Kansas Agricultural Experiment Station Research Reports

Volume 0
Issue 1 *Cattleman's Day (1993-2014)*

Article 20

2012

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Abstract

Cattle entering feedlots typically are adapted to finishing diets over a period of 2 to 4 weeks by gradually replacing forages with concentrate feeds using a series of step-up diets. Without proper adaptation, naïve cattle are highly susceptible to ruminal acidosis, a disorder associated with excessive production and accumulation of organic acids within the rumen. One of the key metabolic intermediates associated with the manifestation of acidosis is lactic acid, which is derived from fermentation of readily available starches and sugars. Streptococcus bovis is a prolific, rapidly growing, and opportunistic organism that thrives in the presence of readily fermented starches and sugars, and is an important inhabitant of the rumen that is recognized for its ability to produce large quantities of lactate. In unadapted cattle, the relative absence of lactate-utilizing bacteria can lead to the accumulation of lactate, thus predisposing the animals to acidosis. In traditional step-up programs, the gradual replacement of roughages with concentrate feeds provides ample time for proliferation of lactate-utilizing species of bacteria, the most important of which is Megasphaera elsdenii. Lactipro (MS Biotech, Inc., Wamego, KS) is a novel class of probiotic consisting of a highly prolific strain of Megasphaera elsdenii. Because Megasphaera elsdenii is an obligate anaerobe, it must be administered orally to avoid exposure to oxygen. In previous experiments with Lactipro, we have observed that a single oral dose results in rapid colonization of Megasphaera elsdenii within the rumen, effectively preventing the accumulation of lactate following an abrupt diet change from forage to concentrate. The present study was designed to evaluate different step-up regimens, with the objective of decreasing the time and number of diets required to place cattle on high-concentrate finishing diets.

Keywords

Cattlemen's Day, 2012; Kansas Agricultural Experiment Station contribution; no. 12-231-S; Report of progress (Kansas State University. Agricultural Experiment Station and Cooperative Extension Service); 1065; Beef Cattle Research, 2012 is known as Cattlemen's Day, 2012; Beef; Feedlot heifers; Lactipro; Performance; Megasphaera elsdenii

Accelerated Step-Up Regimes for Feedlot Heifers Following Oral Dosing with Lactipro (*Megasphaera elsdenii* strain NCIMB 41125)

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Introduction

Cattle entering feedlots typically are adapted to finishing diets over a period of 2 to 4 weeks by gradually replacing forages with concentrate feeds using a series of step-up diets. Without proper adaptation, naïve cattle are highly susceptible to ruminal acidosis, a disorder associated with excessive production and accumulation of organic acids within the rumen. One of the key metabolic intermediates associated with the manifestation of acidosis is lactic acid, which is derived from fermentation of readily available starches and sugars. *Streptococcus bovis* is a prolific, rapidly growing, and opportunistic organism that thrives in the presence of readily fermented starches and sugars, and is an important inhabitant of the rumen that is recognized for its ability to produce large quantities of lactate. In unadapted cattle, the relative absence of lactate-utilizing bacteria can lead to the accumulation of lactate, thus predisposing the animals to acidosis. In traditional step-up programs, the gradual replacement of roughages with concentrate feeds provides ample time for proliferation of lactate-utilizing species of bacteria, the most important of which is *Megasphaera elsdenii*.

Lactipro (MS Biotech, Inc., Wamego, KS) is a novel class of probiotic consisting of a highly prolific strain of *Megasphaera elsdenii*. Because *Megasphaera elsdenii* is an obligate anaerobe, it must be administered orally to avoid exposure to oxygen. In previous experiments with Lactipro, we have observed that a single oral dose results in rapid colonization of *Megasphaera elsdenii* within the rumen, effectively preventing the accumulation of lactate following an abrupt diet change from forage to concentrate. The present study was designed to evaluate different step-up regimens, with the objective of decreasing the time and number of diets required to place cattle on high-concentrate finishing diets.

