

Equine Nutrition #10

Created for Canadian Pony Club Education

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Minerals

Minerals are elements, or compounds or mixtures of elements

Periodic Table of the Elements																	
1 1IA 1A																	2 VIII 8A
1 H Hydrogen 1.0079	2 IIA 2A											13 IIIA 3A	14 IVA 4A	15 VA 5A	16 VIA 6A	17 VIIA 7A	2 He Helium 4.00260
3 Li Lithium 6.941	4 Be Beryllium 9.01218											5 B Boron 10.811	6 C Carbon 12.011	7 N Nitrogen 14.00674	8 O Oxygen 15.9994	9 F Fluorine 18.998403	10 Ne Neon 20.1797
11 Na Sodium 22.989768	12 Mg Magnesium 24.305	3 IIIB 3B	4 IVB 4B	5 VB 5B	6 VIB 6B	7 VIIB 7B	8 VIII 8	9 VIII 8	10 VIII 8	11 IB 1B	12 IIB 2B	13 Al Aluminum 26.981539	14 Si Silicon 28.0855	15 P Phosphorus 30.973762	16 S Sulfur 32.066	17 Cl Chlorine 35.4527	18 Ar Argon 39.948
19 K Potassium 39.0983	20 Ca Calcium 40.078	21 Sc Scandium 44.95591	22 Ti Titanium 47.88	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.938	26 Fe Iron 55.847	27 Co Cobalt 58.9332	28 Ni Nickel 58.6934	29 Cu Copper 63.546	30 Zn Zinc 65.39	31 Ga Gallium 69.732	32 Ge Germanium 72.64	33 As Arsenic 74.92159	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.80
37 Rb Rubidium 85.4678	38 Sr Strontium 87.62	39 Y Yttrium 88.90585	40 Zr Zirconium 91.224	41 Nb Niobium 92.90638	42 Mo Molybdenum 95.94	43 Tc Technetium 98.9072	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.9055	46 Pd Palladium 106.42	47 Ag Silver 107.8682	48 Cd Cadmium 112.411	49 In Indium 114.818	50 Sn Tin 118.71	51 Sb Antimony 121.760	52 Te Tellurium 127.6	53 I Iodine 126.90447	54 Xe Xenon 131.29
55 Cs Cesium 132.90543	56 Ba Barium 137.327	57-71	72 Hf Hafnium 178.49	73 Ta Tantalum 180.9479	74 W Tungsten 183.85	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.22	78 Pt Platinum 195.08	79 Au Gold 196.9665	80 Hg Mercury 200.59	81 Tl Thallium 204.3833	82 Pb Lead 207.2	83 Bi Bismuth 208.98037	84 Po Polonium [208.9824]	85 At Astatine 208.9871	86 Rn Radon 222.0176
87 Fr Francium 223.0197	88 Ra Radium 226.0254	89-103	104 Rf Rutherfordium [261]	105 Db Dubnium [262]	106 Sg Seaborgium [266]	107 Bh Bohrium [264]	108 Hs Hassium [269]	109 Mt Meitnerium [268]	110 Ds Darmstadtium [269]	111 Rg Roentgenium [272]	112 Cn Copernicium [277]	113 Uut Ununtrium unknown	114 Uuq Ununquadium [289]	115 Uup Ununpentium unknown	116 Uuh Ununhexium [288]	117 Uus Ununseptium unknown	118 Uuo Ununoctium unknown
Lanthanide Series		57 La Lanthanum 138.9055	58 Ce Cerium 140.115	59 Pr Praseodymium 140.90765	60 Nd Neodymium 144.24	61 Pm Promethium 144.9127	62 Sm Samarium 150.36	63 Eu Europium 151.9655	64 Gd Gadolinium 157.25	65 Tb Terbium 158.92534	66 Dy Dysprosium 162.50	67 Ho Holmium 164.93032	68 Er Erbium 167.26	69 Tm Thulium 168.93421	70 Yb Ytterbium 173.04	71 Lu Lutetium 174.967	
Actinide Series		89 Ac Actinium 227.0278	90 Th Thorium 232.0381	91 Pa Protactinium 231.03588	92 U Uranium 238.0289	93 Np Neptunium 237.0482	94 Pu Plutonium 244.0642	95 Am Americium 243.0614	96 Cm Curium 247.0703	97 Bk Berkelium 247.0703	98 Cf Californium 251.0796	99 Es Einsteinium [254]	100 Fm Fermium 257.0951	101 Md Mendelevium 258.1	102 No Nobelium 259.1009	103 Lr Lawrencium [262]	
	Alkali Metal	Alkaline Earth	Transition Metal	Basic Metal	Semimetals	Nonmetals	Halogens	Noble Gas	Lanthanides	Actinides							

