Differences in Selenium and Copper Metabolism between Brahman and Angus cattle.

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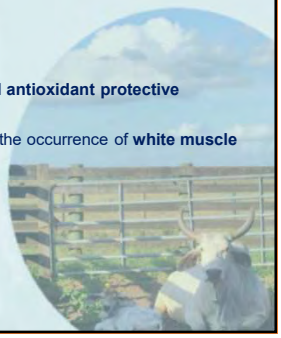
INTRODUCTION

The importance of Selenium (Se):

- Selenium works with vitamin E as a **powerful antioxidant protective mechanism.**
- **Selenium deficiency is** most recognized by the occurrence of **white muscle disease**, and;
  - low fertility,
  - retained placenta,
  - decreased immune response,
  - decreased activity of thyroid hormones.



INTRODUCTION

The importance of Selenium (Se):

- **White muscle disease or weak calf syndrome** – nutritional muscular dystrophy; degeneration and necrosis of skeletal and cardiac muscle.
  - → Antioxidant activity.

INTRODUCTION

The importance of Copper (Cu):

- Copper is typically the **most limiting trace mineral** nutrient.
- Estimated to be essential to over **30 enzymes.**
- Essential for maintenance of:

- reproduction,

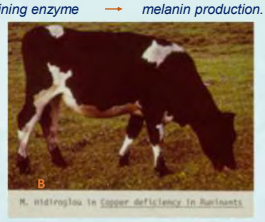
- immunity,

- growth

INTRODUCTION

The importance of Copper (Cu):

- **Copper deficiency:** depigmentation and changes in growth and physical appearance of hair. *Tyrosinase: copper-containing enzyme → melanin production.*

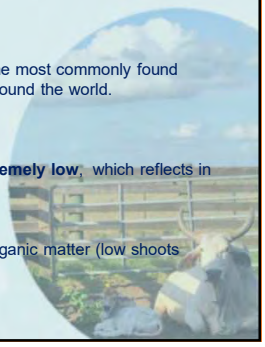


INTRODUCTION

- **Copper (Cu) and selenium (Se)** are among the most commonly found micro-mineral **deficiencies** for grazing cattle around the world.

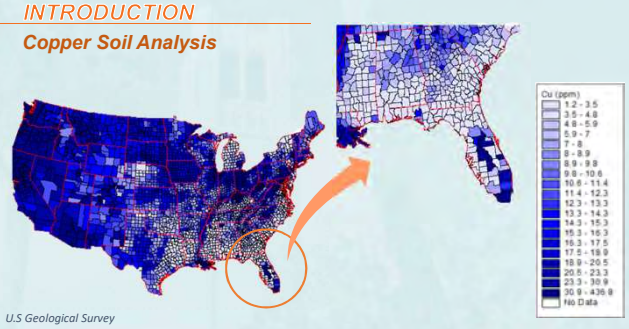
- In Florida, the soil levels of **Cu and Se are extremely low**, which reflects in the mineral concentration of forages.

  - Selenium is not required for plants.
  - Copper Cu is strongly bound to the soil organic matter (low shoots uptake)



