The impact of housing system on feedlot performance, carcass outcomes, and nutrient management of winter and summer fed steers

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Introduction

Finishing cattle under shelter in the Midwest can improve cattle comfort by protecting cattle from exposure to wind, mud, and hot or cold weather. Similarly, research conducted in Canada reported feeding cattle on roller compacted concrete (RCC) surfaced open lot pens tended to improve ADG and feed conversion when compared to cattle finished in traditional soil-based pens. However, performance responses observed across studies have been variable and many studies were conducted in climates unlike Eastern Nebraska/Western Iowa. Additionally, there are limited data comparing manure quantity and quality across housing systems in controlled studies (same cattle sources and diets). Therefore, the primary objective of this project was to determine the differences in finishing performance, carcass characteristics, and manure quantity and quality between finishing housing systems.

Materials and Methods

Finishing Performance and Carcass Characteristics

The procedures used in this study were approved by the University of Nebraska Institutional Animal Care and Use Committee. A finishing experiment using 1856 (initial BW = 811 ± 69 lb) yearling crossbred steers fed for an average of 166 d from October 15th 2024 until April 15th 2025 and 1840 (initial BW = 745 ± 72 lb) yearling crossbred steers fed for an average of 196 d from April 15th 2025 until November 11th 2025 was conducted at the Klosterman Feedlot Innovation Center (Mead, NE) to determine the effect of housing system (roller-

compacted concrete open lot pens, soil-based open lot pens, monoslope deep-pit slatted floor barn, and gable-roof deep-pit slatted floor barn) on finishing performance, carcass characteristics, and manure nutrient composition. Winter fed steers were received at the Eastern Nebraska Research and Extension and Education Center on October 15th, 18th, 22nd, and 25th 2024. Steers were processed, weighed, and assigned to pens at arrival. Summer fed steers were received at the Eastern Nebraska Research and Extension and Education Center on April 15th, 18th, 22nd, and 25th 2025. Steers were processed, weighed, and assigned to pens at arrival. Pens were blocked by arrival date (4 blocks and 2 replications per block) and assigned randomly to 1 of 4 treatments. Cattle were assigned randomly to pens (blocks 1, 3, and 4 = 60 hd/pen, block 2 winter = 52 hd/pen, block 2 summer = 50 hd/pen) based on weight at receiving and expected weight variation from purchase. On arrival steers were administered safeguard (Merk), Bovi-Shield Gold (Zoetis), Ultrabac 7 (Zoetis), Dectomax (Zoetis), and Revalor XS (Merk).

Steers assigned to the roller compacted concrete (RCC) treatment were stocked at 115 square foot per head (Block 2: 132.7 square foot per head in the winter and 138 square foot per head in the summer). Roller compacted concrete pens were bedded with one bale of wheat straw once every two weeks and as needed due to weather in the winter and after cleaning and as needed due to weather in the summer. Bedding added to RCC pens averaged 1.4 lb/steer daily over the winter feeding period and 1.1 lb/steer daily over the summer feeding period. Soil-based open lot pens (Soil) were stocked at 325 square foot per head (Block 2: 375 square foot per head in the winter and 390 square foot per head in the summer). Steers assigned to the monoslope barn and the gable roof barn were stocked at 25 square foot per head (Block 2: 28.8 square foot per head in the winter and 30 square foot per head in the summer).

Steers were fed a starter diet for 10 d after arrival before beginning adaptation to the finishing diet. Following the 10d starter period cattle were adapted to the finishing diet using a 2 ration blend adaptation. Steers were fed twice daily with the starter ration being fed at the first feeding and the finishing diet being fed at the second feeding. Over 6 d steers were fed 75% of the feed call as the starter ration at first feeding and 25% of the feed call as the finishing ration at the second feeding. Steers were then fed the 50:50 starter to finisher blend for 6 d, followed by a 25:75 blend for 6 d before the final finishing diet was fed at 100%. Pens assigned to the roller compacted concrete and soil-based open lot pens were fed a southern plains steam flaked corn based diet while pens assigned to the monoslope barn and gable roof barn were fed a northern plains dry rolled corn and high-moisture corn based diet. Diets contained 5% of a dry meal supplement to provide calcium, trace minerals, vitamins ADE, Rumensin, Tylan (all at targeted levels), and urea to provide rumen degradable protein.