Minerals

- Minerals are:
 - Naturally occurring
 - Solid
 - Inorganic (mostly)
 - Of a fixed chemical formula
 - Of an orderly crystalline structure
- While some of the minerals utilized by horses are pure, the majority of those minerals needed are compounds or mixtures of elements

Minerals ingested by the horse

- Minerals are inorganic compounds
 - They contain no carbon
 - They are the non-biological molecules in food
- Minerals occur naturally in the earth
 - When plants are growing, they pick up minerals from the earth
- The horse's mineral intake is linked to the mineral content of the grain, hay and water it consumes, and the soil in its area (if the horse is on grass)
- Minerals are required in small amounts by the horse
 - Act as components of body tissues
 - Act as vital members of catalytic enzymes
 - Required for growth
 - Required for transport of energy
- Can also be found:
 - in hormones, vitamins and amino acids
 - As cofactors of enzymes

Ash Content

- The total percentage of minerals in the diet is referred to as the *Ash Content*
- The Ash Content is thus named as it would be what remained after the body was consumed by fire
- The Ash Content is approximately 7% of ideal body weight

Micro and Macro Minerals

- ***Macro minerals***

- Elements needed in larger amounts
- Amounts are measured in *grams per day*
- Commonly added to the horse's diet

- ***Micro minerals***

- Elements needed in smaller or trace amounts
- Amounts are measured in *milligrams per day*

Macro or Micro?

MACRO MINERAL

- Calcium
- Phosphorous
- Potassium
- Sodium chloride (salt)
- Magnesium
- Sulfur

MICRO MINERALS

- Cobalt
- Copper
- Fluorine
- Iodine
- Iron
- Manganese
- Selenium
- Zinc

Calcium

- A macro mineral
- Functions:
 - Major constituent of bone (35%)
 - Proper heart and muscle contractions
 - Adequate levels of blood calcium are required for muscular activity
 - Nerve function
 - Conduction of impulses along nerves to muscles
 - Specific metabolic reactions
 - Blood clotting
 - Normal cell membrane function
 - Glandular secretion
 - Temperature regulation
 - Regular activation of enzymes
 - Activation and release of certain hormones
 - Muscular contractions:
 - Skeletal muscle locomotion
 - Contraction of leg and body muscles
 - Contraction of diaphragm
 - Heart muscle to pump blood
 - Smooth muscles (like the GI tract, for normal gut motility and digestion)
 - Plays a role in muscular contractions by activating potassium ion channels

Calcium is a major component of bone



More on calcium

- The daily calcium requirement comes from the diet
 - 50% of dietary calcium is absorbed
 - 70% of dietary calcium is absorbed in growing horses
 - 99% of calcium used is taken from bone stores
 - The body will sacrifice optimum bone strength to maintain blood calcium levels
- Calcium is used in the body in insoluble form (as Ca^{++} ions) for nerve and muscle function
 - The body maintains rigid and controlled levels in the blood (2.9-3.9 mmol/liter) through the mechanism known as homeostasis
 - Vitamin D and hormones PTH (parathyroid hormone) and calcitonin maintain blood calcium levels within normal levels
 - When blood concentration decreases, higher levels of calcium are absorbed
- Excess calcium interferes with the absorption of copper, manganese, zinc and iron

Calcium deficiencies

- Calcium deficiencies result in:
 - Weakened bones
 - Shifting lameness
 - Osteopenia (crooked long bones in growing horses)
 - Metabolic bone disease
- Causes of calcium deficiencies:
 - Excess phosphorous decreases the absorption of calcium
 - Oxalates (available in alfalfa and some pasture grasses) complex with calcium to decrease availability
 - Horses are unable to digest the calcium associated with calcium oxalate crystals
 - Wheat bran is detrimental to calcium balance
 - Nutritional secondary hyperparathyroidism
 - Grains are also high in phosphorous and low in calcium

