Iowa State University

The impacts of trace minerals in the feedlot: from transit to finishing

Dathan T. Smerchek, Ph.D.
Assistant Professor
2:00 PM
August 28th, 2024

Department of Animal Science
Iowa State University
Ames, IA

1

Key takeaways

HOW DO TM IMPACT BEEF PRODUCTION AT VARIOUS POINTS IN THE SUPPLY CHAIN?

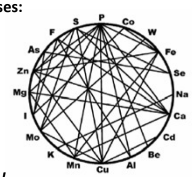
- **NASEM recommendations:**
  - Copper – 10 mg/kg diet DM
  - Manganese – 20 mg/kg diet DM
  - Zinc – 30 mg/kg diet DM
- Samuelson et al. (2016): Various TM **(Zn, Mn, Cu, etc)** are supplemented at greater than NASEM recommendations.

QUESTION OF THE DAY:
Is this the right move? Is "more" always better?

2

General Introduction - Trace Minerals

- Small component of diet….
  BUT they're important!
- **Essential for MANY physiological and metabolic processes:**
  - *Skeletal development*
  - *Protein synthesis*
  - *Energy metabolism*
  - *Immune response*
  - *Antioxidant capacity*
  - *And more!*



Proper TM nutrition is ESSENTIAL for optimal performance!

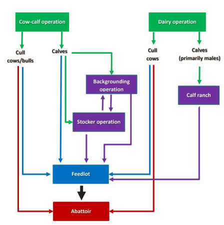
3

Beef Production Cycle

- VERY segmented industry – transit is necessary!

BUT
- **Transit can induce stress** → influence feedlot performance
  - High shrink → poor performance and greater morbidity (Camp et al., 1981).
- **Preconditioning + shorter duration transport** → lower shrink, higher DMI, and improved ADG in the first month post-transport (Schwarzkopf-Genswein et al., 2007)

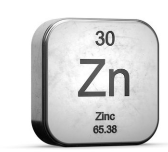
- ***Can TM nutrition impact performance and response to these stressors?***



4

Introduction - Zinc

Zinc:
The most utilized trace mineral in biological processes.
- Enzyme cofactor; more than 300 Zn metalloenzymes
- Extracellular matrix remodeling
- Antioxidant capacity
- Component of transcription factors.
- Immune function
- Satellite cell proliferation and differentiation (Paskavitz et al., 2018).

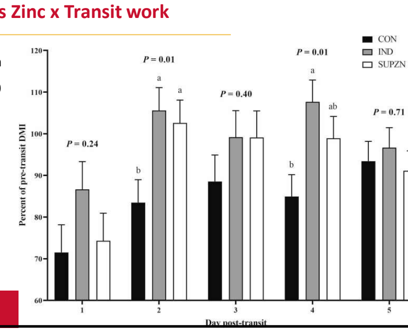


- Zn is not well stored or recycled well in the body. **Must be constantly supplemented.**

5

Introduction – Previous Zinc x Transit work

- Following 18 h transit event, Zn supplementation of 70 and 120 mg Zn/kg DM improved DMI recovery compared to control (Heiderscheit and Hansen, 2022).



6

TRANSIT:
Zinc supplementation prior to transit and transit duration effects on feedlot performance and muscle fatigue on beef steers

A.M. Baumhover[1], B.M. Ortner[1], D.U. Thompson[1], K.S. Schwartzkopf-Genswein[2] and S.L. Hansen[1]
[1] Iowa State University [2]Agriculture and Agri-Food Canada

IOWA STATE UNIVERSITY

7

Study Design

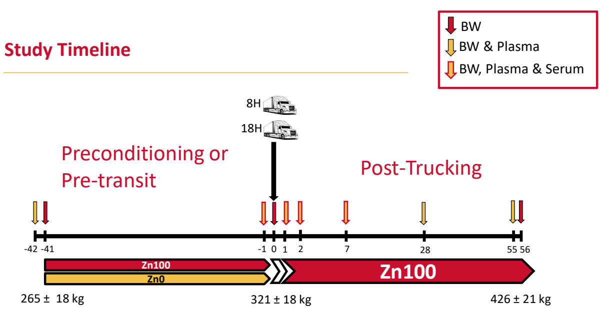
- **Day -41**: 80 steers were selected and stratified by BW into a 2 × 2 factorial
  - 20 steers per treatment
- **Dietary Treatments (DIET)**: **Pre-Conditioning**
  - **Zn0** – no supplemental Zn (basal diet containing **39.5** mg Zn/kg DM)
    - *NRC recommendation is 30 mg Zn/kg DM*
  - **Zn100** – 100 mg supplemental Zn (**Zn as $ZnSO_4$**; analyzed at **139** mg Zn/kg DM)