Feed samples of all ingredients were collected weekly and analyzed for dry matter (DM) content to adjust as-fed amounts in the diets. Monthly composites were dried, ground and analyzed for DM, organic matter, neutral detergent fiber, acid detergent fiber, crude protein, calcium, and phosphorus at WARD Laboratories. Steers were fed ad libitum and feed refusals were collected and weighed as needed. The DM content of refusals was measured to calculate intake of feed from amount of feed offered.

Live performance values such as live final body weight, live average daily gain (lADG), and live gain to feed (lG:F) were calculated using pen weights measured prior to shipping. Carcass adjusted final body weight (final BW) was determined from hot carcass weight using a 63% dress. Carcass adjusted ADG (Adj. ADG) and carcass adjusted G:F (Adj. G:F) were calculated using adj. final BW. Cattle were harvested at a commercial abattoir (Greater Omaha,

Omaha, NE) on March 26th, April 2nd, 9th, and 16th. Steers fed in the monoslope barn and gable roof barn were fed for an average of 162 d while steers fed in the roller compacted concrete and soil-based open lot pens were fed for an average of 169 d in the winter trial and barn cattle were fed 192 d and open lots for 199 d in the summer trial. At harvest hot carcass weight and liver abscess scores were recorded. Carcass characteristics such as longissimus muscle area, 12th rib fat depth, and marbling score were recorded after a chilling for more than 46 hr.

Manure Quantity and Nutrient Analysis

Manure was removed from roller compacted concrete pens approximately monthly in the summer and every 2 months in the summer. Total as-is weight removed from each pen was measured using empty and full axel weights of the manure spreader and tractor or dump truck for each load. At each removal 8 samples (approximately 200g) were collected for nutrient analysis and 8 samples were collected (approximately 600g) for dry matter content from each pen as the manure was loaded. The average DM and total as-is manure weight removed was used to determine total DM removed from each pen. All samples collected for nutrient analysis for each pen were freeze dried, ground, and composited. One composite for each pen at each removal was analyzed at WARD Laboratories for OM, N, P, and K.

Manure was removed from soil-based open lot pens following the removal of cattle in April and November. The manure was scraped and piled in the center of the pen. The total as-is weight removed was measured using the same method used to measure total as-is weight removed for the roller compacted concrete pens. At removal 16 samples (approximately 200g) were collected for nutrient analysis and 16 samples were collected (approximately 600g) for dry matter content from each pen as the manure was loaded. The average DM of the 16 samples and total as-is manure weight removed was used to determine total DM removed from each pen. All

samples collected for nutrient analysis for each pen were freeze dried, ground, and composited. Two composites for each pen were analyzed at WARD Laboratories for OM, N, P, and K.

Manure was pumped from the monoslope barn and gable-roof barn following the removal of cattle in April and again in November. While the manure was removed from each pit 8 samples (approximately 200g) were collected for nutrient analysis. All samples from each pit were analyzed at WARD Laboratories for DM, OM, N, P, and K. The average DM content and the total gallons removed from each pit were used to determine the total DM weight removed from each pit.

Statistical Analysis

Performance data and manure data were analyzed as a randomized complete block design using the MIXED procedure of SAS with pen as the experimental unit. The occurrence of liver abscesses were analyzed as a binomial using the GLIMMIX procedure of SAS. Severity of liver abscesses was analyzed as a multinomial using the GLIMMIX procedure of SAS. Main effects of housing system are presented here for the full year (Winter or Summer feeding period).

Results

Performance and Carcass Characteristics in Open Lots (RCC vs Soil)

