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Limit-feeding a high-concentrate diet may alter nutrient absorption

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LIMIT-FEEDING A HIGH-CONCENTRATE DIET MAY ALTER NUTRIENT ABSORPTION

J. O. Wallace, W. F. Miller, B. J. Johnson and C. D. Reinhardt

Introduction

Feeding newly arrived cattle is commonly characterized by a few days of feeding long-stemmed hay followed by a series of step-up diets, wherein concentrate levels are increased to promote ruminal adaptation to a high-concentrate finishing diet. This is done to give the rumen microbes time to adjust to larger amounts of readily fermentable starches in cereal grains. Rumen epithelial adaptation may be achievable by limit-feeding a finishing diet, with gradual increases in feed intake, until the cattle are on full feed. If this can be achieved without causing ruminal disorders and days off feed, then the cost of feeding cattle can be reduced. By limit-feeding, the higher roughage step-up diets are replaced with a single high-concentrate diet. The cost of grain is less than that of roughage, and there are decreased costs in terms of storage space, waste disposal (due to decreased manure production), and mixing and hauling of rations. The purpose of this experiment was to examine the effects of a traditional step-up program versus a limit-fed finishing diet in terms of dry matter intake, acetate to propionate ratio, and ruminal dilution rate. Diet effects on volatile fatty acid concentration and absorption were also examined by using valerate as a marker for volatile fatty acid absorption.

Procedures

In February 2006, cannulated steers ($n = 4$; average starting weight = 948 lb) were assigned to one of two ration adaptation treatments: 1) limit-fed finishing diet beginning at

1.25% of body weight daily with daily increases of 0.5 lb (LIMIT); or 2) *ad libitum* access to three sequential high-roughage step-up diets and a subsequent finishing diet beginning at 1.5% of body weight daily with daily increases of 1 lb (STEP). If there was more than 0.5 lb of feed refused, feed delivery was not increased the subsequent day. Cattle were stepped up over a 28-day period with seven days per step. Steers were housed in the tie-stall barn at the KSU Dairy Teaching and Research Unit. At the end of the 28 days, steers were placed in an outdoor pen and fed prairie hay and a soybean meal supplement for 21 days. After the three-week rest interval, they were started anew on the adaptation trial, with diets being switched to the opposite of those fed during the first period.

Rumen fluid was collected on days 0, 7, 14, 21 and 28; samples were collected on each collection day over an 8-hour period at 0, 0.5, 1, 1.5, 2, 3, 4, 6, and 8 hours. A basal sample was collected and then each steer was given a single, 1-liter, pulse dose of a 1 molar solution of valerate, with the pH adjusted to 6.0. Samples were analyzed for volatile fatty acids and cobalt, which was a marker for liquid passage from the rumen. Diet samples were collected on each day as the diet was mixed. At the end of the experiment, feed samples were composited and analyzed for neutral detergent fiber and crude protein.

Results

There was an overall diet and day effect on dry matter intake ($P < 0.05$). This was due to experimental design. Once all cattle achieved

ad libitum intake during the fourth week of the experiment, there were no effects of step-up treatment on daily dry matter intake. There was no treatment by week effect on acetate to propionate ratio. There was an overall treatment by week effect on total volatile fatty acid concentrations ($P = 0.05$), but this may be attributable to differences in intake, which were by design. Total volatile fatty acid concentration was different between LIMIT and STEP during weeks 1, 3, and 4 ($P < 0.05$). It was higher for STEP cattle during weeks 1 and 3, but was greater in LIMIT cattle during week 4. There was a tendency for total volatile fatty acids to be higher for STEP cattle during week 2 ($P = 0.06$). During weeks 1 and 4, valerate absorption differed between treatments ($P \leq 0.05$) and tended to differ ($P = 0.09$) during week 2. Valerate absorption was greater for LIMIT steers during week 1 and tended to be higher during week 2, but during week 4 it shifted and was greater in STEP cattle. This may indicate that the conventional step-up diet is more effective at adapting the rumen epithelium to absorb nutrients once cattle are consuming a finishing diet *ad libitum* or may simply reflect changes in the consumptive behavior of cattle as the amount of feed is increased. Total valerate disappearance was af-

ected by treatment during week 4 ($P = 0.05$) and treatments tended to differ during week 1 ($P = 0.08$). Total valerate disappearance tended to be higher in limit-fed cattle during week 1, and was greater in the conventionally fed steers during week 4. No diet by week effects were observed for liquid dilution rate, rumen volume, or rumen turnover.