  All moved to Zn100 diet post transit
- **Transit Duration (DUR)**:
  - **8H** – 8-hour transit (~707 km)
  - **18H** – 18-hour transit (~1608 km)

IOWA STATE UNIVERSITY

8

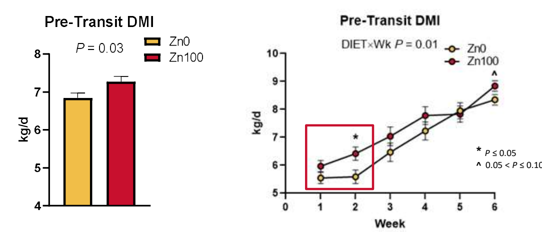
Study Timeline



IOWA STATE UNIVERSITY
Unit or Department Name Here

9

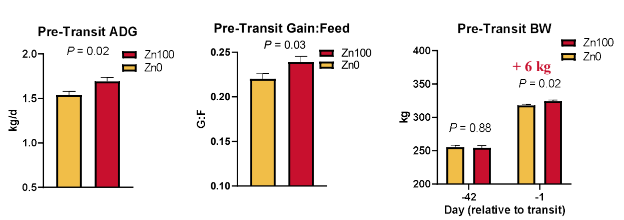
Pre-Transit: Performance



IOWA STATE UNIVERSITY

10

Pre-Transit: Performance

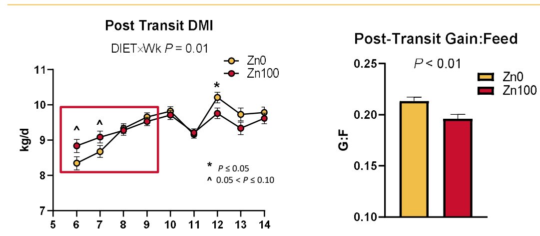


IOWA STATE UNIVERSITY

11

Post-Transit: Performance

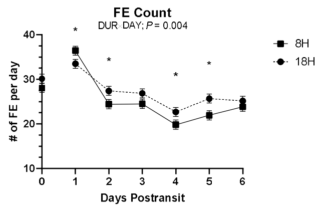
All treatments receiving Zn100 diet

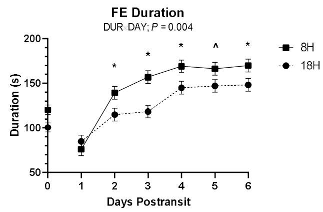


IOWA STATE UNIVERSITY

12

Results – Post-transit - Feeding behavior

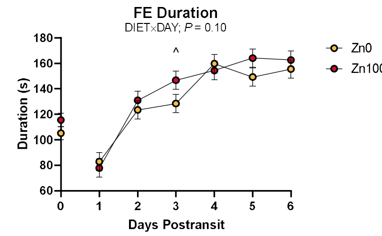




13

Results – Post-transit - Average feed event duration

Tendency for Zn100 to have longer feed events on d 3.



14

Conclusion

- **Zn supplementation** (100 mg Zn/kg DM) **was beneficial to performance during the pre-conditioning and receiving period.**
  - Particularly for the previously unsupplemented steers entering the feedlot.
- **Transit duration matters.**
  - Alters metabolism and recovery rate!
  - May influence feeding behavior post-transit.
    - Prior dietary treatment may influence recovery and feeding behavior post-transit.

15

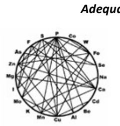
POST-TRANSIT/RECEIVING: A quick look at zinc and immunity in receiving cattle

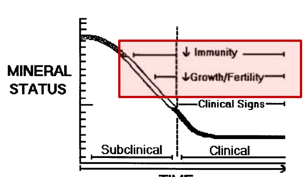
16

Trace Minerals

- Trace minerals (TM) are essential for numerous physiological and metabolic processes
  - *Skeletal development*
  - *Protein synthesis*
  - ***Immune response***
  - *Antioxidant capacity*
  - *Energy metabolism*

Adequate bioavailable TM intake is crucial!

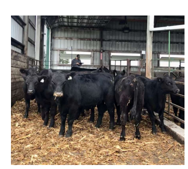




17

Receiving and post-transit

Potential stressors:
- Transportation
- Lack of feed and water
- Unfamiliar feed resources
- Comingled



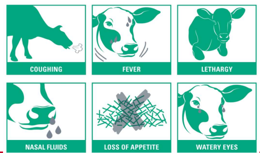
Expectations of the animal:
- Eat
- Drink
- Perform
- **Immune Response**

18

Bovine respiratory disease

Bovine respiratory disease (BRD) complex

- Single largest health issue faced by the feedlot industry
  - 75% of morbidity (Edwards, 1996)
  - 50% to 70% of mortality in feedlots (Loneragan et al., 2001).
- It is estimated that **over $3 billion is spent annually on prevention, treatment, and production losses for this disease.**
  - **HUGE!**



IOWA STATE UNIVERSITY

19

OUR GOAL

Better understand how TM can influence parameters of immune response.

