Table 1. Comparison of trace mineral content between treatments and NRC requirements

	NRC req.	MM[1]	AM[1]	HM[1]
Cobalt, mg/kg	0.15	-	96.48%	180.81%
Copper, mg/kg	10	150%	73.66%	138.03%
Iodine, mg/kg	0.5	-	119.59%	224%
Manganese, ppm	20	50%	87.89%	164.68%
Selenium, mg/kg	0.1	5000%	155.81%	291.94%
Zinc, mg/kg	30	200%	81.94%	153.54%

[1]These are the amount of each mineral found in the supplement relative to NRC requirements.

Table 2. Composition and chemical analysis (DM basis) of the finishing diet

Item		
Ingredient, % DM		SEM[1]
Alfalfa Hay	10.7	
Corn Silage	17.9	
Barley	71.4	
Chemical Analysis		
DM, % as fed	79	0.27
CP, %	13.1	0.09
Fat, %	2.19	0.02
Ash, %	6.59	0.06
Nem, Mcal/lb	0.82	0.003
Neg, Mcal/lb	0.54	0.003
TDN, %	77.22	0.25
Mineral composition		
Calcium, %	0.3	0.01
Phosphorous, %	0.32	0.003
Magnesium, %	0.18	0.004
Potassium, %	0.97	0.02
Sodium, %	0.04	0.002
Iron, ppm	124	28.42
Manganese, ppm	43	2.77
Zinc, ppm	49	1.95
Copper, ppm	12	0.63
Selenium, ppm	0.14	0.01

[1]Standard error of the mean (SEM).

Table 3. Composition of mineral mix (DM basis) added to diet[1]

Item	
Ingredient, %DM	
Calcium, %	5.81
Chlorine, %	0.11
Magnesium. %	1.47
Sulphur, %	0.11
Cobalt, ppm	178.76
Copper, ppm	7,156.28
Copper, ppm (chelate)	1,788.69
Iodine, ppm	463.70
EDDI, mg/lb	262.36
Manganese, ppm	17,075.81
Manganese, ppm (chelate)	4,268.95
Selenium, ppm	142.30
Selenium, ppm (chelate)	46.90
Zinc, ppm	23,881.04
Zinc, ppm (chelate)	5,970.07
Vit A, KIU/lb	540.32
Vit D, KIU/lb	129.47
Vit D-3, KICU/ lb	129.47
Vit E, IU/lb	5,174.52

[1]Mineral was fed at 182.2 g to HM group (n = 10) and 91.1 g to AM group (n = 10).

Table 4. Average cortisol level of steers after travel

	Treatment[1]				SEM[3]	*P-value*[2]
	AM	CON	HM	MM		
Cortisol, ng/mL	34.385	35.591	35.465	35.277	3.430	*0.99*

[1]Treatments include: a diet containing oral supplementation of minerals provided at levels similar to NRC requirements (AM; n = 10), oral supplementation of minerals provided at levels above NRC requirements (HM; n = 10), a MultiMin® injection at labeled dose (MM; n = 10) or no mineral supplementation (CON; n = 10) for the first 40 d of the trial.

[2]P-values indicate effect of treatment.

[3]Standard error of the mean (SEM).

Table 5. Average daily gain of steers throughout the feedlot phase receiving different mineral supplements

	Treatment[1,2]				SEM[4]	*P-value*[3]
	AM	CON	HM	MM		
Average daily gain, kg						
Days 0-13	2.5	2.53	2.81	2.97	0.27	*0.55*
Days 14-27	1.84	2.22	1.8	1.56	0.26	*0.37*
Days 28-40	1.8	2.03	2.19	0.71	0.46	*0.12*
Days 41-55	1.98	1.017	1.12	2.32	0.47	*0.16*
Days 56 - 69	0.82^{ab}	1.72^{ab}	3.05^{b}	0.34^{a}	0.46	***0.05***
Days 70 - 83	2.13	1.29	1.435	2.53	0.44	*0.17*
Days 84-109	1.29	1.45	2.06	1.41	0.26	*0.18*
Days 0-109	1.7	1.72	1.94	1.65	0.10	*0.18*

[1]Treatments include: a diet containing oral supplementation of minerals provided at levels similar to NRC requirements (AM; n = 10), oral supplementation of minerals provided at levels above NRC requirements (HM; n = 10), a MultiMin® injection at labeled dose (MM; n = 10) or no mineral supplementation (CON; n = 10) for the first 40 d of the trial.

[2]Values with different letter superscripts indicate differences ($P < 0.05$) between treatments within that row.

[3]P-values indicate effect of treatment.

[4]Standard error of the mean (SEM).

Table 6. Carcass adjusted performance of Angus steers receiving different mineral supplements

	Treatment[1]				SEM[3]	*P-value*[2]
	AM	CON	HM	MM		
HCW, kg	333.4	333.5	338.5	327.1	17.2	***0.08***
Marbling Score	410.9	424.2	551.2	405.7	24.9	*0.75*
Ribeye Area, cm^{20}	73.6	75.4	74.6	73.0	2.1	*0.88*
Ribeye fat thickness, mm	7.62	7.44	7.65	7.14	0.25	*0.50*
Yield grade	2.3	2.3	2.3	2.1	0.16	*0.76*
Marb:BF ratio[4]	-0.33	0.10	0.10	0.12	0.32	*0.72*

[1]Treatments include: a diet containing oral supplementation of minerals provided at levels similar to NRC requirements (AM; n = 10), oral supplementation of minerals provided at levels above NRC requirements (HM; n = 10), a MultiMin® injection at labeled dose (MM; n = 10) or no mineral supplementation (CON; n = 10). for the first 40 d of the trial.

