Research on Nutritional deficiencies caused by Macroelements and Microelements with special regard to White Muscle Disease As a result of Selenium deficiency

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Introduction

No doubt that the nutritional deficiencies are one of the most common & important problems that hinder any progress in the field of animal breeding & production.
Deficiency = a lack or shortage

General Causes:

- Decrease or absence of the supplement in diet
- Abnormal absorption
- Abnormal utilization
- Supplement is given under the level of the body requirements
We have chosen the subject of the deficiency of the macroelements and microelements as a general background.

In the end we will fully discuss one of the most interesting topics in our study: The White Muscle Disease.
Macro elements

Calcium
Potassium
Chlorine
Magnesium

Phosphorus
Sodium
Sulfur
CALCIUM

Biological functions

1. Skeleton and teeth structure (contain 99% body calcium), combined with phosphorus (the ability of the calcium to be resorbed during periods of high calcium demand e.g. early lactation).

2. Essential cofactor for many enzyme systems, including those needed for nervous transmission and muscle contraction.

3. Play an important role in blood coagulation.
Deficiency symptoms

1. Rickets - misshapen bones, joint enlargement, lameness in growing animals

2. Osteomalacia - brittle bone in adult animals

3. Milk fever (parturient paresis) - most common in dairy cows soon after calving; recumbency, muscular spasms followed by paralysis, unconsciousness and death if not treated.
Dietary sources

- Milk
- Green leafy crops
- Animal by-products e.g. fish meal, meat and bone
- Mineral supplements e.g. ground limestone ($\text{CaCO}_3$), dicalcium phosphate ($\text{Ca}_2\text{PO}_4$)

Cereals are poor sources of Calcium
Calcium: phosphorus ratio

Because of interdependence of calcium and phosphorus utilization, an abnormal dietary ratio may be as harmful as a deficiency of either in the diet.

Generally aim for ratio of 1:1 to 2:1
PHOSPHORUS

Biological functions

1. Skeleton, teeth

2. Vitally important in various aspects of energy metabolism e.g. ATP, sugar phosphates.

3. Enter in the structure of phosphoproteins, nucleic acids and phospholipids.
Dietary symptoms

1. Rickets or osteomalacia

2. Pica (depraved appetite) - chewing of wood, bones, etc

3. Stiff joints, muscular weakness

4. Low fertility.

5. Subnormal milk-yield-and-growth
Soft rips due to phosphorus deficiency
Pica: animal chewing a piece of bone
Locomotor disturbance due to stiff joint
6. Post-Parturient haemoglobinurea
Dietary sources

- Milk
- Cereal grains
- Animal byproducts.
- Grass hays and straws are poor sources.

 Availability decreased when present in phytate salts e.g. in cereal grains
POTASSIUM

Biological functions

1. Regulation of osmotic and acid-base balance (with sodium, chlorine and bicarbonate ions)

2. Major cation of intracellular fluid, with special role in ionic basis of nerve and muscle excitability

3. Cofactor for several reaction in carbohydrate metabolism
Deficiency symptoms

Generally rare in forage-fed animals

Reduced growth, paralysis occasionally seen in calves fed milk replacer low in potassium

Dietary excess more common (rapidly excreted in urine).
Dietary sources

Very high in green forages and hays

Lower in cereal grains
SODIUM

Biological functions

1. Regulation of acid-base and osmotic balance of body fluids

2. Major cation of extracellular fluid, with special roles in nervous transmission and active transport of sugars and amino acids.
Deficiency symptoms

1. Decreased extracellular osmotic pressure and dehydration.

2. Poor growth.

3. Inefficient utilization of digested protein and energy.
Dietary sources

Animal byproducts are good sources

Most plants are poor sources

Supplemented when necessary as common salts.
CHLORINE

Biological functions

1. Acid-base and osmotic regulation

2. HCl and chloride salts in gastric secretions
Deficiency symptoms

1. Metabolic alkalosis (increased bicarbonate compensates for decreased chloride).

2. Growth retardation

Sodium, rather chlorine, is probably the main limiting factor in salt-deficient diets of cattle and sheep.
Dietary sources

