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Effect of oscillating time of feeding and oscillating diet formulation on performance and carcass characteristics in feedlot steers

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ABSTRACT

Smaller farms often lack the control over feeding and weighing that commercial feedlots possess. The objectives of this study were to evaluate the effect of oscillating feeding time and oscillating diet formulation on growth performance and carcass characteristics in feedlot cattle fed dry, whole shelled corn–based diets. A total of 168 steers were blocked by initial BW (280 ± 8.7 kg) and allotted to 24 pens. Pens were assigned to 1 of 3 treatments: (1) control, fed the same diet and at the same time each day; (2) oscillating feeding time, fed the same diet as control fed 1 h earlier on odd days and 1 h later on even days of the experiment; and (3) oscillating diet formulation, fed the diet at the same time every day but with diet formulation changed daily (10% distillers dried grains with solubles was added on the even days and 10% removed on the odd days). Animal performance (BW, DMI, and G:F) was measured over 166 to 174 d. At the end of the experiment, steers were weighed and slaughtered, and carcass characteristics were evaluated. Data were statistically analyzed (PROC Mixed, SAS) using treatment as a fixed variable and pen and block as random variables. There was no treatment effect ($P > 0.05$) for any variable. In conclusion, small daily diet formulation or feed delivery timing variations did not affect performance and carcass characteristics when whole shelled corn was fed to feedlot cattle.

Key words: bunk management, mixing variability, oscillating feeding time

INTRODUCTION

Acidosis is the major digestive disorder in feedlot cattle (USDA, 2000). Nutritional management is the most efficient way to avoid acidosis. Bunk management, which is an approach to deliver feed to cattle, is a nutritional management tool employed in the feedlot (Pritchard and Bruns, 2003). This process includes the delivery of feed in a constant way considering quantity, quality, and time. There have been many studies that evaluated the effect of feed delivered on feedlot performance (Galyean et al., 1992; Pritchard and Bruns, 2003). Bunk management has been around for 100 yr (Mumford, 1907). Mumford (1907) suggested that 15-min changes in feed delivery may cause decreases in performance and that the magnitude of the decrease depends on the extent and frequency of the irregularity. There are studies that evaluated mixing efficiency and its effect in milk production in lactating dairy cows. Sova et al. (2014) conducted an on-farm study with lactating dairy cows and observed a day-to-day CV of 3.5, 4.4, and 4.1% for dietary CP, ADF, and NDF content, respectively. The variation observed in this study decreased milk production. However, a study conducted by Yoder et al. (2013) reported that day-to-day variations with a CV from 2.1 to 6.6% in NDF did not affect milk yield. Despite the importance of bunk management in feedlot performance, to our knowledge there are no studies that have evaluated the effects of diet composition and time of feed delivery on feedlot performance in cattle fed dry, whole shelled corn–based diets. The hypothesis of this study was that small changes in daily feeding time and diet formulation would decrease performance and carcass characteristics in feedlot cattle. The objective of the current study was to evaluate the effect of oscillating time of feeding and oscillating diet formulation on growth performance and carcass characteristics in feedlot cattle.

MATERIALS AND METHODS

Animals, Experimental Design, and Treatments

All procedures involving animals were approved by The Ohio State University Agricultural Animal Care and Use Committee (IACUC # 2015A00000113). The feedlot trial was conducted at The Ohio State University feedlot in Wooster, Ohio. A total of 168 Angus crossbred steers (initial BW 280 ± 8.7 kg) were blocked by initial BW into 2 BW block groups and allotted to 24 pens (8 pens per treatment with 7 animals per pen), resulting in pens of calves in each block that had similar initial BW (257 ± 0.2 and 303 ± 0.6 kg for light and heavy BW blocks, respectively). Pens within each block were then randomly assigned and equally distributed to 1 of 3 treatments: (1) control diet (**CONT**), animals in this group received the same diet at the same time of the day (0900 h) each d of the study; (2) oscillating feeding time (**OFT**), these animals received the

