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Performance and carcass characteristics of finishing beef cattle managed in a bedded hoop-barn system[1]

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ABSTRACT: The use of bedded hoop barns in finishing systems for beef cattle has not been widely researched. In this management system, beef cattle are confined to hoop barns throughout finishing, and bedding is used to absorb animal waste, which results in minimal effluent. The objective of this study was to compare the performance and carcass characteristics of finishing beef steers (n = 1,428) managed in a bedded hoop-barn management system vs. an open-feedlot system with shelter. Six feeding trials were conducted over a 3-yr period. Three trials were conducted during summer-fall and 3 trials were conducted during winter-spring. Crossbred steers were allotted to 3 pens in the hoop-barn system and to 3 pens in the open-lot system (approximately 40 steers per pen in both facility systems). Stocking densities for the steers were 4.65 m^2 per steer in the hoop-barn system and 14.7 m^2 per steer in the open-lot system. The steers were begun on trial weighing 410 and 411 kg (SD = 21), were fed for 102.3 and 103.0 d (SD = 3.8), and were weighed off test at 595 and 602 kg (SD = 21) for the hoop-barn and open-lot systems, respectively. Steer performance measures consisted of ADG, DMI, and G:F. Carcass characteristics were HCW, fat thickness, LM area, KPH percentage, marbling score, USDA yield grade, and USDA quality grade. No year, season, or pen (management system) main effects, or season × management system and year × management system interactions were observed for any of the items measured related to cattle performance or carcass characteristics ($P > 0.05$). Final mud scores (a subjective evaluation of the amount of soil and manure adhering to the hair coat of the animals) were greater for the steers from the open-lot system compared with those from the hoop-barn system ($P < 0.02$), suggesting steers in the hoop-barn system carried less mud than steers from the open-lot system. Average daily cornstalk bedding use in the hoop-barn system was 2.3 kg/steer during summer-fall and 2.6 kg/steer during winter-spring. The performance of finishing cattle managed in a hoop-barn system was not different from the performance of cattle managed in an open-feedlot system with shelter during summer and winter. Managing beef cattle in hoop barns required more bedding but resulted in decreased mud scores compared with cattle managed in an open-lot system with shelter. Hoop barns are a viable alternative housing management system for finishing beef cattle.

Key words: bedding, beef cattle facility, environment, hoop barn, season

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INTRODUCTION

In the Midwest region of the United States, there are many smaller beef cattle feedlots (<2,000 animals) that usually are 1 of 3 types: 1) an earthen open lot with a windbreak fence and mounds, 2) open lots with a shed or shelter, or 3) traditional confinement with slatted floors (Lawrence et al., 2006). Open lots require settling and detention basins to contain runoff (Moody et al., 2006). In confinement-type systems, manure is collected in pits below the slats (Lawrence et al., 2006).

If feedlot effluent is not controlled, there can be major environmental effects (Woodbury et al., 2002). Traditional confinement systems tend to have greater facility

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costs but decreased waste management costs compared with open feedlots (Lawrence et al., 2006), and also tend to have poorer cattle performance because of reduced DMI in summer (Koknaroglu et al., 2008).

Hoop barns provide a versatile alternative housing system for livestock, particularly for swine (Honeyman and Harmon, 2003; Lammers et al., 2007) and dairy cattle (Kammel, 2004). Hoop barns consist of steel arches covered with polyvinyl fabric. The arches are attached to posts or concrete sidewalls. For beef cattle feeding, the cattle are confined in the hoop barn, and bedding is used to absorb animal waste. A bedded hoop-barn system was demonstrated in western Iowa for beef cattle feeding (Honeyman et al., 2008). By covering the pens with a hoop barn, effluent from feeding cattle can be better minimized and managed (Shouse et al., 2004).

