P equations (NRC, 1996). Nutrient excretion was

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Table 1. Growth performance and carcass characteristics for steers fed during WINTER.

Dietary Treatment[a]:	CON	15	30	SEM	*P*-value[b]
Performance					
Initial BW, lb	648	654	650	6	0.61
Final BW, lb[c]	1251	1279	1295	17	0.10
DMI, lb/day[c]	20.7	21.2	21.5	0.4	0.19
ADG, lb[c]	3.55	3.68	3.80	0.10	0.14
Feed: Gain	5.83	5.77	5.66	0.06	0.27
Carcass Characteristics					
Hot Carcass Weight, lb[c]	789	806	816	11	0.10
Marbling Score[d,e]	545[f]	533[f]	577[g]	7	< 0.01
Ribeye Area in.	13.9	14.0	13.7	0.2	0.44
12th Rib Fat, in	0.49	0.47	0.43	0.04	0.29

[a]Dietary treatments: CON = Control corn-based diet with no WDGS, 15% = 15 % WDGS (DM basis), 30 = 30% WDGS (DM basis).
[b]*F*-test statistic for dietary treatment.
[c]Linear effect of WDGS level.
[d]400 = Slight 0, 500 = Small 0.
[e]Quadratic effect of WDGS level.
[f,g]Within a row, means without a common superscript letter differ ($P < 0.05$).

Table 2. Growth performance and carcass characteristics for steers fed during SUMMER.

Dietary Treatment[a]:	CON	15	30	SEM	*P*-value[b]
Performance					
Initial BW, lb	824	825	822	10	0.96
Final BW, lb	1350	1392	1381	18	0.10
DMI, lb/day	25.0	26.0	25.9	0.4	0.13
ADG, lb[c]	3.96[e]	4.27[f]	4.21[f]	0.10	0.05
Feed: Gain	6.53	6.17	6.23	0.16	0.38
Carcass Characteristics					
Hot Carcass Weight, lb[c]	850	877	870	8	0.10
Marbling Score[d]	478	514	498	13	0.09
Ribeye Area in.	13.1	13.0	13.2	0.3	0.85
12th Rib Fat, in	0.47	0.57	0.53	0.14	0.12

[a]Dietary treatments: CON = Control corn-based diet with no WDGS, 15 = 15 % WDGS (DM basis), 30 = 30% WDGS (DM basis).
[b]*F*-test statistic for dietary treatment.
[c]Linear effect of WDGS level.
[d]400 = Slight 0, 500 = Small 0.
[e,f]Within a row, means without a common superscript letter differ ($P < 0.05$).

Table 3. Effect of dietary treatment on nitrogen mass balance during WINTER.[a]

Dietary Treatment[b]:	CON	15	30	SEM	*P*-value[c]
N intake[d]	69.4[i]	79.8[j]	98.4[k]	1.6	< 0.01
N retention[d,e]	12.2	12.7	13.0	0.3	0.08
N excretion[d,f]	57.1[i]	67.1[j]	85.3[k]	1.6	< 0.01
Manure N[d,g]	25.2[i]	24.0[i]	38.1[j]	5.2	0.04
N Run-off	1.03	1.18	1.72	0.36	0.18
N lost[d]	30.9[i]	42.0[j]	45.5[j]	4.6	0.03
N loss, %[h]	55.1	63.8	55.0	6.8	0.37
DM removed	1691	1877	2033	231	0.37
OM removed[d]	350	447	480	58	0.12

[a]Values are expressed as lb/steer over entire feeding period (167 DOF) unless noted.
[b]Dietary treatments: CON = Control corn-based diet with no WDGS, 15 = 15 % WDGS (DM basis), 30 = 30% WDGS (DM basis).
[c]*F*-test statistic for dietary treatment.
[d]Linear ($P < 0.05$) effect of WDGS level.
[e]Calculated using the NRC net protein and net energy equations.
[f]Calculated as N intake - N retention.
[g]Manure N with correction for soil N.
[h]Calculated as N lost divided by N excretion.
[i,j,k]Within a row, means without a common superscript letter differ ($P < 0.05$).

determined by subtracting nutrient retention from intake (ASABE, 2005). Total N lost (lb/steer) was calculated by subtracting manure N (corrected for soil N content) and runoff N from excreted N. Percentage of N lost was calculated as N lost divided by N excretion. Dietary treatments were fed in the same pens for both experiments. Animal performance data were analyzed as a randomized complete block design with pen as the experimental unit. Nutrient balance data were analyzed as a completely randomized design. Orthogonal contrasts were used to test significance for linear and quadratic response to WDGS level for both animal performance and mass balance data.