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same diet as the CONT, but they were fed 1 h earlier on the odd numbered days of the experiment and 1 h later on the even numbered day of the experiment (0800 and 1000 h, respectively); and (3) oscillating diet formulation (**ODF**), these animals received the diet at the same time every day of the study (1100 h), but the diet formulation changed daily. The average diet formulation of the ODF was similar to that of the control, but 10% (as-fed bases) distillers dried grains with solubles was added on the even days and 10% (as-fed basis) removed on the odd days. Because feeding time was an important factor to consider, the feeding schedule was maintained within 10 min of the target feeding time. However, the exact time that the pens were fed was not recorded. Because the quantity of feed delivered was critical, a scale with a resolution of 0.0454 kg was used for feed deliveries to each pen. However, the delivery of corn silage into the mixer had a variation up to 0.454 kg (as-fed basis). This amount represented up to 2.5 or 6% extra corn silage on the growing and finishing diet, respectively. The actual variation in the CONT diet composition was not recorded in this study; therefore, the CV could not be measured. The diet was mixed by adding corn silage, distillers dried grains with solubles, whole shelled corn, and a supplement pellet containing the remaining ingredients. The feed ingredients and composition of the diets are presented in Table 1 and Table 2, respectively. All diets were designed to meet or exceed dietary requirements according to the *Nutrient Requirements of Beef Cattle* (NRC, 2000) for growing and finishing beef steers. Feed was offered using a clean bunk management. For the CONT and the ODF, the bunk reading to estimate refusals were done daily. For the OFT, the reading was done on the even numbered days, and the amount of feed fed on the odd numbered days was the same as on the previous even numbered day. Feed was offered daily. Feed refusals were weighed, recorded, and discarded daily for the CONT and ODF and every other day for the OFT if any feed was left in the bunk. Fresh water was available at all times.

All steers were implanted with Component E-S (200 mg of progesterone and 20 mg of estradiol; Elanco Animal Health, Greenfield, IN) on d 14 of the experiment. All steers were reimplanted with Component TE-S (120 mg of trenbolone acetate and 24 mg of estradiol; Elanco Animal Health) on d 56 when the diets were switched from the growing to the finishing diets and each pen continued with the same treatments. The change of diet from growing to finishing was accomplished in 3 wk by removing 10% of

Table 1. Composition of growing and finishing diets (% DM basis) fed to steers at the same time each day (CONT), at oscillating feeding times (OFT), or at the same time each day but with oscillating diet formulation (ODF)

	Growing diet			Finishing diet		
		ODF			ODF	
Item	CONT and OFT	Odd days	Even days	CONT and OFT	Odd days	Even days
Whole corn	20	20.41	19.61	50	51.02	49.02
Ground corn	4.028	4.108	3.947	6.119	6.242	5.997
Corn silage	50.0	51.02	49.01	20	20.41	19.61
DDGS[1]	20.0	18.37	21.57	20	18.37	21.57
Soybean meal	2.0	2.04	1.96	0	0	0
Urea	0.5	0.51	0.49	0.4	0.408	0.392
Limestone	1.800	1.836	1.764	1.800	1.836	1.764
Rumensin 90[2]	0.015	0.015	0.015	0.02	0.02	0.02
Tylan 40[3]	0.045	0.046	0.044	0.045	0.046	0.044
Trace mineral salt[4]	1.575	1.6074	1.5536	0.8558	0.8726	0.838
Vitamin A, 30,000 IU/g	0.0074	0.0075	0.0073	0.0222	0.0226	0.0218
Vitamin D, 3,000 IU/g	0.0074	0.0075	0.0073	0.7	0.714	0.686
Vitamin E, 44 IU/g	0.0222	0.0226	0.0218	0.0380	0.0388	0.0372

[1]DDGS = distillers dried grains with solubles; Dakota Gold (Marion, OH).

[2]Rumensin 90 (Elanco Animal Health, Greenfield, IN) provided 30 mg or 40 mg of monensin per kg of the CONT diet during the growing and finishing phases, respectively.

[3]Tylan 40 (Elanco Animal Health) provided 36.59 mg of tylosin per kg of the CONT diet during the growing and finishing phases, respectively.

