Influence of forage source on growth performance, feeding behavior and carcass characteristics in finishing steers

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The objectives of this study were to determine if feeding different forage sources at the same neutral detergent fiber (NDF) inclusion level influences growth performance and feeding behavior. Different forage sources (alfalfa hay, corn silage, wheat straw or corn stover) may be used to achieve similar growth performance in finishing diets if fed at similar NDF inclusion, although it may impact feeding behavior.

Summary

Sixty-four steers (867 ± 7.9 pounds of body weight [BW]) were utilized to determine the effect of forage source in finishing diets on growth performance and feeding behavior. Within pen (n = 3), steers were assigned randomly to one of four dietary treatments (n = five or six steers per treatment within pen; n = 16 per treatment) containing different forage sources: 1) alfalfa hay, 2) corn silage, 3) wheat straw, 4) corn stover. Alfalfa hay was provided at 10 percent of diet dry matter (DM), and other forage sources were offered to provide the same percentage of NDF from forage. Intake and feeding behavior traits were calculated from data generated by the Insentec feeding system. Cattle were fed until approximately 1,430 pounds of BW and were marketed in two groups at 117 days (n = 44) and 155 (n = 20) days. Final body weight (BW), average daily (ADG), dry-matter intake (DMI), gain-to-feed ratio (G-to-F), rib-eye area and marbling score did not differ ($P \geq 0.12$) among treatments. The number of daily visits and meals did not differ ($P \geq 0.37$) among treatments. Eating time per visit was greatest ($P = 0.02$) for steers fed wheat straw and least for steers fed alfalfa hay or corn silage, with steers fed corn stover intermediate. Eating time per meal was greatest ($P = 0.05$) for steers fed wheat straw or corn stover and least for steers fed corn silage, with steers fed alfalfa hay intermediate. Eating rate (lb of DMI/min) tended to be greatest ($P = 0.07$) for steers fed alfalfa hay and least for steers fed wheat straw, with steers fed corn silage or corn stover intermediate. These data indicate that growth performance did not differ when different forage sources were fed at a similar NDF inclusion

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level in high-concentrate finishing diets. However, steers fed wheat straw or corn stover spent more time eating per meal to consume a similar amount of DM. Alternative forage sources may be used to achieve similar growth performance in finishing diets if fed at similar NDF inclusion, although it may impact feeding behavior.

Introduction

Forage is important in high-concentrate finishing diets to help maintain rumen function and prevent ruminal acidosis. The use of alternative roughage sources, such as wheat straw or corn stover, has increased in finishing cattle operations in the northern Plains because of increased forage costs and decreased hay availability. Research has suggested that roughage source and concentration influence growth performance of finishing cattle (Galyean and Defoor, 2003).

Research also has suggested that exchanging dietary roughage on the basis of NDF concentration rather than on a DM percentage basis might be more appropriate when formulating finishing diets (Galyean and Defoor, 2003). However, some research (Quinn et al., 2011) also suggests that substituting roughages on the basis of equivalent NDF concentration may be dependent on grain source, grain processing and inclusion of other feed ingredients such as distillers grains. This is likely because different sources of NDF have different digestibility and effects on chewing and ruminating behavior, which largely impacts buffering in the rumen.

Adaptations in feeding behavior may be associated with changes in the rumen environment. Increasing the frequency and distribution of meals throughout the day can moderate ruminal pH (Gonzalez et al., 2012), resulting in a reduced time when rumen pH is low. Little is known about how different forage sources for finishing diets influence feeding behavior.

We hypothesized that feeding different forages as part of a high-concentrate diet to finishing cattle will result in changes in feeding behavior and growth performance. The objectives were to determine the effect of forage source in finishing diets on growth performance and feeding behavior.

Experimental Procedures

Animals, Experimental Design and Dietary Treatments

All procedures with animals were approved by the NDSU Animal Care and Use Committee. Sixty-four steers (867 ± 7.9 pounds BW) predominantly of Angus, Simmental and Shorthorn breeding were blocked by BW to three pens (n = 21 or 22 steers/pen) equipped with Insentec feeders at the NDSU Beef Cattle Research Complex. Within each pen, calves were randomly assigned to one of four dietary treatments (n = five or six steers per treatment within pen; n = 16 per treatment; Tables 1 and 2) containing different forage sources: 1) alfalfa hay, 2) corn silage, 3) wheat straw and 4) corn stover.

Alfalfa hay was provided at 10 percent of the diet DM and the other forage sources were offered to provide the same dietary NDF from forage. Diets were offered for ad libitum intake. Steers were adapted to the final diets by transitioning from 50 to 90 percent concentrate during 21 days. Steers were allowed free access to water. Steers were implanted with 120 milligrams (mg) of trenbolone acetate and 24 mg estradiol (Revalor S; Merck Animal Health, Whitehouse Station, N.J.).