INTRODUCTION

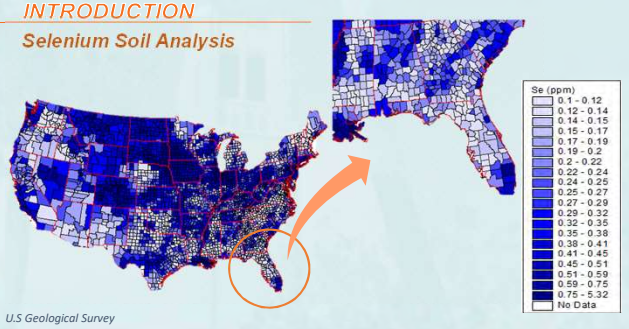
Copper Soil Analysis



U.S Geological Survey

INTRODUCTION

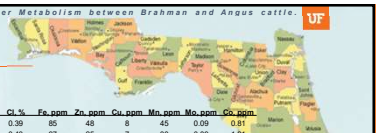
Selenium Soil Analysis



U.S Geological Survey

INTRODUCTION

Forage Analysis



Location A	Ca, %	P, %	Mg, %	K, %	Na, %	S, %	Cl, %	Fe, ppm	Zn, ppm	Cu, ppm	Mn, ppm	Mo, ppm	Co, ppm
Bahiagrass 1	0.44	0.25	0.42	1.38	0.009	0.36	0.39	85	48	8	45	0.09	0.81
Bahiagrass 2	0.47	0.19	0.40	1.37	0.011	0.3	0.43	97	25	7	30	0.09	1.21
Ave	0.46	0.22	0.46	1.38	0.01	0.33	0.41	91	37	7.5	38	0.09	1.01
Stnd.Dev.	0.02	0.04	0.05	0.01	0.001	0.04	0.03	8	16	0.7	10.6	0	0.28

Location B	Ca, %	P, %	Mg, %	K, %	Na, %	S, %	Cl, %	Fe, ppm	Zn, ppm	Cu, ppm	Mn, ppm	Mo, ppm	Co, ppm
Bahiagrass 1	0.38	0.32	0.29	1.87	0.006	0.27	0.37	104	44	8	46	0.2	1.02
Bahiagrass 2	0.45	0.27	0.28	1.57	0.005	0.2	0.32	84	20	6	17	0.1	1.15
Ave	0.42	0.3	0.29	1.72	0.006	0.24	0.35	94	32	7	32	0.15	1.09
Stnd.Dev.	0.05	0.04	0.01	0.21	0.001	0.05	0.04	14	17	1.4	20.5	0.07	0.09

Location C	Ca, %	P, %	Mg, %	K, %	Na, %	S, %	Cl, %	Fe, ppm	Zn, ppm	Cu, ppm	Mn, ppm	Mo, ppm	Co, ppm	Se, ppm
Bahiagrass 1	0.69	0.27	0.35	1.09	0.06	0.32	0.45	207.33	24.33	9.00	28.67	0.47	0.08	0.07
Bahiagrass 2	0.57	0.22	0.37	1.22	0.02	0.21	0.36	152.33	23.33	8.00	56.33	0.53	0.12	0.08
Ave	0.69	0.27	0.35	1.09	0.06	0.32	0.45	207.33	24.33	9.00	28.67	0.47	0.08	0.07
Stnd.Dev.	0.09	0.04	0.01	0.09	0.03	0.08	0.06	38.89	0.71	0.71	19.56	0.05	0.03	0.01

	Ca, %	P, %	Mg, %	K, %	Na, %	S, %	Cl, %	Fe, ppm	Zn, ppm	Cu, ppm	Mn, ppm	Mo, ppm	Co, ppm	Se, ppm
Grand Average	0.58	0.25	0.41	1.24	0.04	**0.32**	0.43	149.1 7	30.67	**8.25**	33.33	0.28	0.54	**0.07**

INTRODUCTION

Cattle Requirements

Macro-minerals, %	Gestation	Lactation	Micro-minerals, ppm	
Potassium	0.60	0.70	***Copper***	***10.00***
Magnesium	0.12	0.20	Iron	50.00
Sodium	0.06	0.10	Manganese	40.00
Sulfur	***0.15***	***0.15***	Zinc	30.00
Calcium	29 – 33 g/d		Cobalt	0.15
Phosphorus	18 – 22 g/d		Iodine	0.50
			Selenium	***0.10***

Data taken from Nutrient Requirements of Beef Cattle, National Research Council, 2016.

INTRODUCTION

U.S. Cowherd

- According to the USDA (2008), the U.S cowherd can be classified as 17.5% purebred, 13.3% composite breeds, **44.9% two-breed crosses**, and 24.3% three – or more breed crosses.
- In the Southern region of the United States the cowherds are predominantly composed of ***Bos indicus* influenced cattle.**
  - → Vast differences in geographies and climatic conditions necessitate the use of a broad spectrum of animal phenotypes that are suited to these environments, encompassing both *Bos taurus* and *Bos indicus* breeds and crosses thereof (Drouillard J., 2018.).