- **Immune cell population**
- **Cell function**

IMMUNE FUNCTION → response to challenge?

Identify indicators of Zn status in relation to immune function.

- Plasma Zn concentrations are a poor indicator of Zn status (won't discuss today)
  → immunce cell Zn content and ZN transporter expression

REFERENCE:
Franco, C. E., E. L. Rients, F. E. Diaz, S. L. Hansen, and J. L. McGill. 2024. **Dietary Zinc Supplementation in Steers Modulates Labile Zinc Concentration and Zinc Transporter Gene Expression in Circulating Immune Cells.** ***Biological Trace Element Research***:1-13.

IOWA STATE UNIVERSITY

20

Experimental Design – Effects of supplemental Zn concentration and source on performance and biomarkers of immune status in receiving steers

Cattle and logistics

- ***72 low-risk weaned Angus crossbred steers*** (initial BW = 284 ± 24.5 kg)
- 42 d feedlot receiving study (Early Nov. – Mid Dec.)

DIETARY TREATMENTS

- **ORG:** Supplemented TM from an organic at 7 g·steer^{-1}·d^{-1} (n = 24 steers).
  - (Zn AA, Mn AA, Cu AA, and Co glucoheptonate; Availa4, Zinpro)
- **ING:** Supplemented inorganic TM equivalent concentrations to ORG (n = 24 steers).
  - ($ZnSO_4$, $MnSO_4$, $CuSO_4$, and $CoCO_3$)
- **ORG+Z:** ORG diet + additional **AvailaZn** to provide 1,000 mg Zn·steer^{-1}·d^{-1} for first 14 d of study (n = 24 steers).
  - ***Further fortification for initial "receiving" phase.***

Scenario:

- Feeding 7 g·steer^{-1}·d^{-1} with a DMI of 8.6 kg/d adds:
  - Zn: 42 mg/kg DM
  - Mn: 23 mg/kg DM
  - Cu: 14.7 mg/kg DM
  - Co: 1.47 mg/kg DM

IOWA STATE UNIVERSITY (Smerchek et al., 2023)

21

Growth Performance – Overall (d 0 – 42) – Exp 1

	Treatments				
	ING	ORG	ORG+Z	SEM[2]	P-value
	n=24	n=24	n=24	-	-
Overall					
Initial BW, kg[3]	284	284	284	5.0	0.99
D 42 BW, kg[3]	359	366	366	3.1	0.21
ADG, kg/d	**1.78[y]**	**1.94[x]**	**1.99[x]**	0.07	**0.07**
DMI, kg/d[4]	8.81	8.94	8.42	0.24	0.21
G:F[4]	**0.193[b]**	**0.217[a]**	**0.231[a]**	0.0091	**0.01**

[1]Initial BW was used as a covariate for all growth performance calculations
[2]Greatest SEM reported
[3]BW presented as BW*0.96
[4] n = 18 for ING

IOWA STATE UNIVERSITY (Smerchek et al., 2023)

22

Markers of activation in immune cell populations on d 14. – Exp 1

- **CD16+ and CD44+ NK cells**
  - Enhanced Cytotoxicity
  - Enhanced migratory and adhesion capabilities
  - ↑ memory-like functions
  - ↑ cytokine production.
- CD16+: Crucial in antibody-dependent cellular cytotoxicity (ADCC).
  - Very effective at eliminating infected or malignant cells.
- **OVERALL:**
  - **More robust/versatile immune response.**

	Treatments				
	ING	ORG	ORG+Z	SEM[1]	P-Value
Day 14					
Steers	n = 24	n = 24	n = 24	-	-
CD8+ T Cells					
Freq. of live, %	4.43	4.55	4.56	0.572	0.98
% CD2+	97.58	97.84	97.43	0.275	0.52
% CD16+	0.10	0.10	0.09	0.770	0.52
% CD25+	0.38	0.35	0.31	0.088	0.81
% CD44+	75.81	79.99	79.19	2.080	0.31
% CD45RO+	26.91	24.53	23.17	2.303	0.50
CD8+ NK Cells					
Freq. of live, %	0.31	0.18	0.27	0.051	0.19
% CD2+	89.12	90.21	88.67	1.409	0.71
% CD16+	**18.08[ab]**	**14.32[b]**	**21.70[a]**	**2.185**	**0.05**
% CD25+	5.57	5.23	4.36	1.434	0.81
% CD44+	**41.62[b]**	**55.06[a]**	**38.78[b]**	**4.819**	**0.04**
% CD45RO+	40.53	37.97	44.24	3.633	0.45
NK Cells					
Freq. of live, %	2.49	2.62	3.27	0.423	0.36
% CD2+	89.12	87.33	89.83	1.863	0.61
% CD16+	22.23	18.45	21.53	2.136	0.39
% CD25+	0.47	0.92	0.83	0.200	0.23
% CD44+	8.71	9.51	8.13	1.076	0.64
% CD45RO+	35.79	31.58	34.46	3.346	0.65

Day 14 data are covariate-adjusted using d 0 values.

