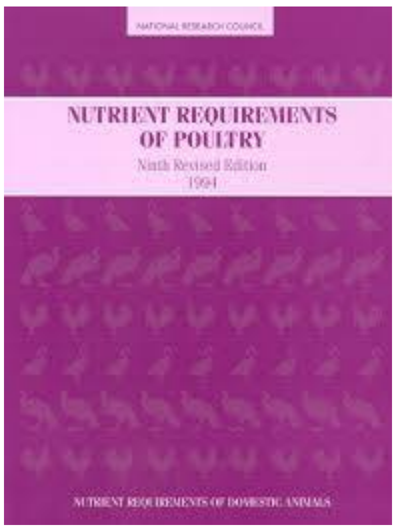
The commercial relevance of micro-mineral nutrition for monogastrics

SOLUTIONS SERVICE SUSTAINABILITY™

Micro Mineral Nutrition World 2014

In spite of all the things we know and understand about nutrition we don´t really know the actual mineral requirements of the animals we feed



"Thus there is a great deal of literature concerning the calcium and phosphorus requirements of the broiler and minimal research concerning requirements for trace elements" (NRC, 1994)

Many nutritionists don´t worry much since they believe that, by using "safely high" levels of Zn, Cu and Mn with inorganic sources, they maximize performance

Many nutritionists believe that using organic minerals is a luxury and can ONLY be used if the use reduces total feed cost, generally done by using lower mineral levels.

Many nutritionists don´t think much about the differences between inorganic and organic mineral molecules and treat them as equivalents.

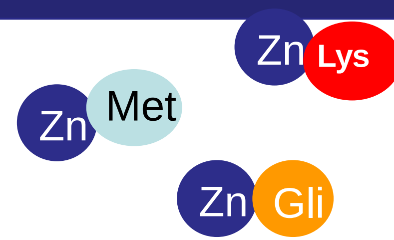
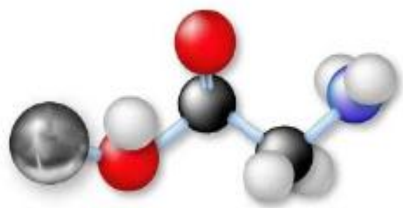
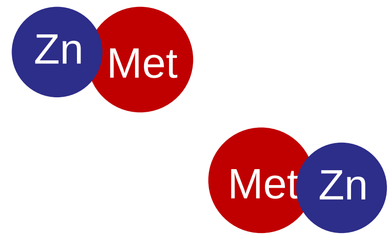
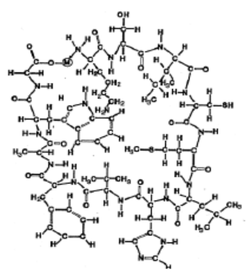
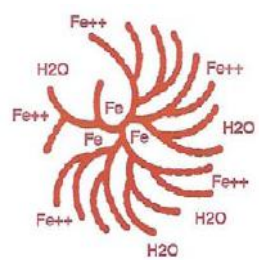
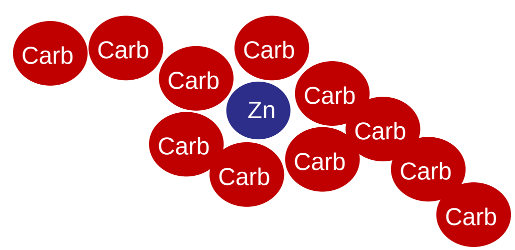
Mineral sources available for commercial animal nutrition

- Inorganic sources of micro minerals
  - Sulphates
  - Oxides
  - TBCC´s
  - ETC
- Organic sources of micro minerals
  - True Chelates (Mintrex, Glycinates)
  - Non-Chelates (many)

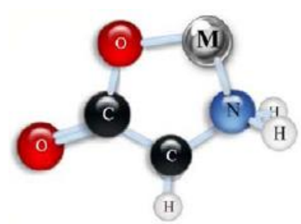
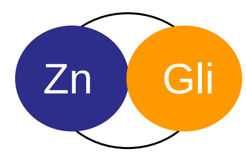
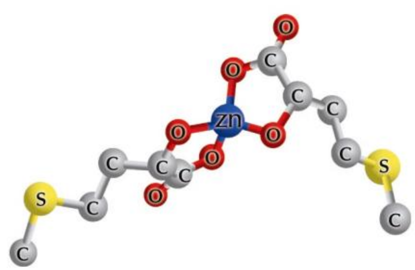
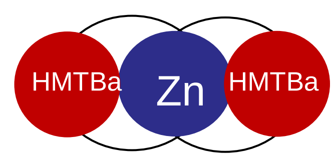
Comparing Organic Trace Mineral Ligands

- Ligands are ions or neutral molecules that bond to a central metal atom or ion.
- *Zinc is Zinc, Copper is Copper, Manganese is Manganese*
- The only reason to feed an organic trace mineral (OTM) over a mineral salt is to deliver minerals to the blood
- The only point of **differentiation** among OTMs is their **ligand**.
- **Structure definition** is critical to determine physical and chemical characteristics as well as consistency from lot to lot
- Chemical and physical **stability** is critical to performance.
- If the molecule disassociates prior to reaching intestinal receptor sites, antagonists can bind the mineral, causing it to precipitate out of solution rendering it unavailable to the animal.
- Receptor site proteins will absorb the soluble mineral and “pass” it to specific “chaperone,” or transport, proteins or enzymes

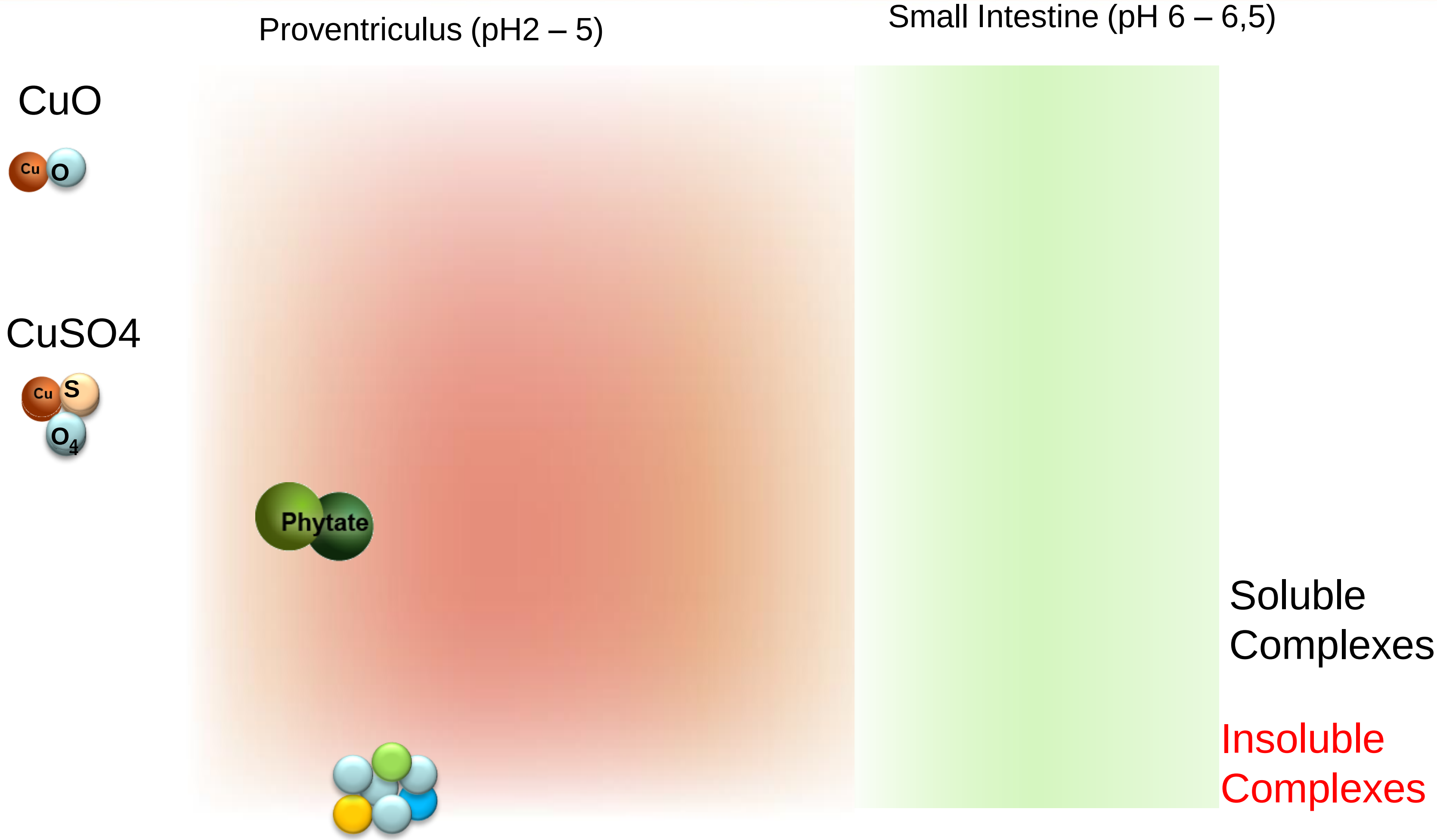
Organic Trace Minerals: Non chelates

AAFCO CLASS OF LIGAND*	MOLECULAR REPRESENTATION	SCHEMATIC MODEL	CHARACTERISTICS
Metal (Amino Acid) Complex Product resulting from complexing a soluble metal salt with an amino acid(s)			• Many of them do not have a defined structure ie, there can be changes in the ligand (different AAs, protein chains or carbohydrates) • Therefore it is not possible to determine the bond strength, the number of bonds, molecular size and the amount of ligands in the product. • The composition can vary and the amount of chelated mineral is uncertain. • Even when the ligand is well known, the protection to the metal is partial since the ligand covers only one side of it.
Metal (Specific Amino Acid) Complex Product resulting from complexing a soluble metal salt with a specific amino acid			
Metal Proteinate Product resulting from the chelation of a soluble salt with amino acids and/or partially hydrolyzed protein			
Metal Polysaccharide Complex Product resulting from complexing a soluble salt with a polysaccharide solution			