Discussion:

Due to the current high cost of roughage and its relatively low nutrient content, the cost of conventional step-up programs for adapting cattle to high concentrate diets is greater than limit-feeding them a finishing diet as a means of ruminal adaptation. Limit-feeding the finishing diet during adaptation proved equally effective to a conventional high roughage step-up program with regard to dry matter intake once *ad libitum* intake of the final finishing diet was achieved by all steers. Valerate, a volatile fatty acid normally present in the rumen at low concentrations, is considered a good marker for absorption of other volatile fatty acids. Therefore, as demonstrated by reduced valerate absorption, limit-feeding may alter the ability of the animal to absorb nutrients due to changes in the rumen epithelium.

Table 1. Composition (dry matter basis) of Three Step-up Diets and Finishing Diet

Item, %	% Concentrate			
	60	71	81	92
Steam-flaked corn	49.51	60.04	70.56	81.09
Ground alfalfa hay	40.00	29.33	18.67	8.00
Corn steep liquor	5.00	5.00	5.00	5.00
Vitamin premix ^a	3.26	3.40	3.55	3.68
Feed additive premix ^b	2.23	2.23	2.23	2.23
Nutrient Composition				
NDF, %	27.17	22.73	21.56	15.94
Crude protein, %	16.01	15.68	16.10	14.78
Calcium, %	0.70	0.73	0.75	0.78
Phosphorus, %	0.35	0.35	0.35	0.36
Potassium, %	0.99	0.90	0.82	0.73
NEg, Mcal/lb.	0.55	0.59	0.64	0.69

^aPremix formulated to provide final diet: 0.14 ppm Cobalt, 10.79 ppm Copper, 0.67 ppm Iodine, 64.76 ppm Manganese, 0.27 ppm Selenium, 64.69 ppm Zinc, and 1.29 KIU/lb Vitamin A.

^bFormulated to provide 300 mg/day Rumensin, and 90 mg/day Tylan.