IOWA STATE UNIVERSITY (Smerchek et al., 2023)

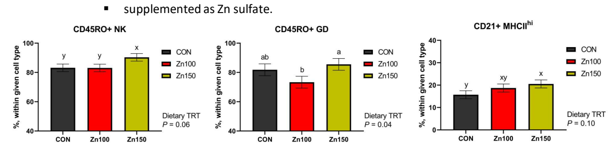
23

Experimental Design 2 – Zn x Receiving

Emma Rients, Carlos Franco, Fabian Diaz, Jodi McGill and Stephanie Hansen

Analyzed Zn concentration, mg/kg DM	
CON	**58**
Zn100	160
Zn150	207

- 72 Angus crossbred steers (261 ± 14 kg)
  - **CON – no supplemental Zn**
  - **Zn100 – 100 mg supplemental Zn/kg DM**
  - **Zn150 – 150 mg supplemental Zn/kg DM**
    - supplemented as Zn sulfate.



Crucial for the initiation and maintenance of robust and specific adaptive immune responses.

IOWA STATE UNIVERSITY (Rients et al., 2024)

24

OVERALL FINDINGS

- **Organic TM supplementation improved growth performance during the receiving period.**
- **TM supplementation, regardless of source, influenced markers of immune function.**
  - Exact relationship between TM and immune markers has not been fully elucidated.
    - More work is needed!

These studies indicate dietary Zn can influence immune cell population and markers of activation within both innate and adaptive immune cells. Pretty cool!

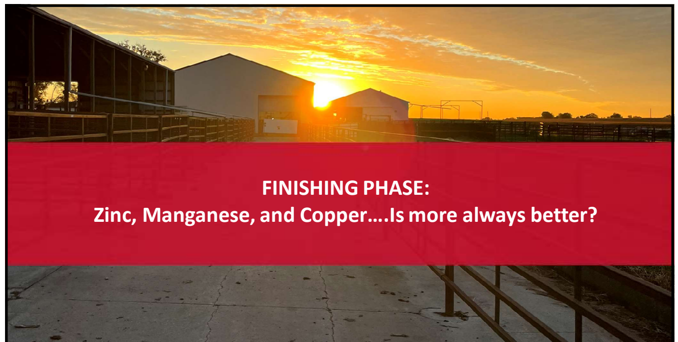
Still a developing and quickly evolving area of research.

- **BRD = HUGE annual economic loss (over $3 billion)**

  Small, real improvements = large returns/efficiency!

IOWA STATE UNIVERSITY

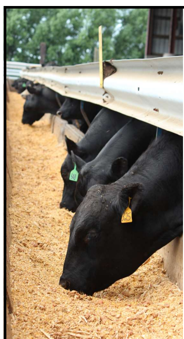
25



FINISHING PHASE:
Zinc, Manganese, and Copper….Is more always better?

IOWA STATE UNIVERSITY

26



General Introduction

- **Major advances**:
  - Beef cattle genetics
  - Growth enhancing technology use
  - Precision cattle feeding

Increase in total pounds of beef produced (Drouillard, 2018).

- Achieved despite shrinking cow herd numbers.
  - *Smallest cow herd since 1962*

- **From 1977 to 2007, a 44% increase in beef cattle growth rates occurred** (Capper, 2011).

IOWA STATE UNIVERSITY

27

General Introduction - Steroidal Implants

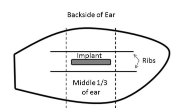
Combination steroidal implant:

TBA (trenbolone acetate) + E_2 (estradiol)

- More than 90% of feedlot cattle are given at least one implant (APHIS, 2013).

