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Effect of rumen-protected branched-chain amino acids on immune response, growth performance, and carcass characteristics of newly received calves[1]

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Introduction

The feedlot receiving period, where calves are transitioned from ranch to feedlot, involves transportation, comingling, and handling stress. These stressors may increase a calf's susceptibility to disease. Waggoner et al. (2007) observed that steers treated for disease in the feedlot tended to have lower carcass prices and lighter carcasses than untreated steers, which resulted in up to a 20% decrease in gross value at slaughter.

The immune system uses key amino acids to make essential proteins that are needed to fight disease. Calder (2006) suggested that when animals contract diseases, nutrients (e.g., amino acids) normally used to support growth are used by the immune system to fight the disease. The body will break down muscle protein to increase the supply of available amino acids to the immune system, which may impair daily gain or even cause body weight loss. Waggoner et al. (2009) countered these negative effects in diseased-challenged steers by increasing dietary crude protein from 14.5% to 16%. We theorized that supplementing key amino acids needed by the immune system would have similar effects to increasing dietary crude protein.

The immune system uses branched-chain amino acids (**BCAA**), which are isoleucine, leucine, and valine, to make proteins that are needed to fight disease. Löest et al. (2001) demonstrated that BCAA are limiting in diets fed to growing steers. Furthermore, Gilliam et al. (2008) demonstrated that calves supplemented with BCAA during a disease challenge retained more nitrogen (i.e., body protein) compared with calves receiving no BCAA. Based on this evidence, we hypothesized that supplementing BCAA to steers during the receiving period will improve gain and resistance to disease. Therefore, the objective of this study was to evaluate the effect of supplemental rumen-protected BCAA on growth and health of newly-received feedlot calves.

Experimental Procedures

All procedures were approved by the New Mexico State University Animal Care and Use Committee. The experiment was a randomized complete block design. One hundred sixty crossbred calves (485 ± 3 lb initial body weight) of sale barn origin (South-Eastern Oklahoma) were transported to the New Mexico State University Clayton Livestock Research Center in Clayton, NM. Calves arrived as two groups (experimental blocks) on 26 and 28 July 2010. Calves were allowed free-choice access to long stemmed wheat hay and water until processing, which occurred on 28 July. At initial processing, bull calves were castrated; 40% of the calves were bulls. Calves were sorted into consecutive sort pens based on processing for a total of 10 calves per pen and 16 pens (8 pens within each arrival date block).

Treatments were no supplemental amino acids (**CON**) or rumen-protected BCAA added to a 68% concentrate receiving diet (Table 1). Beginning the day of processing and continuing daily for 28 days, treatment diets were fed. On day 35 after processing, calves were transitioned to a 75% concentrate growing diet until day 62, after which they were transitioned to an 82% concentrate diet which they remained on until day 90. Calves were then transitioned to a 91% concentrate finishing diet and remained on that diet for the remainder of the feeding period. From day 201 until finish (day 265), wheat silage replaced wheat hay in the 91% concentrate diet (Table 1). Using a "slick bunk" management system, calves were fed twice daily at amounts near free-choice intake.

Each calf was vaccinated for bovine virus diarrhea (Types I and II), bovine parainfluenza 3, bovine respiratory syncytial virus, *L. canicola, L. grippotyphosa, L. hardjo, L. icterohaemorrhagiae,* and *L. pomona* and bovine rhinotracheitis virus (Pyramid 10, Fort Dodge Animal Health, Overland Park, KS); *Cl. chauvoei, Cl. septicum, Cl. novyi, Cl. sordellii*, and *Cl. perfringens* types

C and D (Ultrabac 7, Pfizer animal health, Exton PA), treated for internal and external parasites (Cydectin, Fort Dodge Animal Health, Overland Park, KS), and implanted with 120 mg of trenbolone acetate and 24 mg of estradiol (Revalor S, Intervet, Millsboro, DE) at initial processing. Bulls castrated in the second arrival group also received vaccination for tetanus (Vision C&D-T with SPUR; Intervet, Millsboro, DE). To simulate an immunity challenge, each calf was inoculated (subcutaneous injections) with ovalbumin (chicken egg protein) on day of processing and 14 days later. The inoculation consisted of 2 mL of a 1:1 solution of commercially prepared aluminum hydroxide adjuvant solution (Anhydrogel, Cat. No. A1090 S; Acurate Chemical Corp., Westbury, NY) and sterile saline containing suspended ovalbumin (Cat. No. A5503; Sigma-Aldrich, St.Louis, MO).