An interaction between the types of pens and the season were observed for most performance characteristics. The reason for the interaction was because steers generally performed very similarly between RCC and soil pens in the winter feeding period, but steers fed on soil pens in the summer did slightly better (Table 1). Cattle fed in soil pens had slightly greater ($P = 0.06$) ADG, HCW, and final BW with a 6 lb difference in carcass weight. Cattle consumed a little more feed in the winter if fed in the soil pens which negated then any impact

on feed conversions ($P = 0.58$). For cattle fed in the summer, cattle fed in soil pens consumed 1 lb daily more feed, but gained quite a bit more with 28 lb heavier carcasses and 6% greater ADG compared to RCC steers. As a result, steers were still slightly more efficient with better feed conversion. Feed conversion was only improved 2% in soil pens due to the greater intake compare to steers fed in RCC pens. Bunk space allocation is identical between the pen types (12 inches/steer), so it is unclear why steers fed in the soil pens consumed so much more in the summer, but that response was not observed in the winter. All pens are equipped with 26.7 square feet of shade in summer feeding period, which was equal across housing types. There was a consistent slight increase in dressing percentage for steers fed on RCC compared to soil pens ($P < 0.01$). Cattle on soil pens had better live performance as the live final BW was inflated some compared to carcass weight (i.e., reduced dressing percentage). We strongly recommend producers evaluate the carcass-adjusted performance as all cattle are evaluated for carcass weight by packers, even when selling on a live basis. If cattle dress poorer, then prices are normally adjusted. Cattle were fed Optaflexx for this year instead of Experior as the industry has rapidly transitioned to feeding Experior in the past few years, so overall dressing percentage was lower than industry standards today when cattle are fed Experior. No major differences were observed between housing systems for carcass traits like fat depth, marbling score, ribeye area, or calculated USDA Yield Grades. There were differences between the two groups of steers fed in either winter or summer as you might expect due to different populations and subtle endpoint differences between each turn of cattle.

The occurrence of liver abscesses decreased ($P < 0.01$) by 54% for steers fed on RCC when compared to steers fed on soil-based pens (Table 2) in the winter feeding period. Steers fed on RCC also had lower incidence of liver abscesses in the summer feeding period but was 26%

lower than soil-based pens. Incidence of abscesses was lower than industry averages for the winter feeding period and more 'normal' for summer feeding period. As expected, the distribution of liver abscess severity was similar in trends to overall abscess rate although very few severe (A+) abscesses were observed in the winter feeding period. All types of abscesses were reduced for cattle fed on RCC compared to soil-based pens. This response of liver abscesses in RCC pens being lower than in soil-based pens was unexpected and needs to be corroborated with more years of data. The only plausible explanation is cattle intakes are lower or more consistent in RCC pens (not expected) or cattle may be consuming some of the bedding when first put into pens (some observations support that conclusion as cattle due eat some of the bedding at least the first day when fresh). More bedding was used in the winter in RCC pens so does explain a greater reduction in abscesses for cattle fed on RCC in the winter.

Performance and Carcass Characteristics in Barns (Monoslope vs Gable roof)

No interactions were observed between housing system and season for any performance, carcass traits, or liver abscesses. Performance was impacted by season overall due to different cattle fed in the winter versus the summer (Table 3). The type of barn had very little impacts on all performance outcomes except for ADG. Dressing percentage was the same for barn types so both live and carcass-adjusted ADG was the same response. Surprisingly, cattle fed in gable roof style barn had slightly (1-1.2%) greater ADG ($P = 0.05$) than steers fed in mono-slope barns and this was consistent for both winter and summer feeding periods in these two studies. Cattle had slightly greater intake too in the barn which explained that ADG response, although the intake response was not significant. The feed conversions were identical between the barns. A 3 to 6 lb increase in HCW was observed for gable roof compared to monoslope which tended to be

significant ($P = 0.10$). Bunk space is approximately 7 inches/steer for both barn types. Barn housing type had no impact on carcass traits within each season ($P > 0.18$).

Cattle fed in gable roof barns had lower incidence and severity of liver abscesses ($P < 0.01$) compared to monoslope barns (Table 4). Total abscesses were 20% (summer) to 36% (winter) less for steers fed in the gable roof compared to the monoslope, which is difficult to explain and would need more years of data to determine if this is a consistent observation.