BW and Feed Intake Measurements

Body weights were taken prior to feed delivery on two consecutive days at the beginning and end of the experiment, and every 28 days throughout the experiment. Average daily gain was calculated by regressing BW on the day of the experiment. Final BW was estimated by adding total weight gain (ADG times the number of days on the experiment) to initial BW (average of two days initial BW).

Radio frequency ID tags were placed in the right ear prior to the experiment. Each pen contained eight Insentec electronic feeding stations as described (Swanson et al., 2014), allowing for offering specific diets and monitoring of individual feed intake and feeding behavior characteristics.

Each treatment diet was offered in two feeders per pen. Feeding behavior characteristics were defined as follows: events (number of bunk visits and meals daily), eating time (minutes; per visit, per meal and per day), and feed intake (pounds; per visit, per meal and per minute). These data were summarized as the average of each individual steer throughout the entire experiment. A visit was defined as each time the Insentec system detected a steer at a bunk and feed was consumed. A meal was defined as a distinct eating period, which may include short breaks, but which is separated by intervals of no longer than seven minutes (Forbes, 1995; Montanholi et al., 2010).

Dry-matter intake variance also was calculated throughout the entire feeding period. Diet samples were collected weekly. Samples were dried in a 55 C (131 F) oven and ground to pass a 1-millimeter screen. Samples were analyzed for DM, ash, crude protein, calcium, phosphorus, NDF, ADF, ether extract and starch.

Cattle were fed until approximately 1,430 pounds of BW and were transported to a commercial slaughter facility in two groups at 117 days (n = 44; n = 11 per treat-

ment) and 155 days (n = 20; n = 5 per treatment). Hot carcass weight was measured on the day of slaughter, and carcass measurements were measured following a 24-hour chill. Measurements taken were subcutaneous fat thickness at the 12th rib, rib-eye area, marbling score, and kidney, pelvic and heart fat (KPH).

Data for carcass traits was lost for three steers fed corn silage, one steer fed wheat straw and one steer fed corn stover, so data was available for n = 16, 13, 15 and 15 for the alfalfa hay, corn silage, wheat straw and corn stover treatments, respectively. Data were analyzed as a completely randomized block (slaughter group) design using the Mixed procedure of SAS. The model included the effects of block (slaughter group) and forage source. Differences among treatment least squares means were determined using the protected least significant means approach.

Table 1. Diet and nutrient composition of total mixed diets fed to steers.

	Treatment			
Ingredient, % of DM	Alfalfa	Corn silage	Wheat straw	Corn stover
Corn	76.18	70.00	75.22	73.48
Alfalfa	10.00	-	-	-
Corn silage	-	13.80	-	-
Wheat straw	-	-	7.80	-
Corn stalks	-	-	-	9.80
Corn condensed distillers solubles	10.00	10.00	10.00	10.00
Soybean meal	0.84	3.22	4.00	3.74
Limestone	1.50	1.50	1.50	1.50
Urea	1.00	1.00	1.00	1.00
Salt	0.20	0.20	0.20	0.20
Concentrated separator byproduct	0.15	0.15	0.15	0.15
Vitamin premix[a]	0.05	0.05	0.05	0.05
Trace mineral premix[b]	0.05	0.05	0.05	0.05
Monensin premix[c]	0.02	0.02	0.02	0.02
Tylosin premix[d]	0.01	0.01	0.01	0.01
Analysis				
DM	70.2	60.5	70.9	71.0
OM, % of DM	94.2	94.7	94.1	93.3
CP, % of DM	16.0	16.0	15.5	14.6
NDF, % of DM	26.6	26.9	27.5	26.1
ADF, % of DM	11.0	8.4	11.5	11.1
Ca, % of DM	0.88	0.87	0.89	0.71
P, % of DM	0.56	0.55	0.51	0.49

[a]Contains 48,510 kIU/kg vitamin A and 4,630.5 kIU/lg vitamin D.
[b]Contains 3.62% Ca, 2.56% Cu, 16% Zn, 6.5% Fe, 4.0% Mn, 1,050 mg/kg I, and 250 mg/kg Co.
[c]Contains 176.4 g/kg monensin.
[d]Contains 88.2 g/kg tylosin.

Table 2. Nutrient composition of forages.

