Influence of Method of Supplementation on the Utilization of Supplemental Fat by Feedlot Steers

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ABSTRACT: Seventy-two Holstein steers (273 kg) were used in a 151-d feeding trial to evaluate the influence of method of fat supplementation on growth-performance. Dietary treatments consisted of 1) control diet (no supplemental fat), 2) 5% yellow grease (YG) on grain (YG was first mixed with a portion of the steam-flaked corn in the proportion 25% YG to 75% corn, prior to adding other dietary ingredients), and 3) 5% YG on ration (YG was added to the mixer as the next to the last step, prior to adding molasses.). There were no treatment effects (P > .10) on ADG. The addition of 5% YG decreased (6.3%, P < .01) DMI, and increased feed efficiency (4.7%, P < .01) and diet NE_g (5.7%, P < .01). There were no effects (P > .10) of method of fat supplementation on growth-performance. Six Holstein steers (313 kg) with cannulas in the rumen and proximal duodenum were used in a replicated 3 X 3 Latin square design experiment to evaluate treatment effects on digestive function. There were no treatment effect (P > .10) on ruminal digestion of starch or N. Supplemental YG decreased ruminal digestion of OM (10.4, P < .01) and ADF (36.7%, P < .10). There were no treatment effects (P > .10) on post-ruminal digestion of OM, starch, ADF and lipid. However, saturating a portion of the grain with fat decreased slightly (2.7%, P < .10) post ruminal digestion of N. Supplemental YG decreased (P < .10) total tract digestion of OM (1.8%) and ADF (13.9%). It is concluded that there are no positive associative effects of adding YG directly to steam-flaked corn on growth-performance or digestive function.

Introduction

Typically, the first limiting step toward degradation of feed particles within the rumen is exposure of the substrate to the enzymatic process. This forms the basis for the various processing techniques applied to grains and forages. For example, steam flaking corn disrupts the seed coat and protein matrix surrounding the starch granules, thereby enhancing ruminal and total tract digestion. Saturating the grain with supplemental fat may reduce the exposure rate of starch to ruminal fermentation, and enhance escape of starch to the small intestine. The objective of the present study is to investigate this strategy with respect to feedlot cattle performance and digestive function.

Experimental Procedure

Trial 1. Seventy-two Holstein steers weighing 273 kg were blocked by weight and randomly assigned, within weight groupings, to 12 pens (6 steers/pen). Pens were 43 m^2 with 22 m^2 overhead shade, automatic waterers and 2.4-m fence-line feed bunks. The trial was initiated January 28, 1993. Average daily minimum and

maximum air temperatures during the trial were 13 and 31°C, respectively. There was 2.6 cm precipitation; average daily relative humidity was 41%. Steers were implanted with Synovex-S® (Syntex Corp., Des Moines, IA) upon initiation of the trial and reimplanted with Revalor® (Hoechst-Roussel Agri-Vet, Somerville, NJ) on d 56. Composition of the dietary treatments is shown in Table 1. Diets were prepared at approximately weekly intervals and stored in plywood boxes located in front of each pen. Steers were allowed ad libitum access to experimental diets, with twice-daily feeding. Hot carcass weights were obtained from all steers at time of slaughter. After the carcasses are chilled for 48 h the following measurements were obtained: 1) longissimus muscle area (ribeye area), taken by direct grid reading of the eye muscle at the twelfth rib; 2) subcutaneous fat over the eye muscle at the twelfth rib taken at a location 3/4 the lateral length from the chine bone end; 3) kidney, pelvic and heart fat (KPH) as a percentage of carcass weight and 4) marbling score (USDA, 1965). Retail yields (boneless, closely trimmed retail cuts from the round, loin, rib, and chuck as a percentage of carcass weight) were estimated using the equation of (USDA, 1965). Energy retention was not measured directly in this trial, however, given the assumption that the primary determinant of energy gain (EG) was weight gain, EG was calculated by the equation:

$$EG=ADG^{1.095} .0557BW^{.75},$$

where EG is the daily energy deposited (Mcal/d), ADG is weight gain (kg/d) and BW is the mean body weight (kg; NRC, 1984). Maintenance energy,expended (EM) was calculated by the equation:

$$EM=.O84\ W^{.75}$$

(Garrett, 1971). From the derived estimates for energy required for maintenance and gain, the NEm and NEg values of the diet are obtained by process of iteration to fit the relationship: NEg= .877NE. + .41 (Zinn and Plascencia, 1996). In determining steer performance, initial and final weights were reduced 4% to account for digestive tract fill. Pen means were used as experimental units. The trial will be analyzed as a randomized complete block design experiment (Hicks, 1973). Treatment effects were tested by means of the following orthogonal contrasts: 1) control vs supplemental fat, 2) fat on grain vs fat on total mixed ration.