Phosphorous

- A macro mineral
- Functions:
 - Makes up 14-17% of skeleton
 - Used for energy utilization
 - ADP and ATP
 - For metabolism of photopholipids, nucletic acids, and phosphoproteins
 - Major role in cell membranes
 - Studies have found that aged horses lose the ability to absorb phosphorous

Absorption of phosphorus

- Absorption of phosphorus depends on:
 - Other parts of the diet
 - Type of phosphorus
 - Amount of phosphorus
 - Horse's age
 - Amount of calcium in diet
 - Temperature (higher temperatures = increased absorption)
- Absorption of phosphorus:
 - On average, absorption is 30-50%
 - Adults 35%
 - Growing horses and lactating mares 45%
 - High calcium intake limits the absorption of phosphorus
 - Adding NaCl increases phosphorus absorption by 30-60%
 - Oxalates (present in alfalfa and some pasture grasses) do not affect absorption but do affect retention of phosphorus
 - High levels of phosphorus results in low magnesium absorption

Potassium

- A macro mineral
- Is a major intracellular cation (ion with positive charge found inside a cell)
- Major job involved in skeletal muscle excitability through potassium ion channels
 - 75% of potassium is found in skeletal muscles
 - Every time a horse uses a muscle, he's using potassium
- Influences cardiac activity, especially cardiac muscle
- Important in maintaining the pH and fluid balance in the cells
- Horses that sweat a lot, especially in hot weather, may lose potassium
 - This can be replaced by providing electrolytes
- Horses that are on Lasix (for EIPH) are susceptible to potassium deficiency
- Most forages contain 1-4% potassium so deficiencies are rare

Issues with potassium

- Hypokalemia
 - Increased muscle potential, resulting in hyperpolarization with weakness or paralysis
- Hyperkalemia
 - Decreased membrane potential with resulting hyperexcitability
- Excess potassium interferes with calcium and magnesium absorption
- Excess is typically not harmful except with HYPP (hyperkalemic periodic paralysis)
- Low potassium results in fatigue, muscle weakness, exercise intolerance, decreased water and feed intake, restlessness and spookiness

Magnesium

- A macro mineral
- Essential constituent of bones and teeth
- Activated in numerous enzyme related activities
- Involved in nerve and muscle function
- Thought to have a significant effect in calming horses
 - often given as part of calming supplements
- Excess potassium can inhibit uptake
- Deficiencies are most common in winter, after fields are fertilized, and in spring during times of grass growth
- Horses have limited storage ability for magnesium

Sulfur

- A macro mineral
- Comprises 0.15% of the horse's body weight
- Important component of many compounds required in the body, including:
 - Amino acids, in particular:
 - Methionine
 - Cystine
 - B vitamins, in particular:
 - B₁, or thiamin
 - Biotin
 - Insulin
 - Heparin, an anticoagulant
 - Chondroitin Sulfate
- Deficiencies are rare as sulfur is readily found in all plant materials

Cobalt

- A micro mineral
- Necessary component of vitamin B₁₂ (cobalamin)
 - B₁₂ is the *only vitamin that requires a mineral as a part of its composition*
 - Microbes in the intestines convert cobalt to vitamin B₁₂
- Deficiencies have never been reported in horses
 - The soil in the Atlantic Coastal Plain is deficient in cobalt
- Toxicity is unlikely due to low absorption rates

Copper

- A micro mineral
- Essential to the formation of hemoglobin, cartilage, bone, elastin, and hair pigmentation
- Plays major role in utilization of iron and creation of red blood cells
- Keeps central nervous system running correctly
- An antioxidant

Factors reducing absorption of copper

- There are a number of factors that prevent the absorption rate of copper, including too much of the following :
 - Calcium salts
 - Ferrous sulfide
 - Mercury
 - Molybdenum
 - Cadmium
 - Zinc

Fluorine

- A micro mineral
- Excess fluorine (over 60 ppm) can cause severe skeletal damage
 - Bones become thickened
 - Surface of bones becomes roughened
 - Fetlock joints become enlarged
 - Teeth wear down

Iodine

- A micro mineral
- Helps regulate thyroid activity
- May be deficient in some areas
 - Areas close to the sea/ocean are usually okay
 - If deficient, may need to feed iodized salt
 - If deficient, horse may develop goiter