[2]P-Values indicate differences between treatments.

[3]Standard error of the mean (SEM).

[4]Marbling to backfat ratio was determined using the calculations previously described by Mohrhauser et al., 2015a. [(observation marbling score- marbling score $\bar{x}$)/marbling SD]-[(observation backfat- backfat $\bar{x}$)/backfat SD]

Table 7. Least Square Means Feed Costs ($/Head/Day) and Cost of Gain ($/kg) by Treatment and Feeding Period

Treatment	First 40 Days	Days 40-70	Full 110 Days
	Feed Costs[1] ($/Head/Day)		
AM	$1.80 a	$2.20 a	$2.04 a
MM	$1.82 a	$2.25 a	$2.08 a
Control	$1.78 a	$2.39 a	$2.06 a
HM	$1.93 a	$2.17 a	$2.07 a
	Cost of Gain[2] ($/kg)		
AM	$2.03 a	$3.57 a	$2.73 a
MM	$1.96 a	$3.00 a	$2.51 a
Control	$1.98 a	$3.35 a	$2.56 a
HM	$3.26 a	$4.50 a	$3.02 a

Estimates within a column followed by the same letter (a) are not significantly different (P= 0.05).

[1]Feed Cost is the daily cost of feed and minerals associated with feeding each treatment for the different feeding intervals within the 110 d trial.

[2]Cost of gain is the dollar amount of feed and mineral expenses estimated to achieve 1 kg of weight gain and is equal to the FC/average daily gain.

Figure Caption

Figure 1. Average dry matter intake (DMI) **(A)** and **(B)** average gain:feed ratio over 110 d finishing period in steers receiving a diet containing oral supplementation of minerals provided at levels similar to NRC requirements (AM; n = 10), oral supplementation of minerals provided at levels above NRC requirements (HM; n = 10), a MultiMin® injection at labeled dose (MM; n = 10) or no mineral supplementation (CON; n = 10) for the first 40 d of the trial. Values are represented as the least squares mean ± SEM. P-values of repeated measure analysis for the fixed effects of treatment, time and their interaction are indicated in the top left corner of the graph. Time points with different letters indicate a difference ($P < 0.05$) between the different treatments at that specific time point.

Figure 2. Mean 12th rib fat thickness (**A**) and ribeye area (**B**) of finishing steers as measured by ultrasound over the 110 d finishing period in steers receiving a diet containing oral supplementation of minerals provided at levels similar to NRC requirements (AM; n = 10), oral supplementation of minerals provided at levels above NRC requirements (HM; n = 10), a MultiMin® injection at labeled dose (MM; n = 10) or no mineral supplementation (CON; n = 10) for the first 40 d of the trial. Values are represented as the least squares mean ± SEM. P-values of repeated measure analysis for the fixed effects of treatment, time and their interaction are indicated in the top left corner of each graph. Time points with different letters indicate a difference ($P < 0.05$) between the different treatments at that specific time point.

Figure 3. Mean hepatic cobalt (Co) **(A),** mean hepatic copper (Cu) **(B),** mean hepatic manganese (Mn) **(C),** mean hepatic selenium (Se) **(D),** and mean hepatic zinc (Zn) **(E)** concentrations of finishing steers receiving a diet containing oral supplementation of minerals provided at levels similar to NRC requirements (AM; n = 10), oral supplementation of minerals

provided at levels above NRC requirements (HM; n = 10), a MultiMin® injection at labeled dose (MM; n = 10) or no mineral supplementation (CON; n = 10) for the first 40 d of the trial. Any value below the bold black line is indicative of a clinical deficiency. Values are represented as least squares mean ± SEM. P-values of repeated measure analysis for the fixed effects of treatment, time and their interaction are indicated in the top left corner of the graph. Time points with different letters indicate a difference ($P < 0.05$) between the different treatments at that specific time point.

Figure 4. Average time each animal went up to the bunk defined as mean bunk visit (reading of a single animal EID tag when entering at a bunk whether it consumed feed or not, **(A)** and feed bout (reading of a single animal eid tag when entering a bunk and consumed at least 10 g of feed, (**B**) over 110 d finishing period in steers receiving a diet containing oral supplementation of minerals provided at levels similar to NRC requirements (AM; n = 10), oral supplementation of minerals provided at levels above NRC requirements (HM; n = 10), a MultiMin® injection at labeled dose (MM; n = 10) or no mineral supplementation (CON; n = 10) for the first 40 d of the trial. Values are represented as least squares mean ± SEM. P-values of repeated measure analysis for the fixed effects of treatment, time and their interaction are indicated in the top right corner of the graph. Time points with different letters indicate a difference ($P < 0.05$) between the different treatments at that specific time point.