Experimental Procedures

Three hundred seventy-eight spayed, crossbred heifers (initial body weight 849 ± 24 lb) were utilized in a randomized complete block design to evaluate the efficacy of *Megasphaera elsdenii* in accelerated step-up regimens. Heifers were procured from a grazing operation in Cody, WY, in November 2010, and transported to the Kansas State University Beef Cattle Research Center in Manhattan. Cattle arrived at the research site on a Friday evening and were fed free-choice alfalfa hay until being removed from their pens for processing on Sunday morning. Heifers were weighed individually, uniquely identified with numbered ear tags, vaccinated against common viral and clostridia diseases, treated for internal parasites, and implanted with Revalor 200 (Intervet Inc., Millsboro, DE). After weighing, cattle were stratified by weight and assigned randomly, within strata, to 54 feedlot pens containing 7 heifers each. Pens were randomly assigned to each of 6 experimental treatments, providing 9 replications per treatment. Experimental treatments consisted of 6 different step-up regimes, as summa-

rized in Table 1. The control regimen utilized a total of 5 diets (Table 2), identified as Step 1, Step 2, Step 3, Step 4, and the Finisher. In this regimen, designated as 1234F, heifers did not receive Lactipro, the first 4 transition diets each were fed for 5 days, and the final finishing diet was fed from days 21 to 129. For the remaining step-up regimes, cattle were orally dosed with 100 mL of Lactipro, then started on diets containing progressively less roughage. As with the control regime, the initial diets each were fed for 5 days before changing to the next diet in the sequence. The accelerated step-up regimens consisted of steps 2, 3, and 4, followed by the finisher (234F); steps 3, 4, and the finisher (34F); step 3 and the finisher (3F); step 4 and the finisher (4F); or direct placement onto the finishing diet (F), as shown in Table 1.

Heifers were fed their respective diets free-choice once dailyfor 129 days. Rumensin and Tylan (Elanco Animal Health, Greenfield, IN) were fed at 300 and 90 mg/animal daily. Starting 23 days prior to harvest, Zilmax (Merck Animal Health, Summit, NJ) was included in the diet at the rate of 60 mg/head daily for 20 days, followed by a 3-day withdrawal. Heifers were weighed and subsequently transported to a commercial abattoir where carcass weight and liver abscess scores were collected on the day of harvest. USDA yield and quality grades; 12th rib fat thickness; percentage kidney, pelvic, and heart fat; ribeye area; and marbling score were recorded after chilling carcasses for 24 hours. Statistical analyses were conducted using the MIXED procedure of SAS (Cary, NC). Pen was the experimental unit, step-up regimen was the fixed effect, and block was the random variable. Treatment differences were determined using linear and quadratic contrasts.

Results and Discussion

Overall, health of cattle was excellent throughout the experiment. During the first week, one heifer was treated for respiratory disease, another was diagnosed and treated for possible coccidiosis, and a third heifer was treated for infectious lameness. On day 119 of the experiment, one heifer from the 4F regimen was found dead in the pen, but gross necropsy revealed no obvious cause of death.

Feedlot performance is summarized in Table 3. Step-up regimen had little effect on dry matter intake, although there was a tendency (quadratic effect, $P = 0.07$) for heifers started on the intermediate steps to consume less dry matter. Figure 1 illustrates daily feed intake for each treatment, revealing similar intake patterns throughout the 129-day experiment. Average daily gain and gain efficiency tended to be greatest for heifers stepped up on either the control (1234F) regimen or when placed directly onto feed (F) after processing (quadratic effects, $P < 0.07$ and $P < 0.10$, respectively).

The beneficial effects of *Megasphaera elsdenii* are most often attributed to its ability to metabolize lactic acid under acidic conditions. The capacity for *Megasphaera* to effectively colonize the rumen when pH is low is a characteristic that distinguishes it from other lactate-utilizing species. In previous challenge experiments, we have observed that oral administration of Lactipro following a carbohydrate challenge results in rapid colonization of the rumen by *Megasphaera*, effectively preventing accumulation of lactic acid. Low ruminal pH and the presence of lactic acid likely provide a competitive advantage for *Megasphaera*, thus facilitating its colonization within the gastrointestinal tract. In the present experiment, it is conceivable that some of the step-up regimens

were not sufficiently aggressive to yield ruminal conditions that are conducive to extensive amplification and colonization by *Megasphaera elsdenii*. For example, in the 234F and 34F regimes, little evidence supports a benefit associated with administration of Lactipro, whereas cattle placed directly onto the finishing diet clearly were able to maintain acceptable performance with no evidence of metabolic insult. Cattle started on the 3F regimen also are of notable interest. Again, starting cattle on the step 3 diet may not yield sufficient lactic acid and ruminal acidity to promote optimal colonization by *Megasphaera esldenii*, such that when the cattle are then switched abruptly to the finishing diet, they do not have the full protective effects of *Megasphaera*. Cattle started on step 4 or cattle placed directly onto the finishing diet fared much better, again suggesting that presence of lactate and/or low ruminal pH may be essential for establishment of the organism.