Iron

- A micro mineral
- A constituent of haemoglobin (oxygen carrier, contained in red blood cells)
- Present in myoglobin
- Helps get oxygen to muscles
- Part of some enzymes
 - 60-80% is found in hemoglobin and myoglobin
 - 20% is stored in the liver and spleen
- Iron absorption rates are low
 - 15%, which depends on:
 - Age
 - Amount of iron in diet
- Iron deficiency = anemia (lack of red blood cells)

Excesses and Deficiencies

- Iron deficiency is referred to as anemia
- Over consumption of iron decreases absorption of:
 - Cadmium
 - Cobalt
 - Copper
 - Manganese
 - Zinc

Manganese

- A micro mineral
- Required for enzymes needed for the formation of cartilage
- Deficiencies can cause deafness and severe bone malformation in utero
- Manganese appears in several organs but principally the liver
 - Liver biopsies indicate nutritional status

Selenium

- A micro mineral
- Selenium helps prevent White Muscle Disease, and works in conjunction with Vitamin E to prevent Azoturia
- Selenium has a narrow margin of safety – too much is as bad as too little
- Selenium toxicity is very serious and directly linked to levels of selenium in the soil where the animals lives as well as where the food the animal is ingesting was grown
- Selenium toxicity can cause:
 - Sloughing off of hoof walls
 - Sloughing off of skin; hair loss (alopecia)
 - Behavioural changes
- Several indicator plants grow in soil high in selenium:
 - Milk vetch
 - Prince's plume
 - Goldenweed
- Likewise, alkali lakes are often indicators that soil is high in selenium

Zinc

- A micro mineral
- Required for several enzyme systems such as carboxypeptidases
 - Responsible for insulin production, blood clotting, wound healing
- Highest concentrations in body found in:
 - Eye and prostate gland
- Lowest concentrations in body found in:
 - Milk, blood and brain
- Deficiency affects:
 - Growth
 - Hair loss

Calcium and Phosphorous

- Calcium and phosphorous have an important interrelationship regarding mineralization of bone
 - 99% of calcium and 80% of phosphorous is found in the bones
- Bone is constantly undergoing change
 - During growth
 - During reproduction and lactation
- Bone is dynamic and constantly changing
 - Stresses such as intense work, hard footing, trauma and conformation problems may result in bone remodeling
 - 5% of bone is remodelled on a yearly basis
- Demineralization of bone:
 - When blood calcium drops, parathormone is released from the parathyroid gland
 - This hormone releases calcium from the bones to restore the proper balance in the blood

Ca:Ph

- Low levels of calcium in the diet results in:
 - Removal of calcium from the bones
- This in turn results in:
 - Lameness
 - Thin, weak bones
 - Enlarged head (Big head or Miller's Disease)
- High levels of calcium can interfere with phosphorous and trace mineral absorption
- **2:1** is the **ideal Ca:Ph to feed the *growing horse***
- **2:1** will be the amount that is set in the adult horse's body
- **1.1-1.5:1** is considered sufficient to feed ***mature horses***

Salt

- Salt is a macro mineral
- Salt is a compound made up of Sodium and Chloride (NaCl)
- Horses need more salt than other animals
 - Salt lost due to sweating must be replaced
- Salt is the only mineral compound that horses self-select for when they have a deficiency
- Horse feeds are low in salt so horses need free choice salt licks
- Functions:
 - Acts as a buffer to help maintain acid-base balance of body fluids, osmotic pressure, and proper pH for efficient enzyme action
 - Affects water metabolism
 - Removes waste products from cell
 - Essential component of bile

Electrolytes

- An electrolyte is a substance found in body fluids that conducts electricity in body functions like:
 - Nerve impulses
 - Oxygen and carbon dioxide transport
 - Muscle contractions
 - Sweating during physical exertion can cause the loss of nutrients such as:
 - Calcium
 - Sodium
 - Potassium
 - Chloride
- Loss of these minerals may lead to:
 - Thumps – syndronous diaphragmatic flutter
 - Muscle twitching or spasms
 - Tetany
 - Fatigue
 - Muscle weakness
- Electrolyte supplementation replaces these lost nutrients

Horses that sweat profusely may need electrolyte supplements



Questions

- 1. Define minerals.
- 2. Define ash content.
- 3. Discuss micro minerals and macro minerals.
- 4. Discuss the calcium phosphorous ratio.
- 5. What is salt, why is it important, and in what ways can it be fed?
- 6. What is the importance of calcium?
- 7. What is the importance of iron?