INTRODUCTION

Literature comparing Cu and Se metabolism in beef cattle is scarce:

- ***Langlands et al., 1980:***
  ** Raised as single herd*
  - ***Bos indicus*** (Brahman) cattle showed **greater blood Se** concentration than ***Bos taurus*** (Hereford x Shorthorn)
  - ***Bos indicus*** (Afrikaner and Brahman) showed **greater GSH-Px** activity when compared to ***Bos taurus*** (Hereford x Shorthorn)

Afrikaner cattle

INTRODUCTION

- ***Bass II et al., 1999:***
  ** Se and Vit. E injection*
  - **Jersey** cows had **greater blood Se** concentration than **Holstein** cows when receiving parenteral supplementation.
- ***Pogge et al., 2013:***
  ** Multimin™ injection*
  - **Angus** steers had **greater plasma Se** concentration than **Simental** steers, after the use of Multimin™ injections.

Differences in Selenium and Copper Metabolism between Brahman and Angus cattle. UF

INTRODUCTION

- ***Dermauv et al., 2014:***
  ** Supplemented with low Cu and Mo.*
  - ***Bos indicus*** (Abyssinian Highland) heifers showed **greater Se tissue (kidney) concentration, plasma and liver Cu concentration** than crossbreed heifers (Abyssinian Highland x Holstein).
  - **Differences** were observed in **gene expression of Cu and Se related genes** when comparing *Bos indicus* heifers and crossbreed heifers.

Atp7
Ctr1
CCS
Cox17
Sod1
} Cu related genes; **greater** in Bos indicus heifers.

Gpx1 } Se related gene; **greater** in Bos indicus heifers.

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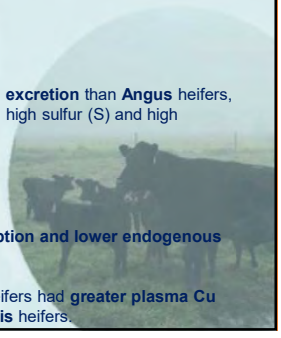
INTRODUCTION

- ***Gooneratne et al, 1994:***
  ** Supplemented high/low Cu, Mo, and S.*
  - **Simmental** heifers had **greater biliary Cu excretion** than **Angus** heifers, when in a diet supplemented with high Cu, high sulfur (S) and high molybdenum (Mo).
- ***Ward et al, 1995:***
  ** Supplemented with Cu, Fe or Mo.*
  - **Angus** steers **showed greater Cu absorption and lower endogenous losses** than **Simental** steers.
  - When not fed supplemental Cu, **Angus** heifers had **greater plasma Cu** concentration than **Simental and Charolais** heifers.

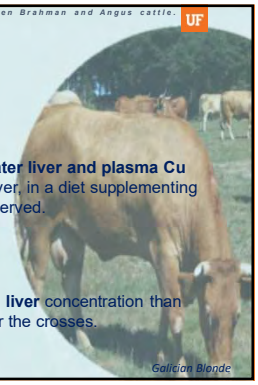


INTRODUCTION

- ***Du et al., 1996:***
  - ** Supplemented with low or high Cu.*
  - **Jersey** cows had **greater liver and plasma Cu** concentrations than **Holstein** Cows.
- ***Mullis et al., 2003:***
  - ** Supplemented with different levels of Cu.*
  - In a high Iron (Fe) diet **Angus steers** had **greater Cu status** (serum, liver and ceruloplasmin concentrations) than **Simental steers.**
- ***Pogge et al., 2013:***
  - ** Multimin™ injection*
  - **Angus** steers had **greater plasma Cu** concentration than **Simental** steers, after the use of Multimin injections.

INTRODUCTION

- ***Fry et al., 2013:***
  - ** Supplemented with corn silage either Cu deficient or adequate.*
  - In a Cu deficient diet **Angus steers had greater liver and plasma Cu concentration than Simental steers**. However, in a diet supplementing adequate level of Cu no differences were observed.
- ***Pereira et al., 2018:***
  - ** Commercial feedlot diet.*
  - Showed that **Holstein** calves had **greater Cu liver** concentration than **Galician Blonde**, with intermediate values for the crosses.



Galician Blonde

INTRODUCTION

- ***Summary of the literature:***

Selenium

- Breed differences (4)
- Antagonist (1)
- Subspecies differences (2)

- Fewer studies looking into differences on Se metabolism.