The performance effects of finishing beef cattle in a hoop barn with bedding are not well documented. The hypothesis for this study was that the performance and carcass characteristics of cattle fed in a bedded hoop-barn system would be similar to those of cattle fed in an open-lot system with shelter. The objective was to compare the performance and carcass characteristics of finishing beef steers in a bedded hoop-barn system with those in an open feedlot with shelter.

MATERIALS AND METHODS

The project was approved by the Iowa State University Institutional Animal Care and Use Committee.

Location and Facility System Treatments

The study was conducted at the Iowa State University Armstrong Research and Demonstration Farm near Lewis, IA (41°19′ N, 95°10′ W). Mean annual rainfall for the site is approximately 71 cm annually. A beef cattle hoop barn (15.2 m × 36.5 m) was erected in November 2004. The hoop barn had 3.1-m sidewalls and the height of the roof was 7.9 m. The hoop barn was oriented north to south with open ends, and had a fenceline bunk along the east side. During the winter-spring, large round bales were stacked 3 high across the north and south ends of the hoop barn for a partial windbreak. There was an earthen feedlot with a shelter open to the south, and a fenceline bunk under roof was built in 1996 (open-lot system). The pens were 12.2 × 48.2 m, including 7.6 m sheltered by roof. The facilities have been described in detail by Honeyman et al. (2008).

Stocking densities for the steers were 4.65 m^2/steer in the hoop-barn system (Shouse et al., 2004) and 14.7 m^2/steer in the open-lot system, with 2.3 m^2/steer under shelter (roof) plus 12.4 m^2/steer of earthen lot area (Honeyman et al., 2008). Manure and bedding management was distinct for the 2 management systems. The pens in the hoop-barn system were bedded weekly by placing large round bales of cornstalks in the pens. Bales were placed in the end of the pen away from the fenceline bunk, and cattle were allowed to spread the bedding. As described by Honeyman et al. (2008), a 6.1-m-wide concrete alley in the pens ran the length of the hoop barn along the feed bunk. The alley was scraped weekly with a tractor and loader. The scrapings were stockpiled and composted for later field application. After the cattle were marketed, all packed bedding was removed from the entire hoop barn.

In the open-lot system, the sheltered area was bedded with cornstalks as needed during the winter-spring trials only. When pens became excessively wet, the area was scraped and cornstalk bedding was added. During the summer-fall trials, the sheltered area stayed dry and did not require bedding. The unsheltered areas of the open-lot system were cleaned and maintained as needed. When the cattle were removed from the open-lot system, the pens were scraped and manure was removed.

Animals

Six feeding trials were conducted from August 2005 to May 2008. Three trials were conducted during the summer-fall (August through November) period and 3 trials were conducted during the winter-spring (December through May) period. For each trial, crossbred steers were placed in 3 hoop-barn pens and 3 open-lot pens (approximately 40 steers per pen). On arrival at the farm, the steers were vaccinated with Cattle Master Gold (Pfizer Animal Health, Lafayette, IN) and implanted with Synovex Choice (Fort Dodge Animal Health, Overland Park, KS). A total of 1,428 steers were allocated to pens for these trials. The cattle were crossbred steers of predominantly Angus breeding and were acquired from area livestock markets. The cattle were kept in source groups and were acclimated approximately 2 wk before allotment. Steers weighed approximately 400 to 420 kg each (SD = 21 kg) at the beginning of the trials. Cattle were balanced by source, hide color, and BW and were randomly allotted to a facility system treatment (hoop-barn or open-lot system) and to pens within a treatment.

Feeding and Husbandry

Cattle were fed daily in a fenceline bunk (30.5 cm/steer) in both facilities. The diet was 78% whole-shelled corn, 17% ground hay (two-thirds alfalfa and one-third bromegrass), and 5% supplement on a DM basis. Water was added to the diet to improve mixing. The amount fed was adjusted daily by pen to approach ad libitum intake.