Implants = *consistent technology → valuable*

- ADG: 16%–20%
- Feed efficiency 5% to 15%
- **Lean tissue mass of the carcass 3% to 10%**
  - ↑*Protein synthesis and* ↑ *muscle hypertrophy*
    - *TM support these processes and many others…*



IOWA STATE UNIVERSITY

28

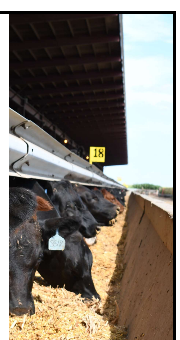
TM supplementation in feedlot diets

As previously discussed:

- Samuelson et al. (2016): Various TM are supplemented at greater than NASEM recommendations: **Zn, Mn, Cu, etc.**

- ***Can TM further optimize growth steroidal implant-induced growth?***

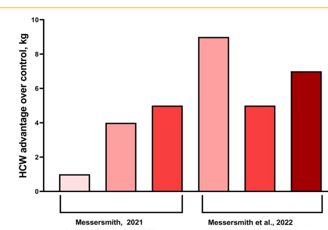
  Niedermayer et al. (2018): Supp TM (Co, Cu, I, Mn, Se, and Zn) at industry concentrations.
  - Non-implanted cattle IND supplementation rates = 13 kg advantage in HCW over un-supplemented cattle.
  - When implanted = 17 kg advantage.



IOWA STATE UNIVERSITY

29

Prior Work – Zn x Implant



IOWA STATE UNIVERSITY

30

Working model – Strategic TM supplementation

1) Cattle growth rates have increased.
2) Implants support and provide increased growth.
3) TM are essential in supporting growth processes.
4) Implants appear to influence TM homeostasis, possibly TM requirement.
5) Greater concentrations of supplemental TM (Co, Cu, Mn, Se, and Zn) increased implant-induced growth.
6) Work focused on Zn found greater concentrations of supplemental Zn further improves implant-induced growth.

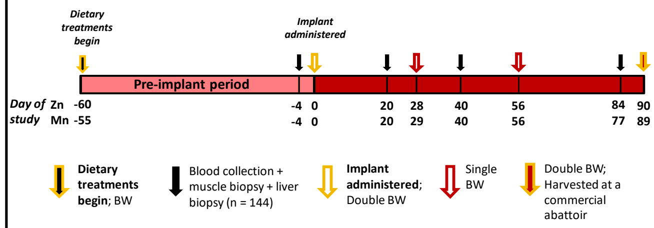
7) Model aim: Strategic supplementation of TM to cattle given a steroidal implant → goal optimize growth and resource utilization.

<u>Questions and gaps in the model:</u>

- Are nutrient requirements (specifically TM) the same for this animal that continues to grow larger and faster?
  - Do NASEM recommendations (for TM) allow for optimal growth?
    - Current TM requirements were established nearly 40 years ago (NRC, 1984).
    - Consideration: *TM requirements are set to prevent deficiencies.*
      - **Mn** = 20 mg Mn/kg DM; **Zn** = 30 mg Zn/kg DM
- Is there an "optimal" concentration of available Zn (or other TM) needed in the diet to support a given growth rate.

31

General Experimental Timeline (Zn and Mn)



32

Experimental Design

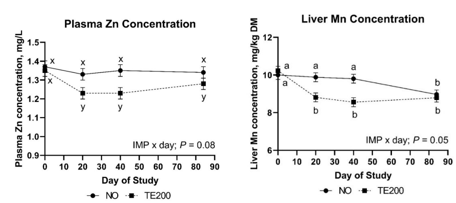
- Angus-cross steers (n = 144; 362 kg ± 20.4) were housed in pens (n = 24) at the Beef Nutrition Farm (BNF) in Ames, IA from November 2021 – April 2022.
- Steers (n = 24 per treatment) were stratified by BW in a 3 × 2 factorial design.

Dietary treatments (ZINC; supplemented as $ZnSO_4$ ***starting on d -60***):
- **Zn0:** no supplemental Zn (<u>analyzed **53 mg Zn/kg DM**</u>)
- **Zn30:** 30 mg supplemental Zn/kg DM; (<u>analyzed 83 mg Zn/kg DM</u>)
- **Zn100:** 100 mg supplemental Zn/kg DM; (<u>analyzed 157 mg Zn/kg DM</u>)

Implant treatments (IMP; administered on d 0):
- **NO:** no implant
- **TE200:** High potency combination implant (TE-200, Elanco, Greenfield, IN; 200 mg TBA + 20 mg E_2)

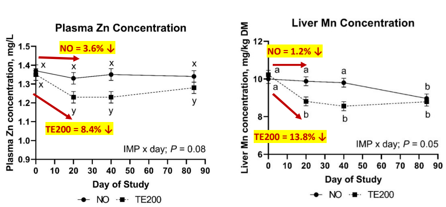
33

Plasma Zn and liver Mn concentration



34

Plasma Zn and liver Mn concentration



35

Growth Performance d 0-28

	NO			TE200				ZINC within NO		ZINC within TE200		Within TE200
	Zn0	Zn30	Zn100	Zn0	Zn30	Zn100	SEM	L	Q	L	Q	No Zn vs Zn
Steers	24	24	24	24	24	24						
Day 0-28												
d 0 BW, kg	466	469	472	473	474	470	3.7	0.22	0.81	0.52	0.70	0.84
d 28 BW, kg	515	516	523	530	537	537	4.9	0.22	0.79	0.89	0.30	0.41
ADG, kg/d	1.74	1.74	1.80	2.02	2.20	2.21	0.072	0.55	0.87	0.12	0.19	0.04
DMI, kg/d	11.7	11.6	12.0	11.8	12.1	12.0	0.24	0.19	0.52	0.73	0.48	0.44
G:F	0.150	0.149	0.149	0.172	0.186	0.186	0.0058	0.90	0.90	0.14	0.17	0.04