Copper

- Breed differences (8)
- Antagonists (4)
- Subspecies differences (1)

Comparation of cattle subspecies using purebred cattle and antagonist?

INTRODUCTION

Objective: The objective of this study was to identify potential differences in metabolism of Cu and Se in purebred Angus (*Bos taurus*) and Brahman (*Bos indicus*) cattle.

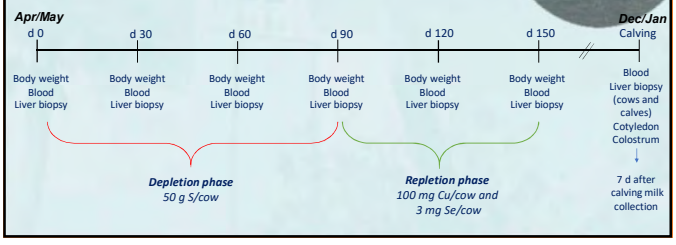
Hypothesis: We hypothesized that Brahma cows (*Bos indicus*) will be less susceptibly to Cu and Se deficiency than Black Angus (*Bos taurus*) cows when supplemented with a high sulfur (S) diet.

MATERIAL AND METHODS

- 2-year study (2017 and 2018) at the Range Cattle Research and Education Center (Ona, FL).
- 8 Angus and 8 Brahman pregnant cows/year individually housed and fed.
- **3 Phases -** Depletion, Repletion, and Calving.
  - ***Depletion:*** 90 days, supplemented with 50 g of S daily to promote Cu and Se deficiency. - 1st to 2nd trimester gestation
  - ***Repletion:*** 60 days, supplemented with Cu (100 mg/cow) and Se (3 mg/cow). – 2nd trimester of gestation.
  - ***Calving:*** Approximately 45 days. Monitored using an intravaginal device. – 3rd trimester of gestation.

MATERIAL AND METHODS

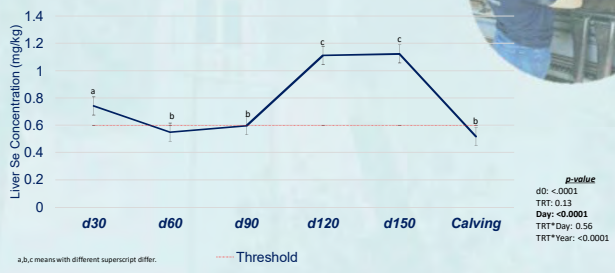
Study Timeline



MATERIAL AND METHODS
Statistical Analysis

- All data were analyzed using the MIXED procedure of SAS.
- Cow and calf were considered the experimental unit.
- Variables were tested for treatment, day, year, and the possible interactions.
- For all the repeated measures d0 was used as a covariate (variance components)
- Significance declared at $P \leq 0.05$ and tendencies observed at $0.05 < P \geq 0.10$

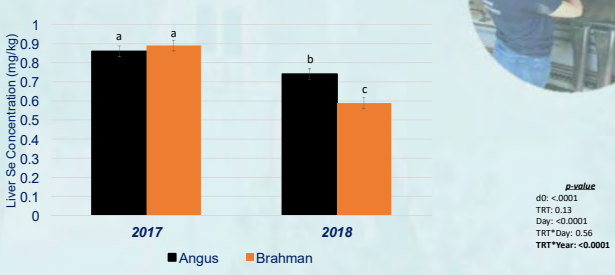
RESULTS AND DISCUSSION
Cows Liver Selenium



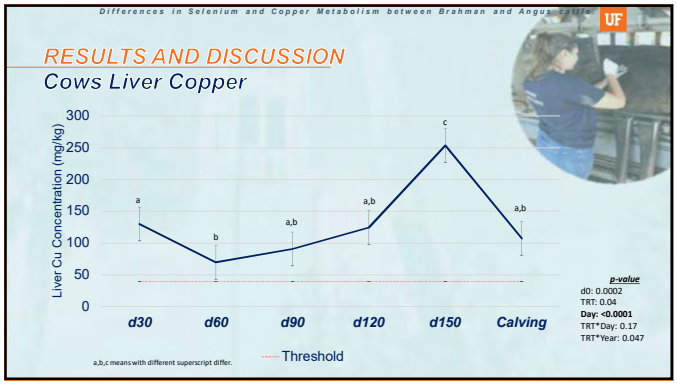
a,b,c means with different superscript differ.