[4]Trace mineral salt contained 31.78% of sodium chloride, 44.48% of calcium sulfate, 19.06% of potassium chloride, 0.38% of copper sulfate, 1.27% of zinc sulfate, 0.61% of magnesium sulfate, 0.007% of cobalt carbonate, and 2.41% of Se for the growing phase, and 31.74% of sodium chloride, 44.40% of calcium sulfate, 19.03% of potassium chloride, 0.41% of copper sulfate, 1.27% of zinc sulfate, 0.76% of magnesium sulfate, 0.007% of cobalt carbonate, and 2.41% of Se for the finishing phase.

Table 2. Analyzed nutrient composition (% DM basis) of the growing and finishing diets fed to steers with the same diet at the same time each day (CONT), the same diet at oscillating feed times (OFT), or at the same time each day but with oscillating diet formulation (ODF)

	Growing diet				Finishing diet			
		ODF				ODF		
Nutrient	CONT and OFT	Odd days	Even days	CV %	CONT and OFT	Odd days	Even days	CV %
NDF, %	30.44	30.49	30.38	0.26	19.20	19.03	19.37	1.25
ADF, %	16.15	16.27	16.02	1.08	8.32	8.28	8.35	0.59
CP, %	14.81	14.49	15.11	2.95	13.53	13.19	13.86	3.47
Ether extract, %	3.20	3.14	3.27	2.85	3.78	3.73	3.83	1.96
Ash, %	5.88	5.89	5.87	0.20	5.31	5.31	5.31	0.04

the corn silage and adding 10% of whole shelled corn per week.

Sampling and Analysis

Weekly feed samples were composited and analyzed for DM to allow determination of DMI. Composite feed samples taken every 14 d were dried in a forced-air oven at 55°C and stored for future analysis.

Steers were individually weighed on d 0, 14, 42, and 56 and then every 28 d during the trial until the last day of the trial (d 169 ± 4). The animals in each pen were closed out together, and each block was off test on 2 consecutive days, making a total of 4 close-out d, 165 and 166 d on feed for the large block, and 173 and 174 d for the small block. All treatments were equally represented in each off-test day. Steers were weighed before feeding and were not withheld from feed or water.

When steers had approximately 1.2 cm of backfat, they were weighed and slaughtered at a commercial abattoir. Hot carcass weight, fat thickness, LM area, KPH, QG, and marbling score were determined by trained personnel at the Ohio Department of Rehabilitation and Corrections. Hot carcass weight was recorded on the day of slaughter and DP was calculated. Hot carcass weight was measured without kidney and kidney fat. The off test weight of the animal was used to estimate DP. Carcasses were chilled for 48 h at −4°C and ribbed between the 12th and 13th ribs to determine s.c. backfat thickness at the 12th rib, LM area, marbling scores, KPH, and USDA QG (USDA, 1997).

Composited feed samples were analyzed for DM (100°C for 24 h), ADF and NDF (Ankom Technology method 5 and 6, respectively; Ankom Technology, Fairport, NY), CP (method 930.15; AOAC International, 1996), ether extract (method 2; Ankom Technology), and total ash (600°C for 12 h).

Statistical Analysis

Data were analyzed as a randomized complete block design using the MIXED procedure of SAS, version 9.4 (SAS Institute Inc., Cary, NC). The blocking criteria was initial BW. Performance data were analyzed as repeated measures and divided into growing and finishing phases due to the different diets. The model included treatments, days, and interactions between treatments and days as fixed variables and pen (experimental unit) and block as random variables. Because there was no time × treatment interaction ($P > 0.1$), the data were reanalyzed using the weight at the end of the growing (d 56) and finishing periods (off test) and the average performance data (DMI, ADG, and G:F) of each period considering treatment as a fix variable, and pen and block as random variables. Data are presented in a table format showing the least squares means and a pooled SEM. For the carcass data, the same model was used.