Cattle were monitored daily for sickness. Cattle that showed disease symptoms (lethargy, nasal and ocular discharge, labored breathing) were scored on a scale of 1 to 3 (1 = mild, 2 = moderate, 3 = severe) for depression and on a similar scale for respiratory symptoms. If the combined depression and respiratory score was 2 or greater, calves were removed from pens for closer examination. Cattle were treated if rectal temperature was 103.3°F or greater, or if combined respiratory and depression scores were 3 or greater. Initial treatment was tulathromycin (Draxxin; Pfizer Animal Health, Exton, PA), second treatment was florfenicol (Nuflor; Intervet, Millsboro, DE) and flunixin meglumine (Banamine; Intervet, Millsboro, DE), and the third treatment was oxytetracycline (Biomycin; Boehringer Ingelheim, St. Joseph, MO) and sulfadimethoxine boluses (Albon; Pfizer Animal Health, Exton, PA). If calves did not recover after three treatments they were removed from the study.

Calves were individually weighed (Silencer, Moly MFG., Lorainne, KS) upon initial processing (day 0), and 14, 28, and 56 days later. Pen weights were taken the day after individual body weights were measured and on the day cattle were transported to the abattoir (9 April 2011). The average of individual weights and pen weights from the following day were used to calculate average daily gain (**ADG**) and gain:feed (**G:F**) ratio. Final shrunk live body weight was calculated from hot carcass weight and averaged with final pen weight for ADG and G:F calculations. Before each body weight measurement, any residual feed in feed bunks was collected, weighed, and a sample was saved for analysis and calculation of dry matter intake (**DMI**). Samples of diets were collected weekly, composited, and analyzed by a commercial laboratory (SDK labs, Hutchinson, KS).

Whole blood and serum samples were collected from the jugular vein on the day of processing and 14, 28, and 56 days later. Whole blood samples were shipped on ice to the New Mexico Veterinary Diagnostic Lab for analysis of total and differential white blood cell (**WBC**) counts. Serum samples were analyzed for ovalbumin-specific antibody concentration using enzyme-linked immunoassay adapted from the procedure described by Rivera et al. (2002).

All data (except morbidity, carcass quality and yield grade) were analyzed using mixed models (SAS Inst. Inc., Cary, NC). Morbidity, carcass quality, and yield grade were analyzed using generalized linear mixed models (SAS Inst. Inc.). Pen was the experimental unit and models included treatment as a fixed effect with arrival date (block) as a random effect. For analysis of blood and serum variables, a repeated measure (i.e., day of sampling) was added to the models. Significance level was $P \leq 0.05$.

Results and Discussion

There were no differences ($P \geq 0.31$) between treatments in the number of calves treated for observed signs of disease or overall mortality (Table 2). Compared with CON calves, BCAA-supplemented calves produced less ($P < 0.01$) specific antibodies to ovalbumin vaccination but had similar ($P = 0.09$) white blood cell concentration. This is in contrast to Carter et al. (2010), who observed an increase of antibody production when supplementing BCAA to yearling steers in Arizona. In the current study, no treatment differences in morbidity or mortality indicated that all calves were able to fight disease regardless of treatment. In whole blood, BCAA calves had a greater ($P < 0.01$) proportion of lymphocytes than CON calves, but CON calves had a greater ($P = 0.02$) proportion of neutrophils than BCAA calves. However, these differences were present before treatments were applied, so we cannot attribute the cause to treatment. There were no differences ($P \geq 0.22$) between treatments in the proportion of monocytes, eosinophils, or basophils.