Organic Trace Minerals: True chelates

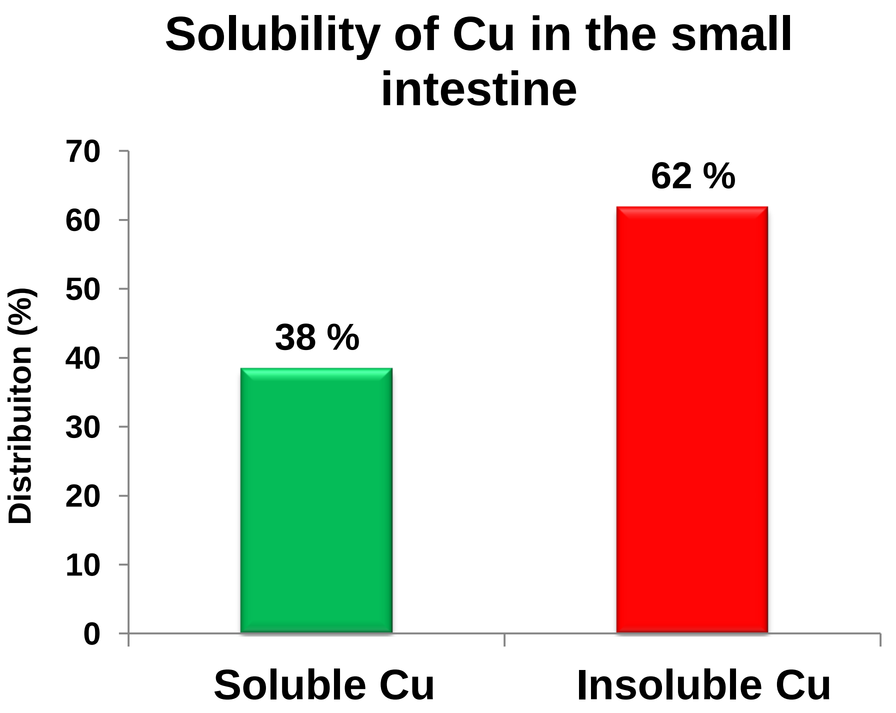
AAFCO CLASS OF LIGAND*	MOLECULAR REPRESENTATION	SCHEMATIC MODEL	CHARACTERISTICS
Chelate Metal Amino acid			• Are true chelates • They have defined structure, composition and sizes
Chelate metal-HMTBA			

Minerals in the Gastric Environment(pH 2 -5)

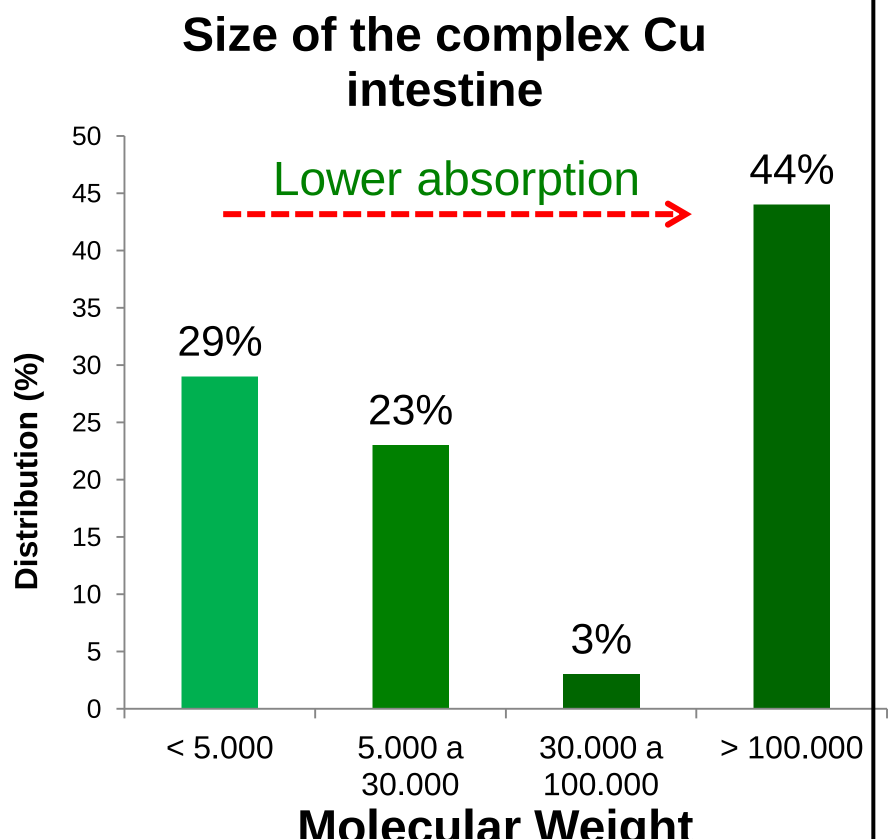


Form of copper present in the duodenum and jejunum

- Experiments done ***in vivo***
- Copper Sulfate = 8 ppm Cu



Soluble portion:

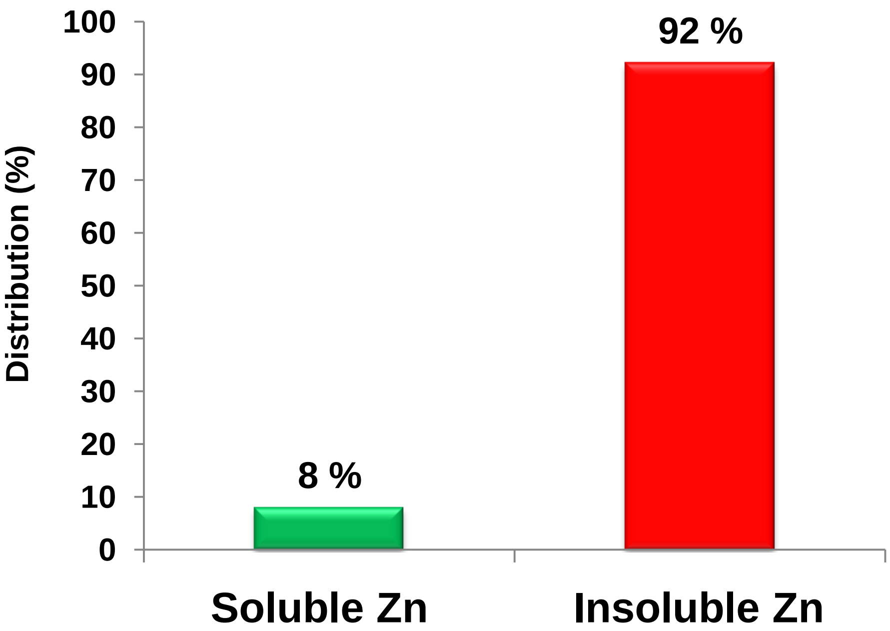


Pang e Applegate, 2007- *Poult. Sci.*

Form of Zinc present in the duodenum and jejunum

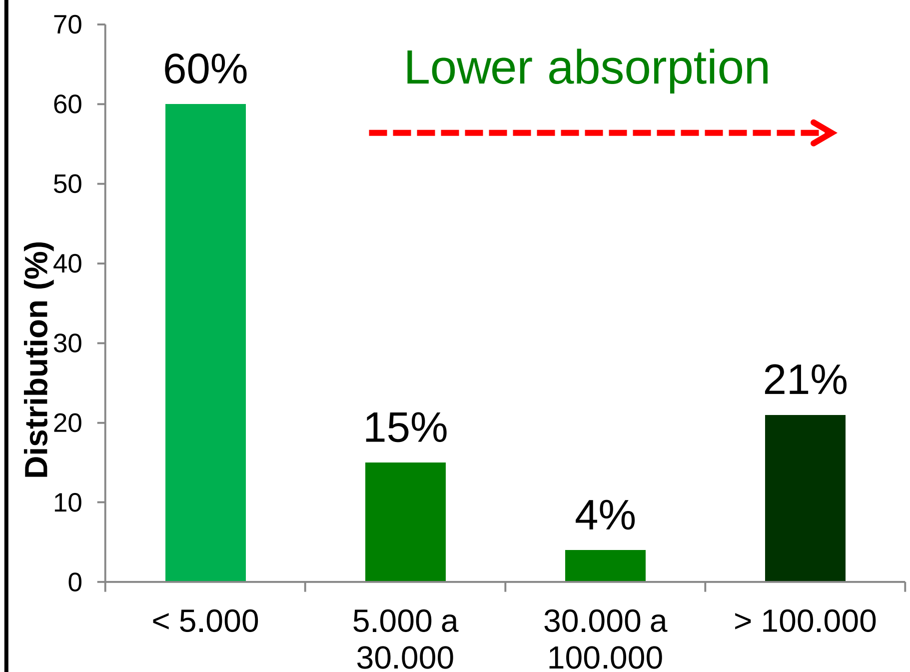
- Experiments conducted ***in vivo***
- Zinc Oxide = 125 ppm Zn

Solubility of Zn in the small intestine



Soluble portion:

