EFFECTS OF B-HYDROXY-B-METHYLBUTYRATE ON PERFORMANCE AND CARCASS QUALITY OF FEEDLOT STEERS

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Story in Brief

Two hundred and fifty-six crossbred steers were used to evaluate the effects of the naturally occurring compound B-hydroxy-B-methylbutyrate (HMB), fed at 0.03% of diet dry matter, on performance, carcass characteristics and tissue composition. Steers were fed in a serial slaughter arrangement with slaughter after 105, 119, 133 and 147 days on feed. Averaged across slaughter date, animal performance was not altered by dietary treatment; however, animal performance was improved with HMB at 105 d but depressed by HMB for steers fed 147 d. Steers fed HMB had numerically higher marbling scores resulting in fewer steers receiving standard quality grades (1.56 vs 6.03%). Steers supplemented with HMB had a higher percentage of carcasses in the upper one-third of the select grade and in the choice quality grades. Steers receiving HMB had less (7.1%) backfat and fewer steers with yield grades of 4 or above (1.56 vs 4.69%). Longissimus from steers fed HMB were more tender than controls but total lipid, protein and moisture were not affected by dietary treatment. Supplementation with HMB tended to enhance the quality of beef carcasses.

(Key Words: Feedlot Steers, Marbling, Tenderness.)

Introduction

HMB is a naturally occurring compound produced during the process of protein breakdown or, more specifically, during degradation of the amino acid leucine. HMB is produced in all animals and humans. Feedlot cattle fed 2-ketoisocaproate (KIC), a precursor of HMB, had enhanced carcass quality (Van Koevering et al., 1989a). When KIC is fed, plasma concentrations of HMB are elevated but KIC concentrations are not changed

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(Van Koevering and Nissen, 1992). Thus, a feedlot study was designed to determine the effects of dietary HMB on animal performance, carcass quality, tissue composition and tenderness.

Materials and Methods

Two hundred and fifty-six crossbred steers were selected from a larger group (n=570) based on uniformity in size, weight and breed. Steers were processed routinely and implanted with an estrogenic implant (24 mg estradiol; Compudose) at a commercial feedlot prior to arrival at Panhandle State University (PSU) in Goodwell, OK. Upon arrival at PSU, steers were individually weighed, identified, and blocked into groups based on initial weight and assigned to pens and allotted to treatments in a randomized block design. Sixteen eight-head pens were allocated to each of the two dietary treatments with four of the 16 assigned to each feeding length. Half the pens of cattle received the basal diet (controls), and half were supplemented with B-hydroxy-B-methylbutyrate (HMB) at 0.03% of the diet dry matter. Steers were fed for 105, 119, 133 or 147 days after arrival at PSU. HMB was fed only for the final 82 days of each feeding period.

Steers were allowed free access to hay and water after allocation. Steers were given ad libitum access to high concentrate diets for the entire feeding period. Cottonseed hulls and chopped alfalfa, used as a roughage source, were sequentially removed from the diet to adapt cattle to their final diet. Diet compositions and analyses are shown in Table 1. Steers were receiving their final ration by day 21 of the study. Steers receiving HMB were placed on the control ration for 5 days prior to slaughter for treatment withdrawal.

Initial weights obtained directly off the truck were used for allocation purposes. Gains and feed efficiency were calculated based on initial shrunk weight and final live weights were shrunk 4% from full weight to account for fill. Cattle were trucked to Dodge City, Kansas for slaughter. At slaughter, livers were examined for the presence and severity of abscesses.

Carcass data were obtained approximately 48 hours postmortem and yield and quality grades were determined (USDA, 1989). An 8 inch section of the longissimus (ribeye) corresponding to the 9-12th rib section was removed from the left side of each carcass and vacuum packaged. Ribeye sections were aged for 14 days at $33^{O}F$ before being frozen and cut into one inch steaks (12th rib end) for analysis.

Concentrations of total lipid, protein and moisture (AOAC, 1984) were determined for the longissimus samples. Steaks were analyzed for tenderness by broiling to a medium degree of doneness ($70^{O}F$ internal temp.)

Table 1. Composition of diets (dry matter basis).