Figure 5. Average amount consumed each time the animal goes to the bunk measured as mean consumption per bunk visit (each time an animal went up to the bunk, **(A)** and consumption per feed bout (when an animal entered a bunk and consumed at least 10 g of feed, **(B)** over 110 d finishing period in steers receiving a diet containing oral supplementation of minerals provided at levels similar to NRC requirements (AM; n = 10), oral supplementation of minerals provided

at levels above NRC requirements (HM; n = 10), a MultiMin® injection at labeled dose (MM; n = 10) or no mineral supplementation (CON; n = 10) for the first 40 d of the trial. Values are represented as least squares mean ± SEM. P-values of repeated measure analysis for the fixed effects of treatment, time and their interaction are indicated in the top left corner of the graph. Time points with different letters indicate a difference ($P < 0.05$) between the different treatments at that specific time point.

Figure 6. Mean time spent with head down per bunk visit (each time an animal went up to the bunk, (**A**) and time spent with head down per feed bout (when an animal entered a bunk and consumed at least 10 g of feed, (**B**) over 110 d finishing period in steers receiving a diet containing oral supplementation of minerals provided at levels similar to NRC requirements (AM; n = 10), oral supplementation of minerals provided at levels above NRC requirements (HM; n = 10), a MultiMin® injection at labeled dose (MM; n = 10) or no mineral supplementation (CON; n = 10) for the first 40 d of the trial. Values are represented as least squares mean ± SEM. P-values of repeated measure analysis for the fixed effects of treatment, time and their interaction are indicated in the bottom left of the graph.

Figure 7. Mean bunk visit duration (each time an animal went up to the bunk, **(A)** (when an animal entered a bunk and consumed at least 10 g of feed, **(B)** over 110 d finishing period in steers receiving a diet containing oral supplementation of minerals provided at levels similar to NRC requirements (AM; n = 10), oral supplementation of minerals provided at levels above NRC requirements (HM; n = 10), a MultiMin® injection at labeled dose (MM; n = 10) or no mineral supplementation (CON; n = 10) for the first 40 d of the trial. Values are represented as least squares mean ± SEM. P-values of repeated measure analysis for the fixed effects

of treatment, time and their interaction are indicated in the top middle of the graph. Time points with different letters indicate a difference.

Figure 8. Average antibody titers for BPIV3 (A) and average antibody titers for BHV **(B)** of finishing steers receiving a diet containing oral supplementation of minerals provided at levels similar to NRC requirements (AM; n = 10), oral supplementation of minerals provided at levels above NRC requirements (HM; n = 10), a MultiMin® injection at labeled dose (MM; n = 10) or no mineral supplementation (CON; n = 10) for the first 40 d of the trial. Values are represented as least squares mean ± SEM. P-values of repeated measure analysis for the fixed effects of treatment, time and their interaction are indicated in the top left corner of the graph.