Manure Quantity and Nutrient Analysis in Open Lots (RCC vs Soil)

Total as-is manure removed from the pen was greater ($P < 0.01$) for steers housed on RCC when compared to steers housed on soil-based pens (Table 5). However, the DM content of manure removed was greater ($P < 0.01$) for steers fed on soil-based pens. More total DM was removed ($P < 0.01$) for steers fed on soil-based pens in the winter, but manure DM removed was similar between steers fed on RCC or in soil pens for the summer (although numerically greater for RCC). The OM content of manure removed from RCC pens was 3.5 to 5 times greater ($P < 0.01$) than the OM content of manure removed from soil-based pens, due to soil contamination that is inevitable in soil pens. These were brand new soil pens so our soil contamination was greater in these pens compare to more established open lots, but we would still expect much greater OM content of manure with no soil contamination in RCC pens. The nitrogen (N) and phosphorus (P) content of RCC manure was greater ($P < 0.01$) than manure from soil-based pens which also appears to be due to less soil contamination. The N:P ratio were similar overall between RCC and soil pens and ranged from 2.4:1 to 2.8:1. When evaluating N flow through the feedlot, steers fed in soil pens had slightly greater N intake and excretion due to greater DMI by cattle in the soil pens (Table 6). Not much of the N is retained by the animal but was also slightly better for soil pens in the summer due to greater ADG and out weights (more protein left in the

cattle). These are relatively small differences, and the majority (85%) of the N we feed is excreted in feces and urine. Total N lost (due to ammonia volatilization) is the major outcome of conducting N mass balance. In this study, there was an interaction between season and open lot type for N losses. We lost 53% from soil pens in the winter period which was less than the 60% lost from RCC pens which agrees well with 20 years of previous work in the winter-spring feeding periods (51% average; Homolka et al., 2021). In the summer, we lost less (73%) from RCC pens as compared to 81% from soil pens, which also agrees with previous work of more losses during summer feeding periods (73% average; Homolka et al., 2021).

Manure Quantity and Nutrient Analysis in Barns (Monoslope vs Gable roof)

A full year (both seasons combined) for manure composition (Table 7) and N mass balance (Table 8) are provided. These are the same pool of cattle fed in the open lots. Replication is different for manure and nutrient flow for barns as three pens comprise a pit. In addition, only 1 pit per diet within housing type was available or used for each season. As a results, these data represent 12 pens of cattle but only 4 pits within each barn type (approximately 240 steers per pit though). Manure characteristics and N mass balance are very similar as expected by barn type. Because the barns were new (pits had not had manure in them) at the start, not all of the manure was able to be removed in the winter feeding period but was more at a steady-state for the summer feeding period. As a results, the N losses are probably a bit inflated for N not removed from corners in the pits from the first feeding period (winter). Still, manure DM removed, N and P content, and N:P ratio illustrate the high-quality nature of liquid barn manure (Table 7). The N:P ratio suggests a more perfect fertilizer for corn acres (4.7:1 to 5.15:1) as compared to open lots (2.5:1 ratio). Manure DM was influenced from adding necessary water to pump pits after each turn so can be influenced by gallons of water we added (and quantified). Lastly, as

expected, less N is lost from deep-pit barn housing systems with our measured N losses of 29 to 31.5% of N excreted which is considerably different than 50 to 80% losses from open lot pens.

Conclusion

Finishing cattle on RCC compared to soil-based pens did not improve performance and in some cases (summer period) resulted in lighter carcasses and lower ADG. Some followup is needed to see if feeding on RCC leads to less liver abscesses and whether this is due to consumption of bedding. Feeding on RCC dramatically improves manure quality due to less soil contamination. The N losses were not impacted by surface overall with more (winter) or less (summer) observed from RCC pens compared to soil. Cattle fed in barns performed very well in terms of carcass, gain, and conversions. Interestingly, cattle were slightly heavier and and gained slightly faster if fed in a gable-roof barn design versus a monoslope. Neither barn type impacted manure characteristics or N mass flow as expected.

Table 1. Effect of open lot housing system by season on finishing performance and carcass characteristics of steers fed a flaked corn diet