Feed efficiency responded in a quadratic manner to progressive elimination of transition diets ($P = 0.01$), with heifers on the 3F step-up regimen having the poorest efficiency. The magnitude of differences between treatments was less pronounced when gain was adjusted to account for differences in dressing percentage ($P = 0.12$), but reveal a similar relationship. Again, these observations may suggest that adopting a more aggressive step-up strategy is necessary to fully exploit the benefits of Lactipro.

Elimination of diets and the time required to place cattle on feed has obvious logistical advantages for feedlots as a result of simplifying and streamlining the step-up process by decreasing the number of loads of feed that must be prepared, potentially decreasing fuel usage and labor requirements, as well as use and handling of roughages.

Step-up regimen had no significant effects on incidence or severity of liver abscesses. Carcass weight; dressed yield; percentage kidney, pelvic, and heart fat; and 12th rib fat thickness also were not affected by step-up regimen (Table 4). Effect of step-up regimen on ribeye area was quadratic ($P = 0.01$) and smallest for carcasses from heifers on the 34F step-up regimen. Additionally, step-up regimen had a quadratic affect on the percentage of yield grade 1 carcasses, with the 34F regimen having the lowest percentage of yield grade 1 carcasses (Table 5). Marbling score was influenced by step-up regimen (Linear, $P = 0.12$; quadratic, $P = 0.02$), with the greatest improvements realized with cattle placed on the more aggressive step-up regimens. Quality grades (Table 6) followed similar trends, but differences among treatments were not significant.

Implications

Heifers can be transitioned to finishing diets more rapidly when *Megasphaera* is dosed at processing without negatively affecting performance or carcass characteristics; however, if heifers are not stepped up aggressively enough, the full benefits from dosing *Lactipro* may not be realized.

Table 1. Step-up regimes for treatment groups

Days on feed	Control (1234F)	Lactipro (*Megasphaera elsdenii*) treatments				
		234F	34F	3F	4F	F
1–5	Step 1	Step 2	Step 3	Step 3	Step 4	Finisher
6–10	Step 2	Step 3	Step 4	Finisher	Finisher	Finisher
11–15	Step 3	Step 4	Finisher	Finisher	Finisher	Finisher
16–20	Step 4	Finisher	Finisher	Finisher	Finisher	Finisher
21–129	Finisher	Finisher	Finisher	Finisher	Finisher	Finisher

Table 2. Composition of experimental diets on a 100% dry matter basis

Ingredient, % of dry matter	Step-up diets				
	Step 1	Step 2	Step 3	Step 4	Finisher
Dry rolled corn	5.69	15.69	25.69	35.69	45.69
Modified wet corn distillers grains	40.00	40.00	40.00	40.00	40.00
Corn silage	50.00	40.00	30.00	20.00	10.00
Supplement[1]	2.14	2.14	2.14	2.14	2.16
Feed additive premix[2,3]	2.16	2.16	2.16	2.16	2.16
Nutrient analyses, %					
Dry matter	48.41	52.21	56.66	61.93	68.28
Crude protein	15.88	15.97	16.06	16.15	16.24
Neutral detergent fiber	38.07	33.87	29.67	25.47	21.27
Crude fat	6.62	6.74	6.86	6.98	7.10
Calcium	0.78	0.76	0.74	0.72	0.70
Phosphorus	0.46	0.47	0.48	0.48	0.49
Potassium	0.94	0.88	0.82	0.76	0.70

[1] Formulated to provide 0.3% salt, 0.1 ppm Co; 1.0 ppm Cu; 0.6 ppm I; 60 ppm Mn; 0.25 ppm Se; 60 ppm Zn; 1,000 IU/lb vitamin A; and 10 IU/lb vitamin E on a dry matter basis.
[2] Formulated to provide 300 mg Rumensin and 90 mg Tylan (Elanco Animal Health, Greenfield, IN) per heifer daily.
[3] Zilmax (Merck Animal Health, Summit, NJ) was fed for 20 days followed by a 3-day withdrawal before harvest.