Figure 1

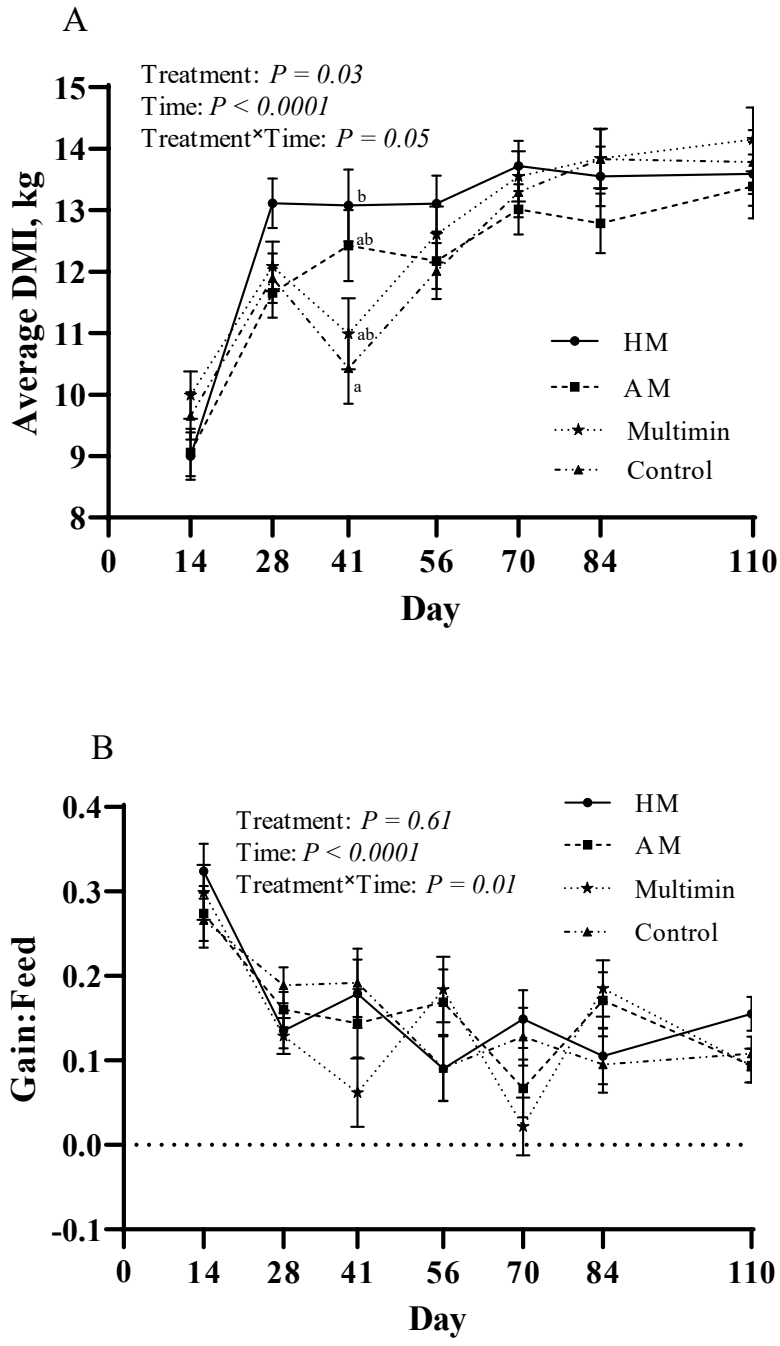

A
Treatment: P = 0.03
Time: P < 0.0001
Treatment×Time: P = 0.05
Average DMI, kg
15
14
13
12
11
10
9
8
b
ab
ab
a
HM
AM
Multimin
Control
0
14
28
41
56
70
84
110
Day
B
Treatment: P = 0.61
Time: P < 0.0001
Treatment×Time: P = 0.01
Gain:Feed
0.4
0.3
0.2
0.1
0.0
-0.1
HM
AM
Multimin
Control
0
14
28
41
56
70
84
110
Day

Figure 2

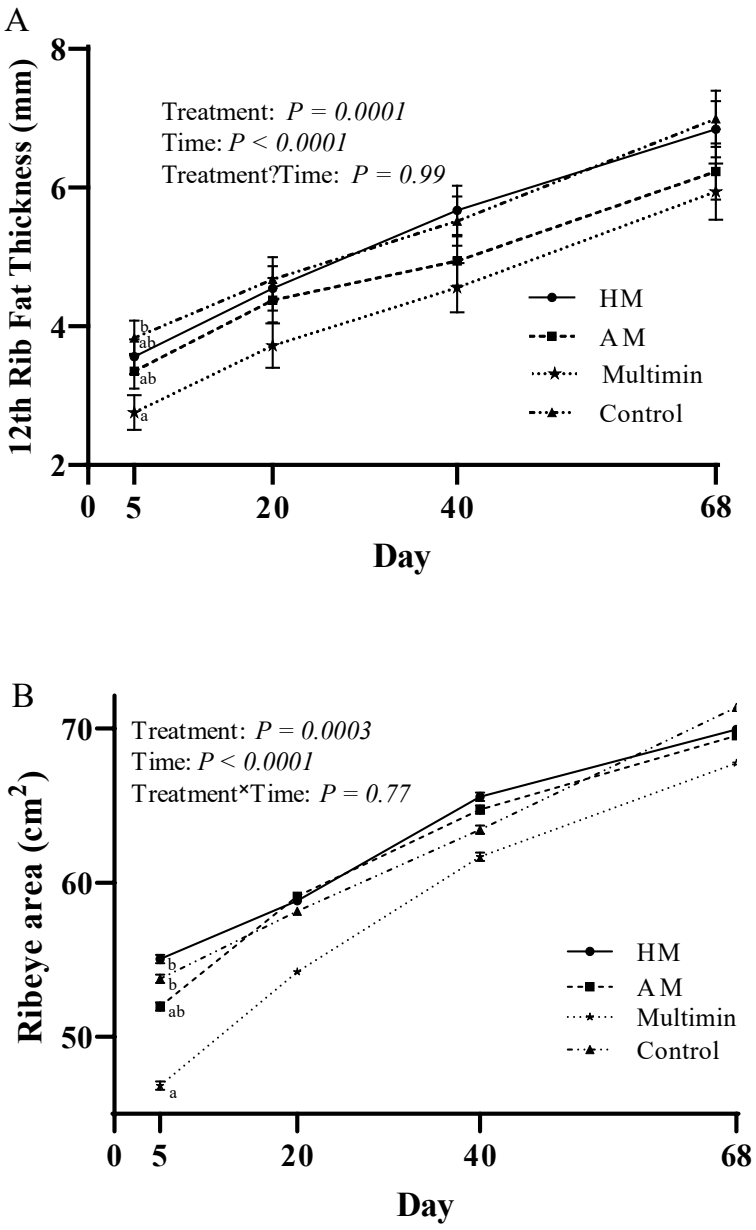

A
12th Rib Fat Thickness (mm)
8
6
4
2
Treatment: P = 0.0001
Time: P < 0.0001
Treatment?Time: P = 0.99
HM
AM
Multimin
Control
b
ab
ab
a
0
5
20
40
68
Day
B
Ribeye area (cm2)
70
60
50
Treatment: P = 0.0003
Time: P < 0.0001
Treatment×Time: P = 0.77
HM
AM
Multimin
Control
b
b
ab
a
0
5
20
40
68
Day