Eight steers were removed from trials because of death (5 steers), or persistent lameness or chronic bloating (3 steers). No pattern of removal was due to management system or season. Steers with a temperature of 40°C or greater were treated with tilmicosin injectable (Elanco, Greenfield, IN) and returned to the pens. In the summer-fall 2005 trial, steers from 1 source were aggressive. These steers were evenly allocated across pens and treatments. The disposition problem caused lameness, resulting in 12 steers from the 6 pens being removed before the beginning of the trial, which resulted in fewer steers compared with other trials.

Performance Measures

Cattle were weighed in the morning before feeding at 28-d intervals. Trials ended when the majority of the steers were deemed to have 10 mm of fat cover and were estimated to grade USDA Choice based on visual assessment. All cattle were weighed off test and were evaluated by a trained university staff member for exterior mud (soil and manure adhering to the hair coat of the animal) at the end of the trial. Mud scores were defined as follows: 1 = no visible mud, clean hide; 2 = small lumps of manure attached to the hide in limited areas of the legs and underbelly; 3 = small and large lumps of manure attached to the hide covering larger areas of the legs, sides, and underbelly; 4 = small and large lumps of manure attached to the hide in even larger areas along the hind quarter, underbelly, and front shoulder; and 5 = lumps of manure attached to the hide continuously on the underbelly and side of the animal from the brisket to the rear quarter.

Cattle were shipped approximately 5 to 7 d after final BW were obtained, depending on the commercial abattoir schedule. On the day of shipment to the abattoir (approximately 93 km from the research farm), cattle were fed one-half the daily ration in the morning, transported late in the afternoon, and processed the next day. Cattle from both management systems were shipped at the same time for each trial. Water was available to steers at all times. Hot carcass weight was measured immediately after slaughter and carcass dressing percentage was determined. At the plant, carcass measurements, including 12th-rib backfat, LM area, percentage of KPH, marbling score, and USDA quality and yield grades, were determined 24 h postmortem.

Labor for delivering bedding to the pens and for cleaning manure from the pens was recorded by management system for each trial. Labor to feed and manage the cattle was not included. The weight of cornstalk large round bales for bedding was recorded by management system for each trial.

Experimental Design

The study consisted of 6 trials; each had 2 management systems, with pens nested in the management system. The experimental unit was a pen of steers. Data from all trials were combined and analyzed as a mixed linear model using the GLM procedure (SAS Inst. Inc., Cary, NC), resulting in an ANOVA with the following factors: year, season, year × season, management system, pen (management system), year × management system, and season × management system. Because there was 1 trial for each year × season combination, the year × season interaction was used for testing the main effects of year and season. The model error was used to test the remaining factors. Least squares means by management system are presented unless noted.

RESULTS

Means for steer performance and carcass measures are presented in Tables 1 and 2, respectively. No year, season, or pen (management system) main effects, or season × management system and year × management system interactions were found for any of the items

Table 1. Performance of finishing steers managed in the bedded hoop-barn system and the open-lot system with shelter[1]

Item	Hoop barn	Open lot	SEM	*P*-value
No. of pens	18	18	—	—
Animals (on test)	712	716	—	—
Animals (off test)	707	713	—	—
Initial BW, kg	410	411	5	0.94
Final BW, kg	595	602	5	0.32
BW gain, kg	185	191	3	0.16
On-test period,[2] d	102.3	103.0	0.9	0.62
Market wt,[3] kg	595	598	5	0.58
ADG, kg/d	1.82	1.87	0.03	0.19
DMI, kg/(steer·d)	12.46	12.46	0.12	0.98
G:F, g/kg	145.7	150.2	2.3	0.18
Mud score[4]	1.86	2.22	0.10	0.02

[1]No season × management system interactions for the items listed were observed ($P > 0.05$). Least squares means are presented. The study consisted of 6 trials in total (i.e., 2 trials each year for 3 yr).

[2]The on-test period was the number of days from the trial beginning BW to the trial off-test BW.

[3]Calculated using HCW ÷ 62% standard yield or dressing percentage.