Animal byproducts are good sources

Most plants are poor sources

**Note:**

1. Because most plants are low in sodium and chlorine, it is usual to supplement diet of herbivores with common salt.

2. Over supplementation of salt can be harmful, causing excessive thirst, muscular weakness and edema
SULFUR

Biological functions

1. Integral component of sulfur amino acids, cystine, cysteine and methionine, which have many important biological roles e.g. synthesis of bioactive (insulin, glutathione) and structural proteins (keratin - wool contains ~ 4% sulfur).

2. Chondroitin sulfate is a constituent of cartilage
Deficiency symptoms

1. Usually associated with protein deficiency

2. Reduced feed intake and cellulose possible where urea is used as replacement for protein nitrogen, resulting in reduced body and wool growth
Dietary sources

Most dietary proteins are generally adequate in sulfur amino acids

Inorganic sulfates can be fed as supplements with urea to balance N:S ratio (10-12:1 is desirable).
MAGNESIUM

Biological functions

Closely associated with calcium and phosphorus

About 70% of total magnesium is in skeleton, remainder in soft tissues and fluids

Commonest enzyme activation e.g. pyruvate dehydrogenase (pyruvate-acetyl CoA).
Deficiency symptoms

1. Young animals e.g. milk-fed calves - low plasma magnesium, depleted bone magnesium, tetany, death if untreated

2. Hypomagnesemic tetany (grass tetany) in cattle, especially dairy cows in early lactation - low plasma magnesium (normal range 1.7-4.0 mg/dl), often associated with low plasma calcium, Nervous irritability, twitching, staggering gait, recumbency, convulsions, death if untreated
Hypomagnesaemia in a cow
Ewe with acute hypomagnesaemic tetany
Dietary sources

Wheat bran, most vegetable protein concentrates are good sources; legumes are better than grasses; variable in forage crops

Most frequently supplemented as magnesium oxide.
TRACE ELEMENTS

Iron
Iodine
Copper
Manganese
Zinc
Cobalt
Molybdenum
Selenium
Chromium
Fluorine
Silicon
Vanadium
Tin
Arsenic
Nickel
IRON

Biological functions

1. >90% body iron is associated with proteins, >50% as hemoglobin; vitally important for oxygen transport in blood.

2. Heme is also a component of oxidizing enzymes e.g. cytochrome peroxidase c,

3. Absorbed iron is transported in blood plasma in the protein transferrin, and stored in spleen, liver, kidney and bone marrow in the protein ferritin.
Deficiency symptoms

*Anemia*, especially in young milk-fed animals without access to soil or pasture, most common in pigs.

Characterized by:

- poor appetite and growth
- labored and spasmodic breathing
Dietary sources

Green leafy plants and seed coats are good

Animal byproducts (meat meal, fishmeal) are excellent

Milk is poor.
COPPER

Biological functions

1. Essential for normal absorption, transport and mobilization of iron, and for hemoglobin synthesis.

2. Integral component of many enzymes (e.g. cytochrome oxidase and non-enzyme proteins).

3. Stored in most body tissues, especially liver.
Deficiency symptoms

1. Anemia

2. Depigmentation of hair and wool (black sheep are sometimes kept as indicators of marginal copper deficiency); loss of wool crimp ("steely" wool).