There were no differences ($P \geq 0.10$) between treatments for initial, final, or carcass-adjusted final body weight (Table 3). From day 0 to 14, DMI, ADG, and G:F were not different ($P \geq 0.17$) between treatments. From day 15 to 28, and from day 29 to 56, DMI was greater ($P \leq 0.05$) for BCAA than CON calves, but there was no difference ($P \geq 0.72$) between treatments for ADG or G:F. From day 57 to finish (day 265), DMI, ADG, and G:F were not different ($P \geq 0.31$) between treatments. For the total feeding period, BCAA calves had greater ($P = 0.05$) DMI than CON calves, but there were no differences ($P \geq 0.63$) in ADG or G:F. These results are in contrast to the results of Carter et al. (2010), who observed a decrease in DMI from day 15 to 28, an increase in ADG from day 29 to 56, and an improvement in feed efficiency from day 0 to finish in yearling steers supplemented with BCAA for 28 days after receiving. It is unknown why supplemental BCAA would increase DMI, but not improve ADG in light weight calves, and conversely decrease DMI, but improve ADG in yearling steers. There was no difference ($P \geq 0.09$) between treatments for hot carcass weight, quality grade, marbling score, yield grade, 12th-rib fat, internal fat, or rib-eye area (Table 4).

In summary, these results indicated that supplementation of rumen-protected BCAA for 28 days after initial processing increased dry matter intake, but did not significantly affect daily gain, feed efficiency, or health of newly received feedlot calves.

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Table 1. Diet composition (dry matter basis) of 68, 75, 82, and 91% concentrate diets fed during the study

	% Concentrate in diet[1]				
Item	68%	75%	82%	91% A	91% B
Ingredient, %					
Corn, steamed-flaked	43.6	45.6	48.7	60.3	60.2
Hay, wheat	32.0	25.0	18.0	9.0	-
Silage, wheat	-	-	-	-	9.0
Wet corn gluten feed	15.0	20.0	25.0	25.0	25.0
Molasses	5.00	5.00	4.00	-	-
Tallow	-	-	-	2.50	2.50
Soybean meal	2.00	2.00	1.50	-	-
Premix-A[2]	1.98	1.99	-	-	-
Premix-B[3]	-	-	2.40	2.40	2.40
Urea	0.40	0.40	0.40	0.60	0.75
Nutrient concentration					
NDF, %	26.0	25.3	23.6	18.0	19.0
CP, %	13.7	13.8	14.2	13.4	13.8
Ca, %	0.72	0.70	0.90	0.79	0.62
P, %	0.33	0.36	0.45	0.42	0.42
Fe, ppm	293	311	135	108	123
Zn, ppm	52.1	42.8	58.4	55.4	46.0
Cu, ppm	15.1	15.5	18.0	18.2	15.0
NEm, Mcal/lb	0.85	0.87	0.92	0.94	0.94
NEg, Mcal/lb	0.56	0.58	0.61	0.64	0.64

[1]Calves were fed 68% concentrate diet from day 0 to 34, 75% concentrate diet from day 35 to 62, 82% concentrate diet from day 62 to 90, 91% concentrate diet from day 91 to 265. Wheat silage replaced wheat hay from day 201 until finish (day 265).

[2]Supplied (% of total dry supplement): limestone (80.96), salt (15.04), zinc sulfate (0.25; 36% Zn), $CaCO_3$, Na-Sel (0.51; .06% Se copper sulfate (0.25; 99% Cu), vitamin E (0.76; 20,000 IU/g) and vitamin A (0.51; 30,000 IU/g), monensin (0.95; Rumensin-80), tylosin phosphate (0.63; Tylan-40).

[3]Supplied (% of total dry supplement): limestone (83.32), salt (12.05), zinc sulfate (0.21; 36% Zn), $CaCO_3$, Na-Sel (0.42; .06% Se), copper sulfate (0.21; 99% Cu), vitamin E (0.33; 20,000 IU/g) and vitamin A (0.21; 30,000 IU/g), mineral oil (1.50), monensin (0.78; Rumensin-80), tylosin phosphate (0.52; Tylan-40).