Trial 2. Six Holstein steer (313 kg) with cannulas in the rumen and proximal duodenum (Zinn and Plascencia, 1993) were used in a replicated 3X3 Latin square experiment to study treatment effects on characteristics of ruminal and total tract digestion. Treatments were the same as those used in trial 1 (Table 1), with .40% chromic oxide added as a digesta marker. Steers were maintained in individual pens (3.9 m^2) with access to water at all times. Diets were fed at 0800 and 2000 daily. Experimental periods consisted of a 10-d diet adjustment period followed by a 4-d collection period. During the collection period duodenal and fecal samples were taken from all steers, twice daily as follows: d 1, 0750 and 1350; d 2, 0900 and 1500; d 3, 1050 and 1650; and d 4,

1200 and 1800. Individual samples consisted of approximately 500 ml duodenal chyme and 200 g (wet basis) fecal material. Samples from each steer and within each collection period were composited for analysis. During the final day of each collection period, ruminal samples were obtained from each steer 4 h after the morning feeding via the ruminal cannula. Ruminal fluid pH was determined (Digi-Sense LCD pH Meter, Cole-Parmer, Chicago, IL) on fresh samples, and samples were strained through four layers of cheesecloth. Two milliliters of freshly prepared 25% (w/v) meta-phosphoric acid was added to 8 mL of strained ruminal fluid. Samples were then centrifuged (17,000 x g for 10 min) and supernatant fluid stored at -20°C for VFA analysis. Upon completion of the trial, ruminal fluid was obtained from all steers and composited for isolation of ruminal bacteria via differential centrifugation (Bergen et al., 1968). Samples were subjected to all or part of the following analysis: DM (oven drying at 105°C until no further weight loss); ash, Kjeldahl N, ammonia N (AOAC, 1975); ADF (Goering and Van Soest, 1970); purines (Zinn and Owens, 1986); lipid (Zinn, 1994); VFA concentrations of ruminal fluid (gas chromatography; Zinn, 1988); chromic oxide (Hill and Anderson, 1958) and starch (Zinn, 1990). Microbial organic matter (MOM) and N (MN) leaving the abomasum was calculated using purines as a microbial marker (Zinn and Owens, 1986). Organic matter fermented in the rumen (OMF) was considered equal to OM intake minus the difference between the amount of total OM reaching the duodenum and MOM reaching the duodenum. Feed N escape to the small intestine was considered equal to total N leaving the abomasum minus ammonia-N and MN and, thus, includes any endogenous contributions. Methane production was calculated based on the theoretical fermentation balance for observed molar distribution of VFA and OM fermented in the rumen (Wolin, 1960) and ruminal OM digestion. The trial was analyzed as a replicated 3 X 3 Latin square according to the following statistical model: $Y_{ijkl}=\mu + B_i + A_{j(i)} + P_k + T_l + E_{ijkl}$, where B_i is block, $A_{j(i)}$ is steer within block, P_k is period, T_l is treatment and E_{ijkl} is residual error. Treatment effects were tested by means of the following orthogonal contrasts: 1) control vs supplemental fat, 2) fat on grain vs fat on total mixed ration.

Implications

Method of fat supplementation does not influence the feeding value of fat for feedlot cattle. Saturation of a portion of the dietary steam-flaked corn with yellow grease does not reduce its negative effects on ruminal fiber digestion, nor does it enhance the proportion of dietary starch that escapes ruminal degradation.

Table 1. COMPOSITION OF EXPERIMENTAL DIETS FED TO STEERS (Trials 1, 2)[a]

Item	Control	Supplemental fat	
		On ration	On grain
Ingredient composition, % (DM basis)			
Alfalfa hay	8.00	8.00	8.00
Sudangrass hay	4.00	4.00	4.00
Steam-flaked corn	80.29	75.29	75.29
Yellow grease[b]			
On grain[c]		5.00	
On ration[d]			5.00
Cane molasses	4.00	4.00	4.00
Limestone	1.77	1.77	1.77
Dicalcium phosphate	.25	.25	.25
Urea	1.19	1.19	1.19
Trace mineral salt[e]	.50	.50	.50
Nutrient composition (DM basis)[f]			
NE, Mcal/kg			
Maintenance	2.15	2.33	2.33
Gain	1.47	1.63	1.63
Crude protein, %	13.0	12.6	12.6
Ether extract, %	3.7	8.4	8.4
Calcium, %	.80	.80	.80
Phosphorus, %	.37	.36	.36

[a]Diets in trial 2 contained an additional .4% chromic oxide as a digesta marker.

[b]Fatty acid profile: C12:0, .30%; C14:0, .76%; C16:0, 14.54%; C16:1, 1.38%; C18:0, 8.61%; C18:1, 48.30%; C18:2, 22.42%; C18:3, 2.26%.

[c]As the first step in preparing the batch, the yellow grease was mixed with a portion of the steam-flaked corn in the proportion 5% grease to 15% corn, prior to adding other ingredients.

[d]Yellow grease was added to the mixer as the next to the last step, prior to adding molasses.

[e]Trace mineral salt contained: $CoSO_4$, .068%; $CuSO_4$, 1.04%; $FeSO_4$, 3.57%; ZnO, 1.24%; $MnSO_4$, 1.07%; KI, .052%; and NaCl,

92.96%.