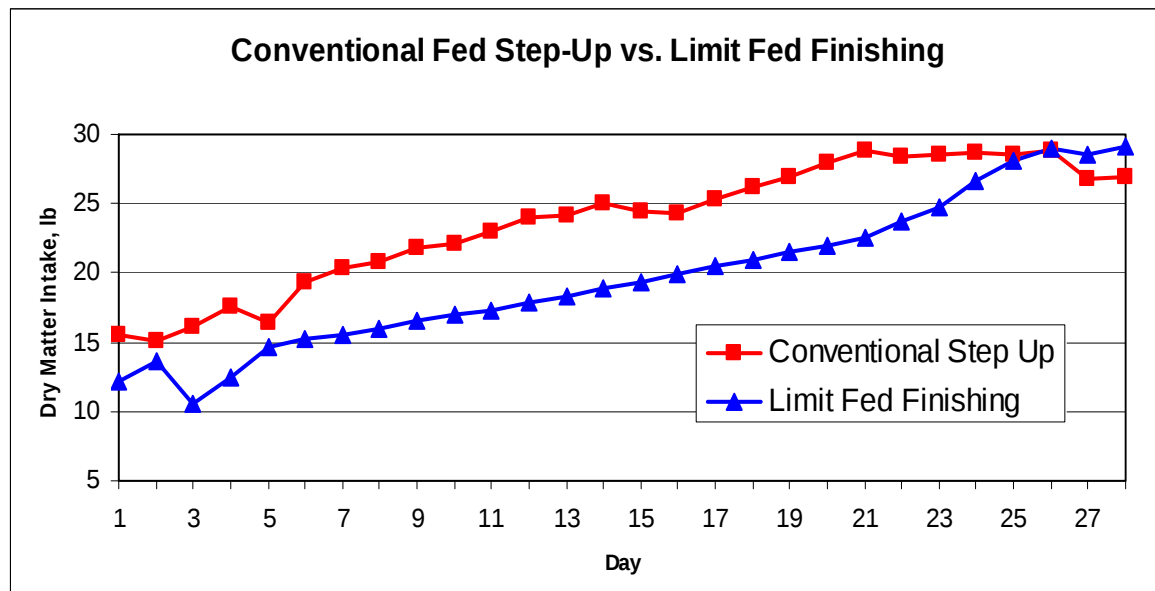
**Figure 1. Daily Dry Matter Intake.**

Table 2. Ruminal Effects of Conventional Step-up Dietary Adaptation vs. Limited Intake of the Finishing Diet

Item	Treatment ^a		SEM ^d	P-value
	Step-up ^b	Limit Fed ^c		
Week 1				
Acetate:propionate ratio	1.49	1.42	0.14	0.61
Total volatile fatty acid, mmol/liter	116.34	99.67	9.42	0.02
Total valerate disappearance, %/hour	0.39	0.56	0.06	0.08
Liquid dilution rate, %/hour	0.13	0.09	0.03	0.41
Valerate absorption, %/hour	0.27	0.46	0.06	0.02
Rumen volume, liters	27.16	29.30	6.88	0.79
Turnover, hours	8.50	13.90	2.36	0.19
Week 2				
Acetate:propionate ratio	1.38	1.23	0.07	0.18
Total volatile fatty acid, mmol/liter	132.84	108.89	8.85	0.06
Total valerate disappearance, %/hour	0.39	0.48	0.04	0.17
Liquid dilution rate, %/hour	0.13	0.07	0.03	0.20
Valerate absorption, %/hour	0.26	0.41	0.05	0.09
Rumen volume, liters	28.67	34.55	8.70	0.58
Turnover, hours	10.85	39.97	19.91	0.34
Week 3				
Acetate:propionate ratio	1.00	1.04	0.07	0.73
Total volatile fatty acid, mmol/liter	120.82	97.52	10.42	0.04
Total valerate disappearance, %/hour	0.65	0.69	0.17	0.76
Liquid dilution rate, %/hour	0.10	0.10	0.03	0.94
Valerate absorption, %/hour	0.55	0.59	0.17	0.81
Rumen volume, liters	39.81	35.85	8.50	0.69
Turnover, hours	15.94	11.37	4.13	0.45
Week 4				
Acetate:propionate ratio	1.64	1.77	0.44	0.48
Total volatile fatty acid, mmol/liter	99.85	107.81	2.80	0.03
Total valerate disappearance, %/hour	0.67	0.39	0.09	0.05
Liquid dilution rate, %/hour	0.13	0.16	0.05	0.81
Valerate absorption, %/hour	0.55	0.23	0.08	0.05
Rumen volume, liters	28.19	22.44	5.56	0.36
Turnover, hours	9.48	13.09	5.17	0.58

^aStep-up = steers fed three step up diets and a finishing diet increasing from 60% to 92% concentrate; Limit Fed = steers fed restricted amounts of the 92% concentrate diet as a means of adaptation.

^bWeek 1 = 60% concentrate; Week 2 = 71% concentrate; Week 3 = 81% concentrate; and Week 4 = 92% concentrate, all diets fed for *ad libitum* intake.

^cWeeks 1, 2, and 3, limit fed 92% concentrate diet starting at 1.25% BW daily and increased 0.5 lb/head daily; during week 4 steers were fed *ad libitum*.

^dSEM = Standard error of the least squares means; n = 4 steers/treatment.