Figure 3

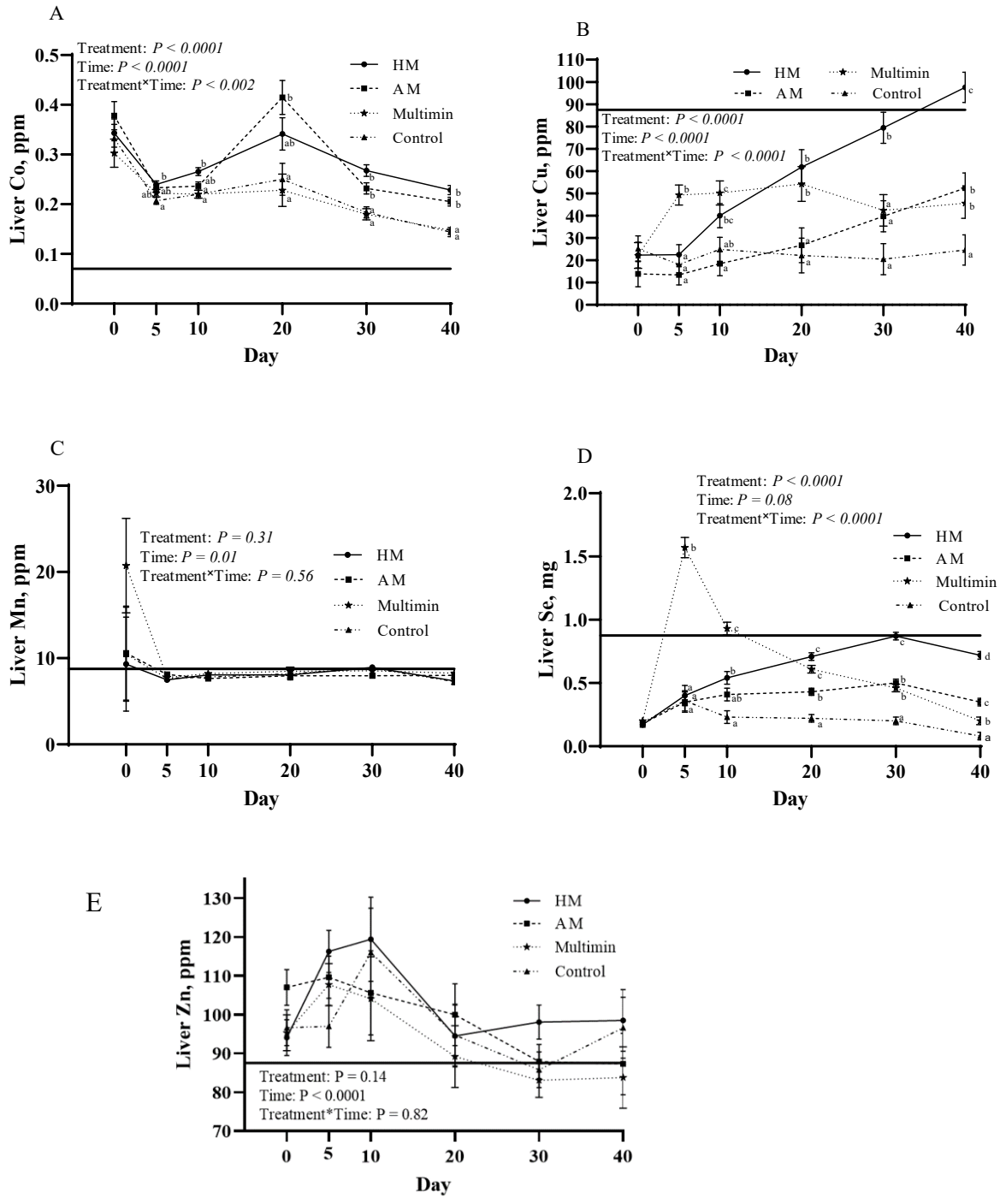
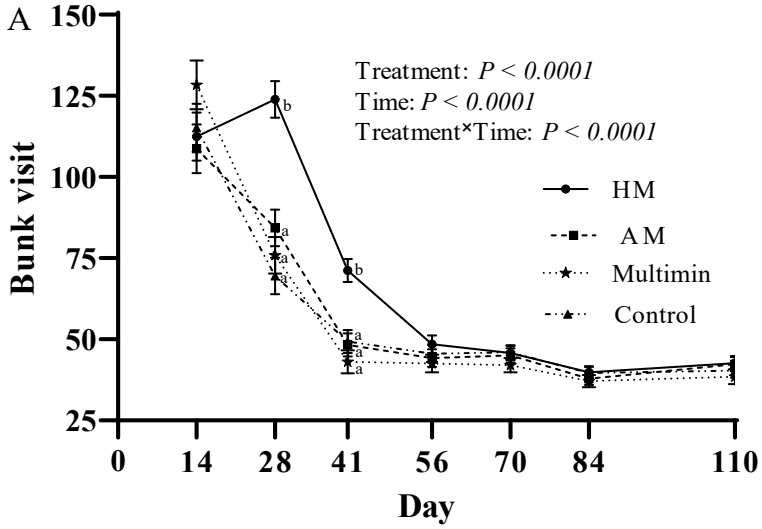

A
Treatment: P < 0.0001
Time: P < 0.0001
Treatment×Time: P < 0.002
HM
AM
Multimin
Control
Liver Co, ppm
Day
B
Treatment: P < 0.0001
Time: P < 0.0001
Treatment×Time: P < 0.0001
Liver Cu, ppm
C
Treatment: P = 0.31
Time: P = 0.01
Treatment×Time: P = 0.56
Liver Mn, ppm
D
Treatment: P < 0.0001
Time: P = 0.08
Treatment×Time: P < 0.0001
Liver Se, mg
E
Treatment: P = 0.14
Time: P < 0.0001
Treatment*Time: P = 0.82
Liver Zn, ppm