[f]Based on tabular values for individual feed ingredients (NRC, 1984) with exception of supplemental fat which was assigned NE_m and NE_g values of 6.03 and 4.79, respectively (Zinn, 1988).

Table 2. Influence of method of fat supplementation on feedlot growth-performance of Holstein steers (Trial 1)

Item	Control	Supplemental fat		SD
		On ration	On grain	
Pen replicates	4	4	4	
Days on test	151	151	151	
Weight, kg[a]				
Initial	273	273	272	1
Final	505	500	502	4
ADG, kg/d	1.53	1.50	1.52	.02
DMI, kg/d[b]	8.23	7.68	7.74	.11
DMI/ADG[b]	5.37	5.12	5.11	.04
Diet NE, Mcal/kg				
Maintenance[b]	2.26	2.36	2.36	.01
Gain[b]	1.57	1.66	1.66	.01
Observed/expected diet NE				
Maintenance[b]	1.06	1.01	1.01	.01
Gain[b]	1.07	1.02	1.02	.01
NE of yellow grease, Mcal/kg				
Maintenance		4.38	4.38	
Gain				

[a]Initial and final live weights reduced 4% to account for fill.

[b]Supplemental fat versus control, P < .01.

Table 3. Influence of method of fat supplementation on carcass characteristics of Holstein steers (Trial 1)

Item	Control	Supplemental fat		SD
		On ration	On grain	
Carcass weight, kg	310	307	310	4
Dressing percentage	61.4	61.3	61.8	.6
Rib eye area, cm^2	79.8	77.8	79.9	1.7

Fat thickness, cm	.45	.39	.46	.08
KPH, %[a]	1.25	1.63	1.63	.37
Marbling score[b]	3.6	3.8	3.6	.2
Retail yield, %	52.5	52.3	52.4	.4
Liver abscess, %	8.5	8.5	4.3	9.4

[a]Kidney, pelvic and heart fat as a percentage of carcass weight.
[c]Coded: Minimum slight = 3, minimum small = 4, etc.

Table 4. Influence of method of fat supplementation characteristics of OM, starch, ADF, N and lipid digestion (Trial 2)

		Supplemental fat		
Item	Control	On ration	On grain	SD
Steer replicates	6	6	6	
Intake, g/d				
DM	6,074	6,125	6,112	
OM	5,755	5,800	5,786	
Starch	3,062	2,974	2,891	
ADF	546	462	495	
N	119	114	117	
Lipid	187	517	530	
Leaving abomasum, g/d				
OM[a]	2,110	2,582	2,526	319
Starch	241	281	273	108
ADF	323	360	349	58
Non-ammonia N	124	123	120	12
Microbial N	65.0	63.2	63.5	10.7
Feed N	59.5	60.1	57.0	8.8
Lipid[b]	419	579	589	92.9
Ruminal digestion, % intake				
OM[b]	74.6	66.4	67.2	3.8
Starch	92.1	90.5	90.3	3.4
ADF[c]	40.3	21.1	29.9	12.9
Feed N	49.71	47.2	51.5	7. 1
Microbial efficiency[d]	15.1	16.5	16.6	2.2
Protein efficiency[e]	1.05	1.08	1.02	.08

Fecal excretion, g/d				
OM	762	834	886	119
Starch	9.2	8.6	11.4	3.7
ADF	251	252	257	45
N	29.3	28.8	30.6	2.7
Lipid[a]	139	194	213	56
Post-ruminal digestion, % leaving abomasum				
OM	63.1	67.5	64.9	4.8
Starch	95.8	96.6	95.6	1.6
ADF	18.3	30.0	24.2	23.0
N[f]	77.5	77.6	75.5	1.6
Lipid	67.2	66.5	64.0	5.2
Total tract digestion, %				
OM[c]	86.7	85.6	84.7	1.6
Starch[f]	99.7	99.7	99.6	.1
ADF[c]	53.9	44.9	47.9	7.5
N	75.4	74.8	74.0	1.6

[a]Supplemental fat versus control, P < .05.
[b]Supplemental fat versus control, P < .01.
[c]Supplemental fat versus control, P < .10.
[d]Microbial N, g/kg OM fermented.
[e]Duodenal non-ammonia N/N intake.
[f]Method of adding fat, P < .10.

Table 5. Influence of method of fat supplementation on ruminal pH, VFA molar proportions and estimated methane production 4 h after feeding (Trial 2)

		Supplemental fat		
Item	Control	On ration	On grain	SD
Steer replicates	6	6	6	
Ruminal pH[a]	5.67	5.91	5.94	. 2 3
Ruminal VFA, mol/100 mol				
Acetate	53.3	56.0	56.1	9.4
Propionate	33.7	32.4	34.5	7.5
Butyrate	13.0	11.6	9.4	3.8
Methane production[b]	.43	.46	.44	.11

[a]Supplemental fat versus control, P < .10.
[b]Methane, mol/mol glucose equivalent fermented.