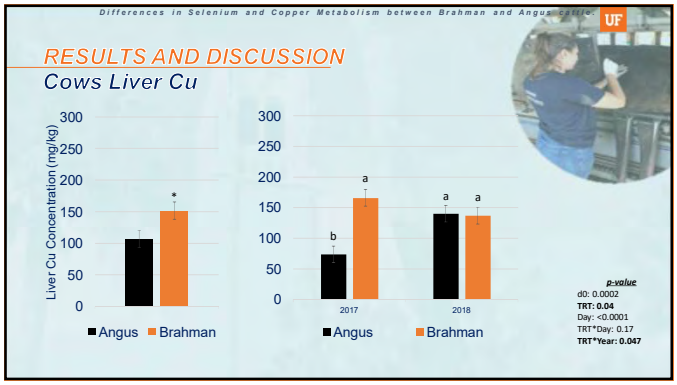
p-value
d0: <.0001
TRT: 0.13
Day: <0.0001
TRT*Day: 0.56
TRT*Year: <0.0001

RESULTS AND DISCUSSION
Cows Liver Selenium



p-value
d0: <.0001
TRT: 0.13
Day: <0.0001
TRT*Day: 0.56
TRT*Year: <0.0001


Differences in Selenium and Copper Metabolism between Brahman and Angus cattle.
UF
RESULTS AND DISCUSSION
Cows Liver Copper
Liver Cu Concentration (mg/kg)
300
250
200
150
100
50
0
a
b
a,b
a,b
c
a,b
d30
d60
d90
d120
d150
Calving
Threshold
a,b,c means with different superscript differ.
p-value
d0: 0.0002
TRT: 0.04
Day: <0.0001
TRT*Day: 0.17
TRT*Year: 0.047


Differences in Selenium and Copper Metabolism between Brahman and Angus cattle.
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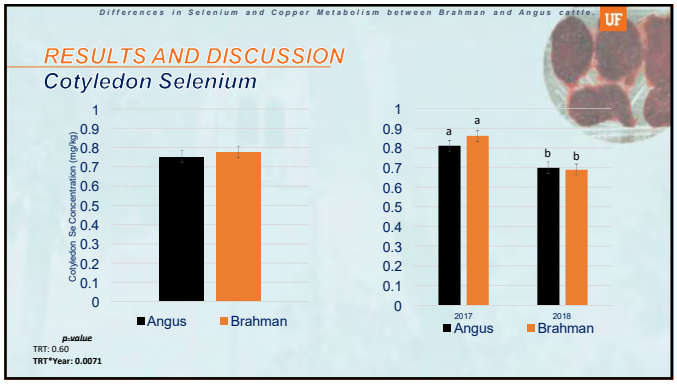
RESULTS AND DISCUSSION
Cows Liver Cu
Liver Cu Concentration (mg/kg)
300
250
200
150
100
50
0
*
a
b
a
a
2017
2018
Angus
Brahman
p-value
d0: 0.0002
TRT: 0.04
Day: <0.0001
TRT*Day: 0.17
TRT*Year: 0.047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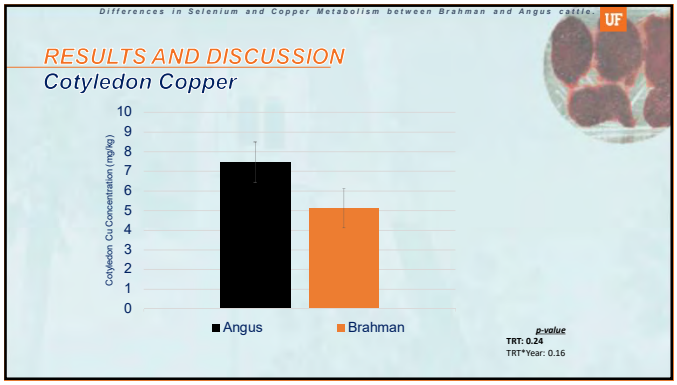
RESULTS AND DISCUSSION
Cotyledon Selenium
Cotyledon Se Concentration (mg/kg)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
a
a
b
b
2017
2018
Angus
Brahman
p-value
TRT: 0.60
TRT*Year: 0.0071