Results

Feedlot Performance

Dry matter intake, ADG, final BW, and HCW increased linearly ($P < 0.05$) with WDGS level in the WINTER experiment (Table 1). Marbling score was greater ($P < 0.01$) for 30WDGS compared with both CON and 15WDGS in the WINTER experiment. Average daily gain and HCW increased linearly ($P < 0.05$) with WDGS level in the SUMMER (Table 2). However, feed efficiencies were not different ($P > 0.10$) among treatments in either experiment. Ribeye area, liver scores, and 12th rib fat depth were not influenced ($P > 0.10$) by WDGS level in either experiment.

Nutrient Balance

Nitrogen intakes were greatest ($P < 0.01$) for 30WDGS, intermediate for 15WDGS, and least for CON in both experiments (Tables 3 and 4). Nitrogen retention increased linearly ($P < 0.05$) with WDGS level in the WINTER due to ADG response, but was not different ($P = 0.16$) in the SUMMER. Excretion of N was greatest ($P < 0.01$) for 30WDGS, intermediate for 15WDGS, and least for CON in both experiments. Manure N was greater ($P = 0.04$) for 30WDGS compared with 15WDGS and CON in the WINTER. Manure N was not different ($P = 0.89$) among WDGS level in the SUMMER. Amount of N lost (lb/steer) was greater ($P = 0.03$) for 30WDGS and 15WDGS compared with CON in the WINTER. In the SUMMER, amount of N lost was greatest ($P < 0.01$) for 30WDGS, intermediate for 15WDGS, and least for CON. When expressed as a per-

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centage of N excretion, loss of N was not different ($P > 0.20$) among dietary treatments in both experiments. The amount of OM removed from the pen surface linearly increased ($P < 0.05$) with WDGS level in the WINTER. Dry matter and OM removed in the SUMMER were greater ($P < 0.05$) for 30WDGS compared with either 15WDGS or CON. These results suggested that WDGS increased OM removed and manure N removed in the WINTER but did not compensate for all of excreted N fed with WDGS. Runoff did not constitute much of what was excreted in either experiment, resulting in 1.8% to 2.0% of N in the WINTER and 2.8% to 4.9% in the SUMMER.

When WDGS was fed, P intake linearly increased ($P < 0.05$) for both experiments (Tables 5 and 6). Retention of P linearly increased ($P < 0.05$) with WDGS level in the WINTER due to ADG response but was not different ($P = 0.16$) among WDGS levels for the SUMMER experiment. Excretion of P linearly increased with WDGS level ($P < 0.01$) in both experiments. Similarly, manure P linearly increased in both experiments with WDGS level ($P < 0.01$). Correcting manure for soil P accounted for 98%, 79%, and 102% of excreted P in the WINTER and 87%, 62%, and 57% of excreted P in the SUMMER for CON, 15WDGS, and 30WDGS, respectively. Lower P recoveries in the SUMMER may be due to the dryer conditions when the pens are cleaned in the fall. In dry conditions P may not be removed because the soil is not as thoroughly mixed with the manure compared with wet conditions found in the spring cleaning. These results for P mass balance are similar to previous studies (*2000 Nebraska Beef Report*, pp. 65-67). Runoff P was not different ($P > 0.10$) among WDGS level and averaged 3.8%, and 9.5% of excreted P for WINTER and SUMMER, respectively.

These data suggest increasing dietary P will increase manure P and the amount of land needed for manure application. The results from this study suggest feeding WDGS improves cattle performance; however, N losses are greater when WDGS are used by feedlot cattle compared with corn in feedlot rations.