[4]Mud score scale: 1 = no visible mud, clean hide; 2 = small lumps of manure attached to hide in limited areas of legs and underbelly; 3 = small and large lumps of manure attached to hide covering larger areas of legs, sides, and underbelly; 4 = small and large lumps of manure attached to hide in even larger areas along hind quarter, underbelly, and front shoulder; and 5 = lumps of manure attached to hide continuously on the underbelly and side of animal from brisket to rear quarter. Mud score was evaluated at the end of the trial.

Table 2. Carcass characteristics of finishing steers managed in the bedded hoop-barn system and the open-lot system with shelter[1]

Item	Hoop barn	Open lot	SEM	*P*-value
HCW, kg	368.7	370.9	2.9	0.59
Fat thickness, cm	1.08	1.08	0.19	0.92
LM area, cm^2	85.0	84.5	0.3	0.38
KPH, %	2.43	2.43	0.07	0.99
Marbling score[2]	1,031	1,027	5	0.61
USDA yield grades 1 and 2, %	63.2	62.9	2.7	0.94
USDA Choice, %	75.4	74.3	2.7	0.78

[1]No season × management system interactions for the items listed were observed ($P > 0.05$). Least squares means are presented. The study consisted of 6 trials total (i.e., 2 trials each year for 3 yr).

[2]Marbling score scale: Slight = 900; Small = 1,000; Modest = 1,100.

measured related to cattle performance or carcass characteristics ($P > 0.05$). The steers were begun on trial at 410 and 411 kg (SD = 21), fed for 102.3 and 103.0 d (SD = 3.8), and weighed off test at 595 and 602 kg (SD = 21) for the hoop-barn and open-lot systems, respectively. Fewer than 1% of the steers begun on test were removed for any reason from either management system. There were no differences in BW gain, ADG, DMI, or G:F ratio ($P > 0.05$). Hot carcass weight, fat thickness, LM area, KPH percentage, marbling score, yield grade, or quality grade did not differ between management systems ($P > 0.05$).

Final mud scores were greater for the steers from the open-lot system than for those from the hoop-barn system ($P < 0.02$, Table 1). The added mud for cattle in the open-lot system may have numerically increased their off-test BW, although the BW between management systems were not different ($P > 0.05$). When the HCW of the cattle in the open-lot system was divided by a standard dressing percentage of 62% (equal to the dressing percentage of the cattle in the hoop-barn system; Table 2), the resulting mean BW were more numerically similar (see market weight in Table 1).

Labor and bedding use by management system is reported in Table 3. Labor use is difficult to transfer accurately to other operations, but there are some comparisons of interest. As expected, more bedding was used in the hoop-barn system than in the open-lot system. Average daily bedding use in the hoop-barn system was 2.3 kg/steer during summer-fall and 2.6 kg/steer during winter-spring, which resulted in approximately 13% more bedding during colder, wetter conditions. No bedding was used in the open-lot system during the summer-fall, and mean daily use during the winter-spring was 1 kg/steer.

Labor for cleaning and bedding generally followed the trends for bedding use, except for the open-lot system after the winter-spring trials (Table 3). When comparing the 2 management systems, the total labor for bedding and cleaning was similar across seasons. The greatest difference was labor distribution (data not shown). The alley of the hoop-barn system was scraped weekly except when manure was frozen, and the bedded area was cleaned after the cattle were removed. The open-lot system was scraped as needed to maintain cattle comfort in response to weather (1 to 5 times per summer-fall period and 10 to 14 times per winter-spring period). Thus, the labor for bedding and cleaning was more evenly distributed throughout the feeding period for the hoop-barn system.