Figure 4


A
Bunk visit
Day
Treatment: P < 0.0001
Time: P < 0.0001
Treatment×Time: P < 0.0001
HM
AM
Multimin
Control

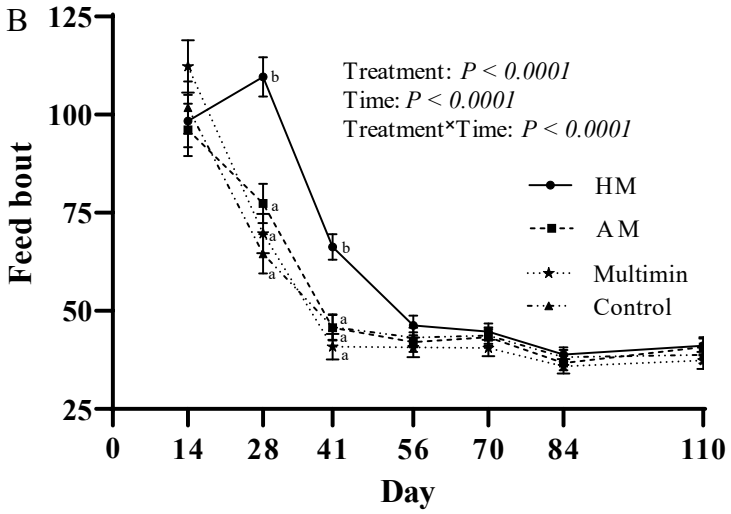
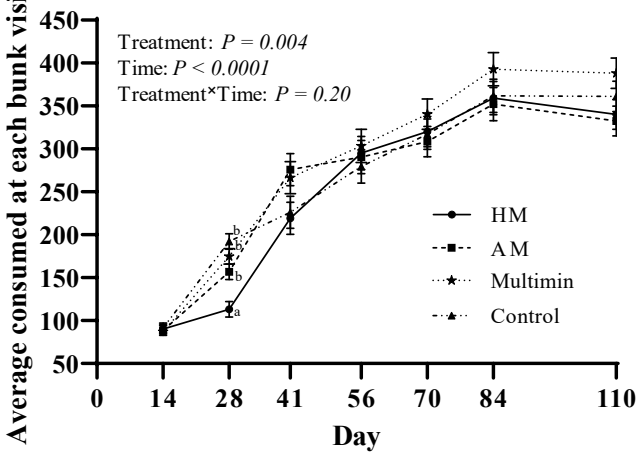

B
Feed bout
Day
Treatment: P < 0.0001
Time: P < 0.0001
Treatment×Time: P < 0.0001
HM
AM
Multimin
Control

Figure 5

A


Average consumed at each bunk visit, kg
450
400
350
300
250
200
150
100
50
Treatment: P = 0.004
Time: P < 0.0001
Treatment×Time: P = 0.20
HM
AM
Multimin
Control
0
14
28
41
56
70
84
110
Day

B

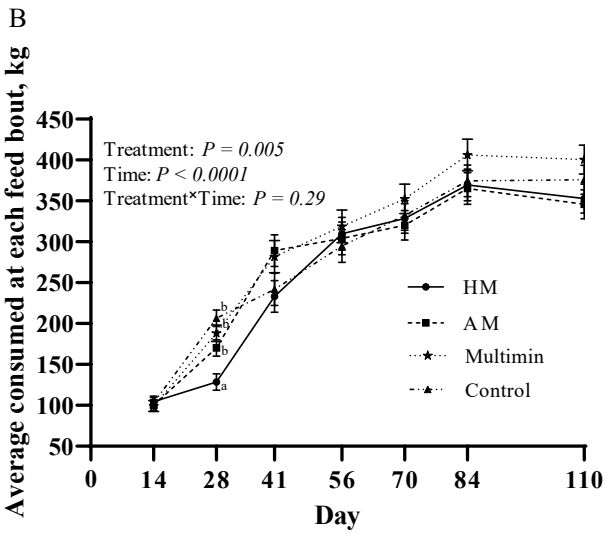

Average consumed at each feed bout, kg
450
400
350
300
250
200
150
100
50
Treatment: P = 0.005
Time: P < 0.0001
Treatment×Time: P = 0.29
HM
AM
Multimin
Control
0
14
28
41
56
70
84
110
Day