Season:	Winter		Summer			*P*- value		
Housing:	RCC	Soil	RCC	Soil	SEM	HS	Season	Int
Pens	8	8	8	8				
DOF	169	169	199	199				
Carcass Adjusted Performance								
Initial BW, lb	811[c]	813[c]	747[b]	744[a]	1.1	0.78	<0.01	0.02
Final BW, lb	1490[a]	1500[a]	1491[a]	1533[b]	3.8	<0.01	<0.01	<0.01
DMI, lb/d	26.5[c]	26.8[d]	24.3[a]	25.3[b]	0.12	<0.01	<0.01	0.02
ADG, lb	4.03[c]	4.08[c]	3.74[a]	3.97[b]	0.020	<0.01	<0.01	<0.01
G:F	0.153[a]	0.152[a]	0.154[a]	0.157[b]	0.0006	0.07	<0.01	<0.01
F:G	6.56	6.59	6.49	6.37	-	-	-	-
Live Performance								
Final BW, lb	1494[a]	1511[b]	1494[a]	1542[c]	4.3	<0.01	<0.01	<0.01
ADG, lb	4.06[b]	4.15[c]	3.75[a]	4.01[b]	0.024	<0.01	<0.01	<0.01
G:F	0.154[a]	0.155[a]	0.154[a]	0.159[b]	0.0007	<0.01	<0.01	0.03
Carcass Characteristics								
HCW, lb	954[a]	960[a]	954[a]	982[b]	2.4	<0.01	<0.01	<0.01
Dress, %	63.8	63.6	63.9	63.6	0.09	<0.01	0.31	0.95
Cal. YG	3.58	3.63	3.90	3.88	0.039	0.83	<0.01	0.43
LM Area, in.^{2}	14.6	14.6	14.3	14.6	0.10	0.09	0.12	0.14
Fat, in.	0.65	0.66	0.74	0.73	0.007	0.86	<0.01	0.45
Marbling	629	634	595	600	6.9	0.50	<0.01	0.97

Table 2. Effect of open lot housing system within season on liver abscess occurrence and severity of steers fed a flaked corn diet

Season:	Winter		Summer		*P*- value		
Housing:	RCC	Soil	RCC	Soil	HS	Season	Int
Pens	8	8	8	8			
DOF	169	169	199	199			
Liver Abscess Occurrence							
Liver Abscesses, %	7.9[a]	17.3[b]	17.4[bc]	23.5[c]	<0.01	<0.01	0.04
Liver Abscess Severity							
0, %	89.8	79.2	81.9	77.1	<0.01	<0.01	0.03
A-, %	6.4	13.9	10.9	12.3			
A, %	1.3	2.2	2.3	3.6			
A+, %	0.4	1.5	5.0	7.0			

Table 3. Effect of slatted floor barn housing type within season on finishing performance and carcass characteristics for steers fed high-moisture/dry-rolled corn diet across both seasons

Season	Winter		Summer			*P*- value		
Housing System	MSB	GRB	MSB	GRB	SEM	HS	Season	Int
Pens	8	8	8	8				
DOF	162	162	192	192				
Carcass Adjusted Performance								
Initial BW, lb	811	811	748	746	1.5	0.37	<0.01	0.68
Final BW, lb	1478	1488	1494	1500	4.3	0.13	<0.01	0.67
DMI, lb/d	26.6	26.8	25.7	25.9	0.14	0.23	<0.01	0.90
ADG, lb	4.12	4.20	3.89	3.93	0.023	0.05	<0.01	0.64
G:F	0.156	0.157	0.152	0.152	0.0010	0.43	<0.01	0.83
F:G	6.41	6.37	6.58	6.58	-	-	-	-
Live Performance								
Live Final BW, lb	1466	1473	1486	1491	3.8	0.11	<0.01	0.77
ADG, lb	4.06	4.11	3.85	3.89	0.015	0.05	<0.01	0.72
G:F	0.153	0.154	0.150	0.151	0.0009	0.42	<0.01	0.93
Carcass Characteristics								
HCW, lb	946	952	957	960	1.9	0.10	<0.01	0.62
Dress, %	64.6	64.6	64.4	64.4	0.07	0.67	<0.01	0.80
Cal. YG	3.25	3.25	3.83	3.77	0.040	0.48	<0.01	0.47
LM Area, $in.^2$	15.1	15.1	14.4	14.6	0.07	0.18	<0.01	0.24
Fat, in.	0.59	0.59	0.72	0.72	0.009	0.44	<0.01	1.00
Marbling	590	585	592	593	6.5	0.79	0.56	0.65

Table 4. Effect of slatted floor barn housing type on liver abscesses for steers fed high-moisture/dry-rolled corn diet across both seasons