Ingredient	Diet Sequence 1	2	3	4	Final
	(%)				
Corn, rolled	38.08	48.08	58.08	68.08	79.58
Alfalfa hay, pelleted	30.00	25.00	18.75	12.50	4.50
Cottonseed hulls	20.00	15.00	11.25	7.50	4.00
Molasses, cane	3.75	3.75	3.75	3.75	3.75
Pelleted supplement[a]	8.17	8.17	8.17	8.17	8.17

Calculated Composition:

Nutrients	Final Diet DM %	Final Diet As Fed %	Supplement DM %	Supplement As Fed %
Dry matter, %	100.00	87.80	100.00	91.76
NEm, Mcal/cwt	92.26	81.00	65.47	60.07
NEg, Mcal/cwt	61.01	53.57	43.64	40.04
Crude protein, %	12.76	11.20	51.34	47.11
Crude fiber, %	5.92	5.19	10.07	9.24
K, %	.69	.60	1.21	1.11
Ca, %	.50	.44	4.48	4.11
P, %	.33	.29	.98	.90

[a] Supplement composition: Cottonseed meal, 67.66%; calcium carbonate, 15.59%; urea, 8.96%; salt, 5.82%; dicalcium phosphate, 1.17%; B-hydroxy-B-methylbutyrate 0 or .53%; vitamin A, D, E, .245%.

and Warner-Bratzler peak shear force was used to determine tenderness. Cooking time and cooking shrinkage also were determined for each steak.

Data were analyzed on a pen basis using the general linear model of SAS with the main effects of treatment, weight block, slaughter date and respective interactions being included in the model. Contrasts were obtained and least squares means are reported.

Results and Discussion

Main effect of dietary treatments are shown in Table 2. Averaged across days on feed, animal performance was not altered by treatment. Significant treatment by slaughter date interactions were detected for daily gain, feed intake, feed efficiency and calculated net energy indicating that

Table 2. Effects of B-Hydroxy-B-Methylbutyrate (HMB) on performance of feedlot steers averaged across slaughter date.[a]

			Effect (P<)	
	Control	HMB	HMB	HMB*Days on feed
Pens, no.	16	16		
Steers, no.	126	128		
Initial wt., lb				
Initial	726	726		
Final[b]	1119	1110	.10	.01
Gains, lb/day				
Pre HMB[c]	3.61	3.57		.09
Overall (carcass)	3.12	3.07		.01
Feed, lb DM/day				
Pre HMB[c]	22.75	22.67		.04
Overall (carcass)	22.44	22.29		.04
Feed/Gain				
Pre HMB[c]	6.38	6.41		
Overall (carcass)	7.21	7.27		.01
Calc. related energy of diet				
ME, Mcal/lb	2.79	2.77		.02
NEm, Mcal/cwt	80.07	79.32		.02
NEg, Mcal/cwt	52.91	52.38		.02

[a] Least squares means.
[b] Calculated as hot carcass weight/.6495 (average dressing % for all steers).
[c] Pre HMB = Time before HMB fed.

slaughter groups reacted differently to treatment. These were examined in more detail (Table 3).

Steers fed HMB for 105 d had higher ($P<.01$) daily gain, feed intake ($P<.10$) and improved feed efficiency ($P<.10$) on a carcass-adjusted basis than control steers (Table 3). However, steers fed for 147 d that received HMB the final 82 d had lower daily gain ($P<.01$), feed intake ($P<.10$) and poorer ($P<.01$) feed efficiency (carcass adjusted basis) than control steers. Note that steers allotted to the HMB treatment in the 147 d period also had lower ($P<.05$) daily gains in the pre-HMB period. This was not the case for the 105 d HMB steers even though HMB steers gained slightly faster in the pre-HMB period. Calculated net energy values were higher ($P<.01$) for controls in the 147 d period (Table 3); this reflects the improvement in efficiency. The differences observed with treatments between slaughter groups is difficult to explain. Individual animal variation may be the primary reason.

Main effects of dietary treatments are in Table 4. Carcass weight tended to be lower ($P<.05$) for HMB steers (Table 4), however, again the interaction of slaughter date and treatment was significant ($P<.01$). Carcass data for individual treatment groups are presented in Table 5. At 105 d, HMB steers had higher ($P<.05$) carcass weights whereas at 147 d, HMB steers had lower ($P<.01$) carcass weights. These effects match the treatment effects on live animal performance. Averaged across treatments, steers supplemented with HMB had 7.1% less ($P<.08$) backfat and fewer carcasses with yield grades of 4 or greater.

The treatment by slaughter group interaction was not significant for the percentage of condemned livers; however, animal groups with higher daily gains had a higher percentage of condemned livers. No differences due to treatment were detected in dressing percentage, ribeye area, percentage kidney, pelvic or heart fat, total maturity or USDA yield grade.