Figure 6

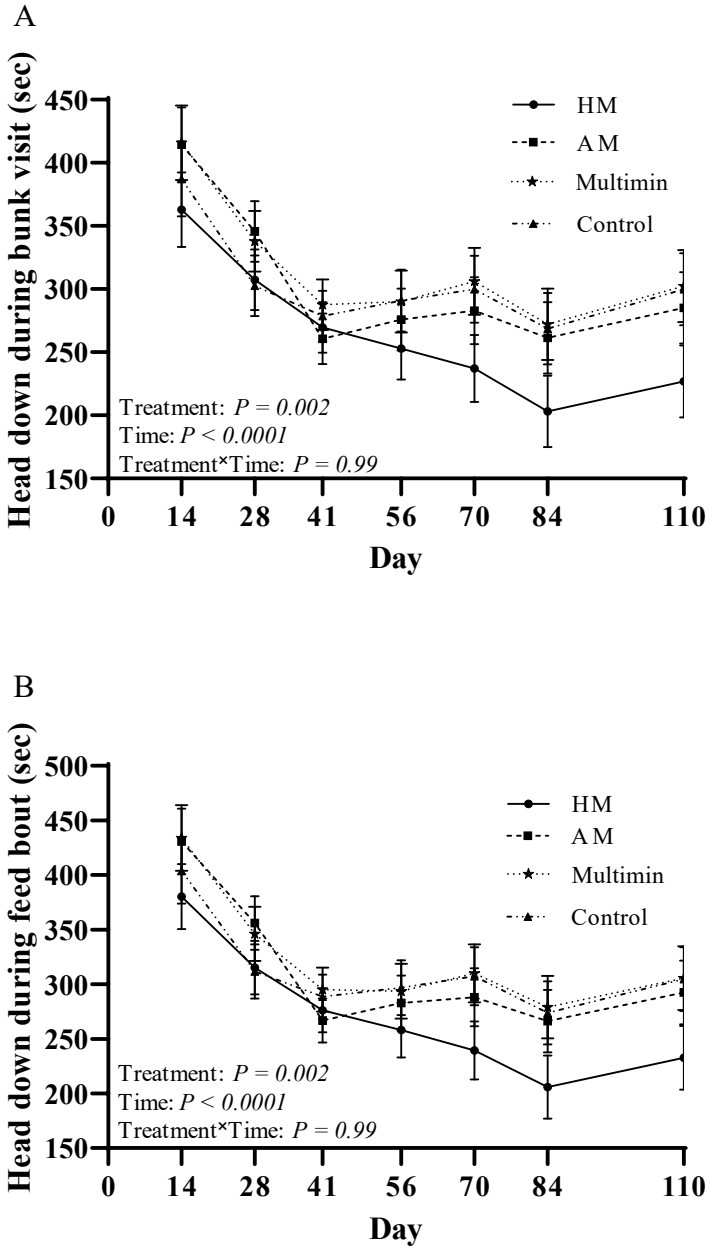

A
Head down during bunk visit (sec)
450
400
350
300
250
200
150
HM
AM
Multimin
Control
Treatment: P = 0.002
Time: P < 0.0001
Treatment×Time: P = 0.99
0
14
28
41
56
70
84
110
Day
B
Head down during feed bout (sec)
500
450
400
350
300
250
200
150
HM
AM
Multimin
Control
Treatment: P = 0.002
Time: P < 0.0001
Treatment×Time: P = 0.99
0
14
28
41
56
70
84
110
Day