Size of Zn complexes in the intestine



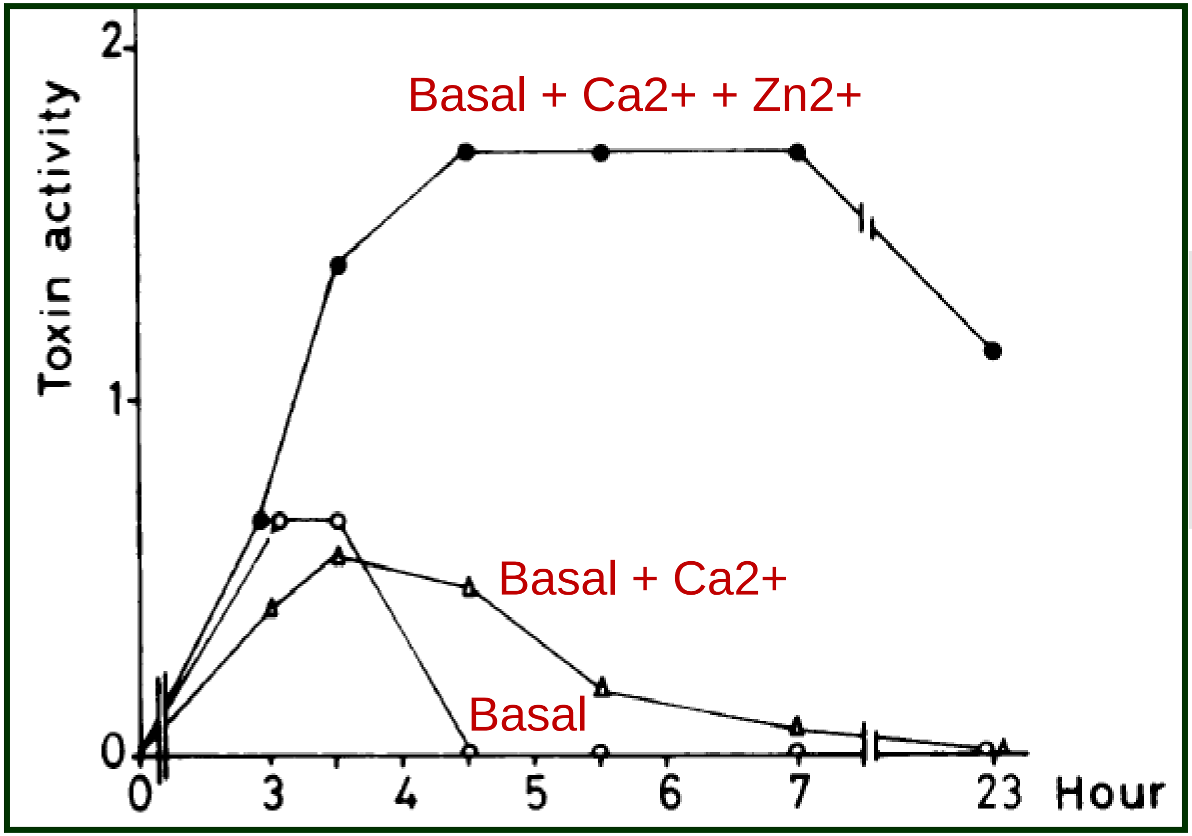
NOVUS

Pang e Applegate, 2007- *Poult. Sci.*

Ideas on Micro Mineral Nutrition World Few Years Ago

We don´t understand what really happens to these minerals throughout the gut, the interactions, etc

Zn as activator of α-toxin of *Clostridium perfringens*



Ca induces denaturation of α-toxin while Zn activates and makes α-toxin stable

Sato et al., 1978

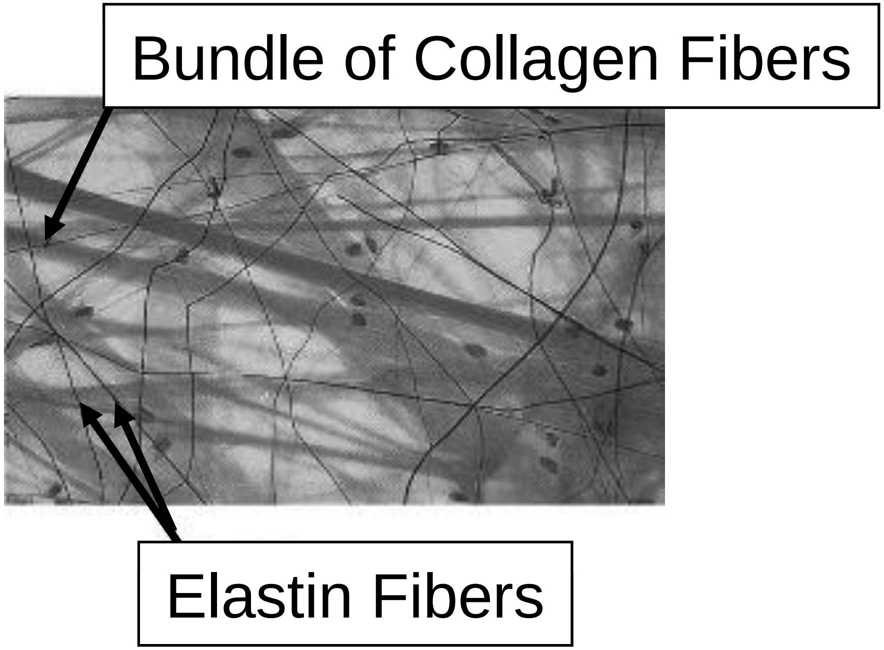
NOVUS®

SOLUTIONS SERVICE SUSTAINABILITY™

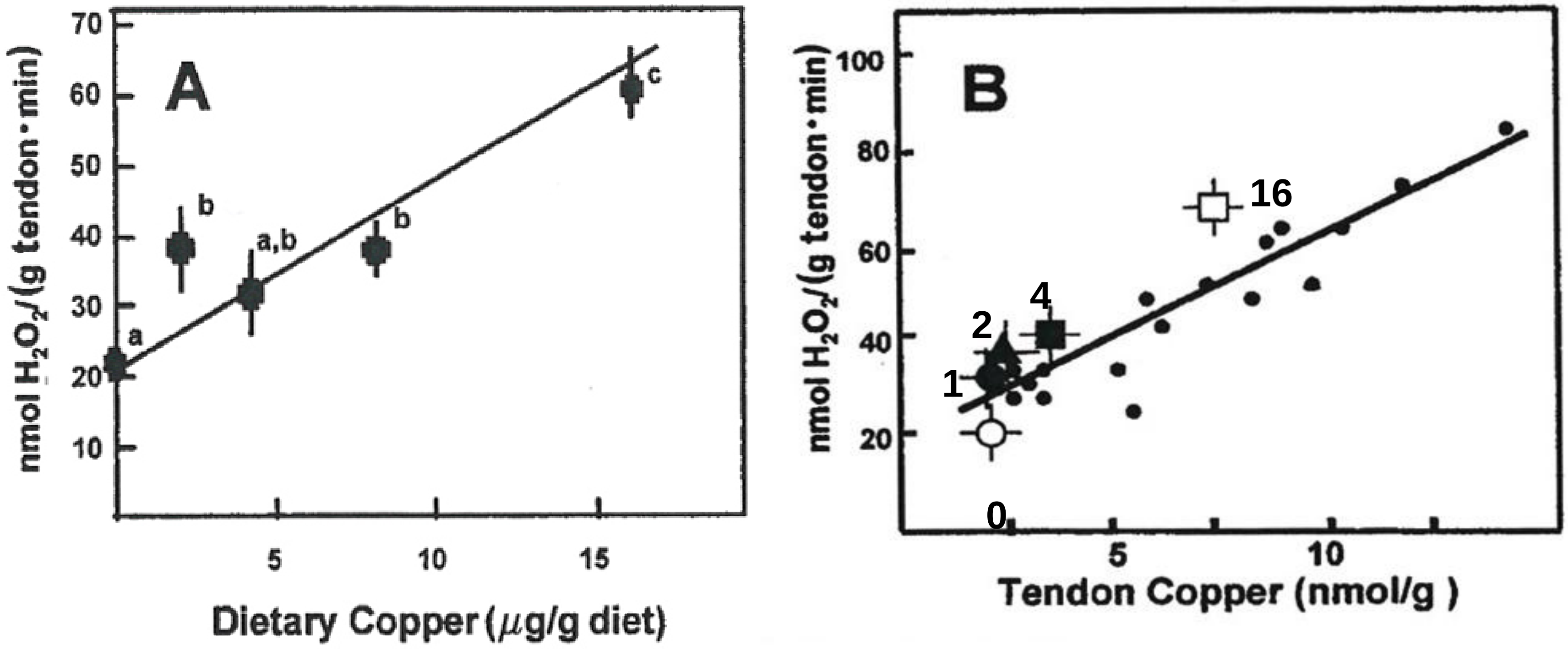
Some Biologic Functions of Zn, Cu and Mn

SOLUTIONS SERVICE SUSTAINABILITY™

Connective Tissue: Essential for Function



Collagen Crosslinking and Dietary Copper



Dietary Cu above that required for optimum performance was associated with increased chick tendon lysyl oxidase activity and tendon Cu was correlated with enzyme activity ($r^2 = 0.88$).

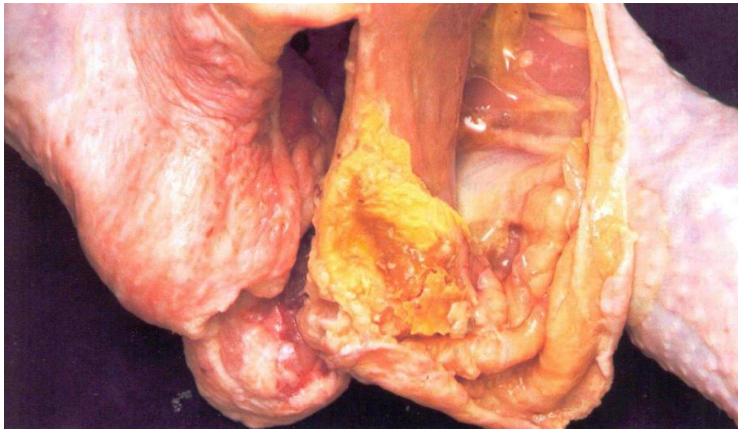
NOVUS

Rucker et al., 1999. J. Nutr.129:2143

Partial condemnations due to skin problems





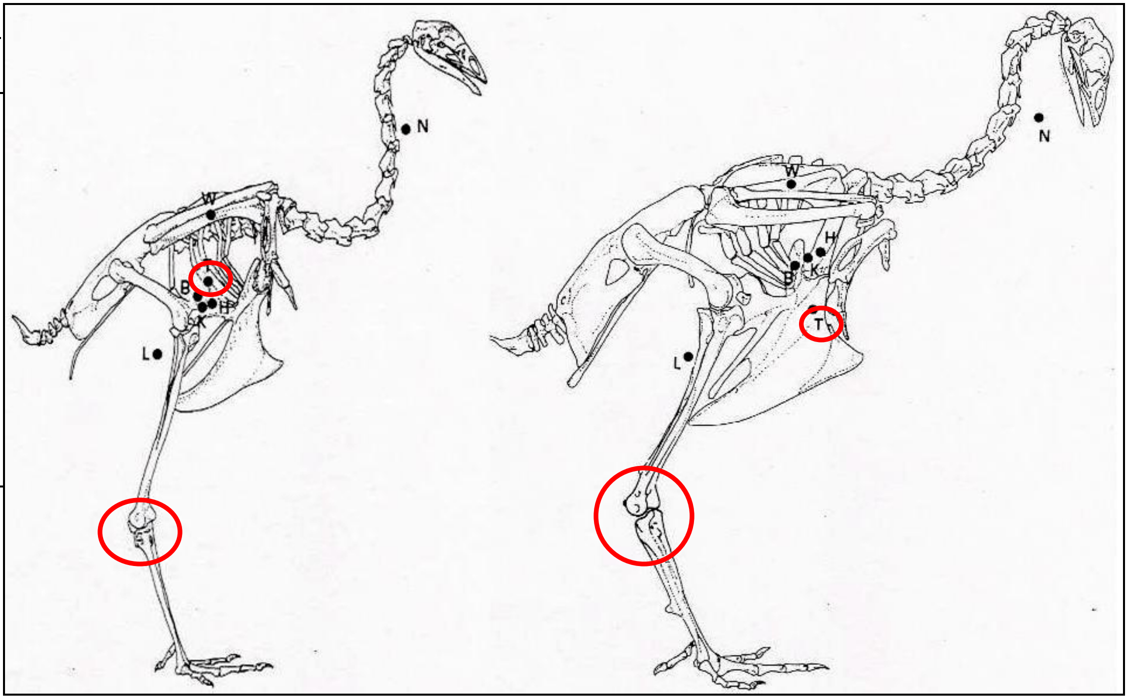


Broiler Breeder Hens: Carcass Effects

Effects of Body Weight and Feed allocation During Sexual Maturation in Broiler Breeder Hens. R.A. Renema