Marbling scores were numerically higher (432 vs 422) for steers fed HMB (Table 6). Fewer ($P<.01$) HMB cattle received Standard quality grades (1.56 vs 6.03%; Table 6). While cattle receiving HMB had a greater number of select quality grades (42.30 vs 34.04; $P<.10$). There were no differences in the percentage of steers with Choice or Prime quality grades. When quality grades were divided into thirds (Table 6), with a low, average, and high category being calculated for each quality grade. Steers supplemented with HMB were more prevalent in the upper one-third of the Select (15.6 vs 8.6%; $P<.09$) and Choice (8.6 vs 5.5%) quality grades. When the high Choice and low Prime steers were combined into a category classified as "High Quality", HMB fed steers were more prevalent than controls (9.5 vs 5.5). Table 7 illustrates the marbling scores and quality grades for individual treatments. In contrast to the animal performance data, there were no significant treatment by slaughter group interactions for

Table 3. Effects of B-Hydroxy-B-Methylbutyrate (HMB) on performance of feedlot steers.[a]

Time on feed, days	105		119		133		147	
Diet	Control	HMB	Control	HMB	Control	HMB	Control	HMB
Pens, no.	4	4	4	4	4	4	4	4
Steers, no.	30[b]	32	32	32	32	32	32	32
Live wt, lb	727	727	726	727	727	726	726	726
Final wt[c]	1023	1057**	1111	1098	1135	1141	1208	1145**
Daily gains, lb								
Pre HMB[d]	3.20	3.42	3.96	3.80	3.58	3.79	3.67	3.27*
Overall (carc)	2.86	3.15**	3.23	3.12	3.08	3.12	3.33	2.88**
Daily feed, lb DM								
Pre HMB[d]	23.11	23.99	22.85	21.50*	22.52	23.10	22.51	22.10
Overall (carc)	21.33	22.39†	22.61	21.62†	22.67	23.05	23.16	22.09†
Feed/Gain								
Pre HMB[d]	7.32	7.10	5.77	5.66	6.30	6.12	6.13	6.76†
Overall (carc)	7.48	7.12†	7.00	6.94	7.37	7.38	6.97	7.65**

Table 3. (Continued).

Time on feed, days	105		119		133		147	
Diet	Control	HMB	Control	HMB	Control	HMB	Control	HMB
Calc. energy of diet								
ME, Mcal/lb	2.70	2.76	2.81	2.84	2.76	2.76	2.88	2.73**
NEm, Mcal/cwt	76.36	78.78	81.06	81.97	78.92	78.66	83.95	77.89**
NEg, Mcal/cwt	50.03	51.93	53.76	54.48	52.10	51.93	55.76	51.20**

[a] Least squares means.
[b] Two steers were removed for reasons unrelated to treatments.
[c] Calculated as hot carcass weight/.6495 (average dressing % for all steers).
[d] Pre HMB = Time before HMB fed.
** Means within a slaughter group differ P<.01.
* Means within a slaughter group differ P<.05.
† Means within a slaughter group differ P<.10.

Table 4. Effects of B-Hydroxy-B-Methylbutyrate (HMB) on carcass characteristics averaged across slaughter date.[a]

	Control	HMB	Effect (P<)	
			HMB	HMB*Days on feed
Pens, no.	16	16		
Steers, no.	126	127		
Carcass wt., lb.[b]	728	721	.05	.01
Dressing percent[c]	65.21	65.15		
Ribeye area, sq. in.	13.17	12.96		
Fat thickness, in.	.42	.39	.08	
KPH, %	1.78	1.77		
Maturity[d]	145	144		
USDA Yield Grade	2.46	2.42		
YG4 ≥ 4, %	4.69	1.56		
Condemned liver %	10.27	12.50		

[a] Least square means.
[b] Carcass weight adjusted for trimloss.
[c] Calculated by dividing final shrunk live weight by carcass weight.
[d] Calculated by averaging lean maturity all skeletal maturity.

marbling score or quality grade, except for standards. Trends with HMB followed those observed previously. With 2-ketoisocaproate (KIC), the precursor to HMB (Van Koevering et al., 1989a) a linear increase in marbling scores was detected with increasing dietary KIC. These increased marbling scores with KIC resulted in a higher percentage of choice cattle.