Differences in Selenium and Copper Metabolism between Brahman and Angus cattle
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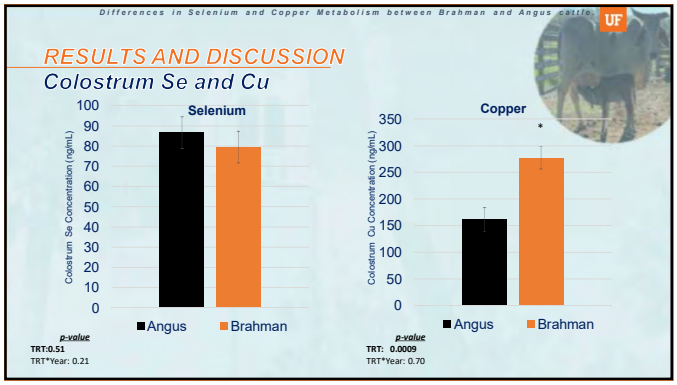
RESULTS AND DISCUSSION
Cotyledon Copper
Cotyledon Cu Concentration (mg/kg)
10
9
8
7
6
5
4
3
2
1
0
Angus
Brahman
p-value
TRT: 0.24
TRT*Year: 0.16


Differences in Selenium and Copper Metabolism between Brahman and Angus cattle
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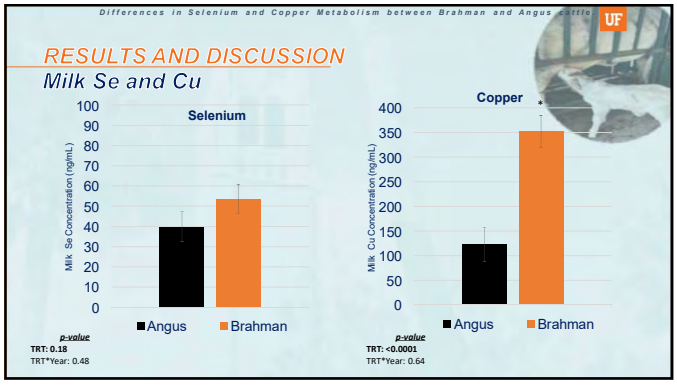
RESULTS AND DISCUSSION
Colostrum Se and Cu
Selenium
Colostrum Se Concentration (ng/mL)
100
90
80
70
60
50
40
30
20
10
0
Angus
Brahman
p-value
TRT:0.51
TRT*Year: 0.21
Copper
*
Colostrum Cu Concentration (ng/mL)
350
300
250
200
150
100
50
0
Angus
Brahman
p-value
TRT: 0.0009
TRT*Year: 0.70