36

Growth Performance d 0-28

	NO			TE200				ZINC within NO		ZINC within TE200		Within TE200
	Zn0	Zn30	Zn100	Zn0	Zn30	Zn100	SEM	L	Q	L	Q	No Zn vs Zn
Steers	24	24	24	24	24	24						
Day 0-28												
d 0 BW, kg	466	469	472	473	474	470	3.7	0.22	0.81	0.52	0.70	0.84
d 28 BW, kg	515	516	523	530	537	537	4.9	0.22	0.79	0.89	0.30	0.41
ADG, kg/d	1.74	1.74	1.80	**2.02**	**2.20**	**2.21**	**0.072**	0.55	0.87	0.12	0.19	**0.04**
DMI, kg/d	11.7	11.6	12.0	11.8	12.1	12.0	0.24	0.19	0.52	0.73	0.48	0.44
G:F	0.150	0.149	0.149	**0.172**	**0.186**	**0.186**	**0.0058**	0.90	0.90	0.14	0.17	**0.04**

IOWA STATE UNIVERSITY

37

Growth Performance Overall

	NO			TE200				ZINC within NO		ZINC within TE200		Within TE200
	Zn0	Zn30	Zn100	Zn0	Zn30	Zn100	SEM	L	Q	L	Q	No Zn vs Zn
Steers	24	24	24	24	24	24						
OVERALL												
d 90 BW, kg	600	595	604	620	628	625	6.2	0.54	0.38	0.68	0.42	0.38
ADG, kg/d	1.49	1.43	1.46	1.64	1.71	1.72	0.045	0.76	0.34	0.25	0.36	0.14
DMI, kg/d	11.2	11.6	11.6	11.6	11.8	11.8	0.23	0.25	0.20	0.55	0.72	0.47
G:F	0.135	0.122	0.126	0.141	0.146	0.146	0.0036	0.22	0.02	0.40	0.44	0.25

IOWA STATE UNIVERSITY

38

Carcass Characteristics

	NO			TE200				ZINC within NO		ZINC within TE200		Within TE200
	Zn0	Zn30	Zn100	Zn0	Zn30	Zn100	SEM	L	Q	L	Q	No Zn vs Zn
Steers	24	24	24	24	24	24						
Carcass Characteristics												
HCW, kg	379	380	385	397	402	398	4.0	0.29	0.99	0.95	0.37	0.51
REA, cm^2	92.0	91.7	90.8	94.0	96.4	92.1	0.22	0.54	0.99	0.17	0.11	0.90
RF, cm	1.42	1.30	1.40	1.40	1.32	1.35	0.028	0.94	0.23	0.77	0.43	0.45
DP, %	63.1	63.7	63.7	63.9	64.0	63.9	0.29	0.19	0.22	0.90	0.86	0.97
Marbling[a]	546	546	550	**521**	**478**	**549**	**21.6**	0.87	0.99	0.16	**0.06**	0.79
YG	2.71	2.70	2.87	2.87	2.65	2.83	0.116	0.26	0.66	0.93	0.15	0.35
EBF, %	30.5	30.0	30.6	**30.4**	**29.5**	**30.6**	**0.42**	0.67	0.30	0.40	**0.08**	0.56

[a]Marbling scores: slight = 300, small = 400, modest = 500, moderate = 600.

IOWA STATE UNIVERSITY

39

Conclusions

Zn supplementation ↑ growth d 0 – 28 post-implant.

- Overall performance not significantly affected:
  - **Total dietary Zn of at least 83 mg/kg DM was adequate to support additional steroidal implant-induced gain early in the implant period.**
- Plasma and liver TM results were generally consistent with prior observations.
  - **Plasma Zn concentration (1.36 mg/L) were quite high on d 0.**
    - Supplemented dietary treatments for 60 d pre-implant
    - Basal diet contained 53 mg Zn/kg DM.
    - Lower growth potential cattle?
- **Supplementing Zn at approximately 100 mg Zn/kg DM may best allow for optimal implant-induced growth.**

IOWA STATE UNIVERSITY

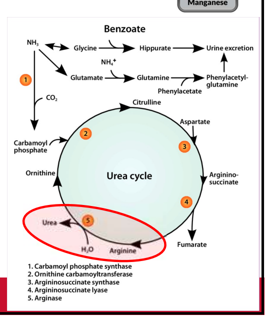
40

Introduction - Manganese

Manganese:

- **Nitrogen metabolism**
  - Arginase (Lapierre and Lobley, 2001)
- **Mitochondrial antioxidant capacity**
  - MnSOD (Miriyala et al., 2012)
- **CHO metabolism**
- **Bone, cartilage, and connective tissue synthesis.**
- **Satellite cell function** (Lee et al., 2009; Gordon et al., 2019)
  Influence differentiation and proliferation in myoblasts

- Liver Mn – **Tightly regulated**
  - Controlled at point of biliary excretion (Miller, 1973; Hambidge et al., 1989).