Table 2. Morbidity, mortality, serum anti-ovalbumin antibody (IgG), total white blood cell (WBC) concentration and differential proportions of WBC in whole blood of beef calves immunized against ovalbumin

	Treatment[1]			
Item	CON	BCAA	SE	*P*-value
Morbidity[2], %				
1 treatment	68.8	65.0	11.2	0.60
2 treatments	13.8	13.8	4.64	0.99
3 treatments	1.25	3.75	1.75	0.31
Mortality, %	2.50	3.75	2.32	0.65
IgG, OD[3]	4.26	3.78	0.10	<0.01
WBC, 1000/µL	8.41	7.76	0.34	0.09
Differential, %				
Neutrophils	27.9	22.4	1.87	0.02
Lymphocytes	62.5	69.7	1.77	<0.01
Monocytes	6.86	5.69	0.67	0.22
Eosinophil	2.07	1.86	0.43	0.49
Basophils	0.58	0.50	0.20	0.63

[1]Calves received either a standard receiving diet (CON) or the same receiving diet top-dressed with rumen-protected branched-chain amino acids (BCAA) for 28 days after initial processing (day 0).
[2]The proportion of calves treated for symptoms of disease.
[3]Optical density at 450 nm.

Table 4. Carcass characteristics for calves receiving a standard receiving diet (CON) or the same diet supplemented with rumen-protected branched-chain amino acids (BCAA)

	Treatment[1]			
Item	CON	BCAA	SE	*P*-value
No. of calves	76	74	-	-
No. of pens	8	8	-	-
HCW[2], lb	853	871	8.33	0.10
Quality grade, %				
Choice	64.5	74.3	5.49	0.21
Select	35.5	25.7	5.49	0.21
Marbleing[3]	425	428	9.99	0.83
Yield grade, %				
1	11.8	6.74	3.92	0.30
2	26.3	24.3	5.15	0.78
3	40.7	46.0	7.89	0.52
4	18.4	18.9	4.55	0.93
5	2.63	4.05	2.29	0.63
12th-rib fat, in	0.61	0.66	0.020	0.09
Internal fat, %	1.89	1.96	0.045	0.24
Rib-eye area, in^2	13.9	13.8	0.169	0.90

[1]Treatment diets were fed for 28 days after initial processing (day 0), after which both treatments were managed the same.
[2]HCW = hot carcass weight.
[3]300 = Slight^{00}, 400 = Small^{00}, 500 = Modest^{00}, and 600 = Moderate^{00}.

Table 3. Initial, final, and carcass-adjusted body weight, dry matter (DM) intake, daily gain and gain:feed ratio for calves receiving a receiving diet (CON) or the same diet top-dressed with rumen-protected branched-chain amino acids (BCAA)

	Treatment[1]			*P*-
Item	CON	BCAA	SE	value
No. of calves	76	74	-	-
No. of pens	8	8	-	-
Body weight, lb				
Initial	483	490	3.59	0.15
Final	1357	1375	9.37	0.20
Carcass-adj.[2]	1336	1365	13.06	0.10
Day 0 to 14				
DM intake, lb	6.65	6.87	0.169	0.17
Daily gain, lb	1.06	1.12	0.917	0.95
Gain:Feed	0.158	0.155	0.135	0.98
Day 15 to 28				
DM intake, lb	11.9	12.7	0.277	0.05
Daily gain, lb	3.50	3.61	0.388	0.84
Gain:Feed	0.293	0.279	0.031	0.72
Day 29 to 56				
DM intake, lb	15.1	16.6	0.449	0.01
Daily gain, lb	2.82	2.97	0.379	0.77
Gain:Feed	0.184	0.180	0.024	0.92
Day 57 to finish[3]				
DM intake, lb	18.5	18.8	0.152	0.31
Daily gain, lb	3.31	3.31	0.051	0.99
Gain:Feed	0.178	0.176	0.002	0.50
Day 0 to finish[3]				
DM intake, lb	17.2	17.6	0.134	0.05
Daily gain, lb	3.17	3.14	0.066	0.96
Gain:Feed	0.182	0.179	0.003	0.63

[1]Treatment diets were fed for 28 days after initial processing (day 0), after which both treatments were managed the same.
[2]Carcass-adjusted final body weight = hot carcass weight divided by 0.638 (average dressing percentage).
[3]Finish = day 265.

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