Differences in Selenium and Copper Metabolism between Brahman and Angus cattle
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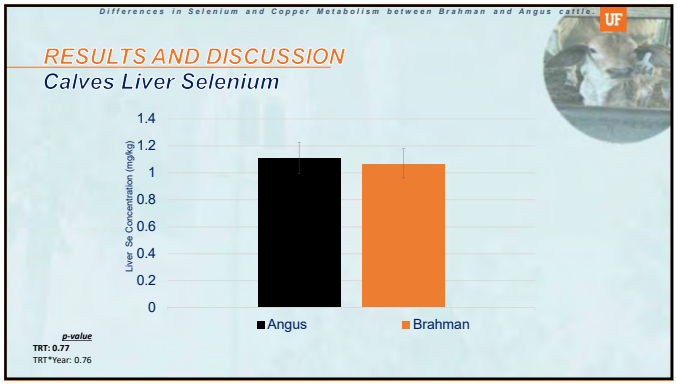
RESULTS AND DISCUSSION
Milk Se and Cu
Selenium
Milk Se Concentration (ng/mL)
100
90
80
70
60
50
40
30
20
10
0
Angus
Brahman
p-value
TRT: 0.18
TRT*Year: 0.48
Copper
*
Milk Cu Concentration (ng/mL)
400
350
300
250
200
150
100
50
0
Angus
Brahman
p-value
TRT: <0.0001
TRT*Year: 0.64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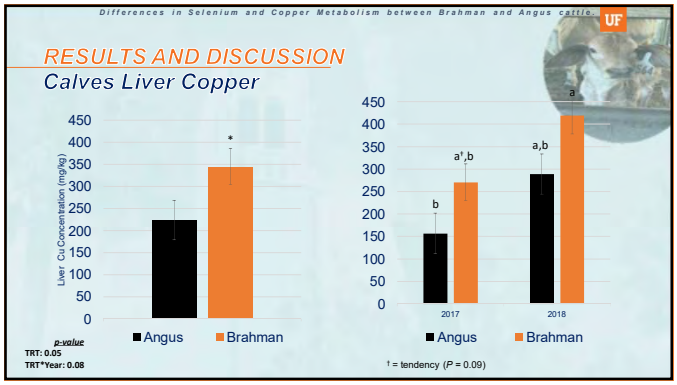
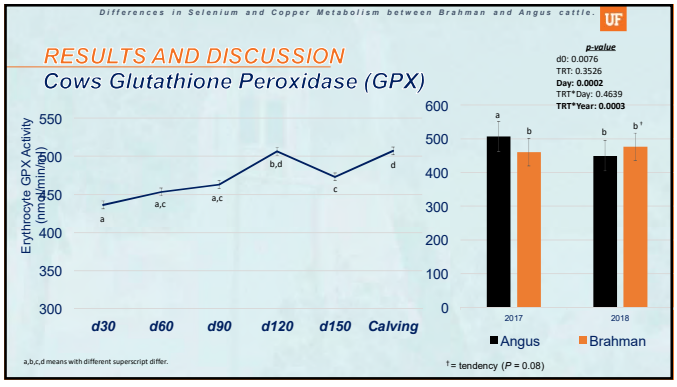
RESULTS AND DISCUSSION
Calves Liver Selenium
Liver Se Concentration (mg/kg)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Angus
Brahman
p-value
TRT: 0.77
TRT*Year: 0.76


Differences in Selenium and Copper Metabolism between Brahman and Angus cattle.
UF
RESULTS AND DISCUSSION
Calves Liver Copper
Liver Cu Concentration (mg/kg)
450
400
350
300
250
200
150
100
50
0
*
Angus
Brahman
p-value
TRT: 0.05
TRT*Year: 0.08
a†,b
b
a,b
a
2017
2018
† = tendency (P = 0.09)


Differences in Selenium and Copper Metabolism between Brahman and Angus cattle.
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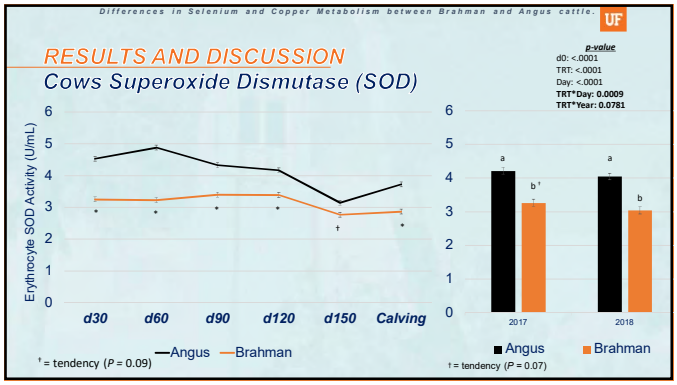
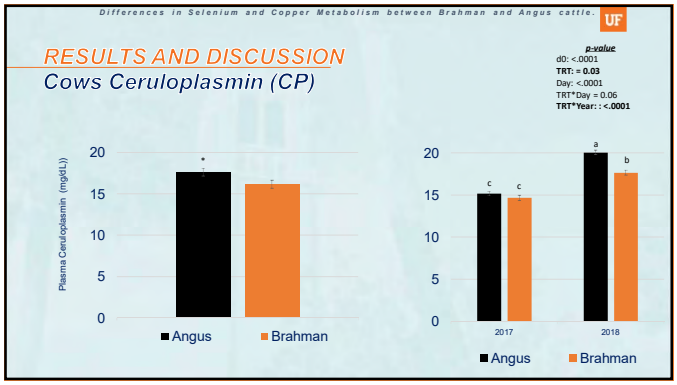
RESULTS AND DISCUSSION
Cows Glutathione Peroxidase (GPX)
Erythrocyte GPX Activity (nmol/min/ml)
550
500
450
400
350
300
a
a,c
a,c
b,d
c
d
d30
d60
d90
d120
d150
Calving
a,b,c,d means with different superscript differ.
p-value
d0: 0.0076
TRT: 0.3526
Day: 0.0002
TRT*Day: 0.4639
TRT*Year: 0.0003
600
500
400
300
200
100
0
a
b
b
b†
2017
2018
Angus
Brahman
† = tendency (P = 0.08)


