

**Table 6-1.** Mineral functions and effects of deficiencies and excesses.

<b>Mineral</b>	<b>Function</b>	<b>Deficiency</b>	<b>Excess</b>
<b>Calcium</b>	Constituent of bone and teeth, blood clotting, muscle function, nerve transmission, membrane permeability	Decreased growth, decreased appetite, decreased bone mineralization, lameness, spontaneous fractures, loose teeth, tetany, convulsions, rickets (osteomalacia in adults)	Decreased feed efficiency and feed intake, nephrosis, lameness, enlarged costochondral junctions. Increased calcium intake is a risk factor for calcium-containing urinary precipitates; however, moderate- to high-calcium levels may be protective against calcium oxalate precipitates. Calcium in meals may bind with oxalate in the gut decreasing the risk.
<b>Phosphorus</b>	Constituent of bone and teeth, muscle formation, fat, carbohydrate and protein metabolism, phospholipids and energy production, reproduction	Depraved appetite, pica, decreased feed efficiency, decreased growth, dull coat, decreased fertility, spontaneous fractures, rickets	Bone loss, uroliths, decreased weight gain, decreased feed intake, calcification of soft tissues, secondary hyperparathyroidism
<b>Potassium</b>	Muscle contraction, transmission of nerve impulses, acid-base balance, osmotic balance, enzyme cofactor (energy transfer)	Anorexia, decreased growth, lethargy, locomotive problems, hypokalemia, heart and kidney lesions, emaciation	Rare. Paresis, bradycardia
<b>Sodium and chloride</b>	Osmotic pressure, acid-base balance, transmission of nerve impulses, nutrient uptake, waste excretion, water metabolism	Inability to maintain water balance, decreased growth, anorexia, fatigue, exhaustion, hair loss	Occurs only if there is inadequate good-quality water available. Thirst, pruritus, constipation, seizures and death
<b>Magnesium</b>	Component of bone and intracellular fluids, neuromuscular transmission, active component of several enzymes, carbohydrate and lipid metabolism	Muscle weakness, hyperirritability, convulsions, anorexia, vomiting, decreased mineralization of bone, decreased body weight, calcification of aorta	Uroliths, flaccid paralysis
<b>Iron</b>	Enzyme constituent, activation of O <sub>2</sub> (oxidases and oxygenases), oxygen transport (hemoglobin, myoglobin)	Anemia, rough coat, listlessness, decreased growth	Anorexia, weight loss, decreased serum albumin concentrations, hepatic dysfunction, hemosiderosis
<b>Zinc</b>	Constituent or activator of 200 known enzymes (nucleic acid metabolism, protein synthesis, carbohydrate metabolism), skin and wound healing, immune response, fetal development, growth rate	Anorexia, decreased growth, alopecia, parakeratosis, impaired reproduction, vomiting, hair depigmentation, conjunctivitis	Relatively nontoxic. Reported cases of zinc toxicity from consumption of die-cast zinc nuts or pennies
<b>Copper</b>	Component of several enzymes (oxidases), catalyst in hemoglobin formation, cardiac function, cellular respiration, connective tissue development, pigmentation, bone formation, myelin formation, immune function	Anemia, decreased growth, hair depigmentation, bone lesions, neuromuscular disorders, reproductive failure	Hepatitis, increased liver enzyme activity
<b>Manganese</b>	Component and activator of enzymes (glycosyl transferases), lipid and carbohydrate metabolism, bone development (organic matrix), reproduction, cell membrane integrity (mitochondria)	Impaired reproduction, fatty liver, crooked legs, decreased growth	Relatively nontoxic
<b>Selenium</b>	Constituent of glutathione peroxidase and iodothyronine 5'-deiodinase, immune function, reproduction	Muscular dystrophy, reproductive failure, decreased feed intake, subcutaneous edema, renal mineralization	Vomiting, spasms, staggered gait, salivation, decreased appetite, dyspnea, oral malodor, nail loss
<b>Iodine</b>	Constituent of thyroxine and triiodothyronine	Goiter, fetal resorption, rough coat, enlarged thyroid glands, alopecia, apathy, myxedema, lethargy	Similar to those caused by deficiency. Decreased appetite, listlessness, rough coat, decreased immunity, decreased weight gain, goiter, fever
<b>Boron</b>	Regulates parathyroid hormone, influences metabolism of calcium, phosphorus, magnesium and cholecalciferol	Decreased growth, decreased hematocrit, hemoglobin and alkaline phosphatase values	Similar to those caused by deficiency
<b>Chromium</b>	Potentiates insulin action, therefore improves glucose tolerance	Impaired glucose tolerance, increased serum triglyceride and cholesterol concentrations	Trivalent form less toxic than hexavalent. Dermatitis, respiratory irritation, lung cancer