	Ingredient			
Ingredient	Alfalfa	Corn silage	Wheat straw	Corn stover
DM, %	83.1	34.7	89.2	89.7
OM, % of DM	89.4	94.0	88.2	81.0
CP, % of DM	16.5	8.77	3.81	4.01
NDF, % of DM	60.2	43.2	73.0	61.8
ADF, % of DM	43.2	22.4	45.5	35.0
Ca, % of DM	1.32	0.46	0.35	0.57
P, % of DM	0.41	0.19	0.22	0.19

Results and Discussion

Initial and final BW did not differ among dietary treatments (Table 3). Dry-matter intake did not differ among treatments. The gain-to-feed ratio did not differ among treatments. The number of visits and number of meals per day also did not differ among dietary treatments (Table 4). But eating time per visit was greatest ($P = 0.02$) in steers fed wheat straw and least for steers fed alfalfa hay or corn silage, with steers fed corn stover intermediate. Eating time per meal was greatest ($P = 0.05$) for steers fed wheat straw or corn stover and least for steers fed corn silage, with steers fed alfalfa hay intermediate. Eating rate (lb of DMI/min) tended to be fastest ($P = 0.07$) for steers fed alfalfa hay and slowest for steers fed wheat straw, with steers fed corn silage or corn stover intermediate. Hot carcass weight, rib-eye area, back-fat thickness, marbling score, KPH and U.S. Department of Agriculture yield grade did not differ among dietary treatments (Table 5).

These data indicate that growth performance and carcass characteristics did not differ when different forage sources contributed similar amounts of NDF in high-concentrate finishing diets. However, steers fed wheat straw or corn stover spent

more time eating per meal to consume a similar amount of DM. This suggests that the source of the NDF does influence feeding behavior.

After the adaptation period in this study, we found very few signs of acidosis. Perhaps if dietary NDF concentrations were lower (less forage), the use of forages that result in more time eating per meal and reduced eating rate may result in improved growth performance. Overall, our results indicate that alternative forage sources, when fed at a similar NDF concentration as used in this experiment, may be used to achieve similar growth performance and carcass characteristics in finishing diets, although it may impact feeding behavior.

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Table 3. Influence of forage source on growth performance in steers fed a high-concentrate diet.

	Treatment					
Item	Alfalfa	Corn silage	Wheat straw	Corn stover	SEM[a]	*P*
Initial BW, lb.	858	865	869	878	15.8	0.85
Final BW, lb.	1445	1426	1426	1434	23.1	0.90
ADG, lb.	4.33	4.18	4.16	4.14	0.145	0.74
DMI, lb.	24.6	23.1	23.3	24.9	0.62	0.12
DMI, % of BW	2.14	2.02	2.04	2.14	0.048	0.15
G:F	0.176	0.180	0.177	0.167	0.0044	0.27

[a]Standard error of the mean (n = 16).

Table 4. Influence of forage source on feeding behavior in steers fed a high-concentrate diet.

	Treatment					
Item	Alfalfa	Corn silage	Wheat straw	Corn Stover	SEM[a]	*P*
Eating events, no./d.						
Visits	26.9	25.9	24.4	27.3	1.52	0.51
Meals	8.46	9.12	8.82	9.07	0.29	0.37
Eating time, min.						
Per visit	3.29[a]	3.41[a]	4.26[b]	3.76[ab]	0.225	0.02
Per meal	10.30[ab]	9.47[b]	11.19[a]	10.92[a]	0.474	0.05
Per day	86.7	85.4	97.0	98.8	4.34	0.06
Feed DMI, lb.						
Per visit	0.93	0.93	1.02	0.95	0.053	0.54
Per meal	2.95	2.57	2.70	2.78	0.109	0.10
Per min. (eating rate)	0.291[e]	0.278[ef]	0.244[f]	0.267[ef]	0.0128	0.07

When the overall p-value < 0.05, means in a row not sharing a common letter (a, b, c, d) differ (P ≤ 0.05). When the overall p-value < 0.10, means in a row not sharing a common letter (e, f, g, h) tend to differ (P < 0.10).

[a]Standard error of the mean (n = 16).

Table 5. Influence of forage source on carcass characteristics in steers fed a high-concentrate diet.

	Treatment[a]					
Item	Alfalfa	Corn silage	Wheat straw	Corn stover	SEM[b]	*P*
Hot carcass weight, kg	381	380	384	388	6.3	0.79
Rib-eye area, in^2	13.1	13.3	13.7	13.7	0.33	0.40
Back fat, in	0.429	0.503	0.484	0.495	0.0550	0.74
Marbling score[c]	432	446	481	465	21.5	0.37
KPH, %	1.84	1.89	1.89	1.98	0.056	0.29
Yield grade	2.96	3.02	2.94	3.03	0.212	0.98

[a]Forage source (n = 16 for alfalfa, n = 13 for corn silage, n = 15 for wheat straw and n = 15 for corn stover).

[b]Standard error of the mean (n = 13).

[c]400 = small[0]; 500 = modest[0].