Breast Muscle Percentage
At Sexual Maturity

	Breast muscle	
Source	Weight	Percentage[1]
	(g)	(%)
Feed[3]		
AL	489.7[a]	14.59[b]
RF	446.7[b]	16.20[a]
SEM	7.7	0.23
Size[4]		
LOW	442.2[b]	15.47
STD	469.6[a]	15.13
HIGH	492.8[a]	15.59
SEM	9.5	0.28
Source of variation		
Feed	0.0002	0.0001
Size	0.002	0.48



Abourachid, 1993;
Emmerson et al, 1997;
Nestor et al, 2001.

Renema et al, 1999. Poult Sci 78:619

Lameness (Bone Health) is currently the 4th most prevalent health issue in US broiler Industry

Financial loss estimated at $120,000,000/year in USA (Cook, 2000)

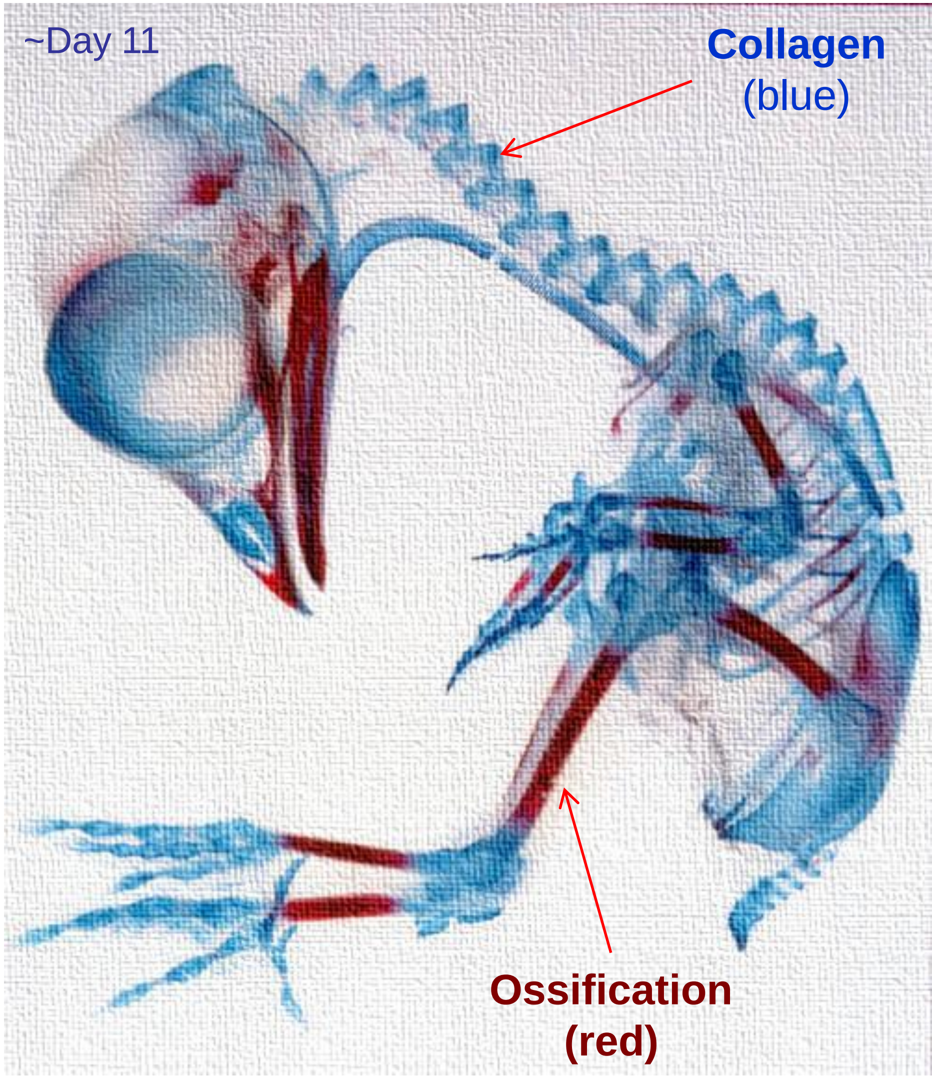
Rank	Condition
1	Enteric
2	Respiratory
3	Skin
4	Lameness
5	Chicks

All top 4 issues associated with Barrier Health

Catalytic properties of enzymes involved in maintaining egg shell/membrane quality and supporting embryogenesis

- **<u>Zn- Carbonic anhydrase</u>**
  - Activity of carbonic anhydrase, an essential enzyme for eggshell formation, has been directly related to zinc status of the hen
  - Zn functions in collagen synthesis
- **<u>Cu- lysyl oxidase</u>**
  - Cu is involved in collagen cross linking
  - Second most common metalloenzyme constituent (after zinc)
- **<u>Mn - glycosyl transferases</u>**
  - Chondroitin sulfate is the structural component of cartilage and provides much of its resistance to compression

(Leeson and Summers, 2001; Hudson et al., 2004; Bellairs & Osmond, 2005 Dibner and Richards, 2006; Dibner et al., 2007; Ferket et al., 2009)



Immune function of trace minerals

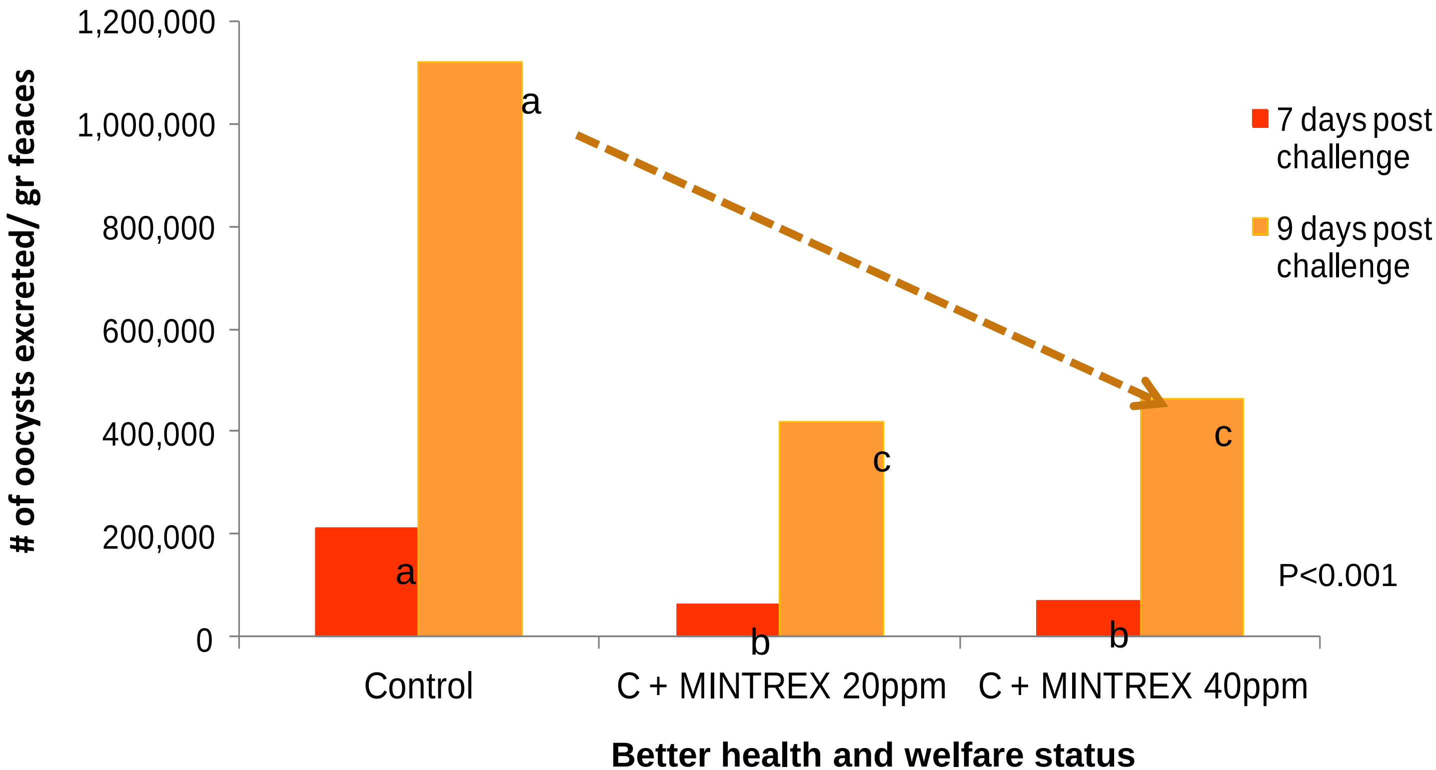
- Zn:
  - Macrophages activity (Ferket et Qureshi, 1992)
  - Cofactor of DNA and RNA polymerase, it influences the number of leucocytes (Gupta et al., 1985)

- Cu:
  - Increases the immune response in an attack (Strain, 1994).
  - Ceruloplasmina: Cu is its cofactor. It protects the membranes from the free radicals of oxygen. The amount of this protein is increased during the attack of E.coli and Salmonella

- Mn:
  - It acts in the activity of neutrofiles and macrophages (Underwood y Suttle, 2001).