Main treatment effects on chemical composition, cooking time and shrinkage, and tenderness are in Table 8 while values for individual treatment groups are presented in Table 9. No differences due to treatment for tissue concentrations of total lipid, protein or moisture were detected. Steers fed HMB had numerically more (4%) lipid deposited within the longissimus muscle similar to previous observations by Van Koevering et al. (1989b) with KIC.

Tenderness, as measured by Warner-Bratzler shear force, was significantly enhanced ($P<.04$) by feeding HMB. Shear force values averaged across slaughter date for HMB (Table 8) were 7% lower ($P<.04$) than for control steers. The decreased shear force value of HMB steaks

Table 5. Effects of B-Hydroxy-B-methyl Butyrate (HMB) on performance of feedlot steers.

	105		119		133		147	
	Control	HMB	Control	HMB	Control	HMB	Control	HMB
Pens, no.	4	4	4	4	4	4	4	4
Steers, no.	30	32	32	31	32	32	32	32
Carcass wt., lb.[b]	669	687*	722	712	738	741	785	743**
Dressing percent[c]	64.70	65.45	65.44	65.12	64.85	64.77	65.86	65.24
Ribeye area, sq. in.	12.87	12.73	12.98	13.03	13.23	13.39	13.61	12.70*
Fat thickness,in.	.36	.32	.40	.38	.44	.42	.49	.43†
KPH, %	1.48	1.47	1.61	1.61	2.00	2.06	2.02	1.95
Maturity[d]	137	139	147	143	148	147	149	148
USDA Yield Grade	2.11	2.13	2.42	2.31	2.56	2.50	2.76	2.73
YG4, %	0	3.13	0	0	3.13	0	15.63	3.13*
Condemned liver, %	3.57	21.88†	9.38	12.50	6.25	12.50	21.88	3.13

[a] Least square means.
[b] Carcass weight adjusted for trim loss.
[c] Calculated by dividing final shrunk live weight by carcass weight adjusted for trim loss.
[d] Calculated by averaging lean maturity and skeletal maturity.
** Means within a slaughter group differ P<.01.
* Means within a slaughter group differ P<.05.
† Means within a slaughter group differ P<.10.

Table 6. Effects of B-Hydroxy-B-Methylbutyrate (HMB) on USDA quality grades of steers.[a]

			Effect (P<)	
	Control	HMB	HMB	HMB*Days on feed
Pens, no.	16	16		
Steers, no.	126	127		
Marbling Score[b]	422	432		
Prime, %				
High, %	0	0		
Average, %	0	0		
Low, %	0	.89		
Total	0	.89		
Choice, %				
High Quality[c], %	5.47	9.49		
High, %	5.47	8.59		
Average, %	13.39	8.71		
Low, %	41.07	37.95		
Total	59.93	55.25		
Select, %				
High, %	8.59	15.63	.09	
Average, %	14.73	11.83		
Low, %	10.38	14.84		
Total	34.04	42.30	.10	
Standard, %				
High, %	6.03	1.56	.01	.02
Average, %	0	0		
Low, %	0	0		
Total	6.03	1.56	.01	.02

[a] Least squares means.
[b] 300-399, slight; 400-499, small
[c] High Quality = a combination of High Choice and Low Prime.

Table 7. Effects of B-Hydroxy-B-methyl Butyrate (HMB) on performance of feedlot steers.

	105		119		133		147	
	Control	HMB	Control	HMB	Control	HMB	Control	HMB
Pens, no.	4	4	4	4	4	4	4	4
Steers, no.	30	32	32	31	32	32	32	32
Marbling Score[c]	371	383	428	438	453	451	437	454
Prime,								
High, %	0	0	0	0	0	0	0	0
Average, %	0	0	0	0	0	0	0	0
Low, %	0	0	0	3.57†	0	0	0	0
Total	0	0	0	3.57†	0	0	0	0
Choice,[d]								
High Quality[e], %	3.13	3.13	3.13	9.82	6.25	12.50	9.38	12.50
High, %	3.13	3.13	3.13	6.25	6.25	12.50	9.38	12.50
Average, %	6.70	3.13	15.63	12.95	18.75	12.50	12.50	6.25
Low, %	20.54	31.25	46.88	33.04	53.13	34.38†	43.75	53.13
Total	30.36	37.50	65.63	55.80	78.13	59.38	65.63	71.88

Table 7. (Continued).