RESULTS AND DISCUSSION

During the growing phase, there were no differences in BW, ADG, DMI, or G:F ($P \geq 0.30$, Table 3) during the growing or the finishing phases. For the growing phase, BW at d 56 were 375, 378, and 377 ± 3.1 kg for the CONT, OFT, and ODF, respectively. Average daily gains during the growing phase were 1.71, 1.75, and 1.75 ± 0.034 kg/d for the CONT, OFT, and ODF, respectively. Dry matter intakes during the growing phase were 7.84, 7.89, and 7.97 ± 0.059 kg/d for the CONT, OFT, and ODF, respectively. Gain-to-feed ratios during the growing phase were 0.218, 0.223, and 0.220 ± 0.0033 for the CONT, OFT, and ODF, respectively. For the finishing phase (d 57 to off test), BW were 564, 570, and 570 ± 3.2 kg for the CONT, OFT, and ODF, respectively. Average daily gains during the finishing phase were 1.66, 1.69, and 1.70 ± 0.04 kg/d for the CONT, OFT, and ODF, respectively. Dry matter intakes during the finishing phase were 9.74, 9.99, and 9.89 ± 0.112 kg/d for the CONT, OFT, and ODF, respectively. Gain-to-feed ratios during the growing phase were 0.171, 0.170, and 0.171 ± 0.0028 for the CONT, OFT, and ODF, respectively. There were no differences in carcass characteristics ($P \geq 0.24$, Table 4).

Table 3. Effect of feeding the same diet at the same time of the day (CONT), the same diet at oscillating feeding time (OFT), and the same time but with oscillating diet formulation (ODF) on performance of feedlot steers

	Treatment				
Item	**CONT**	**OFT**	**ODF**	**SEM**	***P*-value**
Growing					
Initial BW, kg	280	280	279	3.1	0.99
BW d 56, kg	375	378	377	3.1	0.57
ADG d 1 to 56, kg	1.71	1.75	1.75	0.034	0.56
DMI d 1 to 56, kg	7.84	7.89	7.97	0.059	0.30
G:F d 1 to 56	0.218	0.223	0.220	0.0033	0.62
Finishing					
BW off test, kg	564	570	570	3.2	0.61
ADG d 57 to off test, kg	1.66	1.69	1.70	0.040	0.81
DMI d 57 to off test, kg	9.74	9.99	9.89	0.112	0.30
G:F d 57 to off test	0.171	0.170	0.171	0.0028	0.88

These results are contrary to our original hypothesis that daily changes in diet formulation or feeding time would decrease animal performance. It is known that inconsistent feeding behavior is associated with decreases in performance and increased risk of ruminal acidosis (Schwartzkopf-Genswein et al., 2003). In commercial feedlots, the time of feeding and the mixing errors can be greater than in experimental situations, despite efforts to minimize them. Therefore, our objective was to evaluate small changes in feeding time and diet formulation, with the goal to estimate possible losses due to these variables. In beef cattle, the synchrony of nutrient intake has been studied in great detail and summarized in reviews (Cole and Todd, 2008; Hall and Huntington, 2008; Reynolds and Kristensen, 2008). Most of the studies conducted to evaluate changes in nutrient supply evaluated the effect of CP variation in the diet. Johnson (1976) theorized that to maximize bacterial growth efficiency and performance efficiency in ruminants, carbohydrates and CP have to be digested in similar patterns. However, it has been reported that in some ruminant situations that is not the case (Cole and Todd, 2008; Reynolds and Kristensen, 2008). Cole and Todd (2008) reported no effect of the synchrony index, rate of rumen degradation of carbohydrates and CP

Table 4. Effect of feeding the same diet at the same time of the day (CONT), the same diet at oscillating feeding time (OFT), and the same time but with oscillating diet formulation (ODF) on carcass characteristics of feedlot steers

	Treatment				
Item	**CONT**	**OFT**	**ODF**	**SEM**	***P*-value**
HCW, kg	327.3	332.0	333.1	2.99	0.38
DP	58.04	58.22	58.37	0.243	0.65
LM area, cm^2	81.9	83.2	81.9	1.16	0.64
KPH, %	1.82	1.79	1.78	0.086	0.78
Backfat, cm	1.13	1.20	1.26	0.056	0.32
Marbling score[1]	567	565	564	9.7	0.97
YG[2]	2.67	2.69	2.84	0.106	0.48
QG[3]	5.1	5.1	5.1	0.11	0.99
QG ≥Low choice, %	83.9	84.0	76.7	3.29	0.22

[1]Marbling score scale: Marbling 400–490 = slight, 500–590 = small, 600–690 = modest, 700–790 = moderate, 800–890 = slightly abundant.