Table 4. Effect of dietary treatment on nitrogen mass balance during SUMMER.[a]

Dietary Treatment[b]:	CON	15	30	SEM	*P*-value[c]
N intake[d]	63.8 [i]	78.2 [j]	94.6 [k]	1.2	< 0.01
N retention[e]	10.1	10.9	10.8	0.3	0.16
N excretion[d,f]	53.6 [i]	67.3 [j]	83.9 [k]	1.1	< 0.01
Manure N[g]	19.8	21.3	22.1	5.0	0.89
N Run-off	2.6	1.9	3.4	1.2	0.53
N lost [d]	31.2[i]	44.1 [j]	58.4 [k]	5.1	< 0.01
N loss, %[h]	58.1	65.6	69.6	7.2	0.15
DM removed	1140[i]	1167[i]	2208[j]	354	0.02
OM removed[d]	216[i]	237[i]	343[j]	45	0.04

[a]Values are expressed as lb/steer over entire feeding period (133 DOF) unless noted.
[b]Dietary treatments: CON = Control corn-based diet with no WDGS, 15 = 15 % WDGS (DM basis), 30 = 30% WDGS (DM basis).
[c]*F*-test statistic for dietary treatment.
[d]Linear ($P < 0.05$) effect of WDGS level.
[e]Calculated using the NRC net protein and net energy equations.
[f]Calculated as N intake - N retention.
[g]Manure N with correction for soil N.
[h]Calculated as N lost divided by N excretion.
[i,j,k]Within a row, means without a common superscript letter differ ($P < 0.05$).

Table 5. Effect of dietary treatment on P mass balance during WINTER.[a]

Dietary Treatment[b]:	CON	15	30	SEM	*P*-value[c]
P intake[d]	11.5 [i]	14.4 [j]	17.2 [k]	0.3	< 0.01
P retention[d,e]	3.0	3.1	3.2	0.1	0.12
P excretion[d,f]	8.6 [i]	11.3 [j]	14.0 [k]	0.3	< 0.01
Manure P[d]	6.1 [i]	8.4 [i,j]	9.9 [j]	1.1	0.02
Run-off P	0.5	0.3	0.4	0.1	0.66
P manure+soil[d,g]	8.4 [i]	9.0 [i]	14.4 [j]	1.9	0.02
N:P ratio[h]	3.06	2.81	2.65	0.36	0.53

[a]Values are expressed as lb/steer over entire feeding period (167 DOF) unless noted.
[b]Dietary treatments: CON = Control corn-based diet with no WDGS, 15 = 15 % WDGS (DM basis), 30 = 30% WDGS (DM basis).
[c]*F*-test statistic for dietary treatment.
[d]Linear ($P < 0.05$) effect of WDGS level.
[e]Calculated using the NRC net protein and net energy equations.
[f]Calculated as P intake - P retention.
[g]Correction for soil P.
[h]Nitrogen to Phosphorus ratio, DM basis.
[i,j,k]Within a row, means without a common superscript letter differ ($P < 0.05$).

Table 6. Effect of dietary treatment on P mass balance during SUMMER.[a]

Dietary Treatment[b]:	CON	15	30	SEM	*P*-value[c]
P intake[d]	11.4 [i]	13.5 [j]	16.0 [k]	0.2	< 0.01
P retention[d,e]	3.1	3.3	3.3	0.1	0.16
P excretion[d,f]	8.3 [i]	10.2 [j]	12.7 [k]	0.2	< 0.01
Manure P[d]	4.5 [i]	5.7 [i]	9.5 [j]	1.2	< 0.01
Run-off P	1.0	0.7	0.7	0.4	0.79
P manure+soil[d,g]	7.2	6.3	7.2	2.8	0.93
N:P ratio[d,h]	3.06	4.03	3.95	1.26	0.70

[a]Values are expressed as lb/steer over entire feeding period (133 DOF) unless noted.
[b]Dietary treatments: CON = Control corn-based diet with no WDGS, 15 = 15 % WDGS (DM basis), 30 = 30% WDGS (DM basis).
[c]*F*-test statistic for dietary treatment.
[d]Linear ($P < 0.05$) effect of WDGS level.
[e]Calculated using the NRC net protein and net energy equations.
[f]Calculated as P intake - P retention.
[g]Correction for soil P.
[h]Nitrogen to Phosphorus ratio, DM basis.
[i,j,k]Within a row, means without a common superscript letter differ ($P < 0.05$).

[1]Matt K. Luebbe, research technician; Galen E. Erickson, associate professor; Terry J. Klopfenstein, professor, Matt A. Greenquist, research technician, Animal Science, Lincoln.

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