Trace mineral support in coccidiosis control

288 male broilers , supplemented with different levels of MINTREX® Zn and challenged with *E. tenella.*



Ref. Bun et al., 2010, Poultry Science

Immunity and oxidative stress

Maintaining oxidative balance
=
stronger immunity

Immunity

- Inflammatory process, stress hormones (adrenaline, cortisone):

↗ oxygen free radicals

Oxygen free radicals

↗ Damages to cell membranes

Oxidative stress

- Susceptibility to disease
- Hyper activation of immune system
- Role in auto-immune diseases

Some of the benefits attributed to Organic Trace Minerals

1. Catalyse Enzyme activity

- Hundreds of enzymes depend on Zn, Cu y Mn

2. Ensure tissue and structural heatlh.

- Collagen, keratine, elastine and bone formation.
- Bone and feather structure, tendons, eggshell, gut and skin structure, wound healing, etc…

3. Optimize Immune function.

- Ig titters.
- B Cells, T Cells.

4. Reduce the impact of oxidative stress.

- Micro-minerals are cofactors of enzymes such as Superoxide dismutase and Gluthation peroxidase

5. Lower impact to the envirnment and safety of use

- Lower fecal excretion
- Dioxins, etc.

PARADIGM TO BREAK: MINTREX CAN HAVE A DIRECT IMPACT IN PRODUCTION PARAMETERS

- At practical levels of supplementation and by using commercially available sources of minerals, economically important parameters can be optimized:
    - Feed Conversion
    - Weight gain
    - Carcass yield
    - Chick quality
    - Egg production per housed hen,
    - Piglet weight at birth
    - ETC..
- AND, in spite of the economic importance of this topic, many nutritionists know relatively little about Zn, Cu, and Mn nutrition

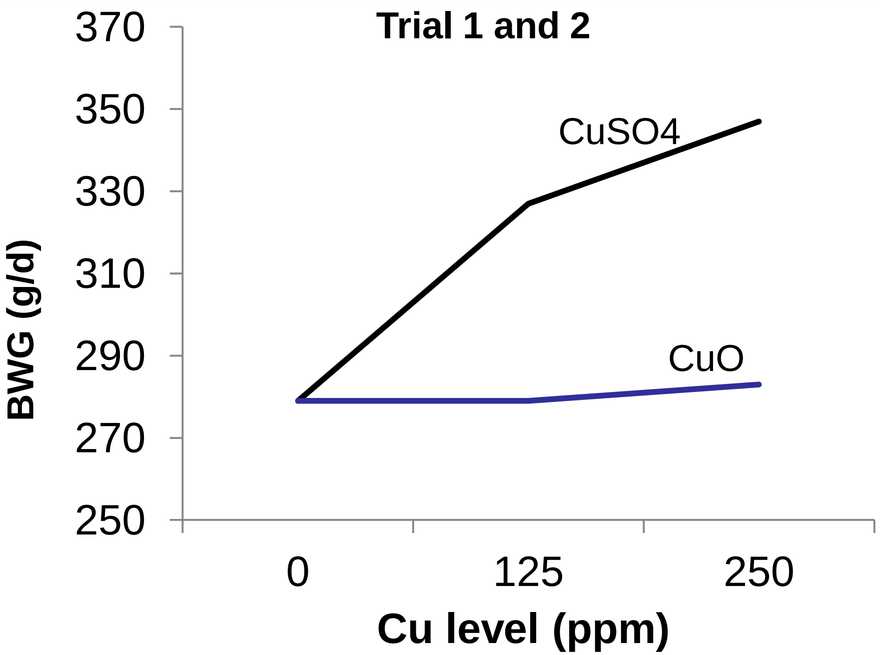
Every Mineral Source Has a Unique Potential to optimize animal performance

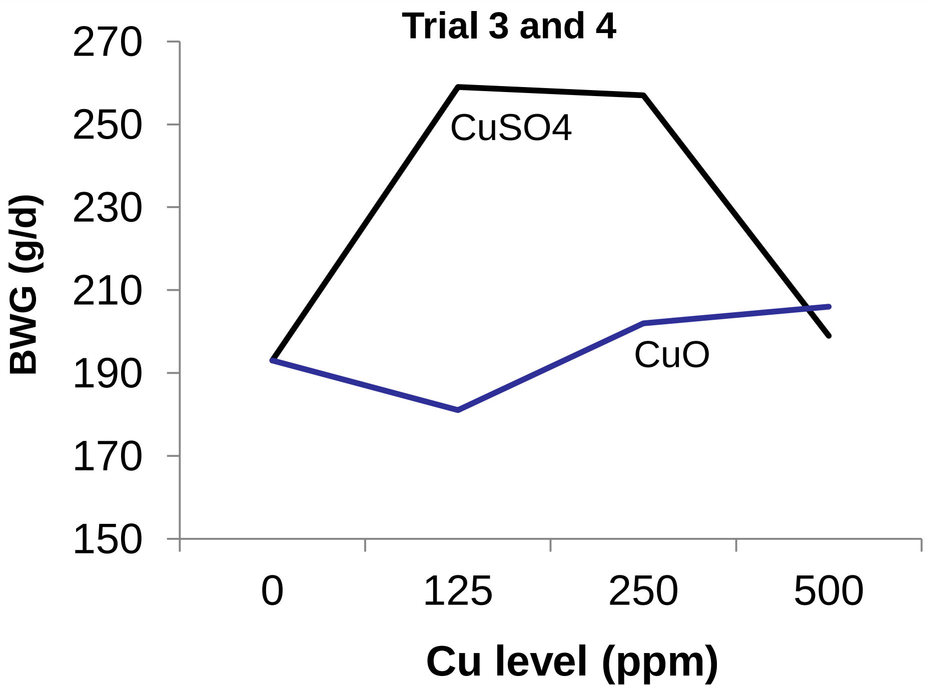
- Inorganics
  - Sulphates
  - Oxides
  - TBCC´s
  - ETC
- Organics
  - True Chelates (Mintrex, Glycinates)
  - Non-Chelates (many)

Every source of mineral has its own unique characteristics and peculiarities

Their peculiarities can produce unique and distinctive animal responses

CuSO4 is irreplaceable vs. CuO in improving growth rate and feed conversion ratio in swine





Copper improved piglet performance in its sulfate form. Copper when supplemented in its oxide form was ineffective, even at high concentrations.
This makes CuSO4 an IRREPLACEABLE source of copper vs. CuO, to achieve optimal piglet performance

J. Anim. Sci. 1989 p.2996-3002

Important Questions to ask?

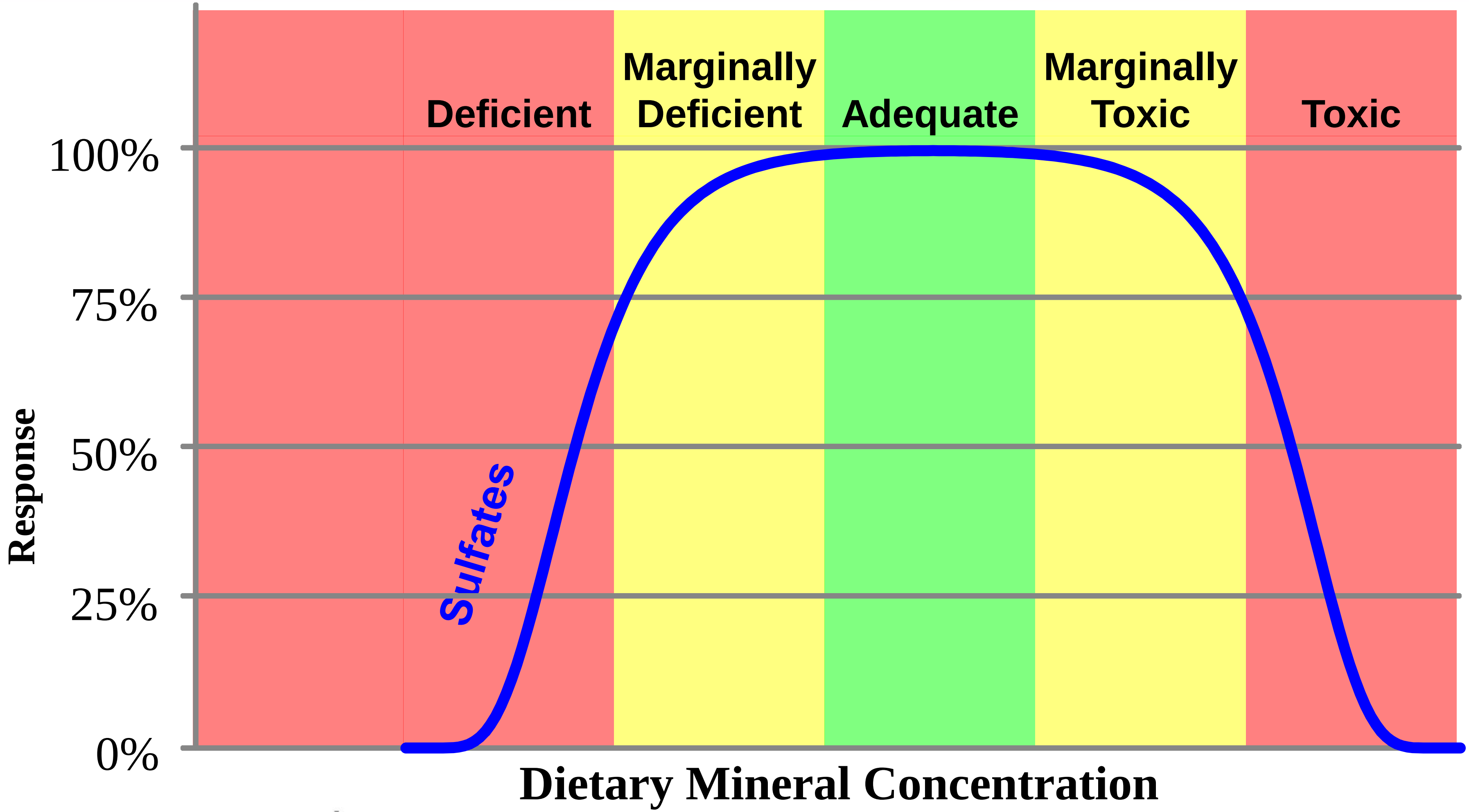
ARE ALL ORGANIC MINERALS IRREPLACEABLE VS. INORGANIC MINERALS?