Tab. 1.8 - I macroelementi: funzioni e sintomi da carenze e eventuale iperdosaggio.

Elemento	Funzioni	Carenza	Iperdosaggio
Calcio	<ul style="list-style-type: none"> <li>- 99% nello scheletro</li> <li>- contrazione muscolare</li> <li>- coagulazione del sangue e della caseina</li> <li>- assorbimento intestinale regolato dal paratormone</li> </ul>	<ul style="list-style-type: none"> <li>- rachitismo</li> <li>- osteomalacia</li> <li>- collasso puerperale o paresi da parto</li> </ul>	<ul style="list-style-type: none"> <li>- antagonista del Mg e dello Zn</li> </ul>
Fosforo	<ul style="list-style-type: none"> <li>- 80% nello scheletro</li> <li>- nelle fosfoproteine e nei fosfolipidi</li> <li>- negli esteri di zuccheri, nucleosidi e nucleotidi (ATP, acidi nucleici)</li> </ul>	<ul style="list-style-type: none"> <li>- rachitismo</li> <li>- osteomalacia</li> <li>- afosforosi con anoressia e depravazione del gusto</li> <li>- ipofertilità con cicli irregolari</li> </ul>	<ul style="list-style-type: none"> <li>- antagonista del Mn</li> </ul>
Potassio	<ul style="list-style-type: none"> <li>- pressione osmotica ed equilibrio acido-base endocellulare</li> <li>- eccitabilità nervosa e muscolare</li> </ul>	<ul style="list-style-type: none"> <li>- ipertrofia cardiaca e renale</li> <li>- tetania muscolare e paralisi (improbabile)</li> </ul>	<ul style="list-style-type: none"> <li>- antagonista del Mg</li> </ul>
Sodio	<ul style="list-style-type: none"> <li>- pressione osmotica e equilibrio acido-base extracellulare</li> <li>- eccitabilità nervosa</li> <li>- nell'assorbimento intestinale attivo di zuccheri e aminoacidi</li> </ul>	<ul style="list-style-type: none"> <li>- disidratazione</li> <li>- accrescimento stentato</li> <li>- calo produttivo generico</li> </ul>	<ul style="list-style-type: none"> <li>- ritenzione idrica (malattia degli edemi)</li> </ul>
Cloro	<ul style="list-style-type: none"> <li>- controllo di Na<sup>+</sup> e K<sup>+</sup> insieme a HCO<sub>3</sub><sup>-</sup> a regolare la pressione osmotica e l'equilibrio acido-base</li> </ul>	<ul style="list-style-type: none"> <li>- accrescimento stentato</li> <li>- calo produttivo e cannibalismo dei polli</li> </ul>	<ul style="list-style-type: none"> <li>- ritenzione idrica (malattia degli edemi)</li> </ul>
Zolfo	<ul style="list-style-type: none"> <li>- negli aminoacidi solforati, nella biotina e tiamina e nel CoA-SH</li> </ul>	<ul style="list-style-type: none"> <li>- dismetabolie ruminanti con scarsi accrescimenti e produzioni stentate (lana)</li> </ul>	
Magnesio	<ul style="list-style-type: none"> <li>- 70% nello scheletro associato a Ca e P</li> <li>- nelle decarbossilasi e nelle fosfo-transferasi</li> </ul>	<ul style="list-style-type: none"> <li>- ipereccitabilità nervosa e muscolare (tetania ipomagnesiaca)</li> </ul>	<ul style="list-style-type: none"> <li>- forte eliminazione di Ca e P per via urinaria</li> </ul>

Tab. 1.9 - I microelementi: funzioni e sintomi da carenze e eventuale iperdosaggio.

