Trace element nutrition and bone metabolism

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The Broiler Skeleton

Bone mineral

• Mineralization
  – Hydroxyapatite $\text{Ca}_{10}(\text{PO}_4)_6(\text{OH})_2$

• Bone strength
  – brittleness

http://www.iupui.edu/~bbml/boneintro.shtml
Cartilage matrix

- Tensile strength & elasticity
Embryonic bone growth

Cartilage model  →  Femur – 20d embryo  →  20d chicken embryo
Embryonic bone growth

Adapted from Kubota et al., (1981)
Bone growth - elongation
Bone growth - width
Trace elements & bones
Trace elements & bones

- **Copper**
  - Lysyl oxidase
    - Elastin and collagen cross-linking
      - Tensile strength and elasticity

A: non-crosslinked collagen fibrils
E,G: crosslinked collagen fibrils after mineralization composed of bundles of subfibrils

Yi & Aparicio, 2013
Trace elements & bones

• Manganese
  – Polymerase & galactotransferase
  • Chondroitin sulfate – hyaline cartilage
Trace elements & bones

• Zinc
  – Collagenase cofactor
    • Collagen formation
  – Alkaline phosphatase
    • Bone mineralization
  – Osteoblast proliferation
  – Growth plate gene expression
Trace element requirements

• Little new research
  – Dietary requirements well understood
  – Low cost of supplementation
  – Tolerance of excess

• Opportunities
  – Selection for rapid growth
  – Maternal nutrient transfer
  – Organic trace minerals
  – Phytase
Broiler 50 years ago  Broiler 30 years ago  Today's Broiler

M. Zuidhof, University of Alberta
Organic trace elements

- Inorganic trace minerals (ITM)

- Organic trace minerals (OTM)
Organic trace elements

Organic forms are assumed to have increased bioavailability

(Lesson, 2003)
Maternal trace element nutrition

Femur width at hatch

P = 0.005

Control  OTM  OTM + ITM  High ITM
Femur length E15

Treatment: P=0.005
BW <.0001

a, b, c LSmeans with different letters are significantly different (P≤0.05).
Phytase

Structure of Phytic Acid (A) and Phytic Acid Chelate (B)

Myo-inositol hexaphosphoric acid
Conclusion

• Trace minerals are essential for bone formation

• Little current research on trace minerals and bone metabolism
  – Physiological limits to skeletal growth/development?
  – Specialized application of supplements
    • Organic trace elements
    • Phytase