FOR PRODUCTION PARAMETERS?

Relevant Questions

DO ALL ORGANIC MINERALS SHOW THE SAME IMPROVEMENTS ON THE SAME PRODUCTION PARAMETERS?

Dose-response of animals fed graded mineral concentrations



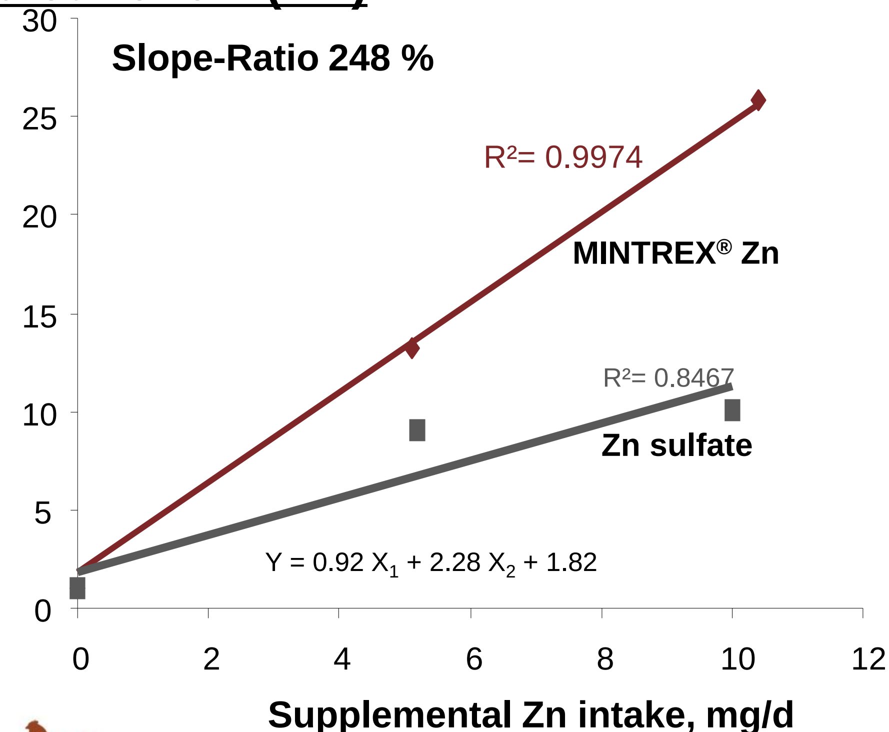
NOVUS

Adapted from Underwood and Suttle, 1999

MINTREX® is more bioavailable than other mineral sources.. BUT, What does that really mean?

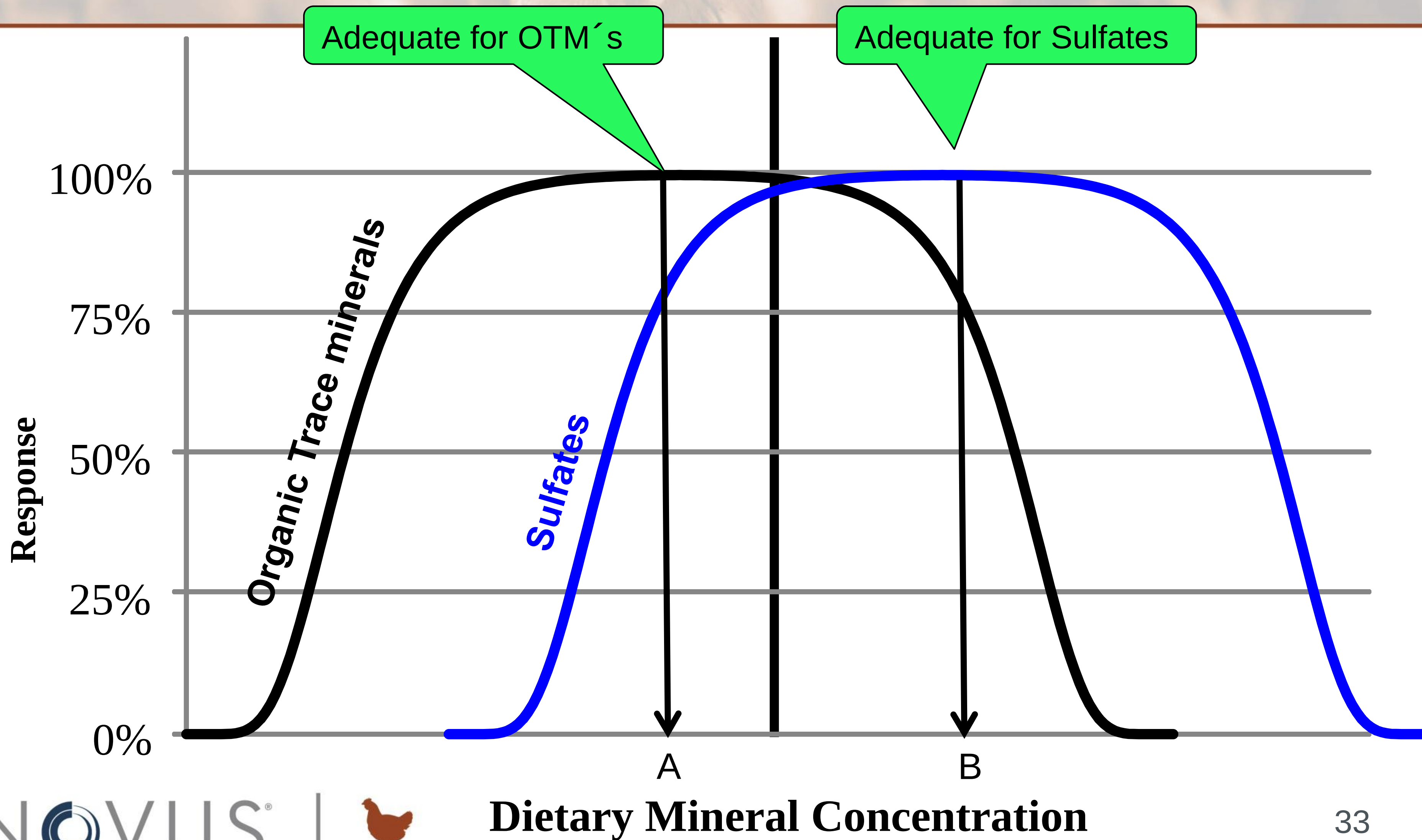
- **Metallothionein (MT) mRNA expression is a marker for Zn absorption/status in multiple species**
- **Mintrex Zn is 248 % more bioavailable compared to ZnSO4**

b) Metalothionein (MT)