3. Bone disorders leading to joint swelling and lameness.

4. Central nervous lesions associated with muscular incoordination (ataxia) in young lambs and calves.
Unthrifty and enlarged fitlock
Enlargement of fetlock joint
Widening and irregularity of the metacarpal physes
Chronic diarrhea and unthriftiness
Lamb unable to stand due to cavitations in the cerebrum “congenital sway back”
Loss of normal wool shape
Dietary sources

Widely distributed in animal feeds but may be low in pastures grown on copper-deficient soils
Biological functions

1. Essential component of vitamin B12, a precursor of coenzymes for several important metabolic reactions which is synthesized by rumen bacteria

2. Probable activator of some enzyme reactions.
Deficiency symptoms

*Wasting disease* in ruminants, characterized by:

- Emaciation
- Anemia
- Listlessness

Alleviated by dietary supplementation with cobalt, or parenteral administration of vitamin B12.
Emaciation with poor hair coat
Unthrifness with ocular discharge
Friable liver duo to cobalt deficiency
Dietary sources

Trace amounts are present in most feeds, pastures may be deficient on cobalt-deficient soils.

Can be supplemented in salt licks, as a cobalt bullet placed in the reticulum, or by fertilizing deficient pastures with cobalt sulfate.
Cobalt toxicity

Very unlikely under normal conditions; wide margin between minimum requirement and toxic levels; poorly retained in tissues.
IODINE

Biological functions

Essential for synthesis of the thyroid hormones, thyroxine and triiodothyronine.

Thyroid hormones are required for normal skeletal, nervous and sexual development, and for synthesis of enzymes involved in oxidative reactions e.g. cytochrome enzymes.
Deficiency symptoms

1. Goiter (enlarged thyroid gland causes swollen neck).
2. Reproductive failure.
3. Neonatal mortality
4. Anoroxia
Goiter
Dietary sources

Traces in most feeds; especially high in marine plants (seaweeds) and fishmeal; deficient in plants grown on iodine-deficient soils.

Can be supplemented as iodized salt (sodium or potassium).
Iodine toxicity

Minimum toxic dietary level varies widely between species.

Toxicity associated with:
  . Decreased feed intake
  . Decreased weight gain
  . Egg production
MANGANESE

**Biological function**

Present in body in extremely small amounts; important activator of several TCA cycle enzymes.
Deficiency symptoms

- Retarded growth
- Skeletal abnormalities
- Neonatal ataxia
- Reproductive failure occasionally observed in pigs, poultry and housed ruminants.
  - Involved, but not exclusively, in development of perosis (slipped tendon malformation of leg bones) in young chicks.
Congenital twisting and flexion of enlarged fitlock
Dietary sources

Widely distributed in animal feeds; adequate levels in most forages and grains but low in corn and most animal byproducts.
Manganese toxicity

Wide margin of safety between normal feed levels and toxic dose.
ZINC

Biological function

1. Integral component of several important enzymes e.g. carbonic anhydrase, pancreatic carboxypeptidases, glutamic dehydrogenase, pyridine nucleotide dehydrogenases.

2. Cofactor for many other enzymes.
Deficiency symptoms

1. Subnormal growth, depressed appetite, poor feed conversion in pigs.

2. Parakeratosis (skin inflammation followed by eruptions which develop into scabs) in young pigs and calves.

3. Deficiency may be aggravated by high dietary calcium levels and alleviated by decreasing dietary calcium and/or calcium: phosphorus ratio.
Parakeratosis with crust around the eye
Dietary sources

Yeast, cereal bran and germ are rich sources.

Availability may be decreased by phytates in some cereal grains.
MOLYBDENUM

**Biological function**

Integral component and probable cofactor of several oxidase enzymes e.g. xanthine oxidase (involved in purine metabolism).
Deficiency symptoms

1. Reduced growth and uric acid production in chicks (uric acid, not urea, is principal end product of nitrogen catabolism in birds).

2. Reduced growth in lambs, related to poor ruminal cellulose digestion.
Molybdenum toxicity

Manifested via reduced copper availability, usually associated with high sulfur intake. Characterized by *diarrhea* and *weight loss*, especially in young calves and lactating cows; also observed in sheep.
**SELENIUM**

**Biological function**

Component of the enzyme Glutathione peroxidase, which catalyzes removal of hydrogen peroxide and protects cells from autooxidative damage.