IOWA STATE UNIVERSITY

41

Prior work - Mn supplementation in beef finishing diets

- Prior studies investigating Mn in finishing cattle….*there aren't many!*
- Legleiter, 2005:
  - Supplemented concentrations of 0 up to 240 mg Mn/kg of DM.
  - Increasing supplemental Mn *did not increase growth performance*.

BUT

- Liver Mn decreases following implant administration (Messersmith, 2018; Reichhardt et al., 2021; Messersmith et al., 2022).
  - **WHY?**

IOWA STATE UNIVERSITY

42

Experimental Design

- Angus-cross steers (n = 144; 359 kg ± 13.4) were housed in pens (n = 24) at the Beef Nutrition Farm (BNF) in Ames, IA from November 2022 – April 2023.
- **Dietary treatments** (MANG; supplemented as $MnSO_4$):
  - **Mn0:** no supplemental Mn (analyzed 14 mg Mn/kg DM)
  - **Mn20:** 20 mg supplemental Mn/kg DM; (analyzed 33 mg Mn/kg DM)
  - **Mn50:** 50 mg supplemental Mn/kg DM; (analyzed 57 mg Mn/kg DM)
- **Implant treatments** (IMP; administered on d 0):
  - **NO:** no implant
  - **REV:** High potency combination implant (Revalor-200; 200 mg TBA + 20 mg E_2, Merck Animal Health, Madison, NJ)

IOWA STATE UNIVERSITY

43

GROWTH PERFORMANCE – Implant period

	MANG				IMP			*P*-value		
	Mn0	Mn20	Mn50	SEM	NO	REV	SEM	MANG	IMP	MANG*IMP
Day 0 - 56										
d 0 BW, kg	463	467	461	2.3	464	464	1.9	0.22	0.96	0.34
d 56 BW, kg	561	560	565	2.9	556	569	2.4	0.49	0.01	0.66
ADG, kg/d	**1.76[ab]**	**1.68[b]**	**1.82[a]**	**0.036**	1.65	1.86	0.029	**0.02**	0.01	0.35
DMI, kg/d	10.6	10.6	10.8	0.17	10.6	10.7	0.13	0.69	0.77	0.78
G:F	**0.168[x]**	**0.159[y]**	**0.168[x]**	**0.0034**	0.155	0.174	0.0027	**0.08**	0.01	0.25
Day 56 - 89										
Final BW	617	613	612	3.7	604	624	3.0	0.63	0.01	0.55
ADG, kg/d	**1.66[x]**	**1.59[xy]**	**1.48[y]**	**0.055**	1.44	1.71	0.045	**0.06**	0.01	0.43
DMI, kg/d	11.1	11.1	11.2	0.17	11.1	11.2	0.14	0.96	0.33	0.57
G:F	**0.143[x]**	**0.137[xy]**	**0.129[y]**	**0.0044**	0.127	0.146	0.0035	**0.10**	0.01	0.49
OVERALL										
Overall ADG, kg/d	1.74	1.66	1.69	0.028	1.58	1.82	0.023	0.14	0.01	0.22
Overall DMI, kg/d	10.9	10.9	11.0	0.15	10.9	11.0	0.13	0.89	0.34	0.77
Overall G:F	0.157	0.150	0.153	0.0026	0.145	0.163	0.0021	0.18	0.01	0.25

IOWA STATE UNIVERSITY

44

Carcass Characteristics

Mn supplementation and steroidal implants influence on carcass characteristics in beef steers.