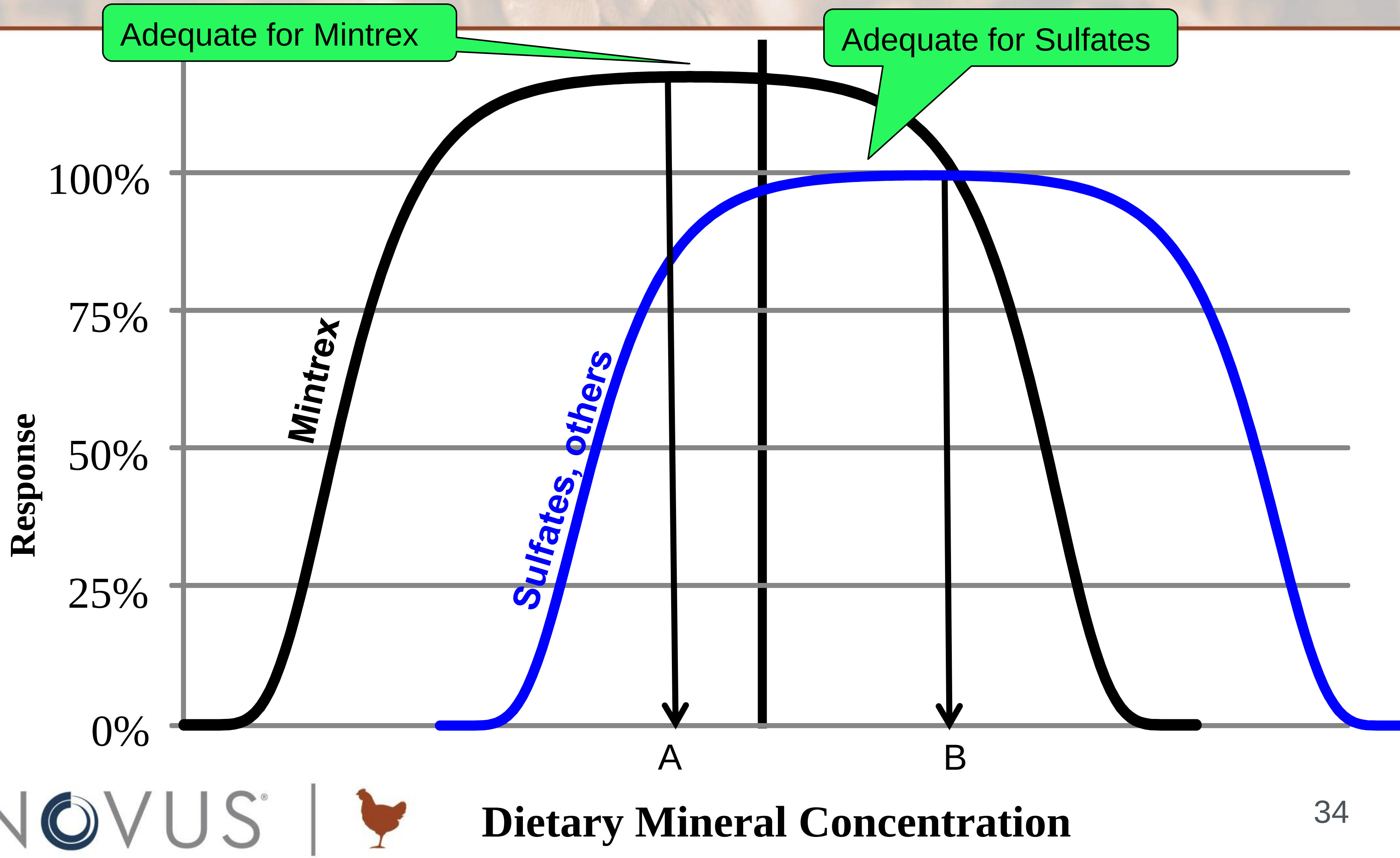


Ref. Richards et al, 2010

Dose-response of OTM vs. ITM

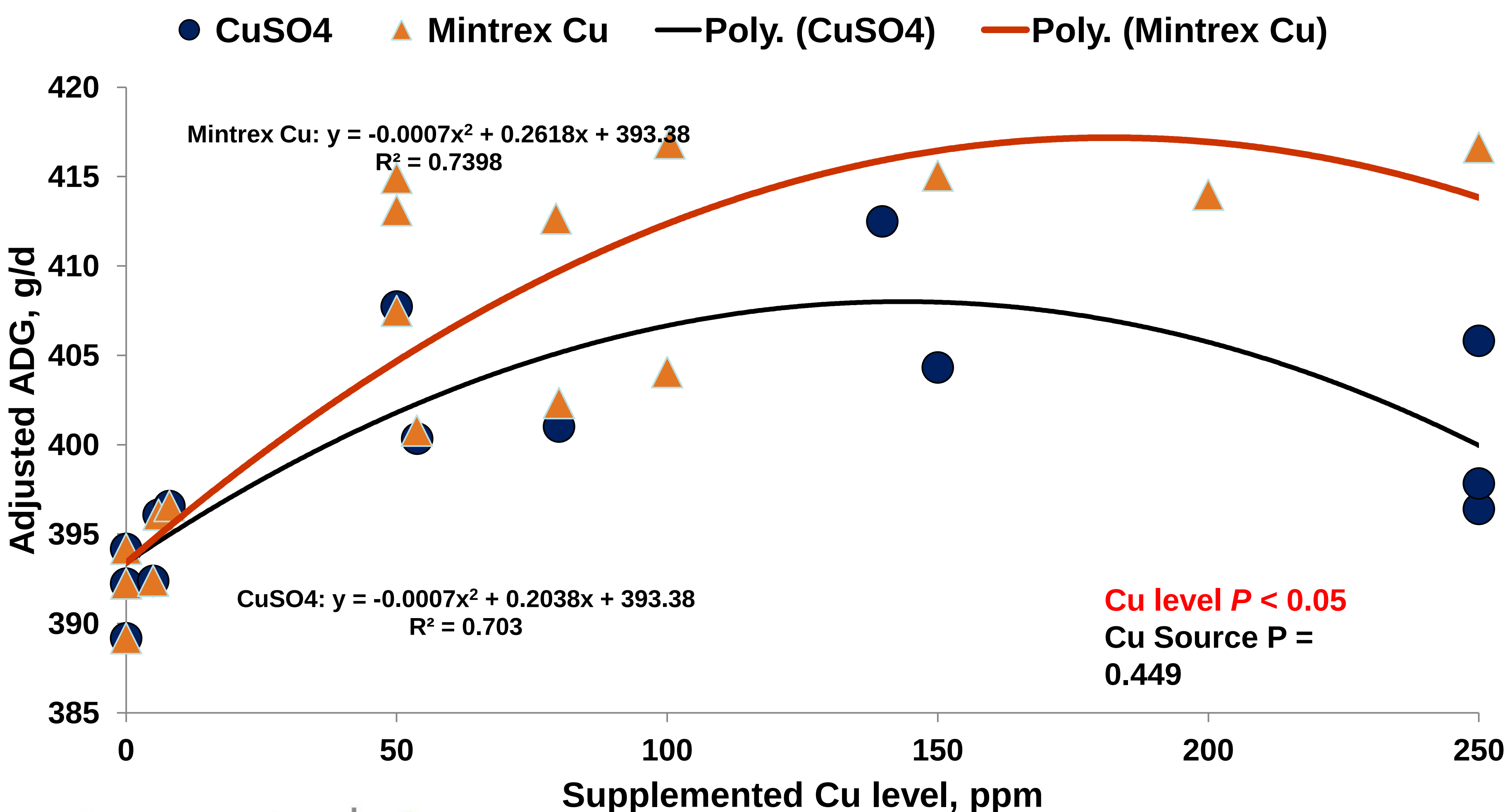


Mintrex vs Other Mineral Sources



Effect of various levels of Mintrex Cu and $CuSO_4$ on overall nursery ADG (0~42 d)

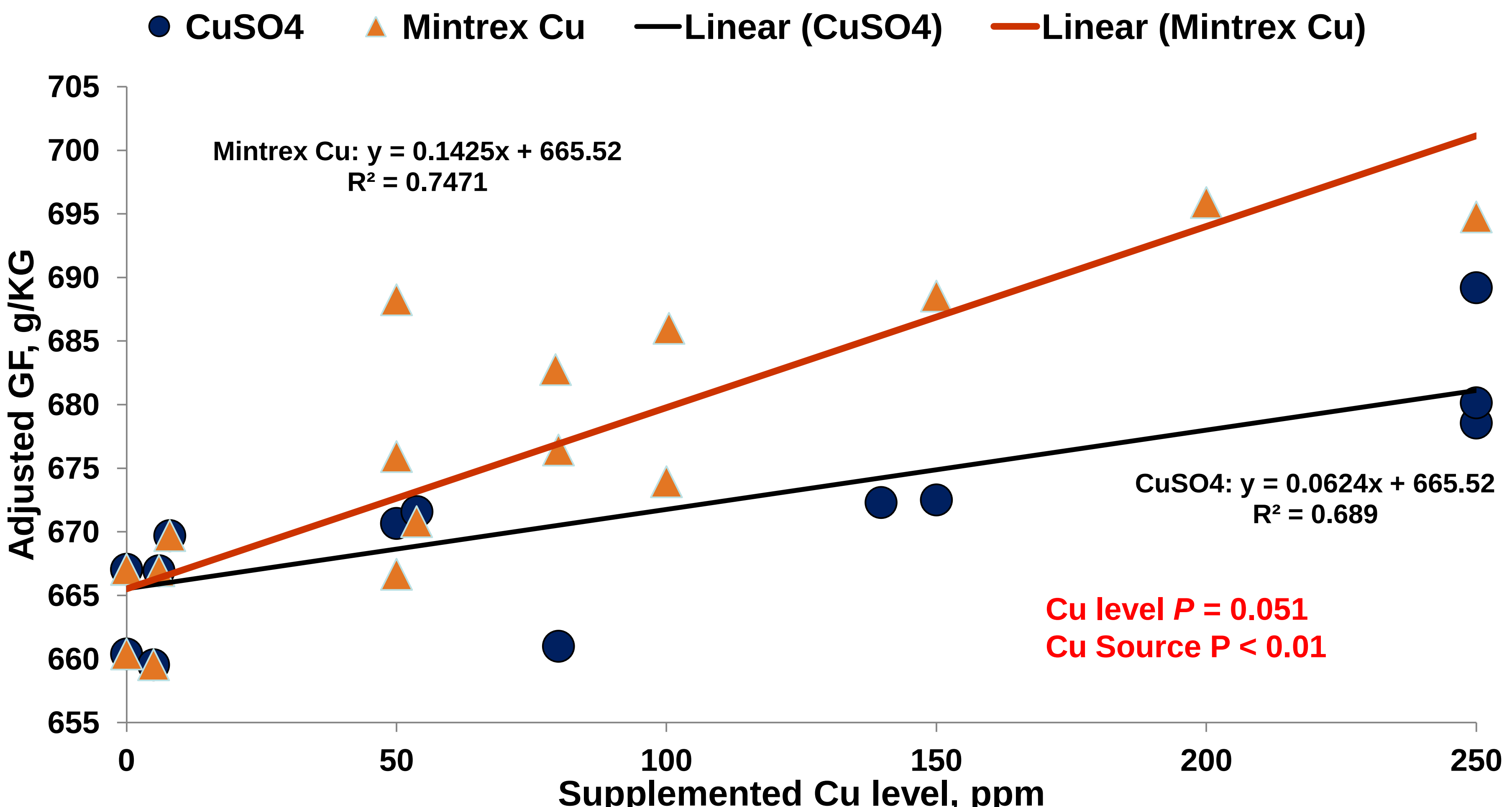
(Data of 6 trials)



NOVUS

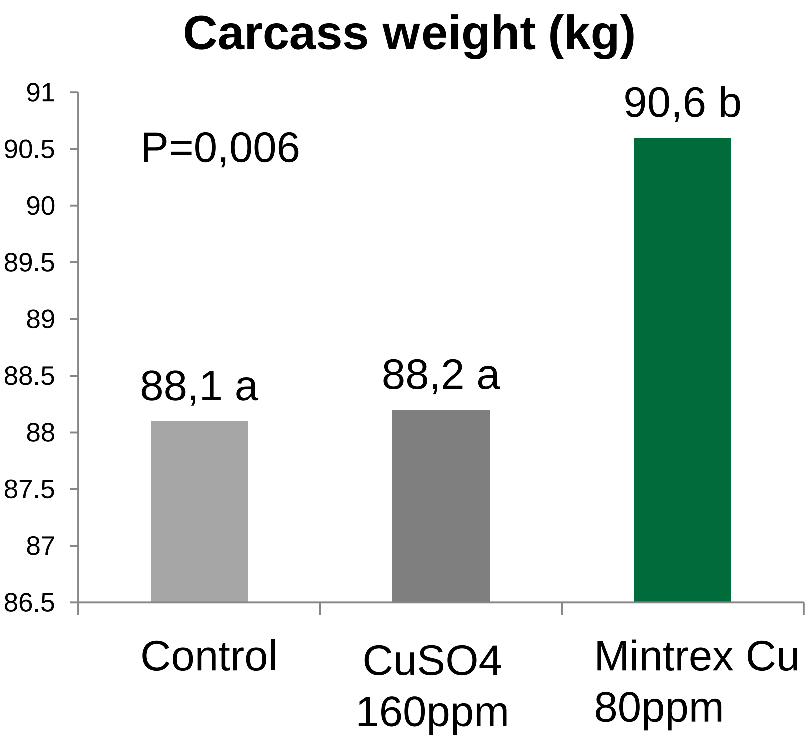
Effect of various levels of Mintrex Cu and $CuSO_4$ on overall nursery G:F (0~42 d)