Table 3. Feedlot performance of heifers orally dosed with Lactipro (*Megasphaerea elsdenii*) at initial processing and placed onto accelerated step-up regimens

Item	Control (1234F)	Lactipro (*Megasphaera elsdenii*) treatments					SEM	F-test *P*-value	Step-up regimen, *P*-value	
		234F	34F	3F	4F	F			Linear	Quadratic
No. of cattle	63	63	63	63	62	63				
Days on feed	129	129	129	129	129	129				
Initial weight, lb	850	850	849	849	848	851	24	0.28	0.89	0.14
Final weight, lb[1]	1322	1314	1307	1297	1310	1316	26.0	0.48	0.50	0.07
Average daily gain, lb/day	3.66	3.59	3.55	3.48	3.59	3.62	0.07	0.52	0.50	0.10
Dry matter intake, lb/day	26.85	27.17	26.78	26.86	26.81	26.70	0.69	0.95	0.29	0.07
Feed:gain, lb/lb	7.29	7.52	7.52	7.71	7.36	7.37	0.200	0.08	0.89	0.01
Carcass adjusted[2]										
Average daily gain, lb/day	3.64	3.60	3.60	3.51	3.56	3.64	0.08	0.82	0.76	0.28
Feed:gain, lb/lb	7.32	7.53	7.43	7.65	7.41	7.30	0.205	0.55	0.88	0.12

[1] Final body weight shrunk (4%).
[2] Hot carcass weight was divided by a common dressing percentage (63.5) and used as final body weight to calculate carcass adjusted average daily gain and gain:feed.

Table 4. Carcass characteristics and liver abscess scores of heifers orally dosed with Lactipro (*Megasphaera elsdenii*) at initial processing and placed onto accelerated step-up regimes

Item	Control (1234F)	Lactipro (*Megasphaera elsdenii*) treatments					SEM	F-test *P*-value	Step-up regimen, *P*-value	
		234F	34F	3F	4F	F			Linear	Quadratic
Hot carcass weight, lb	838	834	833	826	830	838	17.4	0.78	0.75	0.20
Dressed yield, %	63.4	63.5	63.8	63.7	63.3	63.7	0.28	0.78	0.65	0.64
Ribeye area, in.^{2}	14.2	13.8	13.8	13.9	13.7	14.3	0.23	0.10	0.73	0.01
Kidney, pelvic, and heart fat, %	2.47	2.52	2.50	2.42	2.46	2.50	0.06	0.81	0.86	0.67
12th-rib fat, in.	0.44	0.46	0.40	0.44	0.38	0.43	0.02	0.10	0.20	0.31
Liver abscesses, %	15.9	22.2	7.9	11.1	8.0	14.3	4.39	0.15	0.18	0.25
Abscess severity, %										
A-	6.4	6.4	0	3.2	3.2	3.2	2.47	0.41	0.27	0.24
A	1.6	7.9	3.2	3.2	0.0	6.4	2.44	0.17	0.99	0.78
A+	7.9	7.9	4.8	4.8	4.8	4.8	3.03	0.91	0.31	0.64

Table 5. USDA yield grades of heifers orally dosed with Lactipro (*Megasphaera elsdenii*) at initial processing and placed onto accelerated step-up regimes

Item	Control (1234F)	Lactipro (*Megasphaera elsdenii*) treatments					SEM	F-test *P*-value	Step-up regimen, *P*-value	
		234F	34F	3F	4F	F			Linear	Quadratic
USDA yield grade	2.4	2.5	2.4	2.4	2.2	2.3	0.11	0.51	0.18	0.76
Yield grade 1, %	15.9	6.4	11.1	14.3	11.3	20.6	4.57	0.25	0.24	0.10
Yield grade 2, %	42.6	44.4	50.8	46.0	59.7	38.1	6.28	0.22	0.75	0.13
Yield grade 3, %	31.8	44.4	28.6	30.2	27.4	31.8	5.90	0.36	0.32	0.84
Yield grade 4, %	9.5	4.8	9.5	9.5	1.6	9.5	3.43	0.38	0.73	0.67