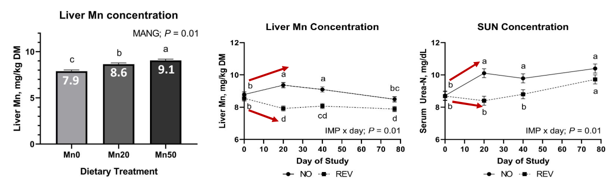
	MANG				IMP			*P*-Value		
	Mn0	Mn20	Mn50	SEM	NO	REV	SEM	MANG	IMP	MANG*IMP
HCW, kg	393	391	390	2.0	384	398	2.0	0.54	0.01	0.20
REA, cm^2	**84.6[a]**	**81.3[b]**	**82.6[ab]**	**0.8**	82.0	83.7	0.6	**0.01**	0.07	0.98
RF, cm	**1.53[y]**	**1.50[y]**	**1.68[x]**	**0.06**	1.56	1.58	0.05	**0.08**	0.82	0.26
DP, %	63.9	63.6	63.7	0.002	63.6	63.8	0.002	0.55	0.35	0.45
Yield Grade	3.56	3.64	3.91	0.086	3.65	3.83	0.069	0.25	0.84	0.23
Marbling[2]	489	514	493	12.4	483	495	10.2	0.45	0.34	0.94
KPH	2.7	2.6	2.6	0.11	2.2	2.8	0.09	0.36	0.34	0.12

[1]d -55 BW served as a covariate in analysis.

IOWA STATE UNIVERSITY

45

Liver Mn and SUN concentration



IOWA STATE UNIVERSITY

46

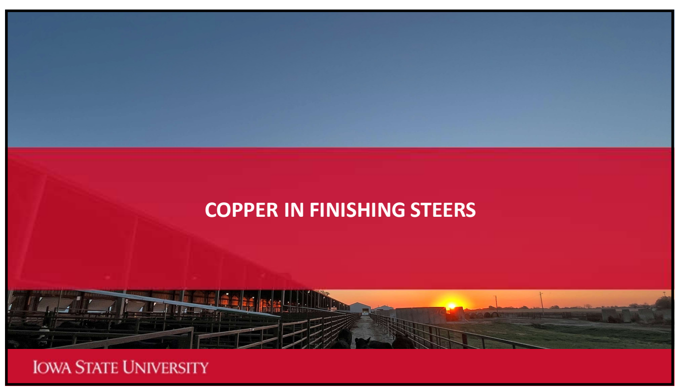
Conclusions

Dietary Mn of 14 mg/kg DM did not seem to limit growth of implanted or non-implanted cattle.

Manganese:
- Supplementation at **NASEM recommendation (20 mg Mn/kg DM) is adequate** to allow for optimal implant-induced growth
- Likely sufficient to offset potential potent Mn antagonists such as Fe, common in cattle feedstuffs.

IOWA STATE UNIVERSITY

47



48

Copper: Review

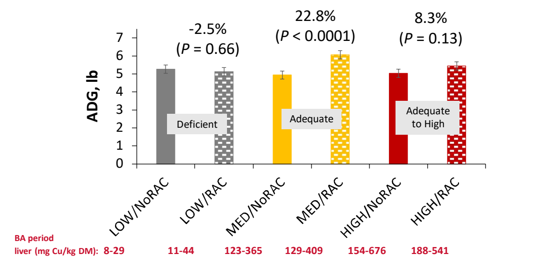
Copper is an essential trace mineral that plays a role in numerous biological processes:

- Extracellular matrix (lysyl oxidase)
- Oxidative phosphorylation (cytochrome c oxidase)
- Free radical scavenging (superoxide dismutase)
- Ceruloplasmin (Fe mobilization, antioxidant, Cu transport)
- Among many others!

Copper's redox potential is fundamental for biological functions
(*This is also why excess Cu can be problematic*)

49

Copper status affects ractopamine response



Messersmith et al., 2022

50

Copper take home message:

- Feedlot cattle do not need greater than NRC (10 ppm) recommendations

51

OVERALL TAKEHOME

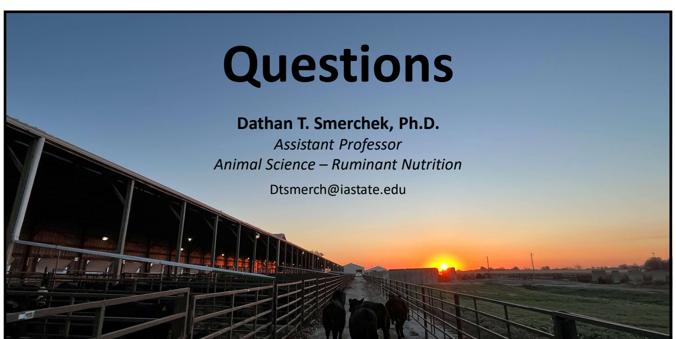
Trace mineral nutrition is VERY important throughout the beef cattle/feedlot production cycle.

Trace minerals can influence:

- Transit stress/stress in general
- Immune function
- Receiving phase performance
- Response to growth enhancing technology (implants and Beta agonists)

All TM are NOT created equally. Different functions, different storage, different requirements.
MORE IS NOT ALWAYS BETTER

52



Questions

Dathan T. Smerchek, Ph.D.
Assistant Professor
Animal Science – Ruminant Nutrition
Dtsmerch@iastate.edu

53