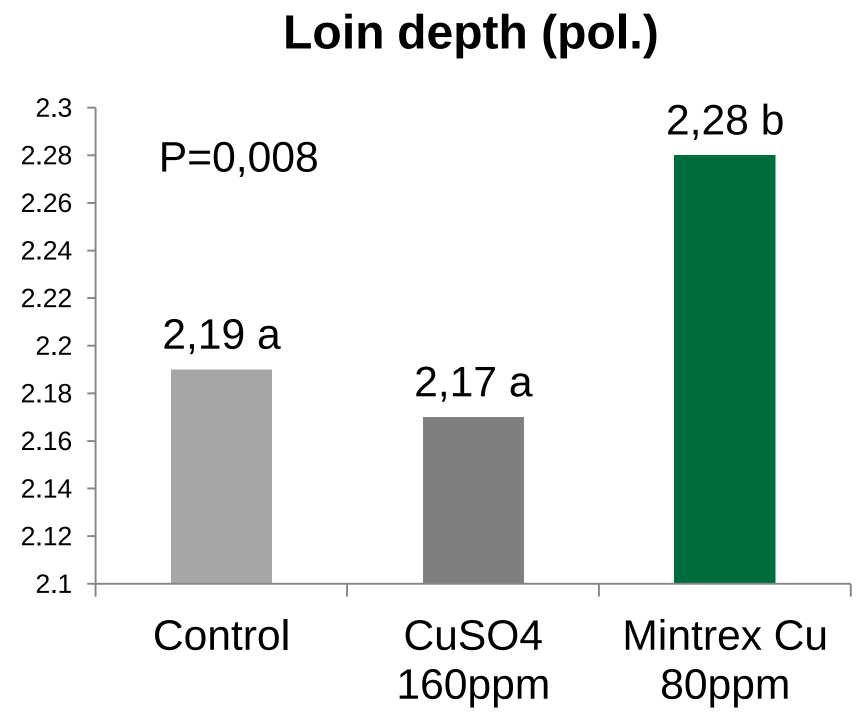
(Data of 6 trials)



NOVUS

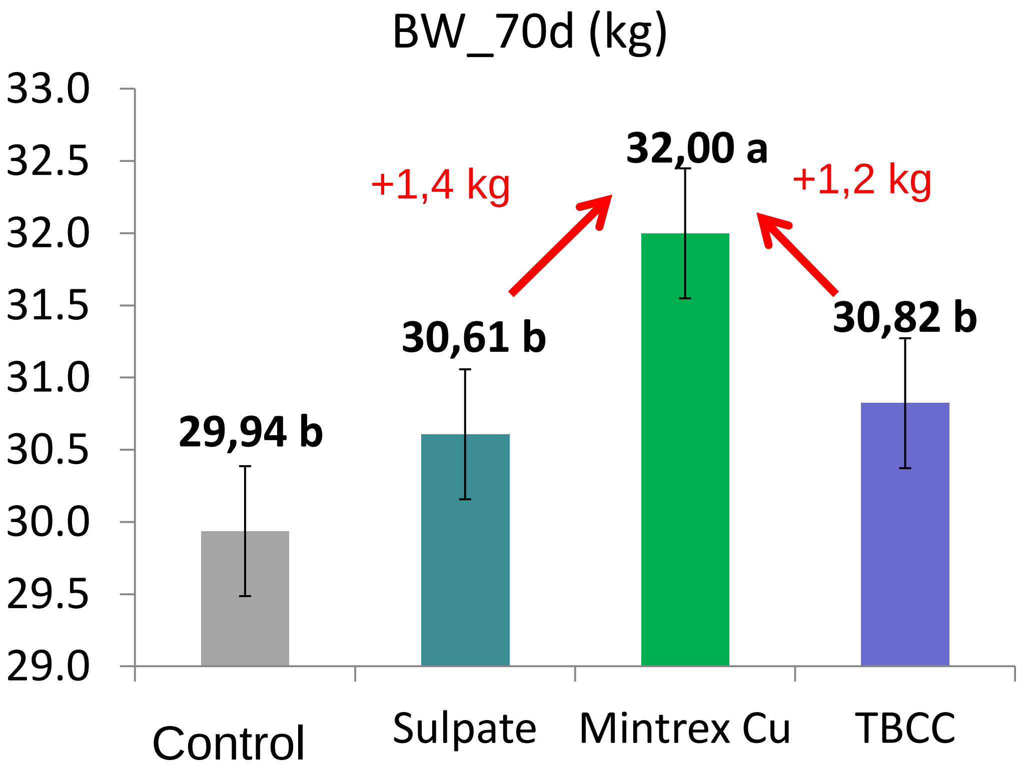
80 ppm of MINTREX Cu Optimzes Carcass Parameters in swine
Initial weight 32 kg / Final weight 120 kg





	Control	CuSO4 160ppm	Mintrex Cu 80ppm
U$/swine	118,7 a	119,4 a	122,8 b

A body weight comparison between 3 sources of Cu included in swine diets

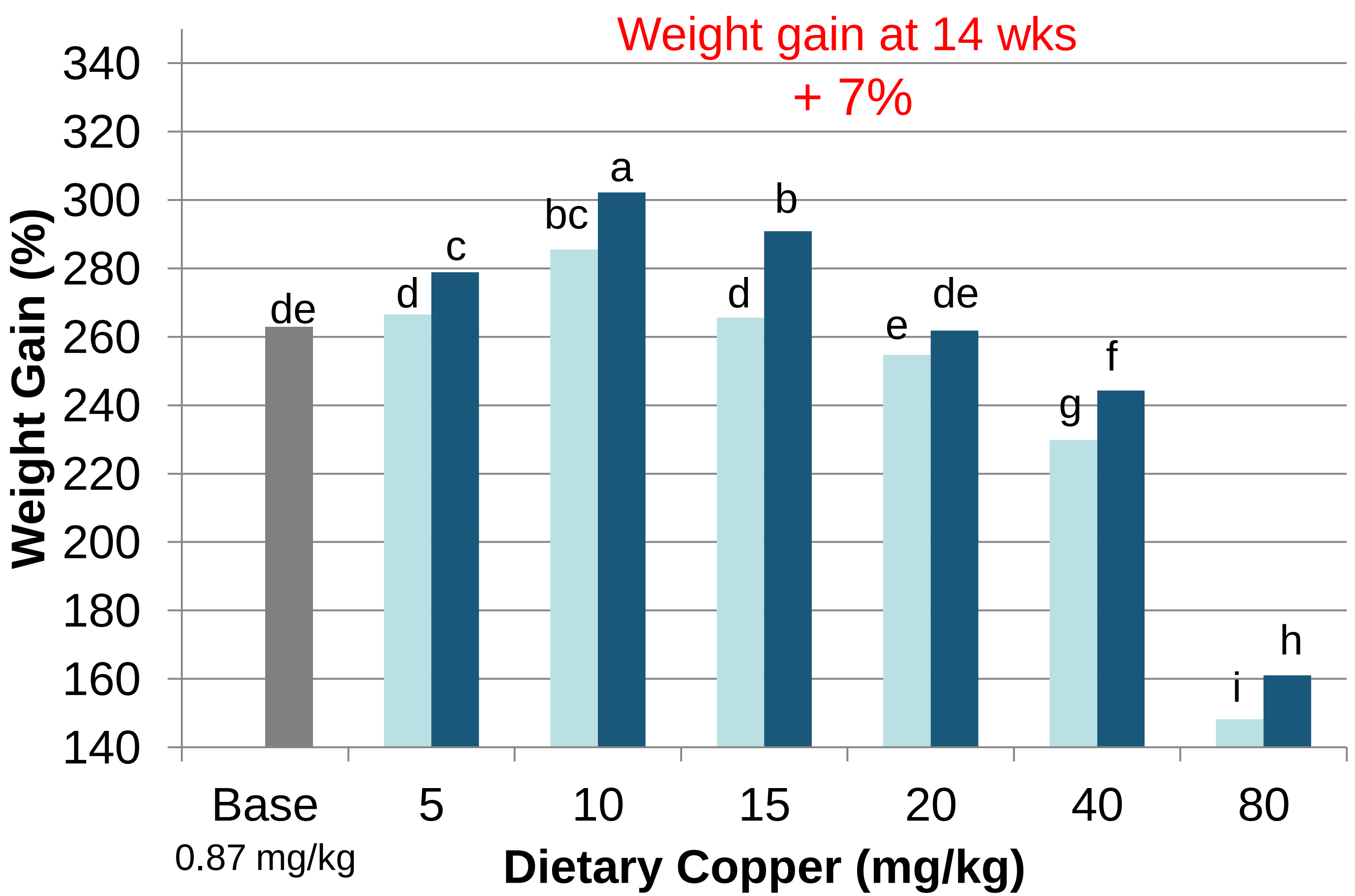


P= 0.0084
CV = 9.77%

Orthogonal contrasts	
Control x All	**0,0142**
Mintrex x (Sulphate +TBCC)	**0,0139**
Sulphate x TBCC	0,7119

NOVUS

In a trial conducted with Olive Flounder- Mintrex Cu improved weight gain when compared to $CuSO_4$



Semi-purified Diets; no added antagonists

The distinctive dose-response curve of any mineral source may depend on a complex combination of unique characteristics such as

- Bio efficacy
- Site of absorption
- Solubility
- Interaction with other components in the diet
- Oxidative balance
- Antimicrobial effect
- ???
- Etc., etc.,

To illustrate how poorly we understand this intraction, try to explain why ZnO at 2,000 ppm benefits piglets that much more compared to ZnSO4 or OTM.. It´s certainly not due to higher bio efficacy...

Take home message

1. Minerals have unique and distinctive effects on animal performance
2. The performance potential of an animal may be determined by the source of mineral it is fed
3. Micro-mineral nutrition may impact economically important performance parameters and therefore deserve more attention