Housing System	Winter		Summer		*P*- value		
	MSB	GRB	MSB	GRB	HS	Season	Int
Pens	8	8	8	8			
DOF	162	162	192	192			
Liver Abscess Occurrence							
Liver Abscesses, %	24.2	15.4	24.2	19.4	<0.01	<0.01	0.56
Liver Abscess Severity							
0, %	76.1	83.7	73.9	79.8	<0.01	<0.01	0.72
A-, %	16.5	11.1	14.8	13.7			
A, %	3.9	2.2	7.0	3.5			
A+, %	3.3	2.0	4.4	3.0			

Table 5. Effect of open lot housing system by season on manure characteristics of steers fed a flaked corn diet

	Southern Plains Diet							
Season	Winter		Summer		SEM	*P*- value		
Housing System	RCC	Soil	RCC	Soil		HS	Season	Int
Pens	8	8	8	8				
DOF	169	169	199	199				
Manure Removed								
As-is Removed, lb	5847.3	4085.2	2360.7	615.5	364.83	<0.01	<0.01	0.98
DM, %	25.28[a]	72.51[c]	32.25[b]	71.38[c]	2.150	<0.01	0.19	0.08
DM Removed, lb	1358.3[b]	2776.1[c]	719.9[a]	442.8[a]	197.7	<0.01	<0.01	<0.01
OM, %	78.40[c]	15.40[a]	77.36[c]	21.25[b]	1.234	<0.01	0.07	0.01
N, %	2.7[c]	0.7[a]	3.4[d]	1.1[b]	0.05	<0.01	<0.01	<0.01
P, %	0.98[c]	0.26[a]	1.47[d]	0.43[b]	0.032	<0.01	<0.01	<0.01
N:P	2.84[b]	2.54[a]	2.37[a]	2.53[a]	0.072	0.31	<0.01	<0.01
C:N	18.50[c]	14.12[b]	14.36[b]	11.52[a]	0.240	<0.01	<0.01	<0.01

Table 6. Effect of open lot housing system by season on nitrogen mass balance (lb/steer over the entire feeding period) for steers fed flaked diets

Season:	Winter		Summer			*P*- value		
Housing:	RCC	Soil	RCC	Soil	SEM	HS	Season	Int
Pens	8	8	8	8				
DOF	169	169	199	199				
Nitrogen Mass Balance								
N Intake, lb	100.2	101.7	102.5	106.4	0.89	<0.01	<0.01	0.18
N Retained, lb	12.6[a]	12.7[a]	14.3[b]	15.2[c]	0.08	<0.01	<0.01	<0.01
N Excreted, lb	87.7	89.0	88.2	91.2	0.87	0.02	0.13	0.34
N Soil, lb	0.0[a]	23.9[c]	0.0[a]	12.7[b]	1.26	<0.01	<0.01	<0.01
N Bedding, lb	1.2	0.0	1.2	0.0	0.04	<0.01	0.55	0.55
N Manure, lb	36.3	18.2	24.6	4.3	1.70	<0.01	<0.01	0.53
N Lost, lb	52.6[b]	47.0[a]	64.7[c]	74.1[d]	1.89	0.33	<0.01	<0.01
N Lost, %	60.00[b]	52.58[a]	73.33[c]	81.34[d]	1.883	0.88	<0.01	<0.01

Table 7. Effect of slatted floor barn housing type on manure characteristics for steers fed high-moisture/dry-rolled corn diet across both seasons[1]

Housing System	MSB	GRB
Pens	12	12
DOF	177	177
Manure Removed		
As-is Removed, lb/steer	11751.3	10756.5
DM, %	8.34	9.04
DM Removed, lb/steer	974.7	956.4
OM, %	67.71	68.48
N, %	5.96	6.83
P, %	1.26	1.32
N:P	4.72	5.15
C:N	5.08	5.58

[1] Whole year balance due to pit pumping variation from new barn.

Table 8. Effect of slatted floor barn housing type on nitrogen mass balance (lb/steer over entire feeding period) for steers fed high-moisture/dry-rolled corn diet across both seasons[1]

Housing System	MSB	GRB
Pens	12	12
DOF	177	177
N Intake, lb	104.6	104.8
N Retained, lb	13.5	13.6
N Excreted, lb	91.1	91.2
N Manure, lb	64.5	65.5
N Lost, lb	26.6	25.6
N Lost, %	31.47	29.05

[1] Whole year balance due to pit pumping variation from new barn.