Figure 7

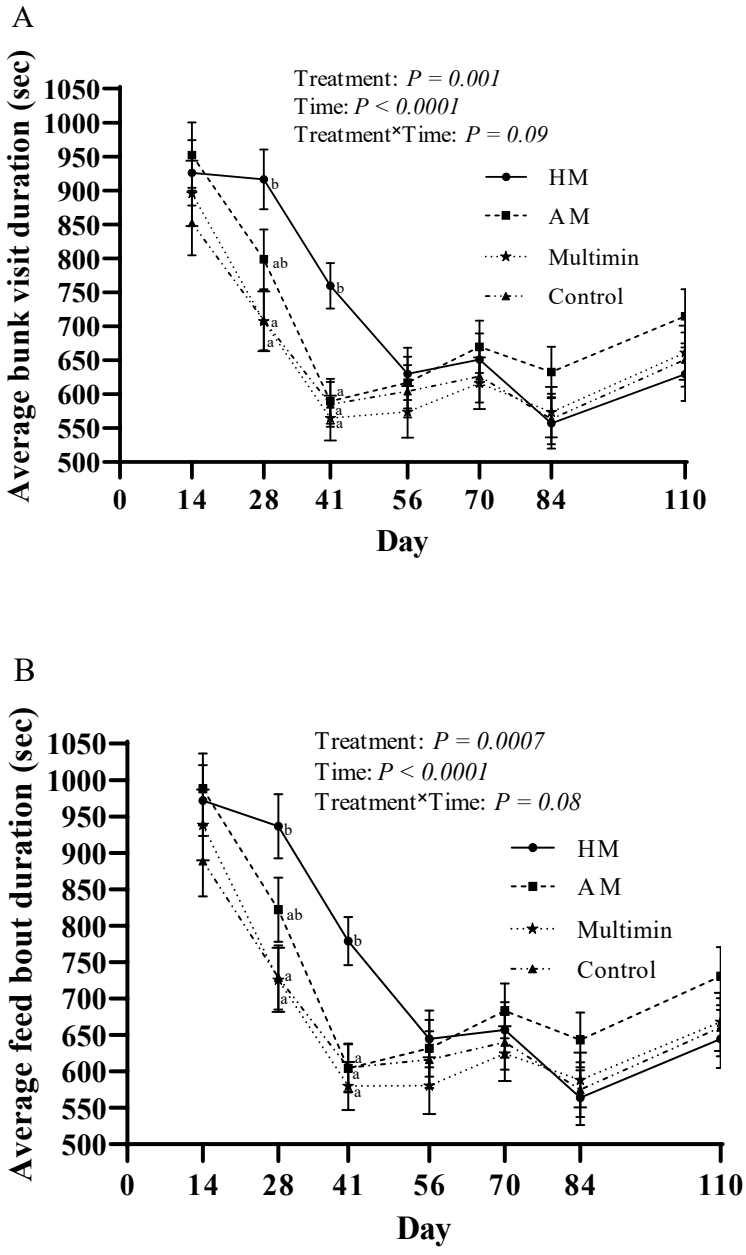
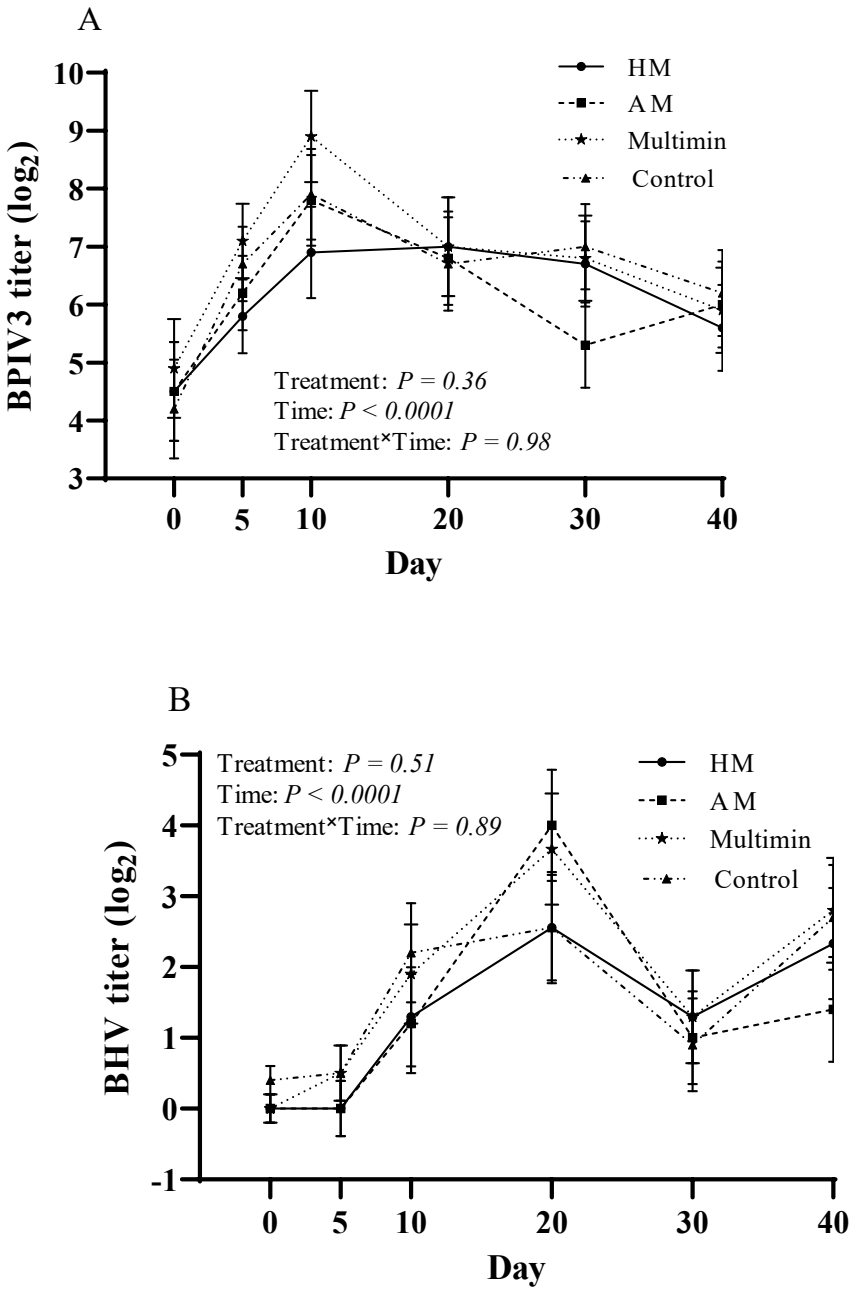

A
Average bunk visit duration (sec)
1050
1000
950
900
850
800
750
700
650
600
550
500
Treatment: P = 0.001
Time: P < 0.0001
Treatment×Time: P = 0.09
HM
AM
Multimin
Control
b
ab
b
a
a
a
a
a
0
14
28
41
56
70
84
110
Day
B
Average feed bout duration (sec)
1050
1000
950
900
850
800
750
700
650
600
550
500
Treatment: P = 0.0007
Time: P < 0.0001
Treatment×Time: P = 0.08
HM
AM
Multimin
Control
b
ab
b
a
a
a
a
a
0
14
28
41
56
70
84
110
Day

Figure 8


A
BPIV3 titer (log2)
10
9
8
7
6
5
4
3
0
5
10
20
30
40
Day
HM
AM
Multimin
Control
Treatment: P = 0.36
Time: P < 0.0001
Treatment×Time: P = 0.98
B
BHV titer (log2)
5
4
3
2
1
0
-1
0
5
10
20
30
40
Day
Treatment: P = 0.51
Time: P < 0.0001
Treatment×Time: P = 0.89
HM
AM
Multimin
Control