Shares this role with vitamin E
Deficiency symptoms

1. Poor weight gain in calves and lambs, and impaired wool growth in lambs.

2. Skeletal and cardiac myopathies (muscle degradation, white muscle disease) in lambs and calves.

3. Reduced hatchability and egg production in hens.
"Alkali disease" or "blind staggers" can occur in ruminants and horses grazing certain pasture species grown on seleniferous soils.
White muscle disease

Nutritional muscular dystrophy  Myodegenerative syndrome

Definition

Acute or chronic disease most seen in sheep less frequent in claves and foals, characterized by degenerative changes of the cardiac and skeletal muscles.
Susceptibility

- Sheep up to 6 months of age, Calves 2-4 months, young foals

- Acute course is seen in fast growing lambs at three to eight weeks of age

- Pregnant ewes which are severely deficient in vitamin E and/or selenium may produce stillborn progeny, or weakly lambs which only survive for a few days before dying of acute heart failure
Predisposing factors

It is quite common for the disease to show up:

- after forced exercise
- vaccination procedures
- sorting
- weaning
- fitting

Main Cause

Lack of Selenium, Vitamin E or both
Pathogenesis

Selenium (as a component of an enzyme called glutathione peroxidase) and Vitamin E have synergistic, and in the same time independent roles in the protection of the integrity of the cell membranes against the damaging effects of lipid peroxides and free radicals produced during normal metabolism.
In the absence of Selenium & Vitamin E

Tissues or cells which undergo rapid increases in oxidative metabolism

Damage the unsaturated fatty acids found in the cell membrane

Degeneration and necrosis of cells & tissues of the muscle

Skeletal muscles may regenerate

Myocardial muscles undergo Fibrosis
Clinical signs

In severe cases *sudden death* may occur from *heart failure*

- Mild stiffness and discomfort
- Chronic lameness
- Swollen hindquarters
- Weakness, animal lie down unwilling to move
- Muscular tremors if the animal is forced to stand for few minutes
. Breathing difficulties may be observed when the muscles controlling breathing are involved.

. Those who are mobile, they may have arched backs and appear to have tucked in flanks.

The *leg muscles* are generally affected *first*, any muscle area including cardiac muscle may be affected. Chronic or borderline deficiencies may result in lung edema resulting in increased pneumonia problems.
WMD sheep: arching back
PM Examination

Pale appearance of the skeletal & respiratory muscles, as they become friable, edematous and may be calcified.
The pelvic girdle muscles of a weaned aged sheep
Marked bilateral distribution of the lesions in back
Necropsy showing pale streaky muscles
Acute muscle necrosis with fragmentation
In the Heart:
White areas of degeneration are visible particularly under the endocardium of the ventricles
Cardiac white muscle of a lamb
Heart muscle showing White Muscle Disease lesions
Diagnosis

Based on:

- Case history
- Clinical signs
- PM examination
- Differential Diagnosis
Differential diagnosis

Tetanus:
tetanus lambs become very rigid and the lambs with white muscle become flaccid.

Intestinal displacement

Lambs with intestinal displacement act similar but exhibit pain and generally die within hours, and usually fewer are affected.
Control/prevention:

If area is deficient in Se, best prevention is to supplement.

A common practice is to inject a Se- Vitamin E shot at birth and again at about 30 days.

Another alternative is to feed supplemental Selenium at 0.3 ppm.

Blood and tissue levels of Selenium and Vitamin E are necessary in order to determine the proper supplementation.

Have to be careful not to add too much and cause toxicity.
Treatment

Treatment is accomplished by the use of both Vitamin E and Selenium because the condition may be caused by a deficiency of Selenium, Vitamin E or both.

- **Injection**- To affected and newborn lambs of WMD.
  - affected- injections of sodium selenite-vit E
  - newborns- injections of Bo- Se

- **Internal diet**- all hay, especially legumes, should contain adequate amounts of vitamin E.
  If none is available, injections may be given to provide the requirement.

*Avoid overdosing of Selenium- can cause toxicity!*
References

- Department Notebook
- The Internet
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