Differences in Selenium and Copper Metabolism between Brahman and Angus cattle.
UF
RESULTS AND DISCUSSION
Cows Superoxide Dismutase (SOD)
Erythrocyte SOD Activity (U/mL)
d30
d60
d90
d120
d150
Calving
Angus
Brahman
† = tendency (P = 0.09)
p-value
d0: <.0001
TRT: <.0001
Day: <.0001
TRT*Day: 0.0009
TRT*Year: 0.0781
2017
2018
† = tendency (P = 0.07)


Differences in Selenium and Copper Metabolism between Brahman and Angus cattle.
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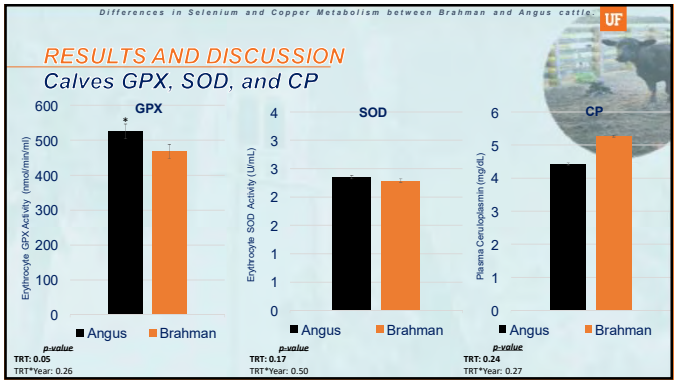
RESULTS AND DISCUSSION
Cows Ceruloplasmin (CP)
Plasma Ceruloplasmin (mg/dL)
Angus
Brahman
p-value
d0: <.0001
TRT: = 0.03
Day: <.0001
TRT*Day = 0.06
TRT*Year: : <.0001
2017
2018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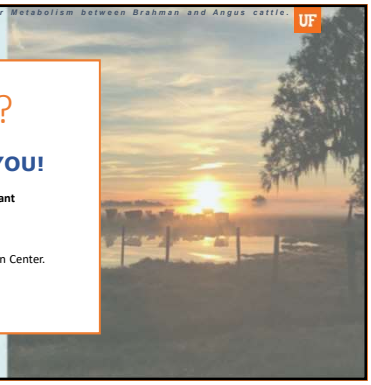
UF
RESULTS AND DISCUSSION
Calves GPX, SOD, and CP
GPX
Erythrocyte GPX Activity (nmol/min/ml)
SOD
Erythrocyte SOD Activity (U/mL)
CP
Plasma Ceruloplasmin (mg/dL)
Angus
Brahman
p-value
TRT: 0.05
TRT*Year: 0.26
p-value
TRT: 0.17
TRT*Year: 0.50
p-value
TRT: 0.24
TRT*Year: 0.27

CONCLUSIONS

- ***Gene expression:*** data on 48 genes involved in the metabolism of Cu and Se should be available in 10/2019, which will corroborate for the better understanding of this study.
- Apparently, there were **no major differences** on the **status of Se** between Angus and Brahman cows.
- **Copper status** was **different between Angus and Brahman** cows, **suggesting possible differences** in the **metabolism** between the two cattle subspecies. Gene expression data will further elucidate these differences.
- Possible **different preferential pathway** (colostrum/milk vs. placenta) for **copper transfer** from dam to calf. Gene expression data of cotyledon tissue may clarify this possibility.



Questions?

THANK YOU!

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