	105		119		133		147	
	Control	HMB	Control	HMB	Control	HMB	Control	HMB
Select,								
High, %	10.71	15.63	12.50	15.63	3.13	21.88*	9.38	9.38
Average, %	21.43	12.50	12.50	12.95	15.63	9.38	9.38	12.50
Low, %	16.52	28.13	9.38	15.63	3.13	9.38	12.50	6.25
Total	49.55	56.25	34.38	44.20	21.88	40.63	31.25	28.13
Standard,								
High, %	20.98	6.25**	0	0	0	0	3.13	0
Average, %	0		0	0	0	0	0	0
Low, %	0		0	0	0	0	0	0
Total	20.98	6.25**	0	0	0	0	3.13	0

[a] Least squares means.
[b] Two steers were removed for reasons unrelated to treatments.
[c] 300-399, slight; 400-499, small
[d] Percent choice includes percent Prime.
[e] High Quality = a combination of High Choice and Low Prime.
** Means within a slaughter group differ P<.01.
* Means within a slaughter group differ P<.05.
† Means within a slaughter group differ P<.10.

Table 8. Effects of B-Hydroxy-B-Methylbutyrate (HMB) on carcass characteristics averaged across slaughter dates.[a]

			Effect (P<)	
	Control	HMB	HMB	HMB*Days on feed
Pens, no.	16	16		
Steers, no.	125	127		
Raw weight, oz.	10.77	10.72		.05
Cooked weight, oz.	7.66	7.67		.05
Cooking Shrink, %	28.92	28.42		
Cooking time, min.	21.20	20.64		
Shear force, lb.	9.79	9.10	.04	
Very Tender[b], %	30.13	39.51		
Tender[c], %	28.35	32.37		
Tough[d], %	41.18	27.34	.03	
Proximate Analysis, %				
Total lipid	3.53	3.68		
Protein	22.51	22.36		
Moisture	73.34	73.28		

[a] Least square means.
[b] Very tender steaks <8.5 lb. shear force.
[c] Tender steaks: 8.5<tender<10.0 lb. shear force.
[d] Tough steaks >10.0 lb. shear force.

Table 9. Effects of B-Hydroxy-B-Methylbutyrate (HMB) on performance of feedlot steers.

	105		119		133		147	
	Control	HMB	Control	HMB	Control	HMB	Control	HMB
Pens, no.	4	4	4	4	4	4	4	4
Steers, no.	29	32	32	31	32	32	32	32
Raw weight, oz.	10.22	10.47	10.30	10.47	11.74	11.56	10.83	10.35*
Cooked weight, oz.	7.11	7.40*	7.36	7.52	8.48	8.30	7.70	7.47†
Cooking shrink, %	30.42	29.31	28.57	28.21	27.80	28.30	28.90	27.86
Cooking time, min.	23.22	21.25	20.41	20.02	21.03	21.94	20.16	19.34
Shear force, lb.	10.08	9.56	9.97	9.46	9.48	8.66	9.63	8.71
Very Tender[b], %	26.66	34.38	28.13	26.79	34.38	53.13	34.38	43.75
Tender[c], %	24.11	25.00	37.50	38.84	28.13	25.00	25.00	40.63
Tough[d], %	52.23	40.63	34.38	31.25	37.50	21.88	40.63	15.63*
Proximate Analysis, %								
Total Lipid	2.69	3.33†	3.69	3.63	3.93	3.58	3.81	4.19
Protein	22.83	22.57	22.42	22.46	22.12	22.12	22.69	22.31
Moisture	73.84	73.44	73.23	73.23	73.23	73.57	73.06	72.87

[a] Least square means.
[b] Very tender steaks <8.5 lb. shear force.
[c] Tender steaks: between 8.5 and 10.0 lb. shear force.
[d] Tough steaks >10.0 lb. shear force.
* Means within a slaughter group differ P<.05.
† Means within a slaughter group differ P<.10.

resulted in 33% fewer steaks being considered as tough (> 10.0 lb shear force) and with 12% more in the tender group (between 8.5 and 10.0 lb) steaks and 22% more in the very tender group (<8.5 lb). This enhancement in tenderness is not easily measured on a economic basis. Yet, surveys have shown that consumers place as high a value on taste and tenderness as on price and fat and cholesterol content.

These data indicate that HMB may enhance carcass quality by increasing tenderness and improving quality grades. The effects of HMB on live animal performance are still unclear. With an increased consumer demand for consistent high quality beef the feeding of HMB to feedlot steers may be beneficial.

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