Table 6. USDA quality grades and marbling scores of heifers orally dosed with Lactipro (*Megasphaera elsdenii*) at initial processing and placed onto accelerated step-up regimes

Item	Control (1234F)	Lactipro (*Megasphaera elsdenii*) treatments					SEM	F-test *P*-value	Step-up regimen, *P*-value	
		234F	34F	3F	4F	F			Linear	Quadratic
Marbling[1]	467	467	466	449	471	497	10.87	0.07	0.12	0.02
Prime, %	0	3.2	0	0	3.2	3.2	1.58	0.30	0.23	0.51
Premium Choice, %	12.7	11.1	9.5	14.3	17.8	17.5	4.44	0.71	0.18	0.50
Total Choice, %	68.3	71.4	73.0	65.1	71.0	71.4	5.85	0.94	0.89	0.95
Select, %	27.0	17.5	15.9	28.6	17.7	15.9	5.27	0.26	0.32	0.98
Sub-Select	0	0	1.6	0	0	0	0.65	0.42	0.77	0.29
Other[2]	1.6	1.6	3.2	0	0	3.2	1.64	0.54	0.99	0.51

[1] Marbling score determined by USDA graders. Values ranging from 400 to 499 represent a small degree of marbling.
[2] The "Other" category includes dark cutters and B-maturity carcasses.

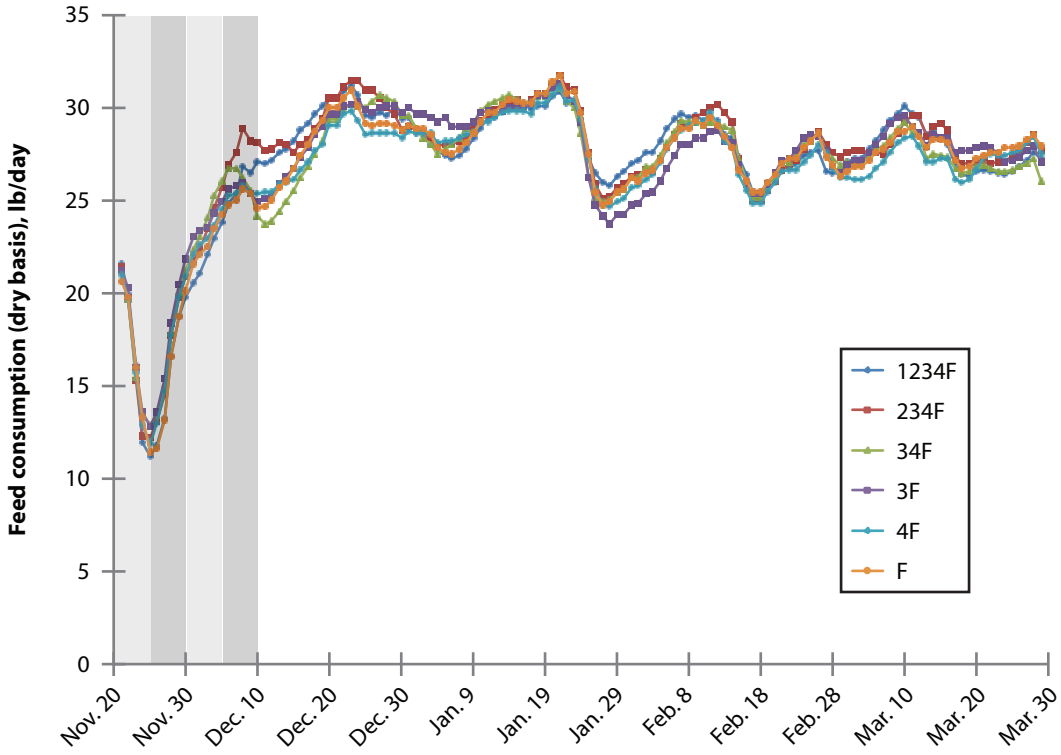

Figure 1. Daily dry matter consumption for finishing cattle stepped up to a final finishing ration using a traditional 5-step regimen (no Lactipro) compared with cattle stepped up to the final finisher using accelerated regimes after oral dosing with Lactipro (*Megasphaera elsdenii*). Step-up diets 1, 2, 3, and 4 each were fed for 5 days before switching to the next diet.