Elemento	Funzioni	Carenza	Iperdosaggio
Ferro	<ul style="list-style-type: none"> <li>- 90% legato a proteine (citocromi, flavoproteine, emoglobina, mioglobina, transferrine ematiche, ferritina, emosiderina)</li> </ul>	<ul style="list-style-type: none"> <li>- compromesse le funzioni connesse alla attività metabolica delle proteine cui è legato, anemia</li> </ul>	<ul style="list-style-type: none"> <li>- afosforosi dismetabolica</li> </ul>
Zinco	<ul style="list-style-type: none"> <li>- in molti enzimi (anidrasi carbonica, carbossipolipeptidasi pancreatici, lattico deidrogenasi)</li> </ul>	<ul style="list-style-type: none"> <li>- paracheratosi cutanea nei suini e nei polli, zoppie, ipoplasia testicolare nei bovini</li> </ul>	<ul style="list-style-type: none"> <li>- stessi sintomi della carenza di Cu, ovvero anemia da Cu</li> </ul>
Rame	<ul style="list-style-type: none"> <li>- nelle proteine plasmatiche ceruloplasmina, eritrocupreina</li> <li>- negli enzimi citocromo ossidasi e tirosinasi</li> <li>- partecipa alla sintesi dell'emoglobina e all'assorbimento del Fe</li> </ul>	<ul style="list-style-type: none"> <li>- anemia, depigmentazione e diarree</li> <li>- degenerazione dei nervi periferici (<i>sway back</i> degli ovini) come per l'eccesso di Mo</li> </ul>	<ul style="list-style-type: none"> <li>- necrosi epatica letale. Tolleranza suini&gt;bovini&gt;ovini</li> </ul>
Molibdeno	<ul style="list-style-type: none"> <li>- nei sistemi enzimatici xantino ossidasi, aldeido ossidasi, citocromo C, solfito ossidasi</li> </ul>		<ul style="list-style-type: none"> <li>- diarree con perdita di peso</li> <li>- interagisce con Cu e S formando un composto insolubile nel digerente</li> </ul>
Selenio	<ul style="list-style-type: none"> <li>- nella glutatione perossidasi</li> </ul>	<ul style="list-style-type: none"> <li>- miopatie (distrofia)</li> <li>- diatesi essudativa dei polli</li> <li>- epatopatie nei suini</li> </ul>	<ul style="list-style-type: none"> <li>- altamente tossico: alopecia, astenia, cirrosi epatica, cecità. Esiti letali</li> </ul>
Iodio	<ul style="list-style-type: none"> <li>- nella triiodotironina e nella tetraiodotironina (T3 e T4)</li> </ul>	<ul style="list-style-type: none"> <li>- gozzo, atricosi, dermatiti</li> <li>- anche in presenza di sostanza goitrogene antinutrizionali</li> </ul>	<ul style="list-style-type: none"> <li>- astenia</li> <li>- ovodeposizione ridotta</li> <li>- mortalità embrionale nei polli</li> </ul>
Manganese	<ul style="list-style-type: none"> <li>- negli enzimi fosfato transferasi, decarbossilasi, arginasi</li> </ul>	<ul style="list-style-type: none"> <li>- crescita stentata con malformazioni scheletriche e zoppie</li> <li>- ipofertilità e aborti</li> <li>- atassia dei neonati</li> </ul>	
Cobalto	<ul style="list-style-type: none"> <li>- componente della vitamina B<sub>12</sub></li> <li>- azione emopoietica sinergica con Fe e Cu</li> </ul>	<ul style="list-style-type: none"> <li>- anemia normocitica conseguenza della povertà del terreno (<i>coast disease</i> in Australia; <i>bush sickness</i> in Nuova Zelanda; <i>pining disease</i> in Scozia)</li> </ul>	
Fluoro	<ul style="list-style-type: none"> <li>- nei denti</li> </ul>	<ul style="list-style-type: none"> <li>- crescita stentata</li> </ul>	<ul style="list-style-type: none"> <li>- lesioni scheletriche</li> </ul>