Table 3. Seasonal labor and bedding use in the bedded hoop-barn system and the open-lot system with shelter[1]

	Summer-fall[2]		Winter-spring[3]		Total[4]	
Item	Hoop barn	Open lot	Hoop barn	Open lot	Hoop barn	Open lot
Mean bedding use, kg/(steer·d)	2.3	0.0	2.6	1.0	4.9	1.0
Minimum	2.0	0.0	2.4	0.6		
Maximum	2.7	0.0	2.7	1.3		
Mean labor use,[5] h/group	21.1	13.6	22.5	28.7	43.6	42.3
Minimum	18.5	12.0	19.8	23.5		
Maximum	24.3	15.3	26.0	35.8		
Mean labor use,[6] min/steer	10.9	6.8	11.3	14.4	22.1	21.2
Minimum	9.3	6.0	9.9	12.0		
Maximum	12.2	7.6	13.1	17.9		

[1]The study consisted of 6 trials total (i.e., 2 trials each year for 3 yr). Arithmetic means are shown.

[2]The summer-fall groups began on test in August and were marketed in November.

[3]The winter-spring groups began on test in December and were marketed in April to May. Arithmetic means are shown.

[4]Total = sum of means for summer-fall and winter-spring.

[5]Labor is for bedding and cleaning manure only.

[6]Labor per group × 60 min ÷ mean number of steers per group.

DISCUSSION

Overall, cattle performed similarly, with similar carcass characteristics for both management systems. Our earlier work (Honeyman et al., 2008) showed that the thermal environment in these 2 facility systems differed. The hoop barn had fewer hours in the "alert" category during the summer, but provided less shelter for cattle during the winter. The alert category is defined as a temperature-humidity index of greater than 74 and less than or equal to 79 (Livestock Conservation Inc., 1970; Hubbard et al., 1999). However, cattle were able to compensate for differences in the thermal environment of the facility systems and performed similarly in both systems.

The thermal environment that cattle experience affects performance (e.g., heat stress can reduce DMI; Blackshaw and Blackshaw, 1994; Brown-Brandl et al., 2005). Providing housing is a way to minimize environmental stress on cattle (Mitlöhner et al., 2002). Environment influences the ME requirement and DMI of cattle (Delfino and Mathison, 1991). Extensive work in Iowa finishing beef cattle in various facility systems showed improved performance and feed efficiency by providing shelter to cattle in open lots (Leu et al., 1977; Muhamad et al., 1983; Koknaroglu et al., 2005). However, this research also showed that cattle in traditional confinement buildings had poorer performance and less DMI than cattle in open lots or open lots with shelters, particularly during the summer.

An analysis of Iowa feedlot performance records revealed that finishing beef cattle managed in lots with shelter had greater ADG than finishing cattle in confinement or open lots during warm seasons, and that finishing cattle managed in confinement had less DMI and ADG than finishing cattle managed in open lots or open lots with shelter in any season (Koknaroglu et al., 2008). In addition, beef cattle performance in Iowa was most negatively affected for lighter cattle during winter and heavier cattle during summer compared with other groups. Shelter was most beneficial during summer (Koknaroglu et al., 2008).

In the current study, cattle assigned to the open-lot treatment were in a facility system similar to the open-lot system with shelter used in the earlier Iowa research. This facility system has been shown to result in better cattle performance compared with traditional confinement or open lots without shelter (Leu et al., 1977; Muhamad et al., 1983; Koknaroglu et al., 2005). In the current study, cattle managed in the bedded hoop-barn system matched the performance of cattle managed in the open-lot system with shelter, even though the cattle were confined in the hoop barn.

In conclusion, the performance of finishing beef cattle managed in a bedded hoop-barn system was not different from the performance of finishing cattle managed in an open-feedlot system with shelter during summer and winter. Therefore, the hypothesis was confirmed. Managing finishing beef cattle in hoop barns required more bedding but resulted in decreased mud scores compared with managing cattle in an open-lot system with shelter. Managing finishing steers in bedded hoop-barn systems may be a viable alternative to open-lot systems, especially in areas with increased rainfall, such as the US Midwest, South, or East, where effluent from feedlots may be challenging to manage.

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