[2]YG was calculated using the YG equation from the USDA beef grading standards (USDA, 1997).

[3]QG: 4 = Select, 5 = Low choice, 6 = Average choice.

in the rumen, with performance data in high concentrate diets. Reynolds and Kristensen (2008) summarized the effect of oscillating protein supplementation and reported that there is no difference in the use of the protein by ruminants, mainly due to N recycling. However, daily oscillations of carbohydrates, due to changes in the ratio of grain to forage, have been connected with acidosis problems in feedlot cattle (González et al., 2012) and decreases in performance. In the current study, daily variation (as CV %) of distillers dried grains with solubles was 11%, which made the variation in dietary CP, NDF, and ADF 2.95, 0.26, and 1.08% on the growing diet and 3.47, 1.25, and 0.59% on the finishing diet. In the current experiment, there were no differences in performance due to the daily diet formulation variation. The lack of decrease in performance due to the diet formulation variation may be because whole shelled corn was fed to the steers. Murphy et al. (1994) reported that feeding whole shelled corn, regardless of the intake, decreased ruminal pH to a lesser extent than rolled corn. When whole shelled corn was fed, ruminal pH was below 5.7 only 2 h/d, but when rolled corn was fed, ruminal pH was below 5.7 for 10 h/d (Murphy et al., 1994). Therefore, in the current study the changes in performance due to changes in diet formulation may be attenuated by the lack of processing of the corn. It is also possible that the variation in dietary nutrient concentration in the current experiment due to diet formulation was too small to produce any type of ruminal dysfunction. A recent study in dairy cows found no effect on animal performance when day-to-day variation (as CV %) of NDF and CP concentration were 6.6 and 5.8 respectively (Yoder et al., 2013).

There are not many studies that have evaluated oscillating feeding time on feedlot performance, and none with dry, whole shelled corn, to our knowledge. It is worth mentioning that despite one of the treatments being oscillating feeding times, the oscillating diet formulation group was fed at a different time (2 h later) than the control group, However there were no differences among groups for performance or carcass characteristics. Cooper et al. (1998) reported that a delay of 4 h in feeding when cattle were fed once a day decreased ruminal pH the following 6 d to a point of subacute acidosis. That change in ruminal pH was associated with a decreased DMI. In the current study, no changes in DMI were observed with the steers fed at alternate times, with a window of 2 h of difference between days. In the current study, ruminal pH was not measured; therefore, we cannot discern if there was a drop in ruminal pH in the animals fed at different times of the day. It is possible that the whole shelled corn in the diet helps attenuate the rate of the decrease in ruminal pH. Consequently, in the present study the decrease in ruminal pH may be similar to the decreases observed by Murphy et al. (1994) but not as low as those observed by Cooper et al. (1998). Therefore, feeding whole shelled corn, instead of ground corn, may mitigate the decrease in DMI.

From these results, we conclude that small daily nutrient variations (less than 3.47, 1.25, and 0.59 CV % on the finishing diet for CP, NDF, and ADF, respectively) or changes in the time of feed delivery within a window of 2 h did not affect performance and carcass characteristics when dry, whole shelled corn was fed to feedlot cattle.

IMPLICATIONS

Bunk management can affect performance, carcass characteristic, and production efficiency of feedlot cattle. A common practice in feedlot production is to feed the exact same diet at the same time every day to avoid changes in the ruminal pH that may decrease performance. When whole shelled corn is fed as the major energy source of the diet, there may be a margin of error for time and nutrient changes that do not decrease performance or carcass characteristics in feedlot cattle. However, more research is needed to establish the maximum daily variation in nutrient concentration and feeding time with different types of diets in which animal performance is not compromised.

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